

Summary Report
Conference on Environmental Dredging Technology

June 21-22, 1994

Institute of Marine and Coastal Sciences
Rutgers--The State University of New Jersey
New Brunswick, New Jersey

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On June 21-22, 1994, a Conference on Environmental Dredging Technology was sponsored by the Port Authority of New York/New Jersey in East Brunswick, New Jersey. This was the fourth in a series of conferences designed to collect and disseminate the best available information on issues associated with the dredging of contaminated sediments. Previous meetings focused on the remediation of sediments, and identification of future disposal alternatives for dredged material.

The conference was organized by the Institute of Marine and Coastal Sciences at Rutgers University, and the Marine Sciences Research Center at SUNY/Stony Brook. Participants addressed two primary concerns: 1) dredge technology and emplacement, and 2) the design and engineering of undersea pits. Accordingly, the conference was divided into two sessions with each focusing on one of these issue areas. The technology session examined techniques that mitigate resuspension and dispersal of dredged material, whereas the session on undersea pits explored recent advances and experience with pits as a disposal alternative. Each session assessed current practices and new or innovative approaches to dredge technology and undersea pits, from both a national and international perspective. Formal talks were followed by workshops where participants discussed and recommended the most promising techniques for the New York/New Jersey Harbor region.

Participants (Appendix I) were drawn from industry, academe, government agencies and included representatives of dredging interests from many foreign countries. International participants and renowned U.S. investigators were asked to serve on a steering committee to review and comment on materials produced by the workshop groups (Appendix II). This document represents the final report on the conference and contains specific recommendations on the most appropriate dredging technology and design of undersea pits which can be used to guide future dredging efforts in the New York/New Jersey Harbor region.

Dredge Technology and Emplacement

Discussion

For many years, conventional dredging techniques have been used to remove sediments from our nation's waterways. These techniques can be divided into two general categories--mechanical and hydraulic.

Mechanical dredges (e.g., clamshell dredge) typically employ a bucket to excavate sediment and place it in a barge for transportation to a disposal site. Hydraulic dredges create a slurry which can be pumped through a pipeline to the surface for transport and disposal. Both of these techniques resuspend sediments which, in many harbors, contain concentrations of heavy metals and organic contaminants. This raises concerns with the potential environmental effects from the dispersal of contaminants during dredging operations.

New technology, along with modifications to conventional dredging practices, have emerged to mitigate sediment resuspension. For example, clamshell buckets (which leak material as the bucket is raised to the surface) have been redesigned to enclose the sediment in an almost watertight manner. Acoustic technology recently has been applied to dredging projects where increased precision minimizes the volume of material to be dredged. Another effort proposes to reduce the frequency of dredging by employing engineering practices to reduce the transport of sediments into harbors. Several of the more promising approaches to environmental dredging are presented below. These are divided into three categories; 1) modifications of existing dredge technology, 2) new technology, and 3) high-resolution imaging systems. Abstracts of each presentation in these categories is presented in Appendix V.

Modifications of Existing Technology

Mechanical dredges have been used for many years to remove harbor sediments. These devices operate by applying direct mechanical force to remove sediments. Advantages of these dredges are that they can be operated in confined areas and areas where obstructions or debris are present. However, when dredging fine, cohesive material such as that found in the NY/NJ Harbor, mechanical dredges can cause significant sediment resuspension. Clamshell bucket dredges fall into this category.

The traditional clamshell dredge was modified to mitigate sediment resuspension and to remove material within very accurate vertical tolerances. This modification is particularly applicable to

environmental or remedial dredging operations where precision removal of contaminated layers of sediment is sought.

In addition to improvements to existing dredging technology, advances in dredge handling and control systems have led to precision dredging capabilities. Advances in the areas of vessel positioning, excavation methods and contaminant transport have been used to remediate contaminated sites including a Superfund project site in Louisiana.

A variety of existing dredging techniques also was evaluated with respect to several criteria including accuracy, turbidity, spillage, mixture concentration and sensitivity for coarse debris.

Each of these criteria was evaluated for a modified disc bottom cutter, siltcutter, large and small auger, bucket dredger and water injection dredging (described in more detail below). From the information presented, it was evident that selection of the most appropriate dredge technique is dependent on specific characteristics of the dredge site--type of sediment and contamination, hydrodynamic conditions and site dimensions. Thus, variable site characteristics dictate that a systems approach to dredge a harbor is warranted. This conclusion supports the need for a fine scale survey of the NY/NJ Harbor as a prerequisite to select the most suitable dredging and disposal techniques for each dredge operation.

New Technology

Although modified conventional technology can be effective in dredging contaminated sediments, new technology has been designed specifically for dredging contaminated sediments. These include special purpose dredges which can be classified as mechanical (enclosed clamshell), mechanical-hydraulic (Mud Cat, remotely controlled Mud Cat, and Clean-up system), hydraulic (refresher, waterless, matchbox, and wide sweeper cutterless), pneumatic (pneuma and oozer), and mechanical-hydraulic-pneumatic (screw impeller, airtight bucket wheel, and pneumatic conveyor). Each of these techniques is described in detail in Randall (1994, see Appendix V).

Presentors characterized many of the new techniques with several participants describing comparative evaluations of prototype dredging equipment in a variety of applications. For example, three types of dredges (cutterhead, matchbox and horizontal auger) were evaluated under two scenarios--a nearshore diked disposal site and confined aquatic disposal facility. Laboratory and field studies along with numerical modeling techniques were used to design the disposal facilities. In particular, the cutterhead dredging technique, combined with a monitoring program and used in the confined disposal facility scenario, demonstrated that remedial dredging of a hot spot could be conducted with reduced releases

of contaminants to the environment.

In another demonstration, a horizontal auger suction dredge was modified to dredge contaminated sediments which were then transported via a flexible pipeline to a demonstration treatment facility. Modifications included a multiflight, variable pitch, dual convergence horizontal auger head. Unlike other cutterhead dredging operations, windrows were virtually eliminated. In addition, a shroud encompassing the auger was increased in size to mitigate sediment resuspension. When resuspension measurements were compared to use of the auger without the shroud, it was clear that the shroud reduced resuspension significantly.

A relatively new dredging concept, water injection dredging, was described (Clausner). This approach fluidizes shoal sediments causing them to flow to deeper areas where they don't affect navigation. This is accomplished by injecting large volumes of low-pressure water into the sediment via a row of jets in a horizontal pipe. This process creates a gravity-driven density current that flows down mild slopes. This technique offers an in situ transport option where sediments are transported to another underwater site. Resuspension of sediments does occur with this technique. Analyses of demonstration tests showed that the density current remained relatively close to the bottom, with the majority of material staying within 2 feet of the bottom.

Two presentors from Japan highlighted innovative techniques which address some of the environmental concerns with dredging operations. In one case (Kato), a technique was developed to conduct thin-layer dredging. With large areas unavailable for land disposal of contaminated sediments, this approach enabled dredgers to remove the surficial layer of harbor sediment which contained the highest concentrations of contaminants. Once the highly contaminated material was removed, the remaining material to be dredged could be dredged and disposed with more traditional methods. Two types of thin-layer dredging equipment were developed and compared--a cylindrical conveyor dredge system and a sandwich type system. The latter proved superior to the cylindrical system in terms of performance and efficiency.

In the second presentation from Japan, several technologies were combined to enhance the transport of dredged material and reduce the amount of sediment volume to be dredged (Nanba). A high-density compressed air process was used in Kumamoto Port to transport dredged material with a reduced water content and thus, reduced sediment resuspension. In addition, the tandem use of a submerged dike and a new breakwater design combined to reduce the amount of sediments to be dredged. These new approaches were critical to protect productive bottoms near Kumamoto Port, and to minimize the amount of upland area needed for disposal.

Also in Japan, remediation dredging of mercury-contaminated

sediments was conducted in Minamata Bay, where public concern focused on bioaccumulation of this contaminant in fish and shellfish consumed by area residents (Nanba). A highly watertight revetment was constructed to confine sediment dredged from the bay.

Four cutterless suction dredges, outfitted with a variety of sensors and cameras, were used to monitor and minimize the amount of material dredged. The contaminated sediment was then placed in the revetment, covered with a sandproof membrane and then soil. Results presented indicated that the dredge operation was conducted with minimal dispersal of sediments.

An innovative approach to reduce future needs to dredge by constructing a current deflecting wall (CDW) also was described (Kirby). This is a passive technique designed to combat eddy-induced shoaling at harbor entrances. Sediment engineering principles are used to alter water circulation and reduce sediment exchanges by natural means. This technique works not by providing a counter-force, but by removing the eddy-generating force itself.

In addition, several environmental benefits arise from this technology; large-scale sediment entrainment is mitigated resulting in higher levels of dissolved oxygen, and the amount of sediment to be dredged and disposed is reduced.

One presenter (Wenzel) described how a vehicle originally designed to mine deep seabed manganese nodules might be applied to dredge contaminated sediments at shallow and deep water depths. He described a bottom crawling dredge with precision sensors and controls to enhance dredge performance. Information also was presented on another vehicle, the Track-Mounted Remotely Operated Dredger (Tramrod), a vehicle designed to use interchangeable cutting devices mounted on a hydraulically-controlled dredging arm.

These devices include a suction head, bucket wheel for digging clays and partly cemented gravels, an environmental disc cutter, environmental blade cutter, and an Archimedes screw-assisted environmental cutter. Dredged material can be transported through a pipe system located to the rear of the system, or pumped as a slurry to the surface where it can be barged, treated or cycloned.

From the presentations, it was evident that dredging technologies exist which reduce sediment resuspension, maximize the volume of contaminated sediment dredged from hot spot areas, and which are cost-effective.

High Resolution Imaging Systems

A Canadian firm has used a ground-penetrating radar to measure layers of contaminants on land and in freshwater settings (Gariepy). In a pilot test with this technology, information on the volume and spatial distribution of contaminants in a fresh water body was collected. This information will be used to assist

in the selection of the most appropriate dredging equipment, and to evaluate the cost associated with the dredging operation. In addition, ground penetrating radar also might be used to identify potential disposal sites which are stable, provide containment, and are isolated from periodic disturbances. Application of this technology in a salt water environment has not been pursued.

Several investigators have developed techniques to determine the characteristics of sub-bottom marine sediments using high-resolution imaging systems. A digital data acquisition system has been combined with specialized processing software to compute the volume and type of material to be removed by dredging (Caulfield).

This information is especially useful to:

- o characterize sediments in order to plan and design sampling and dredging programs,
- o focus remedial dredging operations, and
- o establish a database across broad spatial and temporal scales to support a long-term strategy for dredged material management.

The latter benefit addresses one of the primary needs for managing dredged material in any port--the conduct of a fine-scale survey to characterize the distribution and contaminant concentration of sediments. A recommendation to address this requirement has been made at each of the four dredge-related conferences supported by the Port Authority of NY/NJ, including the conference which is the subject of this document. More details on this recommendation appear in the recommendations presented below.

Recommendations--Dredge Technology and Emplacement

During the breakout session on environmental dredging technology, participants were challenged to identify the best and most appropriate dredging technology for use in the NY/NJ Harbor area.

Specifically, participants were asked:

1. What are the potential advantages and disadvantages of environmental dredging technology which may be applied in the NY/NJ Harbor estuary?
2. What survey information is needed to make decisions on appropriate technology for managing contaminated sediments in the NY/NJ Harbor Estuary?
3. What are the uncertainties associated with each technique?
4. What types of pilot projects do you recommend to address any uncertainties associated with these dredging techniques?
5. Which techniques could be used in tandem with near-term disposal alternatives (e.g., undersea pits) and long-term disposal strategies (e.g., containment islands, upland disposal or other permanent containment facilities)? What advantages/disadvantages are associated with dredging techniques that complement these disposal strategies?

The breakout group found it difficult to address these questions until the survey posed in question #2 is conducted. An accurate characterization of sediment contaminant loads, distribution and transport processes is necessary to determine which sediments and what quantity of dredged material warrant remediation. The group believed this to be a prerequisite for selecting suitable dredging technology and for siting disposal operations. In addition, a detailed characterization of sediments could be used to focus treatment alternatives on sediment sources and depositional areas in the harbor. Geophysical sensing systems such as sidescan sonar, the high-resolution imaging systems discussed during the formal presentations, and associated sampling offer useful techniques for conducting this characterization. An effective, long-term management plan for dredged material, including the most suitable techniques for dredging and disposing of this material, cannot be produced without this survey information.

Undersea Pit Design and Engineering

In the past few years, the design and construction of geotextile containers has received more attention as a potential disposal option for contaminated sediments (Fowler). These containers are made from woven and nonwoven synthetic fabrics, can be fitted with permeable or impermeable liners, and may be mechanically or hydraulically filled inside bottom-dump hopper scows, moored into place, and then dumped. Geotextile containers filled with dredged material have been used in a variety of beneficial applications such as dike construction, underwater stability berms, island construction, barrier island beach repair and stabilization, and containment of contaminated materials. These applications have been limited because of the high water content in the containers, and lack of information on the potential migration of contaminants from the containers. Further, the seam strength typically limits the ultimate strength of the fabric. Nonetheless, serious consideration is being given to proposals to use geotextile containers in conjunction with undersea pits that are capped as an interim disposal measure for contaminated sediments. This approach possesses a number of advantages including better isolation of the material, resistance to dispersal associated with episodic events such as storms, and the ability to place the material in well-defined areas.

One presenter from the Netherlands (Laboyrie) described his country's efforts to design and construct a large-scale, confined disposal site. Roughly 250 million cubic meters of contaminated sediment must be dredged in the Netherlands by the year 2010. Presently, their government is developing two large scale disposal facilities to accomodate between 20 and 30 million cubic meters of this material. Each facility will be constructed as an island in a large lake. Several alternatives were examined prior to the selection of this disposal strategy including upland disposal and construction of undersea pits. Each alternative was evaluated in terms of the following criteria:

- o potential groundwater contamination,
- o potential surface water contamination,
- o environmental effects on biota,
- o architectural integrity,
- o cost, and
- o ease of management and control.

The island approach was selected because excess water could be treated, the site was manageable and, in contrast to undersea or upland disposal, the site would not be forgotten (out of sight, out

of mind). Presently, the Netherlands are debating whether the island option should be constructed as a confined or unconfined disposal site. A cost-benefit analysis is being conducted to assist in making this decision.

Also in the Netherlands, new disposal sites were described for the Port of Rotterdam, which must dredge about 17 million cubic meters of sediment per year (Mollema). Much of this sediment is described as slightly contaminated and is typically disposed at an open ocean site. Monitoring studies indicate that 30% of the 12 million cubic meters dumped annually at this site are transported back to the Port entrance. Consequently, the Port has pursued alternate methods of disposal for this material, especially the construction of undersea pits in combination with sand mining activities. The pits are constructed in 20-25 meters of water with a pit depth of 10-20 meters and a capacity of 5 million cubic meters. One pit is being constructed each year thereby creating a pit field which would be capped by natural processes. Advantages of this approach when compared to the present disposal practice include the reduction of contaminant flux along the Netherlands coast, decreased concentrations of suspended particulates in coastal areas and a positive cost-benefit ratio. One major disadvantage is that no market exists for the quantities of sand ultimately generated by pit construction. Thus, the use of undersea or borrow pits will not replace the open ocean disposal practice entirely.

Recent progress was reported on the use of an Acoustic Doppler Current Profiler (ADCP) to measure concentrations of suspended solids during dredging operations (Kirby). This technology facilitates monitoring of the entire suspended plume on a mesoscopic scale to a depth of 50 meters. The complementary use of an infra-red profiling siltmeter resolves vertical details of the suspended material on a finer scale to fractions of a centimeter.

This permits detection of features such as shear zones and lutoclines within the body of the suspended material. Further, the siltmeter can detect and monitor dredged material during phases of high turbidity. By using the ADCP and siltmeter simultaneously, the entire water column and dredge plume can be monitored. This approach has been used to monitor the emplacement of contaminated sediments in undersea pits in the Port of Hong Kong. Contaminated sediments are mechanically dredged and barged to specially-constructed pits which are monitored by the ADCP and profiling siltmeter. Sand capping is then used to isolate the dredged material from the surrounding environment which includes recreational beaches, aquaculture operations and coral communities.

With the ADCP and profiling siltmeter, monitoring studies can be conducted throughout an entire dredging and disposal operation including the integrity of undersea pits, capping and post-capping activities.

Recommendations--Undersea Pit Design and Engineering

As with the breakout group on environmental dredging technology, participants in the undersea pit design and engineering group were asked to apply the information received during the formal talks to the present dredging situation at the NY/NJ Harbor. These were:

1. What advances in the design and construction of undersea pits and containment islands could be applied to the management of dredged material in the NY/NJ harbor estuary?
2. What other disposal alternatives could/should be used to ensure the optimum use of undersea pits and containment islands?
3. How may undersea pits and containment islands be designed and managed as interim storage facilities for the potential future in situ remediation of contaminated sediments?
4. What site characteristics are important for locating undersea pits and containment islands?
5. What survey information is needed to make decisions on appropriate technology for managing contaminated sediments in the NY/NJ Harbor Estuary?

Several criteria must be met to design and construct undersea pits in a manner that maximizes containment and minimizes environmental disturbance. This objective relies on the selection of a low-energy site where physical forces are minimal. Site selection can be greatly assisted by the collection of information on sediment transport processes recommended in the section on Dredging Technology and Emplacement above. Only with a fine-scale characterization of sediments and the processes that govern their distribution and transport can we begin to address the questions posed above. A survey has been designed by the U.S. Geological Survey to collect this information. Additional federal, state and regional support is required to conduct this project. This survey is a prerequisite for the development of a long-term management plan for dredged material in the NY/NJ Harbor.

Recommendations--Future Directions

Waterborne commerce and the periodic dredging of shipping channels are essential to the economic health and well-being of our nation.

In some states, a sincere effort of cooperation among public interest groups and regulatory agencies has been achieved for dredged material management with a mutual aim toward the establishment of economic and ecologic goals which can be met.

In the NY/NJ Harbor however, lingering concerns regarding the safe disposal of contaminated sediments have polarized opinions within and among the regulatory agencies and public interest groups resulting in multi-year delays for dredging operations. One of the key points at issue is the scientific validity of the risk analysis used by EPA to determine whether the disposal of dredged material represents an "acceptable risk". Not enough data exists to quantify the risk associated with the removal and redeposition of contaminated sediments. This situation poses a problem when attempts are made to relate trace levels of contaminants to environmental risk. To address this challenge, a new and constructive partnership must be pursued among the various parties concerned with dredge-related issues to develop a dredging policy and risk assessment process that is predictable, efficient, environmentally sound and cost-effective.

Successful establishment of the new partnership is dependent on four key issues:

- 1) What is the best approach for all parties to assume responsibility for adopting new dredging and containment technologies?
- 2) How can risk and cost information be generated in a timely manner?
- 3) What is the best way to involve the public constructively in the decision-making process?
- 4) At present, no one is in charge; how do you empower managers to solve dredging issues?

What is the best approach for all parties to assume responsibility for adopting new dredging and containment technologies?

Advances in dredging technology which may provide solutions to the current crisis in the NY/NJ Harbor have lacked implementation because of unknowns associated with their potential environmental effects. All parties have been slow to accept new approaches or techniques for sediment dredging and disposal due to these unknowns. Although this caution is valid, it limits the range of

dredging and disposal alternatives available for consideration, especially as attempts are made to design a long-term strategy to manage dredged material in the region. These limits impose severe constraints for the NY/NJ Harbor which has no near-term disposal method that is acceptable to the public. Rather than preclude alternatives from consideration for lack of information, the public must share some of the risk associated with new technology by agreeing to test new approaches at a demonstration scale and perhaps even at a pilot scale. One such opportunity was presented recently with the proposal to demonstrate the use of a subaqueous borrow pit in Newark Bay. Contaminated sediments were to be dredged from several berths and redeposited into an existing pit a short distance away. Although political support for this trial waned, this is the type of technology demonstration which could provide useful information for regulators and the public to consider when drafting a long-term dredge material management plan for the harbor.

How can risk and cost information be generated in a timely manner?

Often, it may take several years for dredge permit applicants to receive a decision on a proposed project. Much of this time is spent to conduct a risk assessment, and some of the time is used to evaluate the economic benefits and costs of the proposed dredging operation. The time consumed to conduct these activities is compounded when each activity is conducted by a separate federal agency.

The Clean Water Act of 1972, as amended, directs the Army Corps of Engineers to dispose of dredged material into navigable waters of the U.S. via discharge permits. These permits must comply with criteria issued by the Environmental Protection Agency for evaluating contaminated dredged material. As such, the Corps is required to use EPA's criteria in its decision making process, and EPA's oversight includes veto power over dredge permits. Although the risk evaluation is necessary, the division of authority between the Corps and EPA does add time to the permit process. Add to this divided responsibility the interests of state, county and municipal authorities, other federal agencies and public interest groups, and the generation of information to process a permit application may take several years; dredging projects are delayed or rescinded because of the lack of timely information. A mechanism must be developed to ensure that early decisions can be made on proposed dredging projects.

One agency should have the ultimate authority to approve or decline a dredge permit application. This agency must be given the sole responsibility for collecting information on a permit application in a timely manner. This includes soliciting the appropriate input from state, county and municipal authorities, public interest

groups and other federal agencies (especially in terms of risk assessment). A strictly enforced time period must be set for the submission of information pertaining to a permit. During that period, any agency/group would have the opportunity to address the risks associated with the proposed dredging and/or the economic benefits that would accrue from the dredging operation. A set of standards also must be developed by the agency to enable the risks and benefits to be weighed against one another.

What is the best way to involve the public constructively in the decision making process?

Many efforts have been made to engage the public in discussions on dredging issues. Unfortunately, these efforts have not defined a specific role for public participation nor a well-defined mechanism for public input. For example, in 1993 the Corps of Engineers and EPA, along with the states of New York and New Jersey, created the Dredge Management Forum. Membership ranged from those agencies/groups which had some legal responsibility to oversee dredging activities to individuals who simply possessed interest in dredge-related issues. Six subcommittees were formed to begin to solicit opinions and draft positions on key dredging issues:

- o Dredging, Transport and Disposal Technologies
- o Disposal Criteria
- o Closure of the Mud Dump Site/New Ocean Disposal Site Designation
- o Containment Facilities
- o Sediment Decontamination Technologies/Facility Siting
- o Sediment Contamination Reduction

After many meetings during the course of its first year of operation, the Forum was asked to comment on a "Straw Proposal" prepared by EPA, the Corps and the states of New York and New Jersey. Despite the existence of the Forum, public involvement in developing the proposal was not sought, and the document did not reflect the past deliberations of the six Forum subcommittees. As a result the document is still being revised by the federal and state agencies which originally drafted the text.

A new model and hence a new relationship must be established to enhance public input to the decision making process, and to eliminate the paralysis produced by polarization. When the Corps solicits input from parties affected by a dredge permit application (as noted above in #2), the same standards of review and consideration must be given to the risks and/or benefits identified by public interest groups. The public must be treated as an equal among those agencies/groups which have a legal responsibility for dredging activities. In addition to this recognition, the Corps must establish a permanent mechanism where citizens and government

solve dredging problems together. This mechanism should include citizen participation in oversight and monitoring, funding for citizen groups to hire technical consultants, and meetings arranged and run jointly by government and citizen groups.

At present, no one is in charge; how do you empower managers to solve dredging issues?

The present stalemate on dredging issues results from a variety of factors. These include the items addressed in 1-3 above (lack of responsibility among all parties to test and evaluate new dredging and containment technologies, the inability to collect risk and cost information in a timely manner, and the lack of a specific, authorized role for the public to provide constructive input to the decision making process), and the dilemma resulting from two federal agencies sharing responsibility for review of dredge permits. The latter item poses a serious challenge to the efficient handling of dredge-related issues. As suggested in #2 above, lack of a single federal authority to decide on dredge permit applications looms as the primary constraint hindering an efficient, decision making process. This constraint cascades throughout the regulatory framework now used to manage dredge permit applications. In addition, the myriad state, county and local government agencies, as well as the public interest groups, have no clear mechanism to interact with the federal agencies involved with dredge management. As noted in #2 above, the first step to resolve this situation is to establish one entity as the sole authority for managing dredging projects, with well-defined procedures for soliciting and reviewing information on the potential environmental and economic affects of all proposed dredging operations. Once given this authority, the dredging authority must develop new standards to ensure that fair consideration is given to each proposed project. More importantly, these standards should be linked to specific actions or decisions a manager can make on proposed dredging projects. Obviously, these standards must be developed in cooperation with public interest groups.

Appendix I

List of Participants

List of Participants

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