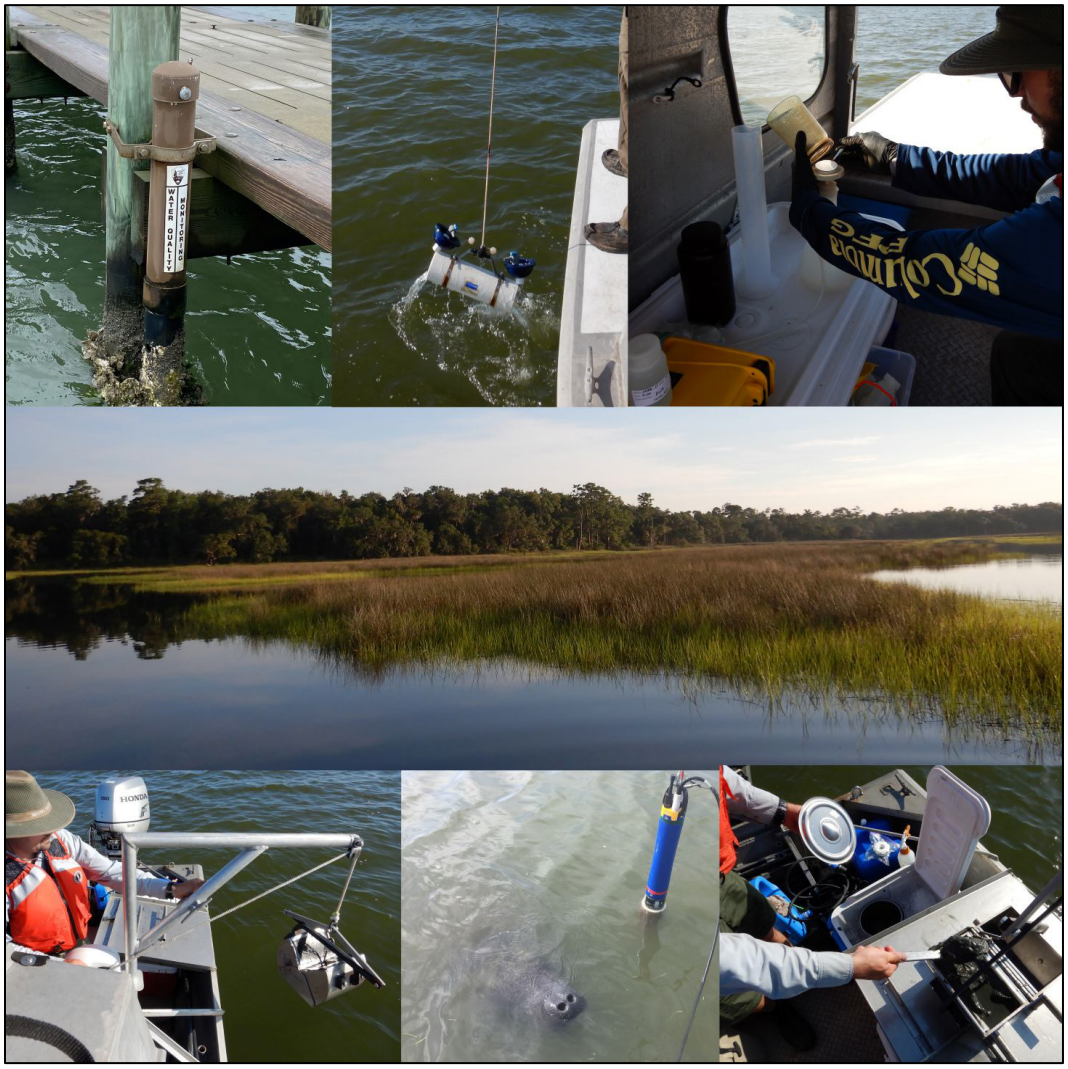
National Park Service
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Natural Resource Stewardship and Science

Protocol for Monitoring Estuarine Water and Sediment Quality in Selected Southeast Coast Network Parks

Protocol Narrative—Version 2.0

Natural Resource Report NPS/SECN/NRR—2023/2528



ON THE COVER

Clockwise from top left, fixed-station sonde housing, collecting water sample during park-wide assessment, processing sample, Brown's Creek at Timucuan Ecological and Historic Preserve, lowering the grab sampler to get sediment, a manatee checks out the sonde, and processing a sediment sample.

Photos by SECN staff.

Protocol for Monitoring Estuarine Water and Sediment Quality in Selected Southeast Coast Network Parks

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Natural Resource Report NPS/SECN/NRR—2023/2528

Eric N. Starkey,[1] M. Brian Gregory,[1] Wendy K. Wright,[1] Joseph C. DeVivo,[1] Eva M. DiDonato,[2] Christina J. Wright, Emma Thompson

[1] National Park Service
Southeast Coast Inventory and Monitoring Network
135 Phoenix Road
Athens, Georgia 30605

[2] National Park Service
Ocean and Coastal Resources Branch, Water Resources Division
1201 Oakridge Drive, Suite 250
Fort Collins, Colorado 80525

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Natural Resource Stewardship and Science
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Executive Summary

The National Park Service (NPS) Inventory & Monitoring Program has initiated estuarine and near-shore water-quality and sediment monitoring in the vicinity of Cape Hatteras National Seashore (CAHA), Cape Lookout National Seashore (CALO), Canaveral National Seashore (CANA), Cumberland Island National Seashore (CUIS), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), and Timucuan Ecological and Historic Preserve (TIMU). This monitoring was initiated programmatically by the Natural Resource Challenge and implemented in 2006 to focus specifically on providing data needed to assess the quality of near-park estuarine waters and benthic sediments. This protocol relies on data collection methods and standard operation procedures (SOPs) currently in use by the U.S. Environmental Protection Agency (EPA) and National Oceanic and Atmospheric Administration (NOAA) monitoring programs with the intent of leveraging the usefulness of NPS data by ensuring its comparability with existing, contemporary, and future data sets collected under these and other state monitoring programs.

The Southeast Coast Network's (SECN) monitoring effort is composed of collecting data from permanent, fixed-station continuous data loggers in combination with analysis of periodic discrete water samples and sediment samples. These data provide park resource managers information on the status of, and trends in, water and sediment quality within and near parks. Fixed-station water-quality monitoring is conducted at seven parks using continuously-recording data loggers (data sondes) that monitor select water-quality parameters at 15- and 30-minute intervals. In addition, at these same permanent locations, monthly hand-collected water samples are analyzed for nitrogen, phosphorus, and chlorophyll *a* concentrations. Methods for the SECN fixed-station water-quality and nutrient sampling are adapted from the National Oceanic and Atmospheric Administration-National Estuarine Reserve Research System (NERRS) Program.

In addition to the permanent sampling sites, multi-day sampling events are conducted at 30 randomly selected sites in the vicinity of seven parks at five-year intervals for the purpose of assessing water and sediment quality conditions. Methods used for collecting data on this longer time frame are adapted from the U.S. Environmental Protection Agency National Coastal Assessment (NCA). The five-year sampling assesses temperature, turbidity, conductivity, pH, dissolved oxygen, conductivity, and water clarity values at each sampling location. Nutrient samples collected in conjunction with the water-quality parameters above include measuring concentration for chlorophyll *a*, total nitrogen, total phosphorus, dissolved inorganic nitrogen and dissolved inorganic phosphorus. As part of this park-wide assessment, sediment quality is sampled at 10-year intervals at 30 randomly selected sites in the vicinity of five parks using a Young-modified Van Veen grab sediment sampler. Sediment samples are analyzed for total organic carbon, sediment grain size, metals, mercury, polycyclic aromatic hydrocarbon (PAH) compounds, polychlorinated biphenyl (PCB) compounds, and pesticides.

By combining these approaches to monitoring, the network gains insight into the status of near-park water-quality as well as information for park managers on the temporal dynamics of water-quality at selected locations in each park. The overarching purposes of this protocol are to provide a monitoring

framework for collecting scientifically sound data and to supply information to help evaluate the status and trends in water- and sediment-quality conditions that may affect the composition, structure, and function of park ecosystems and visitor experiences. These data can then be evaluated to help determine if current management practices are sustaining those functions and uses.

Data collected under this protocol are stored in an SECN-managed database and uploaded annually to the National Park Service's Environmental Quality Information System (EQuIS; Earthsoft 2020) database, maintained by the NPS Water Resources Division (WRD) In addition to utilizing customized data handling and reporting procedures, this protocol and its accompanying SOPs set guidelines for data to be made available internally to park resources managers and employees as well as for publication to larger audiences via annual data summaries (Appendix A).

Acknowledgments

The Southeast Coast Network would like to thank the many participants of various technical and advisory groups who, in the early years of this monitoring program's development phase, helped focus its goals and select appropriate methods for monitoring the estuarine and near-shore waters of park areas along the southeastern Atlantic Coast. Special thanks to Virginia Engle (EPA) for providing help with sampling designs for the coastal assessments and to Jenny Asper and Stephen Cooper (SECN) for cartographic and GIS assistance for this protocol and for providing additional sampling designs for parks not originally included in the first round of park-wide assessments. Julie Dingle, Aaron Rinehart and Daniel McCay provided important technical input on the development and adaptation of the many standard operating procedures. Data management support from Paula Capece, Wendy Wright (SECN) and Dean Tucker has been critical to the success of this monitoring effort. Clark Jones provided editorial critiques and assistance which significantly improved the quality of this protocol. Publication of this document would not have been possible without editorial support and document formatting assistance provided by Mark Hynds.

Revision Log

Revision History Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
2023	Eric N. Starkey and Wendy K. Wright	Updates to sampling design, methods, data management, safety, and appendices. Documentation of adaptive implementation at CONG.	Revisions to the protocol narrative were to align this document with updated SOPs published in 2022. In addition, updates were made in response to the 2021 and 2022 operational reviews and new data management systems in place since this protocol's inception.	2.0

Background and Objectives

In 1999, the National Park Service's Inventory and Monitoring Program initiated a long-term ecological monitoring program known as Vital Signs Monitoring. It was designed to provide the infrastructure to allow more than 270 national park system units to identify and monitor conditions of their highest priority resources (Fancy et al. 2009). Established programmatically under the Natural Resource Challenge, the Southeast Coast Network (SECN) is one of 32 networks formed to implement this integrated monitoring program which is tailored to the specific needs of parks located in similar environmental settings. The overarching purpose of natural resource monitoring conducted under this program is to collect data and produce scientifically sound information on the status of—and long-term trends in—the composition, structure, and function of park ecosystems, as well as determine how current management practices are sustaining those systems. Efforts implemented under the Vital Signs Monitoring Program seek to address the following five major goals for all parks with significant natural resources:

- Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals.

Development of the Protocol for Monitoring Estuarine and Sediment Quality in the Southeast Coast Network

Due to its importance to park resources—both as a natural resource and as an important element of visitor experience—water-quality was selected as one of the 12 core NPS natural resource inventories for which baseline data were collected system wide. In 2001, the network began planning and implementing its long-term Vital Signs Monitoring Program, which included the near-shore waters in the vicinity of monuments, national seashores, and preserves along the Southeast coast. In 2004, SECN staff provided parks with resource prioritization questionnaires and asked natural resource staff to rank the importance of water resources to their parks as well as potential concerns that a monitoring program might address. Findings from this survey indicated that estuarine and marine water-quality were a high priority for the Vital Signs Monitoring to address (DeVivo et al. 2008). In 2005, SECN staff held a scoping meeting with representatives from the National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (EPA), state agencies, and academic institutions whose overlapping interest in marine and estuarine resources helped to focus and shape the fundamental aspects of an estuarine and near-shore water and sediment quality monitoring program that could serve the needs of SECN

coastal parks. These meetings further acknowledged the importance of these types of data to better understand characteristics of water resources, ecological processes, and physical systems within parks. It was recommended that the Southeast Coast Network monitor estuarine water-quality using the probabilistic survey design developed by the EPA's National Coastal Assessment (NCA) Program and augmented by a fixed station monitoring network like those used by the National Estuarine Research Reserve System (NERRS), a partnership program between NOAA and coastal states. Additional recommendations from these meetings also included the need to produce data that would be compatible with existing federal programs and temporally overlapping data collection efforts. Combining the strengths of these two monitoring programs has also been suggested by the National Park Service and National Water Quality Monitoring Council (NWQMC 2006). Existing protocols and published methods are used whenever possible, to allow national and regional data compatibility and help provide context for park water conditions The resulting hybrid group of procedures outlined herein is referred to as the Protocol for Monitoring Estuarine Water and Sediment Quality.

This document has two main goals: (1) to provide an outline for an overall strategy for estuarine water and sediment quality monitoring that is credible and scientifically rigorous, and (2) to provide a specific set of instructions in the form of standard operating procedures (SOPs) that are sufficiently detailed to ensure consistent and comparable data collection in the future. The structure of this monitoring protocol generally adheres to the framework and suggestions of Oakley et al. (2003). This protocol also broadly summarizes important characteristics of water resources along the southeastern U.S. coast, highlighting similarities and differences as they relate to general water-quality conditions and monitoring objectives. This protocol also makes a case for the relevancy of this effort by highlighting known water-quality issues in coastal parks as well as some of the important linkages between coastal water-quality and park resources—some that may help provide early warnings of changing conditions or help explain problematic conditions that may be an issue of concern in the future.

Estuarine Systems and Coastal Landforms in the Southeast Coast Network

The coastal portion of the network is along the southeastern U.S. coast, stretching from Cape Hatteras National Seashore (CAHA) in North Carolina to Cape Canaveral National Seashore (CANA) in central Florida (Figure 1). Although the National Inventory and Monitoring (I&M) network design sought to group similar parks with similar environmental settings and ecologies, the background conditions that influence southeastern coastal waters vary among these parks primarily due to differences in their geomorphic origins and proximity to large rivers and concentrated urban and suburban areas. The common linkage among these areas are the suite of global climate and geophysical processes that resulted in their formation and their dynamic coexistence at the interface between flowing freshwater systems and tidally influenced marine systems.

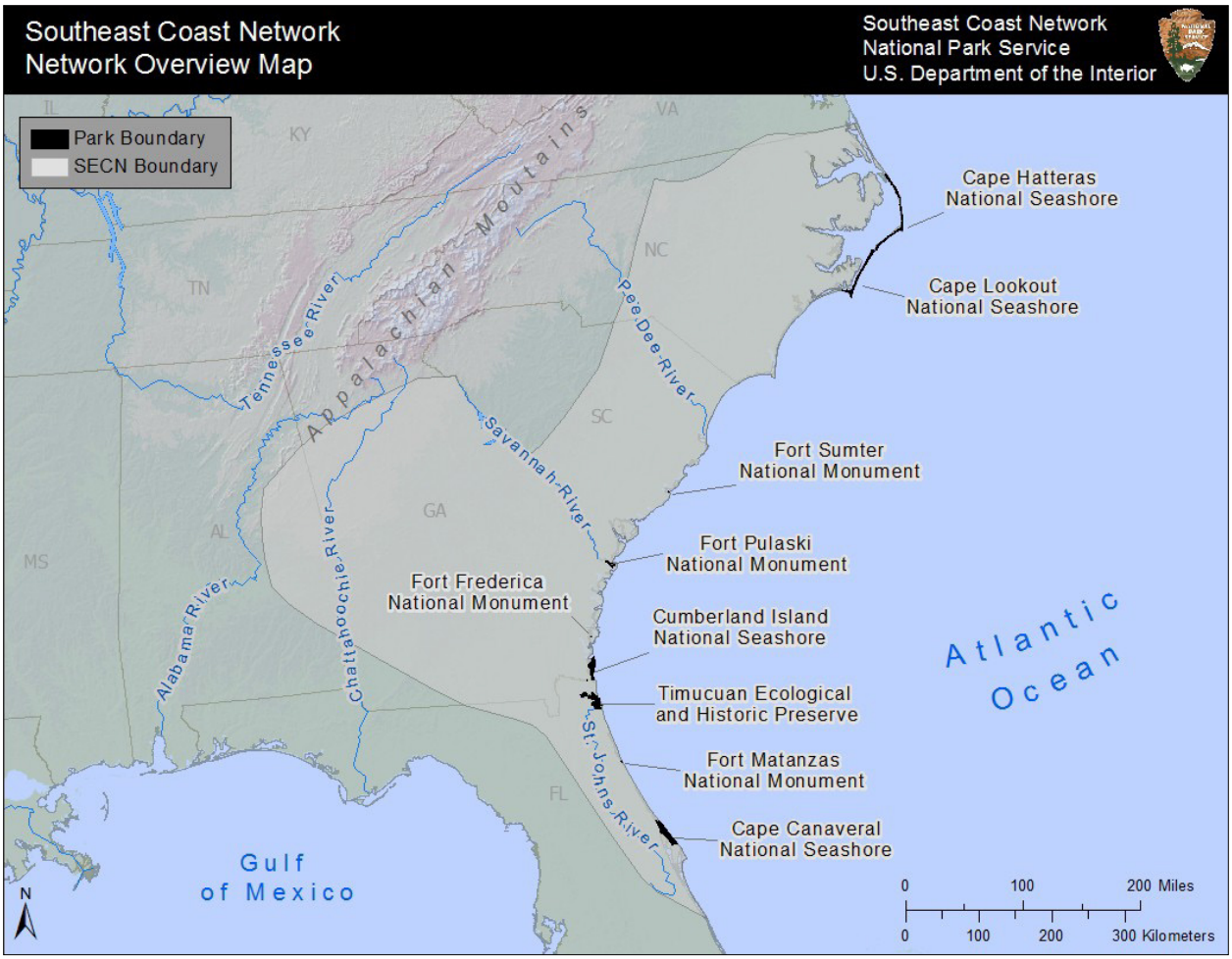


Figure 1. Overview map showing locations of coastal National Park Service units in the Southeast Coast Network.

Estuarine systems in the network were formed by the creation of a semi-protected aquatic zone where freshwater from rivers slowly mixed with salt water from the ocean. Estuarine areas formed by barrier island systems are not unique to the Southeast but form anywhere along a coastline where a gentle sloping coastal plain intersects a wave-energy dominated coastline that has an adequate sediment supply and a tidal range less than three meters (Bascom 1980). These landforms began to form about 15,000 years ago after the cooler global temperatures that caused sea levels to drop by as much as 300 feet (91 meters [m]), began to warm. As the temperatures warmed, the rising Atlantic Ocean pushed landward and flooded the relatively young coastal river and inlet systems that had developed along the late Pleistocene coastline. The slowly rising water along with prevailing winds pushed ridges of sand inland until the ridges either pushed against the existing coastline or stopped moving due to stabilization of the sea levels. The complex land and water forms observed in different areas of the coast resulted as migrating ridges of sand met existing or remnant coastal landforms including older relic dunes or protruding ridges of sedimentary rock (Hoyt 1967). For example, in North Carolina, Cape Lookout and Cape Hatteras National Seashores—as well as the surrounding sound areas—formed as the inland-migrating primary barrier/dune system intercepted the still

standing secondary dune system; the resulting inundation of a large area of low-lying land between the barrier islands and the mainland formed the Pamlico Sound and Back Sound areas.

The barrier island estuarine marsh systems along the South Carolina, Georgia, and northern Florida coasts were formed when the migrating primary barrier systems meet the relic Pleistocene sand dune and ridges and were pushed against them. The extensive marshes around Fort Sumter (FOSU), Fort Pulaski (FOPU), Fort Frederica (FOFR), Cumberland Island (CUIS) and Timucuan Ecological and Historic Preserve (TIMU) are due to the presence of the barrier island system and a magnified tidal amplitude due to the concave shape of the coastline known as the Georgia Embayment. The odd shape of Cumberland Island and Sound are due to the interaction of both the large tidal amplitude and the strong tidal current moving through relatively small river inlets. The low areas behind these barrier islands were well protected from wave energy from the open ocean which has allowed fine silt and clay sediment to accumulate in large muddy flat areas that were colonized by salt tolerant cord grasses—particularly those that could also tolerate the high tidal ranges of this section of the coastline (Johnson et al. 1974).

Similarly, the barrier islands of the east coast of north central Florida formed as the inland migrating sand ridges were pushed against an exposed ridge of coquina. As barrier islands developed in these areas, they were fed by sand transported to the ocean by the larger rivers of Georgia and South Carolina that were moved southward by the long-shore current. The semi-enclosed Cape Canaveral and Mosquito Lagoon areas are unique in that they are believed to have formed as the long-shore current forced a southward migrating cape to progressively form parallel dune ridges along the coast. The outermost ridge in this system was later joined to the landward migrating sand ridge that was being pushed inland by rising sea levels. Mosquito Lagoon, managed as part of Canaveral National Seashore, formed when the low-lying areas behind the barrier islands flooded between 5,000 and 6,000 years ago, forming an almost entirely enclosed body of water. The lagoon currently has no direct connection with the Atlantic Ocean although at least five major inlets have been documented over this period with the most recent closing over 1,500 years ago (Mehta and Brooks 1973).

Although inhabited by Native Americans for thousands of years prior to European colonization due to the abundance of natural resources along the coast, the first European's built forts along the coast because of the strategic positions that overlook important inlets, harbors, or rivers. As early as 1565 at St. Augustine, the first permanent European settlement was established. Today, this 800-mile (1,290 kilometer [km]) stretch of coastline contains some protected natural areas, but much has been extensively developed, especially along the I-95 corridor. Cities of moderate size exist in the vicinity of—or in some cases adjacent to—many of the National Park protected areas. Cities such as Titusville (Fla.), Charleston (S.C.), Nags Head (N.C.), and Beaufort (S.C.) are home to important centers of recreational and commercial fishing and tourism. Additionally, the cities of Jacksonville (Fla.), Savannah (Ga.), and Charleston are large urban areas where shipping and other human activities have caused documented degradation in water resources and may impact conditions on park lands. This degradation could cause unacceptable impacts in the future by further degrading water-quality conditions as well as other scenic values that the parks have been charged to manage and protect.

Near-Park Water-Quality Issues and Rationale for Monitoring

The near-park waters of SECN parks contain important habitat for a variety of fish (Shenker and Dean 1979) and wildlife species. These areas serve as nursery habitats for fish, crustaceans, and shellfish (Weinstein 1979) and foraging habitat for birds and mammals while providing a multitude of recreational opportunities including boating, fishing, and bird watching. These ecosystems are vulnerable to impacts caused by development and use. Severe impacts including alterations to hydrodynamic processes, exposure to levels of chemical contaminants that cause mortality, altered growth, and reduced reproduction in fish, and severe hypoxia have been documented in estuarine habitats and linked to urban and industrial development (Lerberg et al. 2000). In addition, estuarine macrobenthic communities in impacted areas are characterized by low diversity, low numbers of rare and pollution-sensitive species, and low macrobenthic abundances (Lerberg et al. 2000). In areas with increased impervious cover, stormwater runoff is flashy and greater than natural amounts of fresh and polluted waters are released into estuaries (Holland et al. 2004).

Although similar in many ways, the unique set of geomorphic conditions that shaped these coastal areas also contributes to the range of naturally occurring water-quality conditions observed in the vicinity of the parks. Water-quality conditions are primarily related to dominant physical factors such as tidal influence, depth to bed and relative influence of freshwater systems; however, other factors such as the parks proximity to large urban centers or other anthropogenic activities such as large areas of impervious surface and stormwater runoff can exert a significant influence. For example, the water in the vicinity of parks along the Outer Banks are relatively large open and shallow areas, dominated by wind energy with little influence from major rivers which results in clear, shallow waters with an abundance of specialized sea grass habitat (Mallin et al. 2004). The coastal areas from Charleston to Jacksonville are characterized by somewhat more protected estuarine areas dominated by large tidal exchanges and freshwater inflows from larger rivers including the Ashley-Cooper-Wando system in South Carolina, the Savannah, Altamaha, and St. Marys rivers in Georgia and the Nassau and St. Johns rivers in Florida. Near-park estuarine areas in this region of the coast are usually deeper and are naturally more turbid than areas to the north or south and may be moderately stratified with a more saline layer of water near the bottom. Seagrasses are not common in these areas; rather, the higher tidal ranges favor the development of large, flat, and shallow areas drained by pulsing tidal creeks and dominated with Spartina whose growth, nutrient processing abilities, and decomposition can exert a significant influence on observed water-quality patterns. Additionally, the seasonal patterns of discharge into these estuaries from rivers such as the Peedee, Savannah, Altamaha, Satilla, Nassau, and St. Johns significantly influence the observed water-quality conditions along this part of the coast. Mosquito Lagoon, due to its semi-enclosed nature, is influenced more by seasonal weather patterns such as precipitation, evapotranspiration, and wave energy. Seagrass beds are important natural habitats in North Carolina and much of the coastal areas of Florida including Mosquito Lagoon at Canaveral National Seashore. These specialized aquatic habitats provide food, shelter, and nursery areas for commercial and recreational fish species, as well as ecosystem services such as bed stabilization and trapping of sediments. Many areas in Florida have seen significant declines in the amount of seagrass coverage which has been linked to increased dredging, nutrient inputs, and declining water clarity (Gulf of Mexico Program 2004).

Network coastal parks are potentially affected by stressors falling into one of the following categories: changes in water chemistry, hydrologic modification (either flows or freshwater inputs), changes in biological communities and productivity, changes to sediment transport, or changes in sediment contaminants (Table 1). While most of these are caused by forces outside the boundaries (or management control) of SECN parks, all potentially result in changes relevant to the long-term management of park resources and visitor experience. The following sections summarize the general water-quality concerns along the coast and highlight specific or unique water-quality issues at each coastal park in the Southeast Coast Network.

Table 1. Coastal water-quality issues and potential measures for Vital Signs Monitoring.

Category	Issue	Potential Measures
Water Chemistry	Chemical makeup of estuarine waters is susceptible to alteration on both short- and long-term bases as a result of inputs from changes in land side watershed land use and runoff, and down shore or down current transport.	Concentration of nutrient species [A], pH [A], dissolved oxygen [A], turbidity [A], temperature [A], and water clarity [A]
Freshwater Inputs	Salinity is a significant driver of biological community composition and distribution, and can be affected by changes in land use, water demand, and resultant inputs to systems from inflowing rivers. Additionally, short term changes in freshwater availability (and fluctuations in salinity) are driven by stormwater inputs, which are expected to change due to climate change.	Salinity [A], specific conductance [A]
Biological Communities	Productivity and diversity of estuarine biological communities including fish, invertebrates, and plants are affected by a combination of habitat quality, water-quality, and disturbance.	Fish, algae, or benthic macroinvertebrate community measures, bacteria concentration, chlorophyll *a* concentration [A]
Fisheries	Access to quality fisheries (both finfish and shellfish) provide park visitors and surrounding communities with opportunities for enjoyment and economic benefit.	Population demographics, tissue contaminant concentrations
Sediment transport and fate	Dredging activities to maintain the Intracoastal Waterway or other navigation channels occur within or near the boundaries of all SECN parks, potentially altering hydrology, habitat quality, and bioavailability of contaminants. Excessive sedimentation can alter flow patterns or estuarine flushing rates.	Grain size distribution [A], sea grass distribution, benthic macroinvertebrates
Sediment Contaminants	Organic and metal contaminants in sediments potentially persist within estuarine ecosystems and may result in chronic stressors to ecosystem function.	Organic carbon concentrations [A], concentrations of metals [A] and organic compound contaminants [A]

[A] Measures selected for data collection in the Southeast Coast Network Protocol for Monitoring Estuarine Water and Sediment Quality.

Cape Hatteras National Seashore

Cape Hatteras National Seashore is the northern most park unit in the Southeast Coast Network (Figure 2). Located along the northern section of the Outer Banks, Cape Hatteras contains 35,400 acres of land and 74 miles (119 km) of beaches. The U.S. Fish and Wildlife Service administers Pea Island National Wildlife Refuge within the boundary of the seashore. Seashore marshes contribute heavily to primary estuarine productivity and provide habitat for numerous wildlife and aquatic species. The unique and varied habitats, such as mature broad-leafed evergreen forest and shrub, freshwater marsh, and bog support an unusual assemblage of aquatic, terrestrial, and avian species. The seashore has recently been designated a Globally Important Bird Area by the American Bird Conservancy because of the importance of the seashore habitats to avian breeding, migration, and wintering.

The ecological zonation of Cape Hatteras NS is due in part from artificial alterations dating from the turn of the twentieth century. The most important perturbations were due to early efforts at mosquito control and waterfowl management which involved excavation of drainage ditches and construction of water control structures, and vegetative stabilization of primary dunes along the length of the seashore. Later changes were wrought when road construction included excavation of borrow ponds for roadbed material. For the most part, these actions ended by the 1970s, except for localized projects designed to protect specific and discrete portions of infrastructure.

Nags Head and nine other smaller towns border the seashore and cause developmental pressure from outside the park. Visitor and recreational uses represent the major categories of threat to the integrity of natural resources in the park. Replacement of natural areas with impervious surfaces increases stormwater runoff with its associated contaminants, so it may be of potential concern to near-shore water-quality (Mallin et al. 2006). Elevated bacterial levels have resulted in the recent addition of many aquatic areas in the vicinity of the park to the 303(d) list of impaired waters, as well as the prohibition of shell fishing in areas to the south of Kill Devil Hills and Manteo.

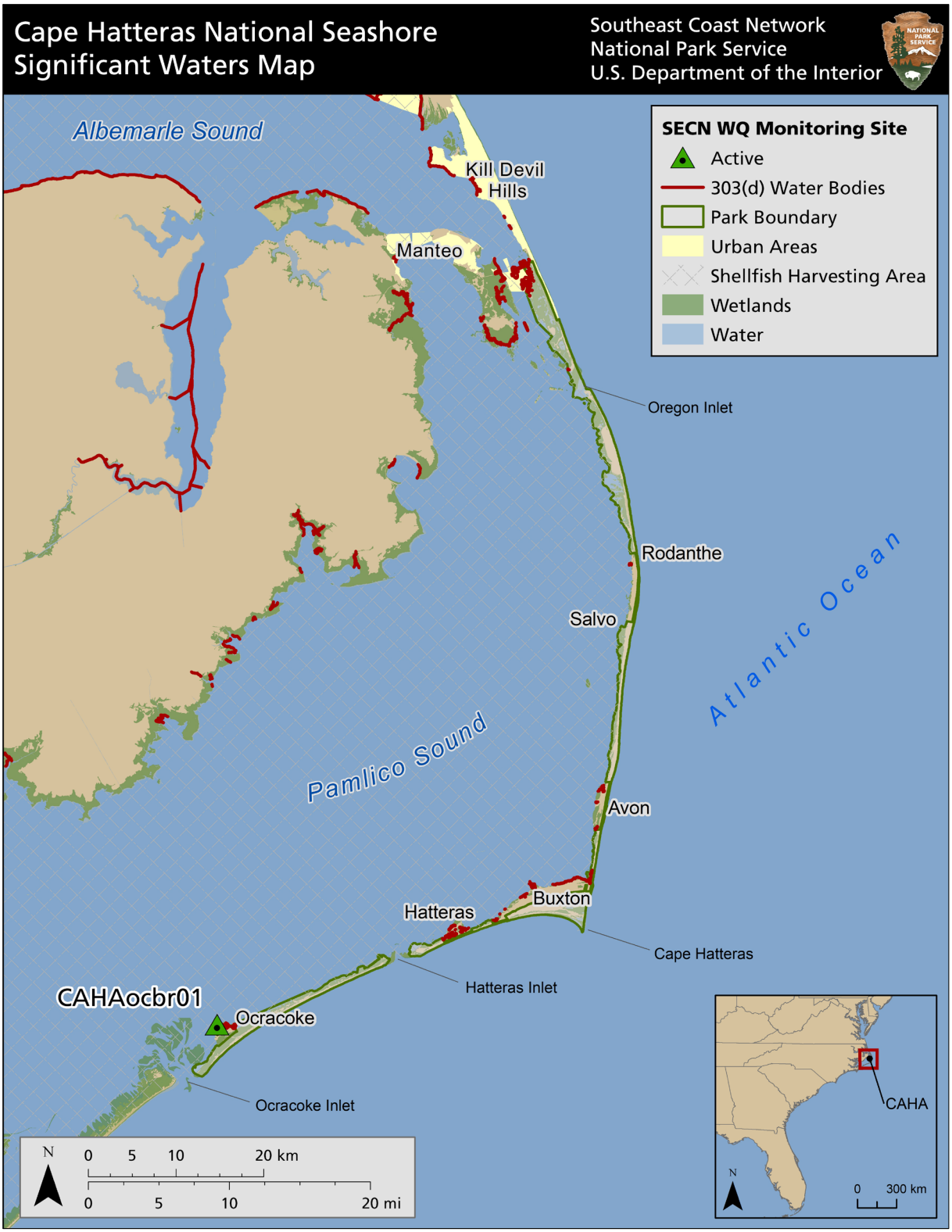


Figure 2. Fixed station monitoring site and estuarine and marine water resources in the vicinity of Cape Hatteras National Seashore in North Carolina. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023), and areas designated as having special uses or restrictions (NCDENR DEH-SSRWQS 2011).

Cape Lookout National Seashore

Cape Lookout National Seashore, located along the southern end of the Outer Banks, is largely undeveloped and accessible only by boat. Cape Lookout NS is made up of three barrier islands covering 56 miles (90 km) of the central coast of North Carolina (Figure 3). Most of the seashore consists of North and South Core Banks, a 44-mile (71-km) long barrier system oriented in a southwest to northeast direction and separated by Ophelia Inlet. Cape Lookout extends into the Atlantic Ocean from its southern end. The other barrier system within the seashore, Shackleford Banks, extends westward from Cape Lookout.

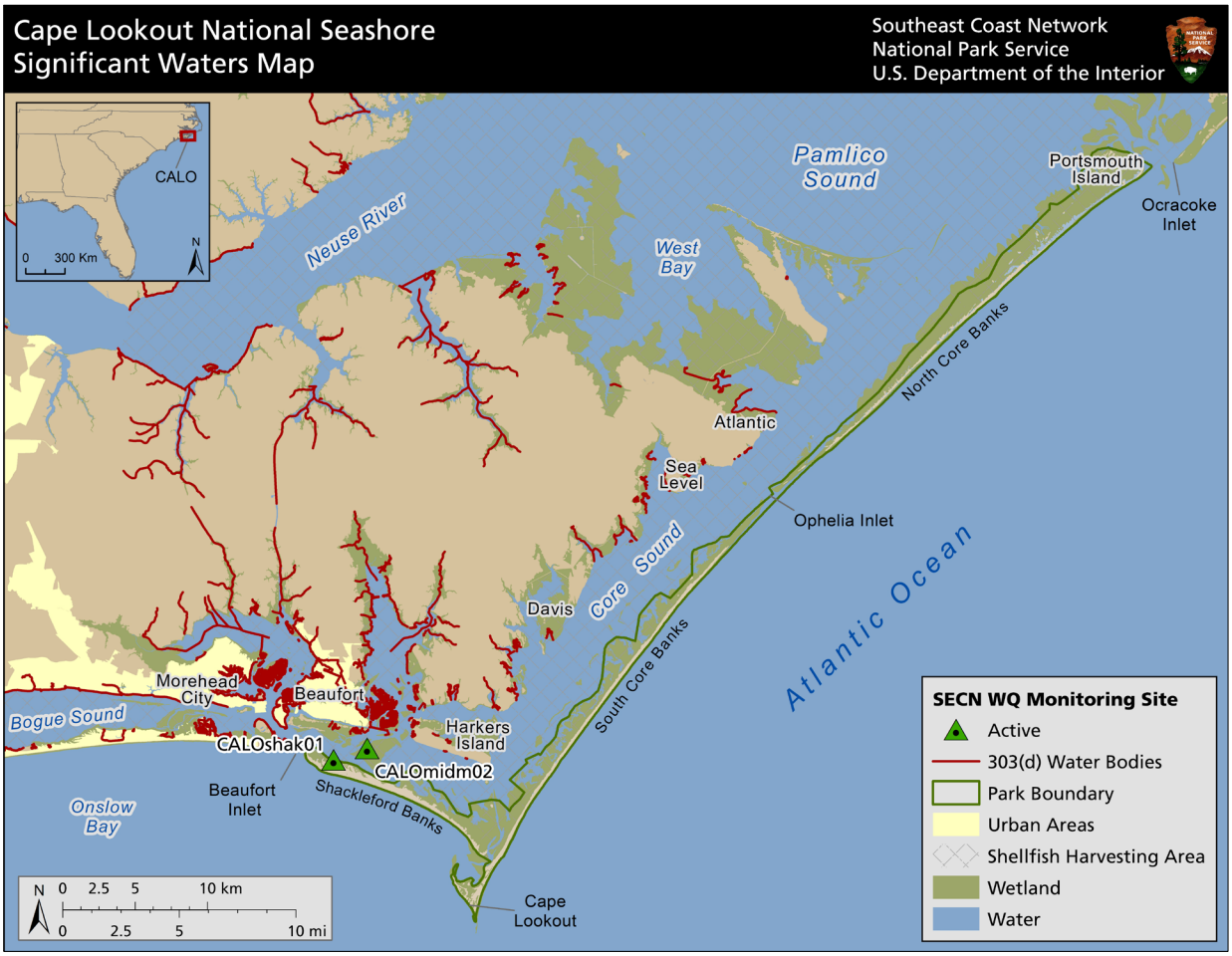


Figure 3. Map of fixed stations monitored by the Southeast Coast Network in Core Sound, and significant waters in the vicinity of Cape Lookout National Seashore, in 2021. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023), and areas designated as having special uses or restrictions such as shellfish harvest areas (NC DENR DEH-SSRWQS 2011).

Core Banks is a long, narrow expanse of low dunes, maritime grasslands, and extensive salt marshes. Shrub thickets border the grassland in many places, and a low maritime forest occupies small areas of higher ground. The islands are generally about 3 to 6 feet (0.9 to 1.8 m) above sea level and 0.6 to1.2 miles (1 to 2 km) wide. For the most part, these areas are open and treeless.

Instead of exhibiting the typical zonation of a wide berm, low dunes, grasslands and shrub thickets, and salt marsh, the northern end of Portsmouth Island is characterized by vast tidal sand flats (averaging 0.6 miles or 1 km in width) located between the berm and the dunes of a series of marsh-fringed islands. At the triangular shaped Cape Lookout, continuous dunes characterize its southwest side, with several small freshwater marshes present in depressions between the dunes. A long spit extends from the western tip of Cape Lookout, where a jetty built in the early 1900s has encouraged accretion in this direction.

Specific issues related to water-quality at Cape Lookout NS include those related to commercial fishing as well as water-quality near the larger areas such as the Back Sound near Shackleford Banks and the populated areas of Morehead City and Beaufort. Although no National Pollutant Discharge Elimination System (NPDES) discharges are located on the on Core or Shackleford Banks (NCDENR 2001), Mallin et al. (2004) reported elevated polycyclic aromatic hydrocarbons (PAH) and metals in the areas near Core Bank. Numerous water bodies in the vicinity of the seashore have also been 303(d) listed for water-quality violations. For example, the marine waters both north and south of Cape Lookout, as well as those off Cape Lookout itself, have been listed for elevated mercury and bacteria levels. Areas in the Core and Bogue Sounds have been listed for elevated pathogen levels which have caused shell fishing areas to be closed or only conditionally approved (Figure 3).

Cumberland Island National Seashore

Cumberland Island National Seashore is off the coast of Georgia between St. Andrews Sound and the mouth of the St. Marys River. At 17.5 miles (28.2 km) long, the seashore is one of the largest and most diverse barrier islands on the Atlantic Coast (Figure 4). Almost half of its 36,415 acres are *Spartina*-dominated salt marsh habitat. These areas include oyster mud flats and six tidal creeks which provide the habitat for a diverse marine-based fauna. The island is known for nesting loggerhead sea turtles, abundant shore birds, undeveloped dune fields, maritime forest ecosystems, and historic structures. Cumberland Island provides habitat for 18 federally-listed threatened or endangered species (Alber et al. 2005) although most are terrestrial or bird species, several species of sea turtles are commonly observed along the beaches and West Indian Manatees are known from the estuarine areas.

Cumberland Island National Seashore was established in 1972 to preserve the scenic, scientific, and historical values of the island as well as to provide public outdoor recreational uses to its visitors. Specified areas of Cumberland Island are also part of the South Atlantic-Carolinian Biosphere Reserve and are permanently protected in a primitive state. The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem.



Figure 4. Fixed station monitoring site and estuarine and marine water resources in the vicinity of Cumberland Island National Seashore in Georgia. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023), and areas designated as having special uses or restrictions.

Water-quality conditions in Cumberland Sound and the Cumberland River are influenced by freshwater inflows mainly from the St. Marys River to the south, the Crooked River near the middle portion of the island and the Satilla River on its northern boundary. St. Marys, Georgia, like other coastal communities, faces increased residential development pressure. The cities of Jekyll Island, Georgia and Brunswick, Georgia located just north of Cumberland Island (as well as Fernandina Beach, Florida located just to the south) have some potential to affect water-quality conditions due to the large amount of wood pulp processing, manufacturing, and shipping activities that occur. Jekyll Island, Georgia, just across St. Andrews Sound from Cumberland Island's northern boundary, is a relatively small resort community but has a permitted wastewater discharge on its southern end. Other activities—such as dredging along the estuarine waters just south and east of the island to maintain the submarine access channel to Kings Bay Submarine Base—have the potential to cause episodic deterioration of the water-quality as well as the scenic attributes of the south end of Cumberland Island. Transportation corridors such as rail, interstate highways, and the intracoastal waterway are also potential sources of pollution, particularly catastrophic spills. The Georgia coast has been going through an era of fast growth in new residential communities, many of which have sought to incorporate marinas. Recreational pressure could increase on the island, and the threat to resources and critical habitats may also intensify. Erosion on the western side of the island is currently being investigated by Cumberland Island National Seashore and the Southeast Coast Network (Bateman-McDonald 2020). The only aquatic areas in the vicinity of the park to be 303(d) listed are the Amelia River just south of Cumberland Island, the St. Mary's River, and parts of Cumberland Sound along the island's southern tip for elevated mercury levels in fish (Figure 4).

Timucuan Ecological and Historic Preserve

Timucuan Ecological and Historic Preserve (TIMU) is situated entirely within Duval County and the city limits of Jacksonville, Florida (Figure 5). The preserve is operated as a partnership park and encompasses approximately 46,000 acres of mostly open water, river and salt marshes between the St. Johns and Nassau Rivers (Figure 5). The southern third of the preserve lies at the mouth of the extensive St. Johns River watershed, which drains parts of the urbanized portions of the City of Jacksonville. The St. Johns River has been heavily impacted by agricultural, industrial, and urban pollution; however, marine tidal waters near its mouth may have helped to ameliorate much of this pollution through dilution and flushing. The northern two-thirds of the preserve lie within the Nassau River drainage basin, a smaller watershed that drains parts of Duval and Nassau counties. The Nassau River watershed has not yet experienced the concentrated urban and industrial growth found along the St. Johns River; still, portions of the watershed have exhibited episodic periods of poor water-quality. The area surrounding the preserve to the west and north is predominantly marsh and low uplands utilized for timbering, residential and agricultural uses. Runoff from upstream agriculture areas, as well as leachate from residential septic systems located near the Nassau River, make nutrients and chlorophyll levels an important concern for areas along this river. In the northern part of the preserve, sections of the upper Nassau River—as well as the estuarine area adjacent to Amelia Island along the South Amelia River—have been 303(d) listed for elevated mercury levels in fish. Elevated mercury in fish has also been the cause of recent 303(d) listings at Cedar Creek Point, the entire length of the St. Johns River through the Jacksonville and in the Intracoastal Waterway to the Atlantic Ocean (Figure 5).

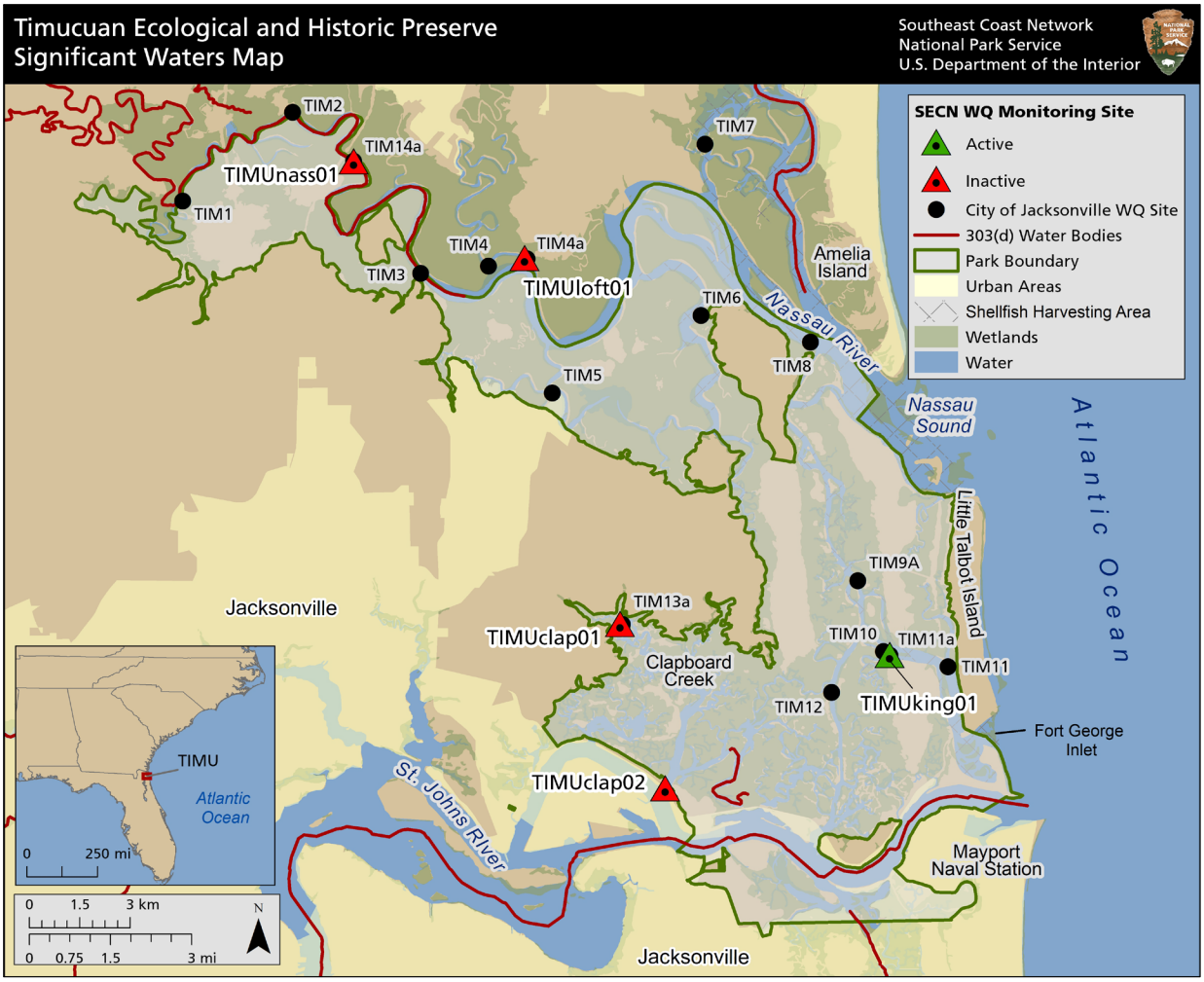


Figure 5. Fixed station monitoring sites and freshwater, estuarine and marine water resources in the vicinity of Timucuan Ecological and Historic Preserve in Florida. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023) and shellfish harvesting area (Florida Department of Environmental Protection 2011).

Canaveral National Seashore

Canaveral National Seashore's natural resources include a diverse assemblage of wildlife, plant communities, geophysical features and natural processes reflecting the complexity of the land/lagoon/sea interface of east central Florida (Figure 6). Unlike many barrier islands, Canaveral Island has only a single dune ridge, averaging approximately 12 feet (3.7 m) in height. For much of its length, the dune is quite stable, backed by a dense growth of saw palmetto (*Serenoa repens*) and several other species of hardy shrubs and grasses.

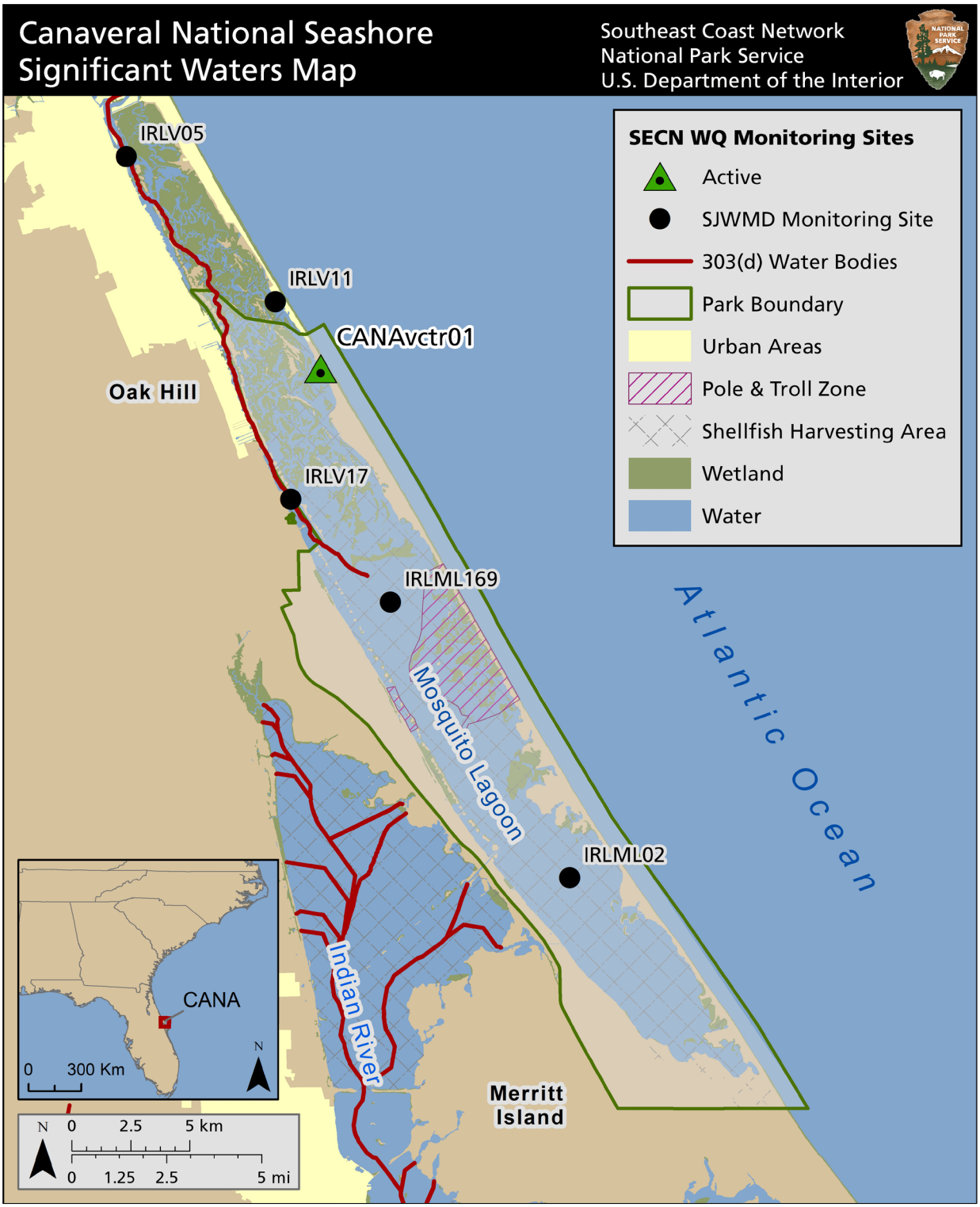


Figure 6. Map of fixed stations monitored by the Southeast Coast Network and St. Johns River Water Management District in Mosquito Lagoon, and significant waters in the vicinity of Canaveral National Seashore. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023), and areas designated as having special uses or restrictions such as shellfish harvest areas and pole and troll (Florida Department of Environmental Protection 2011).

Mosquito Lagoon, extending along the backside of Canaveral's barrier island, is the northernmost part of the Indian River System, an area which contains one of the most diverse assemblages of aquatic species on the entire Eastern Seaboard. This 155-mile (250-km) long lagoon has been designated as an Estuary of National Significance by the EPA and an Outstanding Florida Water by the State of Florida. It contains one of the last significant oyster harvesting areas on the Atlantic Coast that has not been depleted by over harvesting or pollution. Commercial shell fishing is important to the local economy and recreational fishing and shrimping in the lagoon support a multimillion-dollar tourist industry. The estuary also serves as an important nursery area for commercially important ocean-going species such as flounder, mullet, black drum and shrimp.

Although water-quality in the lagoon has been described as good as recently as the early 1990s, rapid population growth in the vicinity of Canaveral National Seashore is causing water-quality concerns in Mosquito Lagoon. Due to its unique semi-enclosed nature, the seashore faces complex issues regarding water-quality. Even though runoff from several canals—along with submarine groundwater discharge—results in a slow net movement of water northward and out of the system through Ponce Inlet (Hall et al. 2001), contaminants are more likely to accumulate in a lagoon system than a back barrier island estuarine system that has large daily exchanges with the ocean. Two of the documented main concerns have been leachate from nearby septic systems and direct discharges of treated wastewater by publicly owned treatment plants (Zarillo et al. 2012). Nearby septic systems threaten water-quality by increasing the loading of pollutants such as phosphorus, nitrogen, and bacteria. During 2010, the cities of New Smyrna Beach and Edgewater discharged some treated effluent into the lagoon. The amount discharged from these facilities has been shrinking over the years as both municipalities have been routing effluent into wastewater reuse programs (Zarillo et al. 2012); however, during especially wet conditions, larger than usual discharges may occur. Currently, park waters are closed to shell fishing when rainfall exceeds 1.5 inches (3.8 centimeters [cm]) in a 72-hour period, due to high fecal coliform levels. Mosquito control is another issue related to water-quality monitoring in Mosquito Lagoon. In the designation of lands for NPS management, both NASA and the State of Florida stipulated that Canaveral National Seashore must cooperate with the local mosquito control districts to control salt marsh mosquitoes. Open Marsh Water Management (OMWM) techniques and chemicals are currently being used in Mosquito Lagoon. Recently 303(d) listings indicate that mercury levels in fish are a concern within Mosquito Lagoon whereas metals other than mercury have caused adjacent waters in the Indian River System to be listed (EPA 2022). Although the extent of seagrasses in Mosquito Lagoon is currently thought to be stable, seagrass habitat is an important issue in Mosquito Lagoon due to the unique physical and ecological roles it plays in shallow coastal waters.

Smaller Coastal Park Areas

Several small park areas along the coast do not have large areas of natural resources, but their inclusion in the SECN monitoring effort may be warranted due to their significant associations with marine and estuarine water bodies and their potential to be impacted by human activities such as urbanization and shipping. For example, water resources around Fort Sumter in South Carolina could be affected by runoff from the inland areas draining the Cooper, Ashley, and Wando Rivers as well as the populated areas of Mt. Pleasant, Charleston, and James Island. Several areas to the north and

west of Fort Sumter in Charleston Harbor have been recently 303(d) listed (Figure 7). Fort Pulaski in Georgia (Figure 8) is somewhat isolated from potential direct impacts by large expanses of salt marsh, however, its location downstream of Savannah, Georgia and immediately adjacent to one of the busiest commercial shipping routes on the east coast could make aquatic resources surrounding this area particularly vulnerable to periodic water-quality issues. Deepening of the shipping channel adjacent to Fort Pulaski was completed in March of 2022. By deepening the navigation channel, larger ships can now navigate upstream in water immediately adjacent to the Fort. Fort Frederica in Georgia, while relatively buffered from major urban areas, is near several large wood pulp processing facilities with noted water-quality degradations (Figure 9). Fort Matanzas in Florida (Figure 10) is also buffered by salt marshes and marsh areas of the Pellicer Creek Aquatic Preserve west and south of the park. Water-quality can be affected by many activities occurring upstream of the park boundaries, especially given its proximity to the greater St. Augustine urban areas as well as the smaller beach communities and developed residential areas along the Matanzas River.



Figure 7. Estuarine and marine water resources in the vicinity of Fort Sumter National Monument in South Carolina. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023).

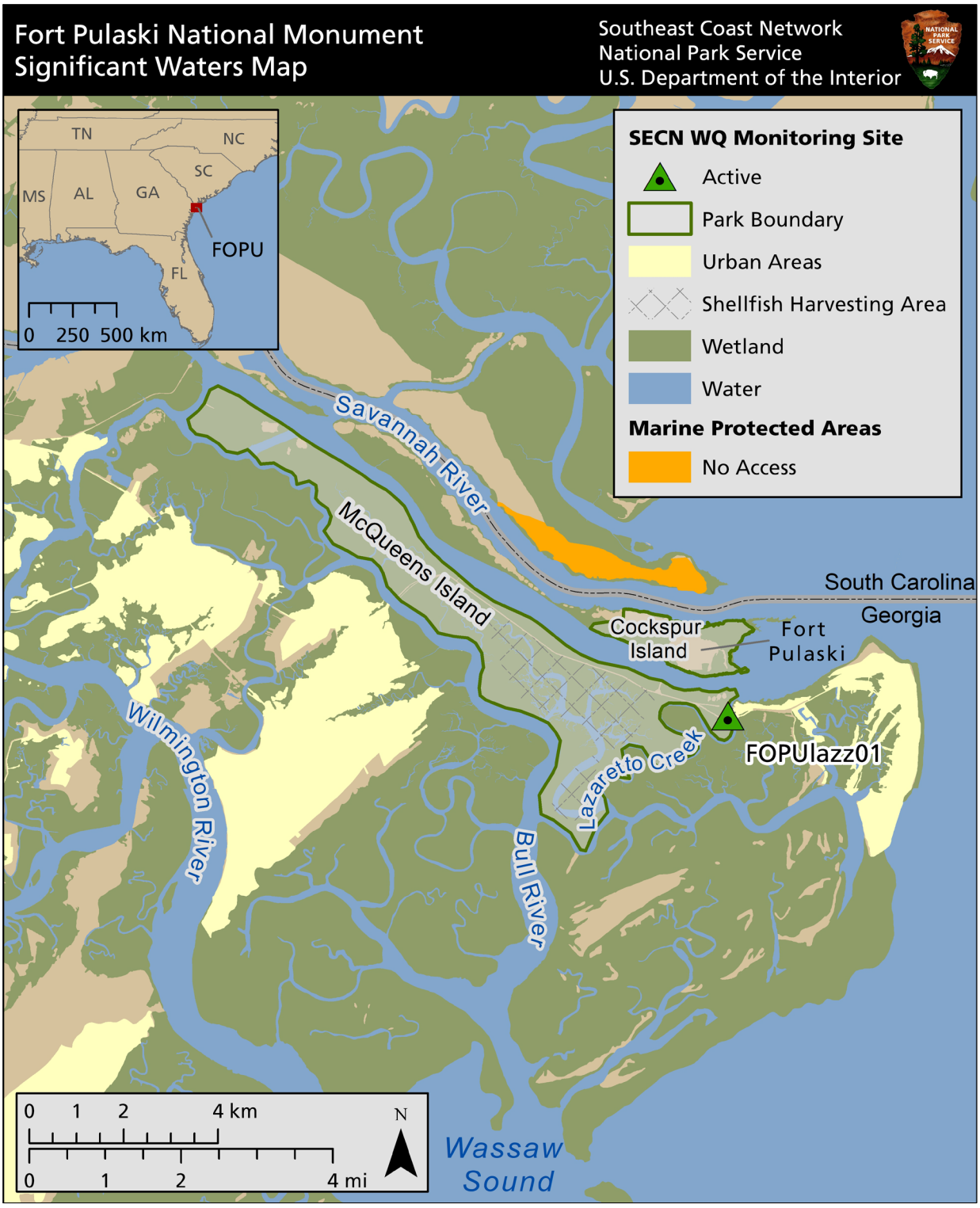


Figure 8. Fixed station monitoring site and estuarine and marine water resources in the vicinity of Fort Pulaski National Monument in Georgia. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), and areas designated as having special uses or restrictions (NOAA 2008).



Figure 9. Estuarine and marine water resources in the vicinity of Fort Frederica National Monument in Georgia. Indicated are areas of salt marsh (FWS 2023), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2023), and areas designated as having special uses or restrictions (NOAA 2008).

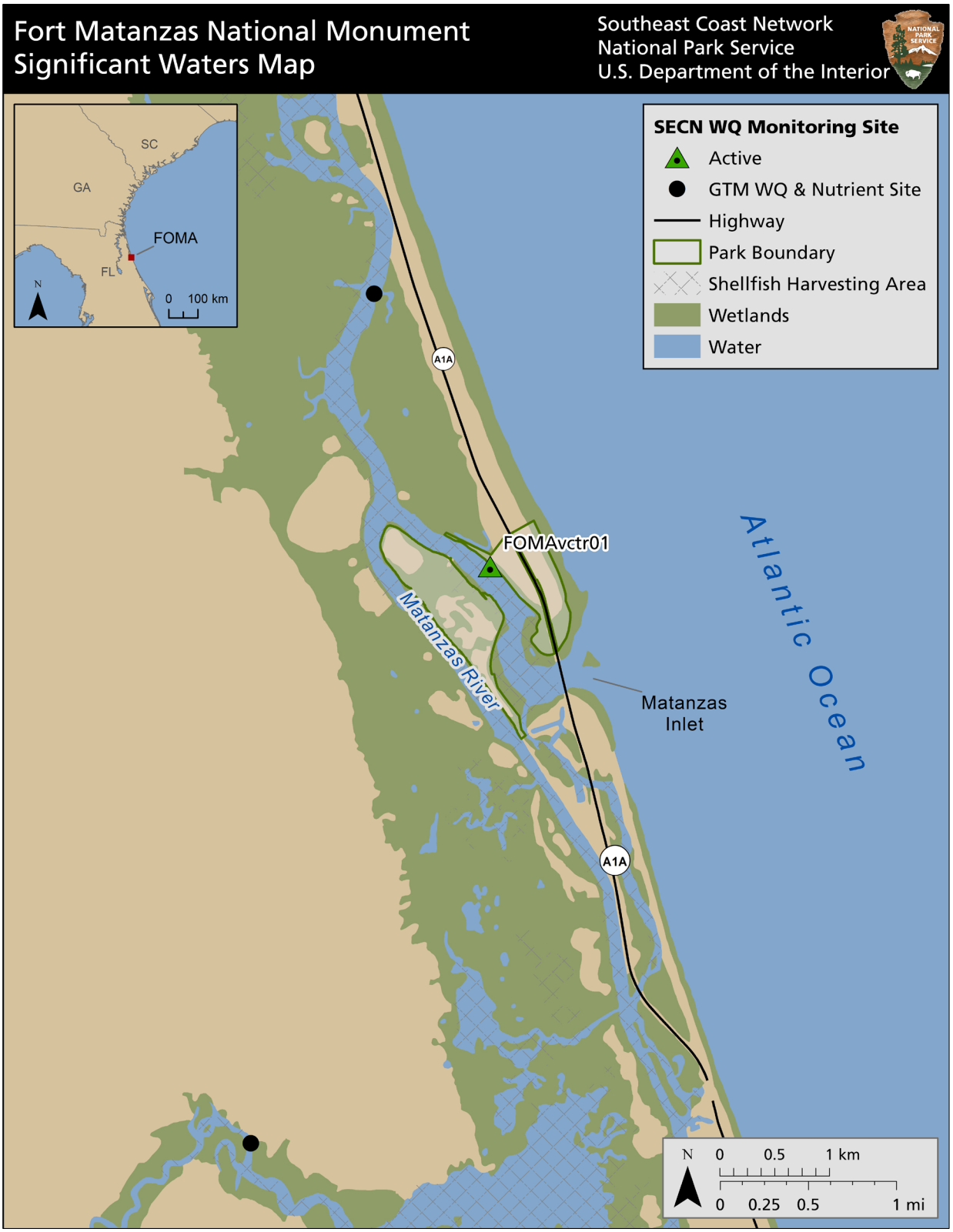


Figure 10. Fixed station monitoring site and estuarine and marine water resources in the vicinity of Fort Matanzas National Monument in Florida. Indicated are areas of salt marsh (FWS 2023), and areas designated as having special uses or restrictions (NOAA 2008).

Measurable Objectives

The Southeast Coast Network identified an overall goal of monitoring the status and trends in water and sediment quality in estuaries surrounding SECN parks. To meet this goal, data are collected and analyzed for four specific monitoring objectives. The Southeast Coast Network assumes responsibility for the minimum datasets required to meet these objectives; however, the network will seek the cooperation of interested partners to collect additional water-quality and/or ancillary data where possible and when it will be in the interest of resource management in networks parks to do so. The Southeast Coast Network is currently working with partners to provide additional data at Canaveral National Seashore (CANA), Timucuan Ecological and Historic Preserve (TIMU), Cape Lookout National Seashore (CALO), and Fort Matanzas National Monument (FOMU). The Southeast Coast Network monitoring objectives are listed below.

1. Determine diel and seasonal water-quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at selected coastal areas near SECN parks using fixed-station continuous data loggers.

2. Determine monthly and seasonal patterns in nutrients (nitrogen, phosphorus, and chlorophyll *a*) at selected coastal areas near SECN parks by collecting discrete water samples.

3. Determine status and spatial variability of water and nutrient chemistry conditions in estuarine waters every five years near SECN parks.

4. Determine status and spatial variability of benthic sediment quality (organic contaminants, carbon, and metal levels) every 10 years in estuarine waters near SECN parks.

Monitoring data are collected for objectives one and two using methods adapted from the NOAA-NERRS Program (Table 2). Monitoring data for objective one is collected from continuous monitoring of water-quality parameters using permanently deployed data sondes at near-shore locations selected to be representative of areas near parks. Dissolved oxygen, salinity, temperature, pH and turbidity measurements are monitored at set intervals (either 30 or 15 minutes). Monitoring data for objective two is collected monthly by analyzing discrete water samples for nitrogen, phosphorus, and chlorophyll *a* concentrations.

Monitoring data are collected for objectives three and four using methods adapted from the EPA-NCA Program (Table 2). Data collected to meet these objectives are interpreted in the context of assessment criteria developed by federal and state agencies as well as any locally-determined criteria developed by SECN parks. Data collected to meet objective three are collected once every five years with the spatial variability component achieved through the use of a spatially-balanced sample designs for each park. Due to the longer response times of sediment processes sediment conditions including organic contaminants, carbon, and metals levels are assessed every 10 years to satisfy the requirements of objective four.

Information regarding status is obtained from analyzing continuous and monthly data collected at selected monitoring locations near parks using continuous and monthly data sets. Over time,

information regarding longer-term water-quality trends may be ascertained from both the continuous and monthly data collection effort as well as from the water and sediment quality monitoring occurring at 5- and 10-year intervals.

Table 2. Relationship between monitoring objectives, sampling methods, and variables measured at SECN parks as part the Protocol for Monitoring Estuarine Water and Sediment Quality. Footnotes indicate minor sampling deviations due to monitoring partnerships or thirdparty data usage [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Objective	Monitoring Methods Adapted from Existing Program	Sampling Method	Sample Interval and window	Parks	Variables Measured	Number of Locations
1	NOAA–NERRS Program	Fixed-station: continuous data from multi-parameter water-quality meter (sonde)	30 minutes	CAHA, CALO [A], CANA, CUIS, FOMA, FOPU, TIMU	Blue green algae [F], chlorophyll *a* [F], dissolved oxygen, pH, salinity, specific conductance, temperature, and turbidity;	8 SECN fixed stations [E]
2	NOAA–NERRS Program	Fixed-station: discrete water samples	Monthly; within three hours of low tide [B,C,D]	CAHA, CALO, CANA [B], CUIS, FOMA [C], FOPU, TIMU [D]	Total dissolved nitrogen, total dissolved phosphorus, dissolved inorganic nitrogen [G], dissolved inorganic phosphorus [G] and chlorophyll *a*;	5 fixed stations sampled by the SECN. And 19 sites near SECN fixed stations sampled by partners/other agencies.
2	EPA-NCA Program	Fixed station: secchi disk	Monthly; within three hours of low tide [B,C,D]	CAHA, CALO, CANA [B], CUIS, FOMA [C], FOPU, TIMU [D]	Secchi depth converted to water clarity.	5 fixed stations sampled by the SECN. And 19 sites near SECN fixed stations sampled by partners/other agencies.
3	EPA-NCA Program	Park-wide synoptic: multi-parameter water-quality meter (sonde) and discrete water samples	5 years; late summer index period (July–September)	CAHA, CALO, CANA, CUIS, FOMA, FOPU, TIMU	Chlorophyll *a* [F], dissolved oxygen, pH, temperature, turbidity, salinity	30 stations (depth profile surface to near bottom)
3	EPA-NCA Program	Park-wide synoptic: secchi disk	5 years; late summer index period (July–September)	CAHA, CALO, CANA, CUIS, FOMA, FOPU, TIMU	Secchi depth converted to water clarity.	30 stations.
3	EPA-NCA Program	Park-wide synoptic: discrete water samples	5 years; late summer index period (July–September)	CAHA, CALO, CANA, CUIS, FOMA, FOPU, TIMU	Total nitrogen, total dissolved nitrogen, total phosphorus, total dissolved phosphorus, dissolved inorganic nitrogen, dissolved inorganic phosphorus and chlorophyll *a*.;	30 stations.
4	EPA-NCA Program	Park-wide synoptic: sediment samples	10 years; late summer index period (July–September)	CAHA, CALO, CANA, CUIS, FOMA, FOPU, TIMU	Organics/metals (i.e., PAH/Pesticides/PCB/ Metals), particle grain size, total organic carbon.	30 stations.

[A] CALO stations are operated by NERRS through a general agreement and collect continuous data at 15-minute intervals.

[B] CANA monthly nutrients and chlorophyll *a* samples are collected at five locations throughout the park by St. Johns River Water Management District (SJRWMD). The SJRWMD's sample window is not restricted by a tidal window because tides have minimal influence within Mosquito Lagoon.

[C] FOMA monthly nutrients and chlorophyll *a* samples are collect by the Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS) program at two sites near the FOMA visitor center. The GTM-NERRS follow NERRS methods and sample within three hours before low tide.

[D] TIMU nutrient and chlorophyll *a* samples are collected bimonthly by the City of Jacksonville (COJ) at 12 sites throughout park as part of a general agreement, The COJ's sample window is not restricted by a tides as per Florida Department of Environmental Protection (FLDEP) protocol.

[E] When adaptive implementation at CONG is included continuous fixed-station monitoring occurs at 10 locations.

[F] Sensors for chlorophyll *a* and blue green algae provide estimated concentrations and do not replace discrete samples to be analyzed by a laboratory. These sensors are deployed at a limited number of fixed stations in locations at risk for algae blooms (e.g., CANA, TIMU).

[G] Quarterly analysis.

Sampling Design

To effectively monitor the diverse and dynamic set of estuarine water resources in the Southeast Coast Network parks, the network proposed a two-pronged monitoring approach collecting data from continuously recording fixed stations located in each park and collecting periodic discrete water samples for analysis (Table 2). Both the permanent static monitoring stations and the periodic discrete water samples collected at pre-selected rotating sites provide comparable data using the same instrumentation and have comparable analysis conducted on water column nutrient constituents. When combined, these two approaches give a more complete picture of physical processes, diurnal and seasonal variations, and spatial patterns during critical portions of the year than either could if implemented singularly. Technically, this is a type of split panel design with single fixed stations in each park and independent sampling conducted on a fixed return interval. Split panel designs are generally thought to provide the best chance of satisfying competing objectives of a monitoring program (Dobbie et al. 2008).

Representativeness and Target Populations

Estuarine waters within and in the vicinity of park property are the target sampling populations. Since the condition of estuaries varies spatially and temporally this protocol uses a separate sampling design to address both respective components.

Temporal representativeness of estuarine water-quality conditions is addressed by monitoring, targeted fixed stations (Table 3). This approach was deemed appropriate, given the logistics required to maintain stations and collect monthly nutrient samples. Core water-quality parameters are recorded continuously (30-minute intervals) and allow for inference over tidal, diel, and seasonal cycles. Monthly nutrient samples collected at the same fixed stations undergo an addition level of temporal stratification which requires samples to be collected within three hours of low tide. Diurnal fluctuations and seasonal differences in water-quality parameters can be inferred using discrete and continuous data from a single fixed station (i.e., temporal variability). However, valid spatial inferences made from these data are limited. In addition, fixed-station data allow park managers to evaluate water-quality conditions more quickly in response to episodic events such as major storms or hurricanes that may influence short-term changes in water-quality conditions.

Spatial representation is addressed by using a spatially-balanced sampling design with sample collections implemented on a five-year rotating schedule (Tables 2 and 4) during the late summer index period (July–September). Late summer is typically a time when water-quality conditions are thought to be at their worst and water-quality issues are most apparent. Using this index period and site selection method allows data to be compared to NCA data which EPA samples during the same index period and using the same site selection method. Although sampling strictly during daylight hours may result in temporally biased data sets, logistical and safety considerations preclude sample collection at night.

Table 3. Fixed-station water-quality monitoring activity matrix (NOAA-NERRS adapted methods). Numbers in parentheses indicate sites monitored by partnerships or other agencies.

Park	Number of Continuous Monitoring Stations	Monitoring Interval (minutes)	Number of Discrete Monitoring Stations	Monitoring Interval
Cape Hatteras National Seashore	1	30	1	Monthly
Cape Lookout National Seashore [A]	2	15	2	Monthly
Canaveral National Seashore	1	30	(5) [B]	Monthly
Congaree National Park	1 [C]	30	1 [C]	Monthly
Cumberland Island National Seashore	1	30	1	Monthly
Fort Matanzas National Monument	1	30	(1) [D]	Monthly
Fort Pulaski National Monument	1	30	1	Monthly
Timucuan Ecological and Historic Preserve	1	30	(12) [E]	Bimonthly

[A] Stations maintained by North Carolina NERRS Program; the 15-minute monitoring interval matches the other NERRS stations.

[B] Nutrients and chlorophyll *a* collected at park and four additional locations by St. Johns River Water Management District.

[C] Adaptive implementation of fixed-station monitoring at a freshwater site.

[D] Nutrient and chlorophyll *a* data collected by GTM NERRS Program at a site near Fort Matanzas NM visitors.

[E] Nutrient and chlorophyll *a* data collected bimonthly by City of Jacksonville at 12 sites throughout park as part of partnership agreements.

Table 4. Park-wide water and sediment quality monitoring activity matrix (EPA-NCA adapted methods). “W” denotes years when only water-quality (core parameters, nutrients, chlorophyll *a*, and water clarity) is assessed. “WS” denotes years when both water and sediment quality (metals, TOC, organics) are assessed. There is a scheduled off year in between each round of sampling. Note that there is no adaptive implementation of park-wide monitoring at Congaree National Park [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	n [A]	2007	2008	2009	2010	2012	2013	2014	2015	2017	2018	2019	2020	2022	2023	2024	2025	2027	2028	2029	2030
CAHA/ CALO [B]	30	–	–	–	WS	–	–	–	W	–	–	–	WS [C]	–	–	–	W	–	–	–	WS
CANA	30	–	–	WS	–	–	–	W	–	–	–	WS	–	–	–	W	–	–	–	WS	–
CUIS	30	WS	–	–	–	W	–	–	–	WS	–	–	–	W	–	–	–	WS	–	–	–
FOMA	30	–	–	–	–	W	–	–	–	WS	–	–	–	W	–	–	–	WS	–	–	–
FOPU	30	WS [D]	–	–	–	–	W	–	–	–	WS	–	–	–	W	–	–	–	WS	–	–
TIMU	30	–	WS	–	–	–	W	–	–	–	WS	–	–	–	W	–	–	–	WS	–	–

[A] Number of sites

[B] Waters of Pamlico Sound are assessed as a single water body during the same sampling event.

[C] Sampling delayed until 2021 due to COVID-19 pandemic.

[D] Sediment and core water-quality parameters were sampled during 2007 as part of parks baseline water-quality inventory.

Site Selection for Fixed-Station Monitoring

At seven coastal parks with significant aquatic resources (Cape Hatteras National Seashore, Cape Lookout National Seashore, Canaveral National Seashore, Cumberland Island National Seashore, Fort Matanzas National Monument, Fort Pulaski National Monument, Timucuan Ecological and Historic Preserve) one or more long-term fixed monitoring sites were established by the SECN staff and resource management within each park (Table 3). In some cases, these decisions involved consultation with contractors and/or other partners with whom network and park staff have chosen to cooperate. Criteria for consideration when placing these sites included, but were not limited to, factors such as site accessibility, park management/resource concerns, habitat type and location of existing or historic sites.

Decisions for the placement of these sites were made by park managers with guidance from SECN staff. If there was a current or potential problem area in the park, this is where the primary site was generally established. At Cape Lookout National Seashore, a secondary site was used as a reference in a less impacted area. Additional sites at Timucuan Ecological and Historic Preserve and Cumberland Island National Seashore were installed either for comparability between two similar areas or to assess differences between areas around a park. To maximize comparisons, it was critical that the second site was in a similar habitat type with similar conditions with respect to water depth, salinity, flow, etc. These additional sites were decommissioned in 2010 due to lack of park support or funding (Appendix B). All sites monitored as part of the fixed-station network are listed in Table 5, with additional details for each site provided in Appendix B. Fixed-stations that are part of adaptive implementation at Congaree National Park (CONG) are discussed in Appendix C.

Site Selection for Park-Wide Monitoring

For each park survey, 30 primary sites and 30 alternate sites are randomly selected using protocols developed by the EPA (Stevens 1997; Stevens and Olsen 1999; Stevens and Olsen 2004). These sites are not stratified, change from survey to survey and are selected from the estuarine water body that surround the parks but does not include marine waters. Southeast Coast Network staff worked directly with EPA personnel to select sampling locations within appropriate park boundaries for the next seven rounds of sampling (35 years). The selection process was based on the EPA's Environmental Monitoring and Assessment/National Coastal Assessment protocols. Cape Hatteras National Seashore and Cape Lookout National Seashore are combined into one study design since the park boundaries on the estuarine side are limited in size, and virtually the same water body is being sampled throughout (Albermarle-Pamlico Sound). Maps and GPS coordinates of sampling locations (and alternate sites) to be used through 2030 are available upon request and stored on SECN servers. If other parks are added to the sample rotation or if sampling objectives necessitate new and/or different sets of sites, appropriate and compatible probabilistic methods will be used to select sites. The SOP 1.2.01 *Park-wide Assessment Spatially-Balanced Sampling Location Generation Using ArcGIS 10*—Version 2.0 (Cooper and Starkey 2022) provides additional details on site selection methods. Table 4 summarizes the number of sites to be sampled in each park during the five-year sample rotation The number of sites used for park-wide assessments are based on EPA-NCA guidance, are sufficient to capture spatial variability throughout each park, summarize the condition of water resources relative to NCA indices and are sampleable by limited SECN staff.

Table 5. Estuarine water-quality monitoring station information. See Appendix B for additional details [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
CAHA	Pamlico Sound	Ocracoke boat ramp.	Near shore sound	CAHAocbr01	CAHAocbr, OC	High salinity outfall nearby, ease of access	11/4/2005	–	6600 as of 9/16/19
CALO	Core Sound	Shackleford Banks dock	Near shore sound	CALOshak01	CALOshak, CALO01, SH	Proximity to previous water-quality site	11/03/2005	–	03/01/2017
CALO	Core Sound	Middle Marshes area of Rachel Carson Reserve	Near shore sound	CALOmidm02	CALOshak2, CALO02, CALOmm, MM	Selected by NERRS staff to support program goals	04/17/2008	–	06/28/2017
CANA	Mosquito Lagoon	Canaveral NS Apollo Beach visitor center dock	Lagoon	CANAvctr01	CANAvctr	Access, interpretive opportunity and relatively pristine location	7/21/2005	–	01/14/2014
CONG [D]	Cedar Creek	Near Bannister Bridge Canoe Access	Freshwater stream	CONGbann01	–	For comparison with CONGccbr01 and evaluation of nutrient concerns.	07/03/2019	–	07/03/2019

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive Implementation at CONG (see Appendix C).

[E] Florida Department of Environmental Protection.

Table 5 (continued). Estuarine water-quality monitoring station information. See Appendix B for additional details [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
CONG [D]	Cedar Creek	Bridge B on Cedar Creek	Freshwater stream	CONGccbr01	CONGccbr CCBR, CC	Interior of park, paired with USGS gauge and relatively representative of Cedar Creek throughout park.	08/09/2006	–	08/22/2018
CUIS	Old House Creek	Old House Creek Dock	Tidal creek	CUISold02	CUISold, CUIS02	Comparison site for CUISplum; representative on tidal creek habitat	01/06/2007	09/07/ 2010	All 6600
CUIS	Brickhill River	Plum Orchard Dock	Near shore sound	CUISplum01	CUISplum, CUIS01, CIP	Potentially impacted by shoreline changes; relatively accessible	08/04/2005	09/07/ 2010	All 6600
CUIS	Cumberland Sound	Sea Camp dock	Near shore sound	CUISseac03	CUISseac, CUIS03, SC	Located at a site where data could be used to meet data needs by USGS; representative of near-shore sound habitat	09/08/2010	–	01/18/2018

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive Implementation at CONG (see Appendix C).

[E] Florida Department of Environmental Protection.

Table 5 (continued). Estuarine water-quality monitoring station information. See Appendix B for additional details [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
FOMA	Matanzas River	Fort Matanzas NM visitor center dock	Tidal inlet/river	FOMAvctr01	FOMA, FOMA01	Selected by park staff; only structure to which the sonde mount could be affixed	05/25/2010	–	01/08/2014
FOPU	Lazaretto Creek	Lazaretto Creek fishing pier	Tidal creek	FOPUlazz01	FOPUlazz, FOPUfish, FOPU	Only structure at the park to which the station housing could be mounted	08/14/2006	–	02/25/2015
TIMU	Clapboard Creek	Piling in Clapboard Creek. ~4.0 river miles (6.5km) upstream of St. Johns River	Tidal creek	TIMUclap01	TIMUclap01, TIM13A	Area of expected rapid urban growth; representative tidal creek habitat	06/22/2005	06/06/ 2011	All 6600
TIMU	Clapboard Creek	Heckscher Drive Bridge	Tidal creek	TIMUclap02	TIMUclap02	Selected and operated by FLDEP [E]	10/24/2016	–	~9/2020

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive Implementation at CONG (see Appendix C).

[E] Florida Department of Environmental Protection.

Table 5 (continued). Estuarine water-quality monitoring station information. See Appendix B for additional details [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
TIMU	Fort George River	Kingsley Plantation dock	Tidal inlet/river	TIMUking01	TIMUking, TIM11A	Baseline data and interest in changes to site due to inlet migration/management	06/22/2005	–	01/14/2014
TIMU	Lofton Creek	Piling in Lofton Creek. Confluence with Nassau River	Tidally influenced river	TIMUloft01	TIMUloft, TIM4A, LC	Area of expected residential and urban growth; representative tidal riverine/creek habitat	07/01/2005	06/03/2011	All 6600
TIMU	Nassau River	Piling in Nassau River. Near highway 17	Tidally influenced river	TIMUnass01	TIMUnass, TIM14A	Indicator of water-quality from the upper reaches of the Nassau River	07/17/2009	06/03/2011	All 6600

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive Implementation at CONG (see Appendix C).

[E] Florida Department of Environmental Protection.

Nutrient Chemistry Measurements

Nutrients (nitrogen and phosphorus) in estuarine waters exist in many forms (Figure 11) and are an important part of an estuarine water-quality monitoring program as eutrophication is an existing (Mallin et al. 2000) and growing concern in coastal waters (Bricker et al. 1999). Due to the important management concerns associated with eutrophication (e.g., phytoplankton blooms, hypoxia/anoxia and fish kills), monitoring nutrient levels is a major focus of this water-quality monitoring protocol. Although the guiding principle of the Southeast Coast Network development strategy was to adopt existing protocols and methods so that compatible data sets could be easily generated and used by managers, the question of which nutrient pool to regularly monitor became an issue of contention due to inconsistencies between NPS-WRD guidance, advisement by our network technical advisory group, and published EPA-NCA and NERRS Program documentation.

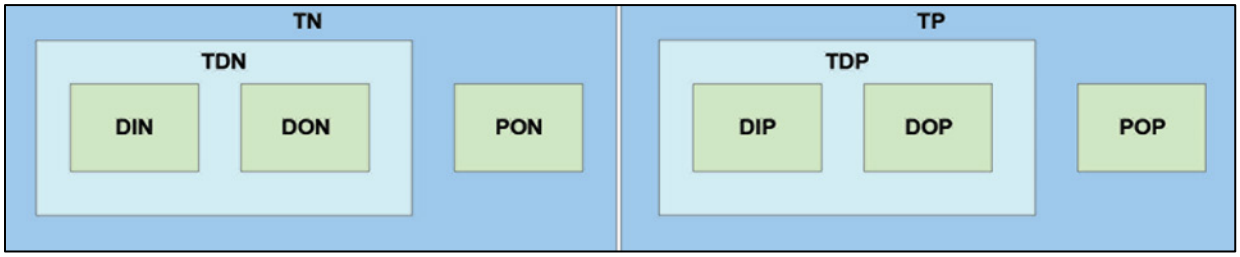


Figure 11. Nitrogen and phosphorus pools considered for monitoring in SECN park waters as part of the Estuarine Water and Sediment Monitoring Protocol. TN = total nitrogen, TDN = total dissolved nitrogen, DIN = dissolved inorganic nitrogen, DON = dissolved organic nitrogen, PON = particulate organic nitrogen, TP = total phosphorus, TDP = total dissolved phosphorus, DIP = dissolved inorganic phosphorus, DOP = dissolved organic phosphorus, POP = particulate organic phosphorus.

Suggested options included monitoring total nitrogen (TN), and total phosphorus (TP) suggested by NPS-WRD and the NERRS Program or monitoring dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorous (DIP) as is recommended by the EMAP-NCA Program. The Southeast Coast Network adopted the recommendation of a regional technical advisory group, which was to implement a hybrid approach between the two above suggestions.

- Samples collected at fixed monitoring stations are analyzed for the following: total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), dissolved inorganic nitrogen (DIN) [DIN= NO_{23}+NH_4], dissolved inorganic phosphorus (DIP) [DIP=PO_4], and chlorophyll *a*. Note that DIN and DIP are assessed quarterly.
- Samples collected during the synoptic park-wide assessment are analyzed for the following: total nitrogen (TN), total phosphorus (TP), total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), and chlorophyll *a*.

This approach results in a more complete picture of near-shore nutrient level status as well as dynamics in the vicinity of SECN parks while preserving the ability to appropriately interpret data in the context of established water-quality criteria and thresholds. The Southeast Coast Network will

adapt its analytical methods based on any future changes in the EPA-NCA and NOAA-NERRS Program to ensure continued data compatibility.

Field Methods and Laboratory Standards

Fixed-Station Monitoring Elements

Field methods and laboratory criteria for the fixed-station monitoring portion of the estuarine water and sediment quality protocol have been adapted from those in use by the NOAA-NERRS Programs (Wenner and Geist 2001; NERRS 2011; NERRS 2012) and the USGS (Wagner et al. 2006). The adoption of these methods allows the Southeast Coast Network to meet monitoring objectives and provide data that are nationally and regionally compatible (NERRS 2011).

Methods for fixed-station monitoring are divided into those associated with continuous and discrete data and are discussed below. Note that fixed-station sondes are serviced, data are downloaded, and discrete water samples are taken during the same site visit.

Continuous Data

Fixed-station continuous water-quality data are collected using multi-parameter sondes, probes, and accessories (e.g., 6600 Series; EXO Series, YSI Incorporated; Yellow Springs, Ohio). Sondes are installed, calibrated, deployed, and retrieved following SOP 1.2.08 *Fixed-Station Installation of Water-Quality Data Sonde Housing*—Version 3.0 (Starkey and McCay 2022a) and SOP 1.2.09 *Fixed-Station, Water-Quality Data Sonde Maintenance, Calibration, Deployment, and Retrieval*—Version 3.0 (McCay et al. 2022). These SOPs are based on the combination of procedures outlined in National Estuarine Research Reserve's (NERRS) System-Wide Monitoring Program (SWMP) Standard Operating Procedure (NERRS 2011), EXO specific user manual (YSI 2021), and Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting (Wagner et al. 2006). This combination of methods allows for data processing and quality control measures to be implemented consistent with other NPS Inventory and Monitoring networks and provide regional comparison with estuarine water-quality data collected by other agencies.

For each monitoring station, a sonde is calibrated, deployed for up to six weeks, and then retrieved for post-deployment drift checks. When a sonde is removed for calibration and maintenance it is replaced by another recently calibrated sonde, (i.e., there are two sondes for each monitoring station, one that is deployed and one that came back from the field and is being prepared for the next deployment). While deployed, each sonde logs data at 30-minute intervals for the following parameters: water temperature, salinity, dissolved oxygen, depth, pH, and turbidity. In locations deemed at elevated risk for algal blooms (CANA and TIMU), chlorophyll *a* and blue green algae readings are also logged. The duration of each deployment depends on the amount of instrument biofouling which varies among locations in the network as well as seasonally. Determination of the maximum acceptable deployment time was made for each site by analyzing the data from each deployment during the first year of implementation and is seasonally adjusted to ensure data quality while minimizing site visits.

Discrete Data

Nutrients and Chlorophyll *a*

Monthly water samples are collected near the monitoring station, approximately 0.5 m (1.6 ft) from the surface using a cleaned Van Dorn water sampler (horizontal). SOP 1.2.11 *Fixed-Station Water Sample Collection and Processing*—Version 2.0 (McCay and Starkey 2022) outlines the procedures in more detail. These discrete samples are then submitted to a contracted laboratory for monthly analysis of total dissolved nutrients and chlorophyll *a.* In addition, quarterly analysis is completed that allow for the calculation of dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP). In summary, as outlined in SOP 1.2.07, *Estuarine Water and Sediment Laboratory Analysis Method Performance Criteria and Requirements*—Version 2.0 (Starkey and McCay 2022b) samples are analyzed for the following constituents.

- Monthly
    - Total Dissolved Nitrogen (TDN): EPA Method 353.2
    - Total Dissolved Phosphorus (TDP): EPA Method 365.1
    - Chlorophyll, Active: EPA Method 445.0 – fluorometric, SM10200H.3
- Quarterly—for calculation of DIN and DIP
    - Ammonium (NH_4): Standard Method 4500G
    - Nitrite + nitrate (NO_{23}): EPA Method 353.2 Cadmium
    - Phosphate (PO_4): EPA Method 365.1

Note that dissolved inorganic nitrogen (DIN) is calculated as NO_{23}+NH_4 and that DIP = PO_4.

Water Clarity

During each monthly site visit, a Secchi disk is used to measure the transparency of the water column (i.e., Secchi disk depth). Secchi depth has been used for decades and ensures back compatibility with older data sets. See SOP 1.2.11 *Fixed-Station Water Sample Collection and Processing*—Version 2.0 (McCay and Starkey 2022) for detailed field procedures. Methods outlined in Smith et al. (2006) and EPA 2016 allow for the conversion of Secchi depth readings to water clarity values that are adjusted based on naturally occurring turbidity conditions. Refer to SOP 2.2.08 *Fixed-Station Water-Quality Data Summary Reporting Manual*—Version 2.1 (Starkey and Wright 2022a) for more details about the conversion of Secchi depth to water clarity.

Park-Wide Assessment Monitoring Elements

Field methods and laboratory criteria for the synoptic park-wide monitoring of water-quality follow those in use by the EPA-NCCA (EPA 2014). Monitoring elements described below were chosen from the EPA-NCCA Field Operations Manual (EPA 2001) to aid in providing an overall assessment of ecosystem condition. The EPA-NCCA Program, which published the operations manual, was designed to provide a quantitative assessment of the regional extent of environmental problems by measuring status and change in selected indicators of ecological condition. It provides a strategy to identify and bound the extent, magnitude, and location of environmental degradation and improvement on a regional scale and has been adopted by the Southeast Coast Network in part to

provide additional and comparable data to park managers. For programmatic details of the NCCA, users should consult the original NCCA documentation (EPA 2001) and the most recent version of the field operations manual (EPA 2014).

Additional guidance from the NPS Water Resource Division deemed that chlorophyll *a*, nutrients and water-clarity measurements be adopted for monitoring in coastal parks in addition to the suggested core water-quality parameters (water temperature, dissolved oxygen, pH, and salinity/conductivity) (Roman et al. 2003). The Southeast Coast Network added these additional measures to the park-wide water-quality data collection effort but opted to not implement the entire suite of analyses suggested by the EPA-NCCA Program (e.g., fish tissue analysis). All SOPs for the park-wide monitoring elements have been published separately and are listed in Appendix A (Table A-2).

Park-wide assessment of water-quality occurs once every five years at Cape Hatteras National Seashore, Cape Lookout National Seashore, Canaveral National Seashore, Cumberland Island National Seashore, Fort Matanzas National Monument, Fort Pulaski National Monument, and Timucuan Ecological and Historic Preserve (Table 4). The sampling period is July through September and based on the time frame when biota are most active and hypoxia is most prevalent. Sites are visited by boat and sampled within a three-to-five day window so that data collected over the event are comparable. Sampling events are planned so data collection is completed in the shortest time frame possible, and if practical, without major rainfall-runoff event interruptions that would make data interpretation more difficult. In all cases, parks are given adequate notification prior to the network staff conducting sampling trips. The steps necessary to prepare for fieldwork are outlined in SOP 1.2.19, *Parkwide Assessment Preparation for Fieldwork*—Version 1.0 (Starkey 2022). Procedure for accessing sites and determining if they meet site selection criteria set by EPA and the Southeast Coast Network are covered in SOP 1.2.02 *Park-wide Assessment Navigation and Field Evaluation of Sampling Locations*—Version 2.0 (Starkey and McCay 2022c).

The sections below provide an overview of the elements selected for inclusion in the Southeast Coast Network monitoring protocol and describe what is measured at each of the selected monitoring stations.

Field Measurements

Location and Event Information

At each of the selected random stations, basic physical and descriptive information is recorded on the Location and Event Form. These data include date and time of sampling event, actual GPS coordinates of sampling site, crew members, weather conditions, habitat types, and the presence of submerged aquatic vegetation and/or marine debris. In addition, photos are taken in each cardinal direction. When considered together, this information may be used to help interpret water-quality results. Procedures for the initial assessment of a monitoring station are covered in SOP 1.2.02 (Starkey and McCay 2022c).

Hydrographic Profile

Hydrographic profiles are recorded using a multi-parameter water-quality meter. Profiles include recording temperature, dissolved oxygen, salinity, pH, turbidity, and chlorophyll *a* value at the 0.1

meter (0.3 ft), 0.5 meter (1.6 ft) and every 1 meter (3.3 ft) from depths 1 meter to 10 meters (33 ft). The procedures for conducting the hydrographic profile are outlined in SOP 1.2.03 *Park-wide Assessment Field Water Quality Measurements*—Version 2.0 (Starkey and Gregory 2022a). These profiles are important for characterizing the waterbody, interpretation of nutrient samples, and provide near bottom dissolved oxygen for the NCCA index of water-quality.

Water Clarity

Secchi disk depth is measured as an estimate of the transparency of the water column and allow estimation of water clarity values (SOP 1.2.03 [Starkey and Gregory 2022a]). Secchi depth has been used for decades and continued use of this method ensures back compatibility with older data sets. Conversion of Secchi disk measurements to water clarity is discussed in SOP 2.2.04 *Park-wide Assessment Water and Sediment Quality Data Summary Reporting Manual*—Version 2.0 (Starkey and Wright 2022b), Smith et al. 2006 and EPA 2016.

Water Chemistry

Nutrients and Chlorophyll *a*

Water samples are collected using a horizontal Van Dorn sampler from the surface (0.5 meter [1.6 ft]) or mid-depth if the station is less than 1 meter (3.3 ft). Samples are then processed and submitted to a contracted laboratory for analysis of total nitrogen (TN), total phosphorus (TP), total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), ammonium (NH_4^+), nitrites (NO_2), nitrates (NO_3), dissolved inorganic phosphorus (DIP or PO_4) and chlorophyll *a*.

As outlined in SOP 1.2.07, *Estuarine Water and Sediment Laboratory Analysis Method Performance Criteria and Requirements*—Version 2.0 (Starkey and McCay 2022b) samples are analyzed using the following methods:

- Total Nitrogen (TN): EPA Method 353.2 and Standard Methods 4500-N C and 4500-NO3 F
- Total Phosphorus (TP): EPA Method 365.1 and Standard Methods 4500-P.B.5, and 4500 P.E.
- Total Dissolved Nitrogen (TDN): EPA Method 353.2
- Total Dissolved Phosphorus (TDP): EPA Method 365.1
- Ammonium (NH_4^+): Standard Method 4500G
- Nitrite + nitrate (NO_{23}): EPA Method 353.2 Cadmium
- Phosphate (PO_4): EPA Method 365.1
- Chlorophyll, Active: EPA Method 445.0 – fluorometric, SM10200H.3

Laboratory method performance requirements are described in SOP 1.2.07 (Starkey and McCay 2022b).

Sediment Chemistry

Sediments are sampled on a 10-year rotating basis. The decision to schedule sediment quality assessments on a 10-year interval is due to the overall cost of sediment analysis, and the expected slower response time for sediment contaminants to accrue. Sediments are collected for a variety of analyses using a Ponar grab sampler with doors (stainless steel, 9-inch [width] × 9-inch [length],

sample volume 8,200 milliliters [mL]). This sampler allows for collection of sediment samples for chemical analyses without contamination. Procedures for sample collection are described in SOP 1.2.05 *Park-wide Assessment Benthic Sediment Collection and Processing*—Version 2.0 (Starkey and McCay 2022d). Sediment samples are analyzed for the following constituents:

- Total Organic Carbon (SW9060)
- Sediment Grain Size (Method ASTM D422-63)
- Metals (EPA Methods 6010 and 6020)
- Mercury (EPA Method 7471)
- PAH Compounds (EPA 8270/PAH Low Level)
- PCBs and PCB Compounds (EPA Methods 8081 and 8082)
- Pesticides (EPA Method 8081)

Suggested analytical methods for sediment contaminants are further described in section 4.0 of the EPA National Coastal Condition Assessment Laboratory Methods Manual (2009). In addition, section 5.1 of this manual describes the analytical methods for sediment grain size. However, laboratories contracted by the Southeast Coast Network may use a different analytical method if the lab is able to achieve the same performance requirements as the standard methods.

Quality Assurance and Quality Control Procedures

Quality assurance and quality control (QA/QC) procedures are implemented throughout data collection and entry and are based on existing methods from the NOAA-NEERS Program, EPA-NCCA, and USGS. Detailed QA/QC procedures for each of the monitoring components (i.e., fixed-station continuous, fixed-station discrete, and park-wide discrete) are covered in the respective SOPs. A summary of each approach is provided below. As part of overall QA/QC procedures, staff tasked with collecting water-quality data are trained in the proper methods for recording data, using instruments, collecting samples and processing data.

Fixed-Station Continuous

Data sondes are calibrated prior to all deployments following procedures set forth in the sonde/sensor specific user manuals (YSI 2021) and the National Estuarine Research Reserve's (NERRS) System-Wide Monitoring Program (SWMP) Standard Operating Procedure (NERRS 2011). These calibrations assure data are collected in a consistent and repeatable manner. Post-deployment, sensors are checked for fouling and calibration drift according to USGS procedures (Wagner et al. 2006). Continuous data may be corrected for known bias caused by sensor fouling and calibration drift. The decision to apply data corrections is a departure from the NERRS Program SOP (NERRS 2011) but is consistent with other NPS and USGS continuous monitoring approaches and provides a robust dataset relatively free of measurable bias. The raw dataset is maintained alongside the corrected version. In addition, all data are screened for outliers and abnormal readings. Following procedures adapted from the USGS (Wagner et al. 2006), ratings of data quality (grades) are applied to the final dataset based on the total correction applied to the data. All data corrections and grades are checked and approved by a secondary reviewer.

In addition, pre-deployment, deployment, retrieval, and post-deployment data are verified upon entry in the SECN Estuarine Water Quality Database.

SOPs with specific QA/QC, data verification and validation procedures for continuous data include:

- 1.2.09 *Fixed-Station Water-Quality Data Sonde Maintenance, Calibration, Deployment and Retrieval*—Version 3.0 (McCay et al. 2022)
- 2.2.07 *Estuarine Water-Quality Monitoring Data Management and Database Technical Documentation*—Version 2.0 (Wright et al. 2022)
- 2.2.09 *Fixed-Station Continuous Water-Quality Data Entry, Processing, and QA/QC* (Starkey et al. 2022a)

Fixed-Station and Park-wide Discrete Nutrients and Chlorophyll a

Field QA/QC samples (i.e., field duplicates and field blanks) constitute at least 10% of samples collected throughout the year for fixed-stations, and 10% of sites sampled during a park-wide assessment. A field duplicate is a duplicate environmental sample collected by the same team or by another sampler or team at the same place, at the same time and not simply a split sample. A field blank is a sample of DI water lacking nutrients and chlorophyll *a*. These samples are collected on randomly selected sites and dates and submitted with regular samples. Sites requiring a QA/QC sample are identified prior to field sampling.

To ensure comparable data of acceptable quality, the Southeast Coast Network requires all participating laboratories use approved EPA methods and quality assurance criteria that meets or exceeds those recommended by the National Water Quality Monitoring Council for the National Water Quality Monitoring Network as recommended in Caffrey et al. (2007) and shown in Table 6.

Contracted analytical laboratories follow QA/QC procedures in accordance with National Environmental Laboratory Accreditation Program (NELAP) accreditation. Laboratory QA/QC checks must include running laboratory blanks, check samples and duplicate samples. This information is provided with sample results by batch. Other QA/QC information including documentation of instrument calibration slopes, limits of detection, statement of instrument comparability, and standard reference material is available upon request or posted at designated internet sites.

In addition, all water sample forms and laboratory results entered in the SECN Estuarine Water Quality Database are double checked against the original datasheets and data supplied by the lab.

The SOPs with specific QA/QC, data verification and validation procedures for discrete data include:

- 1.2.04 *Park-wide Assessment Water Sample Collection and Processing*—Version 2.0 (Starkey and Gregory 2022b)
- 1.2.07 *Estuarine Water and Sediment Laboratory Analysis Method Performance Criteria and Requirements*—Version 2.0 (Starkey and McCay 2022b)
- 1.2.11 *Fixed-Station Water Sample Collection and Processing*—Version 2.0 (McCay and Starkey 2022)

- 2.2.10 *Fixed-Station Discrete Water-Quality Data Entry, Processing, and QA/QC* (Starkey et al. 2022b)
- 2.2.11 *Park-wide Assessment Data Entry, Processing, and QA/QC* (Starkey et al. 2022e)

Table 6. Minimum laboratory method performance requirements and analysis methods to be used for SECN water chemistry and chlorophyll *a* sample analysis (modified from EPA 2009).

Analyte	Units	MDL Objective [A]	Transition Value [B]	Precision Objective [C]	Accuracy Objective [D]	Potential Methods conforming to NELAC guidance
Ammonia (NH_3)	mg N/L	0.01 (0.7 µeq/L)	0.10	± 0.01 or ±10%	± 0.01 or ±10%	EPA Method 350.2 Standard Method 4500-NH_3 G-1997
Nitrate-Nitrite (NO_3-NO_2)	mg N/L	0.01	0.10	± 0.01 or ±10%	± 0.01 or ±10%	EPA Method 353.2 Enzyme Catalyzed Reduction method ASTM D-7781
Total Nitrogen (TN)	mg/L	0.01	0.10	± 0.01 or ±10%	± 0.01 or ±10%	EPA Method 353.2 Standard Methods 4500-N C and 4500-NO3 F
Total Phosphorous (TP) and ortho-P	µg P/L	2.0	20.0	± 2 or ±10%	± 2 or ±10%	EPA Method 365.1 Standard Methods 4500-P.B.5, and 4500 P.E
Nitrate (NO_3)	mg N/L	0.01 (10.1 µeq/L)	0.1	± 0.01 or ±5%	± 0.01 or ±5%	EPA Method 353.2 Enzyme Catalyzed Reduction method ASTM D-7781 Calculation [NO23]-[NO2]
Chlorophyll-*a*	µg/L in extract	1.5	15	± 1.5 or ±10%	± 1.5 or ±10%	EPA Method 445.0 Standard Method 10200H.3

[A] The method detection limit is determined as a one-sided 99% confidence interval from repeated measurements of a low-level standard across several calibration curves.

[B] Value for which absolute (lower concentrations) vs. relative (higher concentrations) objectives for precision and accuracy are used.

[C] For duplicate samples, precision is estimated as the pooled standard deviation (calculated as the root-mean square) of all samples at the lower concentration range, and as the pooled percent relative standard deviation of all samples at the higher concentration range. For standard samples, precision is estimated as the standard deviation of repeated measurements across batches at the lower concentration range, and as percent relative standard deviation of repeated measurements across batches at the higher concentration range.

[D] Accuracy is estimated as the difference between the measured (across batches) and target values of performance evaluation and/or internal reference samples at the lower concentration range, and as the percent difference at the higher concentration range.

Park-wide Discrete-Sediment

Quality control (QC) duplicate samples are taken at 10% of sites sampled for sediment (i.e., three sites/park) during each park-wide assessment. These sites are randomly selected before departure from the office. **The QC duplicate is a new sample collected at the same place and time and is not a split sample of the initial grab.**

As done with nutrient samples, the contracted analytical laboratories follow QA/QC procedures in accordance with National Environmental Laboratory Accreditation Program (NELAP) accreditation. Laboratory QA/QC checks must include running laboratory blanks, check samples and duplicate samples. This information is provided with sample results by batch. Other QA/QC information including documentation of instrument calibration slopes, limits of detection, statement of instrument comparability, and standard reference material is available upon request or posted at designated internet sites.

Suggested analytical methods for sediment contaminants are described in section 4.0 of the EPA National Coastal Condition Assessment Laboratory Methods Manual (2009). However, some laboratories might employ other analytical methods if the lab is able to achieve the same performance requirements as the standard methods. Method performance requirements for inorganic and organic contaminants in sediment can be found in SOP 1.2.07 *Estuarine Water and Sediment Laboratory Analysis Method Performance Criteria and Requirements*—Version 2.0 (Starkey and McCay 2022b).

In addition, all sample forms and laboratory results entered in the SECN Estuarine Water Quality Database are double checked against the original datasheets and data supplied by the lab.

SOPs with specific QA/QC, data verification and validation procedures for sediment data include:

- 1.2.05 *Park-wide Assessment Benthic Sediment Collection and Processing*—Version 2.0 (Starkey and McCay 2022d)
- 1.2.07 *Estuarine Water and Sediment Laboratory Analysis Method Performance Criteria and Requirements*—Version 2.0 (Starkey and McCay 2022b)
- 2.2.11 *Park-wide Assessment Data Entry, Processing, and QA/QC* (Starkey and McCay 2022e)

Data Management

Data management is a critical component of a successful monitoring implementation. A well-designed data management system consists of several interwoven components, and will produce high-quality data products that are robust, defensible, and easily integrated into applications for further development or publication.

With some exceptions, data collected by the National Park Service Inventory and Monitoring Division are considered an "open government data asset." Open data assets are public assets that require transparency and availability in reporting and publication, including:

- Data should be machine readable,
- Data are available, or could be made available, in an open format,
- Not encumbered by restrictions…that would impede or restrict the use or reuse,
- Based on an underlying open standard which is maintained by a standards organization,
- Available at no cost to the public, and
- Has no restrictions on copying, publishing, distributing, citing, or adapting such asset.

The SECN Estuarine Water and Sediment Quality data system maintains three separate data sets:

- Continuous data being gathered by data sondes deployed at permanent stations,
- Monthly discrete data collected at a subset of those stations, and
- Park-wide data collected in probabilistic studies that occur on a rotation. The park-wide monitoring includes water-quality and sediment condition data.

The water and sediment quality data collected by the network are unconstrained and published wholly in their final accepted state with no reservation for sensitive data.

For more information see Public Law 115-435 (Title I 2019).

Data Management System

Water and sediment data collected by the network are stored in two distinct data systems.

1. Continuous data are managed and stored in Aquarius. For more information see SOP 2.2.09 *Fixed-Station Continuous Water-quality Data Entry, Processing, and QA/QC* (Starkey et al. 2022a).

2. Quality control information for deployment and retrieval of continuous data sondes, all discrete data, and analytical results for fixed station monitoring and parkwide assessments are stored in the Southeast Coast Network (SECN) Estuarine Water Quality Monitoring Database (EWQD). This database was custom built by the network and is made up of a SQL backend hosted on a Reston server which is maintained by the central support office, and a Microsoft Access front end. Database improvements and maintenance are managed by network staff and tracked using DevOps. For more information, see SOP 2.2.07 *Estuarine Water-Quality*

Monitoring Data Management and Database Technical Documentation—Version 2.0 (Wright et al. 2022), SOP 2.2.10 *Fixed-station Discrete Water-Quality Data Entry, Processing and QA/QC* (Starkey et al. 2022b) and SOP 2.2.11 *Park-wide Assessment Data Entry, Processing and QA/QC* (Starkey et al. 2022e).

Workflow across the two data systems is shown in Figure 12 and is discussed in more detail in the following sections.

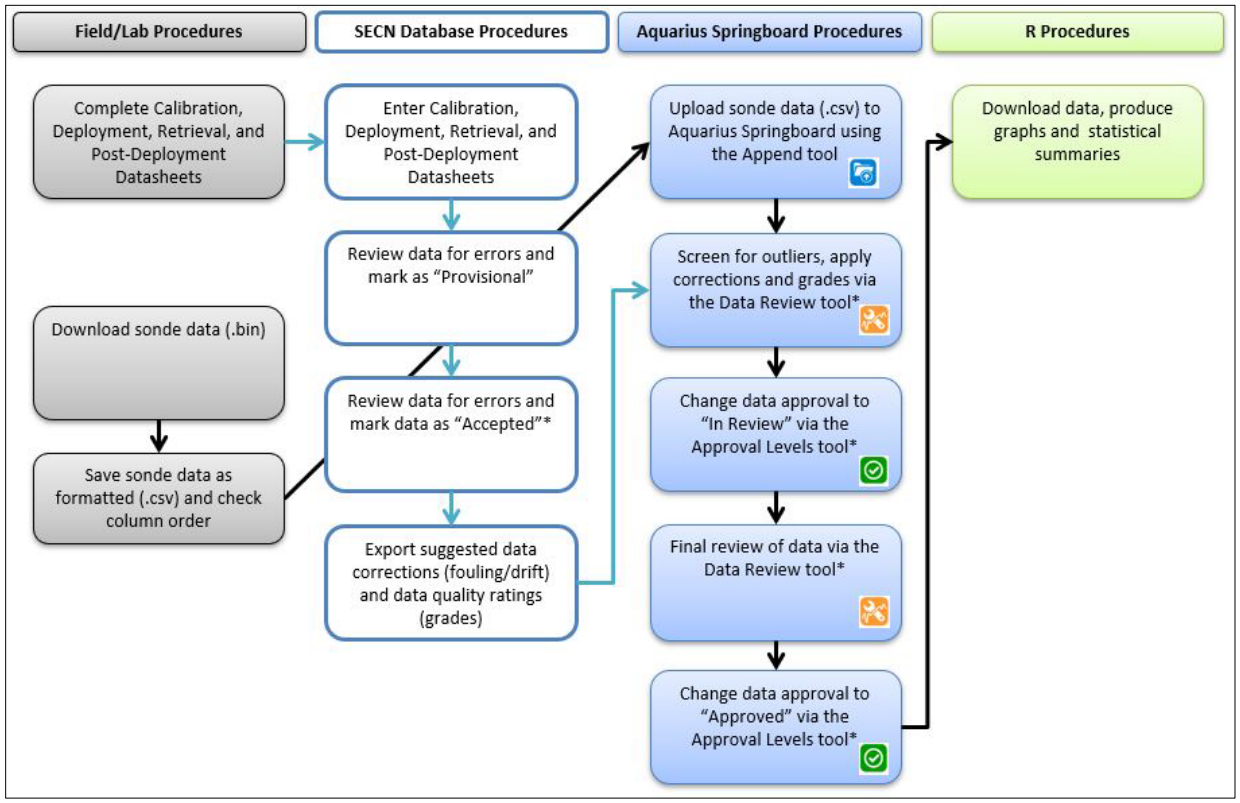


Figure 12. General sonde data processing workflow across multiple data systems. Arrows represent the flow of data and information. Blue arrows represent the flow of QC data that are used to process continuous sonde data. Boxes with an asterisk indicate an independent double check process between the SECN Aquatic Ecologist and SECN Hydrological Technician.

Field Data Collection

Field data collection consists of several components:

- Installation of equipment for fixed-station monitoring
- Location of sites for park-wide assessments
- Quality assurance and quality control of equipment before deployment
- Deployment and collection of sonde units
- Collection of discrete water samples and field measures
- Quality assurance and quality control of equipment post-retrieval

- Processing of water and sediment samples for shipping to laboratory

Figures 13 and 14 outline the activities and workflows from which data are generated from fixed-station and park-wide monitoring components of the protocol with corresponding SOP numbers related to specific data handling procedures (see Appendix A for complete SOP list). Data entry and processing workflows for each component are covered separately below.

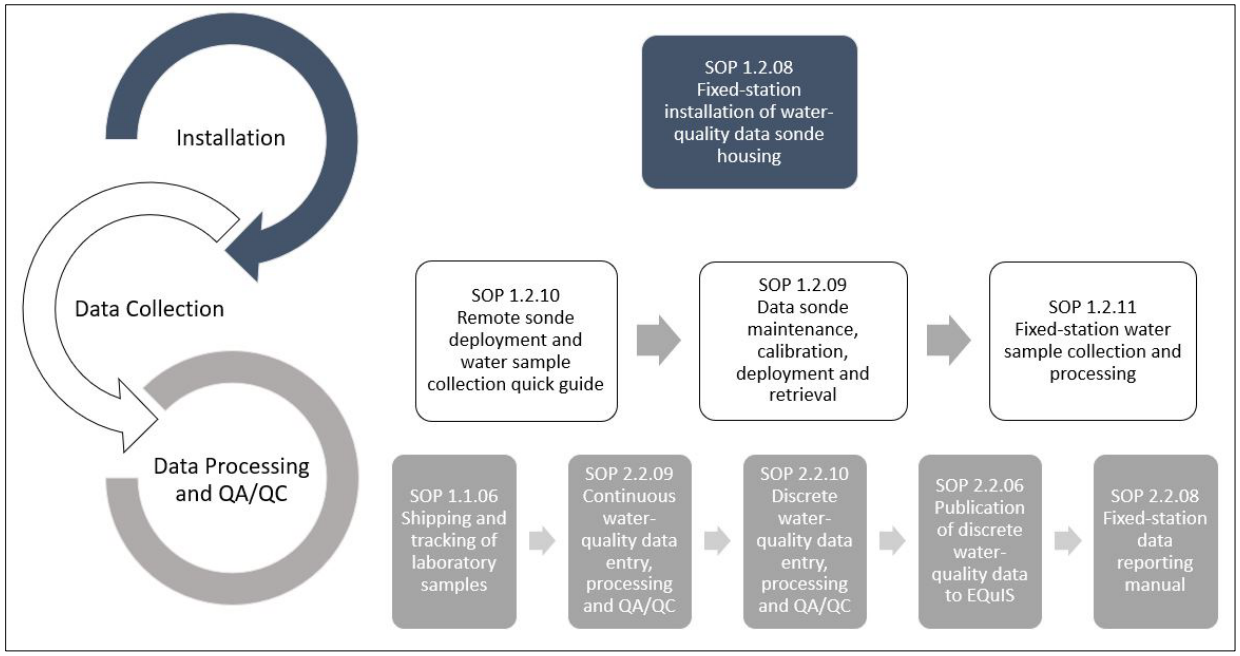


Figure 13. Process flow chart and associated standard operating procedures required for implementation of fixed-station component of the Protocol for Monitoring Estuarine Water and Sediment Quality. Numbers refer to applicable SOPs and color-coding matches specific SOPs to general elements of data processing workflow.

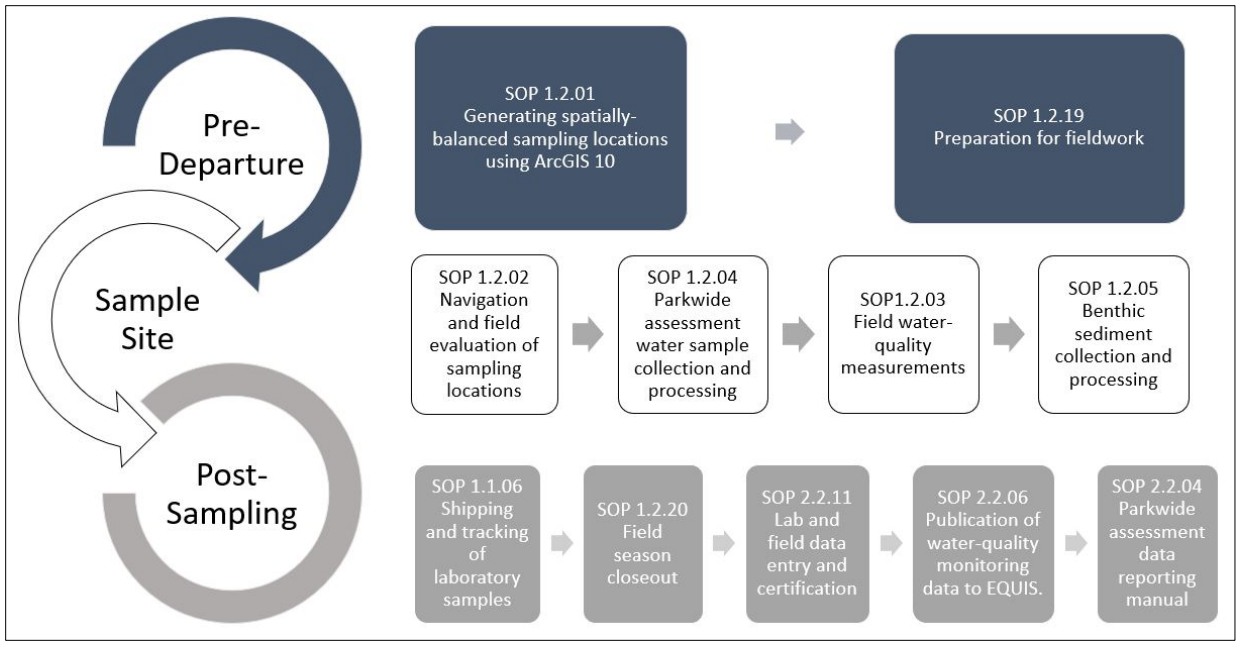


Figure 14. Process flow chart and associated standard operating procedures required for implementation of the park-wide component of the Protocol for Monitoring Estuarine Water and Sediment Quality. Numbers refer to applicable SOPs and color-coding matches specific SOPs to general elements of data processing workflow.

Data Entry, Verification, and Processing

The data entry and processing workflow for each component of the monitoring protocol are shown in Figures 15 and 16. The overarching steps in the process include the following:

1. Raw data are entered into the corresponding data system (Aquarius or EWQD) within thirty days of collection, download, or receipt from the lab. Upon entry, data are considered “Raw” (“Working” in Aquarius) and are marked as such in the data system.

2. Data in EWQD and Aquarius are verified against the original paper or electronic data files.

3. Data in EWQD and Aquarius are validated to ensure data are realistic for a given site, season, and conditions. Upon verification and validation, data are considered “Provisional” (“In Review” in Aquarius) and are marked as such in the data system.

4. Provisional data are reviewed and approved. All issues identified during the verification and validation process must be resolved before final review and acceptance of the data. Upon review, data are considered “Accepted” (“Approved” in Aquarius) and are marked as such in the data system.

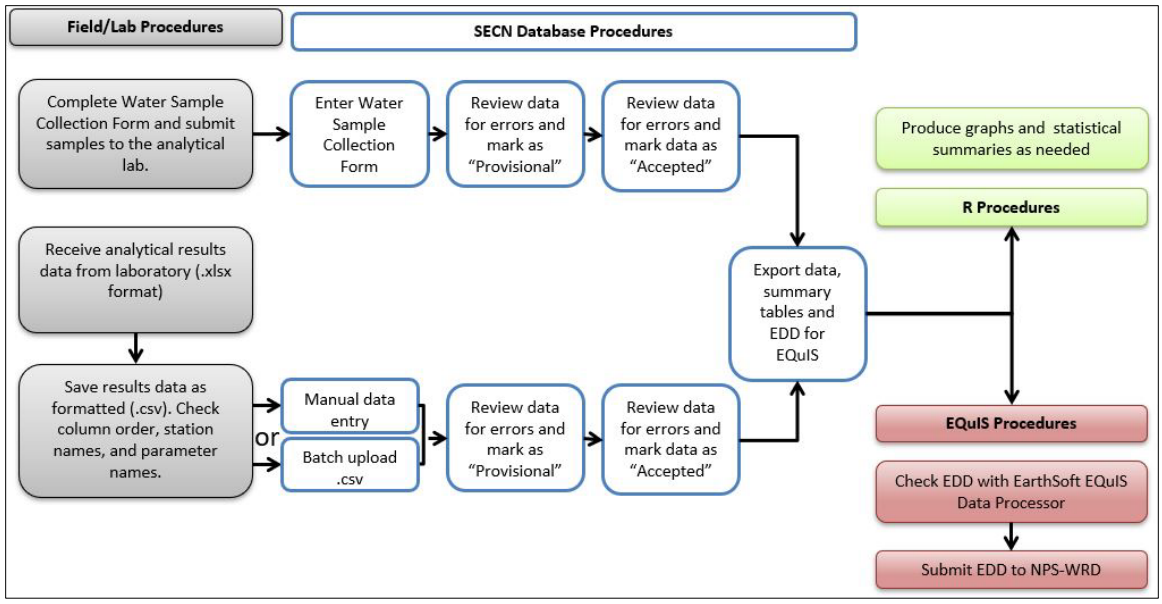


Figure 15. General fixed-station discrete data entry and processing workflow. Arrows represent the flow of data and information between steps and across data systems.

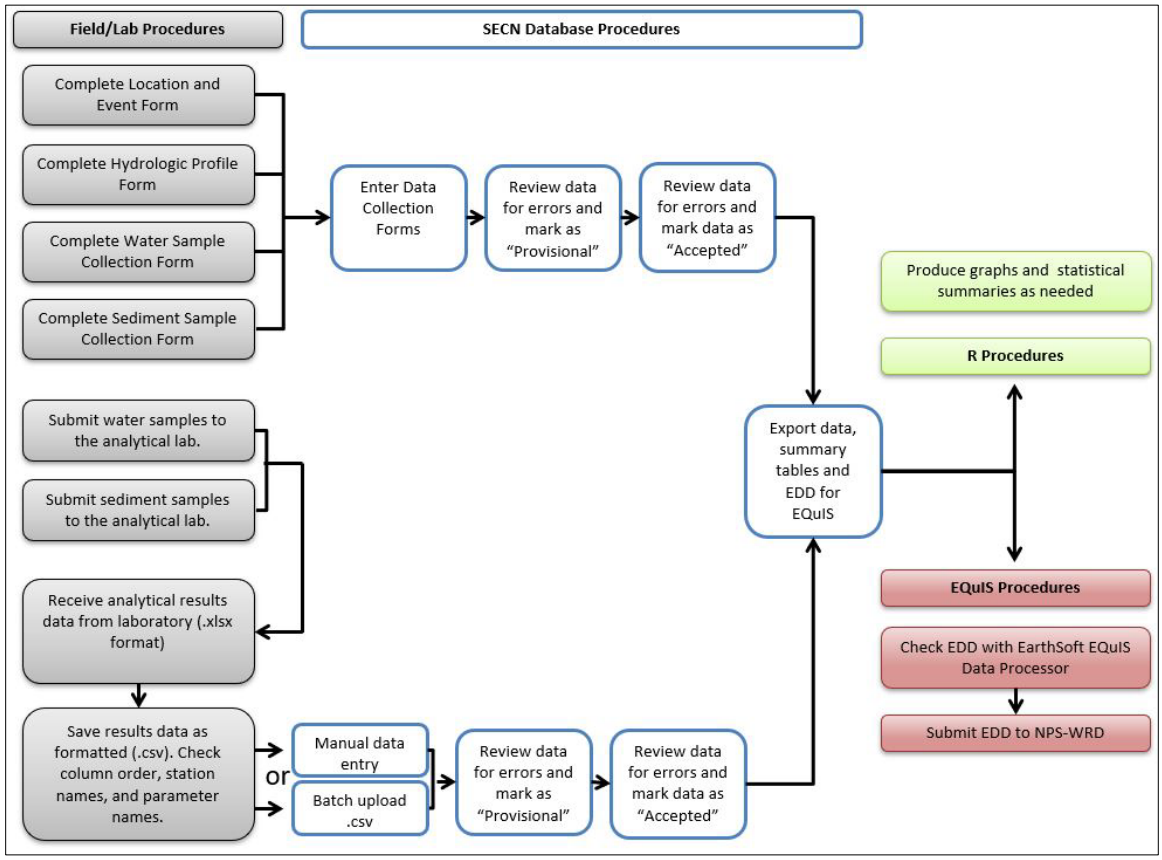


Figure 16. General park-wide assessment data entry and processing workflow. Arrows represent the flow of data and information between steps and across data systems.

Specific procedures and timelines for data entry, processing and approval can be found in the following SOPs:

- SOP 2.2.09 *Fixed-Station Continuous Water-quality Data Entry, Processing, and QA/QC* (Starkey et al. 2022a)
- SOP 2.2.10 *Fixed-station Discrete Water-Quality Data Entry, Processing and QA/QC* (Starkey et al. 2022b)
- SOP 2.2.11 *Park-wide Assessment Data Entry, Processing and QA/QC* (Starkey et al. 2022e)

Data Availability

Once data have been collected and processed with all applicable quality assurance and quality control procedures, they are reported or published in one of several formats across three repositories. Data publication, reporting, metadata, and archiving methods and requirements frequently change as new technology becomes available. For the most recent information and requirements, contact the network data manager or protocol lead.

Integrated Resource Management Application (IRMA) and Datastore

The National Park Service DataStore is a digital repository for documents and datasets relative to park resources. Printed reports and resource briefs are published here, along with any published data packages. A list of reports published for this protocol are also available on the Southeast Coast Network Estuarine Water Quality web page.

Aquarius

The Aquarius web portal, also housed under the IRMA umbrella, stores the network continuous data. Aquarius also contains tools used in the data QA/QC and data processing steps. Aquarius offers data visualization and statistics, and the option to download bulk csv files. It also specifies grade (data quality) and approval (e.g., working, rejected, approved) levels. The Aquarius web portal is available to Department of Interior users and the public.

National Water Quality Monitoring Council

The water quality portal is a multi-agency cooperative service that integrates water-quality data from hundreds of federal, tribal, state, and local agencies. Data stored in the SECN EWQD (discrete nutrient and sediment data and associated QA/QC information and metadata) are exported from the SQL database in an electronic data deliverable (EDD) format and processed by the NPS Water Resources Division (WRD) before uploading to the water quality portal. An SOP for this process is currently in draft (SOP 2.2.02 *Exporting and Publishing Fixed Station Water Quality Monitoring Data to EQUIS—Version 2.0* (Wright and Flanders 2023). More information about querying the water quality portal and available search links is in Appendix D.

Metadata

Rich metadata accompanying datasets are essential for realizing the promise of open data and open science. Metadata provide all the details about a dataset, including methods of data collection, spatial and temporal coverage, and attribute definitions and units, that allow a researcher to understand and assess the dataset's fitness for use for a particular purpose.

The FAIR Guiding Principles for scientific data management and stewardship (Wilkinson et al. 2016), embraced globally by the informatics community, underscore the importance of metadata for **F**indability, **A**ccessibility, **I**nteroperability, and **R**euse of datasets. Data are more findable if they have a descriptive title, well-chosen keywords, and an abstract. Data accessibility is enhanced by the presence of a globally unique and persistent identifier, such as a DOI, in metadata. Interoperability of data relies on the structure of the metadata and the use of vocabularies common to a discipline, so the meaning of the data can be understood across data sources. Data reusability is optimized when metadata are complete and detailed.

Reporting and Analysis

Data Analysis and Reporting Guidelines

Current guidelines for data analysis and reporting requirements are provided in an Inventory and Monitoring memo (Gallo 2018b). IMD programmatic guidance requires annual reporting of vital signs data. Analysis and reporting requirements vary by length of protocol implementation. A summary of data analysis and reporting requirements outlined in the brief are available in Table 7.

Table 7. Summary of data analysis and reporting requirements.

Type of Report	Timing	Example Analyses	Purpose	Required?
Published data set	Annual (or every year data are collected).	Data review and certification.	Ensure data integrity, security, availability, and transparency.	yes
Resource brief, status report, or update to interactive visualizer	Annual (or interval defined in protocol).	Limited to analyses that are cited in protocol.	Inform stakeholders, maintain relevance	no
Baseline Status (and possibly trend if applicable)	Completed once, after one cycle of data collection or not more than 5 years.	Summary or simple statistics of protocol measures and variability to establish definitions/ benchmarks of comparison for future data analyses.	Provide the baseline (if appropriate) for comparison for later analysis. Evaluate metrics relative to benchmarks.	yes
Protocol Evaluation	After every data collection cycle; starting no later than after the second cycle of data collection or 10 years of protocol implementation	Power analyses or simulations to determine if data collected are adequate to meet the objectives of the protocol.	Determine whether protocol objectives, standards, or methods require modification.	yes
Synthesis OR Trend report	At least once every three cycles per protocol, starting no later than after three cycles of data collection or 15 years of protocol implementation.	Exploratory analyses to identify or hypothesize relationships between monitoring, inventory, or other data sets and consequent implications for NPS resource management. Analyses to detect linear trends or non-linear changes over time.	Detect or document trends or lack of trends. Address questions, assumptions, or hypotheses defined in protocol objectives or vital signs monitoring plans. Establish or justify new assessment thresholds, management triggers, or recommended management actions.	yes

Reporting for the estuarine water and sediment quality monitoring effort is completed in the following ways: fixed-station data summaries (protocol initiation–2021), parkwide assessment data summaries (protocol initiation–2021), integrated fixed-station and park-wide assessment data summaries 2022 and beyond), and a dashboard for display of fixed-station continuous and discrete data (2022 and beyond). Each of these report types is described below.

Fixed-Station Annual Data Summary Report

Following the onset of monitoring through 2021, annual fixed-station data reports were published as short, concise NPS Natural Resource Data Series (NRDS) reports that highlighted the recent data collection efforts as well as any issues or areas of potential concern. Reports summarized known conditions and/or major water-quality issues present in or near the park and provided a brief outline of methods used to collect samples and process data. The overall intent of these reports was to provide a temporal (annual) look at water-quality in each park unit monitored by the estuarine water-quality monitoring protocol. All data reports contained a bulleted list of significant findings as part of the executive summary section and were published in conjunction with a two-page resource brief containing an abbreviated subset of significant findings along with some limited project information including broader programmatic overview of the sampling effort. Published fixed-station reports are available via the NPS Integrated Resource Management Applications (IRMA) Data Store. A template for these reports can be found in SOP 2.2.08 *Fixed-Station Water-Quality Data Summary Reporting Manual*—Version 2.1 (Starkey and Wright 2022a).

Park-wide Assessment Annual Data Summary Report

Following the onset of monitoring through 2021, parkwide assessment reports were published as NPS Natural Resource Data Series (NRDS) reports and summarized findings from the most recent round of sampling in a park. While temporally limited in scope, these reports were intended to show the spatial variability of water/sediment quality during a single sample event. These reports outlined known conditions and/or major water-quality issues present in or near the park and provided a brief outline of methods used to collect samples and process data. In addition, these reports included assessment of water and sediment quality relative to the EPA's National Coastal Condition Assessment criteria. These condition scores and results were then plotted on maps to show the spatial distribution of sites rated as Good, Fair, and Poor. Published park-wide reports are available via the NPS Integrated Resource Management Applications (IRMA) Data Store. A template for these reports can be found in SOP 2.2.04 *Park-wide Assessment Water and Sediment Quality Data Summary Reporting Manual*—Version 2.1 (Starkey and Wright 2022b).

Integrated Fixed-Station and Parkwide Assessment Report

Starting in 2022, the Southeast Coast Network reports the results of fixed-station and park-wide monitoring efforts in a single integrated report published as a NPS Natural Resource Report Series (NRR). As previously done in the fixed-station and park-wide summary reports cited in the section above, integrated reports will present findings from recent monitoring and additionally show the status relative to the long-term dataset. As sufficient data become available, these reports will include analysis of trends. The intent of these reports is to provide park managers with a temporally and spatially extensive look at water-quality in and around the park. These reports will be published on

the same rotation as the park-wide assessment sampling (Table 4). Changes to the report style and cycle will make the reporting timelier and more comprehensive.

Fixed-Station Data Summary Dashboard

In the absence of annual data summary reports for all parks each year, the Southeast Coast Network intends to provide park managers with an .html style dashboard providing access to the most recent data and summarize data using graphs. In addition, all approved continuous data are available via the Aquarius Web Portal.

Analysis of Trends

In order to determine to what extent conditions or constituent concentrations are changing in the water and sediment, the integrated reports will use specific and appropriate tests for trends at each site including the Mann-Kendall method which is appropriate for a step-wise trend comparison of water-quality data collected on an annual or seasonal basis. The Mann-Kendall test computes Kendall's tau nonparametric correlation coefficient and its test of significance (Helsel et al. 2020) for any pair of X,Y data. Various other methods may be used to detect trends and progressive changes of conditions in the near-shore water of Southeast Coast Network parks including methods that are optimized for parametric and nonparametric datasets.

Scientific Journal Articles and Conference Presentations

Other types of reports may be published by the Southeast Coast Network and will depend on specific water-quality or monitoring issues and the nature of the partnership or audience interested in the specific water-quality or monitoring effort and personnel time and funding. Publication of findings in scientific journals will allow the network to reach a broader scientific community and promote investigation by members of the scientific community, either independently or in cooperation with the network. Ultimately, publication in peer-reviewed publications and the collaboration that ensues will foster a greater understanding of water-quality and processes that affect conditions in and around waters of the network parks. Similarly, the presentation of findings or subsets of data at conferences will allow the network to reach the broader scientific community even at smaller regional venues. Attendance and presentation of data at these conferences often fosters partnership efforts. All journal article and conference presentations developed by the Southeast Coast Network will be made available to parks whose data is included with the report or presentation.

Personal Requirements and Training

The staffing model implemented for this protocol relies heavily on network staff to conduct fixed-station and parkwide assessment field work, data processing, and analysis. In some cases, when objectives overlap, partnerships with park staff or other agencies such as the North Carolina NERRs program and the City of Jacksonville (Florida) increase the operational efficiency of data collection. Water and sediment samples are analyzed by a contracted certified laboratory. Staff is comprised of a protocol lead, and a hydrologic technician. The protocol lead is responsible for all operations outlined in this protocol narrative and associated standard operating procedures. The hydrologic technician's main responsibility is operation and maintenance of the fixed monitoring stations and associated data entry. The hydrologic technician position requires monthly sampling and maintenance trips to most parks which, due to the long travel distances and complicated access logistics, requires one full week of travel per month. Additional responsibilities are devoted to station data management and assistance with parkwide water-quality assessments and associated data management tasks.

Personnel and Qualifications

Protocol Lead

The protocol lead is responsible for overall implementation of the protocol, including the certification and analysis of data, revisions to standard operating procedures as needed, and assisting park and partner staff with the interpretation of findings and incorporation of results into park management. The incumbent must have the knowledge, skill, and ability to apply known theories, principles, and concepts of aquatic ecology sufficient to design and implement scientific studies related to estuarine, freshwater, and/or marine water resources; as well as the ability to statistically analyze data, synthesize information, write reports, and publish papers related to monitoring results. The incumbent is also responsible for ensuring the collection of high-quality data and interpretation of findings within the context of established assessment criteria, regulatory requirements, and management targets. The protocol lead will routinely be required to perform statistical tests and analysis, use geographic information systems and modeling procedures to analyze and synthesize data, and communicate and interact effectively with a wide variety of audiences, in both technical and non-technical language, for the presentation and preparation of letters, memoranda, reports, management plans, environmental assessments, briefings, and peer-reviewed scientific papers.

Hydrologic Technician

The hydrologic technician serves as the lead for all field operations including the management and maintenance of existing fixed water-quality monitoring stations to ensure consistent collection of scientifically credible data meeting programmatic standards as outlined in standard operating procedures. The incumbent must have the knowledge and ability to use, maintain, and troubleshoot water-quality monitoring equipment in use by the network, primarily YSI data sondes and associated probes. In addition, the incumbent should have some background analyzing water-quality data, preferably in estuarine or marine environments, sufficient to assess the validity of data using standard data quality control procedures The hydrologic technician is also responsible for providing technical support to NPS and external agency partners who are collaborating on protocol implementation.

Routine duties of this position include calibration of sondes, station maintenance, discrete and continuous data entry, data collection, monthly site visits, quality control procedures, continuous data correction and flagging, basic interpretation of continuous water-quality data.

Physical Scientist

The physical scientist provides Geographic Information System (GIS), and spatial data management assistance when needed in support of both fixed-station and park-wide data collection and reporting activities. Routine assistance will be in the form of downloading the most recent aerial imagery, producing park-wide assessment field maps, and configuring park-wide result maps. The annual workload for all tasks is expected to be less than 16 hours.

Data Manager

The data manager is responsible for ensuring that the protocol's data management system and processes meets NPS and federal information management standards, including data and database security, and data quality and documentation. The data manager is also responsible for the functionality and maintenance of the database system, including the front and back end. The incumbent applies knowledge of programming, data management, database applications, GIS, network priorities, and national Inventory and Monitoring guidelines and directives, to plan, develop, and support application programs and systems. The incumbent synthesizes a wide range of data types including biological, physical, and bibliographical in both tabular and spatial formats to assure that metadata for these data sets is complete, current, and in compliance with current standards. The incumbent also provides coordination and oversight for the population and maintenance of national information management systems (e.g., IRMA and EQuIS). Finally, the incumbent develops documentation for current and future users of the network's information management system, in the form of user manuals and overall technical documentation (e.g., roles and responsibilities, workflows, data dictionaries and entity relationship diagrams).

Training

As outlined in the memo "Requirements for Inventory and Monitoring Division Water Quality Sampling" issued by the Chief of Inventory and Monitoring Division (IMD) and Chief of the Water Resource Division (WRD) on January 11, 2018, requirements for training have been standardized across all networks (Gallo 2018a).

At least one staff member per network that has implemented a water-quality monitoring protocol (including the actual collection of water-quality samples) must complete an approved water-quality field methods training class. Training must be kept current with at least one staff member having completed approved training within the last three years.

To satisfy this requirement, the IMD has developed a course in collaboration with the USGS covering methods for discrete and continuous water-quality monitoring techniques, which is designed to promote basic knowledge and core competencies in skills required to implement water-quality monitoring protocols across the Division, as well as foster IMO-wide consistency in field methods among networks. A complete list of approved training courses is available from IMD.

USGS and other partners may offer other courses that are tailored more specifically to networks' monitoring protocols. These courses may be substituted for the IMD-designed class after consultation with the network's Regional Program Manager and the IMD Deputy Chief for Science. Approval of alternative training will be based on the training provider, alignment of coursework with the network's protocol(s), and inclusion topics such as equipment maintenance and methods for quality assurance and quality control.

In addition, the network's aquatic ecologist and hydrologic technician will be required to take additional training offered by the manufacture of data sondes (e.g., YSI) and software used to manage the continuous data (e.g., Aquatic Informatics).

Key Partnerships

City of Jacksonville and Florida Department of Environmental Protection

Since 2005, the Southeast Coast Network has been working collaboratively with the City of Jacksonville (COJ)-Environmental Quality Division and the State of Florida Department of Environmental Protection (DEP), to jointly monitor water resources in and around Timucuan Ecological and Historic Preserve (TIMU). The area of cooperation includes the watersheds of the Timucuan Ecological and Historic Preserve and the Nassau River-St. Johns River Marshes Aquatic Preserves, which are ecologically important as an estuary that is influenced by expanding urban areas, vast salt marshes and surrounding uplands. The water-quality of the area is affected by commercial development, commerce routes, residential development, silviculture activities, and recreation. The area is important as a vast nursery for many species of plants and animals, including many economically important species of vertebrates and invertebrates. These agencies, in cooperation with the Southeast Coast Network, have agreed to collaborate to preserve, protect, and enhance the water-quality in the areas within and adjacent to the preserve by working cooperatively in the following ways.

1. The City of Jacksonville will share data from their bi-monthly fixed-station discrete monitoring at 12 sites located in the park. The Southeast Coast Network will financially support sampling and analysis of water samples for chlorophyll *a.* The City of Jacksonville will maintain the authoritative dataset for their project and provide the Southeast Coast Network with data as needed.

2. The State of Florida's Department of Environmental Protection will continue fixed-station continuous monitoring as warranted at one or more locations within or adjacent to the park (as of 2022, Clapboard Creek Heckscher Drive station) and share data as needed. The network will provide limited data management support and the FDEP will maintain the authoritative dataset for their project(s).

North Carolina National Estuarine Research Reserve

Since 2008, the Southeast Coast Network has operated under a memorandum of understanding or general agreement with the State of North Carolina, North Carolina Department of Environmental Quality (NCDEQ), Division of Coastal Management (NCDCM), is the National Oceanic and

Atmospheric Administration's (NOAA) state partner for the North Carolina National Estuarine Research Reserve (NCNERR) Program.

The objective of this agreement is to facilitate long-term water-quality monitoring at fixed stations within Cape Lookout National Seashore (CALO) following protocols developed by NOAA's National Estuarine Research Reserve System (NERRS) System-wide Monitoring Program and adopted by the National Park Service and Southeast Coast Network. One monitoring station is in the CALO Shackleford Banks area and the other along the CALO Rachel Carson Reserve boundary.

Both monitoring stations are mutually beneficial to the SECN Inventory and Monitoring Program and the North Carolina National Estuarine Research Reserve. The NOAA's System Wide Monitoring Program (SWMP) is a monitoring program started by the NERRS in 1994. Its overall goal is to monitor weather and water-quality within the NERRS system. This long-term dataset allows changes in estuarine conditions to be observed. The Southeast Coast Network's program is an NPS monitoring program with the same overall goals and design as the NERRS System Wide Monitoring Program.

Cape Lookout National Seashore and the Rachel Carson Reserve of NCNERR share a common boundary. Thus, it is cost effective and beneficial for the parties to work together to accomplish the goals of both monitoring programs at the same time without duplication. By implementing the NERRS protocols at Cape Lookout National Seashore, an understanding of short-term variability and long-term trends in water-quality will be available for management purposes for both the NPS and the NCDCM.

U.S. Geological Survey (USGS)

Since 2010, the Southeast Coast Network has supported an interagency agreement with the USGS to operate and maintain a real-time weather station and tidal gage at Cumberland Island National Seashore's (CUIS) Sea Camp Dock (USGS 02228295 CUMBERLAND SOUND AT SEA CAMP DOCK, NR ST MARYS, GA). These data are disseminated via the internet on the USGS NWIS web page. Data provided by this station supports the interpretation of data collected from the co-located Southeast Coast Network discrete fixed monitoring station and is useful for monitoring ongoing and storm conditions from the mainland. In addition, the station also provides USGS with data from an area along Georgia's coast where a data gap has historically existed in its accurate water-level gage network.

Operational Requirements

Annual Workload

Field work for this protocol is conducted year-round requiring close coordination between the protocol lead and the hydrologic technician due to periods where tasks overlap (Figure 17). Major tasks include a reporting period during late February to April, and park-wide monitoring trips during July and August. This late summertime period is the suggested index period for estuarine sampling (EPA 2001) and usually corresponds to the expected period of the worst water-quality conditions in estuaries.

The workload for the hydrologic technician will consist of tasks and subtasks related to collecting data, data entry, QA/QC, procuring equipment, shipping samples to contracted labs, and performing maintenance on sondes and sonde housings.

Permitting Requirements

No state, federal, or park permitting or compliance is required to implement this protocol.

Facilities and Equipment

The large amount of traveling required to maintain operations requires at least one vehicle capable of towing a boat and a boat capable of accessing near-park estuarine water throughout the network. Other necessary facilities include a wet-lab for storage, calibration, and maintenance of water sampling equipment for both the park-wide and the fixed-station components of the protocol. General laboratory space is sufficient, assuming it has adequate bench space; however, storage for flammable and toxic chemicals is also required. Each monitoring station setup requires two data sondes so calibrations and post-deployment readings can be conducted in a laboratory environment and sonde-swaps can be conducted efficiently. In addition, sufficient duplicate backup equipment (sonde body, sensors, grab samplers, etc.) must be stocked to make repairs within the monthly turn-around between data retrieval trips. Shipping is a considerable budget consideration due to the complicated logistics involved in remote deployments and the use of a contracted laboratory for sample analysis.

Operation Costs

Operational costs include 1.5 FTE split between three positions with the hydrologic technician being almost 80% dedicated to day-to-day protocol activates. The fixed station monitoring involves year-round activities with the park-wide assessments occurring during the late summer period in four of every five years. The sediment component is added to the park-wide assessments during every other assessment (every 10 years). Table 8 summarizes annual operational costs by position and work element.

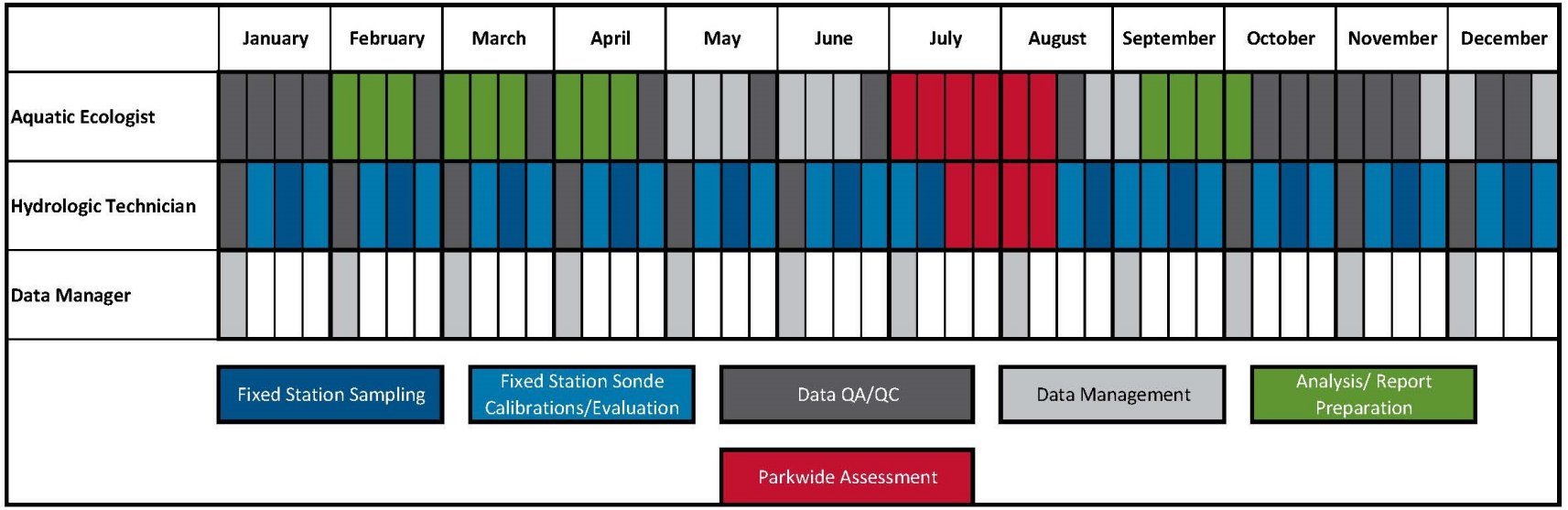


Figure 17. General staffing matrix for the Estuarine Water and Sediment Quality Monitoring Protocol with approximate time periods required to complete major tasks associated with fixed-station and park-wide monitoring. Time periods for specific tasks associated with key personnel are outlined in color.

Table 8. Approximate annual operating costs (based on FY 2022 dollars) for implementation of Protocol for Monitoring Estuarine Water and Sediment Quality.

Category	Item	Cost $ Low (FY2022)	Cost $ High (FY2022)	Notes
Personnel	Protocol Lead	76,888	76,888	0.60 FTE, GS-12 GS 12-5 =$94,924 + .35= $128,147
	Hydrological Technician	50,992	50,992	0.80 FTE, GS-06/07 7-1=47,216 =.35=$63,741
	Data Manager	12,814	12,814	0.10 FTE, GS-12-5 12-5 =$94,924 + .35= $128,147
	Personnel Total	**140,694**	**140,694**	**–**
Fixed-Station Water-quality Monitoring	Nutrient Analyses	7,010	7,010	–
	Sonde/Probe Repairs	8,000	8,000	–
	Station Infrastructure Maintenance	1,000	1,000	–
	Sonde replacements	13,000	13,000	one per year + sensors
	Calibration Standards	3,000	3,000	–
	Travel: Sonde run and sampling	3,000	3,000	–
	Shipping	2,500	3,000	–
	Total Non-Personnel Fixed-Station Monitoring Costs	**37,510**	**38,010**	**–**
Park-wide Monitoring (5 and 10 Year) Assessment Costs	Nutrient Analyses	2,600	5,200	Sample rotation may include 30 or 60 sites depending on the year.
	Sediment Analyses [A]	12,500	25,000	Sample rotation may include 30 or 60 sites depending on the year. Sediment sampling completed every other sampling round (i.e., every 10 years). For sediment, the Cost $ Low column represents years where 30 sites are sampled. During years without sampling the cost is $0.00

[A] Sediment samples collected and analyzed at each park once every 10 years. Costs associated with sediment sampling only incurred by the Southeast Coast Network four years out of every 10-year sampling cycle.

Table 8 (continued). Approximate annual operating costs (based on FY 2022 dollars) for implementation of Protocol for Monitoring Estuarine Water and Sediment Quality.

Category	Item	Cost $ Low (FY2022)	Cost $ High (FY2022)	Notes
Park-wide Monitoring (5 and 10 Year) Assessment Costs (continued)	Shipping	200	1,500	–
	Boat maintenance	500	500	–
	Travel: Sampling	2,500	2,500	–
	Total Non-Personnel 5- and 10-year Assessment Costs	**18,300**	**34,700**	**–**
Total Water and Sediment Quality Protocol Implementation Costs		**196,504**	**213,404**	**–**

[A] Sediment samples collected and analyzed at each park once every 10 years. Costs associated with sediment sampling only incurred by the Southeast Coast Network four years out of every 10-year sampling cycle.

Safety

Implementation of this protocol has multiple complex risks. Staff will continuously evaluate all risks at the programmatic, personnel, and site level. Programmatic-level safety information is presented here and procedures to mitigate risks associated with specific activities related to protocol implementation (e.g., safe operations of watercraft, vehicle operation, injury reporting and accident reporting) are presented in Appendix E and in task specific SOPs.

Job Hazard Analyses (JHAs) have been established for the following tasks: fixed-station water-quality monitoring, park-wide assessment of water-quality, on-road driving, towing, and boating. JHAs include the risks associated with each task and risk abatement strategies (including training needs).

When the protocol was initially established a programmatic-level Green-Amber-Red (GAR) risk analysis was used to assess whether implementation of this protocol could be accomplished within an acceptable level of risk.

Specific safety concerns identified by the GAR include:

- Crew members will spend many hours (and miles) driving to, between, and from sampling locations to conduct the requisite sampling.
- Crew members may occasionally work in park areas outside of communications range (either by park radio or by cell phone).

Injury or loss of life while in transit to and from field sites—as well as while in transit to or to perform data collection activities from watercraft—are the most significant risks encountered when conducting this activity.

Based on the protocol JHAs and associated risk abatement measures it was determined this protocol can be safely implemented provided network and partner staff implement it in accordance with the referenced SOPs and recommended risk abatement strategies (Appendix E; Starkey 2021; SECN 2021a; SECN 2021b; SECN 2021c; SECN 2021d). In addition to standard operating procedures developed to safely implement this protocol, specific training needs for all staff have been identified including certification in basic first aid and motorboat operation training (Appendix E). To increase the overall level of safety and awareness, obtaining additional levels of training beyond basic certifications will be encouraged.

Safety procedures will be routinely reviewed with network staff and partners before field operations as prescribed in SOPs. Personnel-level JHAs for staff will be reviewed and revised annually as a part of the performance review cycle. Safety SOPs are reviewed at least annually and updated as necessary to ensure they adequately mitigate risks to personnel, property, and the public.

In addition to protocol-specific safety procedures and guidelines, SECN staff will follow the general guidelines set forth in the NPS Occupational Safety and Health Program (Directors Order #50B, September 2008). These procedures are generally outlined below.

1. Adhere to established occupational safety and health procedures, including those contained within Reference Manual 50B.
2. Work collaboratively with supervisors to develop, revise and use JHAs or equivalent for all routine tasks, and help develop and use site-specific safety plans for non-routine, complex, multi-phase jobs.
3. Properly use and maintain required clothing and/or personal protective equipment.
4. Maintain a level of personal wellness and fitness as needed for assigned work tasks.
5. Identify and, where appropriate, correct unsafe conditions and work practices.
6. Report unsafe/unhealthful conditions and/or operations to his or her immediate supervisor or the appropriate chain of command.
7. Report mishaps, including minor accidents and "near-misses," to a supervisor as soon as possible, but in no case later than the end of the work shift.
8. Participate in establishing a safe working culture, and practice safe work procedures, even when working alone.

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Appendix A. Standard Operating Procedures for Coastal Monitoring and Assessment Protocol

To ensure consistent procedures network-wide as standard operating procedures (SOPs) are revised, updated, and re-published, the Southeast Coast Network maintains a single library of SOPs that are shared across all network protocols and operations. The latest approved versions of operational SOPs are always available for download at the NPS Integrated Resource Management Applications portal.

All SECN SOPs conform to a standard three-part numbering system to aid in the identification of the portion(s) of the program to which the procedures apply (Table A-1). The SOPs are regularly updated. The Southeast Coast Network maintains the complete collection of the most recent and working versions of all SOPs on the Southeast Coast Network share drive, and all published SOPs are available and versioned on the datastore.

Table A-1. Numbering system and categories for Standard Operating Procedures (SOPs) used by the Southeast Coast Network. Within each category, SOPs are numbered sequentially as they are produced.

Level 1	Level 2	Topic
1	1.1.x	General field methods shared by multiple branches of the network. Typically those related to GIS, GPS location, photopoints, or use of shared instrumentation.
	1.2.x	Field methods for water resource monitoring.
	1.3.x	Field methods for coastal resource monitoring.
	1.4.x	Field methods for terrestrial resource monitoring (plants and animals).
2	2.1.x	Data management procedures shared by multiple branches of the network, such as those pertaining to reporting, file management.
	2.2.x	Data management procedures related to water resource monitoring.
	2.3.x	Data management procedures related to coastal resource monitoring.
	2.4.x	Data management procedures related to terrestrial resource monitoring (plants and animals).
3	3.1.x	Field Safety.
	3.2.x	Equipment use and maintenance.
4	4.1.x	Network administration.
5	5.1.x	User Manuals.

The following subset of the network's SOPs are included/referenced in the implementation of the SECN Coastal Monitoring and Assessment Protocol (Table A-2). All SOPs are subject modification as EPA-NCA and NOAA-NERR guidance documents are updated, SECN updates will occur in accordance with SOP 2.1.01 *Revision of Southeast Coast Network Protocols and Standard Operating Procedures*—Version 3.1 (Wright and Curry 2021).

Table A-2. Standard Operating Procedures required to implement the SECN Estuarine and Sediment Monitoring Protocol. Table lists SOPs by task category, SOP number, title, and Integrated Resources Management Applications (IRMA) Record Numbers. Note that SOP numbers not shown pertain to other monitoring efforts (e.g., SOP 1.1.07) or have been retired and are no longer in use.

Subject	SOP#	Citation	IRMA Record Number
Monitoring	1.1.06	Starkey, E. N., and D. L. McCay. 2022. Estuarine water and sediment shipping and tracking of laboratory samples—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.1.06. Southeast Coast Network, Athens, Georgia.	2284582
	1.2.01	Cooper, C. S., and E. N. Starkey. 2022. Parkwide assessment, generating spatially-balanced sampling locations using ArcGIS 10-Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.01. Southeast Coast Network, Athens, Georgia.	2284576
	1.2.02	Starkey, E. N., and D. McCay. 2022. Park-wide assessment navigation and field evaluation of sampling locations—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.02. Southeast Coast Network, Athens, Georgia.	2284594
	1.2.03	Starkey, E. N., and M. B. Gregory. 2022. Park-wide assessment field water-quality measurements—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.03. Southeast Coast Network, Athens, Georgia.	2284595
	1.2.04	Starkey, E. N., and M. B. Gregory. 2022. Parkwide assessment water sample collection and processing–Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.04. Southeast Coast Network, Athens, Georgia.	2284596
	1.2.05	Starkey, E. N., and D. McCay. 2022. Parkwide assessment benthic sediment collection and processing—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.05. Southeast Coast Network, Athens, Georgia.	2284597
	1.2.07	Starkey, E. N., and D. L. McCay. 2022. Estuarine water and sediment laboratory analysis method performance criteria and requirements—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.07. Southeast Coast Network, Athens, Georgia.	2284602
	1.2.08	Starkey, E. N., and D. McCay. 2022. Fixed-station installation of water-quality data sonde housing—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.08. Southeast Coast Network, Athens, Georgia.	2284578

Table A-2 (continued). Standard Operating Procedures required to implement the SECN Estuarine and Sediment Monitoring Protocol. Table lists SOPs by task category, SOP number, title, and Integrated Resources Management Applications (IRMA) Record Numbers. Note that SOP numbers not shown pertain to other monitoring efforts (e.g., SOP 1.1.07) or have been retired and are no longer in use.

Subject	SOP#	Citation	IRMA Record Number
Monitoring (continued)	1.2.09	McCay, D. L., E. N. Starkey, and M. B. Gregory. 2022. Fixed-station, water-quality data sonde maintenance, calibration, deployment, and retrieval—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.09. Southeast Coast Network, Athens, Georgia.	2284553
	1.2.10	McCay, D., and E. N. Starkey. 2022.Fixed-station remote sonde deployment and water sample collection quick guide—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.10. Southeast Coast Network, Athens, Georgia.	2284574
	1.2.11	McCay, D. and E. N. Starkey. 2022. Fixed-station water sample collection and processing—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.11. Southeast Coast Network, Athens, Georgia.	2284575
	1.2.19	Starkey, E. N. 2022. Parkwide assessment preparation for fieldwork—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.19. Southeast Coast Network, Athens, Georgia.	2294038
	1.2.20	Starkey, E. N. 2022. Parkwide assessment field season closeout—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.2.20. Southeast Coast Network, Athens, Georgia.	2294039
Data Management	2.1.01	Wright, W., and S. Curry S. 2022. Revision of Southeast Coast Network Protocols and Standard Operating Procedures—Version 3.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.01. Southeast Coast Network, Athens, Georgia.	2284603
	2.2.04	Starkey, E. N. 2022. Parkwide assessment data reporting manual—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.04. Southeast Coast Network, Athens, Georgia.	2284678
	2.2.06	Wright, W., and B. Flanders.2022. Exporting and publishing fixed-station water quality monitoring data to EQUIS-Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.06. Southeast Coast Network, Athens, Georgia.	2284579

Table A-2 (continued). Standard Operating Procedures required to implement the SECN Estuarine and Sediment Monitoring Protocol. Table lists SOPs by task category, SOP number, title, and Integrated Resources Management Applications (IRMA) Record Numbers. Note that SOP numbers not shown pertain to other monitoring efforts (e.g., SOP 1.1.07) or have been retired and are no longer in use.

Subject	SOP#	Citation	IRMA Record Number
Data Management (continued)	2.2.07	Wright, W., B. Flanders, and E. N. Starkey. 2022.Estuarine water quality monitoring data management and database technical documentation—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.07. Southeast Coast Network, Athens, Georgia.	2284577
	2.2.08	Starkey, E. N., D. McCay. 2022. Fixed-station data reporting manual—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.08. Southeast Coast Network, Athens, Georgia.	2294701
	2.2.09	Starkey, E. N., D. McCay, B. Flanders, and W. Wright. 2022. Fixed-station continuous water quality data entry, processing, and QA/QC. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.09. Southeast Coast Network, Athens, Georgia.	2284064
	2.2.10	Starkey, E. N., D. McCay, W. Wright, and B. Flanders. 2022. Fixed-station discrete water quality data entry, processing and QA/QC. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.10. Southeast Coast Network, Athens, Georgia.	2284605
	2.2.11	Starkey, E. N., and D. McCay. 2022. Park-wide assessment: field data entry and certification. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.11. Southeast Coast Network, Athens, Georgia.	2284600
Safety	3.1.01	Starkey, E. N. 2021. Reporting of On-duty injury, illness, near misses, hazards, and exposure—Version 5.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.01. Southeast Coast Network, Athens, Georgia.	2284673
	3.1.02	Southeast Coast Network. 2021. Safe operation of Southeast Coast Network Watercraft—Version 2.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.02. Southeast Coast Network, Athens, Georgia.	2284674
	3.1.03	Southeast Coast Network. 2021. Vehicle use and operation—Version 2.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.03. Southeast Coast Network, Athens, Georgia.	2284675

Table A-2 (continued). Standard Operating Procedures required to implement the SECN Estuarine and Sediment Monitoring Protocol. Table lists SOPs by task category, SOP number, title, and Integrated Resources Management Applications (IRMA) Record Numbers. Note that SOP numbers not shown pertain to other monitoring efforts (e.g., SOP 1.1.07) or have been retired and are no longer in use.

Subject	SOP#	Citation	IRMA Record Number
Safety (continued)	3.1.04	Southeast Coast Network. 2021. Motor vehicle accident reporting procedures—Version 2.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.04. Southeast Coast Network, Athens, Georgia.	2284676
	3.1.7	Southeast Coast Network. 2021. Communicating field operations with SECN Parks—Version 3.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.07. Southeast Coast Network, Athens, Georgia.	2284677

Literature Cited

Wright, W., and S. Curry S. 2021. Revision of Southeast Coast Network Protocols and Standard Operating Procedures—Version 3.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.01. Southeast Coast Network, Athens, Georgia. Available at: DataStore - SOP 2.1.01 Revision of Southeast Coast Network Protocols and Standard Operating Procedures—Version 3.1 (nps.gov) (last accessed March 2023).

Appendix B. Fixed-Station Site Descriptions

Since the program's inception, 16 fixed monitoring stations have been deployed and managed by the Southeast Coast Network and partner agencies (Table B-1 to B-3). Of those, 11 are operational.

Data pertaining to station installation and maintenance are recorded at the time of station deployment, during routine sampling and station maintenance visits, and otherwise as needed (McCay et al. 2022; Starkey and McCay 2022). The most current station information regarding fixed monitoring stations are retained on the SECN share drive, and included when reporting and publishing data.

Table B-1. SECN estuarine water-quality monitoring fixed-station information. Florida Department of Environmental Protection (FLDEP) [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	HUC 12 Code	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
CAHA	Pamlico Sound	30201050207	Ocracoke boat ramp.	Near shore sound	CAHAocbr01	CAHAocbr, OC	High salinity outfall nearby, ease of access	11/4/2005	–	6600 as of 9/16/19
CALO	Back Sound	30203010704	Shackleford Banks dock	Near shore sound	CALOshak01	CALOshak, CALO01, SH	Proximity to previous water-quality site	11/03/2005	–	03/01/2017
CALO	Back Sound	30203010704	Middle Marshes area of Rachel Carson Reserve	Near shore sound	CALOmidm02	CALOshak2, CALO02, CALOmm, MM	Selected by NERRS staff to support program goals	04/17/2008	–	06/28/2017
CANA	Mosquito Lagoon	30802020400	Canaveral NS Apollo Beach visitor center dock	Lagoon	CANAvctr01	CANAvctr	Access, interpretive opportunity and relatively pristine location	7/21/2005	–	01/14/2014
CONG [D]	Cedar Creek	30501100310	Near Bannister Bridge Canoe Access	Freshwater stream	CONGbann01	–	For comparison with CONGccbr01 and evaluation of nutrient concerns.	07/03/2019	–	07/03/2019
CONG [D]	Cedar Creek	30501100310	Bridge B on Cedar Creek	Freshwater stream	CONGccbr01	CONGccbr CCBR, CC	Interior of park, paired with USGS gauge and relatively representative of Cedar Creek throughout park.	08/09/2006	–	08/22/2018

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive implementation at CONG (see Appendix C).

Table B-1 (continued). SECN estuarine water-quality monitoring fixed-station information. Florida Department of Environmental Protection (FLDEP) [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	HUC 12 Code	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
CUIS	Old House Creek	30702030503	Old House Creek Dock	Tidal creek	CUISold02	CUISold, CUIS02	Comparison site for CUISplum; representative on tidal creek habitat	01/06/2007	09/07/2010	All 6600
CUIS	Brickhill River	30702030503	Plum Orchard Dock	Near shore sound	CUISplum01	CUISplum, CUIS01, CIP	Potentially impacted by shoreline changes; relatively accessible	08/04/2005	09/07/2010	All 6600
CUIS	Cumberland Sound	30702030503	Sea Camp dock	Near shore sound	CUISseac03	CUISseac, CUIS03, SC	Located at a site where data could be used to meet data needs by USGS; representative of near-shore sound habitat	09/08/2010	–	01/18/2018
FOMA	Matanzas River	30802010404	Fort Matanzas NM visitor center dock	Tidal inlet/river	FOMAvctr01	FOMA, FOMA01	Selected by park staff; only structure to which the sonde mount could be affixed	05/25/2010	–	01/08/2014

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive implementation at CONG (see Appendix C).

Table B-1 (continued). SECN estuarine water-quality monitoring fixed-station information. Florida Department of Environmental Protection (FLDEP) [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	HUC 12 Code	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
FOPU	Lazaretto Creek	30601090307	Lazaretto Creek fishing pier	Tidal creek	FOPUlazz01	FOPUlazz, FOPUfish, FOPU	Only structure at the park to which the station housing could be mounted	08/14/2006	–	02/25/2015
TIMU	Clapboard Creek	030801031602	Piling in Clapboard Creek. ~4.0 river miles (6.5km) upstream of St. Johns River	Tidal creek	TIMUclap01	TIMUclap01, TIM13A	Area of expected rapid urban growth; representative tidal creek habitat	06/22/2005	06/06/2011	All 6600
TIMU	Clapboard Creek	030801031602	Heckscher Drive Bridge	Tidal creek	TIMUclap02	TIMUclap02	Selected and operated by FLDEP	10/24/2016	–	~9/2020
TIMU	Fort George River	30702050304	Kingsley Plantation dock	Tidal inlet/river	TIMUking01	TIMUking, TIM11A	Baseline data and interest in changes to site due to inlet migration/ management	06/22/2005	–	01/14/2014

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive implementation at CONG (see Appendix C).

Table B-1 (continued). SECN estuarine water-quality monitoring fixed-station information. Florida Department of Environmental Protection (FLDEP) [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Waterbody	HUC 12 Code	Site Location	Water Body Description	Station Name and Aquarius Identifier [A]	Synonyms [B]	Site Selection Criteria	Date Established	Date Inactive	Date switched from YSI 6600 to EXO [C]
TIMU	Lofton Creek	030702050303	Piling in Lofton Creek. Confluence with Nassau River	Tidally influenced river	TIMUloft01	TIMUloft, TIM4A, LC	Area of expected residential and urban growth; representative tidal riverine/creek habitat	07/01/2005	06/03/2011	All 6600
TIMU	Nassau River	030702050302	Piling in Nassau River. Near highway 17	Tidally influenced river	TIMUnass01	TIMUnass, TIM14A	Indicator of water-quality from the upper reaches of the Nassau River	07/17/2009	06/03/2011	All 6600

[A] Aquarius Time-Series Software.

[B] Synonyms used by collaborators, the SECN data management system prior to 2020, and select reports/publications prior to 2017.

[C] Continuous water-quality monitoring sonde model.

[D] Adaptive implementation at CONG (see Appendix C).

Table B-2. SECN estuarine water-quality monitoring fixed-station locations.

Station Name	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
CAHAocbr01	35.11836000	−75.98594000	18 N	410111	3886643
CALOshak01	34.6869200	−76.6436400	18 N	349438	3839553
CALOmidm02	34.6945170	−76.6185000	18 N	351755	3840359
CANAvctr01	28.9268045	−80.8250293	17 N	517054	3199888
CONGbann01 [A]	33.839651	−80.860446	17 N	512911	3744385
CONGccbr01 [A]	33.8166900	−80.8280700	17 N	515911	3741844
CUISold02	30.79800	−81.47027	17 N	455011	3407310
CUISplum01	30.85487	−81.46723	17 N	455328	3413611
CUISseac03	30.7643030	−81.4712600	17 N	454900	3403576
FOMAvctr01	29.7146200	−81.2349400	17 N	477275	3287186
FOPUlazz01	32.0141370	−80.8841200	17 N	510943	3542008
TIMUclap01	30.44917	−81.52267	17 N	449818	3368675
TIMUclap02	30.4051320	−81.5084709	17 N	451159	3363788
TIMUking01	30.4411606	−81.4390499	17 N	457843	3367753
TIMUloft01	30.54725	−81.55278	17 N	446980	3379558
TIMUnass01	30.57300	−81.60600	17 N	441891	3382437

[A] Adaptive Implementation at CONG (see Appendix C).

Table B-3. Cooperator monitoring station locations and names. These stations are within or adjacent to each park and provide important supplementary data. City of Jacksonville (COJ), Saint Johns River Water Management District (SJRWMD), Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS), Florida Department of Environmental Protection (FLDEP). Links are provided for sources where data or protocols are available to the public [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Organization	Station Name/Code/ID [A]	Water Body	Description	Type of Data	Protocol Used	Nutrient Sampling Window	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
TIMU	COJ	TIM1	Thomas Creek	Thomas Creek at confluence with Nassau River	Discrete	FLDEP	Any	30.562	−81.659	17 N	436801	3381247
TIMU	COJ	TIM2	Nassau River	Nassau River approximately 50 m downstream of I-95 bridge	Discrete	FLDEP	Any	30.586	−81.625	17 N	440077	3383888
TIMU	COJ	TIM3	Nassau River	Nassau River at confluence with Deese Creek	Discrete	FLDEP	Any	30.543	−81.585	17 N	443887	3379102
TIMU	COJ	TIM4	Lofton Creek	Lofton Creek approximately 50 m upstream from confluence with Nassau River	Discrete	FLDEP	Any	30.545	−81.564	17 N	445903	3379314
TIMU	COJ	TIM4A [B]	Lofton Creek	Lofton Creek piling	Discrete	FLDEP	Any	30.547	−81.552	17 N	447055	3379530
TIMU	COJ	TIM5	Edwards Creek	Edwards Creek at confluence with Samples Creek	Discrete	FLDEP	Any	30.511	−81.544	17 N	447803	3375536

[A] Each organization refers to the station differently (i.e., name, code, ID).

[B] Previously also a continuous monitoring station (see Table B-1).

[C] Inactive station.

Table B-3 (continued). Cooperator monitoring station locations and names. These stations are within or adjacent to each park and provide important supplementary data. City of Jacksonville (COJ), Saint Johns River Water Management District (SJRWMD), Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS), Florida Department of Environmental Protection (FLDEP). Links are provided for sources where data or protocols are available to the public [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Organization	Station Name/Code/ID [A]	Water Body	Description	Type of Data	Protocol Used	Nutrient Sampling Window	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
TIMU	COJ	TIM6	Pumpkin Hill Creek	Pumpkin Hill Creek, east of Broward Island and northwest of Black Hammock Island	Discrete	FLDEP	Any	30.532	−81.498	17 N	452227	3377843
TIMU	COJ	TIM7	Alligator Creek	Alligator Creek approximately 50 m upstream from confluence with Nassau River	Discrete	FLDEP	Any	30.578	−81.497	17 N	452345	3382940
TIMU	COJ	TIM8	Nassau River	Nassau River at confluence with Sisters Creek	Discrete	FLDEP	Any	30.525	−81.464	17 N	455485	3377053
TIMU	COJ	TIM9A	Sisters Creek	Sisters Creek (ICWW Marker 67)	Discrete	FLDEP	Any	30.461	−81.449	17 N	456896	3369955
TIMU	COJ	TIM10	Garden Creek	Garden Creek approximately 50 m upstream of confluence with Ft. George River	Discrete	FLDEP	Any	30.442	−81.441	17 N	457656	3367847

[A] Each organization refers to the station differently (i.e., name, code, ID).

[B] Previously also a continuous monitoring station (see Table B-1).

[C] Inactive station.

Table B-3 (continued). Cooperator monitoring station locations and names. These stations are within or adjacent to each park and provide important supplementary data. City of Jacksonville (COJ), Saint Johns River Water Management District (SJRWMD), Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS), Florida Department of Environmental Protection (FLDEP). Links are provided for sources where data or protocols are available to the public [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Organization	Station Name/Code/ID [A]	Water Body	Description	Type of Data	Protocol Used	Nutrient Sampling Window	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
TIMU	COJ	TIM11	Fort George River	Ft. George River at northeast corner of island	Discrete	FLDEP	Any	30.438	−81.421	17 N	459575	3367396
TIMU	COJ	TIM11A [B]	Kingsley Plantation Dock	Kingsley Plantation Dock	Discrete	FLDEP	Any	30.441	−81.439	17 N	457848	3367735
TIMU	COJ	TIM12	Sisters Creek	Sisters Creek near mouth of Cedar Point Circle (ICWW Marker 77)	Discrete	FLDEP	Any	30.431	−81.457	17 N	456115	3366634
TIMU	COJ	TIM13A [B]	Clapboard Creek	Clapboard Creek	Discrete [C]	FLDEP	Any	30.449	−81.522	17 N	449882	3368656
TIMU	COJ	TIM14A [B]	Nassau River	Nassau River	Discrete [C]	FLDEP	Any	30.573	−81.606	17 N	441891	3382437
CANA	SJRWMD	IRLV05	Indian River North	Just south of New Smyrna Beach at channel marker 47 near the South Canal discharge	Discrete	SJRWMD	Any	29.008056	−80.909444	17 N	508819	3208882

[A] Each organization refers to the station differently (i.e., name, code, ID).

[B] Previously also a continuous monitoring station (see Table B-1).

[C] Inactive station.

Table B-3 (continued). Cooperator monitoring station locations and names. These stations are within or adjacent to each park and provide important supplementary data. City of Jacksonville (COJ), Saint Johns River Water Management District (SJRWMD), Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS), Florida Department of Environmental Protection (FLDEP). Links are provided for sources where data or protocols are available to the public [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Organization	Station Name/Code/ID [A]	Water Body	Description	Type of Data	Protocol Used	Nutrient Sampling Window	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
CANA	SJRWMD	IRLV11	Indian River North	East of Cedar Island and west of Bethune Beach and just north of the northern boundary of Canaveral National Seashore; approximately 3 miles northeast of the Canaveral National Seashore Apollo Beach visitor center.	Discrete	SJRWMD	Any	28.952500	−80.844722	17 N	515131	3202733
CANA	SJRWMD	IRLV17	Indian River North	Just south of channel marker 7 near Barlow's Crab Building and the Oak Hill dock.	Discrete	SJRWMD	Any	28.876871	−80.838101	17 N	515788	3194355
CANA	SJRWMD	IRLML169	Indian River - Mosquito Lagoon	Midway between Gaines Island and Vanns Island	Discrete	SJRWMD	Any	28.837492	−80.794820	17 N	520016	3189999
CANA	SJRWMD	IRLML02	Indian River - Mosquito Lagoon	Between Pardon Island and Cucumber Island; south of Haulover Canal	Discrete and Continuous	SJRWMD	Any	28.731915	−80.717235	17 N	527612	3178317

[A] Each organization refers to the station differently (i.e., name, code, ID).

[B] Previously also a continuous monitoring station (see Table B-1).

[C] Inactive station.

Table B-3 (continued). Cooperator monitoring station locations and names. These stations are within or adjacent to each park and provide important supplementary data. City of Jacksonville (COJ), Saint Johns River Water Management District (SJRWMD), Guana Tolomato Matanzas (GTM), National Estuarine Research Reserve System (NERRS), Florida Department of Environmental Protection (FLDEP). Links are provided for sources where data or protocols are available to the public [CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve].

Park	Organization	Station Name/Code/ID [A]	Water Body	Description	Type of Data	Protocol Used	Nutrient Sampling Window	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
FOMA	GTM NERRS	GTMFMWQ	Matanzas River	In the Matanzas River just south of Devil's Elbow	Continuous	NERRS	w/in 3hrs before low tide	29.737041	−81.245953	17 N	476216	3289673
FOMA	GTM NERRS	GTMFMNUT	Matanzas River	In the Matanzas River just south of Devil's Elbow	Discrete	NERRS	w/in 3hrs before low tide	29.737041	−81.245953	17 N	476216	3289673
FOMA	GTM NERRS	GTMPCWQ	Pellicer Creek	In the Pellicer Creek Aquatic Preserve near Faver-Dykes State Park Campground	Continuous	NERRS	w/in 3hrs before low tide	29.667071	−81.257403	17 N	475092	3281923
FOMA	GTM NERRS	GTMPCNUT	Pellicer Creek	In the Pellicer Creek Aquatic Preserve near Faver-Dykes State Park Campground	Discrete	NERRS	w/in 3hrs before low tide	29.667071	−81.257403	17 N	475092	3281923

[A] Each organization refers to the station differently (i.e., name, code, ID).

[B] Previously also a continuous monitoring station (see Table B-1).

[C] Inactive station.

Cape Hatteras National Seashore – Ocracoke Boat Ramp (CAHAocbr01)

Station Description

Station located at Cape Hatteras National Seashore (CAHA) at the Ocracoke boat ramp on the park dock behind a large parking lot. This site regularly sees heavy boat traffic in spring, summer, and autumn. Nearby habitats include Pamlico Sound waters, sandy bottom, rock rip-rap shoreline with some Spartina marsh grass ponds nearby. Nearby shoreline includes rock rip-rap for shoreline stabilization, some nearby Spartina marsh grass, and a concrete boat ramp and dock.

Site Operation Notes

The station is operated in partnership with CAHA staff. The SECN staff are responsible for calibrating equipment and, on a monthly basis, sending data sondes, nutrient sample jars to CAHA personnel for deployment and retrieval.

Justification for Location

This site was chosen because it is easily accessible, has adequate water depth, has established mounting structure, and there is a nearby (200 meters [650 ft]) municipal water desalination outfall. Water-quality concerns in this area include a high salinity outfall nearby, and when water levels are high, septic systems can overflow.

Cape Lookout National Seashore Shackleford Banks (CALOshak01)

Station Description

This site is located at the most concentrated user area on Shackleford Banks, approximately 0.5 miles (0.8 km) from Beaufort Inlet. The station is located at Cape Lookout National Seashore at the park dock on Shackleford Banks. A boat is required to access the island. Boat traffic is heavy in this area and tides range from 0.5–1 meter (2–3 ft).

Site Operation Notes

The site was established November 3, 2005, and is managed under a formal partnership agreement with NOAA and N.C. Department of Natural Resources as a part of the NCNERR program. The station was deployed so the unit hangs approximately 0.5 meter (1.6 ft) from the bottom. Shoreline description: sandy beach. The Southeast Coast Network has provided all station equipment and routinely maintains the station and NCNERR staff are responsible for monthly sonde retrievals and redeployments as well as collecting monthly discrete water samples. All lab analyses are conducted under SECN lab contracts.

Justification for Location

The site chosen because of proximity to previous water-quality site operated by the North Carolina National Estuarine Research Reserve Program.

Cape Lookout National Seashore Shackleford Banks 2 (CALOmidm02)

Station Description

This site is in the middle of the shallow bay, known locally as Back Sound. It is located east of Beaufort Inlet Channel and east/northeast of CALOshak01. The station is not mounted to any permanent structure such as a dock or piling; it is housed (horizontally) in a modified crab pot, to keep it submerged in water and protected from damage. A crab buoy is attached to the housing to aid in locating the sonde for retrievals. Boat access is the only way to travel to the site, identified by a buoy.

Site Operation Notes

The site is managed under a formal partnership agreement with NOAA and N.C. Department of Natural Resources as a part of the NCNERR program. The Southeast Coast Network has provided all station equipment and routinely maintains the station and NCNERR staff are responsible for monthly sonde retrievals and redeployments as well as collecting monthly discrete water samples. All lab analyses are conducted under SECN lab contracts.

Justification for Location

Site was selected by NCNERR staff to support NCNERR research program goals.

Canaveral National Seashore Visitor Center (CANAvctr01)

Station Description

The station is at Canaveral National Seashore on the northeast side of Mosquito Lagoon on the dock behind the Apollo Beach visitor center. Primary emergent vegetation along the nearest shoreline is salt marsh cordgrass (*Spartina alterniflora*) and black mangrove (*Avicennia germinans*). The area on either side of the dock is covered with rip-rap (broken pieces of concrete) in a prior attempt to curb erosion. Just landward of the emergent vegetation Groundsel (*Baccharis* spp.) is the dominant plant species. Boat traffic in the lagoon is very heavy on weekends, and moderate to light during the week. Occasionally boats will pull up to the dock where the monitoring station is located. The main boat ramp is just to the north of the visitor center dock. Currents in the lagoon are primarily wind driven. No fishing or crabbing is allowed from the visitor center dock.

Water-quality is designated as Fair and Class II, which is suitable for shellfish propagation and harvesting. Normal tide fluctuation is only a matter of inches. The water is saline (averaging about 32 ppt.), and water temperatures can exceed 29°C (68°F) during summer months. Submerged vegetation consists primarily of manatee grass (*Syringodium filiforme*) and shoalweed (*Halode wrightii*). Oyster reefs and salt marsh islands are nearby. Marsh species include saltgrass (*Distichlis spicata*), seashore paspalum (*Paspalum varigatum*), seashore dropseed (*Sporobolus virginicus*), saltwort (*Batis maritima*), glasswort (*Sarcocornia perrennis*), annual glasswort (*Salicornia bigelowii*) and salt marsh cordgrass.

Site Operation Notes

Station was deployed July 1, 2005, so that unit hangs 1 meter (3.3 ft) from bottom. Anti-fouling paint was put on the inside bottom of the PVC tube, on the sonde guard, and mesh protecting the guard. In September 2005, anti-fouling paint was applied to the sonde probes due to reports of excessive

biofouling. The SECN staff are responsible for data sonde retrievals and deployments, and annual station maintenance. Fouling of the probe by barnacles is a persistent problem.

Justification for Location

This location was chosen because (1) it is easily accessible for park staff, (2) water depth is acceptable, (3) it provides an interpretive opportunity for park guests, and (4) it is a relatively pristine location compared to the other side of the lagoon.

Congaree National Park Bannister Bridge (CONGbann01)

Discussed in Appendix C. Adaptive Implementation at Congaree National Park.

Congaree National Park Cedar Creek Bridge B (CONGccbr01)

Discussed in Appendix C. Adaptive Implementation at Congaree National Park.

Cumberland Island at Old House Creek Dock (CUISold02)

Station Description

This station is on a floating dock on the Old House Creek a smaller tidal creek draining a large are of salt marsh. Tidal fluctuations are large although tidal currents are not as strong as those in the larger tidal rivers in the vicinity. This station typically receives very little recreational traffic and is primarily used by island residents to dock small watercraft.

Site Operation Notes

Originally operated by CUIS staff, the site was discontinued in 2010.

Justification for Location

The site was selected based on park recommendation as a comparison site for CUISplum01.

Cumberland Island at Plum Orchard Dock (CUISplum01)

Station Description

Located in the Brickhill River on the dock for the Plum Orchard Historic District, 375 meters (1,230 ft) south-southwest of the mansion. Station is on an outside piling of the northern floating dock wing. Dock is used by the park's concessioner operated ferry for Plum Orchard tours, as well as general park operations and island residents.

Currents are strong in the area. Flow direction with tide and water source for these currents is not understood. Recreational boat traffic is heavier on the weekends than it is during the week, and there is a seasonal fluctuation to this activity. Typically, there is low to moderate fishing nearby. The dock accommodates a ferry every second and fourth Sunday of the month, and some barges load and unload from the dock.

Outside bend of the Brickhill River, 1.3 kilometers (0.8 mi) from its southern terminus with the Cumberland Sound. Shoreline morphology ranges from gentle slope to cut bank ranging from approximately 0.25 to 3.0 meters (0.8 ft to 9.8 ft) in height. Erosional nature of outside bend is magnified/modified by boat wakes as well as headwalls and rubble along shoreline of Plum Orchard

District. Heavy erosion at immediate dock area in 2005 was due to use as unimproved boat ramp and surface runoff from local upland.

Site Operation Notes

Station was deployed August 4, 2005, so that unit hung 1 meter (3.3 ft) from bottom. Anti-fouling paint was put on the inside bottom of the PVC tube, on the sonde guard, and mesh protecting the guard. In September 2005, anti-fouling paint was applied to the sonde probes due to reports of excessive biofouling. Originally operated by CUIS staff, the site was discontinued in 2010 due to lack of park support.

Justification for Location

Water-quality in the area is potentially impacted by shoreline changes. Site was chosen because it is relatively accessible and has adequate water depth. Vessel traffic on Brickhill River is primarily recreational but, station is approximately 1.3 kilometers (0.8 mi) from the Intracoastal Waterway and Cumberland Sound. Periodic activity around dock area includes twice monthly ferry trips, boat launching and recovery, and landing of goods off light barges.

Cumberland Island at Sea Camp Dock (CUISseac03)

Station Description

This station is on the northwest corner of the non-floating portion of a large dock owned by the National Park Service. This dock is near the Cumberland Island National Seashore's public camping area known as Sea Camp and is used by workers going to and from the island and serves as an arrival point for many of the island's visitors.

The station is on a tidal river, part of the Intracoastal Waterway, close to the sound. The station is on the backside of an older barrier island consisting of complex dune ecosystems, forests and salt marsh. The river has shifting sand bars and heavy siltation issues. The nearby shoreline is highly eroded with accreted sand and silt along the river. Remnants of old rip-rap are also present in the area.

Site Operation Notes

This monitoring station was installed October 1, 2010, by the USGS and consists of a 6-inch (10.2 cm) PVC pipe. Current USGS weather and water level data are available for this location and made available real-time via the internet at USGS website. The SECN staff are responsible for monthly discrete sampling, data sonde retrievals and deployments, and annual station maintenance

Justification for Location

The site was selected as a replacement for CUISplum01 and CUISold02 when decommissioned and was at a site where data could be used to meet data needs by USGS for hydrologic modeling purposes.

Fort Matanzas Visitor Center Dock (FOMAvctr01)

Station Description

Station is on the southside of the dock at the Fort Matanzas visitor center. The dock is used for park staff as well as park's concessioner. The Matanzas Inlet and River are heavily used for fishing and general recreational purposes due to its beaches, access to the open ocean, as well as the intracoastal

waterway. Vegetation types include salt marsh and mangroves. The adjacent shoreline is mostly sandy with mixed forest and marsh.

Site Operation Notes

The site was established May 25, 2010, and consists of a PVC pipe attached to the dock. The SECN staff are responsible for monthly data sonde retrievals and deployments, and annual station maintenance. Discrete sampling is done by the GTM Research Reserve at a nearby site (station name gtmfmwq).

Justification for Location

The location was selected by park staff because it is the only structure to which the station could be affixed.

Fort Pulaski National Monument Lazzaretto Creek Fishing Pier (FOPUlazz01)

Station Description

Station is on the southside of the fishing pier on Lazaretto Creek. The dock is popular with locals and tourists alike year-round. The station is at Fort Pulaski National Monument roughly 1 mile (1.6 km) beyond the entrance to the visitor center. Lazzaretto Creek is a tidal creek that drains into the Savannah River near the Atlantic Ocean. The area is predominately salt marsh, and popular with anglers and boaters. The nearby shoreline is very silty, with evidence of erosion and accretion.

Site Operation Notes

The station was established August 14, 2006, and consists of a 20-foot (6.1 m) PVC pipe attached to the railing and anchored with a fence post at the bottom such that the data sonde sits approximately 1 meter (3.2 ft) off the bottom. The SECN staff are responsible for monthly discrete sampling, data sonde retrievals and deployments, and annual station maintenance.

Justification for Location

The site was selected because it is the only structure at the part to which the station housing could be mounted.

Timucuan Preserve at Clapboard Creek (TIMUclap01)

Station Description

Affixed to a single piling placed in upper Clapboard Creek near the point where Bogey Branch enters Clapboard Creek. This station is where emergent vegetation is changing from salt to freshwater species. The creek is narrow (< 150 feet or 45 meters wide) at this point, and experiences only occasional boat traffic mostly from smaller, shallow draft fishing boats. Bogey Branch drains into Clapboard Creek within 600 feet (183 m), and Tidewater, a residential subdivision slated to build several hundred single family homes, is approximately 0.4 kilometer (0.25 mi) upstream of the monitoring site. The water is predominantly salt water, with the sampling location approximately 19 kilometers (12 mi) from the ocean.

Site Operation Notes

The site was established October 1, 2004, and the sonde was installed within a capped and locked 4-inch (10.2 cm) diameter PVC tube. The tube was attached to an individually-placed piling with

galvanized steel hangers and suspended approximately 0.5 meter (1.6 ft) above the substrate. Although originally operated by Florida Department of Environmental Protection, this site was discontinued in 2011 due to rescission of state funding.

Justification for Location

Clapboard Creek is in the Timucuan Preserve and forms the western boundary of the St. Johns River – Nassau River Marshes State Aquatic Preserve. Clapboard Creek receives freshwater from several small creeks that drain Clapboard Swamp. Upper Clapboard Creek is an area of expected rapid urban growth. The placement of a monitoring device here will collect data as a baseline before development begins and to determine the effects of the freshwater inputs from the Clapboard Swamp.

Timucuan Preserve at Clapboard Creek (TIMUclap02)

Station Description

Affixed to the Heckscher Drive Bridge in lower Clapboard Creek near the Saint Johns River. This site experiences regular fishing boat traffic.

Site Operation Notes

This site was established October 24, 2016, by the Florida Department of Environmental Protection (FLDEP). Site maintenance, and sonde deployments and retrieval were done by the Florida Department of Environmental Protection from 2016 to present. The Florida Department of Environmental Protection followed in-house sonde calibration, deployment and retrieval methods and the Southeast Coast Network provided continuous data processing assistance 2016–2019. These data were stored in the SECN database and in Aquarius. Due to changing FLDEP methods, limited sensors, and data management priorities the Florida Department of Environmental Protection began managing data generated from this station starting in 2019.

Justification for Location

Selected by the Florida Department of Environmental Protection to monitor water-quality conditions impacted by development and ongoing projects on the Saint Johns River.

Timucuan Preserve at Kingsley Plantation (TIMUking01)

Station Description

Located on the Fort George River at the northeast corner of the elevated section of the dock at Kingsley Plantation in Timucuan Ecological and Historic Preserve. The sampling location is approximately 4 kilometers (2.5 mi) from the ocean and is predominantly salt water. This area experiences heavy boating traffic on weekends in the spring and summer. The nearby shoreline is lined with Spartina and Juncus, with some oyster beds present.

Site Operation Notes

Established March 1, 2004, the sonde is suspended within a 4-inch (10.2 cm) diameter PVC tube directly affixed to one of the corner dock pilings with galvanized steel hangers.

The site was originally operated by Florida Department of Environmental Protection, but discontinued in 2011 due to rescission of state funding. In 2012, the Southeast Coast Network began operating the station with network staff being responsible for monthly data sonde retrievals and

deployments, and annual station maintenance. Monthly nutrient sampling does not occur at this site because the City of Jacksonville collects water samples nearby (station name: TIM11A).

Justification for Location

The Ft. George River provides clean ocean water during each tide cycle. This water flows to vast Spartina marshes considered to have very good water-quality. Due to the presence of jetties at the mouth of the St. Johns River, large quantities of sediment are being deposited in the Ft. George River. This data will serve as baseline data against which future conditions may be measured.

Timucuan Preserve at Lofton Creek (TIMUloft01)

Station Description

This monitoring station is near the mouth of a tidal creek that has a strong blackwater influence and can sometimes tend more toward freshwater than saline. The sampling location is in Lofton Creek near its intersection with the Nassau River, approximately 17.5 kilometers (10.9 mi) from the ocean. This monitoring station is the shallowest of the sites operated at Timucuan Ecological and Historic Preserve, and by virtue of its proximity to the confluence with the Nassau River, experiences swift currents and complex flow patterns. The banks of this creek are lined with Spartina and Juncus, and oyster beds are present near the sampling site.

Site Operation Notes

Established July 1, 2005, the sonde was held within a capped and locked 4-inch (10.2 cm) diameter PVC tube. The tube is attached to an individually-placed piling and the sonde's probes are suspended approximately 1 foot (0.3 m) above the substrate. On occasion, the data sonde's probes can be exposed for short periods. Because the probes are stationed approximately 1 foot off the substrate, and because at times the water level just barely covers them, turbidity levels can be elevated when there is debris on the surface or when swiftly receding waters agitate the bottom. Although originally operated by Florida Department of Environmental Protection, this site was discontinued in 2011 due to rescission of state funding.

Justification for Location

Lofton Creek, which drains over 20,000 acres (8,094 hectares [ha]), is a major freshwater source for the Nassau River. Growth in residential and urban development is planned for as large tracts of property that are currently held in silviculture are converted to housing and population density increases.

Timucuan Preserve at Nassau River (TIMUnass01)

Station Description

The Nassau River data sonde site is on the south bank of the river at a point where salinities on an outgoing tide are low enough for it to be considered a freshwater site. The banks of the river where the station is located are undeveloped, and the river's width at this location is approximately 450 meters (1,500 ft). There is a small boat launch at the US 17 crossing, and although the site is downstream enough to not be directly influenced by runoff from road traffic, under unusual conditions (truck spill) there could be noticeable effects. This is also an area of swift moving currents which experiences a sizeable tidal range.

River with tidal influence (though relatively low conductivity) dominated by salt marsh. Sampling location is approximately 12 miles (20 km) “as the crow flies” from the ocean. The adjacent stream bank is lined with Spartina and Juncus.

Site Operation Notes

The site is a single piling installed near the south bank of the river, approximately 0.2 mile (0.3 km) east of the US 17 crossing. The sonde is suspended within a 4-inch (10.2 cm) diameter PVC tube directly affixed to a single piling with galvanized steel hangers. The monitoring probes extend below the lower edge of the PVC tube just enough so they receive unimpeded current flow. The probes are suspended at a depth of approximately 1 meter (3.3 ft) above the substrate. The site was established July 17, 2009. Although originally operated by Florida Department of Environmental Protection, this site was discontinued in 2011 due to rescission of state funding.

Justification for Location

This site is near the westernmost boundary of the Nassau River/St. Johns River Marshes Aquatic Preserves and serves as an indicator of water-quality from the upper reaches of the Nassau River as it enters Timucuan Ecological and Historic Preserve. Though technically not pristine, there has been relatively little commercial, industrial, or residential development in the headwaters of this system, as much of the surrounding lands support silviculture. Aside from serving as a “background” site, this location was chosen to expand upon a wealth of historic data already available from a variety of monitoring entities and agencies.

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Appendix C. Adaptive Implementation at Congaree National Park (CONG)

Introduction

At the request of Congaree National Park (CONG), the Southeast Coast Network began implementation of select components of this protocol at Congaree National Park in August 2006. While the park does not include estuarine resources, the techniques for monitoring water-quality are largely the same as those outlined throughout this protocol and associated standard operating procedures. However, because Congaree National Park is not an estuarine park, details of implementation at the park are presented in this appendix rather than in the body of the document.

Background and Objective

While Congaree National Park is not part of estuarine water-quality monitoring, a subset of methods and objectives have been selected for implementation. The Southeast Coast Network has identified the following monitoring objective for which data are collected and analyzed as part of this effort:

- Determine daily and seasonal water-quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at fixed monitoring stations using continuous data loggers. Specific conductance is reported at Congaree National Park instead of salinity.

In 2006 the Southeast Coast Network (SECN) began collecting water-quality data on Cedar Creek to provide additional data to help assess water-quality conditions and determine short- and long-term trends in water-quality conditions within Congaree National Park.

Upon initial implementation, a single site on Cedar Creek (CONGccbr01) at Bridge B was chosen as a long-term fixed water-quality monitoring site because of its proximity to an existing U.S. Geological Survey gaging station (02169672) and provide managers with additional water-quality and hydrologic information on a stream representative of those draining the Congaree River floodplain (Figure C-1 and Table C-1).

In 2019, a secondary fixed water-quality monitoring site was installed on Cedar Creek (CONGbann01) at Banister Bridge (Table C-1). This site was temporarily established to explore differences in water chemistry as Cedar Creek flows through the park. In January 2023, data analysis indicated the Cedar Creek Bridge B site is more representative of conditions in the park than the Bannister Bridge location. Bannister Bridge receives no backwater effect from the Congaree River whereas Bridge B is occasionally impacted by Congaree River floodwater. As a result, the Bannister Bridge site was retired in February 2023.

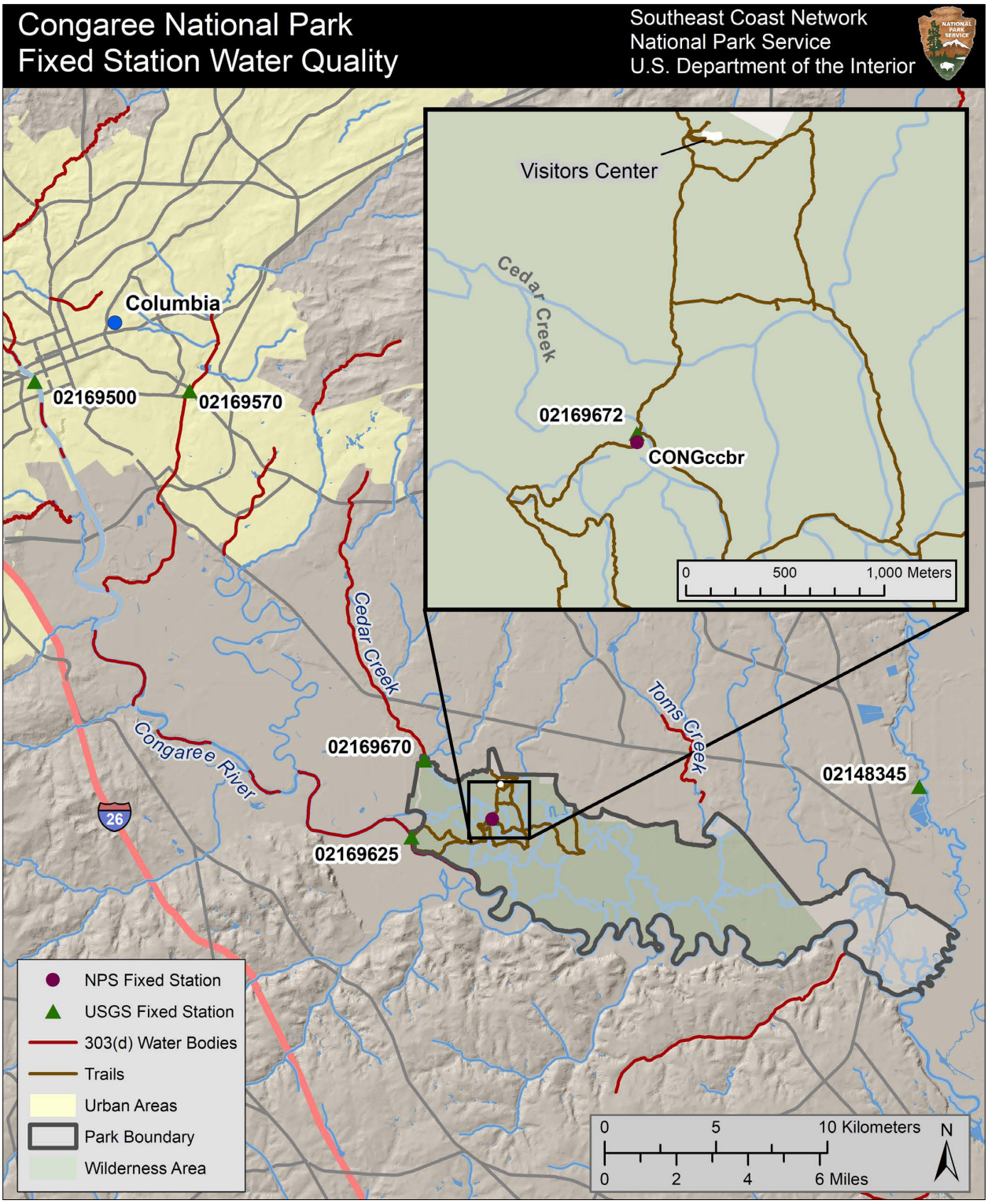


Figure C-1. Location of continuous water-quality monitoring station at Congaree National Park in South Carolina. Map shows water resources in the vicinity of Congaree National Park near Columbia, South Carolina and indicates areas of urbanization (USCB 2023), 303(d) listed water bodies (EPA 2023). Note that CONGccbann01 is not shown on this map due to its temporary installation near USGS station 02169670.

Table C-1. Congaree water-quality monitoring station locations.

Station Name	Latitude	Longitude	Zone	Easting (X)	Northing (Y)
CONGbann01	33.839651	−80.860446	17 N	512911	3744385
CONGccbr01	33.8166900	−80.8280700	17 N	515911	3741844

Study Area

Congaree National Park is adjacent to the Congaree and Wateree rivers in southeast Richland County, South Carolina, approximately 20 miles (32.2 kilometers) southeast and downstream of the capital city of Columbia (Figure C-1). Encompassing 26,027 acres (40.7 square miles [mi^2]), the park protects old-growth trees and diverse plant and animal life within the largest intact expanse of old-growth bottomland hardwood forest remaining in the United States. Periodic flood waters from the adjacent rivers flow through the bottomland forest in winter and spring, carrying the nutrients and sediments that nourish and rejuvenate this unique floodplain ecosystem. Nearly 90 species of trees grow within the park, with many recognized as national and state champions for their size. Forested wetlands, oxbow lakes, and slow-moving creeks and sloughs provide superb habitat for fish, birds, reptiles, mammals, and other aquatic life. The diversity of flora and fauna, tall tree canopy, champion trees, and intact floodplain ecosystem earned the park the designation of an International Biosphere Reserve, National Natural Landmark, Globally Important Bird Area, Wetland of International Importance through the Ramsar Convention, and congressionally designated Wilderness Area (NPS 2012).

Congaree National Park is drained by two major tributaries that meander through a spatially complex network of channel features such as abandoned channels, oxbow lakes as well as artificial dikes built to divert flows. These features are located throughout the Congaree River floodplain and support lateral and vertical hydrologic exchanges between the river and the floodplain (Meitzen 2011).

Cedar Creek is the largest floodplain tributary that flows through Congaree National Park (Shelley et al. 2012). The floodplain portion of Cedar Creek in Congaree National Park is formed by the confluence of two upland creeks called Cedar and Meyers Creeks. The combined upland watershed represented by these two creeks is 11 kilometers (6.8 miles [mi]) wide, 23 kilometers (14.3 mi) long and covers more than 170 square kilometers (65 square mi).

Cedar Creek is a black water system characterized by clear, tea-colored water associated with organic acids leached by groundwater percolating through the soil profile. This translates into relatively high dissolved organic carbon values and relatively low values for dissolved oxygen, conductivity, alkalinity, and pH (Birch 1984; Maluk and Abrahamsen 1999; Andersen et al. 2010; NPS unpublished data). Blackwater streams can also become highly turbid during rain events when fine sediments that have settled onto the stream's benthos in the gentle, slow moving currents of base-flow are mobilized and become suspended in the water column as the stream's stage increases. As with other blackwater streams, during high flow events, upland watershed runoff, intra-floodplain

runoff, and back-flooding of the Congaree River lead to increases in the suspended sediment concentration as well as other changes in water-quality (Birch 1984).

Although, the water-quality standards promulgated by the State of South Carolina do not differentiate between different types of freshwater streams, what is considered normal water-quality in a coastal plain blackwater stream can be different than what is considered normal for a non-blackwater system. The State of South Carolina has acknowledged that certain water bodies may have normally occurring conditions outside the range set forth in its water-quality standards (SCDHEC 2012).

Cedar Creek supports diverse aquatic communities and provides recreational opportunities (mainly canoeing and fishing) for park visitors. In 2006, waters of Cedar Creek within Congaree National Park were reclassified from a general freshwater classification to an Outstanding Resource Waters (ORW), and a portion of Cedar Creek was upgraded to Outstanding National Resource Waters (ONRW), the first such designation of its kind in South Carolina (SCDHEC 2012). Cedar Creek outside of the park boundary is classified as freshwater, from the park boundary to Wise Lake is classified as ORW (this is the section that the water-quality station is on), and from Wise Lake to the confluence of the Congaree River is classified as ONRW.

Portions of three water bodies (Congaree River, Tom's Creek, and Cedar Creek) adjacent to Congaree National Park are 303(d) listed as impaired or threatened for a variety of reasons (Figure C-1; EPA 2022). The Congaree River has been listed for elevated levels of fecal coliform for recreational purposes. The upstream section of Cedar Creek, before it enters the park boundary, has been listed for not meeting the criteria for macroinvertebrates communities in 2008 and 2010. Sections of Tom's Creek have been listed for elevated levels for fecal coliform, macroinvertebrate communities, and pH values (EPA 2022).

Methods

Data collection methods are based on those employed by the National Estuarine Research Reserve Program (Wenner and Geist 2001) and the efforts at Congaree National Park are in conjunction with a water-quality monitoring operation at coastal parks throughout the network. Methods for the calibration, deployment and retrieval of data loggers, data entry and processing are the same as those outlined for estuarine water-quality monitoring.

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Appendix D. Water Quality Portal Site and Organization Identifiers

Table D-1. Water Quality Portal discrete fixed-station identifiers and organizational identifiers for sites in and near SECN parks. Note that not all SECN fixed station sites listed in Appendix B, Table B-1 are shown here due to other agencies/organizations conducting sampling (i.e., CANA [SJRWM], FOMA [GTM NERRS], TIMU [COJ]. In addition, some TIMU data [TIM 1 – TIM 13] may also be found in the Project Identifier SECN_EWQM_FIXED_LEGACY. Water Quality Portal (https://www.waterqualitydata.us/). CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve.

Park	SECN Site ID	Water Quality Portal MonitoringLocationIdentifier	Water Quality Portal OrganizationIdentifier	Water Quality ProjectIdentifier
CAHA	CAHAocbr01	11NPSWRD_WQX-CAHA_OCBR01	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
CALO	CALOshak01	11NPSWRD_WQX-CALO_SHAK01	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
CALO	CALOmidm02	11NPSWRD_WQX-CALO_MIDM02	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
CONG	CONGccbr01	11NPSWRD_WQX-CONG_CCBR01	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
CUIS	CUISold02	11NPSWRD_WQX-CUIS_OLD02	11NPSWRD_WQX	SECN_EWQM_FIXED_LEGACY
CUIS	CUISplum01	11NPSWRD_WQX-CUIS_PLUM01	11NPSWRD_WQX	SECN_EWQM_FIXED_LEGACY
CUIS	CUISseac03	11NPSWRD_WQX-CUIS_SEAC03	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
FOPU	FOPUlazz01	11NPSWRD_WQX-FOPU_LAZZ01	11NPSWRD_WQX	SECN_EWQM_FIXED and SECN_EWQM_FIXED_LEGACY
TIMU	TIMUclap01	11NPSWRD_WQX-TIMU_13A	11NPSWRD_WQX	SECN_EWQM_FIXED_LEGACY
TIMU	TIMUking01	11NPSWRD_WQX-TIMU_KING01	11NPSWRD_WQX	SECN_EWQM_FIXED_LEGACY
TIMU	TIMUloft01	11NPSWRD_WQX-TIMU_4A	11NPSWRD_WQX	SECN_EWQM_FIXED_LEGACY
TIMU	TIM1	21FLJXWQ_WQX-TIM1	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)

Table D-1 (continued). Water Quality Portal discrete fixed-station identifiers and organizational identifiers for sites in and near SECN parks. Note that not all SECN fixed station sites listed in Appendix B, Table B-1 are shown here due to other agencies/organizations conducting sampling (i.e., CANA [SJRWM], FOMA [GTM NERRS], TIMU [COJ]. In addition, some TIMU data [TIM 1 – TIM 13] may also be found in the Project Identifier SECN_EWQM_FIXED_LEGACY. Water Quality Portal (https://www.waterqualitydata.us/). CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve.

Park	SECN Site ID	Water Quality Portal MonitoringLocationIdentifier	Water Quality Portal OrganizationIdentifier	Water Quality ProjectIdentifier
TIMU	TIM2	21FLJXWQ_WQX-TIM2	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM3	21FLJXWQ_WQX-TIM3	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM4	21FLJXWQ_WQX-TIM4	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM4A	21FLJXWQ_WQX-TIM4A	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM5	21FLJXWQ_WQX-TIM5	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM6	21FLJXWQ_WQX-TIM6	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM7	21FLJXWQ_WQX-TIM7	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM8	21FLJXWQ_WQX-TIM8	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM9A	21FLJXWQ_WQX-TIM9A	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM10	21FLJXWQ_WQX-TIM10	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM11	21FLJXWQ_WQX-TIM11	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM11A	21FLJXWQ_WQX-TIM11A	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM12	21FLJXWQ_WQX-TIM12	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM13A	21FLJXWQ_WQX-TIM13A	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
TIMU	TIM14A	21FLJXWQ_WQX-TIM14A	21FLJXWQ_WQX	TIM (STORET) and TIM RUN (STORET)
CANA	IRLV05	21FLSJWM-IRLV05	21FLSJWM	IR
CANA	IRLV11	21FLSJWM-IRLV11	21FLSJWM	IR

Table D-1 (continued). Water Quality Portal discrete fixed-station identifiers and organizational identifiers for sites in and near SECN parks. Note that not all SECN fixed station sites listed in Appendix B, Table B-1 are shown here due to other agencies/organizations conducting sampling (i.e., CANA [SJRWM], FOMA [GTM NERRS], TIMU [COJ]. In addition, some TIMU data [TIM 1 – TIM 13] may also be found in the Project Identifier SECN_EWQM_FIXED_LEGACY. Water Quality Portal (https://www.waterqualitydata.us/). CAHA: Cape Hatteras National Seashore; CALO: Cape Lookout National Seashore; CANA: Canaveral National Seashore; CUIS: Cumberland Island National Seashore; FOMA: Fort Matanzas National Monument; FOPU: Fort Pulaski National Monument; TIMU: Timucuan Ecological and Historic Preserve.

Park	SECN Site ID	Water Quality Portal MonitoringLocationIdentifier	Water Quality Portal OrganizationIdentifier	Water Quality ProjectIdentifier
CANA	IRLV17	21FLSJWM-IRLV17	21FLSJWM	IR
CANA	IRLML169	21FLSJWM-IRLML169	21FLSJWM	IR
CANA	IRLML02	21FLSJWM-IRLML02	21FLSJWM	IR
FOMA	GTMFMNUT	21FLGTM_WQX-GTMFMNUT	21FLGTM_WQX	GTM-NERR
FOMA	GTMPCNUT	21FLGTM_WQX-GTMPCNUT	21FLGTM_WQX	GTM-NERR

Data Links 2008–2021

https://www.waterqualitydata.us/data/Result/search?project=SECN_EWQM_FIXED_LEGACY&mimeType=csv&zip=yes&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/data/Result/search?project=SECN_EWQM_FIXED&mimeType=csv&zip=yes&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/data/Result/search?project=TIM%20RUN&project=TIM&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&zip=yes&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/data/Result/search?siteid=21FLGTM_WQX-GTMFMNUT&siteid=21FLGTM_WQX-GTMPCNUT&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&zip=yes&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/data/Result/search?siteid=21FLSJWM-IRLV05&siteid=21FLSJWM-IRLV11&siteid=21FLSJWM-IRLV17&siteid=21FLSJWM-IRLML169&siteid=21FLSJWM-IRLML02&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&zip=yes&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

Query Links 2008–2021

To modify the search, click “Advanced” then click “Sample Results (biological metadata)”

https://www.waterqualitydata.us/#project=SECN_EWQM_FIXED&mimeType=csv&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/#project=SECN_EWQM_FIXED_LEGACY&mimeType=csv&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/#project=TIM%20RUN&project=TIM&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/#siteid=21FLSJWM-IRLV05&siteid=21FLSJWM-IRLV11&siteid=21FLSJWM-IRLV17&siteid=21FLSJWM-IRLML169&siteid=21FLSJWM-IRLML02&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

https://www.waterqualitydata.us/#siteid=21FLGTM_WQX-GTMFMNUT&siteid=21FLGTM_WQX-GTMPCNUT&startDateLo=01-01-2008&startDateHi=01-01-2021&mimeType=csv&dataProfile=biological&providers=NWIS&providers=STEWARDS&providers=STORET

Appendix E. Job Hazards Risk Assessment and Training and Proficiencies

Hazards, risks, and abatement actions associated with the implementation of the Southeast Coast Network (SECN) estuarine water and sediment quality monitoring protocol can be found in the Job Hazard Analysis stored on the Southeast Coast Network server. (S:\Safety\SECN SafetyPlan-JHAs\JHAs). JHAs have been established for the following tasks:

- Fixed-station water-quality
- Park-wide assessment of water-quality
- On-Road driving
- Towing
- Boating

Table E-1 outlines both required and optional trainings needed to safely fulfill activities associated with the implementation of this protocol.

Table E-1. Safety training needs assessment for each position. Note the Physical Scientist and University of Georgia Intern may serve a supporting role for this protocol but will not be implementing water-quality monitoring on their own [R = required, O = Optional].

Training Topic	Training Frequency	Aquatic Ecologist (supervisor)	Hydrologic Technician	Physical Scientist	UGA Intern	Notes	Source of Training
AEDs / First Aid / CPR	Initial/Refresher	R	R	R	R	Refresher every 2 years	In person Red Cross, wilderness first aid, or similar.
Bloodborne Pathogens	Initial/Refresher	O	O	O	O	Optional unless employees that are expected to have contact with bloodborne pathogens.	DOI Talent: Bloodborne Pathogens (BLM) BLM-B-024 or similar.
Boating Operations (MOCC)	Initial/Refresher	R	R	O	–	For all employees that will be using a boat. Refresher every 5 years	SECN SOP 3.1.02 Safe Operation of Southeast Coast Network Watercraft—Version 2.1 or newer AND In-person DOI MOCC (register via DOI Talent).
Cold Stress	Initial/Refresher	R	R	R	O	For employees that will be conducting fieldwork in the winter. Refresher as needed.	Typically covered during first aid training.
Driver Safety [Defensive Driving]	Initial/Refresher	R	R	R	O	All employees that operate a GOV must review the SOP. Refresher every 3 years.	SOP 3.1.03 Vehicle Use and Operation—Version 2.1 or newer AND Minimum of an online course such as those offered by the national safety council.
Severe Weather Emergency Action Plan	Initial/Refresher	R	R	R	O	Annual review of the Severe Weather Emergency Action Plan (SWEAP)	Review SECN Severe Weather Emergency Action Plan. Available on SECN share drive S:\Safety\SWEAP
Employee Assistance Program Orientation	Initial	R	R	R	R	Review information on EAP website.	Employee Assistance Program | U.S. Department of the Interior (doi.gov)
Fall Protection (Competent Person)	Initial/Refresher	–	–	–	–	No fall protection program currently in place or needed at this time.	DOI Talent or in person training.
Fall Protection (User)	Initial/Refresher	–	–	–	–	No fall protection program currently in place or needed at this time.	DOI Talent or in person training.

Table E-1 (continued). Safety training needs assessment for each position. Note the Physical Scientist and University of Georgia Intern may serve a supporting role for this protocol but will not be implementing water-quality monitoring on their own [R = required, O = Optional].

Training Topic	Training Frequency	Aquatic Ecologist (supervisor)	Hydrologic Technician	Physical Scientist	UGA Intern	Notes	Source of Training
Fire Extinguisher Use	Initial/Refresher	R	R	R	O	For all employees that operate a GOV. Refresher every 5 years.	In Person. May be done with MOCC.
Government Motor Vehicle Accidents SOP	Initial/Refresher	R	R	R	O	All employees that operate a GOV must review the SOP. Refresher every 3 years.	SOP 3.1.04 Motor Vehicle Accident Reporting Procedures—Version 2.1 or newer.
Hazard Communication (GHS & Site Specific)	Initial/Refresher	R	R	O	O	For all employees that will be handling or be exposed to hazardous materials.	Instructor lead or DOI Talent: Hazard Communication-Cal/OSHA (ehs_cal_a06_sh_enus), and Hazard Communication Impact: Safety Data Sheets (ehs_ci_a25_sh_enus).
Hazard Reporting	Initial/Refresher	R	R	R	R	–	DOI Talent: Hazard Communication: An Employee's Right to Understand (ehs_hsf_c94_sh_enus),
Hearing Conservation	Initial/Refresher	–	–	–	–	No hearing conservation program currently in place or needed at this time.	DOI Talent or in person training.
Hearing Protection	Initial/Refresher	–	–	–	–	No hearing conservation program currently in place or needed at this time.	DOI Talent or in person training.
Heat Stress	Initial/Refresher	R	R	R	R	All that will be conducting fieldwork in the summer. Refresher as needed.	Typically covered during first aid training. Also DOI Talent: Heat Stress (FWS-SAF3122)
Laboratory Safety	Initial/Refresher	R	R	O	O	–	DOI Talent: Laboratory Safety 1720. USGS
Ladders (Walking and Working Surfaces)	Initial/Refresher	O	O	O	O	For all employees who will be working on elevated surfaces. Refresher as needed.	DOI Talent: Walking & Working Surfaces 1430. USGS
Lightning Safety Awareness	Initial/Refresher	R	R	R	R	All that will be conducting fieldwork.	Lightning Safety Awareness and National Weather Service Lightning Safety Awareness Week

Table E-1 (continued). Safety training needs assessment for each position. Note the Physical Scientist and University of Georgia Intern may serve a supporting role for this protocol but will not be implementing water-quality monitoring on their own [R = required, O = Optional].

Training Topic	Training Frequency	Aquatic Ecologist (supervisor)	Hydrologic Technician	Physical Scientist	UGA Intern	Notes	Source of Training
Office Safety/Ergonomics	Initial/Refresher	R	R	R	R	–	DOI Talent: Office Safety – Cal/OSHA (ehs_cal_a04_sh_enus)
Operational Leadership	Initial/Refresher	R	R	R	O	–	In Person
Power Tools	Initial/Refresher	R	R	O	O	For all employees who will be using power tools.	Read and follow manufacture instructions and DOI Talent: Hand and Power Tool Safety (ehs_hsf_c62_sh_enus)
PPE	Initial/Refresher	R	R	R	O	For all employees who will complete tasks requiring PPE	DOI Talent: Personal Protective Equipment 1413. USGS
Reporting Injuries/Illnesses	Initial/Refresher	R	R	R	R	Review SOP. Refresher every 3 years.	SECN SOP 3.1.01 Reporting of On-Duty Injury, Illness, Near Misses, Hazards and Exposure v5.0 or newer.
Safe Lifting Practices	Initial/Refresher	O	O	O	O	For employees who will be lifting/moving heavy objects.	DOI Talent: Back Safety and Injury Prevention (ehs_hsf_c59_sh_enus)
Supervisory Safety Training	Initial/Refresher	R	–	–	–	Required for supervisors. Refresher as needed.	DOI Talent: BLM/FWS/NPS Supervisory Skills Workshop (BLM-TC-1430-53/FWS/NPS-SUPSKILLS) and Occupational Safety and Health for DOI Supervisors (DOIU-1312-OLT-DOI-08152014)
Towing a Trailer	Initial/Refresher	R	R	R	–	For all employees who will be towing a trailer. Refresher every 3 years	https://one.nhtsa.gov/cars/problems/Equipment/towing/index.htm
Watercraft (non-motorized)	Initial/Refresher	R	R	R	O	For all employees that will be using a non-motorized boat. Refresher every 5 years.	SECN SOP 3.1.02 Safe operation of Southeast Coast Network watercraft v2.1 or newer

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525