# FINAL
# INTEGRATED
# FEASIBILITY REPORT
# AND
# ENVIRONMENTAL IMPACT STATEMENT

## COASTAL STORM DAMAGE REDUCTION

## BOGUE BANKS, CARTERET COUNTY

## NORTH CAROLINA

**August 2014**

**US Army Corps of Engineers**

**Wilmington District**

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# Executive Summary
# Bogue Banks Coastal Storm Damage Reduction Feasibility Study, Carteret County, NC

The purpose of this study is to evaluate coastal storm damage reduction along Bogue Banks, a barrier island approximately 25 miles long located on North Carolina's central coast in Carteret County. The feasibility study is a cost-shared effort with Carteret County as the non-Federal study sponsor. Project Delivery Team (PDT) representatives included participants of Federal, State, and local governments in the effort to identify cost-effective, publicly acceptable, and environmentally and technically sound alternatives to reduce storm damages along the project shoreline. This study identified coastal storm damage problems on Bogue Banks, inventoried opportunities for addressing these problems as well as any planning constraints that could impact plan formulation, and analyzed alternatives. This analysis identified the National Economic Development (NED) plan, which is the plan that maximizes net benefits to the nation through reduction of future storm damages.

The island of Bogue Banks is located in Carteret County along North Carolina's central coast. Bogue Banks is the longest island south of Cape Lookout, and is a 25 mile long barrier island, stretching from Bogue Inlet on the west to Beaufort Inlet on the east. The barrier island, separated from the mainland by Bogue Sound, runs east to west, with the ocean beaches facing due south. Bogue Banks is developed and can be accessed by one of two bridges across Bogue Sound, either from Morehead City to Atlantic Beach, which is the more heavily traveled bridge, or from Cape Carteret to Emerald Isle. The State park/communities of Bogue Banks are (from east to west) Fort Macon State Park, Atlantic Beach, Pine Knoll Shores, Salter Path/Indian Beach, and Emerald Isle. Bogue Banks includes some hotels/motels but is dominated by private homes. Bogue Banks also contains areas of maritime forest. Stores and other commercial properties are found in all five main communities. The footprint of the study area includes the marine environment offshore of Bogue Banks, the barrier island, and the sub-aerial terrestrial beach.

In all cases where technically sound and environmentally feasible, both structural and non-structural measures were considered in the development of alternative solutions to the ongoing coastal storm damage reduction problems along the project area. The non-structural measures analyzed included demolition and relocation; retreat; and floodplain and regulatory restrictions. Demolition and relocation was found have greater costs than benefits, and therefore, was not recommended for implementation. Retreat was not considered a practicable alternative given the narrow width of the barrier island; and regulatory restrictions are assumed to be continued in perpetuity as an integral part of any alternative. The structural measures analyzed in detail (dune and berm construction) were shown to have a more favorable benefit/cost ratio and provided the greatest potential for an effective solution.

The Recommended Plan is the NED plan (Alternative 9), which consists of an 119,670 linear feet main beach fill (22.7 miles), with a consistent berm profile across the entire area, and dune expansion along 5.9 miles of the project shoreline (Figure ES-1). The main beach fill is bordered at the ends of the project by a 1,000 ft tapered transition zone berm. Material for the beach fill would be dredged from offshore borrow sources and transported to the beach for beach fill construction. The renourishment interval for the project is three years.

Table ES-1 below provides the details of the Recommended Plan dimensions expressed relative to the 117 study area reaches utilized in the analysis for plan formulation purposes. Reach 1 begins at the western end of the Bogue Banks project shoreline. All elevations for the current project in the main report and appendices reference NAVD 88.

Table ES-1

| Reaches | Length (ft) | Landward Dune Slope (X:1) | Max Dune Elevation (ft) | Dune Width (ft) | Seaward Dune Slope (X:1) | Berm Height (ft) | Berm Width (ft) | Berm Seaward Slope (X:1) |
|---|---|---|---|---|---|---|---|---|
| 4-10 | 4,876 | 4 | 16 | 95 | -4 | 5.5 | 50 | -15 |
| 11-15 | 5,633 | 4 | 15 | 45 | -4 | 7 | 50 | -15 |
| 16-21 | 6,891 | 4 | 20 | 10 | -4 | 7 | 50 | -15 |
| 22-92 | 82,053 | 4 | x | x | -4 | 7 | 50 | -15 |
| 93-110 | 15,274 | 4 | 18 | 40 | -4 | 5.5 | 50 | -15 |
| 111-117 | 4,943 | 4 | x | x | -4 | 5.5 | 50 | -15 |

The Recommended Plan is considered to be environmentally acceptable. Coordination with resource agency representatives was initiated early in the study and appropriate avoidance and minimization measures (i.e. environmental windows, beach placement activities, borrow site selection and use, etc.) were developed and integrated into project alternatives during the plan formulation process in order to reduce project impacts. These measures reduced significant direct impacts; however, incidental impacts were still documented with respect to specific species and their associated habitat requirements, including listed species such as piping plovers and sea turtles.

The analysis and design of the Recommended Plan contained in this report complies with the National Environmental Policy Act (NEPA). A separate Environmental Impact Statement (EIS) will not be provided because the document is a fully integrated report that complies with both NEPA requirements and USACE' water resources planning process and its requirements. A Biological Assessment of project impacts was prepared and informal Section 7 coordination successfully completed with the US Fish and Wildlife Service (FWS). The FWS and the National Marine Fisheries Service (NMFS) have been actively involved throughout the formulation of this project and provided comments on the draft report during public review. These agencies will have another formal opportunity to review and comment on the final report during the 30-day state and agency review period. USACE will obtain a Section 401 Water Quality Certification from the North Carolina Division of Water Resources (NCDWR) for the proposed project and will comply with its requirements. The project will also be in compliance with Section 404 of the Clean Water Act.

The estimated First Cost of the Recommended Plan is $37,327,000 October 2014 price level, which would be cost-shared 65% Federal ($24,263,000) and 35% non-Federal ($13,064,000). Operations and maintenance costs are estimated at $75,000 a year and would be a 100% non-Federal responsibility. The project includes a 3 year renourishment cycle (16 total renourishments) with an estimated cost of $14,341,000 per renourishment. Renourishments would be cost-shared on a 50% Federal and 50% non-Federal basis. The benefit cost ratio is 2.45 to 1. The total cost for initial construction and the 16 renourishments is $266,783,000 ($37,327,000 for initial construction plus 229,456,000 for the 16 renourishments).

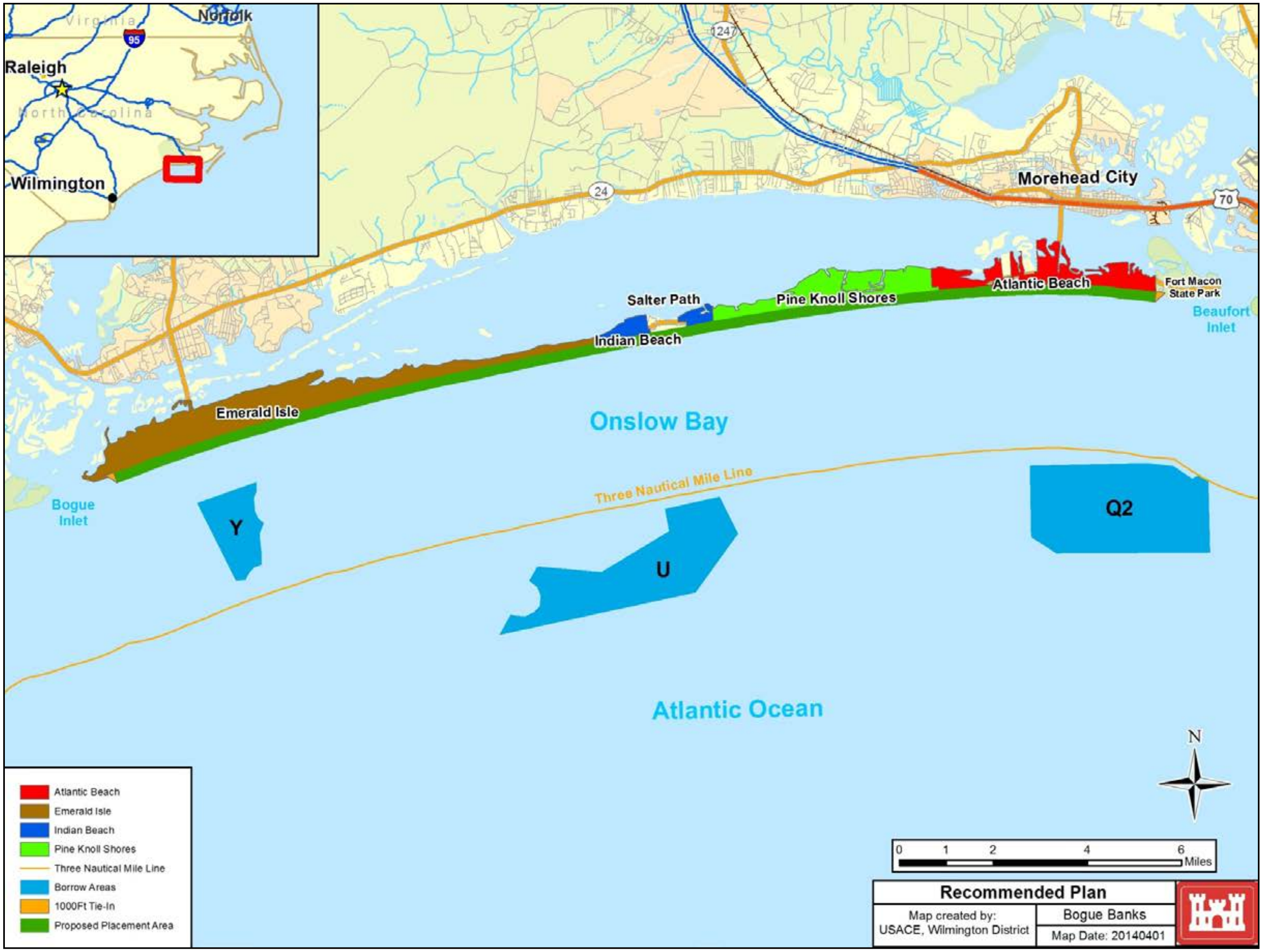


Figure ES-1. Recommended Plan

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Integrated NEPA/Feasibility Report chapters are denoted with a "*"

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# List of Acronyms and Abbreviations

| | |
|---|---|
| AA | Average Annual |
| AIWW | Atlantic Intracoastal Waterway |
| ASA-CW | Assistant Secretary of the Army - Civil Works |
| BBR | Bogue Banks Restoration Project |
| BCR | Benefit Cost Ratio |
| BOEM | Bureau of Ocean Energy Management |
| CBRA | Coastal Barrier Resources Act |
| CBRS | Coastal Barrier Resources System |
| CEM | Corps of Engineers manual |
| CEQ | Council on Environmental Quality |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CHETN | Coastal and Hydraulics Engineering Technical Notes |
| CSDR | Coastal Storm Damage Reduction |
| cy | cubic yards |
| CZMA | Coastal Zone Management Act |
| CZMP | Coastal Zone Management Program |
| DCAR | Draft Coordination Act Report |
| DEIS | Draft Environmental Impact Statement |
| EC | Engineer Circular |
| EIS | Environmental Impact Statement |
| EQ | Environmental Quality |
| ER | Engineer Regulation |
| FEMA | Federal Emergency Management Agency |
| ft | feet |
| FY | Fiscal Year |
| HAPC | Habitat Areas of Particular Concern |
| LERRD | Lands, Easements, Rights-of-Way, and Relocations |
| LPP | Locally Preferred Plan |
| MAFMC | Mid-Atlantic Fisher Management Council |
| MLW | mean low water |
| NC | North Carolina |
| NED | National Economic Developmen |
| NEPA | National Environmental Policy Act |
| NMFS | National Marine Fishery Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NTU | Nephelometric Turbidity Unit |
| O&M | Operations and Maintenance |
| OCS | Outer Continental Shelf |
| ODMDS | Offshore Dredged Material Disposal Site |
| OMRR&R | Operation, maintenance, repair, replacement, and rehabilitation |
| OSE | Other Social Effects |
| PED | Preconstruction Engineering and Design |
| PPA | Project Partnership Agreement |
| RED | Regional Economic Development |
| RSDs | Ripple Scour Depressions |
| SAD | South Atlantic Division |
| SAFMC | South Atlantic Fishery Management Council |
| SARBO | Sout Atlantic Regional Biological Opinion |
| SAW | South Atlantic - Wilmington |
| SBEACH | Storm-induced BEAch Change |
| TCM | Travel Cost Method |
| TSP | Tentatively Selected Plan |
| USACE | US Army Corps of Engineers |
| USFWS | US Fish and Wildlife Service |
| WRDA | Water Resource Development Act |
| yr | year |

# INTEGRATED FEASIBILITY REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

# COASTAL STORM DAMAGE REDUCTION

# BOGUE BANKS, CARTERET COUNTY

# NORTH CAROLINA

## 1. STUDY OVERVIEW*

This Integrated Feasibility Report and Final Environmental Impact Statement examine the feasibility and Federal interest in a project providing coastal storm damage reduction along Bogue Banks, in Carteret County, North Carolina. Bogue Banks consists of a barrier island about 25 miles long located on North Carolina's central coast, about 95 miles north of the city of Wilmington, North Carolina. Carteret County is the non-Federal sponsor of this study, which was conducted as a 50-50 cost-shared effort between Carteret County and the US Army Corps of Engineers, Wilmington District. The location of the study area is shown in Figure 1.1.

### 1.01 Report Organization

This report is an integrated Feasibility Report and Final Environmental Impact Statement (EIS), containing elements that are required for both a U.S. Army Corps of Engineers (USACE) Feasibility Report as well as a Final EIS per the National Environmental Policy Act (NEPA). Sections which integrate both NEPA and Feasibility Report elements and requirements are denoted with an asterisk ("*") at the end of the section title. Section 2* contains background information on the environment that could be affected by a USACE project resulting from the study. Section 3* discusses the primary coastal storm damage problems and opportunities at Bogue Banks. Section 4* details the existing and future without project conditions of the study area. Section 5* describes the development and comparison of alternative plans, including the no action plan, and the identification of the Recommended Plan. Section 6* is a detailed description of the Recommended Plan. Section 7* describes the effects the Recommended Plan would have on significant environmental resources in the area. Section 8 contains information on plan implementation such as schedule, project cost, and implementation cost-sharing. Section 9* lists the study's compliance with all applicable environmental laws and Executive Orders. Section 10* is a summary of agency and public involvement that has been undertaken throughout the course of the study. Sections 11, 12, 13*, 14*, and 15* contain, respectively, the report conclusions, recommendations, project point of contact, literature references, and list of report preparers. A number of supporting Appendices are also included as part of this report.

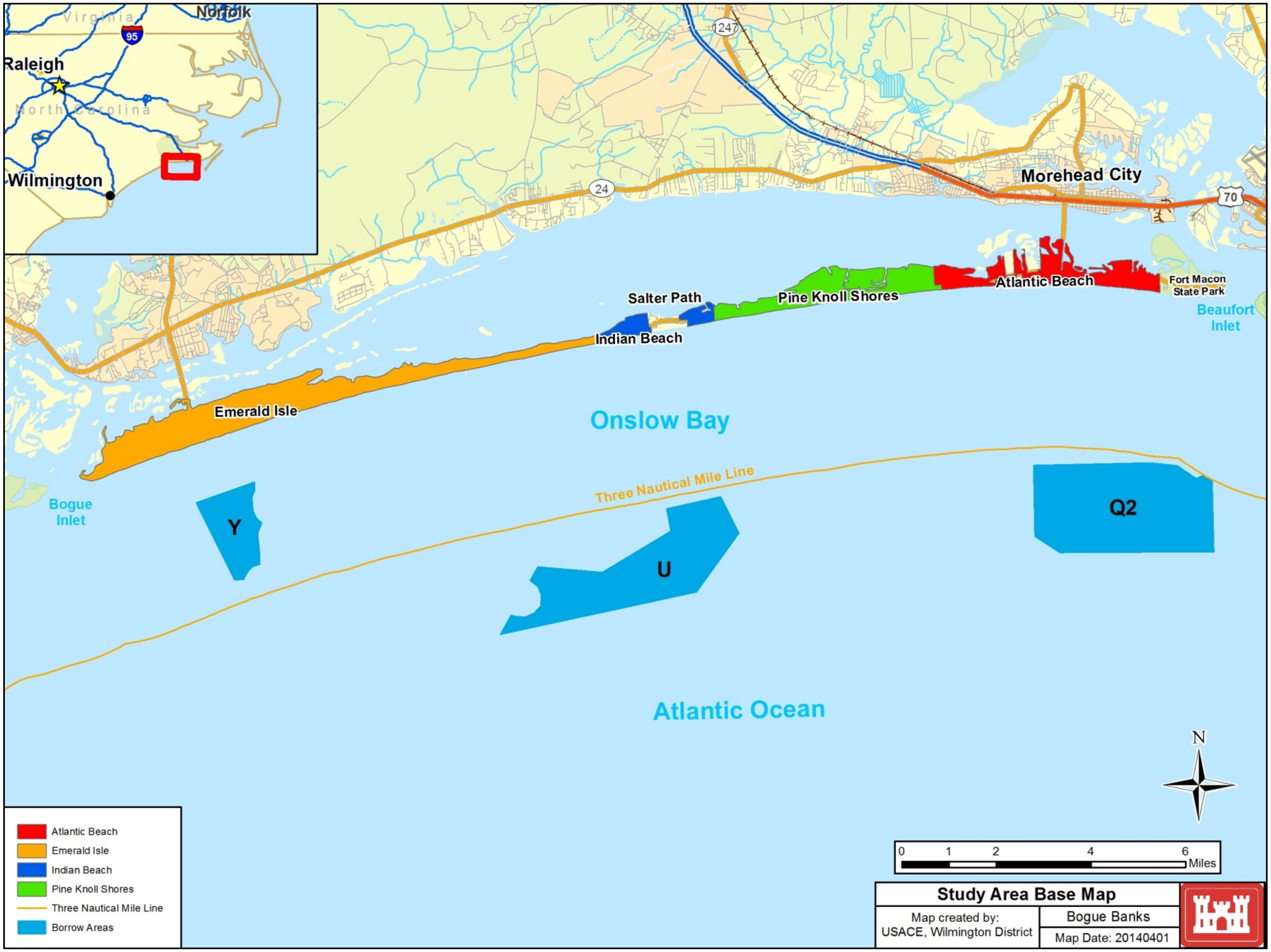



Figure 1.1. Bogue Banks Study Area Base Map, including potential offshore borrow locations (Y, U, and Q2).

## 1.02 Study Authority

Coastal Storm Damage Reduction (CSDR) for Bogue Banks was previously studied in a 1984 Chief of Engineers report. None of the analyzed coastal storm damage reduction plans were found to be economically feasible at that time. This current study was conducted pursuant to a subsequent congressional resolution issued in 1998. The authorizing resolution states:

> **RESOLUTION ADOPTED JULY 23, 1998 BY THE UNITED STATES HOUSE OF REPRESENTATIVES:**
> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers dated November 27, 1984, on Bogue Banks and Bogue Inlet, North Carolina, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of shore protection and related purposes for Bogue Banks, North Carolina.*

This feasibility study is partial response to the study authority and is being cost-shared 50/50 under a Feasibility Cost-sharing Agreement signed with the local project sponsor, Carteret County on February 8, 2001.

## 1.03 Study Area

The barrier island of Bogue Banks is located in Carteret County on North Carolina's central coast. The island faces the Atlantic Ocean on the south and extends approximately 25 miles from Bogue Inlet on the west to Beaufort Inlet on the east. Bogue Sound separates Bogue Banks from the mainland to the north. Communities on the island, from west to east include Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach. To the east of Atlantic Beach is Fort Macon State Park. The island is, on average, approximately one half mile wide.

Over the past 35 years Bogue Banks has developed rapidly as a tourist-oriented ocean resort community for outdoor recreation, fishing, and entertainment. Land use is primarily recreational, residential and commercial properties, with the highest density along the oceanfront and Bogue Sound. Based on the 2010 census, the permanent, off season population is about 6,600 residents, but increases vastly in the summer. During the summer months a large portion of the homes within the study area are available as summer rentals to vacationers primarily from inland North Carolina and other locations around the Eastern United States. Tourist-associated income is critical to the region's economic vitality and growth. With the exception of some higher elevation areas, the entire island is subject to hurricane storm surge flooding.

The study area extends from Bogue Inlet at the west end to Atlantic Beach on the east end, approximately 22.7 miles. For the coastal engineering analysis the study area extends another 2 miles eastward through Fort Macon and Beaufort Inlet, although this area is not being considered for coastal storm damage reduction measures. From the ocean shoreline the study area extends landward approximately 500 feet to encompass the first three rows of development. Seaward the study area extends from the shoreline approximately 1 mile. The study area also includes three offshore borrow sites lying 1 to 5 miles from the shoreline (shown in Figure 1.1). One of these sites (Q2) includes a portion of the Morehead City Ocean Dredged Material Disposal Site (ODMDS). The borrow area within the three mile limit line indicated on Figure 1.1 is within the jurisdiction of the State of NC and the ones offshore of the three mile limit are within the jurisdiction of the Bureau of Ocean Energy Management (BOEM). See Sections 1.07 and 10.02 regarding BOEM's involvement in this study.

## 1.04 Purpose and Need for Action

The purpose and need for coastal storm damage reduction along Bogue Banks is the reduction in storm damages and land loss resulting from beach erosion, wave attack, and flooding along the ocean shoreline. A wide variety of possible measures would reduce the impacts of erosion, waves, and flooding on commercial and residential property and infrastructure within the study area. Some of the measures would also provide incidental environmental and recreational benefits.

## 1.05 Scope of Study

This study consists of the problem identification and plan formulation addressing coastal storm damage reduction issues along Bogue Banks. As mentioned above all but the final two miles of island shoreline are included within the scope of this analysis. This study provides the analysis of measures and plans determining whether there is a Federal interest in project participation, and, if so, the identification of the NED plan with the highest net benefits to the Nation.

## 1.06 Study Process

U.S. Army Corps of Engineers (USACE) studies for water and related land resources follow detailed guidance provided in the *Planning Guidance Notebook* (Engineer Regulation 1105-2-100). This guidance is based on the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* that were developed pursuant to Section 103 of the Water Resources Planning Act (P.L. 89-80) and Executive Order 11747, which were approved by the U.S. Water Resources Council in 1982 and by the President in 1983. A defined six-step process is used to identify and respond to problems and opportunities associated with the Federal objective and specific State and local concerns. The six steps are as follows:

Step 1: Identify Problems and Opportunities
Step 2: Inventory and Forecast Conditions
Step 3: Formulate Alternative Plans
Step 4: Evaluate Alternative Plans
Step 5: Compare Alternative Plans
Step 6: Select Recommended Plan

The process involves an orderly and systematic approach to making evaluations and decisions at each step so that the public and the decision makers can be informed of basic assumptions made, the data and information analyzed, risk and uncertainty, the reasons and rationales used as decision making criteria, and the effectiveness and impacts of each alternative plan. Subject to positive economic justification, this process concludes with the selection of a Recommended Plan. Specific aspects of this planning process are described in more detail in other sections of this document.

## 1.07 Cooperating Agencies

Pursuant to Section 1501.6 of the Council on Environmental Quality (CEQ) NEPA Regulations 40 C.F.R. §1501.6, eligible Federal, State, and local agencies, along with stakeholders interested in or affected by the Federal agency decision on this project have been invited to participate on the study as a cooperating agency. The Bureau of Ocean Energy Management (BOEM) is the only agency which has agreed to participate as a Cooperating Agency during the preparation of the Integrated Feasibility Report and Environmental Impact Statement. BOEM has assisted and will continue to assist in developing information and preparing environmental analyses in areas in which the BOEM has special expertise. This assistance enhances the interdisciplinary capability of the study team. See Section 10.02 for more information about BOEM's involvement is this study.

## 1.08 Prior Studies and Reports

The USACE has conducted a number of prior studies in the Bogue Banks vicinity and has prepared a number of related engineering, planning, and environmental reports. These studies have addressed coastal storm damage reduction as well as navigation needs. Reports particularly pertinent to the present study are briefly described below.
Positive project recommendations contained within these reports were all eventually implemented.

- U.S. Army Corps of Engineers, Chief of Engineers. 1984. Bogue Banks and Bogue Inlet, North Carolina. This report concluded that all plans evaluated for beach erosion control and hurricane protection along Bogue Banks were not economically feasible, and recommended that no further studies be made at that time.

- U.S. Army Corps of Engineers, Wilmington District. 1990. Feasibility Report and Environmental Assessment, Morehead City Harbor Improvement, Morehead City, North Carolina. Revised December 1990.

- U.S. Army Corps of Engineers, Chief of Engineers. 1991. Morehead City Harbor, North Carolina. This report presents the results of investigations for deepening this navigation project to 45 feet Mean Low Water (MLW).

- U.S. Army Corps of Engineers, Wilmington District. 1991. Environmental Assessment and Finding of No Significant Impact, Maintenance Dredging of the Morehead City Harbor Project (Outer Harbor Segment), by Ocean-Certified Hydraulic Pipeline, Bucket and Barge, or Hopper Dredge with Beach Disposal or Ocean Dumping, Carteret County, North Carolina. This report addressed the environmental consequences of expanding the range of dredging methods to include ocean-certified hydraulic pipeline dredge, ocean-certified bucket and barge dredge, and hopper dredge with direct pumpout capability for performing routine maintenance of the Morehead City outer harbor channels at Range A, the Cutoff Channel, and Range B. Areas for placement of dredged material included the Ocean Dredged Material Disposal Site (ODMDS) and the ocean beach at Bogue Banks. Environmental impacts were determined as not significant.

- U.S. Army Corps of Engineers, Wilmington District. 1992. Environmental Assessment and Finding of No Significant Impact, Design Memorandum, Morehead City Harbor Improvement, Morehead City, North Carolina, Project Modifications.

- U.S. Army Corps of Engineers, Wilmington District. 1993. Environmental Assessment and Finding of No Significant Impact, Disposal of Dredged Material on the Ocean Beach of Bogue Banks from the Combined Maintenance Dredging and Deepening of Morehead City Harbor Inner Harbor Navigation Channels and Pumpout of Brandt Island Upland Diked Disposal Site, Carteret County, North Carolina.

- U.S. Army Corps of Engineers, Wilmington District. 1994. Environmental Assessment, Designation and Use of a Placement Area for Underwater Nearshore Berm, Morehead City Harbor Project, Morehead City, North Carolina. (and FONSI, 1994).

- U.S. Army Corps of Engineers, Wilmington District. 1997. Environmental Assessment and Finding of No Significant Impact, Advanced Maintenance Dredging (Range B), Morehead City Harbor, Carteret County, North Carolina. This report addressed the construction and maintenance of a widener 50 feet wide and 3,400 feet long at the western edge of Range B to help alleviate shoaling of the channel that sometimes occurs between scheduled maintenance dredging events. Environmental impacts were determined not significant.

- U.S. Army Corps of Engineers, Wilmington District. 2001. Morehead City Harbor (Pine Knoll Shores), North Carolina; Section 111 Feasibility Report. This study investigated the potential impacts of the Morehead City Harbor navigation project on nearby ocean shorelines between Barden Inlet and Bogue Inlet, and in particular the shoreline of Pine Knoll Shores. The study found no direct evidence that the harbor project has had a negative impact on any of the shorelines in the vicinity, including Pine Knoll Shores. However, the report suggested that alternative sand management practices in conjunction with harbor maintenance may be beneficial with regard to long-term stability of the shoreline.

- U.S. Army Corps of Engineers, Wilmington District. 2003. Morehead City Harbor, Carteret County, North Carolina; Section 933 Evaluation Report and Environmental Assessment. This report presented the results of investigations for the beneficial placement of beach fill to be obtained by maintenance dredging of the Morehead City Harbor navigation project and by recycling previously dredged material from the adjacent Brandt Island confined disposal area. The study recommended placement of this material in a 30-foot-wide berm along 38,000 linear feet of Bogue Banks beaches at Pine Knoll Shores, Indian Beach, and Salter Path. This berm would tie into the existing Federal base disposal area that extends along 32,000 linear feet of beach at Fort Macon State Park and Atlantic Beach.

- U.S. Army Corps of Engineers, Wilmington District. 2013. Morehead City Harbor, Morehead City, NC, Draft Integrated Dredged Material Management Plan (DMMP) and Environmental Impact Statement. A DMMP is required for all federal harbor projects where there is an indication of insufficient disposal capacity to accommodate maintenance dredging for the next 20 years.

Listed below are other recent reports prepared by the Wilmington District for studies in nearby areas.

- 1975 Final Environmental Impact Statement, Maintenance of the Atlantic Intracoastal Waterway, North Carolina.

- 1976 Final Environmental Impact Statement, Maintenance of the Atlantic Intracoastal Waterway Side Channels, North Carolina.

- 1983 Bogue Inlet, North Carolina, Section 107 Detailed Project Report and Environmental Impact Statement.

- 1988 Environmental Assessment and Finding of No Significant Impact for Maintenance Dredging of the Channel to Bogue Inlet, Atlantic Intracoastal Waterway (AIWW) Side Channel and the Bogue Inlet Crossing of the AIWW Section I, Tangent G), Carteret and Onslow Counties, North Carolina.

- 1997 Environmental Assessment, Channel Wideners at Inlet Crossings, Atlantic Intracoastal Waterway (AIWW), North Carolina.

## 1.09 Existing Federal and Non-Federal Projects

**Federal Projects:** Federal projects in the vicinity of Bogue Banks include several navigation projects, which are listed and briefly described below.

- **Fort Macon State Park:** The State park is located on Bogue Banks on the west side of Beaufort Inlet. The park is protected from erosion by a project that includes 7,750 feet of beach berm with a top elevation of 8 feet and a crown width of 100 feet, a stone revetment with a top elevation of 12 feet and length of 250 feet at Fort Macon Point, a stone-masonry wall with a top elevation of 12 feet and a length of 530 feet at Fort Macon Point, and a stone groin with a top elevation of 9 feet and a length of about 1,670 feet extending seaward from Forth Macon Point approximately parallel to the channel in Beaufort Inlet. The hard structural features were constructed by USACE over a number of years in the 1960's.

- **Morehead City Section 933:** From 2004-2007, approximately 3.2 million cubic yards (cy) of maintenance material dredged from Morehead City Harbor was placed in various locations in Bogue Banks as part of the Section 933 project.

**Non-Federal Projects:** The Bogue Banks Restoration (BBR) Project was implemented by Carteret County as an interim measure, to coincide with placement of material associated with Morehead City Harbor dredging, until a full USACE Coastal Storm Damage Reduction project could be implemented. The BBR project was implemented in 3 phases and placed approximately 4.3 million cy of material along the island from 2001-2005.

Together, the Morehead City Section 933, Morehead City Harbor Maintenance, and non-Federal Bogue Banks Restoration Project constituted the Carteret County Shore Beach Preservation Plan. The purpose of the plan was to provide short-term, interim storm damage reduction until a long term project can be instituted. Uncertainties related to funding, timing of construction, and project scope result in unpredictable and unreliable effectiveness relative to coastal storm damage reduction.

**Disposal of Dredged Material**: A summary of the volume and location of material historically placed from various projects along Bogue Banks is shown in Figure 1.2. Historically, the disposal of dredged material from area navigation channels has intermittently occurred at the west and east ends of the Bogue Banks shoreline. It should be noted that the purposes of these actions is beneficial use of dredged material, not coastal storm damage reduction. Disposal activities near Bogue Inlet (at the west end) are indicated in red on Figure 1.2 and involved disposal of material from the Bogue Inlet AIWW crossing. Disposal activities near Beaufort Inlet (at the east end) are indicated in yellow and orange on Figure 1.2, and involve disposal of material from Morehead City inner harbor maintenance material and Brandt Island pump out. These navigation- related disposal activities could occur in the future however, given funding uncertainties and the uncertainties related to any specific determination of disposal locations, these potential future events are not included as an element of the Future Without Project Condition in this feasibility study.

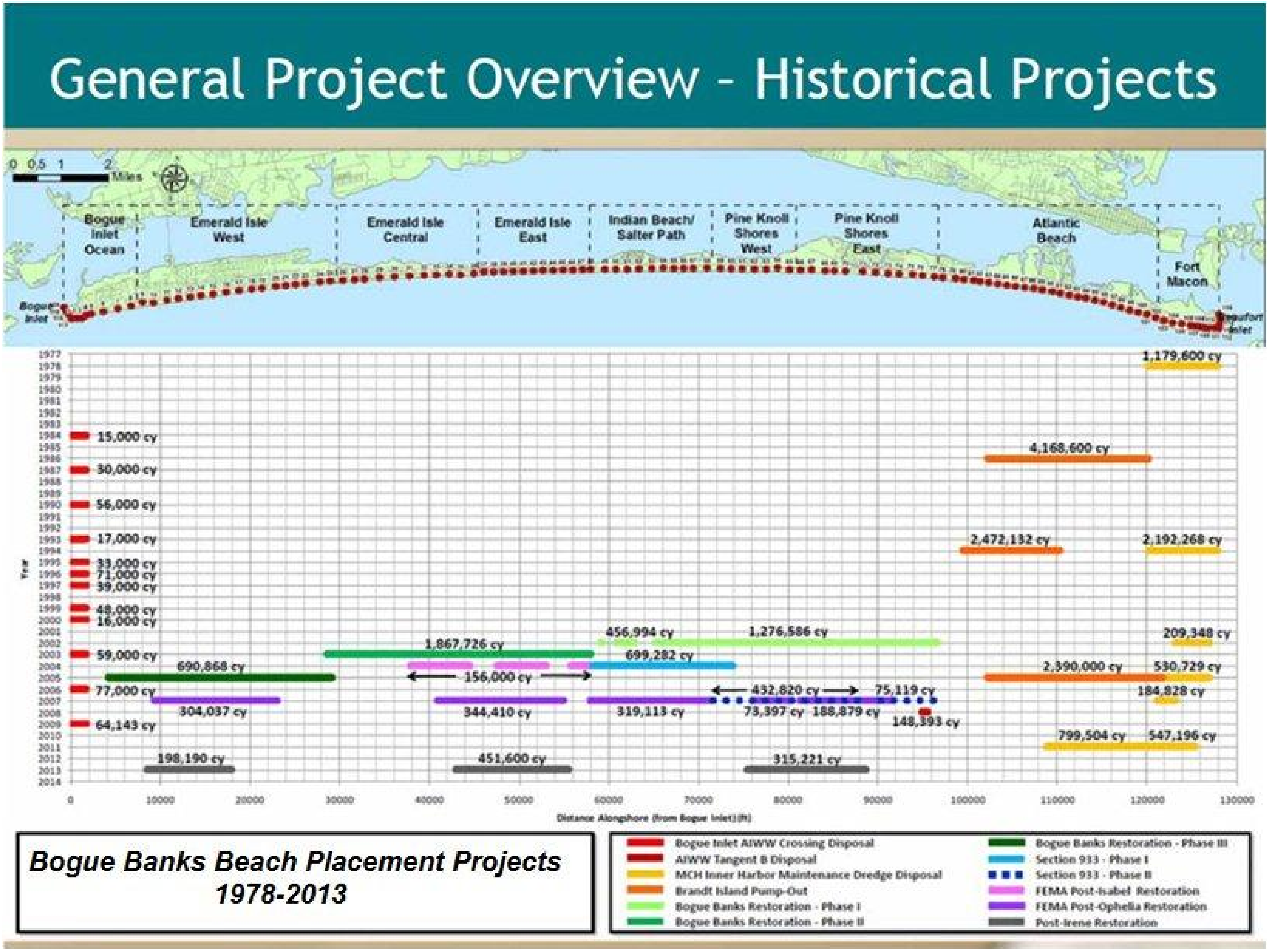



Figure 1.2. Historical placement of material on Bogue Banks Shoreline, 1978-2013.

The restoration project nourishments within the center portion of the study are as shown in Figure 1.2 include the one-time Bogue Banks nourishment project, and post-hurricane emergency stabilization and restoration efforts.

Carteret County is currently in the planning stages of a response plan that would serve as a contingency plan in the event that Federal participation is either not supported or not funded and their coastal storm damage issues become critical. County officials have indicated that these efforts are indeed fallback plans in the event that storm or hurricane damage is incurred. Accordingly, these plans are not considered to indicate a questionable need or commitment on the part of the non-Federal sponsor for a Federal project.

**Federal Navigation Projects:** Federal navigation projects in the area are indicated below.

- **Atlantic Intracoastal Waterway (AIWW):** The AIWW provides an important inland navigation route from Norfolk, Virginia, to the St. Johns River, Florida. In the study area, the AIWW is located north of the barrier islands. The 308-mile-long North Carolina portion is the State's only north-south commercial navigation thoroughfare. The authorized project includes a navigation channel with a depth of 12 ft. and widths varying from 90 ft. in land cuts to 300 ft. in open waters; side channels and basins at a number of locations; and five highway bridges. The main channel of the AIWW in North Carolina was completed in 1940, and it has since been maintained by dredging to remove shoals that develop. Some of the dredged material removed during maintenance activities is beach-quality sand. That material is placed directly on nearby ocean beaches when consistent with USACE regulations; otherwise, it is stockpiled in confined disposal areas near the shoreline of the AIWW. USACE also maintains 2 nearby side channels of the AIWW – Peletier Creek and Swansboro Creek, although these are infrequently dredged.

- **Morehead City Harbor:** The harbor is one of North Carolina's two deep-draft ports. The current Federal authorization consists of both deep draft and shallow draft portions. The deep draft portion consists of an entrance channel (Range A) 47 feet deep at mean low water (MLW) and 450 feet wide from the Atlantic Ocean through the ocean bar of Beaufort Inlet; then the Cutoff Channel, which is 45 feet deep by 400 feet wide; then the Connecting Channels (Ranges B and C), which are 45 feet deep by 400 feet wide; then the East Leg and Turning Basin, which are 45 feet deep, and the West Leg and Northwest Leg, which are 35 feet deep. The shallow draft portion extends from the Northwest Leg to the AIWW in Bogue Sound and consists of a 12 feet deep by 100 feet wide Entrance Channel, a 12 feet deep by 200-400 feet wide Waterfront Channel, and a 6 feet deep by 75 feet wide Bogue Sound Channel. Since 1978, about 9 million cy of material dredged during harbor maintenance has been placed on the eastern end of the island.

- **Beaufort Harbor**: This harbor's entrance channel, known as Bulkhead Channel, connects with Morehead City Harbor at Range B. Features include a channel 15 feet deep and 100 feet wide in Bulkhead and Gallants Channels; a channel 15 feet deep and 100 feet wide through a basin 12 feet deep and 600 feet wide in front of the Town of Beaufort and continuing through Taylors Creek to a point 3 miles east of Beaufort; a channel 12 feet deep and 150 feet wide to a basin 400 feet wide and 900 feet long in Town Creek; and a channel 14 feet deep and 70 feet wide extending from Bulkhead Channel up Morgan Creek 1,900 feet to a turning basin 14 feet deep, 150 feet wide, and 300 feet long. The project also includes a stone bulkhead from Town Marsh across Bird Shoal to the west end of Carrot Island, as well as jetties and sand fences at Fort Macon and Shackleford Point, and other shore protection.

- **Bogue Inlet Channels**: Navigation needs through Bogue Inlet, located at the western end of Bogue Banks, are addressed by a channel 2.7 miles long, 6 feet deep, and 90 feet wide from the AIWW to the inlet gorge (Channel to Bogue Inlet project) and a channel 8 feet deep and 150 feet wide from the seaward side of the ocean bar to the inlet gorge (Channel through Bogue Inlet project). These two channels were constructed as modifications of the AIWW.

- **Atlantic Beach Channels**: Located in Bogue Sound opposite Morehead City and adjacent to Atlantic Beach, this project consists of a 2.8 miles of channels 6 feet deep and 50 feet wide. One channel extends from the AIWW to the marina east of Money Island and a second channel extends from the intersection of Money Island and Causeway Channels to the southern end of Causeway Channel.

# 2. AFFECTED ENVIRONMENT*

Bogue Banks is the longest island south of Cape Lookout. It is a 25 mile barrier island, stretching from Bogue Inlet to Beaufort Inlet in Carteret County. The barrier island, separated from the mainland by Bogue Sound, runs east to west, with the ocean beaches facing due south. Bogue Banks is developed and can be accessed by one of two bridges across Bogue Sound, either from Morehead City to Atlantic Beach, which is the more heavily traveled bridge, or from Cape Carteret to Emerald Isle. The State park/communities of Bogue Banks are (from east to west) Fort Macon State Park, Atlantic Beach, Pine Knoll Shores, Salter Path/Indian Beach, and Emerald Isle. Bogue Banks includes some hotels/motels but is dominated by private homes. Bogue Banks also contains areas of maritime forest. Stores and other commercial properties are limited to the five main communities. The footprint of the study area includes the marine environment offshore of Bogue Banks, the barrier island, and the sub-aerial terrestrial beach.

The existing conditions of significant resources found within the vicinity of the project area, in both the marine and terrestrial environment, are described below.

## 2.01 Physical Resources

### 2.01.1 Geology and Sediment

The project area is located in the lower Atlantic Coastal Plain Physiographic Province, along the central coast of North Carolina. More specifically, the project encompasses the Atlantic Ocean shoreline of the barrier island of Bogue Banks, which lies between Bogue Inlet at its western end and Beaufort Inlet at its eastern end. The project site encompasses erosive and depositional environments along the ocean shoreline of the barrier island that include nearshore littoral settings, two active coastal inlets, and the barrier island of Bogue Banks.

The prominent geographical feature of the region is Cape Lookout (see Figure 2.2), which is composed of a lobate sand body ranging up to 90 feet in thickness and covering an area of approximate 100 square miles. The western edge of the Cape Lookout shoal lies immediately east of the Morehead City Harbor entrance channel and the barrier island of Bogue Banks. Holocene age shoreface deposits underlie Bogue Banks, to the west of the channel. The barrier sands of the island are prograding seaward over these deposits at present. Bogue Sound, landward of this island, is underlain by back-barrier lagoonal sequence of sediments having a greater abundance of clays than Back Sound to the east. The entire sequence of barrier/back-barrier sediments in the area represents several transgressive/regressive ocean events that occurred during Pleistocene and Holocene time.

## 2.02 Water Resources

### 2.02.1 Water Quality

Bogue Sound is the body of shallow water to the north of Bogue Banks, separating the barrier island from the mainland of Carteret County. The Sound is bordered by Bogue Inlet and the White Oak River to the west and Beaufort Inlet and the Newport River to the east. The Atlantic Intracoastal Waterway (AIWW) traverses the northern portion of Bogue Sound in an east-west orientation. Salinity varies in the Sound, with the highest levels (about 34 ppt) closest to the two inlets where the tidal influence is strongest. The North Carolina Division of Water Resources (NC DWR) has designated Bogue Sound as having Outstanding Resource Waters (ORW) due to its high quality.

The Newport River watershed (subbasin 03-05-03) is located just east of the White Oak River which flows into the eastern end of Bogue Sound before entering the Atlantic Ocean near Morehead City. There are 74 stream miles, 34,445 estuarine acres and 25 miles of Atlantic coastline in this subbasin (NCDENR 2007).

Bogue Sound also provides diverse aquatic resources. Over 6100 acres of submerged aquatic vegetation (SAV) were located in the sound in 1993 (NOAA 2002). These beds have been designated as Essential Fish Habitat (EFH) by the South Atlantic Fishery Management Council (SAFMC) for their high value to blue crab (*Callinectes sapidus*), juvenile fish, and shrimp (*Penaeus* sp.). All five species of sea turtles found in North Carolina waters and the West Indian manatee (*Trichechus manatus*), all federally-protected species, may forage in Bogue Sound during warmer summer months. As herbivorous and/or omnivorous species, these aquatic species forage upon SAV beds for nourishment.

Bogue Sound is of moderate size for North Carolina (with a maximum fetch of about 23 miles), larger than any open-water sound to the south but covering less area than Albemarle or Pamlico Sounds to the north (which have maximum fetches of 30-70 miles). The southern portion of the sound along Bogue Banks contains several areas of sand shoals and *Spartina* spp. marsh. Shellfish beds and submerged aquatic vegetation (SAV) occur throughout the sound. Comparatively deeper waters allow navigational use and transport of larval stages of fishery resources.

Water quality standards are State regulations or rules that protect lakes, rivers, streams and other surface water bodies from pollution. These standards are used to determine if the designated uses of a water body are being protected. Those uses are defined by the classifications assigned to the water body. Surface Water Classifications are designations applied to surface water bodies, such as streams, rivers and lakes, which define the best uses to be protected within these waters (for example swimming, fishing, drinking water supply) and carry with them an associated set of water quality standards to protect those uses.

All surface waters in North Carolina are assigned a primary classification by the North Carolina Division of Water Resources (NCDWR) (15A NC Administrative Code 02B .0301 to .0317). Waters in the vicinity of the study area fall into three classifications. Waters of the Atlantic Ocean, Beaufort Inlet and parts of Bogue Inlet and Bogue Sound are classified as *SB* and are suitable for primary recreation, including frequent or organized swimming and all *SC* uses (secondary recreation such as fishing, boating, and other activities involving minimal skin contact, aquatic life propagation and survival, and wildlife). Stormwater controls are required under the Coastal Area Management Act (CAMA), and there are no categorical restrictions on discharges. Parts of Bogue Inlet and Bogue Sound meet the *SA HQW* classification and are suitable for shellfishing for marketing purposes as well as all *SB* and *SC* uses. All *SA* waters are *HQW* (High Quality Waters) by definition, and stormwater controls are required, and domestic discharges are prohibited.

If any waterbody does not meet the State designated use standards, it is considered impaired and is placed on the 303(d) list, as required under section 303(d) of the Clean Water Act of 1972. Atlantic Ocean waters are listed as impaired due to a mercury fish advisory. The 303(d) list is a list of Integrated Reporting Category 5 impaired waters. Integrated Reporting Categories, which are based on EPA guidance, represent varying levels of water quality standards attainment, ranging from Category 1, where monitored parameter(s) meets a water quality standard, to Category 5, where a pollutant impairs a waterbody and a Total Maximum Daily Load (TMDL) target is required.

North Carolina began monitoring the state's coastal recreational waters in 1997. To comply with the swimming water quality levels set by the EPA and the state, water test results have to fall below a set average as well as a single-sample level. The average is the geometric mean of five weekly samples taken within a 30- day period. The N.C. Recreational Water Quality Program's staff measure levels of enterococci bacteria in water samples and issue swimming advisories when those levels exceed established limits. The geometric mean cannot exceed 35 enterococci per 100 milliliters of water. Waters tested at the Boat Landing Tourist Center in Bogue Sound returned results of 10 or fewer Enterococci bacteria per 100mL of water spanning January 17 – September 20, 2012 with the lone exception of 31 Enterococci per 100mL of water recorded on July 26, 2012 (NCDMF, 2012).

There are 14 National Pollutant Discharge Elimination System (NPDES) sites in Carteret County. Two are classified as major: Morehead City's Waste Water Treatment Plant, which has a flow of 1.7 million gallons, and; the town of Beaufort's waste water treatment plant, which has a flow of 1.5 million gallons. The remaining 12 NPDES sites are all classified as minor.

2.02.1.1 Groundwater. Groundwater resources on Bogue Banks are present in an unconfined sand aquifer, an upper confined aquifer, and a lower confined aquifer. The unconfined aquifer (freshwater lens) in areas occupied by dunes will yield as much as 30 gallons per minute of freshwater to a horizontal well. In other parts of the seashore this aquifer is subject to periodic overwash from the ocean, thus temporarily contaminating it with saltwater. Some high dunes on Bogue Banks offer some protection from overwash to the unconfined aquifer. Any lowering of the water table will cause a rise of the saltwater/freshwater interface.

The lower confined aquifer, which occurs between depths of 150 and 550 feet, contains freshwater. Potential yield is estimated to be as much as 500 gallons per minute per well. The estimated freshwater yield from all aquifers depends on the position of the saltwater interface at any site. Water samples from the seashore generally meet drinking water standards set by the U.

S. Environmental Protection Agency although some samples contained excess concentrations of chloride, iron, and manganese. Excessive chloride in the area is indicative of the presence of saltwater. Excessive iron and manganese occur naturally in some groundwater and may also be dissolved from well casings or pumping equipment.

Groundwater is plentiful throughout the county. It is near the surface in most places, particularly during the winter and early spring. Thousands of feet of sedimentary deposits underlie the area. The upper part of these deposits contains aquifers that supply water for domestic use. The surficial aquifer ranges from near the surface to a maximum depth of 75 feet. It is thickest east of Morehead City. Early in the development of the county, the main source of domestic water was from shallow wells in this aquifer. The use of shallow wells has decreased considerably because of the small yield in some places, the high content of dissolved iron in the water, and the risk of contamination. The underlying limestone of the Yorktown or Castle Hayne Formations, or both, is a more productive artesian aquifer and is the main source of water supply in the county today. The water is generally hard, but low in iron. Water from wells near the coast and especially on the Outer Banks may be salty, but layers of fresh groundwater can be found at lower depths

## 2.03 Air Quality

The Wilmington Regional Office of the North Carolina Department of Environment and Natural Resources has air quality jurisdiction for the project area. The ambient air quality for Carteret County has been determined to be in compliance with the National Ambient Air Quality Standards, and this county is designated as an attainment area (Personal Communication, Brad Newland, Engineer, NC Division of Air Quality, 26 November 10).

The State of North Carolina does have a State Implementation Plan ("SIP") approved or promulgated under Section 110 of the Clean Air Act, as amended.

## 2.04 Marine Resources

A description of marine environments that accurately represents current conditions is reflected in the US Fish and Wildlife Service (FWS) *Draft Fish and Wildlife Coordination Act Report, Bogue Banks Shore Protection Project, Carteret County, NC*, November 2002 (USFWS 2002) which states:

> *"…. The Cape Lookout area is more diverse than most marine areas along the U.S. Atlantic coast due to the mixing of the Gulf Stream from the south with the Labrador Current from the north. As a result of this oceanographic mixing, the marine flora and fauna are a mixture of cold-water and warm-water species. Highly migratory aquatic species such as whales and recreationally important finfish are common. Seabirds from the Arctic and the tropics co-mingle, with the unique east-west orientation of Bogue and Shackleford Banks often providing the first or last landfall for north-south migrating birds."*

### 2.04.1 Nekton

Nekton collectively refers to aquatic organisms capable of controlling their location through active movement rather than depending upon water currents or gravity for passive movement. Nekton of the nearshore Atlantic Ocean along Bogue Banks, North Carolina can be grouped into three categories: estuarine dependent species; permanent resident species; and seasonal migrant species. The most abundant nekton of these waters are the estuarine dependent species which inhabit the estuary as larvae and the ocean as juveniles or adults. This group includes species which spawn offshore, such as the Atlantic croaker (*Micropogon undulatus*), spot (*Leiostomus xanthurus*), Atlantic menhaden (*Brevoortia tyrannus*), star drum (*Stellifer lanceolatus*), southern kingfish (*Menticirrhus americanus*), flounders (*Paralichthys* spp.), mullets (*Mugil* spp.), anchovies (*Anchoa* spp.), blue crab (*Callinectes sapidus*), and penaeid shrimp (*Penaeus* spp.), as well as species which spawn in the estuary, such as red drum (*Sciaenops ocellatus*) and weakfish (*Cynoscion regalis*). Species which are permanent residents of the nearshore marine waters include the black sea bass (*Centropristis striata*), longspine porgy (*Stenotomus caprinus*), Atlantic bumper (*Chloroscombrus chrysurus*), inshore lizardfish (*Synodus foetens*), and sea robins (*Prionotus* spp.). Common warm water migrant species include the bluefish (*Pomatomus saltatrix*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*Scomberomorus cavalla*), cobia (*Rachycentron canadum*), Florida pompano (*Trachinotus carolinus*), and spiny dogfish (*Squalus acanthias*).

### 2.04.2 Nearshore Ocean

The following is taken from the North Carolina Coastal Habitat Protection Plan (Deaton et al. 2010).

Offshore sand bottom communities along the North Carolina coast are relatively diverse habitats containing over a hundred polychaete taxa (Lindquist et al. 1994; Posey and Ambrose 1994). Tube dwellers and permanent burrow dwellers are important benthic prey for fish and epibenthic invertebrates. These species are also most susceptible to sediment deposition, turbidity, erosion, or changes in sediment structure associated with sand mining activities, compared to other more mobile polychaetes (Hackney et al. 1996). In South Carolina, 243 species of benthic invertebrates were documented in the nearshore subtidal bottom (Van Dolah et al. 1994). Polychaetes and amphipods were the most abundant, although oligochaetes, bivalves, and crabs were also highly represented (Van Dolah et al. 1994). On ebb tide deltas, polychaetes, crustaceans (primarily amphipods), and mollusks (primarily bivalves) were the most abundant infauna, while decapod crustaceans and echinoderms (sand dollars) dominated the epifauna. Because periodic storms can affect benthic communities along the Atlantic coast to a depth of about 115 ft (35 m), the soft bottom community tends to be dominated by opportunistic taxa that are adapted to recover relatively quickly from disturbance (Posey and Alphin 2001). Many faunal species documented on the ebb tide delta are important food sources for demersal predatory fishes and mobile crustaceans, including spot, croaker, weakfish, red drum, and penaeid shrimp. These fish species congregate in and around inlets during various times of the year (Peterson and Peterson 1979), presumably to enhance successful prey acquisition and reproduction.

Benthic communities approximately 2 miles inshore of the Morehead City ODMDS were sampled by Peterson and Wells (2000).The stations were arranged in a grid of three transects with three stations on each transect at the 19-, 26-, and 36-foot isobaths. Taxa in order of abundance included polychaetes, annelids, bivalve mollusks, amphipod crustaceans, echinoderms, and nematodes. The total density of infaunal invertebrates ranged from 5-14 per 76 $cm^2$ and total densities of larger epifaunal invertebrates ranged from 3 to 43 individuals per 10 $m^2$. This sampling is thought to be representative of those occupying this environment over a broad geographic area.

### 2.04.3 Surf Zone Fishes

The surf zone along the area beaches provides important fishery habitat on which some species are dependent. Surf zone fisheries are typically diverse, and 47 species have been identified from North Carolina; however, the actual species richness of fishes using the North Carolina surf area for at least part of their life history is much higher (Ross, 1996; Ross and Lancaster, 1996). According to Ross (1996), the most common species in the South Atlantic Bight surf zone are Atlantic menhaden (*Brevoortia tyrannus*), striped anchovy (*Anchoa hepsetus*), bay anchovy (*A. mitchilli*), rough silverside (*Membras martinica*), Atlantic silverside (*Menidia menidia*), Florida pompano (*Trachinotus carolinus*), spot (*Leiostomus xanthurus*), Gulf kingfish (*Menticirrhus littoralis*), and striped mullet (*Mugil cephalus*). Two species in particular, the Florida pompano and gulf kingfish (*M. littoralis*) seem to use the surf zone exclusively as a juvenile nursery area and are rarely found elsewhere. The major recruitment time for juvenile fishes to surf zone nurseries is late spring through early summer (Hackney et al., 1996). Recent studies by Ross and Lancaster (1996) indicate that the Florida pompano and gulf kingfish may have high site fidelity to small areas of the beach and extended residence time in the surf zone, suggesting its function as a nursery area. Major surf zone species consume a variety of benthic and planktonic invertebrates, with most of the prey coming from the water column. The dominant benthic prey are coquina clams; however, that is not the dominant food item throughout the South Atlantic Bight. Furthermore, many surf zone fishes exhibit prey switching in relation to prey availability, which could minimize potential adverse effects of beach nourishment (Ross, 1996).

### 2.04.4 Larval Fishes

Beaufort Inlet passes approximately 142,000,000 $m^3$ of water on spring tides (Jarret, 1976). Thus, Beaufort Inlet is an important passageway for the larvae of many species of commercially or ecologically important fish. Spawning grounds for many marine fishes are believed to occur on the continental shelf with immigration to estuaries during the juvenile stage. The shelter provided by the marsh and creek systems within the sound serves as nursery habitat where young fish undergo rapid growth before returning to the offshore environment. Transport from offshore shelves to estuarine nursery habitats occurs in three stages: offshore spawning grounds to nearshore, nearshore to the locality of an inlet or estuary mouth, and from the mouth into the estuary (Boehlert and Mundy, 1988). Hettler et al. (1997) documented, through analysis of larvae otoliths, that a large number of young *B. tyrannus* larvae averaging 55 days post hatch arrived in mid-March on the date of maximum observed daily concentration (160 larvae per 100 m3). For all species recorded in this study, abundance varied as much as an order of magnitude from night to night. The methods these larvae use to traverse large distances over the open ocean and find inlets are uncertain. Various studies have hypothesized such mechanisms as passive wind and depth-varying current dispersal and active horizontal swimming transport. However, little is known regarding larval distribution in the nearshore area.

During the winters of 1992-1993 and 1993-1994, Hettler and Hare (1998) conducted an experiment at Beaufort Inlet, North Carolina in order to further understand the estuarine ingress of offshore spawning species. A complex lateral structure in estuarine circulation, independent of the inlet opening size, was found in regards to larval concentration with significant interactions among inlet side, distance offshore, and date of ichthyoplankton tows. Length of species caught varied by cruise, inlet side, and distance offshore. The differences in larval concentration offshore and inshore and the species differences in length suggest species-specific rates controlling the net number of larvae entering the nearshore from offshore, the net number of larvae entering the inlet mouth from nearshore, and the larval mortality in the nearshore zone. Results from this study suggest two bottlenecks for offshore-spawning fishes with estuarine juveniles: the transport of larvae into the nearshore zone and the transport of larvae into the estuary from the nearshore zone (Hettler and Hare, 1998). Egg and larval transport from offshore spawning grounds to the inshore environment of Beaufort Inlet has been studied by Hettler and Hare (1998) in seven estuarine dependent species, including Atlantic menhaden (*Brevoortia tyrannus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), pinfish (*Lagodon rhomboides*), summer flounder (*Paralichthys dentatus*), southern flounder (*P. lethostigma*) and Gulf flounder *(P. albigutta*). Research conducted by the National Marine Fisheries Service (NMFS) Beaufort Laboratory through June 2002, collected a total of 120 species of larval fish fauna off the Beaufort Inlet and adjacent waters.

According to Hettler and Hare (1998), average weekly concentration (number per 100 $m^3$) for all of the above estuarine dependent species, with the exception of Gulf flounder, was calculated during the October 1994 to April 1995 immigration season. Concentrations were 22.9, 4.8, 25.7, 12.4, 0.3, and 0.8 larvae/100m3 respectively (Hettler et. al., 1998). According to the spring tide flow calculated by Jarret (1976) and calculated daily larval concentration, approximately 32.5, 6.8, 36.5, 17.6, 0.43, and 1.1 million larvae pass through the inlet during a single spring tide for each respective species. Concentrations for all species combined entering the inlet during a single tidal prism range from 0.5 to 5 larvae m-3. Therefore, daily calculated larval concentration for all species within the tidal prism ranges between 66 to 710 million (Personal Communication, Larry Settle, Fishery Biologist, NMFS, 27 June 2002).

### 2.04.5 Benthic Resources—Beach and Surf Zone

The intertidal zone of the beach shoreface is extremely dynamic and is characterized as the area from mean low tide landward to the high tide mark. The area serves as habitat for invertebrate communities adapted to the high-energy, sandy-beach environment. Important invertebrates of the surf zone and beach/dune community include the mole crab (*Emerita talpoida*), coquina clams (*Donax variabilis*), polychaete worms, amphipods, and ghost crabs (*Ocypode quadrata*). Mole crabs and coquinas represent the largest component of the total macrofaunal biomass of North Carolina intertidal beaches, and they are consumed in large numbers by important fish species such as flounders, pompanos, silversides, mullets, and kingfish (Reilly and Bellis 1978).

Beach intertidal macrofauna are also a seasonally important food source for numerous shorebird species.

Through studies supported by the FWS and the USACE, the distributions and abundance of these animals on Atlantic Coast beaches is fairly well documented. Extensive sampling of the intertidal and nearshore beach environment was performed and documented in the USACE', New York District's biological monitoring report titled, *Final Report for The Army Corps of Engineers New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Sea Bright to Manasquan Inlet, Beach Erosion Project* (USACE 2001a). Results of that study indicate that the intertidal infaunal assemblage was dominated by rhynchocoels; the polychaetes *Scolelepis squamata, Protodriloides (LPIL),* and *Microphthalmus* spp.; oligochaetes; the mole crab *E. talpoida*; and a number of haustoriid amphipods. The nearshore infaunal assemblage included many of the same taxa but was dominated by the wedge clam, *D. variabilis*, the polychaete *Magelona papillicornis*, the clams *Spisula solidissim*a and *Tellina agilis*, and the amphipods *Acanthohaustorius millsi* and *Psammonyx nobilis*, and the polychaete *Asabellides oculata*. Those documented infaunal assemblages are consistent with other studies throughout the Atlantic Coast (USACE 2001a). In North Carolina, including the project area, infaunal assemblages are dominated by *D. variabilis*, *D. parvula*, and *E. talpoida*, which function as an important first link in the flow of energy in the intertidal system (Leber 1982; Reilly and Bellis 1978). Other organisms occurring less frequently are Amphipods (*Haustorius canadensis, Talorchestia megalopthalma*, and *Amphiporia virginiana*) and Polychaetes (*S. squamata* and *Nephtys picta*) (Lindquist and Manning 2001; Nelson 1989; Leber 1982; Reilly and Bellis 1978).

### 2.04.6 Hardbottoms

Of special concern in the offshore area are hardbottoms, which are localized areas, not covered by unconsolidated sediments and where the ocean floor is hard rock. Hardbottoms are also called "live bottoms" because they support a rich diversity of invertebrates such as corals, anemones, and sponges, which are refuges for fish and other marine life. They provide valuable habitat for reef fish such as black sea bass, red porgy, and groupers. Hardbottoms are also attractive to pelagic species such as king mackerel, amberjack, and cobia. Along the North Carolina coast, hardbottoms are most abundant in southern portion of the State. Review of data provided by the Southeast Monitoring and Assessment Program (SEAMAP) and the results of surveys from Tidewater and Geo-Dynamics identified one area of hardbottom off Pine Knoll Shores, about 2 miles south of the project area.

A hardbottom description from the USFWS *Draft Fish and Wildlife Coordination Act Report, Bogue Banks Shore Protection Project, Carteret County, NC*, November 2002 (USFWS 2002) states:

> *"Bogue Banks serves as a transitional marine environment in another way as well – the seafloor offshore is dominated by hardbottoms to the west and softer sediment substrates to the east. Several studies have documented the hardbottom areas offshore…. The hardbottoms approach the beaches of Bogue Banks fairly closely, as evidenced by the fairly regular occurrence of coral and other encrusting organisms washing up on the beaches of the island…."*

Mapping of potential hardbottom areas in the nearshore zone is shown in Figure 2.1. Investigations by USACE of hardbottom resources in the area (USACE 2009) concluded that no hardbottom resources are present, based on four primary factors:

(1) A re-analysis and interpretation of sidescan sonar data concluded that no signatures indicative of hardbottom habitats existed in the survey area.

(2) Ground-truthing operations confirmed sidescan sonar interpretation of seafloor morphologies of interest.

(3) No hardbottom was found during ground-truthing operations.

(4) An analysis of historic beach profiles along Bogue Banks (Moffat and Nichol, 2008) does not suggest any rock outcrops along beach profiles.

Hardbottom surveys of the borrow areas were also conducted by USACE (2008). Borrow area Q2 does not contain hardbottoms. A small area (9 acres) of low relief hard bottom was identified in the western portion of Borrow Area U.
Areas of low relief hard bottom totaling about 22 acres were identified along the eastern side and within Borrow Area Y. Artificial reef material was also noted just outside the borrow areas to the south.

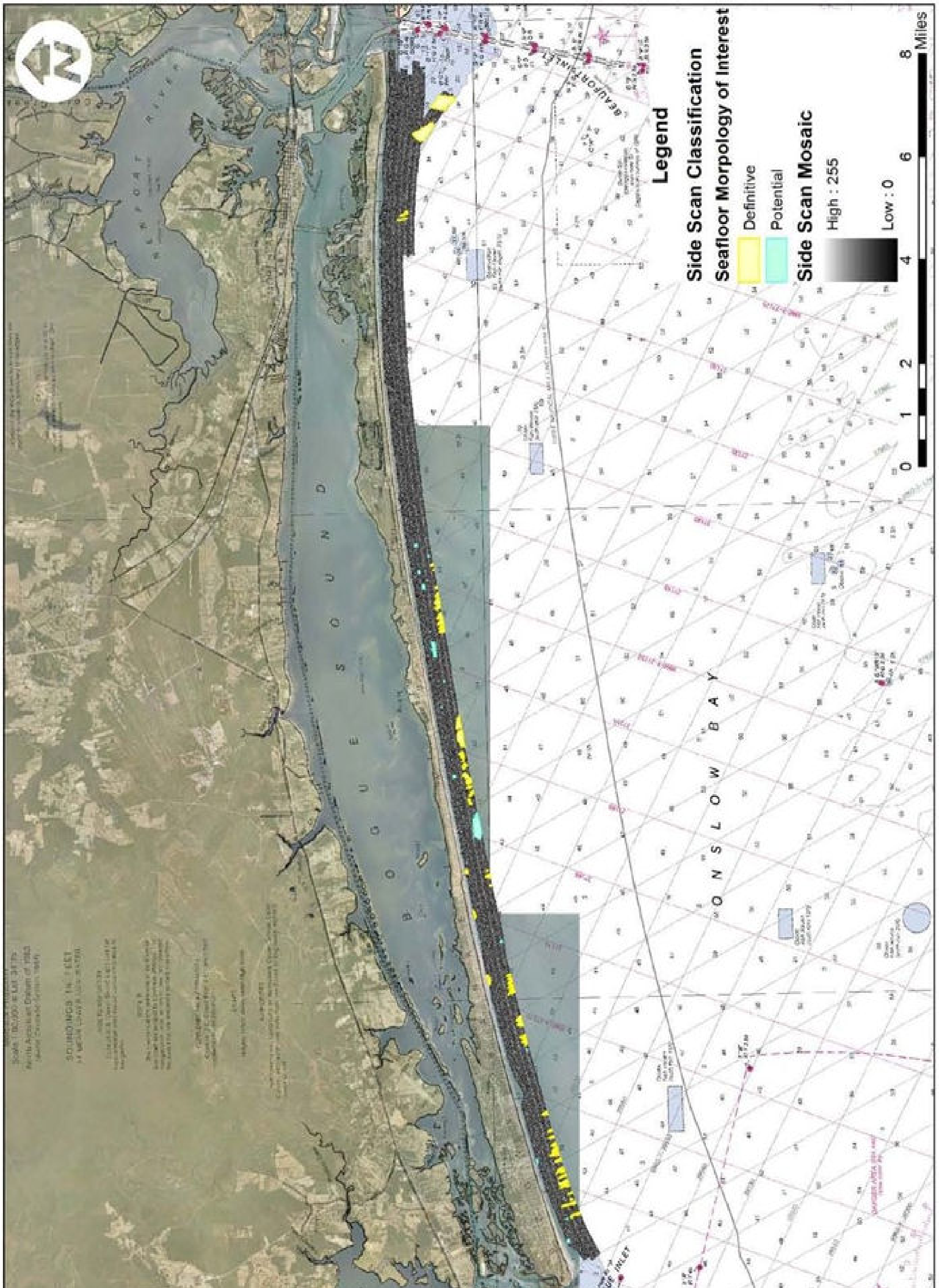



Figure 2.1 Mapping of potential hardbottom areas in the nearshore zone.

### 2.04.7 Essential Fish Habitat

The 1996 Congressional amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (PL 94-265) set forth new requirements for the National Marine Fisheries Service (NMFS), regional fishery management councils (FMC), and other Federal agencies to identify and protect important marine and anadromous fish habitat. These amendments established procedures for the identification of Essential Fish Habitat (EFH) and a requirement for interagency coordination to further the conservation of Federally managed fisheries. Table 2.1 shows the categories of EFH and Habitat Areas of Particular Concern (HAPC) for managed species which were identified in the Fishery Management Plan Amendments affecting the South Atlantic area. Table 2.2 lists the Federally managed fish species of North Carolina for which Fishery Management Plans have been developed by the South Atlantic Fishery Management Council (SAFMC), Mid-Atlantic Fishery Management Council (MAFMC), and National Marine Fisheries Service (NMFS).

### 2.04.8 Ambient and Anthropogenic Noise

Any harbor or open-water coastal environment has a number of underwater ambient noise sources such as commercial and recreational vessel traffic, dredges, wharf/dock construction (e.g., pile driving), natural sounds (e.g., storms, biological), etc. To better assess potential species effects (i.e., disturbance of communication among marine mammals) associated with dredge specific noise from navigation maintenance, deepening, or borrow area dredging operations, Clarke et al. (2002) performed underwater field investigations to characterize sounds emitted by bucket, hydraulic cutterhead, and hopper dredge operations. A summary of results from the study are presented below and are a first step toward developing a dredge sounds database that will encompass a range of dredge plant sizes and operational features.

**Cutterhead Suction Dredge**

Noise generated by a cutterhead suction dredge is continuous and muted and results from the cutterhead rotating within the bottom sediment and from the pumps used to transport the effluent to the placement area. The majority of the sound generated was from 70 to 1,000 hertz (Hz) and peaked at 100 to 110 decibel (dB) range. Although attenuation calculations were not completed, reported field observations indicate that the cutterhead suction dredge became almost inaudible at about 500 meters (Clarke et al. 2002).

**Hopper Dredge**

The noise generated from a hopper dredge is similar to a cutterhead suction dredge except there is no rotating cutterhead. The majority of the noise is generated from the dragarm sliding along the bottom, the pumps filling the hopper, and operation of the ship engine/propeller. Similar to the cutterhead suction dredge, most of the produced sound energy fell within the 70- to 1,000-Hz range, however peak pressure levels were at 120 to 140 dB (Clarke et al. 2002).

**Bucket Dredge**

Bucket dredges are relatively stationary and produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying. The noise generated from a mechanical dredge entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the closed bucket up through the water column, and emptying the bucket into an adjacent barge. On the basis of the data collected for this study, which included dredging of coarse sands and gravel, the maximum noise spike occurs when the bucket hits the bottom (120 dB peak amplitude). A reduction of 30 dB re 1 µPa/m occurred between the 150 m and 5,000 m listening stations with faintly audible sounds at 7 km. All other noises from the operation (i.e., winch motor, spuds) were relatively insignificant (Clarke et al. 2002)."

| ESSENTIAL FISH HABITAT | GEOGRAPHICALLY DEFINED HABITAT AREAS OF PARTICULAR CONCERN |
|---|---|
| **Estuarine Areas** | **Area - Wide** |
| Estuarine Emergent Wetlands | Council-designated Artificial Reef Special Management Zones |
| Estuarine Scrub / Shrub Mangroves | Hermatypic (reef-forming) Coral Habitat & Reefs |
| Submerged Aquatic Vegetation (SAV) | Hard Bottoms |
| Oyster Reefs & Shell Banks | Hoyt Hills |
| Intertidal Flats | *Sargassum* Habitat |
| Palustrine Emergent & Forested Wetlands | State-designated Areas of Importance of Managed Species |
| Aquatic Beds | Submerged Aquatic Vegetation |
| Estuarine Water Column[2] | |
| Seagrass | |
| Creeks | |
| Mud Bottom | |
| **Marine Areas** | **North Carolina** |
| Live / Hard Bottoms | Big Rock |
| Coral & Coral Reefs | Bogue Sound |
| Artificial / Manmade Reefs | Pamlico Sound at Hatteras / Ocracoke Islands |
| *Sargassum* | Capes Fear, Lookout, & Hatteras (sandy shoals) |
| Water Column[2] | New River |
| | The Ten Fathom Ledge |
| | The Point |

[1]Essential Fish Habitat areas are identified in Fishery Management Plan Amendments for the South Atlantic and Mid-Atlantic Fishery Management Councils. Geographically Defined Habitat Areas of Particular Concern are identified in Fishery Management Plan Amendments affecting the South Atlantic Area. Information in this table was derived from Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies. February 1999 (Revised 10/2001) (Appendices 4 and 5).
[2]EFH for species managed under NMFS Billfish and Highly Migratory Species generally falls within the marine and estuarine water column habitats designated by the Fishery Management Councils.

Table 2.1. Categories of Essential Fish Habitat and Habitat Areas of Particular Concern identified in Fishery Management Plan Amendments affecting the South Atlantic Area.[1, 2]

| E-EGGS<br>L-LARVAL<br>J-JUVENILE<br>A-ADULT<br>N/A-NOT FOUND | Beaufort Inlet | Bogue Sound | Bogue Inlet | Atlantic Ocean South of Cape Hatteras |
|---|---|---|---|---|
| **COASTAL DEMERSALS** | | | | |
| **Red Drum** | **E L J A** | **E L J A** | **E L J A** | **JA** |
| **Bluefish** | **J A** | **J A** | **J A** | **ELJA** |
| **Summer Flounder** | **L J A** | **L J A** | **L J A** | **ELJA** |
| **INVERTEBRATES** | | | | |
| **Brown Shrimp** | **E L J A** | **L J A** | **E L J A** | **ELJA** |
| **Pink Shrimp** | **E L J A** | **L J A** | **E L J A** | **ELJA** |
| **White Shrimp** | **E L J A** | **L J A** | **E L J A** | **ELJA** |
| **Calico Scallop** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **COASTAL PELAGICS** | | | | |
| **Dolphinfish** | **J A** | **N/A** | **J A** | **ELJA** |
| **Cobia** | **L J A** | **J A** | **L J A** | **ELJA** |
| **King Mackerel** | **J A** | **J A** | **J A** | **ELJA** |
| **Spanish Mackerel** | **L J A** | **L J A** | **L J A** | **ELJA** |
| **HIGHLY MIGRATORY** | | | | |
| **Bigeye Tuna** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **Bluefin Tuna** | **N/A** | **N/A** | **N/A** | **JA** |
| **Skipjack Tuna** | **N/A** | **N/A** | **N/A** | **JA** |
| **Yellowfin Tuna** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **Swordfish** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **Blue Marlin** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **White Marlin** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **Sailfish** | **N/A** | **N/A** | **N/A** | **ELJA** |
| **Little Tunny** | **N/A** | **N/A** | **N/A** | **ELJA** |
| SHARKS | | | | |
| Spiny Dogfish | J A | N/A | J A | JA |
| Smooth Dogfish | J A | J | J A | JA |
| Small Coastal Sharks | J A | J A | J A | JA |
| Large Coastal Sharks | J A | N/A | J A | JA |
| Pelagic Sharks | N/A | N/A | N/A | JA |
| Prohibited/Research Sharks | J A | N/A | J A | JA |
| SNAPPER/GROUPER | | | | |
| Black Sea Bass | L J A | L J A | L J A | ELJA |
| Bank Sea Bass | N/A | N/A | N/A | ELJA |
| Rock Sea Bass | J | J | J | ELJA |
| Gag | J A | J | J A | ELJA |
| Graysby | N/A | N/A | N/A | ELJA |

Table 2.2. Essential Fish Habitat (EFH) Species for Coastal NC (part 1 of 3).

| E-EGGS<br>L-LARVAL<br>J-JUVENILE<br>A-ADULT<br>N/A-NOT FOUND | Beaufort Inlet | Bogue Sound | Bogue Inlet | Atlantic Ocean South of Cape Hatteras |
|---|---|---|---|---|
| Speckled Hind | N/A | N/A | N/A | ELJA |
| Yellowedge Grouper | N/A | N/A | N/A | ELJA |
| Coney | N/A | N/A | N/A | ELJA |
| Red Hind | N/A | N/A | N/A | ELJA |
| Goliath Grouper | N/A | N/A | N/A | ELJA |
| Red Grouper | N/A | N/A | N/A | ELJA |
| Misty Grouper | N/A | N/A | N/A | ELJA |
| Warsaw Grouper | N/A | N/A | N/A | ELJA |
| Snowy Grouper | N/A | N/A | N/A | ELJA |
| Yellowmouth Grouper | N/A | N/A | N/A | ELJA |
| Black Grouper | J | J | J | ELJA |
| Scamp | N/A | N/A | N/A | ELJA |
| Blackfin Snapper | N/A | N/A | N/A | ELJA |
| Red Snapper | N/A | N/A | N/A | ELJA |
| Cubera Snapper | N/A | N/A | N/A | ELJA |
| Lane Snapper | N/A | N/A | N/A | ELJA |
| Silk Snapper | N/A | N/A | N/A | ELJA |
| Vermillion Snapper | N/A | N/A | N/A | ELJA |
| Mutton Snapper | N/A | N/A | N/A | ELJA |
| Gray Snapper | J | J | J | ELJA |
| Gray Triggerfish | N/A | N/A | N/A | ELJA |
| Yellow Jack | J | J | J | ELJA |
| Blue Runner | J | J | J | ELJA |
| Crevalle Jack | J | J | J | ELJA |
| Bar Jack | J | J | J | ELJA |
| Greater Amberjack | N/A | N/A | N/A | ELJA |
| Almaco Jack | N/A | N/A | N/A | ELJA |
| Banded Rudderfish | N/A | N/A | N/A | ELJA |
| Atlantic Spadefish | N/A | N/A | N/A | ELJA |
| White Grunt | N/A | N/A | N/A | ELJA |
| Tomtate | N/A | N/A | N/A | ELJA |
| Hogfish | N/A | N/A | N/A | ELJA |
| Puddingwife | N/A | N/A | N/A | ELJA |
| Sheepshead | J A | J A | J A | ELJA |
| Red Porgy | N/A | N/A | N/A | ELJA |
| Longspine Porgy | N/A | N/A | N/A | ELJA |

Table 2.2 (cont). Essential Fish Habitat (EFH) Species for Coastal NC (part 2 of 3).

| E-EGGS<br>L-LARVAL<br>J-JUVENILE<br>A-ADULT<br>N/A-NOT FOUND | Beaufort Inlet | Bogue Sound | Bogue Inlet | Atlantic Ocean South of Cape Hatteras |
|---|---|---|---|---|
| Scup | N/A | N/A | N/A | ELJA |
| Blueline Tilefish | N/A | N/A | N/A | ELJA |
| Sand Tilefish | N/A | N/A | N/A | ELJA |
| | | | | |
| SMALL COASTAL SHARKS | | | PROHIBITED SHARKS | |
| | | | | |
| Atlantic Sharpnose Shark | | | | Sand Tiger |
| Finetooth Shark | | | | Bigeye Sand Tiger |
| Blacknose Shark | | | | Whale Shark |
| Bonnethead | | | | Basking Shark |
| LARGE COASTAL SHARKS | | | | White Shark |
| Silky Shark | | | | Dusky Shark |
| Tiger Shark | | | | Bignose Shark |
| Blacktip Shark | | | | Galapagos Shark |
| Spinner Shark | | | | Night Shark |
| Bull Shark | | | | Reef Shark |
| Lemon Shark | | | | Narrowtooth Shark |
| Nurse Shark | | | | Shark |
| Scalloped hammerhead | | | | Smalltail Shark |
| Great Hammerhead | | | | Atlantic Angel Shark |
| Smooth Hammerhead | | | | Longfin mako |
| | | | | Bigeye Thresher |
| PELAGIC SHARKS | | | | Sharpnose Sevengill shark |
| Shortfin Mako | | | | Bluntnose sixgill Shark |
| Porbeagle | | | | Bigeye Sixgill Shark |
| Thresher Shark | | | | |
| Oceanic Whitetip Shark | | | | |
| Blue Shark | | | RESEARCH SHARKS | |
| | | | | Sandbar Shark |

Table 2.2 (cont). Essential Fish Habitat (EFH) Species for Coastal NC (part 3 of 3).

The State of North Carolina, Department of Environment and Natural Resources, Division of Marine Fisheries Artificial Reef Program manages six reefs that are located off Bogue Banks (see Figure 2.2). They are AR 315, AR 320, AR 330, AR 340, AR 342, and AR 345. AR 342, also known as the Onslow Bay Sport Fishing Club Reef, is located on the southern border of borrow area Y. This reef is made up mostly of concrete pipe, tires and 10 train boxcars.

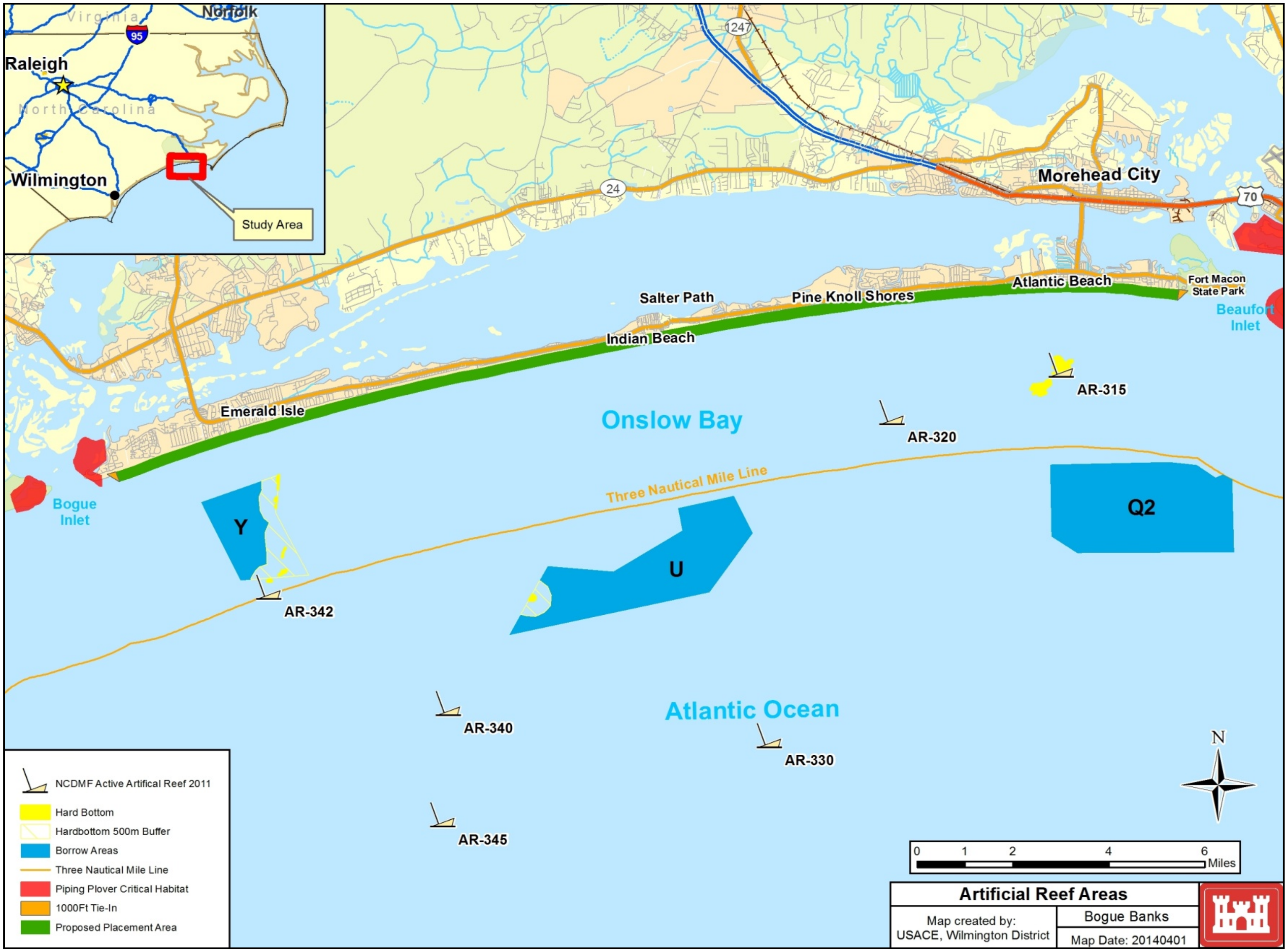



Figure 2.2. Location of artificial reefs in project vicinity.

## 2.05 Wetlands and Floodplains

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions (33 C.F.R. § 328.3). Wetlands possess three essential characteristics: hydrophytic vegetation, hydric soils, and wetland hydrology.

No wetlands are found along the ocean shoreline of the project area. Along the beaches of Bogue Banks, the oceanside shorelines of Bogue and Beaufort Inlets, and the proposed borrow areas there are no Section 404 jurisdictional wetlands (having the three essential characteristics) that would be impacted by the proposed project.

The 100-year flood plain is established by the Federal Emergency Management Agency (FEMA) and is identified on Federal Insurance Rate Maps. Base flood elevations for flood zones and velocity zones are also identified by FEMA, as are designated floodways. All portions of the project area are within the 100-year floodplain.

Any placement of material on the beach would occur within the 100-year floodplain and would therefore constitute an alteration of the floodplain, displacing the floodplain seaward. Placement of dredged material on Bogue Banks cannot be accomplished outside the floodplain.

## 2.06 Terrestrial Resources

Terrestrial beach and dune communities that may be impacted by proposed project actions occur along most of the Bogue Banks shoreline. Terrestrial habitat types within the areas include sandy or sparsely vegetated beaches and dune communities. The first line of stable vegetation is outside or landward of the proposed project limits. Utility corridors may have herbaceous or shrub cover. Mammals occurring in this environment are opossums, cottontails, red foxes, gray foxes, raccoons, feral house cats, shrews, moles, voles, and house mice. The terrestrial resources of Bogue Banks are Vegetation, Wildlife, Birds, and Mammals and are described below.

### 2.06.1 Vegetation

When compared to most of North Carolina's upland communities, the beach and dune community in the project area could be considered lacking in species variety in both plants and animals. The environment on the beach is severe because of constant exposure to salt spray, shifting sands, wind, and sterile soils with low water retention capacity. Beach vegetation known from the area includes beach spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile edentula*) and pennywort (*Hydrocotyle bonariensis*). The threatened plant, seabeach amaranth (*Amaranthus pumilis*) occurs sporadically along the dune faces of Bogue Banks. The dunes along Bogue Banks are more heavily vegetated with American beach grass (*Ammophila breviligulata*), panic grass (*Panicum* *amarum*) sea oats (*Uniola paniculata*), broom straw (*Andropogon virginicus*) and salt meadow hay (*Spartina patens*) being commonly observed.

The zones and some of their dominant plants, according to Godfrey and Godfrey (1976) are:

Beaches--essentially devoid of vegetation except unicellular algae.

Berms--created by a few plants such as sea oats growing in the driftline, which may build small dunes, depending on storm frequency.

Tidal Flats--intertidal areas essentially unvegetated except for stands of salt marsh cordgrass; found at inlets.

Dunes--Low scattered dunes formed by sea oats in overwash-influenced areas, and high densely vegetated dune fields where vines such as Virginia creeper may be found on the back side.

Open Grasslands--sparsely vegetated by salt meadow cordgrass and pennywort, both of which grow up through sand after burial in overwash.

Closed Grasslands--greater cover of pennywort, broomsedge, and hairgrass; Also species of rush where water stands. Salt meadow cordgrass, closer to the water table.

Woodlands--shrub thickets of wax myrtle, silverling, or of yaupon and live oak; maritime Virginia red cedar, and American holly. Both protected lands. Marsh elder, and forests of live oak, are on higher ground.

High Salt Marshes--dominated by black needlerush and salt meadow cordgrass; flooded by spring and storm tides.

Low Salt Marshes--dominated by salt marsh cordgrass and is flooded at mean high tide.

Subtidal Marine Vegetation--extensive stands of eelgrass and widgeon grass in protected, shallow waters.

2.06.1.1 Maritime Forest. Bogue Banks supports the most abundant remaining maritime forest on a North Carolina barrier island. Several tracts totaling over 1,000 acres have remained intact, although development has resulted in fragmentation of much of the forest on the island. This forest provides valuable habitat for mammals, reptiles, and migratory and resident songbirds (USFWS, 2002).

2.06.1.2 Beach and Dune. A still current description of the terrestrial barrier island from USFWS, *Draft Fish and Wildlife Coordination Act Report, Bogue Banks Shore Protection Project, Carteret County, NC*, November 2002 (USFWS 2002) states:

*"The comparatively high sediment volume composing the interior of the barrier island creates one of the highest dune ridges in North Carolina along the oceanic beach. The northern, or landward, side of the dune system is generally vegetated by dense maritime forest or scrub-shrub along Bogue Banks. In western and central Emerald Isle, eastern Indian Beach, Pine Knoll Shores, and portions of Atlantic Beach, the dune system consists of multiple dune ridges reaching 4 to 5 m (~13 – 16.4 ft) in elevation…."*

*"Bogue Banks contains approximately 25 miles of southward-facing oceanfront beaches. The oceanic shoreline can be divided into several ecological niches: the dune; dry beach; wet beach; and shoreface. ….*

*The southernmost dune ridge typically has an erosional scarp facing the beach. These dune scarps supply clean, quartz sand to the beach during storm events, naturally dissipating wave energy.*

*The dry beach is found between the dune toe or scarp and the mean high water (MHW) line. Along virtually the entire length of Bogue Banks the dry beach is narrow and occasionally nonexistent during spring high tides or minor storm events. This ecological niche provides habitat for several species of amphipods, nesting sea turtles, burrowing ghost crabs and loafing shorebirds and colonial waterbirds.*

*The native beach sands of Bogue Banks are light brown in color with periodic patches of black where heavy minerals (e.g., garnet, magnetite, ilmenite) have been deposited by storm or spring tide waves on the normally dry beach….*

*The wet beach is the area subject to daily tidal flux. This ecological niche is subject to wave action which creates alternating periods of subaqueous and subaerial conditions. The fauna adapted to this environment are concentrated in the top 5 to 10 centimeters (cm; ~2-4 inches)…and are sensitive to the grain size, geomorphology and swash energy of the intertidal zone… Therefore the fauna are patchily distributed depending upon the specific physical and hydrologic characteristics at any given location along and across the beach….*

*The native wet beaches of the project area often have depressed infaunal populations due to beach scraping and beach fill activities relative to pre-project levels…. The substrate providing the habitat for the infauna is naturally light brown quartz sand with patches of well-rounded, marine shell hash and black to purple heavy minerals.*

*The portion of the beach that remains wet during all tidal stages is the shoreface. This ecological zone supports a diverse faunal community of infaunal invertebrates and surf zone fishery resources. Bogue Banks tends to have a single or double sand bar and trough bathymetry, generating several ecological niches. This area extends from 0 to approximately 9.1 m (30 ft) of water depth along Bogue Banks.*

### 2.06.2 Wildlife

Following are descriptions of wildlife found on Bogue Banks.

2.06.2.1 Mammals. Gray squirrels and marsh rabbits are abundant on Bogue Banks. White-tailed deer are present, though not in high density. Furbearers that have been observed include raccoon, mink, muskrat, otter, fox, nutria, and opossum. A total of about 30 mammal species are believed to be present on Bogue Banks and neighboring Shackleford Banks and Cape Lookout. This list contains 14 species that are primarily carnivorous and 18 rodent species (http://www.nps.gov/calo/naturescience/mammals.htm).

In the herbaceous dune areas on Bogue Banks, mammals occurring here are opossums, cottontails, raccoons, feral house cats, shrews, moles, voles, and house mice.

2.06.2.2 Reptiles and Amphibians. A total of 93 amphibian and reptile species are believed to be present on Bogue Banks. Species observed include southern leopard frog, green tree frog, black rat snake, eastern cottonmouth, yellow-bellied turtle, and snapping turtle. On Bogue and Shackleford Banks the list of species includes 42 amphibian and 51 reptile species. The largest group of amphibians is frogs, which include 18 species, followed by salamander/newts, 14 species; toads, 6 species; and other amphibians, 4 species. The largest group of reptiles is snakes, 31 species, followed by turtles, 11 species; and lizards/skinks, 9 species.

2.06.2.3 Birds. The inlet shorelines on Bogue Banks have consistently supported nesting habitat for shorebirds and colonial waterbirds. Black skimmers, least terns (*Sterna antillarum*), and Wilson's plovers (*Charadrius wilsonia*) are nesting on bare sandy flats adjacent to the inlet (Personnel Communication, David Allen, NC Wildlife Resources Commission). Historically, piping plovers (*Charadrius melodus*), common terns (*Sterna hirundo*), willet (*Catoptrophorus semipalmatus*), and American oystercatcher also have nested in these areas. During migratory periods, piping plover, Wilson's plover, semipalmated plover (*Charadrius semipalmatus*), red knot (*Calidris canutus*), sandwich tern (*Sterna sandvicensis*, Foster's tern (*Sterna forsteri*), Royal tern (*Sterna maxima*), least tern, gull-billed tern (*Sterna nilotica*), common tern, black tern (*Chlidonias niger*), Caspian tern (*Sterna caspia*), herons, egrets, marbled godwit (*Limosa fedoa*), laughing gull (*Larus atricilla*) and cormorant are commonly found in and around the inlets. Overwintering bird species include piping plover, brown pelican, cormorants, Foster's tern, Royal tern, dunlin, and various gull species (Fussell 1985).

In the herbaceous dune areas, marsh hawks, kestrels, and other bird of prey forage. Other birds occurring in this area are mourning doves, swallows, fish crows, starlings, meadowlarks, redwinged blackbirds, boat-tailed grackles, and savannah sparrows. Mammals occurring here include opossums, cottontails, gray foxes, raccoons, feral house cats, shrews, moles, voles, and house mice.

Colonially nesting waterbirds (gulls, terns, and wading birds) are an important part of the project area ecosystem and add a vital element to the overall aesthetic appeal of the area for the many tourists that visit it each year. These species formerly nested primarily on the barrier islands of the region but have had most of these nesting sites usurped by development or recreational activities. With the loss of their traditional nesting areas, these species have retreated to the relatively undisturbed dredged material disposal islands, which border the navigation channels in the area. These islands often offer ideal nesting areas as they are close to food sources, well removed from human activities, and are isolated from mammalian egg and nestling predators (USFWS 2002).

Species of colonial waterbirds which have been documented to nest on the disposal islands in Bogue Sound or inlets of the project area are shown on table 2.3. Data was taken from the U.S. Fish and Wildlife Service (USFWS) Draft Coordination Act Report, Bogue Banks Shore Protection Study (USFWS 2002). Other species also use the islands for loafing or roosting during migratory periods or the winter months. No nesting by colonial waterbirds or shorebirds has been recently documented on the oceanfront beaches of Bogue Banks. The beaches are utilized by birds for foraging and loafing, however (USFWS, 2002).

| Common Name | Scientific Name |
|---|---|
| least (little) tern | *Sterna albifrons* |
| Forster's tern | *Sterna forsteri* |
| common tern | *Sterna hirundo* |
| gull-billed tern | *Gelochelidon nilotica* |
| black skimmer | *Rynchops niger* |
| glossy ibis | *Plegadis falcinellus* |
| great egret | *Casmerodius albus* |
| snowy egret | *Egretta thula* |
| cattle egret | *Bubulcus ibis* |
| tricolored heron | *Hydranassa tricolor* |
| green heron | *Butorides striatus* |
| little blue heron | *Egrette caerulea* |
| black-crowned night-heron | *Nycticorax nycticorax* |
| great blue heron | *Plegadis falcinellus* |

Table 2.3. Colonial waterbirds that have been documented to nest on the disposal islands in Bogue Sound or inlets in Carteret County, NC (USFWS 2002).

## 2.07 Threatened and Endangered Species (includes State Protected Species)

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531–1543), provides a program for the conservation of threatened and endangered (T&E) plants and animals and the habitats in which they are found. The lead Federal agencies for implementing the ESA are the USFWS (http://www.fws.gov/) and the NOAA Fisheries Service (http://www.nmfs.noaa.gov/). In accordance with Section 7 (a)(2) of the ESA, USACE and BOEM have been in consultation with the USFWS and NMFS since beginning this study.

Updated lists of threatened and endangered (T&E) species for the project area were obtained from NMFS (Southeast Regional Office, St. Petersburg, FL) and the USFWS (Field Office, Raleigh, NC). These were combined to develop the composite list shown in table 2.4, which includes T&E species that could be present in the area based upon their historical occurrence or potential geographic range. However, the actual occurrence of a species in the area depends upon the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors.

Additionally, Table 2.5 provides a list of all State Protected Species that may occur in the project area. Mr. John Finnegan, Information Systems Manager, North Carolina Natural Heritage Program, Office of Conservation, Planning and Community Affairs, NC Department of Environment and Natural Resources provided the list species found in Table 2.5.

| Species Common Names | Scientific Name | Federal Status |
|---|---|---|
| *Vertebrates* | | |
| American alligator | *Alligator mississippiensis* | T(S/A) |
| Eastern cougar | *Felis concolor couguar* | Endangered***** |
| North Atlantic Right whale | *Eubaleana glacialis* | Endangered |
| Blue Whale | *Balaenoptera musculus* | Endangered |
| Sei whale | *Balaenoptera borealis* | Endangered |
| Sperm whale | *Physeter macrocephalus* | Endangered |
| Finback whale | *Balaenoptera physalus* | Endangered |
| Humpback whale | *Megaptera novaeangliae* | Endangered |
| Green sea turtle | *Chelonia mydas* | Threatened[1] |
| Hawksbill turtle | *Eretmochelys imbricata* | Endangered |
| Kemp's ridley sea turtle | *Lepidochelys kempii* | Endangered |
| Leatherback sea turtle | *Dermochelys coriacea* | Endangered |
| Loggerhead sea turtle | *Caretta caretta* | Threatened |
| West Indian Manatee | *Trichechus manatus* | Endangered |
| Piping Plover | *Charadrius melodus* | Threatened |
| Red-cockaded woodpecker | *Picoides borealis* | Endangered |
| Roseate tern | *Sterna dougallii* | Threatened |
| Red knot | *Calidris canutus rufa* | Candidate Species |
| Smalltooth sawfish | *Pristis pectinata* | Endangered |
| Shortnose sturgeon | *Acipenser brevirostrum* | Endangered |
| Atlantic Sturgeon | *Acipenser oxyrhynchus oxyrhynchus* | Endangered |
| *Invertebrates* | | |
| a skipper (butterfly) | *Atrytonopsis sp1* | FSC |
| *Vascular Plants* | | |
| Rough-leaved loosestrife | *Lysimachia asperulaefolia* | Endangered |
| Seabeach amaranth | *Amaranthus pumilus* | Threatened |

**1Green turtles are listed as threatened, except for breeding populations in Florida and on the Pacific Coast of Mexico, which are listed as endangered.**

**KEY:**

Status Definition

Endangered - A taxon "in danger of extinction throughout all or a significant portion of its range."

Threatened - A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

FSC – Federal Species of Concern. A species under consideration for listing, for which there is insufficient information to support listing at this time.

T(S/A) - Threatened due to similarity of appearance (e.g., American alligator)--a species that is threatened due to similarity of appearance with other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to Section 7 consultation.

Species with 1 asterisk behind them indicate historic record: * Historic record - the species was last observed in the county more than 50 years ago.

Table 2.4. Threatened and Endangered Species Potentially Present In Carteret County, North Carolina.

| Name Category | Scientific Name | Common Name | State Status |
|---|---|---|---|
| **Vascular Plant** | Amaranthus pumilus | Seabeach Amaranth | T |
| | Calopogon multiflorus | Many-flower Grass-pink | E |
| | Dichanthelium caerulescens | Blue Witch Grass | E |
| | Lysimachia asperulifolia | Rough-leaf Loosestrife | E |
| | Myriophyllum laxum | Loose Water-milfoil | T |
| | Platanthera integra | Yellow Fringeless Orchid | T |
| | Pyxidanthera brevifolia | Sandhills Pixie-moss | E |
| | Rhynchospora macra | Southern White Beaksedge | E |
| | Rhynchospora odorata | Fragrant Beaksedge | E |
| | Rhynchospora pleiantha | Coastal Beaksedge | T |
| | Solidago verna | Spring-flowering Goldenrod | T |
| | Spiranthes longilabris | Giant Spiral Orchid | T |
| | Stylisma pickeringii var.pickeringii | Pickering's Dawn flower | E |
| | Utricularia olivacea | Dwarf Bladderwort | T |
| | | | |
| **Vertebrate Animal** | Acipenser brevirostrum | Shortnose Sturgeon | E |
| | Alligator mississippiensis | American Alligator | T |
| | Ammodramus henslowii susurrans | Eastern Henslow's Sparrow | SC |
| | Caretta caretta | Loggerhead Sea turtle | T |
| | Charadrius melodus | Piping Plover | T |
| | Charadrius wilsonia | Wilson's Plover | SC |
| | Chelonia mydas | Green Sea turtle | T |
| | Crotalus adamanteus | Eastern Diamondback Rattlesnake | E |
| | Crotalus horridus | Timber Rattlesnake | SC |
| | Dermochelys coriacea | Leatherback Sea turtle | E |
| | Egretta caerulea | Little Blue Heron | SC |
| | Egretta thula | Snowy Egret | SC |
| | Egretta tricolor | Tricolored Heron | SC |
| | Eretmochelys imbricata | Hawksbill Sea turtle | E |
| | Falco peregrinus | Peregrine Falcon | E |
| | Gelochelidon nilotica | Gull-billed Tern | T |
| | Haematopus palliatus | American Oystercatcher | SC |
| | Haliaeetus leucocephalus | Bald Eagle | T |

Table 2.5. List of State Protected Species Potentially Present in Carteret County. E (Endangered), T (Threatened), and SC (Special Concern) status species are given legal protection status by the NC Wildlife Resources Commission. (Part 1 of 2).

| Name Category | Scientific Name | Common Name | State Status |
|---|---|---|---|
| **Vertebrate Animal** | Heterodon simus | Southern Hognose Snake | SC |
| | Ixobrychus exilis | Least Bittern | SC |
| | Lampropeltis getula sticticeps | Outer Banks Kingsnake | SC |
| | Laterallus jamaicensis | Black Rail | SC |
| | Lepidochelys kempii | Kemp's Ridley Sea turtle | E |
| | Malaclemys terrapin centrata | Carolina Diamondback Terrapin | SC |
| | Neotoma floridana floridana | Eastern Woodrat-Coastal Plain population | T |
| | Nerodia sipedon williamengelsi | Carolina Watersnake | SC |
| | Ophisaurus mimicus | Mimic Glass Lizard | SC |
| | Passerina ciris ciris | Eastern Painted Bunting | SC |
| | Peucaea aestivalis | Bachman's Sparrow | SC |
| | Picoides borealis | Red-cockaded Woodpecker | E |
| | Plegadis falcinellus | Glossy Ibis | SC |
| | Puma concolor couguar | Eastern Cougar | E |
| | Rana capito | Carolina Gopher Frog | T |
| | Rynchops niger | Black Skimmer | SC |
| | Sistrurus miliarius | Pigmy Rattlesnake | SC |
| | Sterna dougallii | Roseate Tern | E |
| | Sterna hirundo | Common Tern | SC |
| | Sternula antillarum | Least Tern | SC |
| | Trichechus manatus | West Indian Manatee | E |

Table 2.5 (cont). List of State Protected Species Potentially Present in Carteret County. E (Endangered), T (Threatened), and SC (Special Concern) status species are given legal protection status by the NC Wildlife Resources Commission. (Part 2 of 2).

### 2.07.1 Piping Plover Critical Habitat

Piping plover critical habitat identifies specific areas that are essential to the conservation of the species, and may require special management considerations or protection. The primary constituent elements for the piping plover wintering habitat are those habitat components that are essential for the primary biological needs of foraging, sheltering, and roosting, and only those areas containing these primary constituent elements within the designated boundaries are considered critical habitat. The primary constituent elements are found in coastal areas that support intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide.

Figure 2.3 shows locations of the designated critical habitat for wintering piping plover in the vicinity of the study area. Unit NC-10 encompasses the westerly tip of Bogue Banks and is located within the study area.

Figure 2.3. General locations of the designated critical habitat for the Wintering Piping Plover.

### 2.07.2 Butterflies

The Natural Heritage Program is currently conducting a status survey under contract with the US Fish and Wildlife Service of a rare butterfly that is known only from Bogue Banks and adjoining islands. This species, *Atrytonopsis* new species 1, is associated with the Dune Grass natural community and its larvae are believed to feed solely on seaside little bluestem (*Schizachryium littorale*), a common to dominant member of that community. Most of the known populations occur in naturally vegetated dune fields located behind the primary beaches along the ocean. Populations are also known from dredged material disposal islands that support seaside little bluestem, including Brandt Island.

### 2.07.3 Loggerhead Critical Habitat

On July 18, 2013, NOAA proposed critical habitat for the Northwest Atlantic Ocean loggerhead sea turtle Distinct Population Segment (DPS) (*Caretta caretta*) within the Atlantic Ocean and the Gulf of Mexico. The project is located in the Northwest Atlantic Ocean DPS and is part of the Bogue Banks and Bear Island, Carteret and Onslow Counties Recovery Unit LOGG-N-3 (Figure 2.4).

Recovery Unit LOGG-N-03 contains a nearshore zone that is a transitional habitat area for hatchling transit to open waters, and for nesting females to transit back and forth between open waters and nesting beaches during their multiple nesting attempts throughout the nesting season. The unit consists of nearshore area from Beaufort Inlet to Bear Inlet (crossing Bogue Inlet) and seaward 1.6 km (one mile). This unit is adjacent to high density nearshore reproductive habitat (Bogue Inlet to Bear Inlet) and is adjacent to the expansion of high density nearshore reproductive habitat (Beaufort Inlet to Bear Inlet) of loggerhead sea turtles in North Carolina (NMFS 2013).

USFWS has also proposed to designate a total of 90 critical habitat units: eight units in North Carolina; 22 units in South Carolina; eight units in Georgia; 47 units in Florida; three units in Alabama; and two units in Mississippi. The project is located in USFWS critical habitat unit LOGG-T-NC-01 (Bogue Banks, Carteret County) and includes lands from the mean high water (MHW) line to the toe of the secondary dune or developed structures. This shoreline area is adjacent to the LOGG-N-03 nearshore zone recovery unit indicated in Figure 2.4.

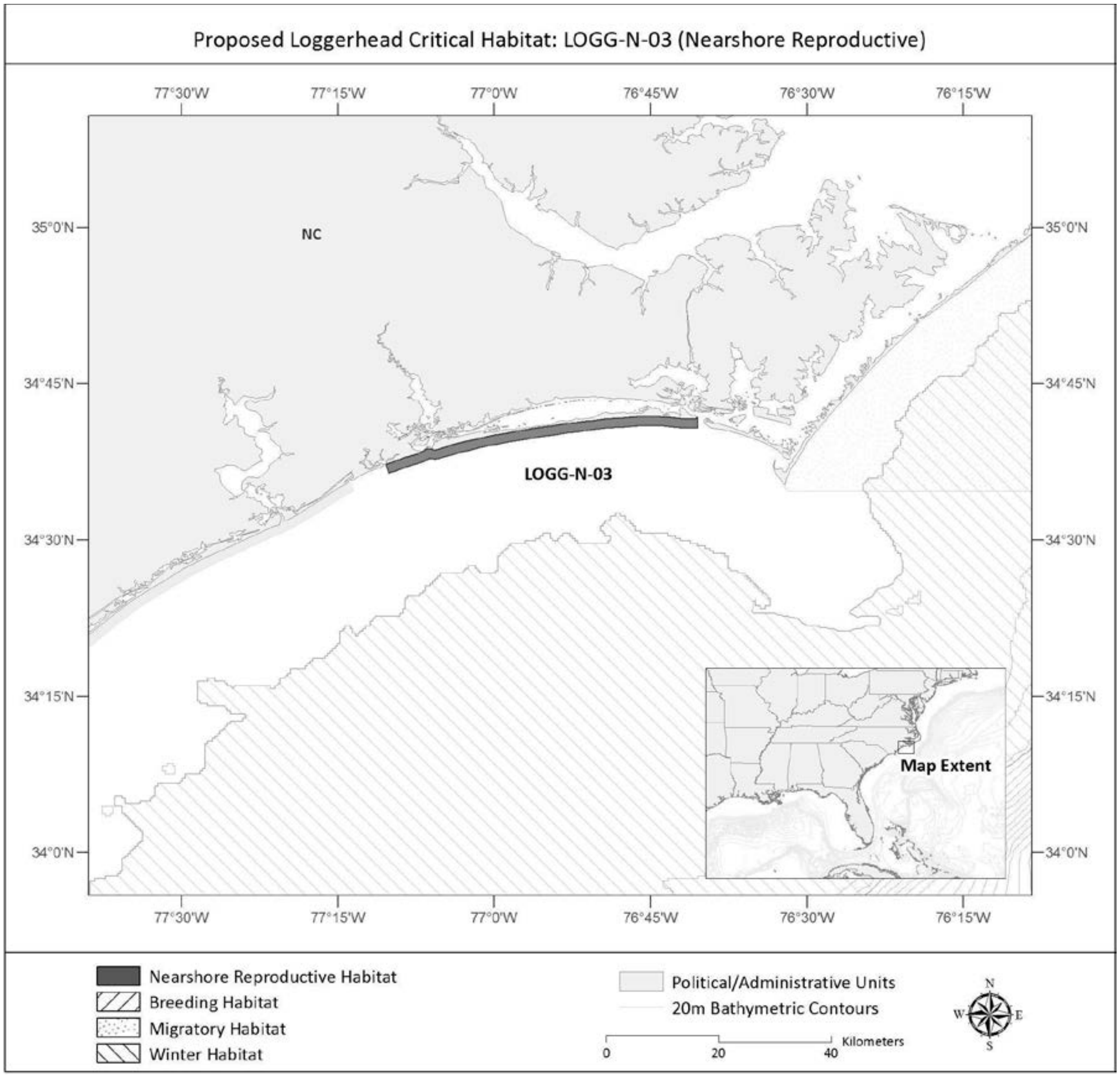


Figure 2.4 Proposed Loggerhead Critical Habitat

### 2.07.4 Red Knot

On September 27, 2013 the USFWS proposed the red knot (*Calidris canutus rufa*) for "threatened" status under Endangered Species Act. As one of the longest-distance migrants of the animal kingdom, the red knots fly more than 9,300 miles from south to north every spring and repeat the trip in reverse every autumn. They winter and migrate in large flocks containing hundreds of birds at the tip of South America in Tierra del Fuego, in northern Brazil, throughout the Caribbean, and along the U.S. coasts from Texas to North Carolina. The rufa red knot breeds in the tundra of the central Canadian Arctic from northern Hudson Bay to the southern Queen Elizabeth Islands (http://www.fws.gov/northeast/redknot/).

Due to the long migrations, the red knots use critical stopover areas to rest and feed along the way. The red knots may utilize portions of the project area as stopovers areas during their migrations.  They time stopovers with the spawning season on intertidal invertebrates to take advantage of easily digestible food such as clams, mussels and horseshoe crab eggs (http://www.fws.gov/northeast/redknot/).

## 2.08 Cultural Resources

The Area of Potential Effect (APE) was determined to be all areas associated with material placement activities, including pump-out locations and pipeline corridors, as well as potential offshore borrow areas. It is anticipated that resources in the APE will be limited to shipwrecks; however, the potential for submerged prehistoric sites was also considered in the assessment of potential project effects. The recommendations contained herein are made in consideration of provisions of the National Historic Preservation Act and the Abandoned Shipwreck Act and include requirements for offshore remote sensing survey and onshore pedestrian survey.

### 2.08.1 Prehistoric

Submerged prehistoric sites are assumed to date between early settlement circa 13,000 before present (B.P.) and circa 3,000 B.P. when sea levels reached present day levels (TRC 2012; Anderson et al. 1996). This time frame correlates with the Paleoindian period (12,500–10,000 B.P.) and the Archaic period (10,000–3,000 B.P.) with the later Woodland period postdating submerged sites (TRC 2012).

Due to a lack of sea level data for the Middle Atlantic region, TRC (2012) proposed using the sea level curves developed for New Jersey.  Using these curves, sea levels would have been 70 m lower than present day sea levels circa 13,000 B.P., 15 m lower circa 8,000 B.P., and 12 m lower circa 6,000 B.P. (TRC 2012). Bathymetric charts indicate depths over proposed borrow areas to be roughly 14 to 17 m.  The New Jersey curves place paleoshorelines within the project area during the Early Archaic period circa 8,000 B.P.

The project is located within a high sensitivity area (areas exposed when human occupation was possible) with a high potential (in the vicinity of paleochannels) for containing submerged prehistoric sites (TRC 2012). The series of paleochannels are located seaward from Bogue Banks into the outer continental shelf; however, the channels have been truncated by the modern shoreface to a depth of about 12 m (Hine and Snyder 1985). While buried paleochannels do occur in the project area, the infilling of the channels appears to have been completed during the mid-Pleistocene (Hine and Snyder 1985; Ocean Surveys Inc. 2004).

The prehistoric site preservation potential within northern Onslow Bay is extremely low. Based on seismic and vibracore data, Hine and Snyder (1985) concluded the Holocene coastal lithosomes are virtually non-existent on the middle and inner portions of Onslow Bay. A later investigation within Onslow Bay by Ocean Surveys Inc. (2004) indicated the severity of the Quarternary erosional transgressions almost entirely limited the shelf stratigraphic record to paleofluvial channel-fill sequences.

### 2.08.2 Historic

Existing shipwreck compilations for the project area generally include wrecks from the Cape Lookout vicinity because many earlier ship losses are recorded by vicinity only. For the project vicinity as a whole, including the vicinity of Cape Lookout, there are at least 31 recorded shipwreck losses covering the period 1665 to 1970.

In addition to records and site data held by the NC Underwater Archaeology Branch, the following documents have been reviewed for information on upland and underwater resources: (USACE 1978); (Angley 1984); (Brooks et al. 1996); (Tidewater Atlantic Research 1992; 1997); and (MATER 2008).

Beaufort Inlet was established as a Port of Entry in 1722 and was protected by a series of fortifications including Fort Dobbs and Fort Hampton, built around 1756, and Fort Macon built between 1826 and 1834 (Angley 1982; MATER 2008). Fort Macon saw considerable action during the Civil War, was converted to a Federal prison during the period 1866-76, and was reactivated during WWII as part of the Atlantic coastal defense. Fort Macon is now a popular NC State Park.

Shipwrecks in the Beaufort Inlet vicinity include the eighteenth-century wrecks *El Salvador*, *Adventure*, and the *Queen Anne's Revenge*. Beaufort Inlet is also the location of the Civil War wreck of the *Quinebaugh*, a Civil War era steamer. In 1923, the tug *Juno* also sank in Beaufort Inlet.

English colonial settlement of the Bogue Inlet vicinity occurred around 1711. Early settlements on the oceanfront of Bogue Banks include the sound-side communities of Rice Path, Yellow Hill, Bell Cove, and Middletown (Angley 1984). Middletown was an early casualty of erosion, so its residents moved to establish the community of Salter Path (Angley 1984). Confederate Fort Huggins was built early in the war along the west side of the channel leading from Bogue Inlet to Swansboro.

Shipwrecks in the Bogue Inlet vicinity include the schooner *Colonel Hanson* that ran aground at or near the inlet and the Confederate side-wheel steamer *Pevensey* that was chased ashore several miles east of Bogue Inlet and blew up on Bogue Banks (MATER 2008). The Bogue Inlet vicinity was also the site of six other sinkings during the twentieth century, including the *W.E. Hutton*, sunk by a German submarine in 1942. U-Boats sank 259 ships along the eastern seaboard of the U.S., and Cape Hatteras earned the infamous moniker "Torpedo Junction" (MATER 2008).

During the late 1960s and early 1970s, Tucker Littleton, a local amateur historian and archaeologist, recorded one or two oceanfront sites and numerous sites along the sound associated with the area's maritime history. Later work by coastal archaeologists Tom Loftfield, David Phelps, and archaeologists from the National Park Service have also located maritime sites bordering Bogue Sound and a few scattered remains of wreckage on the beach.

The potential for significant cultural materials over the upland or intertidal portions of the project area is considered low due to the loss of shoreline and dune erosion. The documented loss for the shoreline between 1936 and 1994 is 120 ft. Therefore, cultural material in these areas would likely be remnants of highly disturbed sites or even redeposited materials. A determination that the historical and archaeological record does not support a recommendation for archaeological survey of the beach operations was made in coordination with the NC Office of State Archaeology, (NC SHPO letter dated April 24, 2002).

The potential for encountering shipwrecks or other cultural material over offshore portions of the project area is considered high. Significant numbers of vessel losses are documented for the Bogue Banks area and Bogue and Beaufort Inlets. All locations identified as acceptable options for beach access for pipeline, pipe staging areas, location of pipeline routes, and offshore anchoring will be coordinated with the NC Office of State Archaeology.

A remote sensing survey of the offshore borrow areas was conducted between December 2006 and July 2007 (See Appendix E – Archaeological Survey, for more details). No magnetic or acoustic anomalies were identified that could be associated with submerged cultural resources within Borrow Area U. One magnetic and acoustic anomaly that may be associated with a submerged cultural resource was identified in Borrow Area Y. No known submerged cultural resources are located within the ODMDS; however, three targets identified by magnetic signature, and one target identified by magnetic and acoustic signatures are located within 500 to 2,300 feet north of the ODMDS.

## 2.09 Aesthetic and Recreational Resources

The total environment of barrier islands, beaches, ocean, estuaries, and inlets attract many residents and visitors to the area to enjoy the total aesthetic experience created by the sights, sounds, winds and ocean sprays. Two ocean piers (Oceana and Sheraton Hotel) are located in the project area and are considered important recreational facilities. During fall months, recreational surf fishing is a popular activity. Fort Macon State Park and the North Carolina State Aquarium in Pine Knoll Shores also provide recreational activities for residents and visitors.

## 2.10 Recreational and Commercial Fishing

Commercial and recreational fishing are important industries along Bogue Banks. In Carteret County there are several major centers of fishing activity, recreational and commercial fishing centers at Morehead City and Beaufort. The project area is heavily used by all fishing interests including surf and pier fishermen, charter boats, and commercial gill-netters and trawlers. Important commercial species include menhaden, thread herring, croaker, and summer flounder. Total commercial landings utilizing

Morehead City and Beaufort during 2011 was about 2.1 million pounds at a commercial value of $4.7 million (NCDMF 2013).

The beaches of Bogue Banks are used by off road vehicles (ORVs) and surf fishermen. These two interests constitute the major user groups of the project area and contribute to the local economy. The use of ORVs on the beach is generally restricted to the months of October-April; however numerous public beach access points are available for foot travel year round. The Oceana and Sheraton Hotel piers are located in the Town of Atlantic Beach, which is within the proposed project limits. These ocean piers, private recreational vessels, and charter boats that use the near-shore waters also contribute to the local economy.

## 2.11 Socioeconomics

Carteret County is located on the lower coastal plain of eastern North Carolina. The county seat of Beaufort lies 150 miles east of Raleigh and 90 miles north of Wilmington, North Carolina. The principal industries are tourism, construction, services, sport and commercial fisheries. The county is also home to a growing retirement population attracted to the area by a mild climate and beautiful natural surroundings. Tourism is generated by the 65 miles of south-facing beaches, Fort Macon State Park, NC Aquarium, NC Maritime Museum, and Cape Lookout National Seashore. Large numbers of vacation homes, motels, restaurants, and shopping centers have been developed to serve the local, retirement, and tourist populations.

From 2000 to 2010, the population of Carteret County grew at a rate of about 12 percent (i.e., 2000 population was 59,404 and 2010 population was 66,469). About 40 percent of the residents live in one of the county's municipalities. Table 2.6 shows the year round populations of the beach towns and Carteret County since 2000. With its overwhelming economic emphasis on tourism, retail sales in Carteret County comprise the most important source of jobs and income for the county's economy. In 2007, total crop sales for Carteret County were over 20 million dollars, with corn and soybeans as the leading commodities.

| Town/County/State | Population (2000) | Population (2010) |
|---|---|---|
| Atlantic Beach | 789 | 1,495 |
| Pine Knoll Shores | 1,524 | 1,337 |
| Indian Beach | 95 | 112 |
| Emerald Isle | 3,488 | 3,655 |
| Carteret County | 59,404 | 66,469 |
| North Carolina | 8,046,813 | 9,535,483 |

Table 2.6. Population statistics (year-round) for beach towns, Carteret County, and North Carolina.

In 2010, Carteret County was racially composed of 90.1% White, 7.4% Black, 2.5% Hispanic, 0.5% American Indian, 0.7% Asian, and 0.1% Native Hawaiian or Pacific

Islander, and about 1.1% of the population identify with two or more races (US Census 2010). The total racial percent of the population may be greater than 100% because Hispanic individuals may be identified in more than one group.

Any individual with total income less than an amount deemed to be sufficient to purchase basic needs of food, shelter, clothing, and other essential goods and services is classified as poor. The amount of income necessary to purchase these basic needs is the poverty line or threshold and is set by the Office of Management and Budget (US Census 2010). The 2010 poverty line for an individual under 65 years of age was $11,161. The poverty line for a three-person family with one child and two adults was $17,268. For a family with two adults and three children, the poverty line was $25,603 (US Census 2010).

Carteret County per capita income for 2010 was $26,501 and the median household income for 2010 was $49,711. In 2010, in North Carolina the per capita income was $35,249 and the median household income was $44,357. In 2010 the poverty rate in Carteret County was around 11.8% and for children ages 0-17 the poverty rate increased to 18.9%. Comparatively, in 2010 the poverty rate for the State of North Carolina was 16.2% and for children ages 0-17, the state-wide poverty rate was 22.5% (US Census 2010).

## 2.12 Other Significant Resources (Section 122, PL 91-611)

Section 122 of P.L. 91-611 identifies other significant resources which must be considered during project development. These resources, and their occurrence in the study area, are described below.

### 2.12.1 Air, Noise and Water Pollution

Air Quality. The ambient air quality for Carteret County has been determined to be in compliance with the National Ambient Air Quality Standards, and this county is designated as an attainment area (Personal Communication, Brad Newland, Engineer, NC Division of Air Quality, 26 November 2010).

Noise. Noise generators in the study area include the sound of the breakers, visitor populations, the Port of Morehead City Harbor and traffic on the beach. The sounds of breakers are tranquil and add to the pleasure experienced by visitors on Bogue Banks. Complaints of municipal residents concerning noise in the downtown area of Morehead City due to the port and urban traffic as well as the towns on Bogue Banks are normal. However, these towns on the mainland and Bogue Banks do not experience a problem to the extent that maximum densities for residential dwellings have been established nor have noise level reduction standards (outdoor to indoor or indoor to outdoor) been established. No major airports or other area establishments or entities are affecting unbearable noise levels on the community (Carteret County 2010). The Town of Morehead City has a Noise Ordinance Code (Code 1973, § 13-37; Ord. No. 1987-03, 4-14-87) that is enforced 24 hours a day (Town of Morehead City 2009). Additionally, any harbor or open-water coastal environment has a number of underwater ambient noise sources such as commercial and recreational vessel traffic, dredges, wharf/dock construction (e.g., pile driving), natural sounds (e.g., storms, biological), and so on.

Any harbor or open-water coastal environment has a number of underwater ambient noise sources such as commercial and recreational vessel traffic, dredges, wharf/dock construction (e.g., pile driving), natural sounds (e.g., storms, biological), etc. To better assess potential species effects (i.e., disturbance of communication among marine mammals) associated with dredge specific noise from navigation maintenance, deepening, or borrow area dredging operations, Clarke et al. (2002) performed underwater field investigations to characterize sounds emitted by bucket, hydraulic cutterhead, and hopper dredge operations. A summary of results from the study are presented below and are a first step toward developing a dredge sounds database that will encompass a range of dredge plant sizes and operational features.

- **Cutterhead Suction Dredge**
  Noise generated by a cutterhead suction dredge is continuous and muted and results from the cutterhead rotating within the bottom sediment and from the pumps used to transport the effluent to the placement area. The majority of the sound generated was from 70 to 1,000 hertz (Hz) and peaked at 100 to 110 decibel (dB) range. Although attenuation calculations were not completed, reported field observations indicate that the cutterhead suction dredge became almost inaudible at about 500 meters (Clarke et al. 2002).
- **Hopper Dredge**
  The noise generated from a hopper dredge is similar to a cutterhead suction dredge except there is no rotating cutterhead. The majority of the noise is generated from the dragarm sliding along the bottom, the pumps filling the hopper, and operation of the ship engine/propeller. Similar to the cutterhead suction dredge, most of the produced sound energy fell within the 70- to 1,000-Hz range, however peak pressure levels were at 120 to 140 dB (Clarke et al. 2002).
- **Bucket Dredge**

Bucket dredges are relatively stationary and produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying. The noise generated from a mechanical dredge entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the closed bucket up through the water column, and emptying the bucket into an adjacent barge. On the basis of the data collected for this study, which included dredging of coarse sands and gravel, the maximum noise spike occurs when the bucket hits the bottom (120 dB peak amplitude). A reduction of 30 dB re 1 µPa/m occurred between the 150 m and 5,000 m listening stations with faintly audible sounds at 7 km. All other noises from the operation (i.e., winch motor, spuds) were relatively insignificant (Clarke et al. 2002)."
Water quality. Water quality in the area is discussed in detail in Section 2.02.1 earlier in this report.

### 2.12.2 Man-made and Natural Resources, Aesthetic Values, Community Cohesion, and Availability of Public Facilities and Services

The towns of Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach are all small beach communities located on the barrier island commonly referred to as Bogue Banks and separated from the mainland by Bogue Sound and associated marsh communities. The Atlantic Beach Bridge towards the east of the island and North Carolina Highway 58 to the west allow for vehicle traffic to enter and leave the island. Traffic congestion is not of significant concern, however, peak summer season traffic can be heavy with the influx of seasonal tourists to the island.

Fort Macon, located in Atlantic Beach, was constructed following the war of 1812 to guard Beaufort Inlet and Beaufort Harbor. Beaufort Harbor was North Carolina's only deepwater ocean port at the time. In 1936, Fort Macon State Park opened as a public area and tourist attraction. It is currently the second most visited State park in North Carolina. Fort Macon State Park also completely surrounds the United States Coast Guard Station at Fort Macon, which allows visitors the chance to view Coast Guard Cutter ships moored there.

Near the center of the island, in Pine Knoll Shores, exists one of three North Carolina Aquariums. The aquariums were established in 1976 to promote awareness, understanding, appreciation, and conservation of the diverse natural and cultural resources of North Carolina's ocean, estuaries, rivers, streams, and other aquatic environments. On the same property, the 273 acre Theodore Roosevelt natural area offers the public the opportunity to see native plants and animals as they exist in their natural environment.

The Oceana and Sheraton piers are located in the Town of Atlantic Beach, which are within the proposed project area. These structures offer recreational opportunities to fishermen, beachgoers, and sightseers and are an amenity linked to many commercial enterprises in the area.

Numerous emergency service locations for fire and EMS, and police services exist on the island, allowing expedited response to urgent response incidents at Bogue Banks. For example, the Pine Knoll Shores Fire and EMS Department responsibilities include fire suppression, education, and prevention as well as emergency medical services, water rescue, and natural disaster response while their Police Department functions promoting public safety, preventing, suppressing, and investigating crimes, and providing emergency and non-emergency services. The emergency services offered by neighboring towns at Bogue Banks employ similar functionality.

### 2.12.3 Employment and Tax and Property Values

Principal industries in Carteret County are tourist-oriented commercial, construction, services, sport and commercial fisheries. Carteret County historically has one of the lowest property tax rates in North Carolina, and the 2010 tax rate of $.23/$100 valuation is the lowest rate of any North Carolina county. The sales assessment ratio for Carteret County is $1.0657 and the effective tax rate is $.2451 (Carteret Economic Development, 2012).

### 2.12.4 People, Businesses, and Farms

The majority of Carteret County residents inhabiting beach towns live in Emerald Isle (Table 2.6). With its overwhelming economic emphasis on tourism, retail sales in Carteret County comprise the most important source of jobs and income for the county's economy. Agriculture is also an important contributor to the economy; in 2007, total crop sales for Carteret County were over 20 million dollars, with corn and soybeans as the leading commodities.

### 2.12.5 Community and Regional Growth

From 2000 to 2010, the population of Carteret County grew at a rate of about 12 percent (i.e., 2000 population was 59,404 and 2010 population was 66,469). The county population is projected to grow to about 74,000 in 2030. About 40 percent of the residents currently live in one of the county's municipalities.

## 2.13 Hazardous and Toxic Materials

The communities of Bogue Banks are small and mostly residential. There are several hotels and gas stations that dot the island, but most of the land contains private houses, which are rented out during the summer, or maritime forest. Stores and other commercial properties are limited to the five main communities.

A search of the USEPA Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) found two sites located in Carteret County. The first one was the US Reserve XVIII Airborne Corps located on 405 Fisher Street, Morehead City. The second site was the Southern Skimmer Drum site located at 1001 Sensation Weight Road, Beaufort. This site was listed Cleaned Up on August 1, 2010. Both sites are not on the National Priorities List (NPL) and are not located near the project area.

A search of the USEPA Brownfields-Cleanups, Cleanups, and Resource Conservation and Recovery Act Information (RCRAInfo) showed no documented hazardous material spills or associated environmental issues within the project area.

## 2.14 Coastal Barrier Resources Act (CBRA) Areas

The Coastal Barrier Resources Act (CBRA) of 1982 established the John H. Chafee Coastal Barrier Resources System (CBRS), comprised of undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts. The USFWS maintains the repository for CBRA maps enacted by Congress that depict the CBRS, and has promulgated regulations implementing the CBRA.

CBRA maps show two CBRA sites on Bogue Banks, Fort Macon Unit (NC-04P) and the Roosevelt Natural Area (NC-05P). Both units are designated “P”, which USFWS has defined as “otherwise protected area”. Since both units are owned by the State of North Carolina this area would not need protection from future private development. Additionally, USFWS defines the “P” designation as an area that is not regulated by CBRA since it is State owned property. CBRA maps for the Bogue Banks area are shown in Figures 2.5 and 2.6.

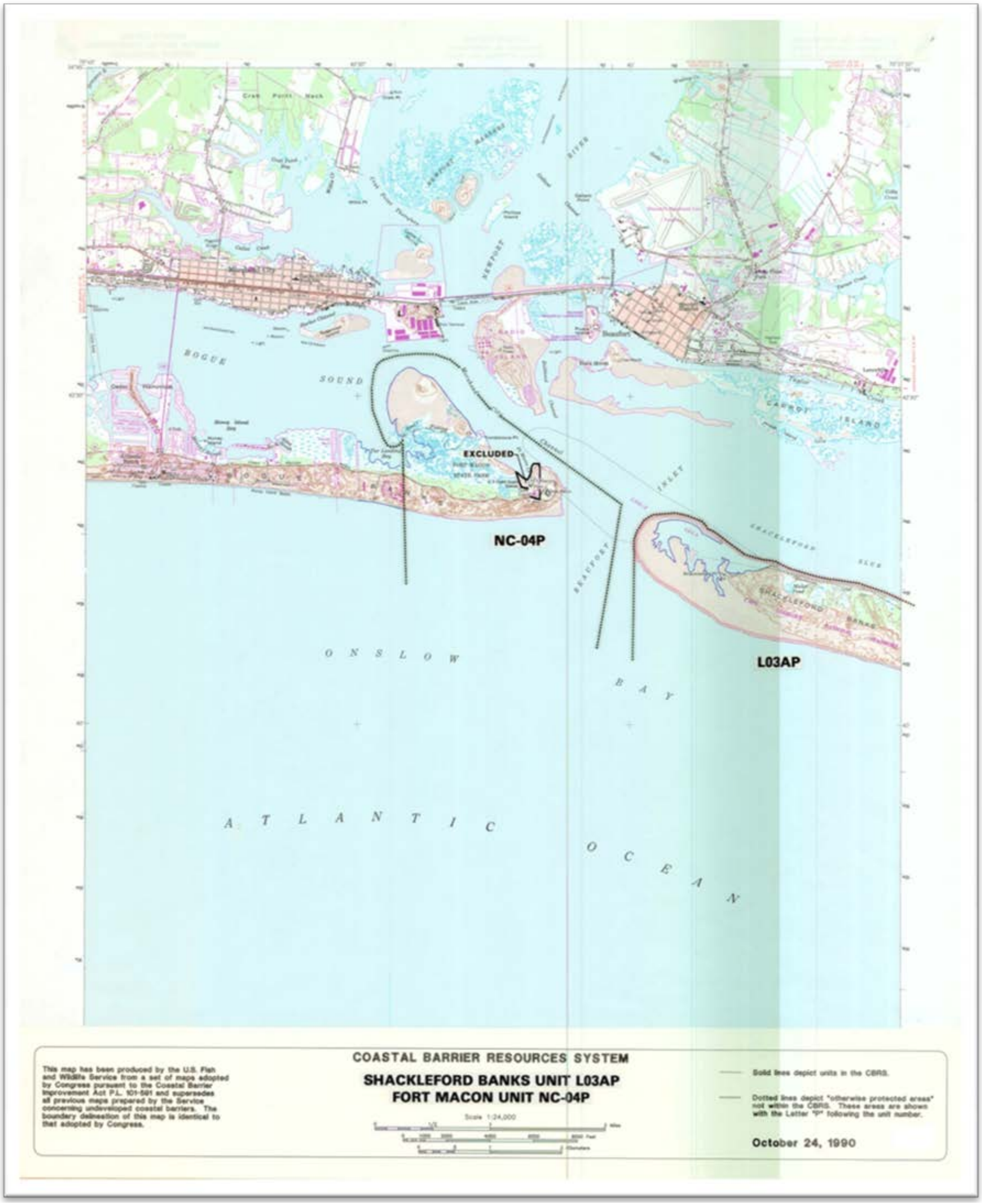


Figure 2.5. Location of CBRA unit NC-04P.


Figure 2.6. Location of CBRA unit NC-05P.

# 3. PROBLEMS AND OPPORTUNITIES*

The primary concerns identified in the study area by the non-Federal sponsor and the general public are potential economic losses resulting from (1) damages to structures and their contents due to hurricane and storm activity, and (2) the loss of beachfront land due to progressive and long-term shoreline erosion. The loss of the beachfront threatens not only the local economy, visitation, and tourist-related commercial enterprises, but has National Economic Development impacts as well, when resources that could be used elsewhere are devoted to storm recovery and rebuilding efforts. In addition, periods of severe shoreline recession can adversely affect nesting habitat for endangered and threatened sea turtles and shorebirds, and beach width available for recreational opportunities. This section describes these problems, and opportunities for improvement, in more detail.

## 3.01 Long-Term Erosion

"Long-term erosion" as used in this report refers to long-term shore processes that reduce the width of the shoreline. These processes include longshore and cross-shore sediment transport resulting from both tropical and storm induced wave conditions. Without-project shoreline changes can be assessed by extrapolating historic shoreline erosion/accretion rates out into the future, thereby identifying areas likely to be problematic and prone to storm damage. The storm-induced erosion component of shoreline change, although devastating to development, is generally of a short-term nature. Following storms, the coastline tends to reshape itself into its former configuration, as the majority of sand displaced from the beach is returned by wave action. The beach shape then conforms to the prevailing wave climate and littoral processes. Long term erosion in most areas generally ranges from about 1 to 3 feet/year, although it is much higher nearer to Beaufort Inlet. Due to a realignment of the inlet channel, the study area near Bogue Inlet is accretional.

## 3.02 Coastal Storm Damage

"Coastal storm damage," as used in this report, refers to damages incurred to property and infrastructure due to flooding and wave impact during hurricanes and extratropical events, as well as short-term erosion which occurs during these events. These short-term effects can be exacerbated in areas that are also experiencing long-term erosion. When the island is under hurricane and storm attack, the full force of the waves is felt along the immediate ocean shoreline; as the waves break and spill over the ocean edge of the island, development in upland areas is subject to the force of the waves.

Devastating hurricanes and extratropical events periodically strike coastal North Carolina. Storms occur in cycles with the recent years being fairly active. Bogue Banks suffers the effects of many of these storms. Most recently, Hurricane Irene in 2011 damaged three of the fishing piers on the island. Although a coastal storm damage reduction project was not found to be economically feasible for the area in the earlier 1984 study, the amount and value of infrastructure in the area has greatly increased since that time. A good summary of North Carolina's recent hurricane and tropical storm history can be found on the North Carolina Department of Public Safety's Website, at http://www.ncdps.gov/Index2.cfm?a=000003,000010,000025,000185,001329

## 3.03 Loss of Beach Recreation Usage

All reaches in the study area are available for a multitude of beach recreation activities—swimming, surfing, wading, walking, sightseeing, picnicking, sunbathing, surf fishing, jogging, and so on. As the State population increases, the number of visitors to these beaches is expected to increase as well. The concern regarding beach recreation is that long term shore erosion will continue to narrow the amount of beach available for recreational use. As the available width decreases, some of those recreational opportunities are reduced and eventually lost altogether. Maintaining or expanding the current beach width would increase recreational opportunities and benefits in the study area.

## 3.04 Impacts to Sea Turtle and Shorebird Habitat

A shoreface composed of beach, berm, and dune components can provide valuable nesting habitat for sea turtles and the beaches and inlets of the project vicinity are heavily used by migrating shorebirds. These areas offer high value habitat for breeding birds including terns, skimmers, piping plovers, Wilson's plovers, and American oystercatchers. However, long-term shoreline erosion processes coupled with historical short term storm events have led to substantial sediment losses from the shoreface. As a result of those existing erosional trends, substantial portions of the berm and dune system have historically been lost in areas where the shoreline is being squeezed between the ocean and adjacent development. Limited, high-quality turtle nesting habitat along the shoreline is consequently impacted, placing the sea turtles at risk in the eroded areas.

Without beach renourishment actions to replace the eroded material, the number of nest relocations necessitated from beach erosion would be expected to increase. The average yearly number of recorded nestings at Bogue Banks from 2010-2013 was 38 with Emerald Isle being the most utilized (http://www.seaturtle.org/nestdb/?view=1 2014). Persistent erosion could lead to site-specific loss of nesting habitat. Additionally, as short-term erosional processes scour the existing shoreface and the nesting beach environment slowly erodes away, large scarps may form at the toe of the primary dune, preventing a turtle from encountering suitable nesting habitat above the mean high tide line. Reestablishing a berm and dune system with a gradual slope can enhance nesting success of sea turtles by providing suitable nest sites without escarpment obstacles and away from tidal inundation.

## 3.05 Opportunities

There are potential opportunities to address these aforementioned problems through structural and non-structural measures that could be implemented by as part of a cost-shared Federal project. Measures taken to reduce long term erosion and coastal storm damages can also incidentally benefit recreation and the environment. These measures are discussed in more detail in Section 5 of this report.

# 4. EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS*

The existing condition of significant resources in the area was described in Section 2 of this report. This section focuses on further quantifying the existing and future without project physical shoreline and economic conditions, which will form the primary basis for the comparison of benefits of project alternatives. The future without project condition (FWOP) refers to the most likely future that would occur without a Federal coastal storm damage reduction project in place.

## 4.01 Without-Project Analysis – Key General Assumptions

The key assumptions made for this study are:

- Current physical and social trends occurring from the recent past until the present will continue into the future for the 50-year period of analysis

- Damaging storms will continue to occur with comparable strength and frequency as have occurred in the past

- There will continue to be a demand for residential structures in the study area

- Existing structures will be rebuilt after being damaged or destroyed by storms

- No new structures will be built on currently undeveloped lots. This is a conservative approach with regards to benefits since additional structures would result in additional FWOP damages, hence increased benefits.

- No other coastal storm damage reduction project in the study area will be constructed over the period of analysis (see Figure 1.2 for a summary of previous beach placement actions in the area). Although Carteret County is in the planning stages of a local long-term project, the purpose of the non-Federal planning effort is to provide a contingency plan in the event that the Federal project does not receive authorization or funding. The County has no schedule or intent to actually implement such a program at this time as their support for the feasibility study and their interest in implementing a Federal project in partnership with the Corps of Engineers remains very high. Accordingly, the FWOP analysis in this study assumed no local project implementation. This assumption was deemed valid for several reasons: 1) the high level of uncertainty about any actions regarding the timing, location, and quantities of any future placement make it impossible to accurately model the effects; consequently development of any specific FWOP condition that included local nourishment would potentially be less accurate than a FWOP that assumed no nourishment at all; 2) Any non-project related beach fill placements that occur in the future would reduce the cost of the Federal project by reducing required nourishment volumes; and; 3) Assuming no new beach placement in the FWOP minimizes the risk of exceeding the Section 902 limit (the risk is that the total project cost would be underestimated if non-Federal beach placement predicted for a FWOP did not actually occur), and better ensures that storm damage reduction benefits will be realized with a federal project in place.

- Disposal of dredged material is not factored into analysis of future shoreline change owing to uncertainties related to funding and potential placement. Material from Federal maintenance dredging activities of the Morehead City Harbor (which includes Beaufort Inlet) has been placed on Atlantic Beach in the past. These placements occurred in 1986, 1994, 2005, 2011 (see Figure 1.2) and most recently in 2014. However, future placement is not guaranteed and would depend upon funding, navigation needs, and other potential factors. As an example, material dredged from local navigation channels could be placed in more cost effective offshore locations, rather than on the beach. In addition, as disposal actions, these placements are not designed for coastal storm damage reduction purposes. Incorporating these future placement activities into the without project condition is difficult from a modeling perspective, and made even more so because of uncertainties surrounding the frequency, location, and amount of future placement.

- The FWOP does not attempt to model the potential reaction of individual homeowners to worsening erosion, or the effect of FEMA response to disaster declarations. In the absence of a large scale protective feature, in the future individual private property owners may undertake some of their own measures to protect their homes and business as they become increasingly threatened. Also, some minor emergency beach nourishment may be accomplished after declared disasters when Federal Emergency Management Agency (FEMA) funding is available. However, the scope and extent of these activities are difficult to predict, and most likely would not significantly alter the relative comparison of alternatives, the feasibility of a large scale Federal coastal storm damage reduction project, or its costs and benefits. As such, these activities are not being modeled in the future without project condition.

## 4.02 Without-Project Analysis – Sea Level Rise Assumptions

Engineer Circular 1165-2-212 on sea level rise (USACE, 2011) provides USACE guidance for incorporating the potential direct and indirect physical effects of projected future sea level change in the engineering, planning, design, and management of USACE projects. The guidance states that potential sea level rise must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. This guidance recommends a multiple scenario approach to address uncertainty and help develop better risk-informed alternatives. Planning studies and engineering designs should consider alternatives that are developed and assessed for the entire range of possible future rates of sea level rise. The alternatives should be evaluated using "low", "intermediate", and "high" rates of future sea level rise for both "with" and "without" Project conditions. The local historical rate of sea level rise should be used as the low rate. The intermediate rate of local mean sea level rise should be estimated using the modified Curve I from the National Research Council (1987). The high rate of local sea level rise should be estimated using the modified Curve III from the National Research Council report. This high rate exceeds the upper bounds of the 2007 IPCC estimates, thus allowing for the potential rapid loss of ice from Antarctica and Greenland. The sensitivity of alternative plans and designs to the rates of future local mean sea level rise should be determined. Design or operations and maintenance measures should be identified to minimize adverse consequences while maximizing beneficial effects. For each alternative sensitive to sea level rise, potential timing and cost consequences should be evaluated during the plan formulation process.

The without project analysis assumes that sea level rise will occur at the historical rate. Accelerated sea level rise rates would lead to higher storm surges and increase erosion rates, resulting in increased damages in the without project condition. Previous feasibility studies (USACE 2010) have demonstrated that the increase in beach fill project benefits (i.e., the amount of damages prevented as compared to the without project condition) under accelerated sea level rise scenarios outpaces the corresponding increase in project costs, leading to higher net benefits when compared to using the historical sea level rise rate. Hence, the use of the historical rate can be considered a conservative assumption in terms of project economics. The sea level rise rate used in the without project condition is 0.008432 ft/yr (0.4216 ft total over 50 years). The effect of accelerated sea level rise rates is discussed later in this report in Section 6.09.5.

## 4.03 Existing and Future Without Project Shoreline Conditions

For the purposes of the coastal analysis and characterizing the physical characteristics of the shoreline, the study area was divided into 13 coastal reaches. A coastal reach is an area where the beach profile is consistent enough that the entire reach can be adequately characterized through a single representative profile. Each coastal reach had similar erosion rates and physical morphology. Particular attention was paid to important profile features such as dune height, berm height and width, and offshore bar location. In addition, shoreline orientation was also taken into consideration.

This coastal reach characterization is necessary for the numerical modeling of the shoreline response to storms using the Storm-induced Beach Change (SBEACH) model. The SBEACH model output of shoreline responses is then used as an input into the Beach-*fx* model, which uses a Monte Carlo simulation to track beach profile evolution over time and measure average economic damages over multiple project life cycles. The calibration of the SBEACH and Beach-*fx* models is discussed in detail in Appendix A. In the Beach-*fx* model, events of interest (storms, beach nourishment) take place at calculated times. As each event takes place, the model simulates the physical and economic responses associated with that event. A set of idealized beach profiles, as defined by key data points, are tracked by the simulation model as the beach profile evolves over time. Figure 4.1 depicts the features that are measured in an idealized profile.

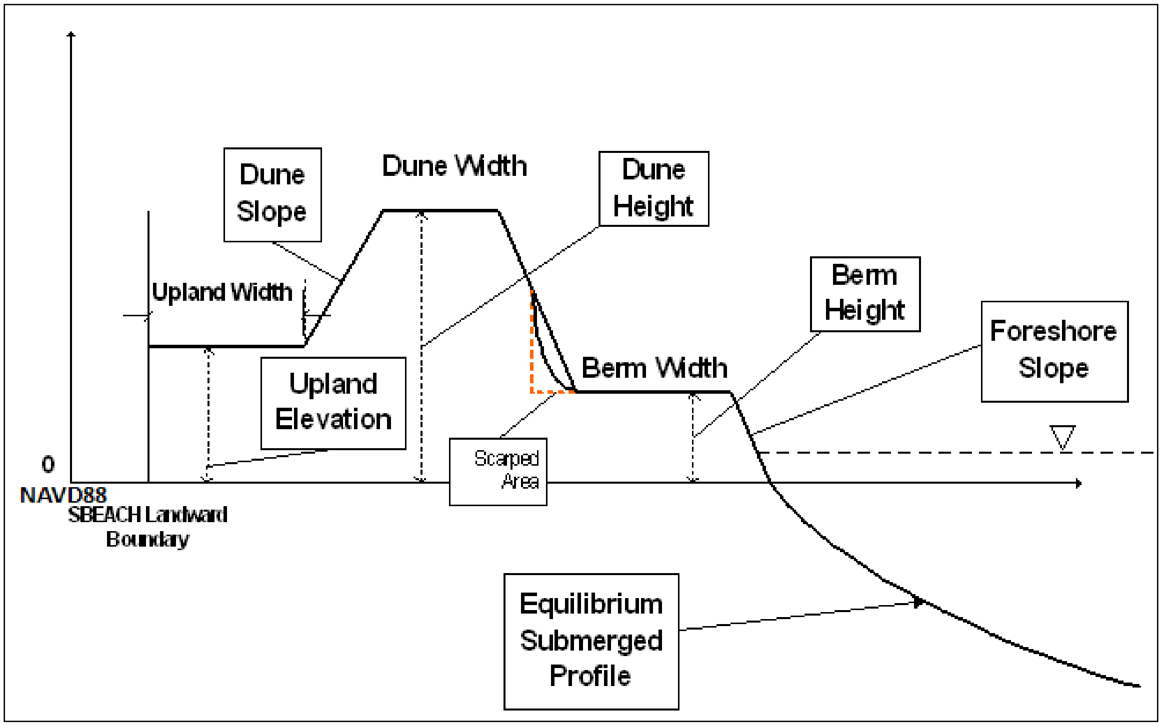



Figure 4.1. Features of an idealized shore profile cross-section.

Details on how these coastal reaches were determined are contained in Appendix A (Coastal Engineering). A map of these coastal reaches is shown in Figure 4.2 below.


Figure 4.2. Delineation of coastal reaches along the study area.

The characteristics of the existing, idealized profile at each of the 13 reaches are contained in Table 4.1. As shown in the table, a fairly substantial dune already exists in parts of the study area. Additionally, there are also over 600 structures currently built fully or partially on top of the dunes which were taken into consideration when developing and evaluating the project alternatives.

| Coastal Reach | Town(s) Included | Upland Elevation (ft) | Landward Dune Slope (X:1) | Dune Elevation (ft) | Dune Width (ft) | Seaward Dune Slope (X:1) | Berm Height (ft) | Berm Width (ft) | Foreshore Slope (X:1) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EI | 8 | 10 | 11 | 95 | -10 | 5.5 | 135 | -15 |
| 2 | EI | 8 | 4 | 15 | 15 | -4 | 7 | 125 | -15 |
| 3 | EI | 12 | 4 | 20 | 5 | -4 | 7 | 70 | -15 |
| 4 | EI | 12 | 4 | 26 | 25 | -4 | 7 | 85 | -15 |
| 5 | EI | 12 | 4 | 20 | 25 | -4 | 7 | 70 | -15 |
| 6 | EI/IB | 20 | 4 | 22 | 15 | -4 | 7 | 55 | -15 |
| 7 | IB/SP | 12 | 4 | 28 | 90 | -4 | 7 | 65 | -15 |
| 8 | IB/SP/PKS | 12 | 4 | 18 | 100 | -4 | 7 | 80 | -15 |
| 9 | PKS | 12 | 4 | 20 | 30 | -4 | 7 | 65 | -15 |
| 10 | PKS/AB | 12 | 4 | 18 | 100 | -4 | 7 | 65 | -15 |
| 11 | SB | 12 | 4 | 18 | 10 | -4 | 5.5 | 75 | -15 |
| 12 | AB | 12 | 10 | 14 | 40 | -10 | 5.5 | 30 | -15 |
| 13 | FMSP | 12 | 10 | 16 | 10 | -10 | 5.5 | 5 | -15 |

Table 4.1. Dimensions for existing condition idealized profiles at the 13 coastal reaches. EI = Emerald Isle, IB = Indian Beach, SP = Salter Path, PKS = Pine Knoll Shores, AB = Atlantic Beach, FMSP = Fort Macon State Park

Total shoreline change rates in the without project condition were determined for 118 study economic reaches and are shown in Figure 4.3. An economic reach contains one or more similar, adjacent damageable elements (structures). Economic reaches in the study area vary in length from 188 to 1,968 ft, but average approximately 1,000 ft long (see Section 4.04). A description of how these rates were calculated is contained in Appendix A (Coastal Engineering). The Beach-*fx* model is calibrated so that it matches these rates in the without project condition. Shoreline change rates ranged from 8.45 (accretionary) to -8.63 (erosion) ft/yr, with the higher rates being seen near the inlets. For the majority of the study area, erosion occurs and is around 2 ft/yr. The exception is in reaches 21-41, where erosion is generally between 0-1 ft/yr. (see Figure 4.3). The reason for this slight difference in that area is unknown, but could potentially be due to different offshore conditions in that vicinity.

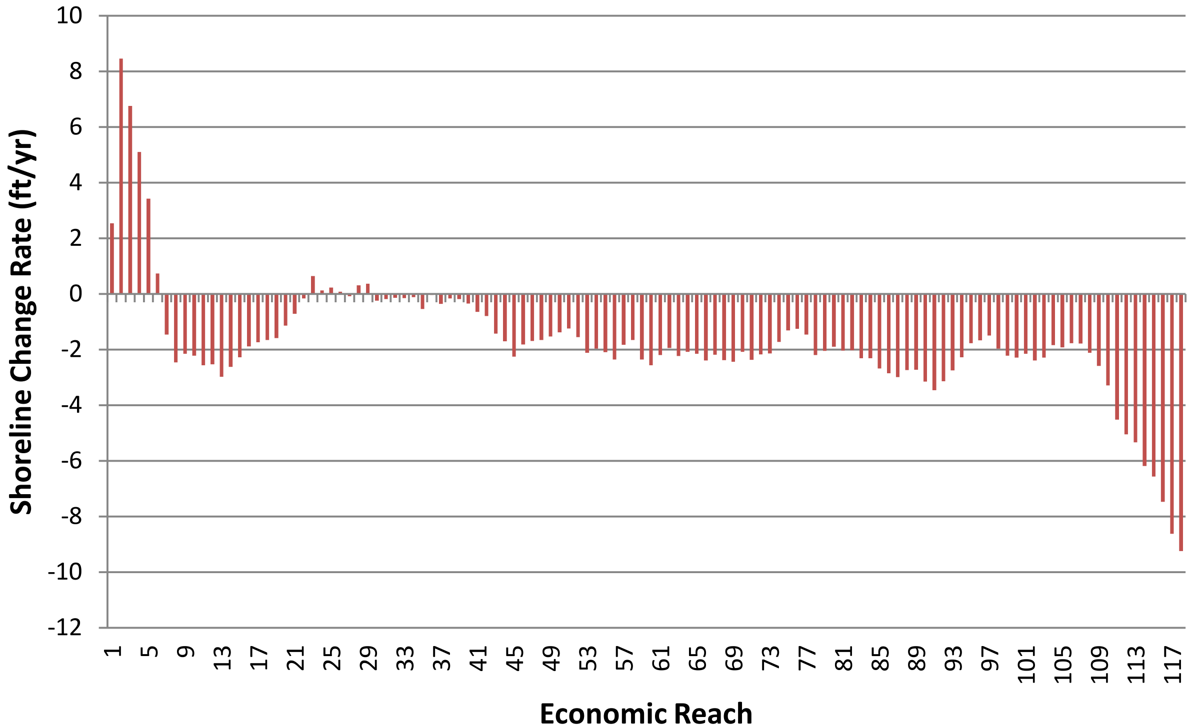



Figure 4.3. Average annual shoreline rates of change at each of the 118 economic reaches in the study area. A positive number indicates accretion, a negative number indicates erosion.

## 4.04 Existing and Future Without Project Coastal Storm Damages

For purposes of economic analysis, the study area was divided into 118 smaller economic reaches. An economic reach contains one or more similar, adjacent damageable elements. Economic reaches in the study area vary in length from 188 to 1,968 ft, but average approximately 1,000 ft long. Average annual coastal storm damages to the study area were estimated using the Beach-*fx* model.

The estimated average total without project damages over 50 years for each of the 118 economic reaches, based on 300 life-cycles, are depicted in figure 4.4. Damages are fairly comparable across reaches, although there are several notable exceptions (Appendix B, Attachment 4, Addendum 1,provides additional information on structures that constitute higher damages relative to other reaches). The total without project damages (structure and contents) in the study area over 50 years, in present value, is $306,115,000. At the fiscal year (FY) 2011 discount rate of 4.125%, total average annual without project structure and content damages are estimated at $14,556,000 per year. Average annual without project damages resulting from land loss (which are calculated based on the erosion rates presented in Section 4.03) are estimated at $2,748,000. Thus, the total average annual damages in the study area in the future without project condition are $17,304,000. Appendix B (Economics, Parking and Access)

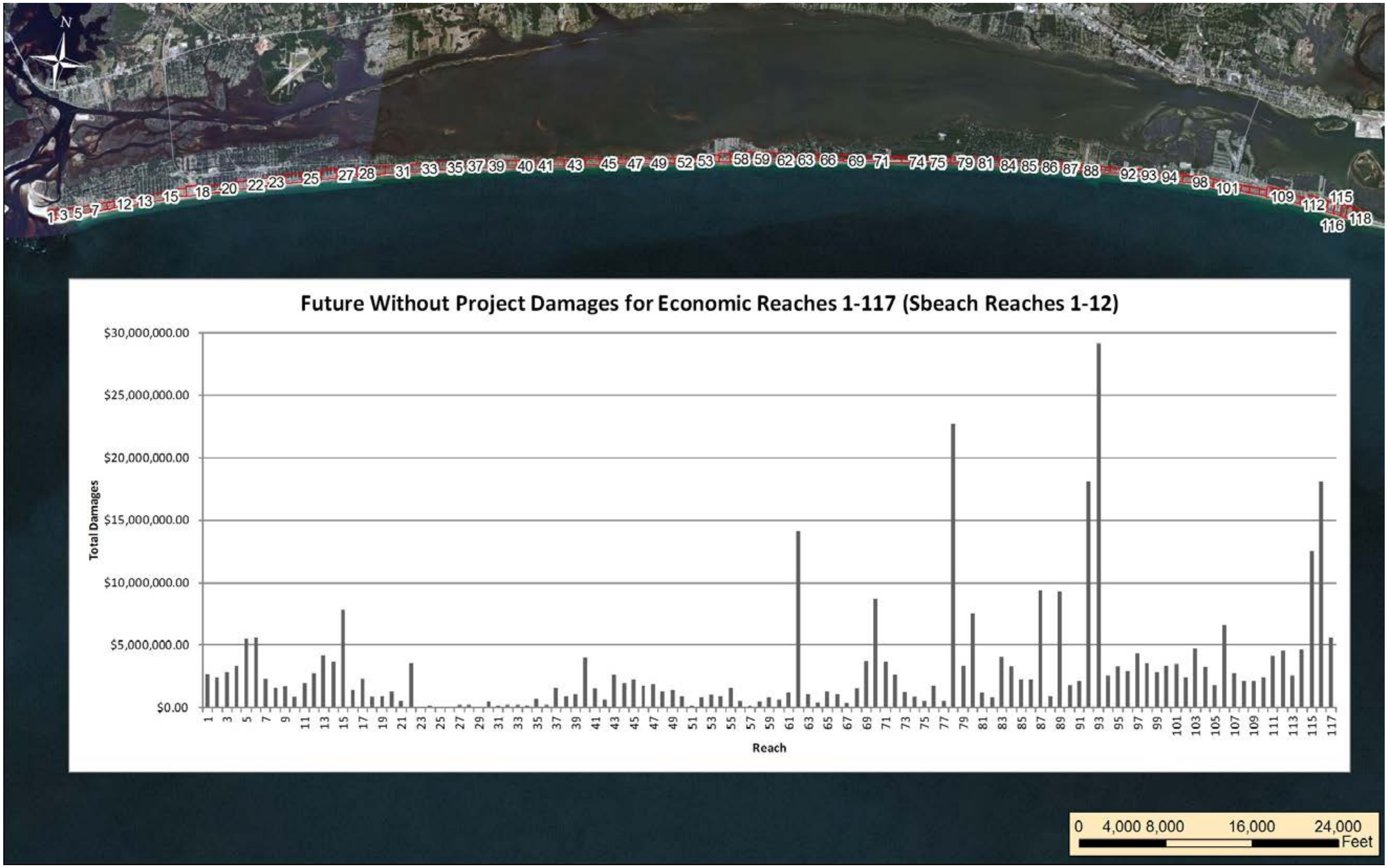



Figure 4.4. Total future without project damages (contents plus structures plus land loss) over 50 years by economic reach. Reach 1 is at the western end of the study area near Bogue Inlet and reach 118 is at the eastern end near Beaufort Inlet.

contains more details on the calculation of land loss value and the determination of structure and content value. The existing berm width along reaches 23 to 36 is currently wider than the surrounding beaches, actually approximating what eventually was determined to be the design template for the proposed project (that is, a 50 foot beach width). As mentioned above, the reason for this short stretch of wider beach is not definitively known although it has been hypothesized that there may be an offshore feature that is impacting this specific area. However, as future storms erode the entire island shoreline, it is expected that this area will also continue to erode in relative fashion, and expected future structural damages result in CSDR outputs between reaches 22 and 36 that are high enough on which to justify Federal interest in a project alone.

## 4.05 Existing and Future Without Project Recreation Conditions

The study area has a fairly robust tourist-oriented commercial industry. Visitors come to enjoy both the developed beach areas as well as other nearby protected areas such as Fort Macon State Park and the Theodore Roosevelt Natural Area, and to take advantage of other ocean-based recreational opportunities. Bogue Banks will likely continue to serve as a popular tourist destination in the future, although in the without project condition the recreational value of the area may decline as the beach continues to erode and the beach width available for typical beach-going activities is reduced.

## 4.06 Future Without Project Environmental Conditions

The existing environmental conditions of the area are detailed in Section 2 of this report. The following subsections detail the future without project conditions of several environmental resources that would be particularly impacted without a project.

### 4.06.1 Threatened and Endangered Species

Long-term shoreline erosion processes coupled with historical short term storm events are expected to lead to substantial sediment losses from the shoreface. As a result of those losses, limited, high-quality turtle nesting habitat along the shoreline is likely to be negatively impacted, placing the sea turtles at risk in the eroded areas. Without beach renourishment actions to replace the eroded material, the number of nest relocations necessitated from beach erosion would be expected to increase. The average yearly number of recorded nestings at Bogue Banks from 2010-2013 was 38 with Emerald Isle being the most utilized (http://www.seaturtle.org/nestdb/?view=1 2014). Persistent erosion could lead to site-specific loss of nesting habitat. Additionally, as short-term erosional processes scour the existing shoreface and the nesting beach environment slowly erodes away, large scarps are expected to form at the toe of the primary dune, preventing a turtle from encountering suitable nesting habitat above the mean high tide line.

USACE has surveyed Bogue Banks for seabeach amaranth since 1991. Since 2001, the amount of Amaranth surveyed has sharply reduced from over 1,900 to approximately 50 in the study area. Although hurricane events result in a reduction in plant numbers immediately following the event, long-term beach erosion is probably the primary threat to the continued presence of seabeach amaranth in the area as evidenced by the consistent decline in plant numbers since 2001. A future without project condition would likely see a continued loss of seabeach amaranth habitat. In the event that the beach and dune erode back to the infrastructure, it is possible that no seabeach amaranth habitat would be available in the developed portion of the study area.

#### 4.06.2 Beach and Dune

Major erosion is caused by northeasters that frequently occur along Bogue Banks during the colder months, as well as tropical cyclones occurring in the warmer months. Based on the calculated average erosion rate per year, it is anticipated that a good portion of the beach will continue to erode from the existing condition back into the dune. Once the beach has eroded back into the dune, escarpments will occur resulting in wave reflection off the escarpment with subsequent increased erosion, scouring, and loss of intertidal beach habitat. As the beach and dune complex erode back important habitat for a variety of plants and animals would be endangered including loss of the dune grasses and associated fauna. The intertidal beach habitat and benthic invertebrate community is a significant resource for feeding shorebirds and surf zone fishes. Additionally, beach habitat for loafing and nesting shorebirds as well as nesting sea turtles would be degraded or lost as the beach and dune are eroded into the coastal infrastructure.

#### 4.06.3 Community Cohesion, Public Facilities and Services

Ongoing erosion of the beach and degradation of the dune system by coastal erosion and flooding would result in damage to public facilities, roads, and utilities. Population displacements would be anticipated in the wake of significant storm damage, and damages to one or both of the bridges connecting the island to the mainland would splinter the communities on the island, and potentially impact hurricane evacuation and recovery efforts before/after a large storm event. Hospital services must be obtained off the island, and the ability of the resident in these communities to reach critical care facilities could significantly be impaired under FWOP conditions. Fire and police service on the island could also be disrupted by coastal erosion and flooding.

#### 4.06.4 Floodplains

The floodplain in the study area is being adversely affected by erosion and the continued deterioration of the beach and dune complex. Those effects would become more pronounced as the beach continues to erode and future storms encroach on the area.

## 4.07 Existing and Future Without Project Socioeconomic Conditions

The population of Carteret County, along with that of the rest of the State of North Carolina, is predicted to increase over the next 20 years. The State of North Carolina Office of State Planning projects that the population of Carteret County will increase from 66,469 in 2010 to 69,157 in 2020, to 71,852 in 2030. However, in a future without project condition where the beach is allowed to erode away, a large economic impact would likely be felt by all communities on the island, as many commercial businesses are dependent upon the income generated by year-round tourists. Should beach utility drop below a critical level associated with shoreline erosion, these significant revenues gained from tourist-oriented business could be expected to markedly decrease as recreational opportunities and environmental quality diminish.

## 4.08 Existing and Future Without Project Condition – General Conclusions

Coastal storms will always be a threat to our national shorelines, including those in the Bogue Banks area. Long term erosion will continue to reduce the amount of protective and recreational beach, resulting in increased vulnerabilities for structures and diminished recreational capabilities impacting local businesses. As the population of the State and the island continues to grow throughout the period of analysis, the associated impact to the region and the Nation in terms of loss of revenue and tax base will increase into the future as well. Under FWOP conditions, national economic damages on the order of several hundred million dollars over the 50 year period of analysis will be incurred. There will also be high potential for additional impacts to the regional economy, recreational opportunities, and the local environment.

Locally sponsored renourishment efforts and previous smaller scale Federal projects have helped to re-establish the coastline to some degree; however, there are no definitive plans to provide additional nourishments in the future.

# 5. PLAN FORMULATION AND EVALUATION OF ALTERNATIVES*

The planning process applied to this study and detailed below followed the 6-step process indicated earlier in Section 1.06. After problem identification, opportunities for addressing those problems were developed; alternatives were formulated and then screened down to a refined list; these final alternatives were evaluated, and then compared against one another in an iterative process aimed at identifying the National Economic Development (NED) Plan.

## 5.01 Goals and Objectives

As outlined in the 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, the Federal objective in water resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment. The Federal objective leads to the general overall goal of this study:

**Goal**: Reduce the adverse economic effects of coastal storms and erosion at Bogue Banks, while protecting the Nation's environment.

Identifying and considering the problems, needs, and opportunities of the study area in the context of Federal authorities, policies, and guidelines resulted in the establishment of the following specific objective:

**Objective**: Over a 50-year period of analysis, reduce the risk of coastal storm damages (as measured by increases in NED benefits), to approximately 23 miles of shoreline at Bogue Banks while minimizing or avoiding impacts to natural resources.

Although achieving the study objective would likely also have positive effects on the environment (such as the preservation of sea turtle and shorebird nesting and foraging habitat) as well as benefits associated with recreational use of the restored beach, and reduced damages to roads and utilities were evaluated. However, those benefits are considered incidental to the objective of providing coastal storm damage reduction benefits.

For example regarding roads, the main evacuation route is located in most instances four or more rows back from the beach, it was determined that it, and the main utility corridor have a very low likelihood of significant damage due to erosion, undermining or water destruction, but would instead most often suffer damage from deposition of sediment due to tidal overwash, and even then, only in very large events, and on a highly localized basis. Stub roads that access the beach would also have a low likelihood of destruction due to erosion or undermining, but could also suffer from overwash deposition in small areas of the project. This all would be very hard to predict and quantify. The damages from this source were preliminarily estimated to be less than 1% of the total potential damage suite, and having little historical basis for estimating their potential costs were, therefore, not included in the economic analysis of damages.

Alternatives in this study were not formulated for the purpose of addressing these incidental objectives.

## 5.02 Constraints

The formulation of alternatives to address the study objective is limited by planning constraints. Specific to this project, the formulation of alternative plans is potentially constrained by:

a. Geographic limits of the study authority.

b. The amount of existing space on the island that is available for mass relocation of vulnerable structures.

c. Avoidance or minimization of impacts to threatened and endangered sea turtle and shorebird nesting habitat.

## 5.03 Formulation and Evaluation Criteria

Alternative plans are evaluated by applying numerous, rigorous criteria. Four general criteria are considered during alternative plan screening: completeness, effectiveness, efficiency, and acceptability.

Completeness: Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. Completeness also includes consideration of real estate issues, operations and maintenance (O&M), monitoring, and sponsorship factors.

Effectiveness: Effectiveness is the extent to which the alternative plans contribute to achieve the planning objectives. The plan must make a significant contribution to the problem or opportunity being addressed.

Efficiency: Efficiency is the extent to which an alternative plan is the most cost effective means of achieving the objectives. The plan outputs cannot be produced more cost-effectively by another plan.

Acceptability: Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies. Appropriate mitigation of adverse effects shall be an integral component of each alternative plan. The project should have evidence of broad-based public support and be acceptable to the non-Federal cost-sharing partner.

There are also specific technical criteria related to engineering, economics, and the environment, which also need to be considered in evaluating alternatives. These are:

**Engineering Criteria:**

- The plan must represent a sound, acceptable, and safe engineering solution.

**Economic Criteria:**

- The plan must contribute benefits to NED.
- Tangible benefits of a plan must exceed economic costs.
- Each separable unit of improvement must provide benefits at least equal to costs.
- Recreation benefits may not be more than 50 percent of the total benefits required for economic justification (a benefit cost ratio > 1.0).

**Environmental Criteria:**

- The plan would fully comply with all relevant environmental laws, regulations, policies, executive orders.
- The plan would represent an appropriate balance between economic benefits and environmental sustainability.
- The plan would be developed in a manner that is consistent with the USACE' Environmental Operating Principles.
- The plan would be formulated to avoid adverse impacts to the environment. In cases where adverse effects cannot be avoided, mitigation must be provided to minimize impacts.

## 5.04 Environmental Operating Principles

The USACE Environmental Operating Principles (Principles) were developed to ensure that Corps of Engineers missions include totally integrated sustainable environmental practices. The Principles provided corporate direction to ensure the workforce recognized the Corps of Engineers role in, and responsibility for, sustainable use, stewardship, and restoration of natural resources across the Nation and, through the international reach of its support missions. More information on the Principles can be found here: http://www.usace.army.mil/Missions/Environmental/EnvironmentalOperatingPrinciples.aspx

Specifically for this project, these Principles were adhered to during the planning process with regards to the screening of potential borrow areas, and the proposed timing of construction activities to avoid impacts to listed species to the maximum extent practicable.

## 5.05 Identification, Examination, and Screening of Measures

A variety of potential measures can be considered and combined when formulating alternative plans for reducing coastal storm damages. These measures generally are categorized as either structural or non-structural. Structural measures are those that directly affect the conditions that cause storm damage – in this case erosion, wave attack and/or flooding. Non-structural measures are those taken to reduce damages without directly affecting those conditions driving project area damages. A No Action Alternative is developed to provide a baseline condition against which to measure comparative plan effectiveness. Under the No Action alternative, FWOP conditions remain in place without implementation of a Federal project.

### 5.05.1 Structural Measures

Preliminary measures considered to address the coastal storm damage vulnerabilities along the project area include a variety of structural measures and non-structural measures for addressing coastal storm damage reduction exist. This includes “soft” structures such as beach fills, and “hard” structures such as breakwaters, seawalls, revetments, and groins. These structures and their associated characteristics are discussed below:

- ***Beachfill***. Beach fill measures consist of berms, dunes, and terminal sections. Measures generally involve variations in dune width, dune height, and berm width. Beach fill measures are considered some of the most appropriate and effective measures, as they mimic the natural environment and can be designed to optimize storm damage reduction outputs. Although incidental to formulation efforts for this project, beach fill measures which widen the existing berm also provide more recreational benefits than hard structures, and expand the area available for sea turtle nesting and shorebird nesting and foraging. Additionally, a beach fill alternative is naturally adaptable to various sea-level rise scenarios. However, in order to fully realize project outputs, the beach fill template may need to be periodically renourished throughout the life of the project. Figure 5.1 shows an example of a beach fill being constructed. This preliminary alternative was determined to have potential and was carried forward into detailed evaluation and analysis.
- ***Groin Field***. Groins are rock or concrete structures that can take the form of a terminal groin at the terminus of a shoreline littoral cell (e.g. near an inlet) or a groin field consisting of multiple groin structures parallel to one another along a project reach. Groin fields generally must be ‘filled’ with sand in the area between each structure, and they can be used to reduce the future renourishment requirements needed to maintain a given template. Groin fields can present a risk of potential adverse effects on adjacent shorelines due to trapping sand that would d otherwise have naturally nourished downcoast beaches, or shunting sand offshore outside the limits of transport capabilities to return to the beach. Groins and groin fields often have high initial construction costs, and in most cases

would likely require extensive mitigation and monitoring. Accordingly, groins and groin fields were screened out from further consideration based upon their high implementation costs, likely adverse environmental effects and mitigation requirements, and the relative efficiency of beach re-nourishment as an alternative. .

- ***Terminal groin at Bogue Inlet***. Construction of a single terminal groin at Bogue Inlet was also considered as a preliminary measure. The terminal groin would still need to be built in conjunction with a beach fill, but would allow any beach fill template to be built all the way to the groin rather than tapering it off at about 1,000 ft prior to the inlet. The groin would also reduce erosion on the eastern side of the structure within the beach fill area, however the construction of a groin could increase erosion on the western (downdrift) side of the structure. This would increase the threat to any structures that would be west of the terminal groin. Additionally, any benefits of the terminal groin for storm damage reduction would likely not be substantial - the Bogue Inlet area has a low existing dune height and the groin would not prevent damages from wave attack or flooding. Also, the area around Bogue Inlet is currently accretionary, hence the trapping of additional sand is likely to provide only minimal reduction of erosion related damages. A terminal groin would also have a high initial construction cost as compared to a tapered berm in the area, and would likely incur significant mitigation and monitoring costs. Consequently, this measure was not carried further into detailed analysis.
- ***Seawalls, bulkheads, and revetments***. Seawalls, bulkheads, and revetments can be effective for reducing structural damage due to wave and water level attack; however in some cases they may actually induce beach erosion. Additionally, these hard structures are not readily adaptable to sea level rise. It is anticipated that these structures would have substantial adverse environmental effects with regard to endangered sea turtle utilization of the beach; these effects are not likely to be mitigated below a level of significance. These measures were not carried forward into detailed evaluation.
- ***Breakwaters.*** Breakwaters can be used in erosional hotspots where it is difficult to maintain a beach fill; however, no such condition appropriate for breakwaters was found in the study area. Moreover, while offshore breakwaters may reduce erosion in their lee, the benefits may be offset by accelerated erosion of the downdrift shoreline because of interruption of the littoral drift. Breakwaters were therefore not carried forward into detailed evaluation.
- ***Vegetation and sand fencing.*** Vegetation and sand fencing help retain windblown sand but do not provide adequate storm damage reduction for moderate to severe storms, and hence are not adequate as a stand-alone measure. However, any dune construction measure would also include appropriate vegetation planting therefore this measure was carried forward into detailed evaluation as part of the beach fill plans.

Based on the above analysis, hard structures were effectively screened out and not considered for further detailed analysis. In addition, the North Carolina Coastal Zone

Management Plan (CZMP) currently bans the building of hard structures for mitigating erosion along the state coast, except in limited cases. As such, any hardened structure proposed by the USACE for the project would face issues of public acceptability and would be difficult to implement.  Consequently, the only structural measures that were considered for detailed evaluation were beach fills.

Figure 5.1. Example of beach fill being constructed (Masonboro Island, NC).

### 5.05.2 Non-Structural Measures

Nonstructural measures considered in this analysis included changes in regulations and physical modifications to reduce damage.

- ***Floodplain and Building Code Regulations*****.** Regulatory measures include coastal building codes, building construction setbacks, and floodplain regulations. Most regulatory measures have already been instituted at the local level. These regulations provide indirect benefit to storm damage reduction, primarily to new and future construction. Although they are not carried into detailed evaluation as a stand-alone measure, they are considered as part of the existing and future without project conditions, and are an integral part of any final project alternatives.

- ***Removal (Retreat, Relocation and Demolition)*****.** Another non-structural measure consists of reduction of the damage threat by removing beachfront structures from the threat. Potential removal measures involve retreat, relocation, and/or demolition. Retreat consists of moving an existing structure away from the shoreline a short distance within the same property parcel. Relocation is achieved by moving an existing structure away from the shoreline to a vacant property. Acquisition of the property and demolition of the structure is a third measure where retreat or relocation is not feasible. As the Bogue Banks area is already near full build-out, and most parcels do not have adequate depth to move a structure back a significant distance within a parcel, the retreat and relocation non-structural measures were determined to be impractical and screened out from further consideration.

- ***Flood Proofing of Structures.*** Flood proofing of structures was evaluated in the first round of measure development, evaluation and screening. Elements of this measure could include water-tight sealing of doors, windows and other entry points, ensuring that utilities and infrastructure would not be damaged by floodwater, in some cases elevation of air conditioning units, or by elevation of entire structures. This measure (or group of measures) was determined to be technically infeasible due to the nature of much of the existing structure base. Most structures could not be flood proofed by these means due to the nature of materials used in construction, the lack of water-tight flooring and siding, and other issues; many other structures are already elevated above the level of the 1% chance event, and therefore, would not benefit from flood proofing except during very extreme storm or hurricane events. This measure was thus, screened from further consideration.

Based on this initial measures screening, only the No Action, Removal/Demolition Measure, and Beach Fill Measure carried forward into more detailed evaluation. The structural (Beach Fill) and non-structural measures can be applied independently or in combinations with each other to develop alternative plans.

## 5.06 Identification of Alternative Plans

### 5.06.1 Beach Fill Alternatives.

Beach fill plans were initially formulated to encompass the entire Bogue Banks shoreline, with the exception of coastal reach 13 (economic reach 118). This reach contains Fort Macon State Park and does not include any significant damageable elements. The two basic types of beach fills that were considered are a berm only and a berm and dune together. These beach fill plans will have tapered transition sections where needed, although these are not included in the initial comparison of alternatives.

***Dune and Berm Designs***. For all plans the berm elevation is kept at the elevation of the existing berm, which is either 5.5 ft or 7 ft (NAVD 88) depending on the location. All elevations for the current project in the main report and appendices reference NAVD 88. An artificially high berm would result in persistent scarping along the beach face and would not be environmentally desirable. The beach fill alternatives analyzed and modeled consisted of (1) alternatives containing combinations of different dune widths added to the front of the existing dune, coupled with different berm widths; and (2) berm-only plans which do not involve any dune construction.

Because of the large number of houses (i.e. >600) that have been built on top of the existing dune in the study area, these alternatives would require a large buyout of property, making them economically infeasible. The exception to this is in coastal reach 1 (part of Emerald Isle adjacent to Bogue Inlet), which has a relatively low dune with no houses on it. For this reach, alternatives which added to the existing dune height were also considered. All beach fill alternatives evaluated would not impact the structures currently built fully or partially on top of the dunes.  The final list of beach fill alternatives that were evaluated in detail can be found in Section 5.07 below.

***Potential Borrow Areas.*** Three offshore borrow locations were identified as sources for providing enough compatible material for a 50 year beach fill project. These three areas were depicted in Figure 1.1 earlier in this report, and consist of Borrow Area Y (approximately 1-3 miles offshore the western end of Bogue Banks), Borrow Area U (approximately 4-5 miles offshore of the center of Bogue Banks), and Q2 (approximately 3-5 miles offshore the eastern end of Bogue Banks). The costs of the beach fill alternatives considered in this study are based on dredging material from these three locations and transporting it to the closest location onshore.  The sediment compatibility of Bogue Inlet was also analyzed, however the use of Bogue Inlet was not further considered because of potential environmental issues and risks regarding the effects of dredging on the adjacent shorelines. Additional environmental and engineering evaluations would need to be conducted if Bogue Inlet were to be brought back into consideration as a sand source.

Detailed information on how these sites were characterized and their boundaries determined are contained in Appendix C (Geotechnical Engineering). A summary of the size and available borrow volumes for the three sites is shown in Table 5.1. These volumes account for the avoidance of any hardbottom areas. The available volume also incorporates a 1-foot vertical buffer. The vertical buffer may come into play if the bottom portions of useable material are being dredged, as hopper dredges generally have about a 1-foot tolerance with regards to accuracy. Additional geotechnical borings will be taken at these sites during the Preconstruction Engineering and Design (PED) phase of the study. Based on those results, the borrow area boundaries and available beach compatible volumes will likely be updated.

| Borrow Area | Depth (ft) | | | Footprint Area (acres) | Volume (mcy) |
|---|---|---|---|---|---|
| | Min | Max | Avg | | |
| Y | 2.2 | 7.6 | 4.4 | 1,100 | 4.6 |
| U | 1.4 | 4.0 | 2.8 | 3,450 | 8.9 |
| Q2 | 3.1 | 8.1 | 5.3 | 4,400 | 28.3 |
| Total | | | | | 41.8 |

Table 5.1. Depth, area, and volume of material at each of the three borrow sites.

* Borrow area Q2 is part of the Morehead City ODMDS, and hence is a place where placement of dredge material is acceptable. As such, the volume in Q2 may fluctuate in the future as additional dredged material is placed in the ODMDS.

***Beach Compatibility of Borrow Material***. Historical performance in North Carolina and other states has shown that borrow areas containing no more than 10 percent fines are generally compatible for placement on the beach. The State of North Carolina's Coastal Management Program includes the recent enactment of 15A NCAC 07H .0312 TECHNICAL STANDARDS FOR BEACH FILL PROJECTS (hereafter the NC Sediment Criteria), which are the standards that apply to non-Federal entities regarding placement of beach fill. Beach fill projects include beach nourishment, dredged material disposal, habitat restoration, storm protection, and erosion control. These Criteria have neither been submitted to nor approved by NOAA Office of Ocean and Coastal Resource Management, and therefore do not apply to Federal projects. The NC Sediment Criteria provide requirements for beach fill projects particularly with regard to characterization of sediment on the recipient beach and the sediment being placed. The NC Sediment Criteria standard for governing sediment compatibility for beach nourishment (defined differently than beach disposal from a navigation channel) states that "the average percentage by weight of fine-grained sediment (less than 0.0625 millimeters) in each borrow site shall not exceed the average percentage by weight of fine-grained sediment of the recipient beach characterization plus five (5) percent." The NC Sediment Criteria also states that "the average percentage by weight of calcium carbonate (shell) in a borrow site shall not exceed the average percentage by weight of calcium carbonate of the recipient beach characterization plus 15 percent." The NC Sediment Criteria is not a Federal requirement, but is provided to gain a perspective as to the quality of material in the borrow area which is proposed for placement as nourishment material on the beach. The Wilmington District will continue to use its best engineering judgment, accompanied by appropriate sampling and monitoring, to determine sediment compatibility.

The sediment characterization of the borrow material, as compared to that of the native beach is shown in Table 5.2. The amount of silt in the borrow areas (% passing #200) is well under 10%, and generally only about 1-2% higher than that of the native beach. The percentage of shell in the borrow areas is also well under 15%, and is also comparable to the percentage of shell on the native beach.

| Location | # of Samples | Mean (mm) | Std Dev (mm) | Mean (phi) | Std Dev (phi) | % Passing # 4 | % Passing # 10 | % Passing # 200* | % Visual Shell |
|---|---|---|---|---|---|---|---|---|---|
| ***Native Beach*** | | | | | | | | | |
| Ft. Macon | 34 | 0.21 | 0.57 | 2.23 | 0.80 | 99.8 | 99.0 | 1.6 | 10.9 |
| Atlantic Beach | 82 | 0.18 | 0.58 | 2.45 | 0.79 | 99.6 | 98.7 | 3.4 | 7.1 |
| Pine Knoll Shores | 102 | 0.19 | 0.57 | 2.41 | 0.81 | 99.4 | 98.4 | 3.6 | 8.9 |
| Indian Beach | 34 | 0.21 | 0.52 | 2.28 | 0.93 | 99.5 | 98.2 | 3.2 | 10.9 |
| East Emerald Isle | 47 | 0.20 | 0.60 | 2.3 | 0.74 | 99.6 | 98.8 | 2.6 | 6.3 |
| West Emerald Isle | 67 | 0.19 | 0.62 | 2.37 | 0.68 | 99.4 | 98.7 | 2.4 | 4.9 |
| Bogue Inlet Area | 51 | 0.19 | 0.70 | 2.4 | 0.52 | 99.6 | 99.6 | 1.9 | 4.0 |
| ***Borrow Areas*** | | | | | | | | | |
| Area Y | 8 | 0.28 | 0.54 | 1.84 | 0.90 | 92.1 | 87.7 | 4.2 | 8.2 |
| Area U | 13 | 0.23 | 0.58 | 2.1 | 0.79 | 98.6 | 96.2 | 4.8 | 11.9 |
| Area Q2 | 14 | 0.20 | 0.68 | 2.31 | 0.55 | 98.5 | 97.0 | 3.9 | 7.1 |

* % Passing #200 is comparable to % silt

Table 5.2. Grain size comparison of native beach and borrow material.

### 5.06.2 Removal/Demolition.

A “non-structural-only” alternative consisting of demolition of threatened structures across the entire study area was also identified for further evaluation. This alternative included buyout and demolition of all structures (i.e. >600) currently built fully or partially on top of the dunes.

### 5.06.3 Combination Plan/Structural and non-Structural.

This alternative would entail the combination of Removal/Demolition and Beach Fill.

### 5.06.4 No Action Alternative.

The No Action Alternative remains in the list of final alternative plans. The No Action Alternative would only be recommended if no other acceptable alternatives produced positive net economic benefits, or if other alternatives had unacceptable and unmitigable environmental effects.

## 5.07 Evaluation of Alternative Plans

This section discusses second-tier evaluation of alternative plans.

### 5.07.1 Beach fill Alternatives Evaluation

Nine beach fill alternatives were evaluated in a sequential process using the Beach-*fx* numerical model. The Beach-*fx* model is used to produce the benefits and borrow volumes needed for each alternative, however, it should be noted that the costs produced by the model and presented at this stage are for comparative purposes only, as they only factor in borrow placement costs, but not other miscellaneous costs (mobilization/de-mobilization, monitoring, tilling, walkway replacement, vegetation planting, real estate, administration, PED, etc). The miscellaneous costs will be fairly similar among the various beach fill alternatives, and hence their exclusion would not affect the comparison of alternatives. A full and detailed project cost was only developed for the Recommended Plan. This final cost will inevitably be higher than the costs presented during the alternatives comparison.

A four year renourishment cycle was specified for these initial screening comparative runs (a three year interval was selected for the NED plan as indicated in section 5.08.2). Descriptions of each of these alternatives are presented in Table 5.3. Alternatives 1-5 were analyzed initially. These alternatives were chosen based on an assessment as to what general dimensions of a beach fill plan might be economically viable, gleaned from previous experience with other coastal storm damage studies in North Carolina. Based on analysis of the results from those 5 alternatives, alternatives 6-8 were developed and run in order to better "bracket" the plan with the highest average annual net storm damage reduction benefits. Bracketing is to determine whether or not a larger or smaller sized alternative would not produce greater net benefits than the alternatives that were already run. The net benefits are the average annual reduction of structure, content, and land loss damages (as compared to the without project condition), minus the average annual costs of the alternative. A full display of these values for each of the alternatives is included in Appendix B (Economics, Parking and Access).

In some reaches, the highest net benefits are achieved through a larger plan which includes dune construction, and in other reaches, the highest net benefits are produced with a "berm only" plan, where the dune is not renourished (see Appendix B for details). Therefore, a 9$^{th}$, "hybrid" alternative, was also created and analyzed. The hybrid alternative was designed, based on the output from the other 8 alternatives, to generally maximize benefits across the entire study area while also maintaining a fairly consistent profile template (for instance, by not varying the plan within a single coastal reach) for engineering and construction purposes. Varying the template too much would create "bulges" in the shoreline that would be difficult to maintain.

It should be noted that the berm widths in the analyzed alternatives do not include any advanced maintenance. Advanced maintenance is additional berm width that is placed in front of the design berm in order to ensure the design berm does not fall below a certain width prior to renourishment. Therefore, with advanced maintenance, a 50-ft berm plan would maintain a *minimum* 50 ft berm width for the entire period of Federal participation. However, in this study, a 50-ft berm would be constructed to equilibrate to a *maximum* of 50 ft. The berm would erode and then be built back to 50 ft during each renourishment cycle. The advanced nourishment practice used to be necessary on older USACE CSDR projects to ensure the probability design analysis assumption that the design template was always in place when a storm struck was valid. The old probability analysis did not include benefits for the advanced nourishment but it did include the cost of the advance nourishment. The present analysis allows for the evolution of the design template between renourishments and both the benefits and costs of all the sand placed on the beach are accounted for. It should be noted that since the design template can be degraded the character of the beach can change if the renourishment interval extends too long.

| | | Existing Condition (2010 profile) | | | Alternative 1 | | | Alternative 2 | | | Alternative 3 | | | Alternative 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Profiles based on 2010 survey | | | 50 ft berm width throughout project,5-10 ft dune width additions in reaches 2-12, 2 ft dune height addition in Reach 1 | | | 50 ft berm width throughout project, 10-20 ft dune width additions in reaches 2-12, 2 ft dune height and 10 ft dune width addition in Reach 1 | | | 50 ft berm width throughout project, 20-30 ft dune width additions in reaches 2-12, 4 ft dune height addition in Reach 1 | | | 100 ft berm width throughout project,5-10 ft dune width additions in reaches 2-12, 2 ft dune height addition in Reach 1 | | |
| **Coastal Reach** | **Economic Reaches** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** |
| 1 | 1-10 | 11 | 95 | 135 | 13 | 95 | 50 | 13 | 105 | 50 | 15 | 95 | 50 | 13 | 95 | 100 |
| 2 | 11-15 | 15 | 15 | 125 | 15 | 25 | 50 | 15 | 35 | 50 | 15 | 45 | 50 | 15 | 25 | 100 |
| 3 | 16-20 | 20 | 5 | 70 | 20 | 10 | 50 | 20 | 15 | 50 | 20 | 25 | 50 | 20 | 10 | 100 |
| 4 | 21-29 | 26 | 25 | 85 | 26 | 30 | 50 | 26 | 35 | 50 | 26 | 45 | 50 | 26 | 30 | 100 |
| 5 | 30-42 | 20 | 25 | 70 | 20 | 30 | 50 | 20 | 35 | 50 | 20 | 45 | 50 | 20 | 30 | 100 |
| 6 | 43-52 | 22 | 15 | 55 | 22 | 20 | 50 | 22 | 25 | 50 | 22 | 35 | 50 | 22 | 20 | 100 |
| 7 | 53-58 | 28 | 90 | 65 | 28 | 95 | 50 | 28 | 100 | 50 | 28 | 110 | 50 | 28 | 95 | 100 |
| 8 | 59-73 | 18 | 100 | 80 | 18 | 105 | 50 | 18 | 110 | 50 | 18 | 120 | 50 | 18 | 105 | 100 |
| 9 | 74-85 | 20 | 30 | 65 | 20 | 35 | 50 | 20 | 40 | 50 | 20 | 50 | 50 | 20 | 35 | 100 |
| 10 | 86-92 | 18 | 100 | 65 | 18 | 105 | 50 | 18 | 110 | 50 | 18 | 120 | 50 | 18 | 105 | 100 |
| 11 | 93-110 | 18 | 10 | 75 | 18 | 15 | 50 | 18 | 20 | 50 | 18 | 30 | 50 | 18 | 15 | 100 |
| 12 | 111-117 | 14 | 40 | 30 | 14 | 50 | 50 | 14 | 50 | 50 | 14 | 60 | 50 | 14 | 50 | 100 |

| | | Alternative 5 | | | Alternative 6 | | | Alternative 7 | | | Alternative 8 | | | Alternative 9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50 ft berm width throughout project, no dune additions (berm only plan) | | | 75 ft berm width throughout project, no dune additions (berm only plan) | | | 50 ft berm width throughout project, 20-30 ft dune width additions in reaches 3-12, 35 ft dune width addition in reach 2, 5 ft dune height addition in Reach 1 | | | 50 ft berm width throughout project, 20-30 ft dune width additions in reaches 3-10,12, 40 ft dune width addition in reach 11, 6 ft dune height addition in Reach 1 | | | 50 ft berm width throughout project, 30 ft dune width addition in reach 2 and 11, 5 ft dune width addition in reach 3, 5 ft dune height addition in reach 1 | | |
| **Coastal Reach** | **Economic Reaches** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** | **Dune Height** | **Dune Width** | **Berm Width** |
| 1 | 1-10 | x | x | 50 | x | x | 75 | 16 | 95 | 50 | 17 | 95 | 50 | 16 | 95 | 50 |
| 2 | 11-15 | x | x | 50 | x | x | 75 | 15 | 50 | 50 | 15 | 50 | 50 | 15 | 45 | 50 |
| 3 | 16-20 | x | x | 50 | x | x | 75 | 20 | 25 | 50 | 20 | 25 | 50 | 20 | 10 | 50 |
| 4 | 21-29 | x | x | 50 | x | x | 75 | 26 | 45 | 50 | 26 | 45 | 50 | x | x | 50 |
| 5 | 30-42 | x | x | 50 | x | x | 75 | 20 | 45 | 50 | 20 | 45 | 50 | x | x | 50 |
| 6 | 43-52 | x | x | 50 | x | x | 75 | 22 | 35 | 50 | 22 | 35 | 50 | x | x | 50 |
| 7 | 53-58 | x | x | 50 | x | x | 75 | 28 | 110 | 50 | 28 | 110 | 50 | x | x | 50 |
| 8 | 59-73 | x | x | 50 | x | x | 75 | 18 | 120 | 50 | 18 | 120 | 50 | x | x | 50 |
| 9 | 74-85 | x | x | 50 | x | x | 75 | 20 | 50 | 50 | 20 | 50 | 50 | x | x | 50 |
| 10 | 86-92 | x | x | 50 | x | x | 75 | 18 | 120 | 50 | 18 | 120 | 50 | x | x | 50 |
| 11 | 93-110 | x | x | 50 | x | x | 75 | 18 | 40 | 50 | 18 | 50 | 50 | 18 | 40 | 50 |
| 12 | 111-117 | x | x | 50 | x | x | 75 | 14 | 60 | 50 | 14 | 60 | 50 | x | x | 50 |

Table 5.3. Descriptions of the 9 beach fill alternatives that were evaluated. An ‘x’ indicates no Federal maintenance of the dune feature.

### 5.07.2 Non-structural Alternative Evaluation

One "non-structural only" alternative (alternative 10) was analyzed in detail. The screening process for other alternatives is described in Section 5.05. The non-structural alternative entailed the buyout and demolition of vulnerable properties. The structures included in the analysis are generally those in the first row from the ocean. Those structures further landward from the shoreline are not likely to be as severely threatened for several decades and therefore are not included in the analysis. Of the 1,764 active structures in the structure database, 1,071 were considered for the non-structural alternative. Several broad assumptions were necessary to make a manageable evaluation of the plan. These assumptions include an identical demolition cost across all properties, 100% compliance by property owners, and immediate implementation at the start of the project. A "timed" implementation, where structures would only be removed as they became more vulnerable, would reduce the cost of the plan but would also reduce benefits. The goal of this screening level evaluation was to estimate if a non-structural measure or plan would a) be economically feasible and b) if it was economically feasible, the magnitude of net benefits would be comparable to those derived from a structural plan. A more refined non-structural analysis would only be conducted if *a* and *b* were found to be true through the initial analysis.

The benefits of the non-structural plan were measured by removing all first row structures from the structure file, then running the without project condition again in Beach-*fx*. The difference in average annual damages between this run and the future without project condition with all structures in place is the benefit of the non-structural plan.

The costs of the non-structural plan included structure acquisition cost, a land value acquisition cost, and a demolition/removal cost. These were the only costs used in the analysis. The replacement cost minus depreciation value of the structure from the structure database was also used as the structure acquisition cost. The replacement cost minus depreciation value likely underestimates the actual structure acquisition cost, but was used because those numbers were readily available. For simplification, an identical demolition/removal and land value acquisition cost was used for every structure and lot. Based on the average costs of some demolition/removal activities that took place recently at North Topsail Beach, NC, a $100,000 per lot demolition/removal cost was used in this analysis. An average lot acquisition value of $650,000 was used, which was based on a survey of recent beachfront property real estate comparisons from the Bogue Banks area.

### 5.07.3 Combined Structural/Non-Structural Alternative Evaluation

A combined structural/non-structural alternative would involve structure removal in parts of a study area, and beach fill in other parts (See section 5.05.2). Generally, in a combined plan, the non-structural aspects would have to be implemented at the "ends" of a project or along a lengthy, contiguous stretch of beach, so as not to leave unsustainable small gaps in between the areas where the structural alternative is implemented. Unsustainable small gaps are defined as areas of insufficient length to accommodate necessary transitions between the project and existing conditions. The non-structural analysis showed only 5 reaches that had positive net benefits: 78, 89, 93, 106 and 114 (see Appendix B). The combined structural/non-structural alternative would have 1000 foot sections where the dune and berms would not be constructed and/or maintained. Therefore, there is no viable combined structural/non-structural alternative, and such a plan is screened from further consideration. Further discussion is included in Appendix B, Attachment 4, Addendum 2.

### 5.07.4 NED Comparison of Alternatives

The average annual NED costs, benefits, and net benefits of each of the beach fill alternatives and the non-structural alternative analyzed are shown in Table 5.4. A detailed breakdown of costs and benefits for each alternative by each reach is contained in Appendix B. The alternative with the highest net benefits is Alternative 9, the "hybrid" alternative.

| Alternative | AA Benefits | AA Costs | AA Net Benefits |
|---|---|---|---|
| No Action | $0 | $0 | $0 |
| 1 | $9,600,000 | $3,173,000 | $6,427,000 |
| 2 | $10,209,000 | $3,564,000 | $6,645,000 |
| 3 | $11,644,000 | $4,428,000 | $7,216,000 |
| 4 | $10,493,000 | $6,145,000 | $4,348,000 |
| 5 | $8,667,000 | $2,715,000 | $5,952,000 |
| 6 | $9,031,000 | $4,049,000 | $4,982,000 |
| 7 | $12,022,000 | $4,594,000 | $7,428,000 |
| 8 | $12,114,000 | $4,770,000 | $7,344,000 |
| 9 | $11,249,000 | $3,333,000 | $7,916,000 |
| 10 (Non-Structural) | $11,080,000 | $58,873,000 | ($47,793,000) |

Table 5.4. Comparison of alternative average annual (AA) costs and benefits, October 2010 price level, FY 2011 interest rate (4.125%). Interest rate used was current at the time of analysis.

### 5.07.5 Incremental Plan Justification

According to ER-1105-2-100, plans should be incrementally justified, meaning that the benefits of each added increment of the plan should exceed the costs of that increment. In the case of this study, these increments are additional lengths of beach, as represented by the 117 economic reaches used in the analysis. It should be noted that with beach fill projects, small unjustified increments that are bordered by justified reaches on either side may still be included as part of the project, since having short gaps in the project is undesirable and unsustainable from a coastal engineering perspective. If the reach is unjustified due to a lack of damageable structures, then that portion of the project would be paid for at 100% non-Federal expense if the area remains undeveloped prior to the signing of a Project Partnership Agreement (PPA) for construction. Greater than 50% of the benefits used to justify a reach (i.e., to achieve a benefit/cost ratio (BCR) of > 1) needs to come from coastal storm damage reduction benefits. The remainder can come from any recreation benefits realized. Once a BCR of >1 is achieved, then all recreation benefits can be claimed, even if they exceed the storm damage reduction benefits. For discussion of recreation benefits calculations for this study, see Appendix B or Section 6.07.2 of this report.

The 117 economic reaches used in the alternatives analysis were used as the basis for demonstrating incremental justification. Table 5.5 shows the costs and benefits (split out by storm damage reduction and recreation) at each of these reaches for Alternative 9, which is the plan with the highest storm damage reduction benefits. As shown in this table, reaches 23 and 56 are not economically justified; however, as these reaches are too short for adequate transition features, they must be included in the proposed project. Therefore, the entire length of beach analyzed (reaches 1-117) is incrementally justified and are included as part of the selected plan.

| Reach | Total Benefits(AA) - Storm Damage Reduction Only | AA Recreation Benefits | Total Cost (AA) | Total Net Benefits (AA) | Reach | Total Benefits(AA) - Storm Damage Reduction Only | AA Recreation Benefits* | Total Cost (AA) | Total Net Benefits (AA) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | $91,813 | $42,934 | $11,908 | $122,839 | 60 | $26,424 | $7,086 | $22,580 | $10,930 |
| 2 | $86,464 | $30,638 | $8,401 | $108,701 | 61 | $31,561 | $8,773 | $22,072 | $18,262 |
| 3 | $100,207 | $50,453 | $13,851 | $136,809 | 62 | $441,437 | $10,014 | $20,985 | $430,466 |
| 4 | $118,703 | $39,651 | $10,916 | $147,438 | 63 | $47,423 | $13,754 | $35,798 | $25,380 |
| 5 | $183,140 | $67,147 | $18,498 | $231,789 | 64 | $11,973 | $4,140 | $9,672 | $6,442 |
| 6 | $194,276 | $54,137 | $18,182 | $230,231 | 65 | $21,791 | $1,808 | $4,461 | $19,138 |
| 7 | $83,912 | $60,399 | $38,073 | $106,237 | 66 | $49,686 | $14,409 | $41,846 | $22,250 |
| 8 | $60,692 | $50,051 | $40,257 | $70,487 | 67 | $16,431 | $5,242 | $13,243 | $8,430 |
| 9 | $63,339 | $49,161 | $36,492 | $76,007 | 68 | $19,621 | $5,526 | $15,884 | $9,262 |
| 10 | $33,691 | $30,950 | $23,372 | $41,269 | 69 | $65,598 | $13,335 | $41,603 | $37,329 |
| 11 | $62,729 | $40,225 | $14,910 | $88,044 | 70 | $180,912 | $10,708 | $26,192 | $165,427 |
| 12 | $93,616 | $65,765 | $23,917 | $135,464 | 71 | $63,846 | $11,373 | $34,050 | $41,169 |
| 13 | $106,212 | $76,842 | $34,783 | $148,271 | 72 | $53,578 | $11,388 | $29,950 | $35,016 |
| 14 | $100,422 | $65,629 | $24,973 | $141,078 | 73 | $27,779 | $7,842 | $20,021 | $15,600 |
| 15 | $176,199 | $84,412 | $26,836 | $233,774 | 74 | $40,795 | $12,395 | $33,151 | $20,040 |
| 16 | $35,610 | $35,358 | $14,572 | $56,395 | 75 | $19,700 | $9,611 | $16,791 | $12,520 |
| 17 | $79,132 | $50,938 | $18,883 | $111,187 | 76 | $63,453 | $3,851 | $6,219 | $61,085 |
| 18 | $37,010 | $58,163 | $20,073 | $75,101 | 77 | $22,570 | $9,864 | $20,596 | $11,838 |
| 19 | $37,600 | $56,167 | $18,380 | $75,387 | 78 | $743,560 | $8,375 | $30,615 | $721,320 |
| 20 | $55,160 | $84,702 | $17,082 | $122,780 | 79 | $131,853 | $9,988 | $33,592 | $108,249 |
| 21 | $20,764 | $12,705 | $1,189 | $32,280 | 80 | $76,018 | $6,163 | $18,526 | $63,654 |
| 22 | $6,205 | $13,811 | $807 | $19,209 | 81 | $48,527 | $9,988 | $32,900 | $25,616 |
| 23 | $0 | $0* | $671 | ($671) | 82 | $34,146 | $8,841 | $28,963 | $14,023 |
| 24 | $2,196 | $14,247 | $370 | $16,073 | 83 | $175,466 | $14,092 | $53,801 | $135,757 |
| 25 | $471 | $17,622 | $601 | $17,492** | 84 | $140,956 | $13,749 | $52,477 | $102,228 |
| 26 | $530 | $13,830 | $351 | $14,009 | 85 | $100,806 | $14,061 | $62,221 | $52,646 |
| 27 | $2,432 | $17,999 | $1,157 | $19,274 | 86 | $77,559 | $13,613 | $71,040 | $20,132 |
| 28 | $1,213 | $15,836 | $642 | $16,407 | 87 | $280,848 | $17,271 | $95,043 | $203,076 |
| 29 | $478 | $9,183 | $390 | $9,270 | 88 | $42,944 | $9,935 | $49,304 | $3,575** |
| 30 | $15,577 | $10,467 | $3,884 | $22,160 | 89 | $227,147 | $7,945 | $37,376 | $197,715 |
| 31 | $7,188 | $11,964 | $3,816 | $15,335 | 90 | $81,587 | $8,132 | $45,337 | $44,383 |
| 32 | $10,433 | $10,697 | $3,950 | $17,180 | 91 | $82,521 | $8,726 | $54,305 | $36,942 |
| 33 | $9,618 | $14,260 | $4,278 | $19,600 | 92 | $269,274 | $15,839 | $87,901 | $197,212 |
| 34 | $5,848 | $8,228 | $3,017 | $11,060 | 93 | $1,102,082 | $92,898 | $72,959 | $1,122,021 |
| 35 | $28,155 | $14,404 | $6,700 | $35,860 | 94 | $91,095 | $85,137 | $55,560 | $120,672 |
| 36 | $5,846 | $9,077 | $2,716 | $12,207 | 95 | $108,336 | $71,309 | $37,487 | $142,158 |
| 37 | $15,319 | $13,536 | $5,262 | $23,593 | 96 | $93,600 | $63,971 | $31,881 | $125,690 |
| 38 | $14,580 | $14,301 | $4,519 | $24,363 | 97 | $129,465 | $79,427 | $36,389 | $172,503 |
| 39 | $20,291 | $10,179 | $3,386 | $27,085 | 98 | $112,838 | $87,526 | $50,436 | $149,927 |
| 40 | $117,555 | $16,351 | $6,203 | $127,703 | 99 | $100,416 | $47,653 | $30,454 | $117,615 |
| 41 | $20,814 | $15,835 | $5,849 | $30,800 | 100 | $121,390 | $60,294 | $39,076 | $142,608 |
| 42 | $19,179 | $10,466 | $5,536 | $24,109 | 101 | $131,636 | $80,614 | $50,005 | $162,245 |
| 43 | $79,577 | $18,910 | $46,300 | $52,187 | 102 | $83,403 | $54,236 | $36,390 | $101,250 |
| 44 | $61,648 | $12,770 | $38,781 | $35,636 | 103 | $160,850 | $62,699 | $40,608 | $182,941 |
| 45 | $98,045 | $15,817 | $64,646 | $49,217 | 104 | $116,709 | $65,541 | $35,181 | $147,069 |
| 46 | $61,964 | $10,527 | $34,024 | $38,467 | 105 | $65,305 | $53,756 | $29,963 | $89,098 |
| 47 | $55,570 | $10,635 | $31,580 | $34,626 | 106 | $254,736 | $29,311 | $15,163 | $268,884 |
| 48 | $44,442 | $10,536 | $30,642 | $24,336 | 107 | $108,172 | $52,942 | $27,664 | $133,450 |
| 49 | $45,484 | $10,582 | $27,881 | $28,185 | 108 | $72,544 | $52,942 | $32,242 | $93,244 |
| 50 | $27,827 | $8,171 | $19,186 | $16,811 | 109 | $79,193 | $52,536 | $38,112 | $93,616 |
| 51 | $9,083 | $4,977 | $10,172 | $3,888** | 110 | $88,402 | $48,467 | $42,493 | $94,376 |
| 52 | $35,706 | $15,132 | $41,302 | $9,536** | 111 | $73,347 | $68,415 | $45,049 | $96,713 |
| 53 | $50,068 | $15,305 | $55,050 | $10,002** | 112 | $88,947 | $108,961 | $78,752 | $119,156 |
| 54 | $41,063 | $4,097 | $13,351 | $31,809 | 113 | $66,276 | $69,405 | $53,121 | $82,561 |
| 55 | $73,156 | $9,704 | $34,475 | $48,385 | 114 | $142,422 | $64,676 | $56,506 | $150,591 |
| 56 | $25,754 | $8,356 | $35,164 | ($1,053) | 115 | $414,591 | $66,114 | $61,187 | $419,518 |
| 57 | $8,899 | $3,724 | $11,203 | $1,420** | 116 | $679,570 | $47,908 | $50,326 | $677,151 |
| 58 | $23,526 | $10,852 | $28,179 | $6,199** | 117 | $140,906 | $50,064 | $60,787 | $130,183 |
| 59 | $38,874 | $12,433 | $34,806 | $16,501 | | | | | |

*For the purposes of demonstrating project justification only, the recreation benefits at this reach are capped at the storm damage reduction benefit.

** Recreation benefits needed at this reach to bring BCR > 1

Table 5.5. Values used for incremental plan justification, Alternative 9. October 2010 price levels, FY 2011 interest rate (4.125%).

### 5.07.6 Comparison of Alternatives by RED, EQ, OSE Accounts and P&G criteria

In addition to the NED comparison shown in Section 5.07.4, alternative plans should also be compared based on potential impacts to Regional Economic Development (RED), Environmental Quality (EQ), Other Social Effects (OSE) and Planning and Guidance (P&G) criteria. Although there could be some differences among the various beach fill alternatives as it relates to RED, EQ, OSE, and P&G, these differences would be minor and would not affect plan selection. Thus, for the purposes of the RED, EQ, OSE and P&G evaluation the beach fill alternatives were lumped together into one category, to be compared to the non-structural Removal/Demolition alternative and No-Action alternatives. These comparisons are contained in Tables 5.6, 5.7, 5.8 and 5.9 below.

| Account: RED | | | |
|---|---|---|---|
| | Alternative | | |
| **Item** | **Beachfill** | **Nonstructural** | **No Action** |
| **Sales Volume** | Rental sales and tourism sales preserved or increased | Reduced rental market and tourism market | Similar to nonstructural, although likely to occur at a slower pace |
| **Income** | Increased recreation visitation may improve the income of service industries and rental properties | Decreased recreation visitation may reduce the income of service industries and rental properties | Similar to nonstructural, although likely to occur at a slower pace |
| **Employment** | Seasonal employment may increase due to increased recreation visitation. Temporary increase in employment related to construction activities | Seasonal employment may decrease due to decreased recreation visitation. Temporary increase in employment related to structure removals | Seasonal employment may decrease due to decreased recreation visitation |
| **Tax Changes** | Tax base and property values preserved or increased | Loss of tax base due to numerous structures being removed | Loss of tax base when houses are destroyed and cannot be rebuilt |

Table 5.6. RED comparison of alternatives.

| Account: EQ | | | | |
|---|---|---|---|---|
| | | Alternative | | |
| **Item** | **Sub-Item** | **Beachfill** | **Nonstructural** | **No Action** |
| **Marine Environment** | **Benthic Resources - Nearshore Ocean** | Short term impacts to benthic macro-invertebrates associated with dredging activities | Status quo maintained | Status quo maintained |
| | | Risk of demersal fish entrainment by dredging activities | | |
| | **Benthic Resources - Beach and Surf Zone** | Short term and localized impact to surf zone benthic macro-invertebrate community from direct burial and turbidity associated with beach placement of sediment | Short term reduction in surf zone habitat and benthic macro-invertebrate abundance due to erosion, scarping, and scour of beach habitat towards existing infrastructure (i.e. roads) and short term stabilization techniques (i.e. sand bags). | Long term reduction in surf zone habitat and benthic macro-invertebrate abundance due to erosion and scour of beach habitat towards existing homes, infrastructure (i.e. roads), and short term stabilization techniques (i.e. sand bags). |
| | **Turbidity** | Short term impacts to adult, larval, and juvenile surf zone fishes from elevated turbidity levels associated with beach placement of sediment and dredging activities.activities. | Status quo maintained | Status quo maintained |
| | **EFH-HAPC** | Short term impacts to the physiography of borrow areas | Status quo maintained | Status quo maintained |
| **Terrestial Environment** | **Beach and Dune** | Short term impacts to portions of the existing dune vegetation during construction | Long term degradation of beach habitat due to continued erosion of the berm and dune | Long term degradation of beach habitat due to continued erosion of the berm and dune |
| | | Long term sustainability of dune habitat for nesting sea turtles and other dependent mammal and avian species | | |
| | | Short term impacts to ghost crabs and their beach an dune habitat with long term sustainability of habitat | Short term impacts to ghost crabs and their beach and dune habitat from short term resotarion protection measures (ie, beach scraping, sand bags, dune stabilization) | Short term impacts to ghost crabs and their beach and dune habitat from short term resotarion protection measures (ie, beach scraping, sand bags, dune stabilization) |
| | **Shorebird Habitat** | Short term impacts to shorebird foraging due to a temporary reduction in surf zone macro-invertebrate forage base associated with construction | Short term reduction in surf zone habitat and benthic macro-invertebrate abundance due to erosion, scarping, and scour of beach habitat towards existing infrastructure (i.e. roads) and short term stabilization techniques (i.e. sand bags). | Long term reduction in surf zone habitat and benthic macro-invertebrate abundance due to erosion and scour of beach habitat towards existing homes, infrastructure (i.e. roads), and short term stabilization techniques (i.e. sand bags). |
| | | Prevention of overwash fan habitat for shorebirds form constructed dune | Short term creation of available overwash fan habitat for shorebirds with loss to development in the long term | Short term creation of available overwash fan habitat for shorebirds with loss to development in the long term |

Table 5.7. EQ comparison of alternatives
(part 1 of 2).

| Account: EQ | | | | |
|---|---|---|---|---|
| | | Alternative | | |
| Item | Sub-Item | Beachfill | Nonstructural | No Action |
| **Threatened and Endangered Species** | **Sea Turtles** | Short term decrease in sea turtle nest success associated with changes to the physical characteristics of the beach<br>Long term sustainability of sea turtle nesting habitat due to preservation of the beach berm | Long term decrease in sea turtle nesting habitat and nest success due to beach erosion, scarping and scouring of the dune | Long term decrease in sea turtle nest success due to beach erosion, scarping and scouring of the dune |
| | | Long term reduction of beach lighting impacts to sea turtles from constructed dune<br>Risk of sea turtle entrainment from hopper dredge | Risk of increased beach lighting impacts to sea turtles as dune erodes | Risk of increased beach lighting impacts to sea turtles as dune erodes |
| | **Sea Beach Amaranth** | Deep burial of seeds during construction may slow germination and population recovery over the short-term. | Conditions may be improved by reduced disturbance and maintenance of dynamic sea beach amaranth habitat. | Long term loss of sea beach amaranth habitat as beach erodes. |
| | | Long term benefits of increased available sea beach amaranth habitat | Long term loss of sea beach amaranth habitat as beach erodes. | |
| | **Atlantic Sturgeon** | Risk of Atlantic sturgeon entrainment from hopper dredged. | Status quo maintained | Status quo maintained |
| | **Piping Plover** | Short term impact to piping plover foraging, sheltering, and roosting areas. Long term preservation of these areas. | Short term gain in sheltering and roosting areas associated with storm driven washover fans. Long term loss of habitat areas as beach erodes. | Short term gain in sheltering and roosting areas associated with storm driven washover fans. Long term loss of habitat areas as beach erodes. |
| **Cultural Resources** | | Slight risk of encountering resources associated with beach placement and borrow area dredging, although risk in dredging areas is minimal since they have been surveyed. Long-term protection of potential resources that would be affected by natural processes. | Potential resources would continue to be vulnerable to natural processes. | Potential resources would continue to be vulnerable to natural processes. |
| **Water Quality** | | Short term and localized elevated turbidity and suspended solid levels offshore and in the surf zone environments associated with dredging and beach placement activities | Status quo maintained | Status quo maintained |
| **Air Quality** | | Temporary air pollutant increase associated with dredging and heavy equipment during initial construction and then every three years during renourishment events | Temporary air pollutant increase associated with heavy equipment during structure demolition and removal | Status quo maintained |
| **Noise Quality** | | Temporary noise increase associated with dredging and heavy equipment during initial construction and then every three years during renourishment events | Temporary noise increase associated with heavy equipment during structure demolition and removal | Status quo maintained |
| **Recreational and Aesthetic Resources** | | Improved appearance of beach would enhance recreational experience, and wider berm would increase recreational area | A more natural appearance along the beach that may be valued more by some users. | Recreation capacity would decrease as beach erodes |
| | | Temporary inconvenience to beach users during initial construction and future maintenance, although these would occur during low visitation months (Winter) | Recreation capacity would decrease as beach erodes<br>Temporary inconvenience to beach users during removal and demolition of structures | |
| **Marine Mammals** | | Short-term impacts to foraging. | Status quo maintained. | Status quo maintained. |
| **Physical Processes** | | Evolving profile advances seaward into deeper water until it approaches equilibrium. | Status quo maintained. | Status quo maintained. |

Table 5.7 (continued). EQ comparison of alternatives (part 2 of 2).

| Account: OSE | | | |
|---|---|---|---|
| | **Alternative** | | |
| **Item** | **Beachfill** | **Nonstructural** | **No Action** |
| **Life, Health, and Safety** | Significant reduction in stress related to concern of amount of damage and recovery during and after storms. Evacuation would still be required before storm landfall. | Moderate reduction in stress related to concern of amount of damage and recovery during and after storms. Evacuation would still be required before storm landfall. | No change. Continued stress during damaging storms. Evacuation would still be required before storm landfall. |
| **Community Cohesion** | Reduces displacements of all permanent residents and visitors. | Permanently displaces oceanfront residents/visitors. Periodic displacement of other residents. | Periodic displacement of all permanent residents and visitors. |
| **Community Growth** | Growth trends in population and recreation visitation would continue. | Permanent population will decrease once oceanfront lots are vacated. Overall recreation visitation would likely decrease as the beachfront erodes away. | Recreation visitation would likely decrease as the beachfront erodes away. Permanent population would likely decrease as lots are abandoned. |
| **Traffic and Transportation** | Reduces damages to streets and highways. Minor, short term increase in boat traffic due to dredging operations during initial construction and renourishments. | Continued risks to streets and highways | Continued risks to streets and highways |
| **Community Growth** | Growth trends in population and recreation visitation would continue. | Permanent population will decrease once oceanfront lots are vacated. Overall recreation visitation would likely decrease as the beachfront erodes away. | Recreation visitation would likely decrease as the beachfront erodes away. Permanent population would likely decrease as lots are abandoned. |
| **Environmental Justice** | No effect | No effect | No effect |

Table 5.8. OSE comparison of alternatives

| Account: P&G Criteria | | | |
|---|---|---|---|
| | **Alternative** | | |
| **Item** | **Beachfill** | **Nonstructual** | **No Action** |
| **Acceptability** | Acceptable to state and local entities and is compliant w ith existing law s, regulations, and policies. | Acceptable to state and local entities and is compliant w ith existing law s, regulations, and policies, but is not feasible and w ill not meet the planning objective of reducing the risk of coastal storm damages. | Would continue to be acceptable to state and local entities and is compliant w ith existing law s, regulations, and policies, but w ill not meet the planning objective. |
| **Completeness** | Complete solution. | Not a complete solution because it is not feasible and w ill not meet the planning objective. | Not be a complete solution because it w ould not meet the planning objective. |
| **Effectiveness** | An effective solution because it meets the planning objective. | Not an effective solution because it w ill not achieve the project objective. | Would have no effect on achieving the planning objective. |
| **Efficiency** | Most cost efficient alternative for meeting the planning objective. | Not an efficient solution because it w ill not achieve the project objective. | Not efficient because it does not contribute to planning objective. |

Table 5.9 P&G criteria comparison of alternatives

## 5.08 Plan Selection

### 5.08.1 Identification of NED Plan

Based on the results of the analysis presented in Section 5.07, Alternative 9 is identified as the NED Plan, as it is the alternative with the highest net benefits. The dimensions of the NED plan are summarized in Section 6.01 later in the report.

### 5.08.2 Identification of NED Renourishment Interval

Once the NED Plan was identified as a beach fill alternative of specific dimension, the renourishment interval that maximizes net benefits for that alternative was then identified. Alternative 9 was run again through Beach-*fx* at 3,4, and 5 year renourishment cycles. Renourishment intervals of less than 3 years were not considered, in order to allow adequate environmental recovery time for the beaches. For this comparison, some other updates were also made to the Beach-*fx* modeling runs, which were – a) the FY 2012 interest rate of 4.000% was used, b) plan form rates (i.e., erosion at the ends of the project) were incorporated into the model, and c) reaches 1-3 (adjacent to Bogue Inlet) were modeled as a berm transition zone, as maintaining the full NED Plan template next to the inlet is impractical. The costs included for this comparison include placement plus mobilization/demobilization costs. Table 5.10 shows the results of this analysis.

| Interval (yrs) | Average Annual Benefits | Average Annual Costs | Average Annual NET Benefits |
|---|---|---|---|
| 3 | $11,511,000 | $4,394,000 | $7,117,000 |
| 4 | $11,277,000 | $4,222,000 | $7,055,000 |
| 5 | $11,114,000 | $4,076,000 | $7,038,000 |

Table 5.10. Comparison of benefits and costs for different renourishment intervals. October 2010 price levels, FY 2012 interest rate (4.000%). Price levels only valid for time of comparison.

The 3-year interval has the highest net benefits and is therefore the NED renourishment interval. Because net benefits declined going from a 3 to 4 to 5 year cycle, renourishment cycles of longer than 5-years were not analyzed. The 3-year cycle means the project would be potentially eligible for renourishment every 3 years following initial construction; however, a renourishment event would not occur in areas of the project that were found to be already at or above the design template at the time of survey update. In the Beach-*fx* model, renourishments were only triggered at the designated interval time if either a) the berm eroded to less than 75% of the berm design width, b) the dune eroded to less than 90% of the dune design width, or c) the dune eroded to less than 85% of the dune design height.

### 5.08.3 Identification of a Locally Preferred Plan (LPP)

No Locally Preferred Plan has been identified at this time, as the non-Federal sponsor is in support of moving forward with the NED Plan as the Recommended Plan.

## 5.09 Value Engineering

A Value Engineering (VE) workshop was held 16-18 September 2013 and employed the six-phase Value Engineering Job Plan as sanctioned by USACE and the Society of American Value Engineers International (SAVE). These phases include: Information, Function Analysis, Creativity, Evaluation, Development and Presentation. The VE Team was comprised of USACE Team Members from the Jacksonville and Wilmington Districts. A total of 47 ideas were generated, and some of these were combined into one. The workshop recommended 11 ideas and 7 were adopted for inclusion either in the report, the Preconstruction, Engineering and Design Phase (PED) or both. See Appendix N for the VE report and a description of all recommended and adopted ideas.

# 6. THE RECOMMENDED PLAN*

The purpose of this report section is to centralize information concerning the Recommended Plan. The Recommended Plan is discussed in terms of features, construction, maintenance, real estate requirements, accomplishments, and economic feasibility.

## 6.01 Plan Description and Components

The Recommended Plan is Alternative 9. Alternative 9 consists of an 119,670 ft (22.7 miles) long main beach fill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beach fill is bordered on either side by a 1,000 ft tapered transition zone berm. Material for the beach fill would be obtained from offshore borrow areas by dredging. Typical project plan views and cross sections are contained in Appendix A.

### 6.01.1 Main fill

The Recommended Plan (Figure 6.1) has a main fill length of 119,670 feet, beginning 1,000 feet east of Bogue Inlet (Reach 4) and extending to the boundary of Atlantic Beach and Fort Macon State Park (Reach 117).

The dimensions of the Recommended Plan main fill are shown in Table 6.1 below. Note that the dune dimensions listed for the Recommended Plan integrate and are based on the existing idealized dune dimensions for those reaches, and represent the maximum size of the construction template. However, the actual final project design (which is done during PED) may involve some variations in the constructed dune width and height from what is shown in the table, to account for constructability issues and the avoidance of real estate. However, in no case will the constructed dune exceed the dimensions listed in the Recommended Plan project template.

| Reaches | Length (ft) | Landward Dune Slope (X:1) | Max Dune Elevation (ft) | Dune Width (ft) | Seaward Dune Slope (X:1) | Berm Height (ft) | Berm Width (ft) | Berm Seaward Slope (X:1) |
|---|---|---|---|---|---|---|---|---|
| 4-10 | 4,876 | 4 | 16 | 95 | -4 | 5.5 | 50 | -15 |
| 11-15 | 5,633 | 4 | 15 | 45 | -4 | 7 | 50 | -15 |
| 16-21 | 6,891 | 4 | 20 | 10 | -4 | 7 | 50 | -15 |
| 22-92 | 82,053 | 4 | x | x | -4 | 7 | 50 | -15 |
| 93-110 | 15,274 | 4 | 18 | 40 | -4 | 5.5 | 50 | -15 |
| 111-117 | 4,943 | 4 | x | x | -4 | 5.5 | 50 | -15 |

Table 6.1. Recommended Plan main beach fill dimensions. An "x" indicates that a Federally maintained dune feature is not part of the selected plan in those reaches. Elevations reference NAVD 88.

Typical plan and cross-section views of the project from selected reaches are shown in Appendix A. The average depth of closure for the constructed profile is -19 ft mean low water.

### 6.01.2 Transition Sections

Transition sections are needed to improve project stability and reduce end losses. The transition sections for this project include a 1,000 ft tapered berm at each end of the project. At the west end of the project, the taper extends from Bogue Inlet up to reach 4, at the east end of the project the taper starts at the end of reach 117 and extends into Fort Macon State Park.

## 6.02 Design and Construction Considerations

### 6.02.1 Initial Construction and Renourishment

The Recommended Plan will require an estimated 2.45 million cubic yards of material for initial construction, and about 1.07 million cubic yards for each renourishment cycle (every 3 years). During the 50 year project life, 16 renourishment events would require a total volume of 17.1 million cubic yards of material which, when added to the initial construction volume requirement of 2.45 million cubic yards results in a total project volume requirement of 19.6 million cubic yards of material.

The nourishment material would most likely be pumped to the beach from hopper dredges (although other types of dredges could potentially be used) and shaped on the beach by earth-moving equipment. In both initial construction and during renourishment, material between the toe of dune and mean high water line would be tilled to prevent compaction. Due to limitations in the ability of equipment to shape material underwater, the berm is not constructed in the shape of the design berm profile. Instead, the volume of material necessary to create the design berm is pumped out into an initial construction profile (see Figure 6.2). The initial construction profile would extend seaward of the final design berm profile by a variable distance (approximately 100-150 ft) to cover anticipated sand movement during and immediately after construction. Once sand distribution along the foreshore occurs (about 6 months), the adjusted profile should resemble the design berm profile. Initial construction is anticipated to take 105 days using two dredges, and each renourishment is anticipated to take 90 days using one dredge.

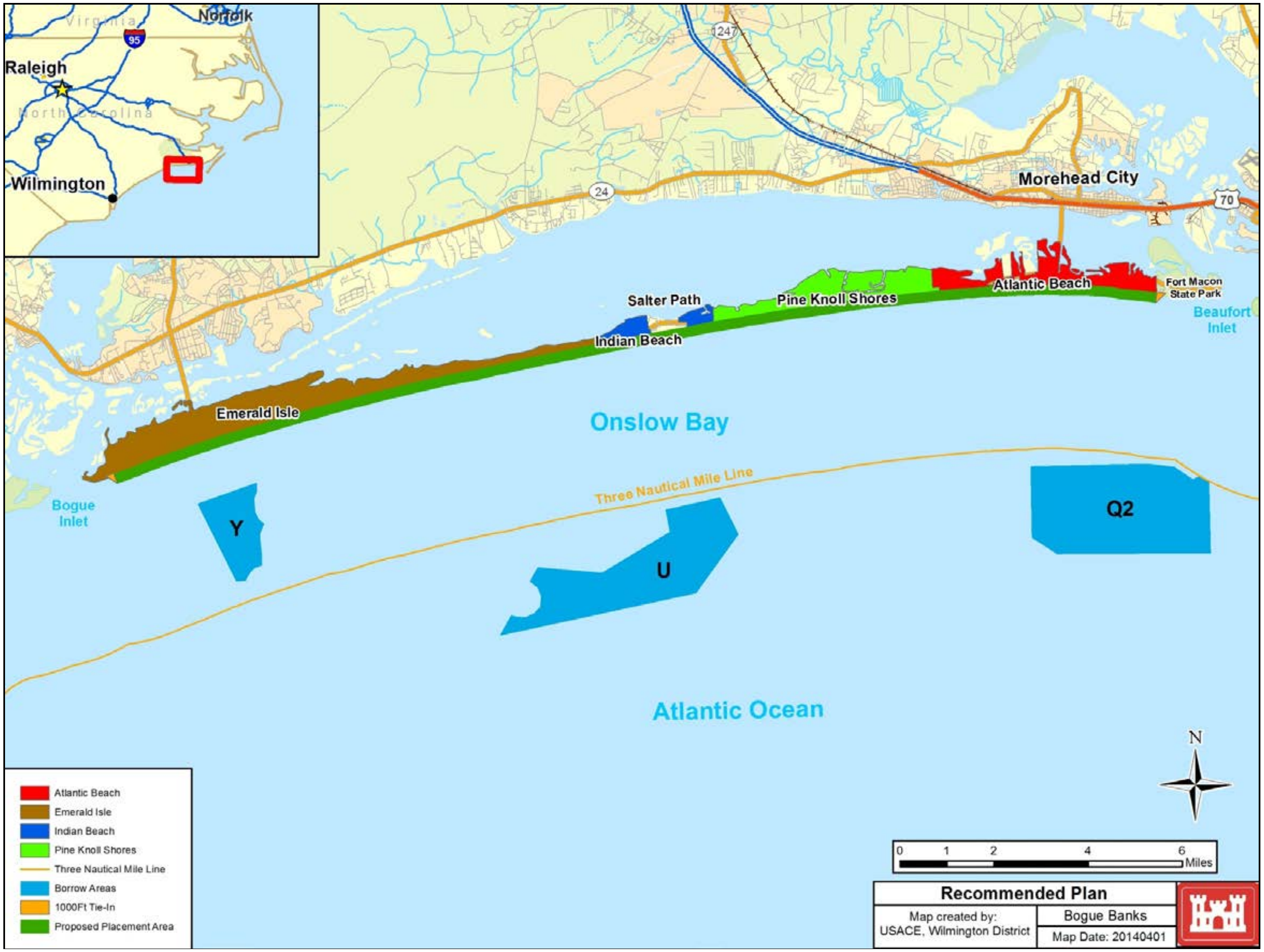


Figure 6.1 Recommended Plan

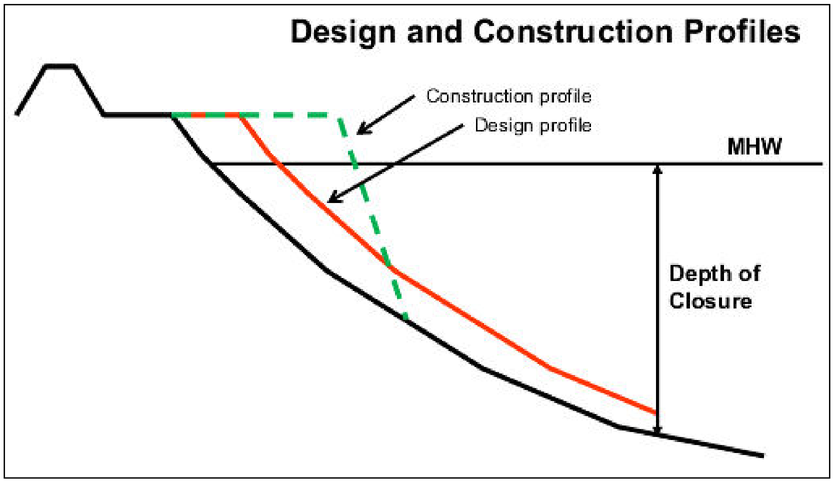


Figure 6.2. Representation of a berm construction vs. design profile.

### 6.02.2 Dune Vegetation

The dune portions of the project would be stabilized against wind losses by planting appropriate native beach grasses. Sand fencing is not needed since the dune will be constructed at the appropriate height. Dune stabilization would be accomplished by planting vegetation on the dune during the optimum planting season following dune construction. Planting stocks would consists of a variety of native dune plants including sea oats (*Uniola paniculata*), American beachgrass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), and seaside little bluestem (*Littoralis variety*). The vegetative cover would extend from the landward toe of the dune to the seaward intersection with the berm for the length of the dune. Plant spacing guidelines would follow the recommendations provided by the North Carolina Sea Grant, *The Dune Book* (Nash and Rogers, 2003). Sea oats would be the predominant plant with American beach grass and panic grass as supplemental plants. Seaside little bluestem would be planted on the backside of the dune away from the most extreme environment. The total area for dune plantings is estimated to be 75 acres.

### 6.02.3 Construction Access

Construction access to the project will be obtained by public roads and rights-of-way. There are sufficient access areas along the beach at the ends of public streets and at public access areas for contractors to move pipe and construction equipment to the beach. Seven publically-owned access areas could potentially be used as construction staging areas. These areas are described further in the Real Estate Plan (Appendix H).

### 6.02.4 Borrow Area

Many possible sequences and methods can be used for placing available material on the beach for the project. In addition to borrow area parameters (material quantities and location), the dredging production rates and dredging window are critical to selecting optimum borrow use plan. Offshore borrow areas beyond 3 nautical miles offshore are also subject to Federal mining requirements of the BOEM. The current borrow areas analyzed as part of the construction scenario involves placing material from Borrow Area Y on reaches 1-36, material from Borrow Area U on reaches 37-79, and material from Borrow Area Q2 on reaches 80-117. This plan is based on the current configurations of the borrow areas. However, the specific borrow areas and corresponding borrow area use plans will be determined and finalized during the PED phase of the study. During that phase, additional vibracore boring data in the borrow areas would be collected as needed and if necessary, additional environmental compliance documentation completed for any change in borrow area designation (see Section 7.01.3 for more detail).

### 6.02.5 Dredging Production.

Dredging production refers to the average volume transported per day and relates to factors such as plant, material, distance, and weather. This information is used to estimate project cost and construction time. Production rates are estimated to average about 12,000- 14,000 cubic yards/day (dependent on placement location) for each hopper dredge for initial construction and for periodic nourishment.

### 6.02.6 Dredging Window.

Hopper dredging operations for the project would work in accordance with the 1997 National Marine Fisheries Service (NMFS) South Atlantic Regional Biological Opinion (SARBO) for the continued hopper dredging of channels and borrow areas in the Southeastern United States or any superseding SARBO that is prepared by NMFS. Under the 1997 SARBO, the NMFS does not place a window on hopper dredging operations from Pawley's Island, South Carolina, through North Carolina. However, for other projects within the vicinity of Bogue Banks, both the USACE South Atlantic Division (SAD) office and South Atlantic Wilmington (SAW) District office have, to the extent practicable, recommended hopper dredging during cold water months when sea turtle abundance is typically low. Specifically, for navigation maintenance dredging at Morehead City Harbor (located at the northern limit of the study area), SAW traditionally recommends hopper dredging during the coldest water months from 1 January to 31 March due to historically high sea turtle abundance and subsequent risk of entrainment within the channel during warmer months (Appendix F).

For this project, the anticipated duration needed for initial construction, utilizing 2 hopper dredges, is approximately 105 days. This duration factors in contingency and weather days. In order to minimize sea turtle entrainment risk, the initial construction hopper dredging will be planned for between Dec 15 through March 31 when water temperatures are cold and sea turtle abundance is low. Though the initial construction window is two weeks earlier than that traditionally implemented by SAW for dredging at Morehead City Harbor, it is not anticipated that this earlier start would result in any greater risk of impact due to annual variation in water temperatures and sea turtle abundance and the lower entrainment risk of hopper dredging within the proposed offshore borrow area (Appendix

F). Hence, a Dec 15 to March 31 window during initial construction is considered practicable for the offshore dredging associated with this project. A 3-year periodic nourishment cycle using 1 hopper dredge is considered for the 50-year life of the project with an anticipated duration of approximately 90 days, which also factors in contingency and weather days. It is planned that all periodic nourishment events would occur within a January 1 to March 31 window. If additional time is necessary (for example, higher than anticipated volumes being needed for a particular nourishment event), the plan would be to begin hopper dredging earlier, rather than finishing later. Dredging that begins anytime in December would be unlikely to carry any measurable amount of additional risk to sea turtles and likely would not require any additional preventative measures. However, this change would still be fully coordinated with the appropriate agencies prior to construction.

#### 6.02.7 Recommended Construction Plan

For initial construction, dredging would potentially begin Dec 15 of the project year and then be completed by March 31 of the following calendar year. It is anticipated that 2 hopper dredges would be used to complete initial construction, although there is possibility that a 3rd dredge could be utilized as well, which could enable construction to be completed more rapidly. If prior to initial construction it is still anticipated that the Dec 15 – March 31 dredging window will be exceeded, the USACE will coordinate with all appropriate agencies and SAD to determine if any appropriate mitigative measures should be taken. However, the window would not exceed November 15 to April 30.

Periodic nourishment would begin in project year 4 and would also consist of hopper dredging because of limited thickness of available material in the borrow areas and long haul distance. Renourishment would begin January 1 for each cycle and proceed until completion, which is anticipated to be prior to March 31 the following year. The plan would require separate contracts for initial construction and for each periodic nourishment cycle.

## 6.03 Public Parking and Access Requirements

ER 1165-2-130 (Federal Participation in Shore Protection) requires reasonable public parking and access to the beach to be provided by the non-Federal sponsor. These requirements ensure that all portions of the project shoreline are available for public use as defined by adequate parking and access facilities. Per ER 1165-2-130, paragraph 6.h.: "Parking should be sufficient to accommodate the lesser of the peak hour demand or the beach capacity", and "public use is construed to be effectively limited to within one-quarter mile from available points of public access to any particular shore. In the event public access points are not within one-half mile of each other, either an item of local cooperation specifying such a requirement and public use throughout the project life must be included in the project recommendations or the cost-sharing must be based on private use." The USACE Wilmington District has further interpreted the policy for adequate parking and access to mean that for participation in coastal storm damage reduction projects within the District's boundaries of North Carolina and Virginia, a minimum of 10 public parking spaces need to be located at each access point.

Appendix B contains an inventory of existing parking facilities and access points along the project shoreline. Maps are provided which identify areas where the non-Federal sponsor will be required to install supplemental public access points and associated parking to meet the peak demand (Figure 6.3). Additional public access points will be required as indicated below in Table 6.2 in order to ensure federal criteria for adequate parking and access are met. It should be noted that although the table below reflects total miles within each municipality, these miles are not necessarily contiguous stretches of shoreline.

| Town | Miles |
|---|---|
| Emerald Isle | 1.0 |
| Indian Beach | 0.1 |
| Salter Path | 0.1 |
| Pine Knoll Shores | 1.0 |
| Atlantic Beach | 1.1 |
| **Total** | **3.3** |

Table 6.2. Project miles requiring additional public access. Miles are not necessarily contiguous.

On January 17, 2013, the District met with the Carteret County and representatives from all towns on Bogue Banks and provided the group with an updated briefing on the Recommended Plan and associated parking and access requirements needed to support Federal interest in project implementation. At this meeting, the consequences of failure to meet these requirements including a reduction in Federal cost-sharing percentage and/or a potential loss of Federal interest in project implementation was presented. At the project Alternative Formulation Briefing on May 10, 2013, Carteret County as the non-Federal project sponsor reiterated their awareness of these requirements and the importance of ensuring and maintaining public access for moving forward with the Federal project, and indicated their express intent to meet these requirements. Subsequent meetings were held with Carteret County and the Carteret County Beach Commission as well as the Towns on Bogue Banks on June 24, 2013 and again on October 9, 2013, following receipt of USACE policy review comments on the draft report. The Sponsor reiterated their commitment again to meet all requirements for parking and access in their public review letter dated 5 September 2013, and confirmed that they will ensure requisite parking and access requirements are satisfied prior to the signing of the PPA to ensure project requirements are met. The Sponsor reinforced their good track record in providing required parking and access associated with the recently constructed Morehead City Harbor Section 933 project (i.e. 2004 and 2007) in which the Towns constructed a total of 9 access/parking areas along ~7 miles of beach.

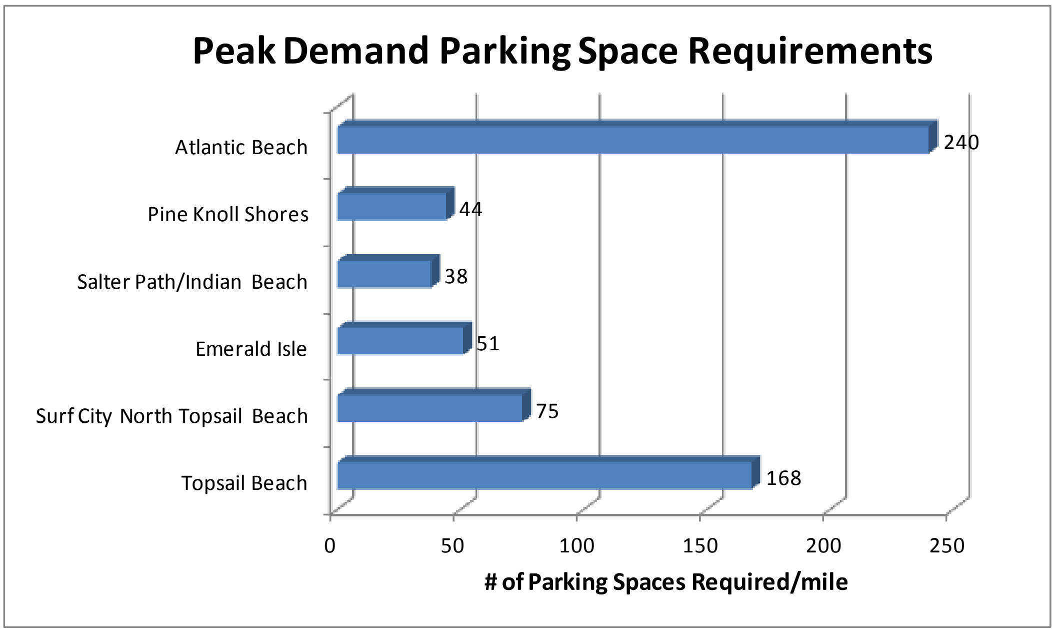



Figure 6.3. Projected peak parking demand parking space requirements per mile for towns within the Bogue Banks study area as well as two previously approved projects at Topsail Beach and Surf City, North Carolina.

Carteret County must address any parking and access deficiencies prior to the signing of the PPA. The local sponsor has indicated that they can and will provide the necessary parking and access to support the project.

## 6.04 Monitoring Requirements

### 6.04.1 Beach Fill Monitoring

A comprehensive monitoring program in accordance with USACE guidance (EM 1110-2-1100, Part V, Chapter 4) is planned for the Bogue Banks project to assess and ensure project functionality throughout its design lifetime. Such monitoring supports the design efforts for periodic renourishment and is cost-shared 50 percent Federal and 50 percent non-Federal, and would begin the year following the start of initial construction. Estimated annual costs for beach fill monitoring over the 50 year project are $187,500, and would cover semiannual beach profile surveys, aerial photography, and an annual monitoring report. This beach fill monitoring is required for post-construction survey to confirm the final constructed beach profile after equilibration. Profile equilibration occurs about 6 months after completion of initial construction. This follow-on post-construction survey is considered continuing construction. Given that the nourishment interval for the proposed project is 3 years, post- and pre-construction surveys could occur in consecutive years. If budgetary constraints lengthen the nourishment interval beyond the three years identified in the NED Plan, any subsequent beach fill monitoring prior to pre-construction surveys conducted for the next nourishment cycle would be considered a local responsibility.

Beach profile surveys would not only allow assessment of anticipated beach fill performance, but also allow determination of renourishment volume requirements. An aerial photographic record of the project would further facilitate assessment of the beach fill performance. The annual monitoring report would present the data collected and the corresponding analysis of project performance, including recommendations on renourishment requirements.

6.04.2 Environmental Monitoring and Other Commitments

The environmental goal of the project is to avoid and minimize adverse impacts to the environment to the maximum extent practicable. A full list of environmental commitments related to construction and maintenance of the proposed project is contained in Appendix G. Costs related to these commitments are factored into the total project construction costs. As part of the *North Carolina Sea Turtle Protection Project*, and with the help of Federal and local agencies and volunteer groups, annual surveys of sea turtle activity have and continue to occur along Bogue Banks. It is recommended that these surveys continue, with or without a project in place.

The placement of material on Bogue Banks may have impacts to the threatened seabeach amaranth. The proposed project limits avoid the inlet vicinity at both ends of Bogue Banks which have historically been areas of consistently higher amaranth abundance. Along the beachfront within the project limits amaranth occurs sporadically along the dune face; however, due to high erosion rates and inundation from storm events its available habitat is deteriorating. Beach nourishment would have initial impacts through burial of existing seeds, and it is unknown if the dredge material from an offshore borrow area will provide enough seed stock to produce viable plants. Plants will not be impacted directly since they are annuals and are not present from 15 December –March 31; however, much of the habitat requirements for seabeach amaranth lost to erosion will be restored.

As part of the informal consultation with the USFWS, they provided a letter dated

February 14, 2014 requesting seabeach amaranth monitoring. The Corps' response was as follows: "Seabeach amaranth monitoring will be conducted for 5 years following the initial sediment placement. The commitment is intended to survey and document presence/absence of plants following Bogue Banks Project nourishment events utilizing offshore borrow sources in order to quantify the number of plants before/after nourishment. Subsequent monitoring will be dependent on results of the initial monitoring" (Appendix L).

The 5 years of monitoring will involve 5 monitoring events: 1) The first during the summer following initial sediment placement, 2) the second summer after placement, 3) the summer before the first renourishment, 4) the summer following renourishment, and 5) the second summer after renourishment. These 5 monitoring events should be sufficient to determine if using offshore borrow areas are impacting seabeach amaranth. The estimated cost is $6,000 per monitoring event, for a total of about $30,000. This amount is included in the project cost estimate. The monitoring costs include per diem, walking the beach by 2 individuals to record presence and number of plants, data recording, compilation, and analysis.

## 6.05 Real Estate Considerations

The requirements for lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs) include the right to construct a dune and berm system along the shoreline of Bogue Banks within the project limits. Privately owned properties included in the Project are considered to be in fee simple ownership. Impacted parcels within the project limits are 897 at Emerald Isle, 76 at Indian Beach, 214 at Pine Knoll Shores and 283 at Atlantic Beach for a total of 1470 impacted parcels. Land lying below MHW is owned by the State. A permit will be obtained from the North Carolina Department of Administration, State Property Office to allow for placement of sand seaward of MHW. Further details are provided in Appendix H (Real Estate Plan).

### 6.05.1 Borrow Areas

Permits and/or consent agreements for sand removal from those portions of the borrow areas within 3 nautical miles of the shore will be from the appropriate state agencies. If sand mining extends outside the state limits into the Outer Continental Shelf (OCS), a noncompetitive negotiated agreement is required from the Bureau of Ocean Energy Management (BOEM).

### 6.05.2 Pipeline

The material for initial project construction and nourishment would be dredged from the offshore borrow areas, and then moved by pipeline to the beach. The pipeline would be routed along the ocean shoreline, where it would be placed either below Mean High Water or in the acquired Perpetual (without any limitation of time) Beach Storm Damage Reduction Easements.

### 6.05.3 Construction Area

Acquisition of lands under the proposed Perpetual Beach Storm Damage Reduction Easement will be along the existing dune system where one is located. Based on a ground examination, it appears that there will be no adverse impact to the upland portion of ownerships. Improvements in the proposed easement area are walkways, beach access crossovers and the fishing pier. Although every effort is made during construction to avoid damage to structures, private landowners have the option to remove their walkways to the beach prior to the start of project construction if they so desire in an effort to avoid damage to the walkways during construction. However, after construction of the project, the landowner would have to obtain a permit from the local authority to replace the walkway.

### 6.05.4 Real Estate Costs

The estimated real estate cost for the project is $4,361,000, which includes a 24% contingency. The cost consists of estimated costs for construction easements and Federal and non-Federal administrative costs. Carteret County has approximately 1190 existing Perpetual Beach Storm Damage Reduction Easements in place; however, each easement will have to be individually reviewed by USACE as to their adequacy for the Federal project during the PED phase of this study. The feasibility study real estate cost estimate assumes that 75% of these easements or 893 will be adequate, leaving an estimated total of 577 new easements to be acquired. The number of new easements to be acquired could either increase or decrease based on the number of local easements determined to be sufficient for the project.  Please refer to Appendix H for more details regarding the project real estate costs.

## 6.06 Operation and Maintenance Considerations

Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) requirements of the sponsors would consist of project inspections and maintenance. The beachfill monitoring actions are different from the non-Federal sponsors’ OMRR&R project inspections and surveillance, which consist of assessing dune vegetation, access facilities, dune crest erosion, trash and debris, and unusual conditions such as escarpment formation or excessive erosion. Periodic renourishment and beachfill monitoring (including the semiannual beach profile surveys) are classified as continuing construction, not as OMRR&R. Dune vegetation maintenance includes watering, fertilizing, and replacing dune plantings as needed. Other maintenance is reshaping of any minor dune damage, repairs to walkover structures and vehicle accesses, and grading any large escarpments. Estimated OMRR&R annual costs are $75,000.

## 6.07 Economics of the Recommended Plan

### 6.07.1 Recommended Plan— CSDR Benefits

Table 6.3 presents the applicable economic results at the October 2014 (FY2015) price level for the Recommended Plan at the interest rate of 3.5%. The Recommended Plan's benefit to cost ratio at 3.5% interest is 2.45 to 1.

| **Interest Rate** | **3.50%** |
|---|---:|
| CSDR Benefit | $11,688,082 |
| CSDR BC-Ratio | 1.93 |
| Rec. Benefit | $3,148,607 |
| Combined Benefit | $14,836,689 |
| Combined BC-Ratio | 2.45 |
| CSDR Only Net Benefit | $5,623,082 |
| Combined Net Benefit | $8,771,688 |
| **Total Annual Cost** | **$6,065,000** |

Table 6.3. The applicable economic results at the FY2015 price level for the Recommended Plan at the interest rate of 3.5%.

### 6.07.2 Recommended Plan— Recreation Benefits

Per ER 1105-2-100, the USACE policy on the application of recreation benefits is that "recreation must be incidental in the formulation process and may not be more than fifty percent of the total benefits required for justification. If the criterion for participation is met, then all recreation benefits are included in the benefit to cost analysis." The Recommended Plan is justified based solely on CSDR benefits, therefore all incidental recreation benefits are being claimed for the project.

Recreation benefits for the project were based on an analysis of willingness to pay for a beach day for the average visitor within a travel cost method (TCM) framework. The TCM makes use of the basic idea that the time and money that households expend in traveling to beaches provide a signal of the value of such resources. Additional socioeconomic characteristics of the individuals using the beach and information concerning substitute sites and environmental quality indicators, based on on-site and telephone surveys, were also included. On-site visitation data for 17 North Carolina beaches were collected between July and August 2003. A telephone survey was conducted in May 2004, with a target population based on the results of the on-site survey conducted in 2003. Results from the TCM measure the incremental value of having access to a beach when other substitute beaches are available, and the value of changes in beach characteristics, such as beach width. More detail on the recreation benefits calculation is provided in Appendix B.

The average annual recreation benefit for the Recommended Plan (at 3.500% interest rate) is $3,148,607.

### 6.07.3 Recommended Plan— Total Benefits

Combining the CSDR benefits and the recreation benefits yields a total average annual benefit for the Recommended Plan of $14,836,688.

### 6.07.4 Recommended Plan—Costs

Determining the economic costs of the Selected Plan consists of four basic steps. First, project First Costs are computed. First Costs include expenditures for project design and initial construction and related costs of supervision and administration. First Costs also include the lands, easements, and all rights-of-way. Total First Costs are estimated to be $37,327,000 at October 2014 (FY2015) price levels. Details regarding this certified cost are contained in Appendix D (Cost Engineering), page D-46 and following.

Second, Interest during Construction is added to the project First Cost. Interest during Construction is computed from the start of PED through the 4 month initial construction period. Interest during Construction for the Selected Plan is estimated to be $161,051. The project First Cost plus Interest during Construction represents the Total Investment Cost required to place the project into operation. The Total Investment Cost for the Selected Plan (Initial Construction) is estimated to be $37,327,000.

Third, Scheduled Renourishment Costs are computed. Those costs are incurred in the future for each of the 16 planned renourishments. Neither discounting to present value, nor escalation for anticipated inflation is included in the determination of these costs. As detailed in Appendix D, the estimated cost is $14,341,000 for each renourishment. Note that this cost includes the cost of the annual beach fill monitoring (see Section 6.04).

Fourth, Expected Annual Costs are computed. Those costs consist of interest and amortization of the Total Investment Cost and the equivalent annual cost of project OMRR&R and beach fill monitoring costs (see sections 6.04 and 6.06). The Expected Annual Costs provide a basis for comparing project costs to expected annual benefits. Expected Annual Costs for the Selected Plan are estimated to be $6,065,000. A summary of the computations involved in each of these four steps is presented in Table 6.4.

| ANNUAL COSTS | | | |
|---|---|---|---|
| interest rate = | 3.500% | years of analysis = | 50 |
| ITEM | FISCAL YEAR | AMOUNT | PRESENT VALUE, 2014 |
| | | | |
| Total Investment Cost | 2019 | $37,327,000 | $37,327,000 |
| | | | |
| Renourishment, HB | 2023 | $14,340,938 | $12,497,000 |
| Renourishment, HB | 2026 | $14,340,938 | $11,272,000 |
| Renourishment, HB | 2029 | $14,340,938 | $10,167,000 |
| Renourishment, HB | 2032 | $14,340,938 | $9,170,000 |
| Renourishment, HB | 2035 | $14,340,938 | $8,271,000 |
| Renourishment, HB | 2038 | $14,340,938 | $7,460,000 |
| Renourishment, HB | 2041 | $14,340,938 | $6,728,000 |
| Renourishment, HB | 2044 | $14,340,938 | $6,068,000 |
| Renourishment, HB | 2047 | $14,340,938 | $5,473,000 |
| Renourishment, HB | 2050 | $14,340,938 | $4,937,000 |
| Renourishment, HB | 2053 | $14,340,938 | $4,453,000 |
| Renourishment, HB | 2056 | $14,340,938 | $4,016,000 |
| Renourishment, HB | 2059 | $14,340,938 | $3,622,000 |
| Renourishment, HB | 2062 | $14,340,938 | $3,267,000 |
| Renourishment, HB | 2065 | $14,340,938 | $2,947,000 |
| Renourishment, HB | 2068 | $14,340,938 | $2,658,000 |
| | | | |
| | | | |
| Subtotal, Renourishments | | $229,455,008 | $103,006,000 |
| Interest During Initial Construction, 3.5% | | | $161,051 |
| **Total Investment Cost, Present Value** | | | **$140,494,051** |
| | | | |
| **Annual Costs** | | | |
| Interest & Amortization, 50 years at 3.5 % | | | $5,990,000 |
| | | | |
| OMRR&R | | | $75,000 |
| | | | |
| Total Annual Cost | | | $6,065,000 |

Table 6.4. Recommended Plan Annual Costs (October 2014 price levels at 3.5% interest).

### 6.07.5 Benefit to Cost Ratio

With expected annual benefits of $14,836,688 and average annual costs of $6,065,000, the benefit to cost ratio for the Selected Plan, is 2.45 to 1. The average annual net benefits are $8,878,000 at 3.5% interest at October 2014 price levels. See Appendix B for explanation of calculation.

## 6.08 Summary of Recommended Plan Accomplishments

The Recommended Plan would reduce coastal storm damages to structures along approximately 23 miles of beachfront. Additionally, the plan would halt future land loss over much of the same area. The Recommended Plan would also increase the recreational value and demand of the beach. The Recommended Plan would also potentially reduce future emergency response costs (although these have not been quantified for this study), and preserve or expand the amount of beach habitat available for sea turtle and shorebird utilization. Finally, the Recommended Plan will benefit the regional economy by maintaining the area as a popular year-round destination and supporting the jobs and businesses associated with that industry.

## 6.09 Evaluation of Risk and Uncertainty

### 6.09.1 Residual Risks

The proposed project would greatly reduce, but not completely eliminate future storm damages. Coastal storm damages are reduced by approximately 62 percent over the 50 year period of analysis; therefore, the residual damages would be 38 percent. The project is designed to reduce damages from storm waves, direct flooding, and erosion, but would not prevent any damage from back bay flooding; therefore, any ground-level floors of structures, ground-level floor contents, vehicles, landscaping, and property stored outdoors on the ground would still be subject to saltwater flooding that flows in through the inlets and the back bay channels. However, back-bay flooding is a relatively minor issue in the first three rows of the island which is where the benefits of the project are being measured and those damages were not claimed as a project benefit. As the project is also not claiming any benefits beyond the third row of the island, damages from flooding to structures past the third row were not been calculated. Structures would also continue to be subject to damage from hurricane winds and windblown debris. Even new construction is not immune to damage, especially from these processes.

The proposed beach fill would reduce damages but does not have a specific design level. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. The project purpose is storm damage reduction, and the berm-and-dune is not designed to prevent loss of life. Loss of life is prevented by the existing procedures of evacuating the barrier island completely, well before expected hurricane landfall and removing the residents from harm’s way. The erratic nature and unpredictability of hurricane path and intensity require early and safe evacuation. That policy should be continued either with or without the storm damage reduction project.

### 6.09.2 Risk and Uncertainty in Economics

The Beach-*fx* model accounts for uncertainty in the economic evaluations through the use of Monte-Carlo simulations to model future damages. The average annual damages reported in this study are based on the damages averaged across 300 life cycles, with each life cycle experiencing a different suite of storms during the period of analysis. Additionally, uncertainty is accounted for in the damage functions that are used to determine the amount of damage incurred to a structure and its contents from a given storm. Each structure type is assigned a minimum, maximum, and most likely damage function, meaning that the amount of damage experienced by a structure due to a specific amount of erosion or water depth can vary between life cycles. An example of one of these damage functions is shown in Figure 6.4 below, the entire suite of damage functions used in this study are contained in Appendix B.

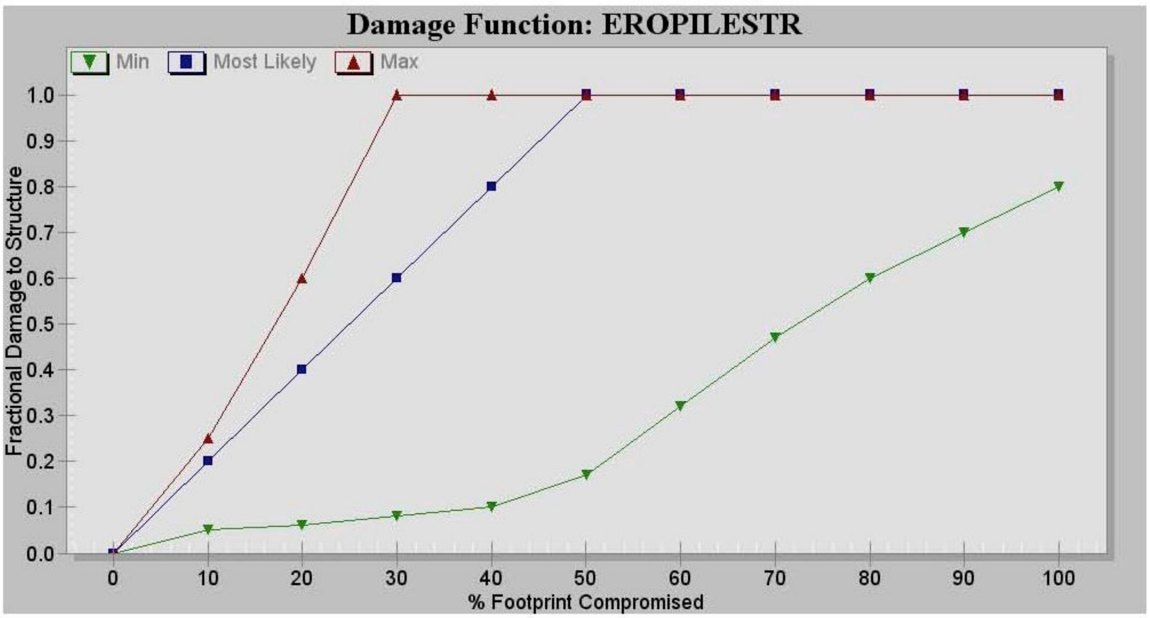



Figure 6.4. Damage functions used to measure erosion damage to structures on 8-ft pile.

### 6.09.3 Risk and Uncertainty in Project Costs

In order to account for uncertainties in the final project costs, which could result from a variety of factors, all costs include an appropriate contingency on top of the actual estimated cost. The contingencies are based on a Cost Schedule Risk Assessment (CSRA), which is included in Appendix D. For this project, a contingency of 24% is being utilized for initial construction and a contingency of 28% is being utilized for renourishments.

### 6.09.4 Risk and Uncertainty in Borrow Availability

An estimated 19.6 million cy of borrow material would be needed over the 50 year project – 3.6 million cy from Borrow Area Y, 6.1 million cy from Borrow Area U, and 9.9 million cy from Borrow Area Q2. The required project volumes are all below the amount of compatible material that has currently been estimated to be available in total at the assessed borrow areas (4.6, 8.9 and 28.3 million cy at Y,U, and Q2, respectively). The overall project would utilize only about 47% of the total volume available at the three sites. Therefore, the risk of running out of material over the 50 year project life is minimal, even if further investigations during PED reveal that less material than originally estimated is actually available at the borrow sites.

### 6.09.5 Risk and Uncertainty in Sea Level Rise Assumptions

Per EC 1165-2-212, a sensitivity analysis on the economics of the Recommended Plan was performed using low and high accelerated sea level rise rates. A full discussion of the accelerated sea level rise rates and how they were calculated for the project area is contained in Appendix A.

The net benefits reported for the Recommended Plan in section 6.07.5 are based on the historical sea level rise rate (0.0084 ft/yr) being applied to both the future with and without project conditions. The Recommended Plan was rerun in Beach-*fx* using both the intermediate (0.0145 ft/yr) and high (0.0341 ft/yr) sea level rise rates for both the future with and without project conditions. In the future without project condition, damages increase under accelerated sea level rise scenarios. Under accelerated sea level rise, damages also increase in the with-project conditions, but to a lesser degree. Table 6.5 shows a comparison of with and without project damages under the various scenarios.

| | FWOP Damages (AA) | With Project Damages (AA) | AA Benefit |
|---|---|---|---|
| **Historical (low)** | $14,497,381 | $5,734,856 | $8,762,525 |
| **Intermediate Rate** | $14,676,977 | $5,797,386 | $8,879,591 |
| **High Rate** | $14,923,307 | $5,879,066 | $9,044,241 |

Table 6.5. Comparison of with and without project damages and benefits under historical, intermediate accelerated and high accelerated sea level rise scenarios. Benefit does not include land loss.

The increases in project costs are relatively minimal under the accelerated sea level rise scenarios. Under assumptions of accelerated sea level rise, project net benefits actually increase and the project remains economically justified. This conclusion supports the concept of beach fill as naturally adaptable to sea level rise fluctuations.

### 6.09.6 Risk and Uncertainty in Future Beach Placement Activities

As discussed in Section 4.01 above (Future Without Project assumptions), continued dredge disposal from maintenance dredging of local navigation channels cannot be consistently relied upon in the future without-project condition. This assumption is due to uncertainties in navigation funding, and also uncertainties associated with timing and placement locations for any dredged material that might become available. In addition, beach placement of dredge material does not provide a consistent or measurable level of damage reduction. As the estimated re-nourishment volumes for the Recommended Plan are based on the assumption of no future maintenance dredging placement disposal on area beaches, any such placement that did occur would have the effect of reducing the amount of renourishment material needed and therefore the cost of the proposed Federal coastal storm damage reduction project. In addition, if at the time of renourishment the beach profile is already at or greater than the design template of the Recommended Plan, then no additional material would be placed for the project at that time.

#### 6.09.7 Risk and Uncertainty in Coastal Storms

Uncertainty regarding the number and intensity of future storms in the area is handled through the Beach-*fx* Monte Carlo simulation, whereby each lifecycle randomly selects (based on actual probabilities of storm occurrence) a suite of storms that will hit the project area over a given lifecycle. The storm suite is selected from a group of 696 plausible storms. However, while the storms are randomly selected, the effect of any given storm on a given shore profile is determined by the SBEACH software, and is fixed. The Beach-fx parameters which dictate storm selection are discussed in Appendix A.

# 7. ENVIRONMENTAL EFFECTS*

This section describes the probable consequences (impacts and effects) of the Recommended Plan and associated actions on significant environmental resources within the proposed beach placement locations and within the borrow areas. Table 5.7 earlier in the report provides a comparative analysis of environmental impacts associated with beach fill, non-structural, and no action alternatives. Details associated with the physical dredging and project construction operations are described in the ensuing paragraphs. Natural communities that would be affected by the proposed action include terrestrial and marine environments as described throughout this section.

## 7.01 Proposed Action

The Recommended Plan consists of an 119,670 ft (22.7 miles) long main beach fill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beach fill is bordered on either side by a 1,000 ft tapered transition zone berm. Material for the beach fill would be obtained from offshore borrow areas by dredge.

The potential sediment borrow sites for both initial construction and nourishment intervals is located south of Bogue Banks between 1 and 5 miles offshore at depths between -40 to -57 ft. MLLW. Initial construction would require estimated 2.45 million cubic yards of borrow material. Renourishment would require about 1.07 million cubic yards of borrow material per event at 3-year intervals. In total, about 19.6 million cubic yards of borrow material would be required for the 50-year project.

### 7.01.1 Dredging Methods and Associated Activities

Sediment will be dredged from the borrow areas and placed on the project area beaches utilizing hydraulic dredges. Hydraulic dredges are characterized by their use of a pump to dredge sediment and transport a slurry of dredged material and water to identified discharge areas along the project. The ratio of water to sediment within the slurry mixture is controlled to maximize efficiency. The main types of hydraulic dredges are cutterhead suction and hopper dredges.

A hopper dredge is most likely to be used for this project. However, there is the potential that a cutterhead suction dredge or a combination of both hopper and cutterhead dredge may be used for initial construction and/or nourishment events throughout the 50 year project. Therefore, potential impacts to specific resource categories evaluated throughout this section will consider both of these actions as appropriate. The following paragraphs discuss the specific operating conditions of these dredge types.

7.01.1.1 Cutterhead Suction Dredge. Cutterhead dredges are designed to handle a wide range of materials, including sands. They are used for new work and maintenance in projects where suitable placement/disposal areas are available and operate in an almost continuous dredging cycle resulting in maximum production, economy, and efficiency. Cutterhead dredges are capable of dredging in shallow or deep water and have accurate bottom and side slope cutting capability. Limitations of cutterhead dredges include relative lack of mobility, long mobilization and demobilization, and inability to work in high wave action and currents.

Cutterhead dredges are rarely self-propelled and; therefore, must be transported to and from the dredge site. Cutterhead dredge size is based on the inside diameter of the discharge pipe which commonly ranges from 6” to 36.” Pipelines associated with CSDR projects are often larger in diameter. They require an extensive array of support equipment including pipeline (floating, shore, and submerged), boats (crew, work, survey), barges, and pipe handling equipment. The cutterhead is a mechanical device that has rotating teeth to break up or loosen the bottom material so that it can be sucked through the dredge (Figure 7.1).

Moving cutterhead suction dredges is a slow process; therefore, efficiency is maximized by dredging in localized areas with deeper dredge cut volumes where the cutterhead is buried in the bottom. A cutterhead removes dredged material through an intake pipe and then pushes it out the discharge pipeline directly into the placement/disposal site. Most, but not all, cutterhead dredging operations involve upland placement/disposal of the dredged material. Therefore, the discharge end of the pipeline is connected to shore pipe. When effective pumping distances to the placement/disposal site become too long, a booster pump is added to the pipeline to increase the efficiency of the dredging operation.

For the Bogue Banks CSDR, where distances between borrow area and the placement beach are likely too long for direct transport via pipeline, cutterhead dredges may place material within scows for transport to the offloading site within the vicinity of the placement area. Hydraulic unloading and recirculation technology could then be used to re-slurry the material utilizing water jets and pumping it from the scow/barge to a placement location along the project. Hydraulic unloaders are typically connected from the end of an excavator arm on a separate barge or as a vessel configuration that functions as a self contained piece of equipment. This technology is not common practice for beach construction projects; however, there may be potential implementation opportunities for this project. Recognizing that hydraulic unloading technology is a methodology to transport sediment from a scow/barge to the project, there is no added level of impact beyond that already being evaluated for the cutterhead suction and hopper dredge operations. Therefore, for the purpose of this impact analysis, this activity will not be evaluated separately.

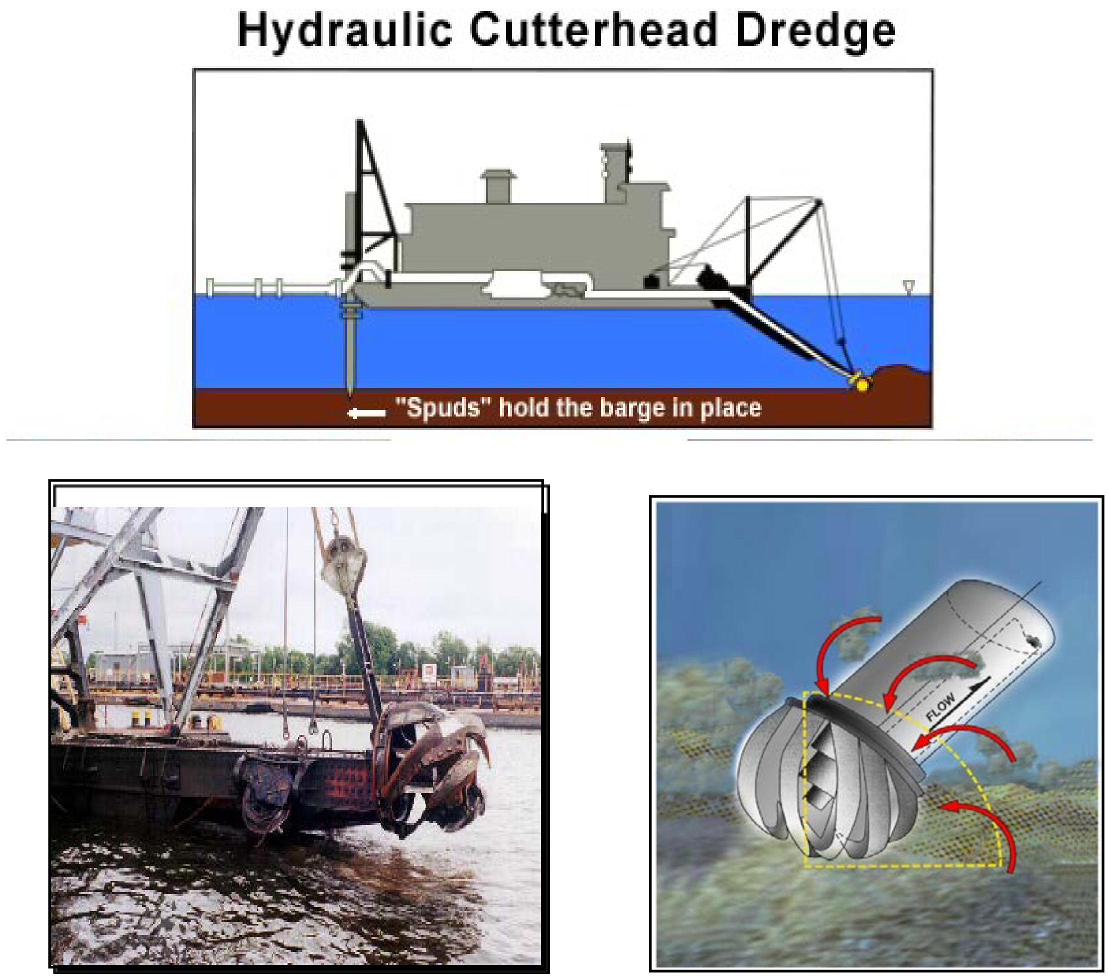



Figure 7.1. Cutterhead pipeline dredge schematic and representative close-up photographs.

7.01.1.2 Hopper Dredge. The hopper dredge, or trailing suction dredge, is a self-propelled ocean-going vessel with a section of the hull compartmented into one or more hoppers. Fitted with powerful pumps, the dredges suck sediment from the channel bottom through long intake pipes, called drag arms, and store it in the hoppers. Normal hopper dredge configuration has two dragarms, one on each side of the vessel. A dragarm is a pipe suspended over the side of the vessel with a suction opening called a draghead for contact with the bottom (Figure 7.2). Depending on the hopper dredge, a slurry of water and sediment is generated from the plowing of the draghead "teeth," the use of high pressure water jets, and the suction velocity of the pumps. The dredged slurry is distributed within the vessel's hopper allowing for solids to settle out and the water portion of the slurry to be discharged from the vessel during operations through its overflow system. When the hopper attains a full load, dredging stops and the ship travels to a pump-out location where the dredged material is re-slurried within the hopper and pumped out to the beach disposal area through a series of shore-pipe.

Hopper dredges are well suited to dredging sand. They can maintain operations safely, effectively, and economically in relatively rough seas and because they are mobile, they can be used in high-traffic areas. They are often used at ocean entrances and offshore, but cannot be used in confined or shallow areas. Hopper dredges can move quickly to disposal sites under their own power (maximum speed unloaded - ≤ 17 knots; maximum loaded - ≤ 16 knots), but since the dredging stops during the transit to and from the disposal area, the operation loses efficiency if the haul distance is too far. Based on the review of hopper dredge speed data provided by the USACE Dredging Quality Management (DQM) program, the average speed for hopper dredges while dredging is between 1-3 knots, with most dredges never exceeding 4 knots. Hopper dredges also have several limitations. Considering their normal operating conditions, hopper dredges cannot dredge continuously.

In order to minimize the risk of incidental takes of sea turtles, USACE requires the use of sea turtle deflecting dragheads on all hopper-dredging projects where the potential for sea turtle interactions exist. The leading edge of the deflector is designed to have a plowing effect of at least 6” depth when the drag head is being operated. Appropriate instrumentation is required on board the vessel to ensure that the critical “approach angle” is attained in order to satisfy the 6” plowing depth requirement (USACE, 1993).

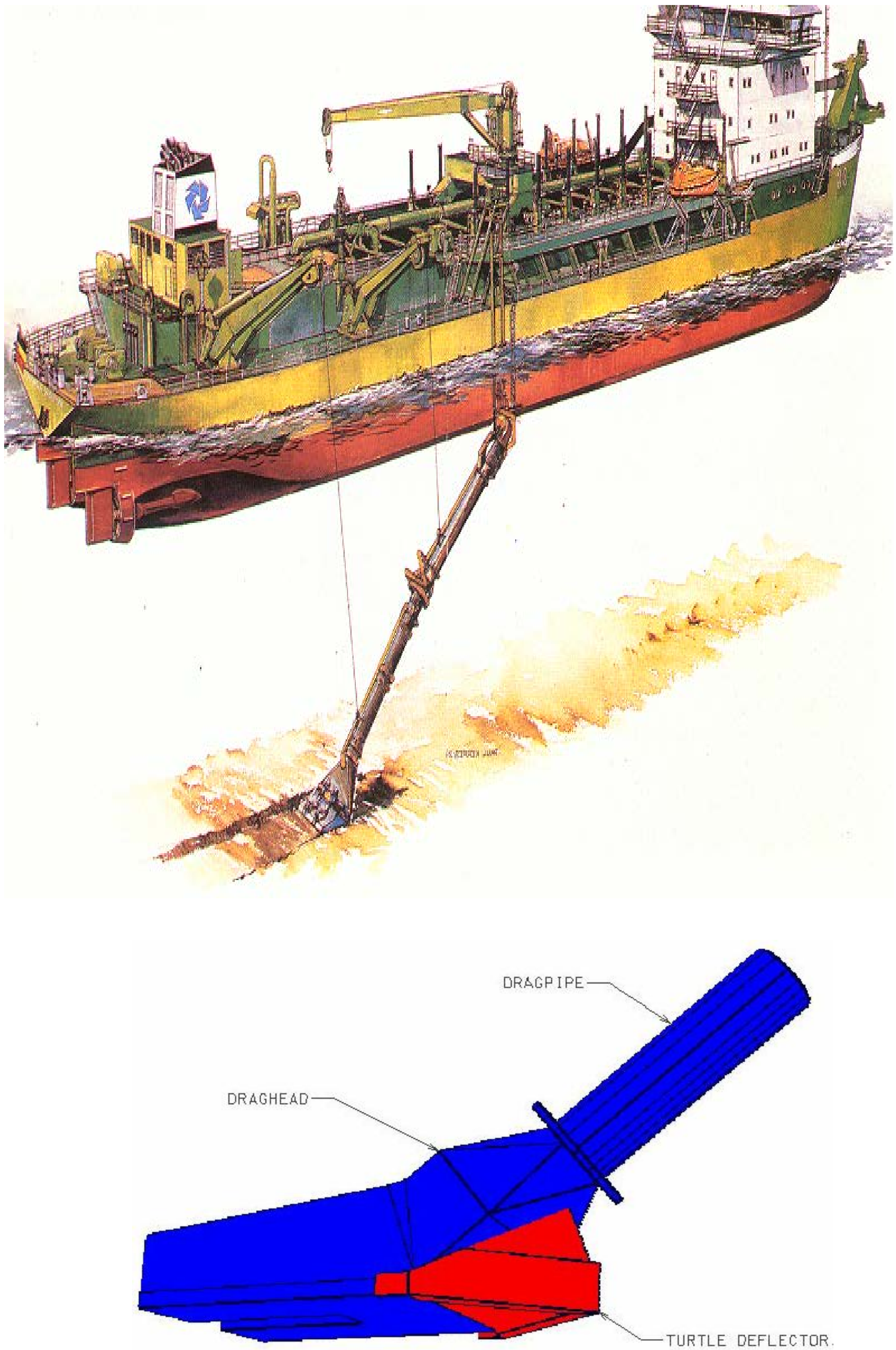



Figure 7.2. Hopper dredge and turtle deflecting draghead schematics.

### 7.01.2 Beach Fill Placement Activities

The history of beach fill placement activities, including both disposal of navigation maintenance dredged material and shore protection projects throughout the North Carolina coastline, consists of myriad actions performed by local, State, and Federal entities. The following paragraphs discuss the construction activities associated with placement of sediment on the beach for the purpose of CSDR:

Construction Operations.

For hydraulic pipeline and hopper dredge operations that include the placement of dredged material on the beach, a pipeline route is extended from the dredge plant to the beach fill placement location. Prior to the commencement of dredging, shore pipe is mobilized to the beach in segments of varying sizes in length and diameter. The mobilization process usually requires the use of heavy equipment to transport and connect pipe segments from the beach access point to the designated placement area. The placement of shore pipe is generally on the upper beach, away from existing dune vegetation and seaward of the toe of the primary dune. The width of disturbance area required to construct the pipeline route varies depending on the size of pipe used for the project. Site context and environmental features are considered for each project so that construction activities are confined to areas with minimal impact to the environment. Once the heavy equipment and pipe is on the beach and the pipes are connected, heavy equipment operation is generally confined to the vicinity of the mean high water line, away from dune vegetation on the upper beach. Within the active disposal area, heavy equipment operates throughout the width of the beach in order to manage the outflow of sediment and construct target elevations for the appropriate beach profile. The following sections describe this process in more detail.

*Pre-Project Coordination*

Contractors have considerable latitude with respect to means and methods to best utilize available equipment and resources. Prior to bid opening for a beach fill placement project, USACE identifies acceptable options for beach access for pipeline, pipe staging areas, and location of pipeline routes. These identified locations are a result of coordination with the local, State and Federal resource agencies, and other stakeholders to identify public concerns relative to real estate easements, permit requirements, environmentally sensitive areas, etc. Contractor bids will incorporate these pre-coordinated and pre-identified sites, which ensures that the location of all equipment and operations is coordinated appropriately and approved by USACE prior to project commencement.

*Mobilization*

Approximately 200 linear feet (or greater) of pipe segments are floated or trucked to the pre-identified staging area on the project site. Floated pipe is pressurized and moved using a tug and barge. Various pipe diameters (12”, 16”, 18”, 20”, 30”, etc) are used depending on the size of the project and the dredge performing the work. Smaller diameter pipe are often made of High Density Polyethylene (HDPE), whereas larger diameter pipe is made of steel. The ability to maneuver (i.e. bend) pipeline alignments is dependent on the size and makeup of the pipe. HDPE pipe is more agile than steel pipe. Dredging production rates decrease as the number of curves and bends in pipeline increase.

*Staging Area*
The pre-identified and coordinated staging area is often within the vicinity of the access point and may contain a majority of the materials needed for the construction and maintenance of the project such as dozers (D7-D9), loaders, cranes, vehicles, pickup trucks, dump shacks, etc. Additional equipment may include fuel tanks, generators, light plant, supply container sheds, bathrooms, etc.

In addition to the staging of equipment, the staging area is a work area for welders and grinders to prepare the pipe segments for connection. Contractors may require additional or different staging areas. Though most pipe preparation occurs during daylight hours, depending on the project schedule and urgency, pipe preparation may or may not occur at night. If nighttime operations occur, lighting will be associated with these activities and must meet USACE and the Occupational Safety and Health Administration (OSHA) standards. The staging area is sited to minimize environmental impacts and is roped off for safety considerations throughout project construction.

*Pipeline Preparation and Connection*
Depending on the type of pipe used for the project, pipeline preparation may entail cutting, grinding, and welding of pipe. For large projects, pipe is moved from the staging area to the pre-identified pipeline route using a wagon pulled by a piece of heavy equipment. Depending on the length of each pipe segment used for a given project, the pipe will be unloaded in piles at secondary staging areas along the designated pipeline route. These piles of pipe are temporary and in some cases are immediately assembled.

Pipe segments in the water extending from the dredge to the beach access point are typically attached using a ball and joint connecting system. From the beach access point to the pipe outflow end, the pipeline may consist of both “straight-line” pipe and “telescope” pipe. Straight-line pipe extends from the beach access to the point on the beach where the construction template is to be achieved. Depending on the material, length, and type of each section of pipe, the straight-line pipe may be bolted with a gasket, welded, or fused together using a fusing machine. The smooth connection points in straight-line pipe allow for a smooth flow of material through the pipeline maximizing production rates. Approximately every 200 feet, at the connection point for two pipe segments, a small hole may be dug to allow the contractor to connect the pipe 360 degrees around. Once the straight-line pipeline is connected and the terminal point of the line is at the pipe outflow end, a y-valve joint will be added and telescope pipe is then connected. Pipe segments are placed one inside the other to generate the telescope pipeline and cedar planks and burlap are used for leak control. These types of connections have a reduced diameter and; therefore, production rates decrease due to the restricted flow of material. The y-valve and connecting telescope pipeline enables the contractor to “walk” the pipeline down the beach as the project is underway and reduce the amount of down time for extending pipe. While material is being placed on the beach and the construction template is achieved, the contractor can extend the telescope pipe at the other end of the y-valve and switch the lines without having to shut down production to extend the pipeline. As a large portion of beach is constructed, additional straight-line pipe will be added to reduce the amount of telescope pipe used and to maintain acceptable levels of production.

*Beach Construction*

The beach building process typically involves the use of bulldozers and sometimes backhoes to distribute the sediment as it falls out of suspension at the outflow end of the pipeline. The sediment slurry is diffused as it is released from the terminal pipe in order reduce the flow velocity onto the beach and minimize the risk of creating scour holes. Dikes are constructed on one or two sides of the effluent area to allow for extended settlement time of suspended solids in order to reduce turbidity levels in the near shore environment. The construction zone, which includes the active disposal area and associated heavy equipment used to redistribute sediment, generally encompasses a fenced off area of 500 feet on each side. The contractor places stakes to mark station locations and elevational requirements for the project template. As sediments fall out of suspension, dozers and backhoes are used to distribute sediment and construct the desired beach template. As target elevations for a given project and station are achieved, the designated construction area moves down the beach to the next station. Upon completion of a given section (generally 500-foot acceptance sections), stakes are removed from the beach. Throughout the duration of the pumping process, the contractor is required to inspect the pipeline route (approximately every 2 hours) in order to check and fix pipe leaks. During all aspects of the construction operation, vehicles and heavy equipment including pickup trucks, all terrain vehicles (ATV's), bulldozers, etc. may traverse the beach. No driving or construction activity is allowed within existing dune vegetation or other environmentally sensitive locations identified prior to construction.

In addition to the heavy equipment and other small vehicles located within the active construction area at the disposal site, the contractor is also required to have a dumpster for trash disposal (a solid waste disposal management plan is required from the Contractor), and bathroom facilities (portable). The contractor may also have an equipment supply container that follows the progression of the disposal area.

*Lighting During Construction*

According to the 2003 U.S. Army Corps of Engineers Safety and Health Requirements Manual (EM 385-1-1), a luminance range of 3-30 $lm/ft^2$ is required for general outdoor work or construction areas. In order to meet these safety standards, appropriate lighting must be provided at night during specific components of the project site (i.e. disposal site, dredge, staging area, etc.). Project construction typically occurs around-the-clock to make efficient use of expensive equipment (the cost of which constitutes a major cost of the operation). Allowing this equipment to be idle at night could double the cost and duration of the operation. Most of the equipment staging, mobilization, and demobilization of pipeline are performed during daylight hours. However, nighttime staging, mobilization, and demobilization may occur if there is a small construction window and the work schedule is tight. For projects where lighting is a concern for sensitive organisms, ample lighting can be obtained without impacting a large area by using light shields and appropriate angling of lights. In addition to staged light in the construction area, the vehicles used for transport, as well as the bulldozers moving sediment, will have lights on the front and back of the equipment. Features within the active disposal area including the dumpster, equipment storage, etc. may also have lighting associated with them. Working around heavy equipment is dangerous anytime. Injuries and fatalities have occurred in both the water and on the beach. Ample lighting of work areas at night is a major human safety consideration.

*Demobilization*

Demobilization is essentially the reverse of the mobilization process and includes the breakdown of all straight-line and telescope pipe, the removal of pipe segments in the staging area, and the removal of all equipment from the staging area. The demobilization process is similar to the mobilization process and functions like a large production line. As the pipe is broken down, pieces of pipe are transported and stacked using trucks, wagons, cranes, etc. and prepared for transport off-site via barges, trucks, or tugs.

### 7.01.3 Vibracore Operations

The proposed borrow areas have been characterized through the use of a number of vibracore samples that were taken during the feasibility study. Vibracore borings are generally drilled using a 3 7/8 inch diameter, 20 foot long, vibracore drill machine. The sampler consists of a metal barrel in which a plastic cylinder is inserted. After the plastic tube is inserted, a metal shoe is screwed onto the plastic tube and then the metal barrel. The shoe provides a cutting edge for the sampler and retained the plastic tube. An air-powered vibrator is mounted at the upper-most end of the vibracore barrel, and the vibrator and the vibracore barrel are mounted to a stand. This stand is lowered to the ocean floor by the vessel’s crane; the vibrator is activated and vibrates the vibracore barrel into the ocean sediment. The sediment sample is retained in the plastic cylinder. All borings are drilled to a depth of 20 feet below the ocean floor, unless vibracore refusal is encountered. During the PED phase of this study, additional vibracore borings will be performed in a grid pattern in the proposed borrow areas, on a 500 foot to 1000 foot spacing, in order to further characterize the sediment and define the useable borrow area boundaries. Hardbottom areas and cultural resources that have been identified in the borrow areas (see Sections 2.04.6 and 2.08) will be avoided during the PED phase vibracoring. Therefore, no physical impacts to existing high valued resources are anticipated from these activities.

## 7.02 Marine Environment

### 7.02.1 Wetlands and Floodplains

The proposed borrow areas for the project are between 1 and 5 miles offshore, therefore, dredging operations would not be expected to adversely affect wetlands and floodplains of the study area. Beach placement operations would not be expected to adversely affect wetlands and floodplains. Section 9 includes additional discussion of wetlands and floodplains pursuant to Executive Order 11988 (Floodplain Management, section 9.07) and Executive Order 11990 (Protection of Wetlands, section 9.08).

### 7.02.2 Inlet, Flats, and Sounds

The proposed borrow areas for the project are between 1 and 5 miles offshore and would not be expected to adversely affect the inlets, flats, and sounds of the study area. Because no sediment would be removed from the inlet complex for beach nourishment, impacts to inlet dynamics would not be expected. Although large quantities of sediment would be added to the project area beaches to construct and maintain the project, the total volume of sediment added to the littoral system would not be expected to be significantly more than pre-project conditions. Therefore, placing additional sediment on the beach would not significantly affect sand flat and shoal development in the inlet systems. The additional material would only accentuate the natural dynamics of the sand sharing system that exists. Therefore, nourishment operations would not be expected to adversely affect the inlet, flats, and sounds of the study area.

### 7.02.3 Surf Zone Fishes

The surf zone is a dynamic environment, and the community structure of organisms that inhabit it (e.g., surf zone fishes and invertebrates) is complex. Representative organisms of both finfish and the invertebrate inhabitants they consume exhibit similar recruitment periods. In North Carolina, the majority of invertebrate species recruit between May and September (Hackney et al., 1996, Diaz, 1980, Reilly and Bellis, 1978), and surf zone fish species recruit from March through September (Hackney et al., 1996). The anticipated construction time frame for the project is from December 15 to March 31 and would avoid a majority of the peak recruitment and abundance periods of surf zone fishes and their benthic invertebrate prey source.

The surf zone represents a Habitat Areas of Particular Concern (HAPC) for some species, including adult bluefish and red drum, which feed extensively in that portion of the ocean. The surf zone is suggested to be an important migratory area for larval/juvenile fish moving in and out of inlets and estuarine nurseries (Hackney et al., 1996). Disposal operations along the beach can result in increased turbidity and mortality of intertidal macrofauna, which serves as food sources for those and other species. However, during disposal operations, the dredged material slurry is managed through the construction of dikes to allow for a larger settling time and reduction of turbidity loads into the surf zone environment. Though mitigation efforts are undertaken to reduce turbidity loads, elevated Nephelometric Turbidity Unit (NTU) levels are still anticipated at the immediate disposal area sites. Therefore, feeding activities of the species could be interrupted in the immediate area of beach sand placement. Mobile fish species are expected to temporarily relocate to other areas as the project proceeds along the beach. However, some species like Florida pompano and Gulf kingfish exhibit strong site fidelity during the middle portion (summer) of the nursery period (Ross and Lancaster, 2002) and might not avoid secondary effects (turbidity) of disposal. Because the project would avoid impacts to the surf zone during the summer months, it is expected that the project would not affect this period of strong site fidelity. Although a short-term reduction in prey availability could occur in the immediate disposal area, only a small area is affected at a time, and once complete, organisms can recruit into the nourished area. Such a recovery would begin immediately after disposal activity if the material is similar to the native beach (see Benthic Resources—Beach and Surf Zone Section 7.02.6).

According to Ross (1996) some surf zone fishes exhibit prey switching in relation to prey availability. Therefore, during periods of low prey availability, as a result of short-term impacts to the benthic invertebrate population during beach disposal activities, surf zone fishes may temporarily use alternative food sources. Considering the dynamic nature of the surf zone, such opportunistic behavior of avoidance and prey switching might enable some surf zone fishes to adapt to disturbances such as beach nourishment. A combination of short-term prey switching and temporary relocation capabilities may help minimize short-term prey reductions during beach disposal operations. Once the placement operation is finished, physical conditions in the impact zone quickly recover and biological recovery soon follows. Surf-feeding fish can then resume their normal activities in the areas. That is supported in Ross and Lancaster's (2002) study in which Florida pompano and Gulf kingfish appeared to remain as long near a recently nourished beach as a beach that was not recently nourished.

Disposal and subsequent turbidity increases may have short-term effects on surf zone fishes and prey availability. However, the opportunistic behavior of the organisms within the dynamic surf zone environment enables them to adapt to short-term disturbances. Because of the adaptive ability of representative organisms in the area and the avoidance of peak recruitment and abundance time frames with a December 15 to March 31 construction time frame, such effects would be expected to be temporary and minor.

### 7.02.4 Larval Entrainment

For many marine fishes, spawning grounds are believed to occur on the continental shelf with immigration to estuaries during the juvenile stage through active or passive transport. According to Hettler and Hare (1998), research suggests two bottlenecks that occur for offshore-spawning fishes with estuarine juveniles: the transport of larvae into the nearshore zone and the transport of larvae into the estuary from the nearshore zone. During that immigration period from offshore to inshore environments, the highest concentration of larvae generally occurs in the inlets as the larvae approach the second bottleneck into the estuary. Once through the inlet, the shelter provided by the marsh and creek systems in the sound serve as nursery habitat where young fish undergo rapid growth before returning to the offshore environment.

Those free floating planktonic larvae lack efficient swimming abilities and are, therefore, susceptible to entrainment by an operating hydraulic or hopper dredge as they immigrate from offshore to inshore waters. However, the proposed borrow areas are located between 1 and 5 miles offshore with the closest inlet (i.e. Beaufort Inlet) located approximately 3.5 miles from the closest portion of the borrow site.  Therefore, though concentrations of larvae would likely be present within offshore borrow areas, dredging activities would not occur in the highest concentration inlet bottleneck areas.

Susceptibility to this effect of entrainment is largely dependent on proximity to the cutter-head or drag-head and the pumping rate of the dredge. Those larvae present near the bottom would be closer to the dredge area and would, therefore, be subject to higher risk of entrainment. Assessment of the significance of the entrainment is difficult. Assuming the very small volumes of water pumped by dredges relative to the total amount of water in the dredging vicinity, a small proportion of organisms are presumed to be affected. Potential reasons for low levels of impact include the extremely large numbers of larvae produced by most estuarine-dependent species and the extremely high natural mortality rate for early life stages of many fish species. As natural larval mortalities might approach 99 percent (Dew and Hecht, 1994, Cushing, 1988), entrainment by a hydraulic dredge would not be expected to pose a significant additional risk in most circumstances. An assessment of potential entrainment effects of the proposed dredging action may be viewed in a more site-specific context by comparing the pumping rate of a dredge with the amount of water present in the affected water body. For the purposes of this assessment, assumptions would be made that inlet bottlenecks would have the highest concentrations of larvae as they are transported into the estuarine environment from the nearshore zone. Larval effects of dredging in this *high-concentration* system would be significantly greater than the entrainment risk of dredging in offshore borrow areas. The distribution, abundance seasonality, transport, and ingress of larval fish at Beaufort Inlet, North Carolina, has been extensively studied (Blanton et al., 1999, Churchill et al., 1999, Hettler and Barker, 1993, Hettler and Chester, 1990, Hettler and Hare, 1998). Therefore, it represents a good case study site for assessing larval entrainment of a hydraulic dredge. The largest hydraulic dredge likely to work in offshore borrow areas would have a discharge pipe about 30 inches in diameter and would be capable of transporting about 30,600 $m^3$ of sand per day (assuming 1 mile of travel) if operated 24 hours (because of breakdown, weather, and the like, dredges generally do not work 24 hours a day, 7 days a week). The dredged sediment would be pumped as slurry containing about 15 percent sand and about 85 percent water by volume. The volume of water discharged would, thus, be about 173,000 $m^3$ per day, or about 2.0 $m^3$ per second. In contrast, the calculated spring tide flow through Beaufort Inlet is approximately 142,000,000 $m^3 \times 2 =$ 284,000,000 $m^3$ (i.e., two tides a day) of water and 264,000,000 $m^3$ during neap tide. Thus, the dredge would entrain only 0.06 to 0.07 percent of the daily volume flux through the inlet. According to Larry Settle (2002), the percentage of the daily flux of larvae entrained during a spring and neap tide is very low regardless of larval concentration and the distribution of larvae within the channel. Under the worst-case scenario with the highest concentrations of larvae possible based on spatial and temporal distribution patterns, the maximum percentage entrained barely exceeds 0.1 percent per day. Although any larvae entrained (calculations indicate 914 thousand to 1.8 million depending on the initial concentration in the tidal prism) would likely be killed, the effect at the population level would be expected to be insignificant. On the basis of those calculations indicating an *insignificant* larval entrainment impact, at the population level, from hydraulic dredging activities within a representative high concentration *inlet bottleneck* at Beaufort Inlet, North Carolina, the risk of larval entrainment from dredging activities in the offshore borrow area associated with this project would likely be even less and would not be expected to adversely affect marine fish larvae.

### 7.02.5 Nekton

Oceanic nekton are active swimmers, not at the mercy of the currents, and are distributed in the relatively shallow oceanic zone. They are composed of three phyla-chordates, mollusks, and arthropods, with chordates (i.e., fish species) forming the largest portion. Any entrainment of adult fish, and other motile animals in the vicinity of the borrow area during dredging would be expected to be minor because of their ability to actively avoid the disturbed areas. Fish species are expected to leave the area temporarily during the dredging operations and return when dredging ceases (Pullen and Naqvi 1983). Larvae and early juvenile stages of many species pose a greater concern than adults because their powers of mobility are either absent or poorly developed, leaving them subject to transport by tides and currents. That physical limitation makes them potentially more susceptible to entrainment by an operating hydraulic dredge (see Section 7.02.4, Larval Entrainment). Benthic-oriented organisms close to the dredge cutterhead or draghead could be captured by the effects of its suction field and entrained in the flow of dredged sediment and water. As a worst-case, it could be assumed that entrained animals experience 100 percent mortality, although some small number might survive. Susceptibility to this effect depends on avoidance reactions of the organism, the efficiency of its swimming ability, its proximity to the draghead, the pumping rate of the dredge, and possibly other factors. Behavioral characteristics of different species in response to factors such as salinity, current, and diurnal phase (daylight versus darkness) are also believed to affect their concentrations in particular locations or strata of the water column. Any benthic oriented organisms present near the ocean bottom (i.e., calico scallops and spiny dogfish, a SAFMC managed species) would be closer to the dredge cutterhead or draghead and, therefore, subject to higher risk of entrainment.

The biological effect of hydraulic entrainment has been a subject of concern for more than a decade, and numerous studies have been conducted nationwide to assess its effect on early life stages of marine resources, including larval oysters (Carriker et al. 1986), post-larval brown shrimp (Van Dolah et al. 1994), striped bass eggs and larvae (Burton et al. 1992), juvenile salmonid fishes (Buell 1992), and Dungeness crabs (Armstrong et al. 1982). The studies indicate that the primary organisms subject to entrainment by hydraulic dredges are bottom-oriented demersal fishes and shellfishes. The significance of entrainment effects depends on the species present, the number of organisms entrained, the relationship of the number entrained to local, regional, and total population numbers, and the natural mortality rate for the various life stages of a species. Assessing the significance of entrainment is difficult, but most studies indicate that the significance of impact is low. Although entrainment of benthic oriented organisms would be expected from the proposed dredging activities, a hydraulic dredge operating in the open ocean would pump such a small amount of water in proportion to the surrounding water volume that any entrainment effects associated with dredging of borrow material for the project are not expected to adversely affect species at the population level. Though entrainment rates for both cutterhead suction and hopper dredges are both expected to be low, the mobile and surficial dredging nature of hopper dredges would likely propose a higher risk of entrainment than cutterhead suction dredges since cutterhead dredges are not mobile and operate most effectively while buried within a small surface area.

Effects of dredging activities on marine mammals and sea turtles are addressed in the NMFS South Atlantic Regional Biological Opinion (SARBO). See section 7.04.2 of this document for more information on the NMFS SARBO. Effects on marine mammals are also discussed in section 7.10.3 and Appendix F. In accordance with T&E species observer requirements for hopper dredging activities (see Appendix F), inflow and overflow screening, as well as NMFS-certified turtle observers is required to assure accountability of species entrained by the draghead. As a component of hopper dredge observer requirements, all other biota (i.e., fish, bivalves) captured by the inflow screening are recorded and submitted to USACE for incorporation into a historic entrainment database. Opportunity to record bycatch on cutterhead suction dredges does not exist since there are no screening measures in place.

### 7.02.6 Benthic Resources—Beach and Surf Zone

Beach fill placement may have negative effects on intertidal macrofauna through direct burial, increased turbidity in the surf zone, or changes in the sand grain size or beach profile. While beach nourishment may produce negative effects on intertidal macrofauna, they would be localized in the vicinity of the nourishment operation.

In a 1999 Environmental Report on the use of Federal offshore sand resources for beach and coastal restoration, U.S. Department of Interior, Bureau of Ocean Energy Management (BOEM) (Previously Minerals Management Service (MMS) provided the following assessment of potential effects on beach fauna from beach nourishment.

> Because benthic organisms living in beach habitats are adapted to living in high energy environments, they are able to quickly recover to original levels following beach nourishment events, sometimes in as little as three months (Van Dolah et al. 1994, Levisen and Van Dolah 1996). This is again attributed to the fact that intertidal organisms are living in high energy habitats where disturbances are more common. Because of a lower diversity of species compared to other intertidal and shallow subtidal habitats (Hackney et al. 1996), the vast majority of beach habitats are re-colonized by the same species that existed before nourishment (Van Dolah et al. 1992, Nelson 1985, Levisen and Van Dolah 1996, Hackney et al. 1996).

As a component of their review of the potential effects of beach nourishment on surf zone fishes and invertebrates in the South Atlantic Bight, Hackney et al. (1996) identified nine fish species and five invertebrate species/groups that are important inhabitants of the intertidal and subtidal beach environment. According to their literature review of associated impacts to these species and how best to protect the natural resources associated with beach nourishment, they identified four management questions to address for each nourishment project: (1) project timing, (2) sediment compatibility, (3) nourishment duration, and (4) innovative ways to minimize effects (i.e., staging nourishment events). Those questions were considered during planning efforts associated with the proposed dredging and beach construction efforts for this project. The proposed dredging window of December 15 through March 31 for initial construction and each nourishment event avoids the identified peak recruitment periods for surf zone fish (March through September [Hackney et al., 1996]) and invertebrate species (May through September [Hackney et al. 1996, Diaz 1980, Reilly and Bellis 1978]) in North Carolina. Beach nourishment would therefore be completed before the onshore recruitment of most surf zone fishes and invertebrate species. To assure compatibility of nourishment material with native sediment characteristics and minimize impacts to benthic invertebrates from the placement of *incompatible* sediment, all sediment identified for use for this project has gone through compatibility analysis and overfill ratio calculations to assure compatibility with the native sediment (see Section 5.06.1 and Appendix C).

In summary, temporary effects on intertidal macrofauna in the immediate vicinity of the beach nourishment project would be expected as a result of discharges of nourishment material on the beach. While the proposed beach fill placement may adversely affect intertidal macrofauna, with the implementation of environmental measures discussed above, such effects would be expected to be localized, short-term, and reversible. Any reduction in the numbers or biomass (or both) of intertidal macrofauna present immediately after beach fill placement may have localized limiting effects on surf-feeding fishes and shorebirds because of a reduced food supply. In such instances, those animals may be temporarily displaced to other locations.

### 7.02.7 Benthic Resources—Nearshore Ocean

The post-dredge infilling rate and quality and type of the material are contributing factors to the recovery of the area dredged. The MMS (now BOEM) (1999) indicates that the bottom substrate at and near a borrow area can be modified in several ways. A change in bottom contour could be evident throughout the project life and post-construction populations can differ from pre-construction conditions. A change in the hydrologic regime as a consequence of altered bathymetry may result in the deposition or scour of fine sediments, which may result in a layer of sediment that differs from the existing substrate. Also, once material in the borrow areas is dredged, it is possible that different post-dredging underlying sediment types would be exposed and would be different from pre-dredging sediment types.

Benthic organisms within the defined borrow area dredged for construction and periodic nourishment would be lost. However, recolonization by opportunistic species would be expected to begin soon after the dredging activity stops. Because of the opportunistic nature of the species that inhabit the soft-bottom benthic habitats, recovery would be expected to occur within 1–2 years. After dredging, benthic abundance quickly increases and reaches maximum density in about six months due to planktonic larva settling in the dredged areas. This density is typically much greater than the pre-dredged level. A steep decline follows due to either overpopulation or predation or both. Biomass exhibits a decline at the same time that abundance declines but, unlike benthic abundance, biomass exhibits a second increasing phase as the “equilibrium,” long-lived species begin to grow in size and biomass and replace the dying opportunists. A compilation of multiple studies of sand dredging in the U.S. outer continental shelf (OCS) reveals immediate-to-short-term declines in macrofaunal abundance ranging from 45-88% and in species richness ranging from 25-60% in borrow areas (Michel et al. 2013).

Monitoring studies of post-dredging effects and recovery rates of borrow areas indicate that most borrow areas usually show significant recovery by benthic organisms approximately 1 to 2 years after dredging (Naqvi and Pullen 1982, Bowen and Marsh 1988, Johnson and Nelson 1985, Saloman et al. 1982, Van Dolah et al. 1984, Van Dolah et al. 1992). According to Posey and Alphin (2000), benthic fauna associated with sediment removal from borrow areas off of Carolina Beach, NC recovered quickly with greater inter-annual variability than differences from the effects of direct sediment removal. However, a potential change in species composition, population, and community structure may occur from the initial sediment removal impact and the change in surficial sediment characteristics, resulting in the potential for longer recovery times (2–3 years) (Johnson and Nelson 1985, Van Dolah et al. 1984). Differences in community structure may occur that may last 2–3 years after initial density and diversity levels recover (Wilber and Stern 1992). Specifically, large, deeper-burrowing infauna can require as long as 3 years to reach pre-disturbance abundance. According to Turbeville and Marsh (1982), long-term effects of a borrow site at Hillsboro Beach, Florida, indicated that species diversity was higher at the borrow site than at the control site. Jutte et al. (1999 and 2001) evaluated recovery rates of post-hopper dredged borrow areas and found that hopper dredging creates a series of ridges and furrows, with the ridges representing areas missed by the hopper dredge. Rapid recolonization rates were documented because of the dredge's inability to completely remove all the sediment. Furthermore, Jutte et al. (2002) documented that dredging to shallower depths is less likely to modify wave energy and currents at a borrow site, thus, reducing the likelihood of infilling of fine-grained sediment.

As identified in Section 2.04.6, low relief hard bottom communities were identified in the U and Y borrow areas. Dredging is not expected to have any adverse direct or indirect effect on hard bottom and associated trophic linkages within the borrow area due to the North Carolina Coastal Resources Commission's 500 meter hardbottom buffer rule [CRC Rule 15A NCAC 07H .0208(b)(12)(A)(iv)]. Effects on estuarine-dependent organisms are not expected to be significant because construction-related activities in the offshore borrow area and on beaches proposed for nourishment would be localized. A study of nearshore borrow areas after dredging offshore of South Carolina revealed no long-term effects on fishery and planktonic organisms, as a result of the dredging (Van Dolah et al. 1992). In a 1999 Environmental Report on the use of Federal offshore sand resources for beach and coastal restoration, BOEM provided the following assessment of potential turbidity impacts.

> The impacts from turbidity on benthic organisms during dredging operations were reviewed in detail by Pequegnat et al. (1978) and Stern and Stickle (1978). Both studies concluded that impacts to the benthic populations of the marine ecosystem from turbidity are local and temporary but not permanent. Similarly, recent studies show that benthic impacts may be limited to the immediate vicinity of dredging operations (e.g., Hitchcock et al. 1998, MMS 1996).

All of borrow areas U and Q2 are located beyond 3 nautical miles offshore and would be subject to Federal mining requirements of the BOEM. Multiple dredging areas within subsections of the borrow site may be used to reduce material transport or allow for concurrent operation of more than one dredge in an area.

### 7.02.8 Essential Fish Habitat

Table 7.1 identifies more than 30 categories of EFH and HAPC. While all those habitat categories occur in waters of the southeastern United States, only a few occur in the immediate project vicinity or the project impact zone. The proposed project would avoid direct effects on estuarine areas, therefore; only identified EFH and HAPC in marine areas might be directly affected. Effects on habitat categories potentially present in the project vicinity are discussed in the following subsections.

7.02.8.1 Effects on the Estuarine Water Column. The proposed borrow areas are between 1 and 5 miles offshore in depths between -40 and -57-ft. MLLW, thus, dredging operations would not be expected to directly affect any estuarine water column, and therefore, would not be expected to directly affect estuarine life cycle requirements of managed species in the South Atlantic Region. However, the Recommended Plan consists of an 119,670 ft (22.7 miles) long main beach fill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). Short-term, elevated turbidity levels could occur during the nourishment operation and could be transported outside the immediate disposal area via longshore and tidal currents. The project limits are bound by Bogue and Beaufort Inlets. Turbidity associated with beach fill placement operations could extend into these inlets and the estuarine water column from longshore currents and tidal influx, however these effects are expected to be minimal.

| Essential Fish Habitat | In/near project vicinity | Project impact area | Dredge plant operation | Sediment disposal activities |
|---|---|---|---|---|
| Estuarine areas | | | | |
| Estuarine Emergent Wetlands | yes | no | no | no |
| Estuarine Scrub/Shrub Mangroves | no | no | no | no |
| Submerged Aquatic Vegetation (SAV) | no | no | no | no |
| Oyster Reefs & Shell Banks | no | no | no | no |
| Intertidal Flats | yes | no | no | no |
| Palustrine Emergent & Forested Wetlands | no | no | no | no |
| Aquatic Beds | no | no | no | no |
| Estuarine Water Column | yes | no | no | no |
| Seagrass | no | no | no | no |
| Creeks | yes | no | no | no |
| Mud Bottom | yes | no | no | no |
| Marine areas | | | | |
| Live/Hard Bottoms | yes | no | no | no |
| Coral and Coral Reefs | no | no | no | no |
| Artificial/Man-made Reefs | yes | no | no | no |
| *Sargassum* | yes | yes | within acceptable limits | no |
| Water Column | yes | yes | within acceptable limits | within acceptable limits |
| Geographically Defined HAPC | | | | |
| Area-wide | | | | |
| Council-designated Artificial Reef Special Mgnt Zones | no | no | no | no |
| Hermatypic (reef-forming) Coral Habitat and Reefs | no | no | no | no |
| Hard Bottoms | yes | no | no | no |
| Hoyt Hills | no | no | no | no |
| *Sargassum* Habitat | yes | no | within acceptable limits | no |
| State-designated Areas of Importance of Managed Species (PNAs) | yes | no | no | within acceptable limits |
| Submerged Aquatic Vegetation (SAV) | no | no | no | no |
| North Carolina | | | | |
| Big Rock | distant offshore | no | no | no |
| Bogue Sound | yes | no | no | no |
| Pamlico Sound at Hatteras/Ocracoke islands | no | no | no | no |
| Cape Fear sandy shoals | distant offshore | no | no | no |
| Cape Hatteras sandy shoals | no | no | no | no |
| Cape Lookout sandy shoals | distant offshore | no | no | no |
| New River | no | no | no | no |
| The Ten Fathom Ledge | no | no | no | no |
| The Point | no | no | no | no |

Table 7.1. Categories of EFH and HAPC and potential impacts.

### 7.02.8.2 Effects on Hard Bottoms

*Borrow Area*

Hard-bottom communities are located within State waters and are scattered throughout the North Carolina coast, including the vicinity of the proposed Bogue Banks coastal storm damage reduction project. These important resources vary in elevation from low relief ephemeral features, which are consistently buried and re-exposed over time, to more stable high relief features. Depending on the proximity of these hard-bottom communities to the proposed project site, they could be vulnerable to shoreline alterations or dredging operations or both (Moser and Taylor 1995). However, as discussed in Section 2.04.6, to develop a detailed understanding of the existing hard-bottom resources within the project area, a literature review of existing hard bottom data sets throughout the study area as well as a side scan survey within the proposed borrow area were implemented (Mid-Atlantic 2008). Based on these data, low relief hard bottom resources have been identified within the borrow areas U and Y and will be avoided using a 500 meter buffer. Potential project effects relative to the beach fill construction and associated equilibration process in the nearshore environment are discussed below.

*Nearshore*

The long-term and short-term limits of cross-shore sediment transport are important in engineering and environmental considerations of beach profile response. Significant quantities of sand-sized sediments can be transported and deposited seaward as a result of short-term erosional events and the equilibration of a constructed beach profile. Over time, the evolving profile advances seaward into deeper water until it approaches equilibrium, however, sediment particles can be in motion at greater depths than those at which profile readjustment occurs. The seaward limit of effective profile fluctuation over long-term time scales is referred to as the *closure depth*. On the basis of the data reviewed to date, no hard-bottom features have been identified in the expected depth of closure for the study.

On the Pacific Coast, Cacchione et al. (1984) identified surficial sedimentary features of the shoreface and inner shelf environments with slight topographic expressions (~1 m (3.28 ft.) total relief) about 100–200 m (328–656 ft.) wide and extending hundreds to thousands of meters in the cross-shore direction. Those features were composed of coarse sand (in some cases shell hash and gravel) and arranged into large wave-generated ripples. Termed ripple scour depressions (RSDs) the features are attributed to areas of intensified cross-shore flow that preferentially winnow fine material, leaving a course lag parallel to flow. Similar geologic features were later identified throughout the Atlantic Coast, including off the coast of North Carolina and South Carolina (McQuarrie 1998, Thieler et al. 1999, Thieler et al. 2001).

Side scan imagery from Theiler et al. (1999) identified subtle shore oblique bathymetric expressions of high acoustic reflectivity dominating the shoreface and inner shelf of Wrightsville Beach, North Carolina, and Folly Beach, South Carolina. The depressional features had 1-m (3.28-ft.) vertical relief across widths of hundreds of meters and were associated with RSDs as defined by Cacchione et al. (1984). According to Thieler (1999), individual RSDs were approximately 40–100 m (131–328 ft.) wide on Wrightsville Beach, North Carolina, and Folly Beach, South Carolina, and are up to 1-m (3.28-ft.) deep on the upper shoreface, but have a much more subdued (~50 cm (~1.6 ft.)) bathymetric expression further offshore. Most depressions develop just outside the surf zone at 3–4 m (9.8–13.1 ft.) water depth and extend into the inner shelf at 15 m (49.2 ft.). Vibracore data from Thieler et al. (2001) indicate that these RSD features are floored by coarse sand, shell hash, and quartz gravel and are surrounded by areas of fine sand. The study sites appear to be relatively stable or represent a recurring, preferential morphologic state to which the seafloor returns after storm-induced perturbations. The apparent stability is interpreted to be the result of interactions at several scales that contribute to a repeating, self-reinforcing pattern of forcing and sedimentary response that ultimately causes the RSDs to be maintained as bedforms responding to both along and across shore flows. The presence of RSDs/Ripple Channel Depressions/sorted bedforms off of Bogue Banks was identified through side-scan imagery and ground-truthed (USACE 2009).

*Pipeline Corridor*

Details associated with potential cutterhead pipeline routes or hopper dredge and/or scow pumpout locations, including anchor points, have not been specified at this point. It is anticipated that any selected offshore pipeline corridor for hopper and/or scow pumpout during construction could extend from the shoreface to approximately 2,500 to 3,000 ft. offshore. Though no hard bottom has currently been mapped, once pipeline corridor and pumpout details are defined, USACE intends to survey all areas before construction to avoid potential impacts. All existing remote-sensing and ground-truth data would be used in combination with the new survey data. All information associated with the surveys, data analysis, identification, and mapping of pipeline corridors, appropriate buffers, and subsequent measures developed to avoid resource impacts would be coordinated with the resource agencies before construction.

#### 7.02.8.3 Effects on Reef-forming Corals

Hermatypic, or reef-forming, corals consist of anemone-like polyps occurring in colonies united by calcium encrustations. Reef-forming corals are characterized by the presence of symbiotic, unicellular algae called zooxanthellae, which impart a greenish or brown color. Because those corals derive a very large percentage of their energy from the algae, they require strong sunlight and are, therefore, generally found in depths of less than 150 ft. They require warm water temperatures (68 °F to 82 °F) and generally occur between 30° N and 30° S latitudes. The Bogue Banks project is located approximately 34 °N latitude. Off the East Coast of the United States, that northern limit roughly coincides with northern Florida, however, they can occur off the North Carolina coast. As identified in Section 2.04.6, low relief hard-bottom communities have been identified in the offshore borrow areas U and Y but due to the 500 meter buffers, no impacts to reef forming corals are anticipated.

#### 7.02.8.4 Effects on Artificial/Manmade Reefs

North Carolina, Department of Environment and Natural Resources, NCDMF Artificial Reef Program manages six reefs that are offshore of the study area. They are AR 315, AR 320, AR 330, AR 340, AR 342, and AR 345. All of these sites except AR 342 are not in the project area. AR 342 is located just south of borrow area Y. A 500 meter buffer from the artificial reef will be used and therefore, dredging and placement of material associated with the Bogue Banks CSDR project would not be expected to adversely affect artificial reef sites managed by the Artificial Reef Program (See Figure 2.2).

#### 7.02.8.5 Effects on Sargassum

Benthic and pelagic *Sargassum* sp. may be found within the vicinity of the proposed project area. *Sargassum filipendula* is a benthic species of *Sargassum* and is often the predominant macrophyte in nearshore areas where *Sargassum* beds grow subtidally in moderately exposed or sheltered rocky or pebble areas near hard bottom or coral reef communities (Schneider et al. 1991). Pelagic *Sargassum* sp. occur in large floating mats on the continental shelf, in the Sargasso Sea, and in the Gulf Stream. Most pelagic *Sargassum* circulates between 20° N and 40° N latitudes and 30° W longitude and the western edge of the Florida Current/Gulf Stream and forms a dynamic structural habitat with a diverse assemblage of marine organisms including fungi, micro- and macro-epiphytes, at least 145 species of invertebrates, 100 species of fishes, four species of sea turtle, and numerous marine birds. It is a major source of productivity in a nutrient-poor part of the ocean. There will be no direct impacts to benthic Sargassum.

Pelagic *Sargassum* is positively buoyant and, depending on the prevailing surface currents, would remain on the continental shelf for extended periods or be cast ashore. Therefore, pelagic *Sargassum* species could be transported inshore from the Gulfstream and drift through the vicinity of the dredge plant operation at the borrow areas. Because it occurs in the upper few feet of the water column, it is not subject to effects from dredging or sediment disposal activities associated with the proposed action (SAFMC 1998.), thus, effects from the dredging or disposal operations would not be expected to be significant.

#### 7.02.8.6 Effects on the Marine Water Column

The potential water quality effects of dredging and beach fill placement are addressed in Section 7.09.2. Dredging and beach fill placement conducted during project construction and periodic nourishment could create effects in the marine water column in the immediate vicinity of the activity potentially affecting the surf zone and nearshore ocean. Such effects could include minor and short-term suspended sediment plumes and related turbidity, and the release of soluble trace constituents from the sediment. Scientific data are very limited with regard to the effects of beach nourishment on fishery resources. The effects could be similar, on a smaller scale, to the effects of storms, storm effects could include increased turbidity and sediment load in the water column and, in some cases, changes in fish community structure (Hackney et. al., 1996). Storms of great severity, such as hurricanes, have been documented to create conditions resulting in fish kills, but such situations are not usually associated with beach nourishment.

In a 1999 Environmental Report on the use of Federal offshore sand resources for beach and coastal restoration, the U.S. Department of Interior, Minerals Management Service (now BOEM) provided the following assessment.

> In order to assess if turbidity causes an impact to the ecosystem, it is essential that the predicted turbidity levels be evaluated in light of conditions such as during storms. Storms on the Mid-Atlantic shelf may generate suspended matter concentrations of several hundred mg/L (e.g., Styles and Glenn 1999). Concentrations in plumes decrease rapidly during dispersion. Neff (1981, 1985) reported that solids concentrations of 1000 ppm two minutes after discharge decreased to 10 ppm within one hour. Poopetch (1982) showed that the initial concentration in the hopper overflow of 3,500 mg/L decreased rapidly to 500 mg/L within 50 m. For this reason, the impacts of the settling particles from the turbidity plume are expected to be minimal beyond the immediate zone of dredging.

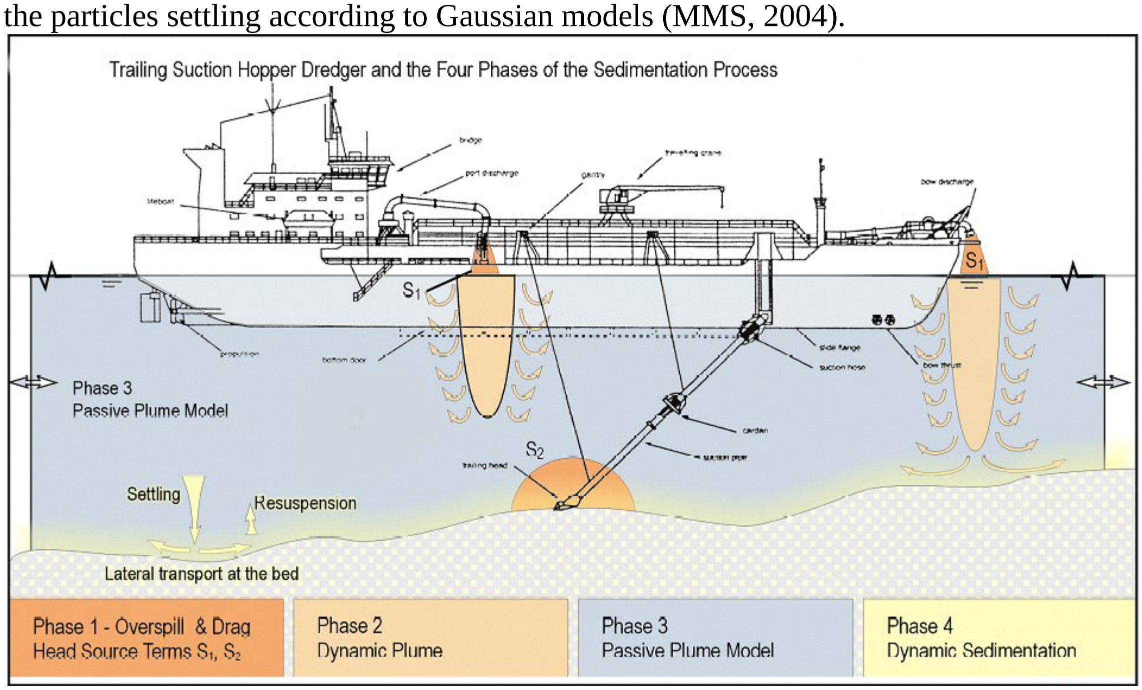
Past projects indicate that the extent of the sediment plume is generally limited to between 1,640 – 4,000 ft from the dredge and that elevated turbidity levels are generally short-lived, on the order of an hour or less (NASA 2013).

Beach nourishment can affect fishery resources and EFH through increases in turbidity and sedimentation that, in turn, can create localized stressful habitat conditions, and can result in temporary displacement of fish and other biota. Because of the low silt/clay content of the sediment proposed for beach fill placement (See Appendix C, Geotechnical Analysis), water column effects would be expected to be localized, short-term, and minor. Furthermore, the beach fill placement operation would be expected to proceed at a slow rate. Mobile biota, including juvenile and adult fish, should be able to relocate outside the more stressful conditions of the immediate nourishment operation. Cumulative effects of multiple, simultaneous beach fill placement operations could be harmful to fishes of the surf zone. However, because of the high quality of the sediment selected for beach fill and the small amount of beach affected at any time, the proposed activity would not be expected to pose a significant threat.

*Hopper Dredge and Scows—Sedimentation and Turbidity*

During dredging operations, marine resources within the vicinity of offshore borrow areas can be affected by turbidity and sediment plumes generated from filling and overflow of hopper dredges and scows depending on the characteristics and suspension time of the sediment being dredged. The discharge of overflow associated with hopper dredges and scows to achieve economic loading releases sediment into the water column. Cutterhead dredge operations are confined to the benthic environment and associated turbidity is more confined. Hopper dredge suction dragheads hydraulically remove sediment from the sand bottom and discharge the material into the storage hoppers on the dredge. The screened sandy material fills the hopper until an economic load is achieved for transit and subsequent pumpout to the beach placement location. As illustrated in

Figure 7.3, the operation has two types of sedimentation and turbidity sources: S1 from the overflow (which for most U.S. dredges now is through the bottom of the hull) and S2 associated with suspension of sediment at the draghead. During filling of the hopper, any fine sediments (primarily silt, clays, and fine-sands) are washed overboard through *overflow* ports (i.e., S1) either over the side of the vessel or through *weirs* that release the slurry through the hull of the vessel. Such *washing* of the dredged material is the predominant source of turbidity plumes and sedimentation generated by the hopper dredge; however, the *washing* effect also makes the hopper load for pumpout to the beach coarser. Some turbidity would be expected from the physical interaction of the draghead with the bottom substrate (i.e., S2) during the dredging operation, however, it would not be expected to be significant considering most of the disturbed sediments would be confined to the suction field of the hopper dredge dragheads and would be dredged and disposed into the hopper. Scows would operate in a similar fashion; however, the material would be dredged by a cutterhead dredge and transported to the scow via a pipeline.  Sediment discharged overboard from the hopper and/or scow overflow moves faster than would be anticipated from simple Gaussian models because of the settlement velocity of component particles. That is because of high sediment concentration and discharge rate of the overflowed material, factors that lead to the development of a density current that moves through the water column in a *dynamic phase* of settlement, at least initially. Sediment is stripped away as the dynamic plume moves through the water column forming a passive plume that is advected and dispersed by ambient currents, with the particles settling according to Gaussian models (MMS, 2004).




Source: MMS, 2004

Note: This figure shows two S1 sources at overflows from a screening operation, in almost all U.S. dredges, the S1 source is through the bottom of the hull.

Figure 7.3. Hopper dredge sedimentation processes.

Hitchcock and Drucker (1996) summarized values for material lost through the overflow process on a typical 4,500 ton hopper dredge operating in U.K. waters. Results from the study indicate that during an average loading time of 290 minutes, 4,185 tons of dry solids are retained as cargo, while 7,973 tons of dry solids are returned overboard from overflow. Sand-sized particles fall directly to the seabed and are reduced to background levels over a distance of 200–500 m (656–1,640 ft.) and smaller, silt-sized particles have a typical settling velocity of 0.1 to 1.0 mm/s and are reduced to background values of 2–5 milligrams per liter (mg/L) over a similar distance. According to Neff (1981, 1985), concentrations of 1,000 mg/L immediately after discharge decreased to 10 mg/L within one hour. The minimal effect of settling particles from hopper dredge turbidity plumes was further supported by a study from Poopetch (1982), which found that the initial hopper dredge overflow concentrations of 3,500 mg/L were reduced to 500 mg/L within 50 m (164 ft.).

The distance that sediment plumes can extend depends on the type of dredge, how it is operated, currents, and the nature of the sediments in the dredged area. Dredging of sandy sediments would minimize the amount of turbidity associated with the dredging operation and would reduce the suspension time and advection distance of overflow sediments. A study performed by Newell and Siederer (2003) in the U.K. (high-current velocities) showed that, in most cases, coarse material up to sand-size particles settles within 200 m (656 ft.) to 600 m (1,968 ft.) of the point source of discharge, depending on depth of water, tidal velocity, and the velocity of flow from the discharge pipe. During hopper dredging operations in the Baltics, Gajewski and Uscinowicz (1993) noted that the main deposition of sand from hopper dredge overflow was confined to distances within 150 m (492 ft.) on each side of the dredge. The study further supported that the initial sedimentation associated with overflow material behaves like a density current where particles are held together by cohesion during the initial phase of the sedimentation process and are mainly confined to a zone of a few hundred meters from the discharge chutes. According to a plume dispersion model developed by Whiteside et al. (1995) (based on field study measurements obtained while hopper dredging in Hong Kong waters), the contours for sediment deposition remain as a narrow band extending for approximately 100 m (328 ft.) on each side of the vessel, consistent with that recorded by Gajewski and Uscinowicz.

Though elevated turbidity levels could occur from hopper dredge and/or scow overflow, the overflow process occurs only during the physical dredging operation and the elevated turbidity values are short term and confined. Because maximum load efficiency would be attained before transit to the pumpout location, overflow of material would not be expected to occur once the dredging process is complete. Once at the pumpout location, all turbid water generated by the hopper dredge slurry for pumpout would be retained in the hopper.

Overall water quality impacts of the proposed action would be expected to be short-term and minor. The various life stages of fish species associated with marine and estuarine resources dependent on good water quality would likely move out of the impact area and are not expected to experience significant adverse effects from water quality changes.

#### 7.02.8.7 Effects on State-Designated Areas Important for Managed Species

Primary Nursery Areas (PNAs) are designated by the North Carolina Marine Fisheries Commission and are defined by North Carolina as tidal saltwaters that provide essential habitat for the early development of commercially important fish and shellfish (http://portal.ncdenr.org/web/mf/, 15 NC Administrative Code 3B .1405). Many fish species undergo initial post-larval development in the areas. PNAs would not be expected to be directly affected by implementing the proposed project. Although the placement area will end short of the inlet area, PNAs adjacent to the inlets could experience indirect and short-term elevated turbidity levels from the nourishment operation on the shoreface. Such turbidity effects are dependent on the location of the outflow pipe and the direction of longshore and tidal currents. As the elevated turbidity levels would be short-term and within the range of elevated turbidity from natural storm events the impacts to State-designated PNAs would be expected to be insignificant.

#### 7.02.8.8 Effects on Cape Lookout Sandy Shoals

The sandy shoals off Cape Lookout are located over 10 miles southeast of the Beaufort Inlet end of Bogue Banks. No effects on these shoals are anticipated.

#### 7.02.8.9 Effects on Bogue Sound

No dredging or material placement will occur in Bogue Sound. Therefore the proposed action will not affect Bogue Sound.

#### 7.02.8.10 Effects on Big Rock and Ten Fathom Ledge

Big Rock and the Ten Fathom Ledge are south of Cape Lookout, North Carolina. Ten Fathom Ledge is at 95–120 m (312–394 ft.) depth on the Continental Shelf in Onslow Bay, North Carolina, and consists of 136 square miles of ocean floor containing patch reefs and rock outcroppings. Big Rock is approximately 36 miles south of Cape Lookout at about 50–100 m (164–328 ft.) of water. Hard substrate consists of algal limestone and calcareous sandstone. Both sites are located great distances from the proposed borrow areas and would not be expected to be affected by implementing the proposed project (SAFMC 1998).

#### 7.02.8.11 Effects on The Point

The Point is near Cape Hatteras near the 200-m (656-ft.) contour and is a confluence zone of six major water masses including the Gulf Stream, Western Boundary Under Current Mid-Atlantic Shelf Water, Slope Sea Water, Carolina Capes Water, and the Virginia Coastal water(SAFMC 1998) . A result of the convergence of the currents is a dynamic and highly productive environment. The Point is about 75 miles northeast of the proposed project, and no effect would be expected

#### 7.02.8.12 Impact Summary for Essential Fish Habitat

The proposed action would not be expected to cause any significant adverse impacts to EFH or HAPC for those species managed by the SAFMC and MAFMC. Physical and biological impacts to EFH are short term and localized on an individual and cumulative effects basis (see section 2.04.7).

## 7.03 Terrestrial Environment

### 7.03.1 Maritime Shrub Thicket

The terrestrial habitats on Bogue Banks represent some of the last remaining tracts of maritime forest and freshwater wetlands on barrier islands in coastal North Carolina. The unusual height and width of the island, along with its geographic orientation, further creates a comparably unique ecological setting. At least 1,015 acres of maritime forest are estimated to be in conservation status on the island, with significant tracts at Fort Macon State Park, the Theodore Roosevelt State Natural Area and the Hoop Pole Creek. Because the maritime shrub thicket community is landward of the proposed project construction limits, no significant effects would be expected.

### 7.03.2 Beach and Dune

The Recommended Plan consists of an 119,670 ft (22.7 miles) long main beach fill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). Where existing dunes are less than 14 ft. elevation (NAVD 88), the constructed dune will cover existing vegetation. All constructed dunes will be vegetated with native dune grasses to minimize any impacts to existing vegetation. The constructed beach berm and dune profile would result in a seaward movement of the shoreline.

Project construction and periodic nourishment would not be expected to have an adverse effect on wildlife found along the beach or that uses the dune areas. However, short-term transient effects could occur to mammalian species using the dune and fore-dune habitat, but those species are mobile and would be expected to move to other, undisturbed areas of habitat during construction and periodic nourishment events. Vegetation of constructed dune areas would be expected to increase the amount and quality of habitat available to mammal and avian species dependent on those areas and minimize impacts to existing vegetation.

Project construction would result in disturbance and removal of some of the existing vegetation along the seaward side of the existing dune. However, construction would be followed by measures designed to stabilize the constructed dunes. Dune stabilization would be accomplished by planting vegetation on the dune during the optimum planting seasons and after the berm and dune construction. Representative native planting stocks may include sea oats (*Uniola paniculata*), American beachgrass (*Ammophila breviligulata*), and panic grass (*Panicum amarum*). The vegetative cover would extend from the landward toe of the dune to the seaward intersection with the storm berm for the length of the dune. Sea oats would be the predominant plant with American beach grass and panic grass as a supplemental plant. Planting would be accomplished during the season best suited for the particular plant. Periodic nourishment of the project would involve placing material along the berm. Therefore, minimal impacts to dune vegetation would be expected from implementing the project.

The placement of sediment along the study area would be expected to directly affect ghost crabs through burial (USACE 2004, Lindquist and Manning 2001, Peterson et al. 2000, Reilly and Bellis 1983). Because ghost crabs are vulnerable to changes in sand compaction, short-term effects could occur from changes in sediment compaction and grain size. According to Hackney et al. (1996), management strategies are recommended to enhance recovery after beach nourishment are (1) timing activities so that they occur before recruitment and, (2) providing beach sediment that favors prey species and burrow construction. Ghost crabs are present on the project beach year-round (Hackney et al. 1996), therefore, direct effects from burial could occur during the proposed construction time frame of December 15 to March 31. However, the peak larval recruitment time frame would be avoided and, because nourished sediment will be compatible with the native beach, it is expected that ghost crab populations would recover within one year post-construction (USACE 2004, Lindquist and Manning 2001, Peterson et al. 2000, Reilly and Bellis 1983). Because ghost crabs recover from short-term effects and because recommended management strategies to avoid long-term effects would be followed, no significant long-term impacts to the ghost crab population would be expected.

The beaches of Bogue Banks are used by off road vehicles (ORVs) and foot traffic. The use of ORVs on the beach is generally restricted to the months of October-April; but numerous public beach access points are available for foot travel year round. However, foot traffic and ORV use is prohibited year round on dunes. Because of the seasonal restriction of ORV use and year-round prohibition on dunes by any travel, ORV activity along with foot travel should not adversely impact beach and dunes. Coordination with the USFWS Raleigh field office confirms that there are no anticipated impacts.

#### 7.03.3 Coastal Barrier Resources Act

Designated maps showing all sites included in the system in North Carolina show Fort Macon Unit (NC-04P) and the Roosevelt Natural Area (NC-05P) to be within the Coastal Barrier Resource System and protected under the Coastal Barrier Improvement Act of 1990 (USFWS 1990). Both units are designated "P", which USFWS has defined as "otherwise protected area". Since both units are owned by the State of North Carolina this area would not need protection from future private development. Additionally, USFWS defines the "P" designation as an area that is not regulated by CBRA since it is State owned property. The only restriction to Federal expenditures in these "P" designated areas is that Federal flood insurance cannot be obtained. Both sites are not in the project area but may benefit from stabilization of the shoreline.

#### 7.03.4 Birds

The waters offshore of the Bogue Banks are very important to migrating and wintering northern gannets, loons, and grebes. Distribution patterns of sea ducks or other birds using the offshore environment in the project vicinity could be affected during dredging operations for construction and periodic nourishment. Congregation or rafting of sea ducks in the areas is primarily for loafing. Because the area of ocean disturbed is small when compared to available loafing or foraging areas, it is expected that any effects would be minor.

Although the project area is heavily developed and sustains heavy recreational use, migratory shorebirds could still use the project area for foraging and roosting habitat. Beach nourishment activities could temporarily affect the roosting and intertidal macro-fauna foraging habitat, however, recovery often occurs within one year if nourishment material is compatible with native sediments. A 2-year study in Brunswick County, North Carolina (USACE 2004) indicated that beach nourishment had no measurable impact to shorebird use. Although temporary impacts to the shorebird prey base could occur in the affected areas, the staggering of the initial construction effort would allow for availability of adjacent unaffected foraging habitat. Because (1) areas of diminished prey base are temporary and isolated, (2) recovery occurs within one year if material is compatible, and (3) adjacent unaffected foraging and roosting habitat would be available throughout the project, it would not be expected that foraging and roosting habitat would be significantly affected by implementing the proposed action.

Although it is possible that shorebird nesting could occur in the project area during the spring and summer months (April 1–August 31), most of the bird species have been displaced by development pressures and heavy recreational use along the beach, thus, traditional nesting areas on the project beach have been lost. Many of the bird species have retreated to the relatively undisturbed dredged material disposal islands that border the navigation channels in the area. Nonetheless, it is possible that shorebird species would still attempt to nest in the project area. To protect bird nesting, the NCWRC discourages beach work between April 1 and August 31. The work is expected to primarily be accomplished within the hopper dredging window of December 15 to March 31, thus avoiding the bird nesting window. However during construction, if a cutterhead suction dredge is used the dredging window could be extended from 15 November to 30 April. Though the beach placement activities would extend into the first month of the bird nesting season, work will be ordered so that pipeline routes and placement locations do not interfere with the most likely locations for bird nesting in the month of April.

On the basis of the following considerations, the proposed construction activities would not be expected to significantly affect breeding and nesting shorebirds or colonial waterbirds in the project area: (1) with the exception of the month of April in the event a cutterhead dredge is used, contractors would adhere to the April 1 to August 31 bird-nesting window. Areas with a higher likelihood of nesting will be completed first so that activities are kept to a minimum during nesting season (2) beach nourishment and construction activities would not occur in the Bogue and Beaufort Inlet complexes, which most likely support foraging, loafing, roosting, and nesting shorebirds, and (3) project construction timing and planning would allow for rapid recovery of intertidal foraging habitat in the project area.

## 7.04 Threatened and Endangered Species

In accordance with Section 7(a)(2) of the ESA of 1973, as amended, USACE initiated informal consultation with both the USFWS and NMFS for the proposed project. USACE will strictly adhere to the 1997 National Marine Fisheries Service South Atlantic Regional Biological Opinion (SARBO) and incidental take statement provided by the NMFS for the continued hopper dredging of channels and borrow areas in the southeastern United States. A Biological Assessment (BA) has been prepared and documents the consultation history with NMFS, references the species and critical habitat impact evaluations provided in the South Atlantic Regional Biological Assessment (SARBA), and formally requests that Section 7 consultation requirements for this project be satisfied under the existing or superseding SARBO. Additionally, a detailed analysis of the proposed project and potential impacts to protected species and their critical habitat under USFWS jurisdiction are included in the BA (Appendix F).

A summary of effect determinations for all listed species identified in the project area relative to both the beach placement and in-water related activities for the project are provided in Table 7.2. All commitments to reduce impacts to listed species are provided in Appendix G.

| Listed Species w/in the Project Area | | Effect Determination | |
|---|---|---|---|
| | | Beach Placement Activities (USFWS) | In-Water Dredging Activities (NMFS) |
| **Sea Turtles** | ***Leatherback*** | MANLAA | MANLAA |
| | ***Loggerhead/Critical Habitat*** | MANLAA / NLAM | MALAA |
| | ***Green*** | MANLAA | MALAA |
| | ***Kemp's Ridley*** | NE | MALAA |
| | ***Hawksbill*** | NE | MALAA |
| **Large Whales** | ***Blue, Finback, Sei, and Sperm*** | NE | NE |
| | ***NARW*** | NE | MANLAA |
| | ***Humpback*** | NE | MANLAA |
| **West Indian Manatee** | | NE | MANLAA |
| **Roseate Tern** | | NE | NE |
| **Red Knot and Piping Plover/Critical Wintering Habitat** | | MANLAA / NLAM | NE |
| **Atlantic Sturgeon** | | NE | MALAA |
| **Shortnose Sturgeon** | | NE | NE |
| **Smalltooth Sawfish** | | NE | NE |
| **Seabeach Amaranth** | | MANLAA | NE |

Notes: No Effect (NE = green), May Affect Not Likely to Adversely Affect (MANLAA = orange), May Affect Likely to Adversely Affect (MALAA = red), and Not Likely to Adversely Modify (NLAM = Orange)

Table 7.2. Threatened and endangered species effects determination for beach placement and dredging activities associated with the proposed project area.

### 7.04.1 Summary of Effects Determinations

*Large Whales—Blue Whale, Finback Whale, Humpback Whale, North Atlantic Right Whale (NARW), Sei Whale, and Sperm Whale*

Of the six species of whales being considered, only the NARW and humpback whale would normally be expected to occur within the project area during the project construction period. Therefore, the proposed project will have no effect on the blue whale, finback whale, sei whale, and sperm whale. Conditions outlined in previous consultations in order to reduce the potential for accidental collision (i.e. contractor pre-project briefings, large whale observers, slow down and course alteration procedures, etc.) will be implemented as a component of this project. Based on the implementation of these conditions, dredging activities associated with the proposed project may affect but are not likely to adversely affect the NARW and humpback whale species.

*West Indian Manatee*

Since the habitat and food supply of the manatee will not be significantly impacted, overall occurrence of manatees in the project vicinity is infrequent, all dredging will occur in the offshore environment, and precautionary measures for avoiding impacts to manatees, as established by USFWS, will be implemented for transiting vessels associated with the project, the proposed action may affect but is not likely to adversely affect the manatee.

*Sea Turtles—Loggerhead, Hawksbill, Kemp's Ridley, Green, and Leatherback*

All five species are known to occur within oceanic waters of the proposed project borrow areas; however, only the loggerhead, green, and leatherback sea turtles are known to nest within the limits of the project beach placement area. Therefore, species specific impacts may occur from both the beach placement and dredging operations. Considering the proposed dredging window to avoid the sea turtle nesting season to the maximum extent practicable, the proposed project may affect but is not likely to adversely affect nesting loggerhead, green, and leatherback sea turtles by altering nesting habitat. Though significant alterations in beach substrate properties may occur with the input of sediment types from other sources, re-establishment of a berm and dune system with a gradual slope will preserve about 138 acres of beach habitat that may potentially be used for nesting by maintaining a 50' wide berm along the entire 22.7 mile project length. Acreage was calculated by multiplying the length of the beach by the width of the berm.

The proposed hopper dredging activities for initial construction, as well as each nourishment interval, may occur in areas used by migrating turtles. Hopper dredges pose risk to benthic oriented sea turtles through physical injury or death by entrainment. Though limiting hopper dredge activities, to the maximum extent practicable, to the 15 December to 31 March dredging window will avoid periods of peak turtle abundance during the warm water months, the risk of lethal impacts still exist as some sea turtle species may be found year-round in the offshore area. Therefore, the proposed hopper dredging activities may adversely affect loggerhead, green, hawksbill, and Kemp's ridley sea turtles. Based on historic hopper dredging take data, leatherback sea turtles are not known to be impacted by hopper dredging operations. Also, for any USFWS terrestrial environment designated as critical habitat, such as Recovery Unit LOGG-N-3, the proposed project will not result in an adverse modification of critical habitat for the threatened loggerhead sea turtle.

*Shortnose Sturgeon*

Although hopper dredges have been known to impact shortnose sturgeons, dredging for this project will occur in offshore environments, outside of its habitat range. Therefore, impacts from dredges are not anticipated to occur. As it is not likely that shortnose sturgeon would be present in the immediate project area and as dredging will occur in the offshore environment, it has been determined that the actions of the proposed project will have no effect on the shortnose sturgeon.

*Atlantic Sturgeon*

A total of 11 Atlantic sturgeon have been incidentally taken by hopper (n=10) and mechanical dredges (n=1) in the South Atlantic region (i.e. Cape Fear River, NC through Brunswick Harbor, GA) since 1990. In North Carolina regions north of the Cape Fear River such as Nags Head (personal communication, Raleigh Bland, USACE Washington Regulatory Field Office, October 2012) and Topsail (personal communication, David Timpy, USACE Wilmington Regulatory Field Office, October 2012), recent dredging and beach nourishment projects have not recorded any takes of Atlantic Sturgeon. Further south, hopper dredging offshore of Kure Beach, NC in 2013 did not result in any Atlantic Sturgeon takes. Though no site specific data pertaining to Atlantic sturgeon distribution within the borrow areas is available, based on the documented migratory pathways from existing tagging data, it is possible that sturgeon may be found in the borrow areas either migrating through or spending time on or near the borrow areas and may be adversely impacted (Eyler et al. 2009).

Hydraulic dredging techniques may also indirectly impact Atlantic sturgeon through (1) short-term impacts to benthic foraging and refuge habitat, (2) short-term impacts to water and sediment quality from re-suspension of sediments and subsequent increase in turbidity/siltation, and (3) disruption of spawning migratory pathways. Therefore, the proposed dredging activities may adversely affect the Atlantic sturgeon species both directly and indirectly.

Atlantic sturgeon are covered by the 1997 SARBO until the new SARBO is developed and finalized. See section 7.04 for more information regarding potential Atlantic sturgeon take. Endangered species observers (ESOs) on board hopper dredges will be responsible for monitoring for incidental take of Atlantic sturgeon. For hopper dredging operations, dragheads as well as all inflow and overflow screening will be inspected for sturgeon species following the same ESO protocol for sea turtles.

*Seabeach Amaranth*

Surveys have been performed by USACE along all of Bogue Banks, NC since 1991 related to various dredged material placement actions. For this project, USACE will monitor for seabeach amaranth for at least 5 years after initial placement of sediment. Because plant numbers have been shown to increase following disposal operations from navigation dredging projects; it is believed that the beneficial use of navigation dredged material contained a seed source. Considering that the borrow areas for this project are well offshore, no seabeach amaranth seed source is expected to be within the nourishment material.

Beach fill placement will restore much of the existing habitat lost to erosion and is expected to provide long-term benefits to seabeach amaranth; however, construction and deep burial of seeds on a portion of the beaches during project construction may slow germination and population recovery over the short-term. Therefore, the project may affect, but is not likely to adversely affect seabeach amaranth.

*Piping Plover*

Designated critical habitat for the wintering piping plover is found at Bogue Inlet at the tip of Bogue Banks labeled as NC-10. The long-term effects of the project may restore lost roosting and nesting habitat through the addition of beach fill; however, short-term impacts to foraging, sheltering, roosting habitat may occur during project construction. Therefore, it has been determined that the project may affect, but is not likely to adversely affect the piping plover.

*Roseate Tern*
Species presence within the study area is severely limited and appropriate habitat requirements are lacking due to the extensive development within the study area. For these reasons it has been determined that the project will have no effect on this species.

*Smalltooth Sawfish*
Based on the current South Atlantic distribution of smalltooth sawfish and only one sighting in North Carolina since 1999, dredge impacts to smalltooth sawfish within the project area are unlikely. Additionally, the take of a smalltooth sawfish by a hopper dredge is unlikely considering the smalltooth sawfishes affinity for shallow, estuarine systems as well as the fact that there has never been a reported take of a smalltooth sawfish by a hopper dredge. Therefore, hopper dredge activities associated with this project will have no effect on smalltooth sawfish.

#### 7.04.2 Consultation Summary—NMFS
On April 30, 2007, USACE formally reinitiated consultation under Section 7 of the ESA in regard to the NMFS SARBO, dated September 25, 1997. The SARBO was issued to USACE' South Atlantic Division for "the continued hopper dredging of channels and borrow areas in the Southeastern United States." On September 12, 2008, SAD provided NMFS with USACE' South Atlantic Regional Biological Assessment (SARBA). The SARBA addresses Federal, Federally permitted, or Federally sponsored (funded or partially funded) dredging activities (i.e., hopper, cutterhead, mechanical, bed leveling, and side cast) in the coastal waters, navigation channels (including designated Ocean Dredged Material Disposal Sites), and sand mining areas in the South Atlantic Ocean (including OCS sand resources under MMS jurisdiction) from the North Carolina/Virginia Border through and including Key West, Florida and the Islands of Puerto Rico and the U.S. Virgin Islands.

As noted in the September 12, 2008, transmittal letter, the U.S. Department of Interior, BOEM, has agreed to a joint consultation with USACE as the lead agency. In May 2007 during a SARBA scoping meeting at the NMFS Southeast Regional Office in St. Petersburg, Florida, USACE and NMFS representatives agreed that all dredging activities in the South Atlantic would continue to work under the 1997 SARBO until the new SARBO was developed and finalized. Therefore, all dredging actions associated with the proposed project would work under the Reasonable and Prudent Measures (RPMs), Terms and Conditions (T&Cs), and Incidental Take Statement (ITS) of the 1997 SARBO until a superseding SARBO is completed. When the NMFS completes the new SARBO, all new RPMs, T&Cs, and ITSs would be adhered to as a component of this project. As of the writing of this Final Integrated Feasibility Report and EIS, the NMFS had not completed the new SARBO and no estimated completion date has been projected. USACE requested concurrence for continued operation under the 1997 SARBO and the NMFS agreed via email on January 17, 2014.

### 7.04.3 Consultation Summary—USFWS

On March 10, 2014, the Service provided the Wilmington District with the Final Fish and Wildlife Coordination Act Report for the Bogue Banks project (Appendix K). The report identified fish and wildlife resources in the project area, alternatives considered, the selection and description of the preferred alternative, an assessment of project impacts on fish and wildlife resources, and recommendations for avoiding or minimizing the potential adverse environmental impacts of the project. A Final Biological Assessment and Section 7 concurrence dated March 10, 2014 is attached (Appendix F).

## 7.05 Physical Resources

### 7.05.1 Wave Conditions

Localized deepening of offshore borrow areas is the only potential source of impacts on wave conditions, however, these changes are not expected to be significant. The borrow area use plan identifies three separate borrow areas scattered across an approximately 20 mile swath in water depths of 40 to 57 feet, which should have less impact on wave conditions than dredging of a large, contiguous area. Appendix A contains an analysis supporting the conclusion that dredging from the borrow areas will have a negligible effect on wave impact to the Bogue Banks shoreline.

### 7.05.2 Shoreline and Sand Transport

Existing water depths in the borrow areas range from 40 to 57 feet, which is substantially deeper than the estimated active profile depth. Accordingly, no impacts to the active profile are expected due to borrow area dredging. Renourishment will take place every 3 years to replenish these losses, unless project monitoring indicates that renourishment can be reasonably delayed. Net movement of this material will be predominantly to the east based on transport analysis, with easterly sediment transport being roughly twice that of southerly transport on average.

### 7.05.3 Geology

The Recommended Plan should not result in any significant changes to the natural geology of the study area.

### 7.05.4 Sediment Compatibility

The sediment that will be utilized from the borrow areas is compatible with the native beach sediment. A full discussion of the material compatibility is included earlier in Section 5.06.2 of this report and Appendix C.

## 7.06 Socioeconomic Resources

### 7.06.1 Commercial and Recreational Fisheries

Subsistence fishing refers to fishing, other than sport fishing, that is carried out primarily to feed the family and relatives of the person doing the fishing. Generally it also implies the use of low tech “artisanal” fishing techniques and is carried out by people who are very poor. Information regarding subsistence fishing in the project area is not known.

Fishing has been an integral part of Carteret County’s heritage and economy for nearly 400 years. This fishery supplies a wide variety of fresh fish, shellfish, crabs, and shrimp to both local residents and large East Coast cities. At one time Carteret County fishermen relied on the demand for a limited supply of high-quality, seasonal seafood, and could earn a sustainable living. During the last ten years, however, an influx of lower-cost, imported seafood began to displace domestic seafood in many commercial markets.

"Carteret Catch" is an organization made up of local fisherman, restaurants, and retailers. Its mission is to sustain the livelihood and heritage of the Carteret County fishing industry through public marketing and education. Its goal is also to make fishing a viable lifestyle and preserve a culture that characterizes the central coastal region of North Carolina.

The Recommended Plan construction impacts on shore fishing would be limited to the area where material is being placed on the beach. Such localized temporary impact can easily be avoided by anglers in the area. Nearshore fishing boats can operate around the dredging equipment operating in the area. Fishing on ocean piers would probably be impacted when disposal is in the vicinity of piers, but this impact would dissipate as disposal operations move away from the piers. The beach nourishment plan would not be expected to affect inside fishing or the operation of commercial fishing boats operating in or going through Bogue or Beaufort Inlets.

## 7.07 Recreation and Aesthetic Resources

Overall, short-term minor adverse and long-term beneficial effects would be expected on aesthetic and recreational resources. Implementing the proposed action could cause temporary reduction of aesthetic appeal and interference with recreational activities in the areas of project construction. However, because project construction would be conducted in relatively small areas at a time, recreational and aesthetic impacts would be localized. Also, construction and maintenance is planned to be completed between December 15 and March 31, thereby avoiding the peak summer tourist season. When work activities in any area are completed, aesthetic values and recreational opportunities would be restored or enhanced as construction equipment is moved away.

The ocean and navigable waters in the vicinity of the study area would be affected to only a minor extent in that dredges, barges, and other watercraft associated with the work would be on-site for several months during construction and during renourishment events. However, that is judged to be an insignificant effect.

Placement of beach fill would result in temporary use of dredge pipeline, bulldozers, and other equipment on the beach. These objects would detract from the normal appearance of the beach as well as create elevated levels of noise (see Section 7.10.1), vibration, lighting, etc. within the construction area. Also, recreational activities on beaches may experience some interruption or interference during work periods, but the degenerated, eroded conditions of the beaches already present recreational constraints. After work is completed on a beach and the heavy equipment is removed, the resulting wider beach would be expected to represent an aesthetic enhancement and an improvement for recreation.

The Recommended Plan would raise the dune in about 0.9 miles of shoreline (reaches 4-10 near Bogue Inlet) by approximately 5 ft. The increased height in dune may affect the visibility of the shoreline from behind the dune in that area.

## 7.08 Cultural Resources

The following determination of effects of the Recommended Plan on historic properties was made in consultation with the North Carolina State Historic Preservation Officer (SHPO). No effect on cultural resources is anticipated for maintenance dredging within controlled or previously dredged channels (SHPO letter dated 04/08/2002).

Construction activities have the potential to encounter buried shipwrecks, but the archaeological and historical record does not support an archaeological survey (SHPO letter dated 04/08/2002). All locations identified as acceptable options for beach access for pipeline, pipe staging areas, location of pipeline routes, and offshore anchoring will be coordinated with the NC Office of State Archaeology. Contractors shall be made aware that in the event unknown resources are encountered, work in that area shall cease until assessment and consultation by the USACE and NC Underwater Archaeology Branch has been completed. No effect to historic properties is anticipated for beach construction and renourishment activities.

No historic properties are located within Borrow Area U. One target that may represent a submerged cultural resource and its recommended protective buffer is located within the hardbottom buffer at Borrow Area Y and will not be affected by borrow area activities. Targets Q2-28, 30, 31, and 32 and their recommended buffer zone lie outside of the O.D.M.D.S. and will not be affected by borrow are activities (SHPO letter dated 01/30/09).

## 7.09 Water Resources

### 7.09.1 Hydrology

Marine waters of the project area display considerable daily variation in current and salinity conditions due to fresh water inflow, tides, and wind. Within the ocean environment, any project-induced changes in the vicinity of the proposed work would be very small (if any) in comparison and are therefore considered to be insignificant.

### 7.09.2 Water Quality

The Recommended Plan will require an estimated 2.45 million cubic yards of borrow material during initial construction, and about 1.07 million cubic yards during each renourishment cycle, which would occur every 3 years. During the 50 year project, this would equate to 16 total renourishment events. In total, it is estimated that 19.6 million cubic yards of material are needed for initial construction and subsequent renourishments during the 50 year project.

The material would most likely be pumped to the beach as a slurry from hopper dredges (although other types of dredges could potentially be used) and shaped on the beach by earth-moving equipment. About 50% of the sand from each disposal operation will be placed in the ocean below mean high water. However after about 6 months when conditions adjust to the final design profile, about 80% of the total sand from the disposal operations will have relocated below mean high water.

Dredging in the selected borrow area would involve mechanical disturbance of the bottom substrate and subsequent redeposition of suspended sediment and turbidity generated during dredging. Factors that are known to influence sediment spread and turbidities are grain size, water currents and depths. Monitoring studies done on the impacts of offshore dredging indicate that sediments suspended during offshore work are generally localized and rapidly dissipate when dredging ceases (Naqvi and Pullen 1983, Bowen and Marsh 1988, Van Dolah et al. 1992). Considering the dynamic nature of sediment movement around the borrow areas, post dredging infilling associated with the natural physical processes of the system is anticipated (See Section 7.02.7). Additionally, infilling is expected from side sloughing of native bottom sediments following dredging activities, which consist of predominately sandy material.

During construction and renourishment, there would be elevated levels of turbidity and suspended solids in the immediate area of sand deposition when compared to the existing non-storm conditions of the surf zone. Significant increases in turbidity are not expected to occur outside the immediate construction/maintenance area (turbidity increases of 25 nephelometric turbidity units [NTUs]) or less are not considered significant). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) would stay close to shore and be transported with waves either up-drift or down-drift depending on wind conditions. Because of the low percentage of silt and clay in the borrow areas (less than 10 percent), turbidity impacts would not be expected to be greater than the natural increase in turbidity and suspended material that occurs during storm events. Any increases in turbidity in the borrow area during project construction and maintenance would be expected to be temporary and limited to the area surrounding the dredging. Turbidity levels would be expected to return to background levels in the surf zone when dredging ends.

Overall water quality impacts of the proposed action would be expected to be short-term and minor. Living marine resources dependent on good water quality should not experience significant adverse effects from water quality changes.

A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be obtained from the NCDWR before construction begins. This project will use the North Carolina Division of Water Resources' March 19, 2012, Water Quality Certification No. 3908: General Certification for Projects Eligible for U.S. Army Corps of Engineers Regional General Permit 198000048 Involving Disposal of Dredged Material on Ocean Beaches Within North Carolina (Personal Communication, Joanne Steenhuis (NCDENR-DWR), 2 October 2013). This general certification has been used for other beach fills, and it is not anticipated that there will be any issues in obtaining the certification.

Pursuant to Section 404 of the Clean Water Act, the effects associated with the discharge of beach fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) evaluation in Appendix J. Incidental fallback associated with hopper dredging operations in the offshore borrow areas is anticipated. Resultant water column impacts associated with sedimentation and turbidity are discussed in Sections 7.02.8.1&6; however, no measureable increase in bottom elevation is expected from the fallback of sediment during the dredging operations and the activity won't destroy or degrade waters of the United States (33 CFR Section 323.2(d)(4)(i)). Therefore, incidental fallback from hopper dredging in the borrow area is not being considered a discharge addressed under the Section 404 (b)(1) Guidelines Analysis.

Overall impacts to aquatic resources are expected to be minor and short-term. Based on the review of alternatives, the Recommended Plan is the least damaging practicable alternative (LEDPA). See also Appendix J.

### 7.09.3 Groundwater

Dredging with beach placement of material would not be expected to adversely affect groundwater of the area. The potential for saltwater intrusion into groundwater does not exist unless a reversal of hydrologic gradient occurs from excessive groundwater pumping. Water supplies of nearby communities would not be expected to be affected by the proposed action.

## 7.10 Other Significant Resources (P.L. 91-611, Section 122)

### 7.10.1 Air Impacts

Temporary increases in exhaust emissions from construction equipment are expected during the construction and periodic renourishment of the Bogue Banks project, however, the pollution produced would be similar to that produced by other large pieces of machinery and should be readily dispersed. All dredges must comply with the applicable EPA standards. Additionally, ozone is North Carolina's most widespread air quality problem, particularly during the warmer months. High ozone levels generally occur on hot sunny days with little wind, when pollutants such as nitrogen oxides and hydrocarbons react in the air. High levels of fine particles are more of a problem in the western Piedmont region but can occur throughout the year, particularly during episodes of stagnant air and wildfires. The project would be constructed outside the ozone season. The air quality in Carteret County, North Carolina, is designated as an attainment area. North Carolina has a State Implementation Plan approved or promulgated under Section 110 of the Clean Air Act. A conformity determination is not required for this project because it is located in an attainment area, the direct and indirect emissions from the project fall below the prescribed de minimis levels, and the ambient air quality for Carteret County has been determined to be in compliance with the National Ambient Air Quality Standards

7.10.2 Water Quality. Water quality impacts are discussed in Section 7.09.2 and in the Section 404(b)(1) (P.L. 95-217) evaluation included with this document as Appendix J.

### 7.10.3 Noise.

Noise in the outside environment associated with beach construction activities would be expected to minimally exceed normal ambient noise in the project area, however, construction noise would be attenuated by background sounds from wind and surf. In-water noise would be expected in association with the dredging activities for this project. Specifically, noise associated with dredging could occur from (1) ship/machinery noise—noise associated with onboard machinery and propeller and thruster noise, (2) pump noise—noise associated with pump driving the suction through the pipe, (3) collection noise—noise associated with the operation and collection of material on the sea floor, (4) deposition noise—noise associated with the placement of the material within the barge or hopper, and (5) transport noise—noise associated with transport of material up the suction pipe. The limited available data indicate that dredging is not as noisy as seismic surveys, pile driving and sonar, but it is louder than for example most shipping, operating offshore wind turbines and drilling (Thomsen et al. 2009).

Dredging produces broadband and continuous, low-frequency sound (below 1 kHz) and estimated source sound pressure levels range between 168 and 186 dB re 1 µPa at 1 m, which can trigger avoidance reaction in marine mammals and marine fish. A micropascal (µPa) is a measurement of pressure commonly applied to underwater sound and 1 pascal is equal to the pressure of one newton over one square meter. In some instances, physical auditory damage can occur. Auditory damage is the physical reduction in hearing sensitivity due to exposure to high-intensity sound and can be either temporary (temporary threshold shift) or permanent (permanent threshold Shift) depending on the exposure level and duration. Other than physical damage, the key auditory effect is the increase in background noise levels, such that the ability of an animal to detect a relevant sound signal is diminished, which is known as *auditory masking*. Masking marine mammal vocalizations used for finding prey, navigation and social cohesion could compromise the ecological fitness of populations (Compton et al. 2008).

According to Richardson et al. (1995) the following noise levels could be detrimental to marine mammals:

Prolonged exposure of 140 dB re 1 µPa/m (continuous man-made noise), at 1 km can cause permanent hearing loss.

Prolonged exposure of 195 to 225 dB re 1 µPa/m (intermittent noise), at a few meters or tens of meters, can cause immediate hearing damage.

According to Richardson et al. (1995), “Many marine mammals would avoid these noisy locations, although it is not certain that all would do so.” In a study evaluating specific reaction of bowhead whales to underwater drilling and dredge noise, Richardson et al. (1990) also noted that bowhead whales often move away when exposed to drillship and dredge sound, however, the reactions are quite variable and can be dependent on habituation and sensitivity of individual animals. According to Richardson et al (1995), received noise levels diminish by about 60 dB between the noise source and a radius of 1 km. For marine mammals to be exposed to a received level of 140 dB at 1-km radius, the source level would have to be about 200 dB re 1 µPa/m. Furthermore, few human activities emit continuous sounds at source levels greater than or equal to 200 dB re 1 µPa/m, however, supertankers and icebreakers can exceed the 195 dB noise levels.

According to Reine et al. (in prep), the highest sound levels are from sediment removal and the transition from transit to pump-out (~172 dB at 3 ft.). The quietest dredging activities would be the seawater pump-out and transiting unloaded to the borrow site (~159-163 dB at 3 ft.). It is also expected that at distances approximately 1.6-1.9 miles from the source, underwater sounds generated by the dredge would attenuate to background levels.

According to Clarke et al. (2002), hopper dredge operations had the highest sustained pressure levels of 120–140 dB among the three measured dredge types, however, the measurement was taken at 40 m from the operating vessel and would likely attenuate significantly with increased distance from the dredge. On the basis of (1) the predicted noise effect thresholds noted by Richardson et al. (1995), (2) the background noise that already exists in the marine environment, and (3) the ability of marine mammals to move away from the immediate noise source, noise generated by bucket, cutterhead, and hopper dredge activities would not be expected to affect the migration, nursing/breeding, feeding/sheltering or communication of large whales.

Similar to conclusions made regarding effects of sound on marine mammals, non-injurious impacts to sea turtles may also occur because of acoustic annoyance or discomfort. It has been hypothesized, on the basis of anatomical studies that sea turtle hearing range centers on low-frequency sounds. Ridgeway et al. (1969, 1970) evaluated the frequency sensitivity of green sea turtles and found that green turtles detect limited sound frequencies (200–700 Hz) and display high level of sensitivity at the low-tone region (approx 400 Hz). According to Bartol et al. (1999), the most sensitive threshold for loggerhead sea turtles is 250–750 Hz with the most sensitive threshold at 250 Hz. Though noise generated from dredging equipment is within the hearing range of sea turtles, no injurious effects would be expected because sea turtles can move from the area, and the significance of the noise generated by the dredging equipment dissipates with an increasing distance from the noise source.

7.10.4 Public Health. Residential and rental houses are the dominant structures along the beaches in the project area. Significant storm damage has the potential to damage the infrastructure which can cause bacterial and other pollutant runoff. Damage to septic tanks in particular could cause public health issues following severe storm events.

### 7.10.5 Man-made and Natural Resources, Aesthetic Values, Community Cohesion, and the Availability of Public Facilities and Services

Beach nourishment would require the extension of dune crossover structures along the beach. Dredging in the offshore borrow area would not be expected to cause significant interference with commercial and recreational boat traffic. The mobility of a hopper dredge would preclude any interference with regular commercial ship traffic as a result of travel to and from the borrow areas.

Impacts to aesthetic values are discussed in Section 7.07. Impacts to natural resources are discussed previously throughout Sections 7.02 and 7.03. Impacts to cultural resources are discussed in Section 7.08. Coastal storm damage risk reduction would benefit numerous roads, business, and residences. Implementing the Recommended Plan would be expected to have beneficial effects on community cohesion and would reduce damages to many public facilities and services (i.e., roads and utilities) from storm events.

### 7.10.6 Adverse Employment Effects and Tax and Property Value Losses

The area of potential effects for this coastal storm damage reduction project will reach as far inland as dunes located waterward of any private properties, residences, or other permanent structures. This includes pipe and material placement as well as scraping and shaping by means of heavy equipment. Tax and property values will not be negatively affected by this project.

Professions utilizing shallow-water or beach areas in which dredging will occur will not be negatively affected by this project in the long term. The in-water effects of dredging and the effects of material placement on land will be temporary and will minimally, if at all, disrupt employment in the area. See section 7.06 for additional information.

### 7.10.7 Injurious Displacement of People, Businesses, and Farms

Dredging and material placement activities will not negatively affect any people, farms, or businesses in Bogue Banks or elsewhere in Carteret County, NC. Aquatic dredging activities may temporarily displace peoples or business activities utilizing shallow-water areas for fishing, recreation, or other purposes; however, this displacement will be short-term and will not have lasting effects. See section 7.06 for additional information.

### 7.10.8 Disruption of Desirable Community and Regional Growth

This coastal storm damage reduction project may enhance community cohesiveness by reducing the risk of population displacement due to storm damage, and will not devalue communities in or near the Bogue Banks project area. Similarly, regional growth will not be negatively affected by this project. See section 2.11 for additional regional growth information.

## 7.11 Hazardous, Toxic and Radioactive Wastes (HTRW)

USACE' standard tiered approach for analyzing the potential for encountering contaminated sediments in the potential borrow areas was used to assess the potential borrow areas for HTRW. According to that analysis, before any chemical or physical testing of sediments would be conducted, a reason to believe that the sediments could be contaminated must be established. The sources of the sediments in the selected borrow areas are derived from sediment transport and deposition by ocean currents. The probability of the areas being contaminated by pollutants is low.

A cultural resources survey, which used magnetometer and side-scan sonar, was completed for the proposed offshore borrow areas. Although the cultural resources survey would have identified large anomalies, it was not intended to identify, nor was it capable of identifying, smaller anomalies. Because the survey did not identify any anomalies, it is presumed that any materials found offshore would be small and therefore would not impede the dredging and disposal operations and would not present a safety hazard to workers on the dredge or to anyone on the beach. However, to minimize the very remote chance of encountering ordnance, the beach would be inspected daily, and any ordnance discovered would be handled in accordance with the Military Munitions Rule, 40 CFR 260-270. The Marine Corps Base Explosive Ordnance Disposal Team would be available (on call) during the dredging process. Additionally, the contract specifications for the proposed project would direct the contractor to immediately stop work and inform the contracting officer if unexploded ordnance is encountered during dredging or disposal. At that time, additional measures would be implemented, as necessary, including inspecting dredged material on the beach and installing outflow screens on the dredge pipeline. Any unexploded ordnance found on the beach would be promptly removed.

The bottom sediments that would be dredged from the borrow areas and placed on the beach would consist of predominately fine- to medium-grain size with some shell. Therefore, no further analyses or physical and chemical testing of the sediments is recommended. It would not be expected that any hazardous and toxic waste sites would be encountered during construction or periodic nourishment. However, if any hazardous and toxic waste sites are identified, response plans and remedial actions would be the responsibility of the local sponsor.

## 7.12 Summary of Cumulative Effects

The Council on Environmental Quality (CEQ) defines cumulative impact as:

*The impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (*40 CFR 1508.7).

For the purposes of this analysis, we are considering proposed projects as well as potential navigation disposals in order to make full disclosure of potential impacts. Many of these projects may never occur for lack of permitting, funding, environmental clearances, or other factors. The detailed analysis of cumulative effects is included in Appendix I. The assessment of cumulative effects focused on effects of the following on important coastal shoreline resources.

1) existing Beach Nourishment projects
2) proposed future Beach Nourishment continued maintenance
3) Federal (USACE) Navigation Beach Disposal (placing navigation maintenance sediment on beaches)
4) existing and potential offshore borrow sites

**No Action Alternative:** The No Action Alternative is where no Federal structural or nonstructural measure is applied. No adverse cumulative impacts are anticipated as a result of implementation of the No Action alternative on Bogue Banks.

**Actions Affecting Beach Resources**
Sources of beach impacts include local beach maintenance activities (i.e. beach nourishment, beach scraping, sand bags, etc.), disposal of dredged material from maintenance of navigation channels, and beach nourishment (berm and dune construction with long-term periodic maintenance).

**Local Maintenance Activity:** Under the existing condition the project area may be subjected to repeated and frequent maintenance disturbance by individual homeowners and local communities following storm events. These efforts are primarily made to protect adjacent shoreline property. Such repairs consist of dune rebuilding using sand from beach scraping and/or upland fill. Limited fill and sandbags are generally used to the extent allowable by CAMA permit. These maintenance efforts could keep the natural resources of the barrier island ecosystems from re-establishing a natural equilibrium with the dynamic coastal forces in some limited areas.

### 7.12.1 Non-Federal Beach Nourishment
Several local beach nourishment efforts have been conducted or are in the permitting process throughout NC (Table 7.3). The number of locally funded beach nourishment activities has increased substantially in the last 10 years as local communities continue to

seek avenues for restoring severely eroding shorelines. Though non-Federal beach nourishment efforts continue to increase, many of these projects are being pursued as one-time interim efforts until the Federal beach nourishment projects can be implemented. Therefore, this increase in permitted non-Federal projects does not necessarily reflect a subsequent increase in resource acreage impacts. Many of the non-Federal projects occur within the limits of Federal projects which are already authorized but un-funded (i.e. Dare County Beaches) or projects which are under study (i.e. Bogue Banks). Beaches that have been nourished pursuant to State and Federal permits, or have submitted a permit application to be nourished, are provided in Table 7.3. Individually, these projects total approximately 97 miles of beach or 29% of North Carolina beaches.

### 7.12.2 Federal (USACE) Beach Nourishment

Federal beach nourishment activities typically include the construction and long-term (50-year) maintenance of a berm and dune. The degree of cumulative impact would increase proportionally with the total length of beach nourishment project constructed. The first Federal North Carolina beach nourishment projects were constructed at Carolina and Wrightsville Beaches in 1965, and totaled approximately 6.4 miles. An additional 3.8 miles of Federal beach nourishment project was constructed in 1998 at Kure Beach. In 2004, a coastal storm damage reduction project along 14 miles of Dare County Beaches was authorized, but has not yet been constructed. Most of the remaining developed North Carolina beaches (including the proposed project area) are currently under study by the Wilmington District for potential future beach nourishment projects (Table 7.4) or are awaiting authorization and/or appropriation. Considering all existing and proposed Federal and non-Federal nourishment projects, and recognizing that some of the projects are overlapping or represent the same project area, approximately 112 miles or 35 % of the North Carolina coast could eventually have private or Federal beach nourishment projects.

| Federal / Non-Federal | Project | Source of Sand for Nourishment | Beachfront Nourished | Approximate Length of Shoreline (miles) | Approximate Distance From the Project Area (miles) |
|---|---|---|---|---|---|
| Non-Federal | *Town of Kill Devil Hills - Beach Nourishment Project | Offshore Borrow Areas | Kill Devil Hills | 4 | 115 |
| | *Town of Nags Head - Beach Nourishment Project | Offshore Borrow Areas | Nags Head | 10 | 110 |
| | *Emerald Isle FEMA Project | USACE ODMDS - Morehead City Port Shipping Channel | Emerald Isle | 4 | 0 |
| | *Emerald Isle "Hotspots" FEMA Project | USACE ODMDS - Morehead City Port Shipping Channel | Emerald Isle | 7 | 0 |
| | *Bogue Banks FEMA Project | USACE ODMDS - Morehead City Port Shipping Channel | Emerald Isle (2 segments), Indian Beach, Salter Path, Pine Knoll Shores | 13 | 0 |
| | *Bogue Banks Restoration Project - Phase I - Pine Knoll Shores and Indian Beach Joint Restoration | Offshore Borrow Areas | Pine Knoll Shores and Indian Beach | 7 | 0 |
| | *Bogue Banks Restoration Project - Phase II - Eastern Emerald Isle | Offshore Borrow Areas | Indian Beach and Emerald Isle | 6 | 0 |
| | *Bogue Banks Restoration Project - Phase III - Bogue Inlet Channel Realignment Project | Bogue Inlet Channel | Western Emerald Isle | 5 | 0 |
| | *North Topsail Dune Restoration (Town of North Topsail Beach) | Upland borrow source near Town of Wallace, NC | North Topsail Beach | NA | 40 |
| | *North Topsail Beach Shoreline Protection Project | New River Inlet Realignment and Offshore Borrow Area | North Topsail Beach | 11 | 40 |
| | *Topsail Beach - Beach Nourishment Project | Disposal Island | Topsail Beach | 6 | 40 |
| | *Topsail Beach - Beach Nourishment Project | New Topsail Inlet | Topsail Beach | 6 | 40 |
| | Figure Eight Island | Banks Channel and Nixon Channel | North & South Sections of Figure Eight Island | 3 | 50 |
| | Rich Inlet Management Project | Relocation of Rich Inlet | Figure Eight Island | NA | 50 |
| | Mason Inlet Relocation Project | Mason Inlet (new channel) and Mason Creek | North end of Wrightsville Beach and south end of Figure Eight Island | 2 | 60 |
| | New Hanover County Beaches - Beach Nourishment | TBD | Wrightsville Beach, Carolina Beach, Kure Beach | TBD | 60 |
| | Bald Head Island Creek Project | Bald Head Creek | South Beach | 0.34 | 80 |
| | Bald Head Island - Beach Nourishment | Offshore Borrow Area (Jay Bird Shoals) | West and South Beach of Bald Head Island | 4 | 80 |
| | Bald Head Island - Terminal Groin and Beach Nourishment | TBD | TBD | TBD | 80 |
| | *Holden Beach - Terminal Groin and Beach Nourishment | TBD | Holden Beach w/in vicinity of Lockwood Folly Inlet | TBD | 100 |
| | *Holden Beach Interim Beach Nourisnment | Offshore Borrow Area | Holden Beach | 4 | 100 |
| | *Holden Beach East & West | Upland Borrow Source (Truck Haul) | Extension of 933 Project | 3 | 100 |
| | *Ocean Isle - Terminal Groin and Beach Renourishment | TBD | Ocean Isle Beach w/in vicinity of Shallotte Inlet | TBD | 100 |
| | Emergency Highway 12 "Mirlo Beach in Rodanthe NC | Offshore Borrow Area | Southern Pea Island to Mirlo Beach | 2 | 100 |

*Projects which may utilize the same borrow sources and/or overlap beach placement locations.

Table 7.3. Summary of non-Federal beach renourishment projects in North Carolina that have recently occurred, are currently underway, or will occur in the reasonably foreseeable future. This list does not include small scale beach fill activities.

| Federal / Non-Federal | Project | Source of Sand for Nourishment | Beachfront Nourished | Approximate Length of Shoreline (miles) | Approximate Distance From the Project Area (miles) |
|---|---|---|---|---|---|
| Federal | *Dare County Beaches, NC Bodie Island (Coastal Storm Damage Reduction) | Offshore Borrow Areas | Kitty Hawk and Nags Head Beaches | 14 | 115 |
| | Dare County Beaches, NC Hatteras to Ocracoke Portion | NA | Hatteras and Ocracoke Island (Hot Spots) | 10 | 75 |
| | Cape Lookout National Seashore -East Side of Cape Lookout Lighthouse | Channel | East Side of Cape Lookout Lighthouse | 1 | 20 |
| | *Beaufort Inlet Dredging - Section 933 Project (Outer Harbor) | Beaufort Inlet Outer Harbor | Indian Beach, Salter Path, and Portions of Pine Knoll Shores | 7 | 10 |
| | *Beaufort Inlet and Brandt Island Pumpout - Section 933 (Dredge Disposal to Eastern Bogue Banks) | Beaufort Inlet Inner Harbor and Brandt Island Pumpout | Fort Macon and Atlantic Beach | 4 | 10 |
| | *Bogue Banks, NC (Coastal Storm Damage Reduction) | Offshore Borrow Areas | Communities of Bogue Banks | 24 | 0 |
| | Surf City and North Topsail Beach - (Coastal Storm Damage Reduction) | Offshore Borrow Areas | Surf City and North Topsail Beach | 10 | 40 |
| | *West Onslow Beach New River Inlet (Topsail Beach) (Coastal Storm Damage Reduction) | Offshore Borrow Areas | Topsail Beach | 6 | 30 |
| | Wrightsville Beach (Coastal Storm Damage Reduction) | Masonboro Inlet and Banks Channel | Wrightsville Beach | 3 | 60 |
| | Carolina Beach and Vicinity, NC Carolina Beach Portion (Coastal Storm Damage Reduction) | Carolina Beach Inlet | Carolina Beach | 2 | 70 |
| | Carolina Beach and Vicinity, NC Kure Beach Portion (Coastal Storm Damage Reduction) | Wilmington Harbor Confined Disposal Area 4 and an Offshore Borrow Area | Kure Beach | 2 | 70 |
| | *Brunswick County Beaches, NC - Oak Island, Caswell, and Holden Beaches (Coastal Storm Damage Reduction) | Offshore Borrow Areas - Frying Pan Shoals | Caswell Beach, Oak Island, Holden Beach | 30 | 100 |
| | *Wilmington Harbor Deepening (Section 933 Project) - Sand Management Plan | Wilmington Harbor Ocean Entrance Channels | Bald Head Island, Caswell Beach, Oak Island | 4 | 70 |
| | *Holden Beach (Section 933 Project | Wilmington Harbor Ocean Entrance Channels | Holden Beach | 2 | 100 |
| | *Oak Island Section 1135 - Sea Turtle Habitat Restoration | Upland Borrow Area - Yellow Banks | Oak Island | 2 | 100 |
| | Ocean Isle Beach, NC (Coastal Storm Damage Reduction) | Shallote Inlet | Ocean Isle Beach | 2 | 100 |

*Projects which may utilize the same borrow sources and/or overlap beach placement locations.

Table 7.4. Summary of Federal beach renourishment projects in North Carolina that have recently occurred, are currently underway, or will occur in the reasonably foreseeable future. This list does not include small scale beach fill activities.

### 7.12.3 Federal (USACE) Navigation Beach Disposal

Maintenance material from dredging the AIWW, inlets, and connecting channels in the vicinity of the study area has historically been disposed within approved disposal limits along the beach (Table 7.5). Throughout North Carolina, a total of approximately 41 miles of beach (~13% of North Carolina beaches) are approved for disposal of beach quality dredged material from maintenance dredging of navigation channels. However, not all of these projects are routinely dredged and a majority of the authorized disposal limits are not actually disposed on to the full extent. Additionally, many of the approved disposal limits overlap with existing Federal or non-Federal nourishment projects. Therefore, without double counting for overlapping beach projects, navigation dredged material is placed along approximately 19 miles, or 6% of North Carolina beaches (Table 7.6). The Wilmington District currently uses about 50 percent of the length of beach in North Carolina that is approved for this purpose and does not anticipate significant increases in beach disposal in the foreseeable future.

Beach quality sand is a valuable resource that is highly sought by beach communities. When beach quality sand is dredged from navigation projects, it has become common practice of USACE to make this resource available to beach communities when applicable laws, regulations, funding and other considerations allow. Placement of this sand on beaches represents return of sediment to the littoral system.

| PROJECT | | DISPOSAL LOCATION | APPROVED DISPOSAL LIMITS | ESTIMATED ACTUAL DISPOSAL LIMITS | ESTIMATED QUANTITY (CY) | COMMENTS |
|---|---|---|---|---|---|---|
| Outer Banks | Avon | Begins at a point 1.15 miles south of Avon Harbor and extends north 3.1 miles | 3.1 miles (16,368 lf) | 0.4 miles or 2,000 linear feet | <50,000 every 6 yrs | Special Use Permit Required From NPS/CHNS |
| | Rodanthe | Extends from rd to Rodanthe Harbor south 700' to south end of beach disposal area (straight out from existing dirt road). North end at Wildlife Refuge Boundary (PINWR) | .91 miles (4,800 lf) | 0.4 miles or 2,000 linear feet | <100,000 every 6 yrs | Special Use Permit Required From NPS/CHNS |
| | Ocracoke Island | Begins at a point 5,000 linear feet south of Hatteras Inlet and extends southward about 3,000 linear feet. | 0.6 miles (3,000 lf) | 0.4 miles or 2,000 linear feet | <100,000 every 2 to 3 years | Special Use Permit Required From NPS/CHNS |
| | Rollinson (Hatteras) | Begins at a point 0.85 miles south of Hatteras Harbor and extends north 5.85 miles to a point north of Frisco, NC | 5.85 miles (30,888 lf) | 0.4 miles or 2,000 linear feet | <60,000 every 2 years | Special Use Permit Required From NPS/CHNS |
| | Silver Lake (Teaches Hole/Ocracoke) | From a point 2,000' NE of inlet and extending approximately 2,000 linear feet (0.4 miles) to the NC (Ocracoke Island) | 0.4 miles (2,000 lf) | 0.4 miles or 2,000 linear feet | <50,000 every 2 years | Special Use Permit Required From NPS/CHNS |
| | Oregon Inlet | Pea Island National Wildlife Refuge (PINWR) | 3 miles (15,840 lf) | 1.5 miles or 7,920 Linear feet | 300,000 Annually | Special Use Permit Required From USFWS/PINWR |
| | Drum Inlet | Core Banks. From a point 2,000 feet on either side of inlet extending for 1 mile in either direction | 2 miles (10,560 lf) | 1 mile or 5,280 linear feet | 298,000 initial, 100,000 maint. (Assume 8 year cycle) | SUP from NPS/CLNS (Included in analysis; however, no determination of site being reused can be made at this time) |
| Beaufort | *Morehead City (Brandt Island) | 2,000 ft west of inlet, Fort Macon and Atlantic Beach to Coral Bay Club, Pine Knoll Shores | 7.3 miles (38,300 lf) | 5.2 miles or 27,8000 linear feet | 3.5 million every 8 yrs | Material from Ocean Bar routinely placed in nearshore berm or ODMDS on annual basis |
| | *AIWW Section I, Tangent B | Pine Knoll Shores, vicinity of Coral Bay | 2 miles (10,500 lf) | 0.4 miles or 2,000 linear feet | <50,000 every 5 years | This area is included every 8 years as part of the pumpout of Brandt Island. Also included in the area under investigation for beach nourishment at Bogue Banks. |

* Navigation disposal sites which may overlap with existing Federal or non-Federal beach nourishment projects.

Table 7.5. Summary of dredged material disposal activities on the ocean front beach associated with navigation dredging. Projects listed and associated disposal locations and quantities may not be all encompassing and represent an estimate of navigation disposal activities for the purposes of this cumulative impacts assessment. (Part 1 of 2).

| PROJECT | | DISPOSAL LOCATION | APPROVED DISPOSAL LIMITS | ESTIMATED ACTUAL DISPOSAL LIMITS | ESTIMATED QUANTITY (CY) | COMMENTS |
|---|---|---|---|---|---|---|
| Swansboro | *AIWW Bogue Inlet Crossing Section I, Tangent H through F | Approx. 2,000 feet from inlet going east to Emerald Point Villas, Emerald Isle (Bogue Banks) | 1 mile (5,280 lf) | 0.4 miles or 2,000 linear feet | <100,000 anually | The Town of Emerald Isle has received permits to place the material directly on the west end of Emerald Isle at Bogue Inlet. |
| Browns Inlet | AIWW Section II, Tangents-F,G,H | Camp Lejeune, 3,000 feet west of Browns Inlet extending westward | 1.58 miles (6,000 lf) | 1 mile or 5,280 linear feet | <200,000 every 2 years | |
| New River Inlet | *AIWW, New River Inlet Crossing Section II, Tangents I & J, Channel to Jax. Section III, tangents 1&2 | N. Topsail Beach, 3,000 feet west of inlet extending westward to Maritime Way (Galleon Bay area) | 1.5 miles (8,000 lf) | 0.8 miles or 4,000 lf | <200,000 annually | Two areas 2,000 linear feet on either side of disposal area are routinely used. |
| New Topsail Inlet (Hampstead) | *AIWW, Sect. III | Topsail Island, Queens Grant | 0.6 miles (2,500 lf) | 0.6 miles or 2,500 lf | <50,000 every 6 yrs | |
| | *AIWW, Topsail Inlet Crossing & Topsail Creek | Topsail Beach, from a point 2,000 feet north of Topsail Inlet | 1 mile (5,280 lf) | 0.4 mi or 2,000 lf | <75,000 annually | |
| Wrightsville Beach | AIWW Sect. III, Tang 11&12 Mason Inlet Crossing | Shell Island (north end of Wrightsville Beach from a point 2,000 feet from Mason Inlet | 0.4 miles (2,000 lf) | 0.4 mi. or 2,000 lf | <100,000 | Not recently required since the inlet crossing closed up. If reopened will be rescheduled if needed |
| | *Masonboro Sand Bypassing | At a point 9,000 feet from jetty extending southward midway of island | 1.2 miles (6,000 lf) | 1 mile 5,280 lf | 500,000 every 4 years | Same time as Wrightsville Beach Nourishment |
| Carolina Beach | AIWW, Section IV, Tangent 1 | Southern end of Masonboro Island at a point 2,000 linear feet from arolina Beach Inlet extending northward to Johns Bay area | 1.3 miles (7,000 lf) | 0.4 miles (2,000 linear feet) | <50,000 annually | This site is used alternately with Carolina Beach Disposal Site on North end of Island |
| | AIWW, Section IV, Tangent 1 | North end of Carolina Beach at Freeman Park | | | | Limits for each disposal event are dependent on the quantity of material to be dredged |
| Caswell Beach | *Caswell Beach | Beachfront on eastern end of island | 4.7 miles (25,000 lf) | 4.7 miles or (25,000 linear feet) | 1.1 million every 6 years | Disposal Material from Wilmington Harbor Ocean Bar Project |
| Bald Head | *Bald Head | Beach front on eastern and western shoreline | 3.0 miles (16,000 lf) | 3.0 miles or 16,000 lf | 1.1 million every 2 years (except every 6th when it goes to Caswell) | Least Costly Disposal Option From Wilmington Harbor Ocean Bar Project. |
| Holden Beach | AIWW | Beach front on eastern end of the shoreline | | | | Limits for each disposal event are dependent on the quantity of material to be dredged |
| Ocean Isle | AIWW | Beachfront on eastern end of the island within the vicinity of Shallotte Blvd | | | | Limits for each disposal event are dependent on the quantity of material to be dredged |

* Navigation disposal sites which may overlap with existing Federal or non-Federal beach nourishment projects.

Table 7.5 *continued*. Summary of dredged material disposal activities on the ocean front beach associated with navigation dredging. Projects listed and associated disposal locations and quantities may not be all encompassing and represent an estimate of navigation disposal activities for the purposes of this cumulative impacts assessment. (Part 2 of 2).

| Project Type | Total Miles Impacted (*w/o double counting for overlapping projects) | % NC Beach |
|---|---|---|
| Federal and Non-Federal Beach Nourishment | 112 | 35 |
| Federal Authorized Beach Disposal | 19 | 6 |
| **TOTAL** | **131** | **41** |

Table 7.6. Summary of cumulative mileage of North Carolina Ocean beach that could be impacted by beach nourishment and/or navigation disposal activities.

### 7.12.4 Offshore Borrow Areas

The Bogue Banks CSDR project borrow areas extend between 1-5 miles offshore at depths between -40' and -57'. There are many possible sequences and methods for dredging and placing available material on the beach for the project and a site specific borrow area use plan has yet to be defined. The initial construction and each nourishment interval will utilize varying components of the borrow site with a sequence of temporary impacts to benthic resources over the life of the project. Subsequent intervals of dredging within the borrow area will likely occur in portions not previously been dredged. This cyclic use of borrow areas would result in cumulative effects from space crowded perturbations on a local scale.

### 7.12.5 Statewide Impacts

Beach compatible sediment identified for all Federal and non-Federal nourishment projects throughout North Carolina is most often identified from: upland sites, maintenance or deepening of navigation channels, and/or offshore borrow areas (Tables 7.3 and 7.4). For the purposes of this impact assessment, only offshore borrow areas are evaluated for cumulative marine resource impacts considering that upland sources are outside of the marine environment and navigation channels are repeatedly dredged already in order to maintain navigability. This assessment also addresses both the impacts to the borrow site and to the beaches where the material is placed. Of all the projects listed with offshore borrow areas in Tables 7.3 and 7.4, there is currently only one Federal (Carolina Beach and Vicinity, NC Kure Beach portion) and four non-Federal (Bogue banks FEMA, Bogue Banks Restoration Project – Phases 1&2, Bald Head Island Beach Nourishment, and Nags Head Beach Nourishment) offshore borrow sites that have received permits and/or authorizations and funding. Other offshore borrow areas identified for projects are either under study and have not been permitted and/or authorized yet or have received permits and/or authorizations but have not been funded or constructed yet. Considering only the projects that are currently in use, significant cumulative impacts associated with time and space crowded perturbations are not expected considering that these borrow areas are spread out throughout the state and the acreage of impact for these borrow areas relative to the available un-impacted sites throughout the state is relatively minimal.

The degree of cumulative impact would increase proportionally with the total length of beach impacted. The most likely projects to increase the length of North Carolina beach placement are beach nourishment projects.

Recognizing that many of the existing or proposed Federal and non-Federal beach nourishment project limits overlap and that some portions of the Federal approved beach disposal limits are within these project areas as well, Table 7.6 provides an estimate of total mileage of North Carolina ocean beach that could cumulatively be impacted by beach nourishment or navigation disposal activities without double counting the overlapping projects. Considering all proposed and existing disposal and nourishment impacts throughout the ocean beaches of North Carolina, a significant portion of the shoreline may have beach placement activities in the foreseeable future, likely resulting in time and space crowded perturbations. However, recognizing the funding constraints to complete all authorized and/or permitted activities, the availability of dredging equipment, etc; it is very unlikely that all of these proposed projects would ever be constructed all at once. Therefore, though time and space crowded perturbations are expected in the reasonably foreseeable future, assuming each project adheres to project related impact avoidance measures, it is likely that adjacent un-impacted and/or recovered portions of beach will be available to support dependent species (i.e. surf zone fish, shore birds, etc.) and facilitate recovery of individual project sites to pre-project conditions. Neither potential impacts to borrow sites nor to beaches on which the material is placed are likely to result in unacceptable Statewide impacts.

#### 7.12.6 Conclusion

Historically, the extent of beach nourishment activities on North Carolina beaches was limited to a few authorized Federal projects including: Wrightsville Beach, Carolina and Kure Beaches, and Ocean Isle Beach. However, in the past 10 years, a significant number of Federal and non-Federal beach nourishment efforts were pursued to provide coastal storm damage reduction along the increasingly developed North Carolina shoreline. Additionally, the number of non-Federal beach nourishment projects has increased in recent years in efforts to initiate coastal storm damage reduction measures while awaiting authorization and funding of Federal projects (i.e. Bogue Banks, Dare County, North Topsail Beach, and Topsail Beach). Considering the extent of coastal development and subsequent vulnerability to long and short term erosion throughout the North Carolina shoreline it is possible that either the proposed Federal or non-Federal beach nourishment projects within the reasonably foreseeable future may be constructed. Furthermore, the frequency of beach disposal activities for protection of infrastructure will continue throughout the state resulting in cumulative time and space crowded perturbations.

Assuming projects continue to adhere to environmental commitments for the reduction of environmental impacts, and un-developed beaches throughout the state continue to remain undisturbed, it is likely that adjacent un-impacted and/or recovered portions of beach will be available to support dependent species (i.e. surf zone fish, shore birds, etc.)

and facilitate recovery of individual project sites to pre-project conditions. Assuming recovery of impacted beaches and the sustainability of un-developed protected beaches (i.e. National/Federal and State Parks and Estuarine Reserves) the potential impact area from the proposed and existing actions is small relative to the area of available similar habitat on a vicinity and statewide basis. Additionally, due to their spread out distribution and small acreage relative to the available un-impacted sites, the cumulative impacts to the borrow areas would be minimal.

# 8. PLAN IMPLEMENTATION

## 8.01 Project Schedule

Table 8.1 shows the current project schedule following an assumed December 2014 project authorization (WRDA) of the project. The schedule assumes expeditious review and approval of the project through all steps, including authorization and funding, and as such is subject to change.

| Activity | Date |
|---|---|
| Sign PPA | Mar 2018 |
| Complete Real Estate Acquisition | Nov 2019 |
| Complete Final Plans and Specs | Mar 2020 |
| Award Construction Contract | Sep 2020 |
| Begin Initial Construction | Dec 2020 |
| Complete Initial Construction | Mar 2021 |
| Begin First Renourishment | Dec 2023 |
| Complete First Renourishment | Mar 2024 |

Table 8.1. Project schedule following assumed December 2015 project authorization.

## 8.02 Division of Plan Responsibilities

### 8.02.1 General

Federal policy requires that costs for water resources projects be assigned to the various purposes served by the project. These costs are then apportioned between the Federal government and the non-Federal sponsor according to percentages specified in Section 103 of the WRDA of 1986 (P.L. 99-662). For projects that provide damage reduction to publicly owned shores, the purposes are usually (1) coastal storm damage reduction and (2) separable recreation. For the Bogue Banks project, there is no separable recreation component.

### 8.02.2 Cost-Sharing

All project costs for the Recommended Plan are allocated to the purpose of hurricane and storm damage reduction. Cost-sharing for initial construction would be 65% Federal/35% non-Federal consistent with requirements specified in Section 103(c)(5) of WRDA 1986 as amended by WRDA 1996. The estimated Federal share of the initial costs of the project is $24,263,000.Non-Federal interests are required to provide all lands, easements, rights-of-way, relocations and disposal (LERRDs) necessary for the project. The value of the non-Federal portion of the LERRD is $3,655,000 and is included in the non-Federal share of initial project construction costs. The remainder of the non-Federal share of initial project construction costs consists of a $9,409,000 cash contribution, or a total non-Federal cost of $13,064,000.

Cost-sharing for periodic nourishment (continuing construction) would be consistent with Section 215 of WRDA 99, which requires that such costs be shared 50 percent Federal and 50 percent non-Federal. Annual beach fill monitoring is also considered part of continuing construction and would be cost-shared 50/50 as well.

Annual OMRR&R costs, such as inspection costs and dune vegetation maintenance costs, are 100 percent non-Federal responsibility. The Federal government is responsible for preparing and providing an OMRR&R manual to the sponsor.

As noted previously, current Federal policy requires that, unless there are other, overriding considerations, the NED plan would be the plan recommended for implementation. However, the non-Federal sponsor can request recommendation of a Locally Preferred Plan (LPP) that differs from the NED Plan if they are willing to pay 100% of the cost differential between the two plans. In this case, the non-Federal sponsor has not elected to pursue a LPP, therefore the Recommended Plan is the NED plan. Cost-sharing for the selected plan is shown in Table 8.2 at October 2014 price levels.

As discussed in section 6.03 above, the non-Federal sponsor has committed to constructing the required additional public accesses and parking requirements needed to support the determination of Federal interest in a CSDR project. Any costs incurred by the sponsor in order to satisfy these requirements are not considered project costs, and are not creditable towards the total amount of the non-Federal sponsor's required contributions. The cost apportionment shown in Table 8.2 is computed to assume that 100 percent of the project would meet these requirements by the time the PPA is executed. If none of the additional required accesses indicated in section 6.03 are obtained, the cost-apportionment for the project would be modified per Table 8.3. This modification increases the non-Federal cost share for initial construction to $16,573,000.

Actual cost-sharing percentages for the project will ultimately be based on a detailed assessment prior to initiation of construction, of the following factors:

a) Adequacy of public access and public parking throughout the constructed project reach;
b) Economic justification of the individual project reaches, and;
c) Presence of undeveloped lots.

All of these requirements may affect the cost-sharing percentages of Federal and non-Federal partners. This issue is also re-visited prior to each re-nourishment, and cost-sharing may be adjusted accordingly. Continued maintenance (of access for the public by both access corridors and public parking) is an especially important factor in ensuring funding of the project. The non-Federal Sponsor for the Bogue Banks project is fully aware of all the factors potentially affecting cost-sharing, and has wholly committed to meeting those requirements.

Cost allocation for undeveloped lots would be 100% non-Federal. The presented cost-sharing percentages assume 100% development along the entire project shoreline. The number of undeveloped first-row lots would be reassessed before the signing of the PPA, and the cost-sharing would be recalculated at that time to reflect any remaining undeveloped lots.

| Initial project construction costs | | | | | |
|---|---|---|---|---|---|
| | Project | Apportionment % | | Apportionment $ | |
| Project purpose | first cost | Non-Federal | Federal | Non-Federal | Federal |
| Coastal storm damage reduction | $37,327,000 | 35% | 65% | $13,064,000 | $24,263,000 |
| LERRD credit | $3,655,000 | 100% | 0% | $3,655,000 | |
| Cash portion | | | | $9,409,000 | $24,263,000 |
| | | | | | |
| Total financial initial project construction costs | | | | | |
| | Project | Apportionment % | | Apportionment $ | |
| Project purpose | first cost | Non-Federal | Federal | Non-Federal | Federal |
| Coastal storm damage reduction | $37,327,000 | 35% | 65% | $13,064,000 | $24,263,000 |
| Total financial cost | $37,327,000 | | | $13,064,000 | $24,263,000 |
| | | | | | |
| Total renourishment costs | | | | | |
| | Total Cost | Apportionment % | | Apportionment $ | |
| Project purpose | (16 renourishments) | Non-Federal | Federal | Non-Federal | Federal |
| Coastal storm damage reduction | $229,450,000 | 50% | 50% | $114,725,000 | $114,725,000 |
| | | | | | |
| | Cost per | Apportionment % | | Apportionment $ | |
| | year | Non-Federal | Federal | Non-Federal | Federal |
| Beach fill Monitoring (Annual) | $187,500 | 50% | 50% | $93,750 | $93,750 |
| | | | | | |
| Annual OMRR&R costs | | | | | |
| | Cost per | Apportionment % | | Apportionment $ | |
| | year | Non-Federal | Federal | Non-Federal | Federal |
| General repair, maintenance, inspection | $75,000 | 100% | 0% | $75,000 | $0 |

Table 8.2. Cost allocation and apportionment, October 2014 price levels.

| | | Fed % (initial) | Non Fed % (initial) | Fed % (renourishment) | Non Fed % (renourishment) |
|---|---|---|---|---|---|
| Total project length (miles) | 22.70 | | | | |
| Length with full access (miles) | 19.45 | 65 | 35 | 50 | 50 |
| Length w/o full access (miles) | 3.25 | 0 | 100 | 0 | 100 |
| % Project Length with adequate access | 85.68 | | | | |
| **Total adjusted cost-sharing %** | | **55.7*** | **44.3** | **42.8*** | **57.2** |
| * Calculated by multiplying the normal cost-sharing % by the % project length with adequate access | | | | | |

Table 8.3. Change in project cost-apportionment if no additional public accesses are obtained.

### 8.02.3 Financial Analysis

The non-Federal sponsor has submitted a statement of financial capability to the USACE.

### 8.02.4 Project Partnership Agreement

A model Project Partnership Agreement (PPA) will establish the responsibilities for project executions between the Federal government and the non-Federal sponsor. The terms of local cooperation to be required in the PPA are described in Section 12, Recommendations. A Letter of Intent acknowledging this process and stating their intent to support project implementation has been obtained from Carteret County.

Federal commitments regarding a construction schedule or specific provisions of the PPA cannot be made to the non-Federal sponsors on any aspect of the Recommended Plan or separable element until the following are true:

- The Recommended Plan is authorized in a Water Resources Development Act (WRDA) or similar legislation.
- Construction funds are appropriated, apportioned by the OMB, and their allocation is approved by the Assistant Secretary of the Army for Civil Works (ASA [CW])
- The draft PPA has been reviewed and approved by the Assistant Secretary of the Army – Civil Works (ASA-CW)

The PPA would not be executed nor would construction be initiated on the project or any separable element until the Final EIS has been fully coordinated and a Record of Decision has been signed.

## 8.03 Views of the Non-Federal Sponsor

The non-Federal sponsor, Carteret County, fully supports the Recommended Plan. A letter of support from them will be included in the Final Feasibility Report and EIS.

## 8.04 Views of the U.S. Fish & Wildlife Service

The USFWS view of the Recommended Plan is reflected in the Final FWCA and included in Appendix K.

# 9. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS*

The following paragraphs summarize the relationship of the proposed action to the most pertinent Federal, State, and local requirements. Table 9.1 at the end of this section lists the compliance status of all Federal laws and policies that were considered for the proposed Bogue Banks project.

## 9.01 Water Quality

### 9.01.1 Section 401 of Clean Water Act of 1977

A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and will be obtained from the NCDWR before construction begins. Work would not proceed until the certificate is received.

### 9.01.2 Section 404 of Clean Water Act of 1977

Pursuant to Section 404 of the Clean Water Act, the effects associated with the discharge of fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) evaluation in Appendix J. Incidental fallback associated with hopper dredging operations in the offshore borrow areas is anticipated. Resultant water column impacts associated with sedimentation and turbidity are discussed in Sections 7.02.8.1&6; however, no measureable increase in bottom elevation is expected from the fallback of sediment during the dredging operations and the activity won't destroy or degrade waters of the United States (33 CFR Section 323.2(d)(4)(i)). Therefore, incidental fallback from hopper dredging in the borrow area is not being considered a discharge addressed under the Section 404 (b)(1) Guidelines Analysis.

## 9.02 Marine, Protection, Research, and Sanctuaries Act

The proposed coastal storm damage reduction project does not involve ocean disposal of dredged material. Therefore, the project would be considered to be in compliance with the requirements of the Marine Protection, Research and Sanctuaries Act. One borrow area being considered for this CSDR project is located within the EPA designated Morehead City ODMDS, however, this use will not adversely affect dredged material disposal there. The Morehead City ODMDS Site Management and Monitoring Plan (SMMP) directs dredged material disposal in a manner that is compatible with the use of the ODMDS as a borrow area for beach placement projects.

## 9.03 Essential Fish Habitat

Potential project effects on EFH species and their habitats have been evaluated and are addressed in Section 7.02.8 of this document. It has been determined that the proposed action would not have a significant adverse effect on such resources. Informal EFH consultation has been ongoing since study commencement. Through coordination of the DEIS document with the NMFS, consultation will be officially initiated and concurrence with USACE findings will be requested. Compliance obligations related to EFH provisions of the 1996 congressional amendments to the MSFCMA (P.L. 94-265) would be fulfilled before initiation of the proposed action.

## 9.04 Fish and Wildlife Resources

The Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, *et seq*), requires that USACE coordinate and obtain comments from the USFWS, the NMFS, where applicable, and appropriate State fish and wildlife agencies, including the NCDMF and the North Carolina Wildlife Resources Commission. The Final Fish and Wildlife Coordination Act Report (Appendix K) has been provided by the USFWS under the Fish and Wildlife Coordination Act.

## 9.05 Endangered and Threatened Species

A Biological Assessment evaluating the potential effects of the proposed action on Federally listed threatened and endangered (T&E) species was prepared and coordinated with the USFWS (Appendix F) (jurisdiction over the Florida manatee, nesting sea turtles, piping plovers, and seabeach amaranth) and NMFS (jurisdiction over other protected marine and aquatic species which can occur in the project vicinity) pursuant to Section 7 of the ESA of 1973 (P.L. 93-205), as amended. All compliance obligations under Section 7 will be satisfied. Environmental commitments to protect listed species, related to the construction and maintenance of the proposed project, are listed in Appendix G. The list of commitments should be considered preliminary at this stage and may be modified pending new information acquired through the public and agency review process.

## 9.06 Cultural Resources

Archaeological surveys of the offshore borrow areas were completed and a report titled *An Archaeological Remote Sensing Survey of Bogue Banks Offshore Borrow Areas, Carteret County, North Carolina by Wes Hall, 2008,* is provided in Appendix E. No significant impacts to known archaeological or historic resources are anticipated. A report summarizing the findings was submitted to the SHPO pursuant to Section 106 of the National Historic Preservation Act and concurrence was obtained on January 30, 2009, that the proposed action would not cause significant adverse impacts to submerged cultural resources assuming avoidance measures are considered.

Section 106 project-specific tribal consultation between the USACE and six federally recognized tribes was initiated on 17 October 2013 for a 30 day review period. Section 106 Review and Findings were sent to the United Keetoowah Band of Cherokee Indians in Oklahoma, Absentee-Shawnee Tribe, Catawba Indian Nation, Cherokee Nation, Shawnee Tribe, and Tuscarora Nation. One response was received from the United Keetoowah Band of Cherokee Indians stating they had reviewed the project and had no objection or comments (See Appendix L – Project Correspondence).

## 9.07 Executive Order 11988 (Flood Plain Management)

Executive Order 11988 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities." The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE' ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the Order. The eight steps and responses to them are summarized below.

1. Determine if the proposed action is in the base flood plain.

Yes, the project is a CSDR project located on portions of the ocean shoreline of Bogue Banks, which is within the 100-year floodplain.

2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

Section 5 of this document has an analysis of practicable alternatives and Section 7 evaluates the environmental impacts of the selected alternative.

3. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

The general public and other interested stakeholders including State, Federal, and non-Governmental (NGO) resource agencies have been a part of the planning process for this study. Specifically, the Draft Integrated Feasibility Report and EIS was circulated for a 45-day Public review in August 2013. All comments were reviewed and integrated into the report and Environmental Impact Statement where appropriate. Also the final report will be circulated for a 30-day review period. The towns of Bogue Banks and Carteret County have been engaged throughout the planning process.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

Potential impacts associated with the proposed alternative are identified in Section 7, "Environmental Effects," of the report. No project components would be located outside of the base flood plain.

5. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.

The proposed CSDR project is in full compliance with the requirements of Executive Order 11988. IWR Report 96-PS-1, Final Report, *An Analysis of the U.S. Army Corps of Engineers Shore Protection Program,* June 1996 states the following:

> The presence of a USACE project has little effect on new housing production. The econometric results presented imply that general economic growth of inland communities is sufficient by itself to drive residential development of beachfront areas at a rapid pace. The statistical evidence indicates that the effect of USACE on induced development is, at most, insignificant, compared to the general forces of economic growth which are stimulating development in these areas, many of which are induced through other municipal infrastructure developments such as roads, wastewater treatment facilities, etc. The results presented for beachfront housing price appreciation are consistent with the findings from the more general econometric model of real estate development in beachfront communities. The increasing demand for beachfront development can be directed related to the economic growth occurring in inland areas. There is no observable significant effect on the differential between price appreciation in inland and beachfront areas due to USACE activity. The housing price study could not demonstrate that USACE shore protection projects influence development. USACE activity typically follows significant development.

The requirements for Federal participation in CSDR projects essentially dictate that these projects be constructed along areas that have a high degree of development. Additionally, part of the conceptual framework of the Unified National Program for Floodplain Management consists of a series of strategies and tools that can be used to manage floodplains to reduce losses to both human and natural resources. As part of the broader, national vision of floodplain management, the Water Resources Council submitted the Unified National Program for Floodplain Management to the President in 1976. That report, which updates the 1966 Unified National Program for Managing Flood Losses, reflects a shift in focus from flood damage reduction to floodplain management. Through Executive Orders and Interagency Task Forces, the 1976 report was revised and strengthened during the 1980s and 1990s and continues to serve as the focus of the national need to evaluate flood damages within the context of floodplain management. In the 1994 Unified National Program Report, four strategies for managing floodplains wisely were developed (FEMA, 1994). One of the four strategies, which is also a purpose of Executive Order 11988, is to preserve and restore the natural resources and functions of floodplains. The 1994 report further identifies beach nourishment and building sand dunes as tools to support this strategy. Clearly, beach nourishment has been accepted as a valuable tool in moderating flooding and protecting floodplains. Placement of beach fill would occur in the floodplain of area beaches. That placement would be conducted specifically for its beneficial effect in offsetting erosion and restoring damaged beaches, and therefore would be judged acceptable. The action would be expected to have an insignificant effect on the floodplain; therefore, the proposed action is in compliance with the requirements of Executive Order 11988 and with State/local floodplain protection standards.

6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the “no action” alternative.

Specific “Commitments to Reduce Environmental Impacts” were identified as a part of the project planning process. These identified commitments will be implemented as part of the project to minimize the project’s potentially adverse impacts. The project includes some incidental environmental benefits associated with the expansion of beach habitat. The No-Action Alternative is discussed in Section 5 of the report, and is not considered a practicable alternative and does not meet the objectives of the study. Furthermore, the nature of the recommended project and the associated floodplain is such that the project and floodplain are able to naturally adapt and equilibrate to changes in SLR, and are thus sustainable during the 50 year project life.

7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

As per item 3 above, the report will be circulated for public review and directly provided to the towns of Bogue Banks and to Carteret County.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The objective of the project is to reduce risks to public health, safety, and property on Bogue Banks. The project is responsive to the EO 11988 objective of “avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative” because it would not induce development in the floodplain, would reduce the hazard and risk associated with floods thereby minimizing the impacts of floods on human safety, health, and welfare, and would restore and preserve the natural and beneficial values of the base floodplain.

## 9.08 Executive Order 11990 (Protection of Wetlands)

Executive Order 11990 directs all Federal agencies to issue or amend existing procedures to ensure consideration of wetlands protection in decision making and to ensure the evaluation of the potential effects of any new construction proposed in a wetland. The proposed action would not require filling any wetlands and would not be expected to produce significant changes in hydrology or salinity affecting wetlands. The proposed action is in compliance with Executive Order 11990.

## 9.09 Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds)

Executive Order 13186 directs departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act. Specifically, the executive order directs Federal agencies, whose direct activities would likely result in the take of migratory birds, to develop and implement a Memorandum of Understanding (MOU) with the USFWS that must promote the conservation of bird populations. As discussed in Section 7.03.4, in consideration of the identified mitigation measures including dredging and placement windows, the proposed project would not be expected to adversely affect migratory birds and therefore, is in compliance with Executive Order 13186.

## 9.10 North Carolina Coastal Management Program

The proposed action would be conducted in the designated coastal zone of North Carolina. Pursuant to the Federal Coastal Zone Management Act of 1972, as amended (P.L. 92-583), Federal activities are required to be consistent, to the maximum extent practicable, with the Federally approved coastal management program of the State in which their activities will occur. The components of the proposed action have been evaluated and determined to be consistent with the North Carolina Coastal Management Program and local land use plans. By letter of September 10, 2013, the NC Division of Coastal Management concurred with the Corps' consistency determination.

### 9.10.1 Areas of Environmental Concern (15A NCAC 07H .0204)

The selected plan would take place in areas under the North Carolina Coastal Management Program designated as an Area of Environmental Concern (AEC) (15A NCAC 07H). Specifically, the activities could affect the following AECs: Coastal Wetlands, Estuarine Waters, Public Trust Areas, Coastal Shorelines, and Ocean Hazard Areas. The following determination has been made regarding the consistency of the proposed project with the State's management objective for each AEC affected:

Coastal Wetlands. Coastal wetlands are defined as any salt marsh or other marsh subject to regular or occasional flooding by tides, including wind tides (whether or not the tide waters reach the marshland areas through natural or artificial watercourses), provided this will not include hurricane or tropical storm tides. The highest priority of use will be allocated to the conservation of existing coastal wetlands. Second priority of coastal wetland use will be given to those types of development activities that require water access and cannot function elsewhere. Unacceptable land uses may include the following examples: restaurants and businesses; residences, apartments, motels, hotels, and trailer parks; parking lots and private roads and highways; and factories. Examples of acceptable land uses may include utility easements, fishing piers, docks, and agricultural uses, such as farming and forestry drainage, as permitted under North Carolina's Dredge and Fill Act or other applicable laws. The management objective is to conserve and manage coastal wetlands so as to safeguard and perpetuate their biological, social, economic and aesthetic values; to coordinate and establish a management system capable of conserving and using coastal wetlands as a natural resource essential to the functioning of the entire estuarine system. No sediment placement and/or dredge pipelines would cover and/or cross coastal wetlands during project construction or renourishment events, therefore no impacts would be incurred, making the project consistent with the management objective for this AEC.

Estuarine Waters. Estuarine waters are defined in G.S. 113A-113(b)(2) to include all the waters of the Atlantic Ocean within the boundary of North Carolina and all the waters of the bays, sounds, rivers, and tributaries thereto seaward of the dividing line between coastal fishing waters and inland fishing waters. The highest priority of use will be allocated to the conservation of estuarine waters and their vital components. Second priority of estuarine waters use will be given to those types of development activities that require water access and use which cannot function elsewhere such as simple access channels; structures to reduce erosion; navigation channels; boat docks, marinas, piers, wharfs, and mooring pilings. The management objective is to conserve and manage the important features of estuarine waters so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and using estuarine waters so as to maximize their benefits to man and the estuarine and ocean system. The selected plan would not directly involve estuarine waters and therefore would not be detrimental to estuarine waters.

Public Trust Areas. These areas include (1) waters of the Atlantic Ocean and the lands thereunder from the mean high water mark to the 3 nautical mile limit of State jurisdiction, (2) all natural bodies of water subject to measurable lunar tides, and all lands thereunder, to the mean high water mark, and (3) all navigable natural bodies of water, and all lands thereunder, except privately owned lakes to which the public has no right of access. Acceptable uses include those that are consistent with protection of the public rights for navigation and recreation, as well as conservation and management to safeguard and perpetuate the biological, economic, and aesthetic value of these areas. The management objective is to protect public rights for navigation and recreation and to conserve and manage the public trust areas so as to safeguard and perpetuate their biological, economic and aesthetic value. Placement of beach compatible material on the project area beaches would result in a wider, more stable beach, thus enhancing recreational opportunities, biological habitat, and economic and aesthetic values. For a more thorough discussion of project impacts, please see Chapter 7 of this report, specifically Sections 7.07 Recreational and Aesthetic Resources, 7.06 Socioeconomic Resources, 7.02 Marine Environment, and 7.03 Terrestrial Environment. The Recommended Plan is an acceptable use within public trust areas and would not be detrimental to the biological and physical functions of Public Trust Areas.

Coastal Shorelines. The Coastal Shorelines category includes estuarine shorelines and public trust shorelines. Estuarine shorelines AEC are those non-ocean shorelines extending from the normal high water level or normal water level along the estuarine waters, estuaries, sounds, bays, fresh and brackish waters, and public trust areas. Acceptable uses will be limited to those types of development activities that would not be detrimental to the public trust rights and the biological and physical functions of the estuarine and ocean system. The management objective is to ensure that shoreline development is compatible with both the dynamic nature of coastal shorelines as well as the values and the management objectives of the estuarine and ocean system. Other objectives are to conserve and manage the important natural features of the estuarine and ocean system so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and using these shorelines so as to maximize their benefits to the estuarine and ocean system and the people of North Carolina. The selected plan would not involve estuarine shorelines and therefore would not be detrimental to these areas. Please see the paragraph above regarding Public Trust Areas and the references to pertinent sections of the FEIS for information regarding public trust shorelines. Although a regional sediment budget analysis has not been completed, it is expected that the proposed action and the combined effects of all other existing and proposed beach projects would have a minimal effect on shoreline and sand transport. Therefore, the proposed project would not be expected to negatively impact coastal shorelines.

Ocean Hazard Areas. These areas are considered natural hazard areas along the Atlantic Ocean shoreline where, because of their special vulnerability to erosion or other adverse effects of sand, winds, and water, uncontrolled or incompatible development could unreasonably endanger life or property. Ocean hazard areas include beaches, frontal dunes, inlet lands, and other areas in which geologic, vegetative and soil conditions indicate a substantial possibility of excessive erosion or flood damage. The specific Ocean Hazard Areas and potential project impacts are described below.

Ocean Erodible Area. This is the area in which there exists a substantial possibility of excessive erosion and significant shoreline fluctuation. The seaward boundary of this area is the mean low water line. The landward extent of this area is determined as follows:

(a) a distance landward from the first line of stable natural vegetation to the recession line that would be established by multiplying the long-term annual erosion rate times 60, provided that, where there has been no long-term erosion or the rate is less than two ft. per year, this distance will be set at 120 ft. landward from the first line of stable natural vegetation. For the purposes of this Rule, the erosion rates will be the long-term average based on available historical data. The current long-term average erosion rate data for each segment of the North Carolina coast is depicted on maps titled *Long Term Annual Shoreline Change Rates* updated through 1998 and approved by the Coastal Resources Commission on January 29th, 2004 (except as such rates may be varied in individual contested cases, declaratory or interpretive rulings). Erosion rates are variable along the study area beaches. There are no detailed records of previous damages caused by erosion, but major erosion can be caused by northeasters that frequently occur along Bogue Banks during the colder months, as well as tropical cyclones occurring in the warmer months. Erosion related to individual storms is not listed separately but are included in the average erosion rates.

(b) a distance landward from the recession line established in Sub-Item (1)(a), above, to the recession line that would be generated by a storm having a one percent chance of being equaled or exceeded in any given year.

Construction of the proposed beach template, would result in a wider, more stable beach, thus providing significant benefits to the ocean erodible area. Beach-related work, including the discharge of dredged material, the associated temporary operation of heavy equipment, and placement of dredge pipeline, would not cause any significant adverse effects to the ocean erodible area.

High Hazard Flood Area. This is the area subject to high velocity waters (including, but not limited to, hurricane wave wash) in a storm having a one percent chance of being equaled or exceeded in any given year, as identified as zone V1-30 on the flood insurance rate maps of the Federal Insurance Administration, U.S. Department of Housing and Urban Development. Placement of beach nourishment on the beach would provide short-term damage reduction benefits for high hazard flood areas.

Inlet Hazard Area. The inlet hazard areas are natural-hazard areas that are especially vulnerable to erosion, flooding and other adverse effects of sand, wind, and water because of their proximity to dynamic ocean inlets. This area will extend landward from the mean low water line a distance sufficient to encompass that area within which the inlet would, on the basis of statistical analysis, migrate, and will consider such factors as previous inlet territory, structurally weak areas near the inlet (such as an unusually narrow barrier island, an unusually long channel feeding the inlet, or an overwash area), and external influences such as jetties and channelization. In all cases, this area will be an extension of the adjacent ocean erodible area and in no case will the width of the inlet hazard area be less than the width of the adjacent ocean erodible area. While components of the proposed action may involve the movement of equipment across these areas, no construction or periodic nourishment activities are proposed for these areas, and no adverse impacts are anticipated.

### 9.10.2 Use Standards (15A NCAC 07H .0208)

Primary Nursery Areas. With the exception of navigation channels, these include most estuarine waters of the project vicinity. Protection of juvenile fish is provided in those areas through prohibition of many commercial fishing activities, including the use of trawls, seines, dredges, or any mechanical methods of harvesting clams or oysters (http://www.ncfisheries.netirules.htm; 15 NC Administrative Code 3B .1405). PNAs would not be directly affected by the project. However, PNAs adjacent to the project area may experience indirect and short-term elevated turbidity levels from the nourishment operation on the shoreface. Such turbidity effects are dependent on the location of the outflow pipe and the direction of longshore and tidal currents. Because the elevated turbidity levels would be short-term and within the range of elevated turbidity from natural storm events, the impacts to State-designated PNAs would be expected to be insignificant.

Submerged Aquatic Vegetation (SAV). A statewide SAV mapping effort was completed in 2007 in partnership with the Albemarle and Pamlico National Estuarine Research Program (APNEP), USFWS, National Oceanic and Atmospheric Administration (NOAA), and NCDMF. No SAV was identified within the immediate vicinity of the project area. All identified SAV locations were on the back side of the barrier island. Considering that SAV does not occur in or near the immediate project vicinity, it would not be directly or indirectly affected by the proposed project.

### 9.10.3 Shoreline Erosion Policies (15A NCAC 07-M .0202)

It is the policy of the State of North Carolina that proposals for shoreline erosion response projects will avoid losses to North Carolina's natural heritage. All means should be taken to identify and develop response measures that would not adversely affect estuarine and marine productivity. The project would not be expected to result in significant adverse impacts to estuarine and marine productivity.

The public right to use and enjoy the ocean beaches must be protected. The protected uses include traditional recreational uses (such as walking, swimming, surf fishing, and sunbathing) as well as commercial fishing and emergency access for beach rescue services. USACE has several requirements that must be met to fully cost-share in a coastal storm damage reduction project, which were discussed earlier in Section 6.03 of this report. Erosion response measures designed to minimize the loss of private and public resources to erosion should be economically, socially, and environmentally justified. This report demonstrates that the proposed CSDR project at is economically, socially and environmentally justified.

### 9.10.4 Shorefront Access Policies (15A NCAC 07M .0300)

Pursuant to 15A NCAC 07M .0300, the public has traditionally and customarily had access to enjoy and freely use the ocean beaches and estuarine and public trust waters of the coastal region for recreational purposes and the State has a responsibility to provide continuous access to the resources. It is the State's policy to foster, improve, enhance and ensure optimum access to the public beaches and waters of the 20-county coastal region. Access will be consistent with rights of private property owners and the concurrent need to protect important coastal natural resources such as sand dunes and coastal marsh vegetation. As discussed earlier in Section 6.03, USACE has several additional requirements that must be met to fully cost-share in a coastal storm damage reduction project.

### 9.10.5 Mitigation Policy (15A NCAC 07M .0701)

It is the policy of North Carolina to require that adverse impacts to coastal lands and waters be minimized through proper planning, site selection, compliance with standards for development, and creation or restoration of coastal resources. Coastal ecosystems will be protected and maintained as complete and functional systems by mitigating the adverse impacts of development as much as feasible by enhancing, creating, or restoring areas with the goal of improving or maintaining ecosystem function and areal proportion. Appendix G lists the environmental commitments to protect listed species related to the construction and maintenance of the proposed project.

### 9.10.6 Coastal Water Quality Policies (15A NCAC 07M .0800)

Pursuant to 15A NCAC 07M.0800, no land or water use will cause the degradation of water quality so as to impair traditional uses of the coastal waters. Protection of water quality and the management of development within the coastal area is the responsibility of many agencies. The general welfare and public interest require that all State, Federal and local agencies coordinate their activities to ensure optimal water quality. Overall water quality impacts of the proposed action are expected to be short-term and minor. Living marine and estuarine resources dependent on good water quality are not expected to experience significant adverse impacts due to water quality changes. A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be requested from the NCDWR at the appropriate time. Project construction would not begin until a Water Quality Certification has been received. Pursuant to Section 404 of the Clean Water Act, the effects associated with the discharge of fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) evaluation in Appendix J. Pursuant to the Sedimentation Pollution Control Act of 1973, a State-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

### 9.10.7 Policies on Beneficial Use and Availability of Materials Resulting From the Excavation or Maintenance of Navigational Channels (15A NCAC 07M .1100)

It is North Carolina's policy that material resulting from the excavation or maintenance of navigation channels be used in a beneficial way wherever practicable. Policy statement .1102 (a) indicates that, "clean, beach quality material dredged from navigation channels within the active nearshore, beach, or inlet shoal systems must not be removed permanently from the active nearshore, beach, or inlet shoal system unless no practicable alternative exists. Preferably, this dredged material would be disposed of on the ocean beach or shallow active nearshore area where environmentally acceptable and compatible with other uses of the beach." Several navigation channels are within the project area vicinity. They are the AIWW, Bogue Inlet, and the Morehead City Harbor Federal Navigation Channel. When practicable, beach compatible, maintenance dredged material from these navigation channels may be placed on the nourished beach.

### 9.10.8 Policies on Ocean Mining (15A NCAC 07M .1200) and 15A NCAC 07H. 0208(b)(12) Submerged Lands Mining

Mining activities affecting the Federal jurisdiction ocean and its resources can, and probably would, also affect the State jurisdictional ocean and estuarine systems and vice-versa. Therefore, it is State policy that every avenue and opportunity to protect the physical ocean environment and its resources as an integrated and interrelated system would be used. Cultural resources and hard-bottom surveys of the offshore borrow area have been completed. Hard bottom was identified in the borrow areas. A buffer has been included to avoid impacts based on report recommendations.

Dredging impacts to the benthic populations of the marine ecosystem from turbidity would be local and temporary but not permanent. Similarly, recent studies show that benthic impacts may be limited to the immediate vicinity of dredging operations. Also, to minimize effects, work would be performed between December 15 and March 31 of the year, during times of low biological activity. For the full discussion of benthic impacts, see Sections 7.02.6 and 7.02.7. Because: (1) the identified cultural and Hardbottom resource sites will be avoided, and (2) the effects of turbidity and sedimentation plumes within the marine water column would be insignificant, the project would not be expected to adversely affect the State jurisdictional ocean and estuarine systems.

The proposed CSDR project conforms to the relevant enforceable policies of Subchapters 7H and 7M of Title 15A of North Carolina's Administrative Code.

### 9.10.9 Other State Policies

The proposed project has been determined to be consistent with other State policies found in the State's Coastal Management Program document that are applicable. Those include the following:

<u>North Carolina Mining Act</u>. The removal of material from the offshore borrow areas that are within 3 nautical miles of shore have been reviewed by the North Carolina Division of Land Resources and a determination has been made that removal of sand from the sea floor within the 3 miles territorial limits is not an activity that would be classified as mining under the North Carolina Mining Act (G. S. 74-7).

<u>North Carolina Dredge and Fill Law</u> (G.S. 113-229). Pursuant to the North Carolina Dredge and Fill Law clean, beach quality material dredged from navigational channels within the active nearshore, beach or inlet shoal systems will not be removed permanently from the active nearshore, beach or inlet shoal system. This dredged material will be disposed of on the ocean beach or shallow active nearshore area where it is environmentally acceptable and compatible with other uses of the beach. When practicable, clean, beach quality material from maintenance dredging of navigation channels may be placed on the nourished study area beaches. Any dredged material from navigation channels would be purely supplemental material that would help maintain the project profile. This statute is not applicable to Federal projects.

Clean Water Act. A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be requested from the NCDWR. Work would not proceed until the Section 401 certification is received.

This project does place beach fill material into waters of the United States and is subject to Section 404 of the Clean Water Act. Pursuant to Section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) Guidelines Analysis in Appendix J of the report. Discharges associated with dredging in the offshore borrow areas are considered incidental to the dredging operation, and therefore, are not being considered as being a discharge addressed under the Section 404 (b)(1) Guidelines Analysis.

Sedimentation and Erosion Control. Pursuant to the Sedimentation Pollution Control Act of 1973, a State-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

### 9.10.10 Local Land Use Plans

On the basis of the information presented in this Feasibility Report and EIS, the proposed project is consistent with the North Carolina Coastal Management Program. By letter of September 10, 2013, the NC Division of Coastal Management concurred with the Corps' consistency determination.

## 9.11 Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA) of 1982 (P.L. 97-348) prohibits expenditure of Federal funds for activities within the designated limits of the Coastal Barrier Resources System unless specifically exempted by Section 6 of the act. Designated maps showing the Coastal Barrier Resources System in North Carolina indicate two sites within the study area limits, but neither area is within the beach fill template. Unit NC-04P is located at Fort Macon and unit NC-05P is located just west of Pine Knoll Shores on the sound side of Bogue Banks. Both units are designated "P" which USFWS has defined as "otherwise protected area". Both units are owned by the State of NC. "P" areas are not regulated by CBRA since it is State property. The only restriction in these "P" designated areas is that Federal Flood insurance cannot be obtained.

## 9.12 Estuary Protection Act

The Estuary (Estuarine) Protection Act provides a means to protect, conserve, and restore estuaries in a manner that maintains balance between the need for natural resource protection and conservation and the need to develop estuarine areas to promote national growth. The act authorizes the Secretary of the Interior to work with the states and other Federal agencies in undertaking studies and inventories of estuaries of the United States. The proposed project would be expected to have minimal effect on the estuarine environment, as discussed in Section 7 of this report; therefore the project would be in compliance with the Estuary Protection Act.

## 9.13 Sedimentation and Erosion Control

Pursuant to the Sedimentation Pollution Control Act of 1973, a State-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

## 9.14 Prime and Unique Agriculture Land

According to the Soil Surveys for Carteret County, North Carolina, the soils on the beach that could be affected by the proposed project are not designated by the Natural Resource Conservation Service as prime or unique agriculture lands. No impacts to prime and unique agriculture lands would be expected to occur.

## 9.15 Environmental Justice

Fishing has been an integral part of Carteret County's heritage and economy for nearly 400 years. This fishery supplies a wide variety of fresh fish, shellfish, crabs, and shrimp to both local residents and large East Coast cities. At one time Carteret County fishermen relied on the demand for a limited supply of high-quality, seasonal seafood, and could earn a sustainable living. During the last ten years, however, an influx of lower-cost, imported seafood began to displace domestic seafood in many commercial markets. Subsistence fishing refers to fishing, other than sport fishing, that is carried out primarily to feed the family and relatives of the person doing the fishing. Generally it also implies the use of low tech "artisanal" fishing techniques and is carried out by people who are very poor. Information regarding subsidence fishing in the project area is not known.

The mission of the Carteret Catch program is a community supported fishery to sustain the livelihood and heritage of the Carteret County fishing industry through public marketing and education. The goal is to make fishing a viable lifestyle and preserve a culture that characterizes the central coastal region of North Carolina.

The 2010 US Census data showed the minority/low-income populations and low-income communities are not found on Bogue Banks (Figure 9.1). The proposed action would impact Bogue Banks beaches and nearshore areas off Bogue. Accordingly, the proposed action would not cause disproportionately high and adverse impacts on minority populations or low income populations (Figure 9.2). No impacts to either minority/low-income populations or low income communities are anticipated as a result of the Proposed Action therefore the action would comply with EO 12898.

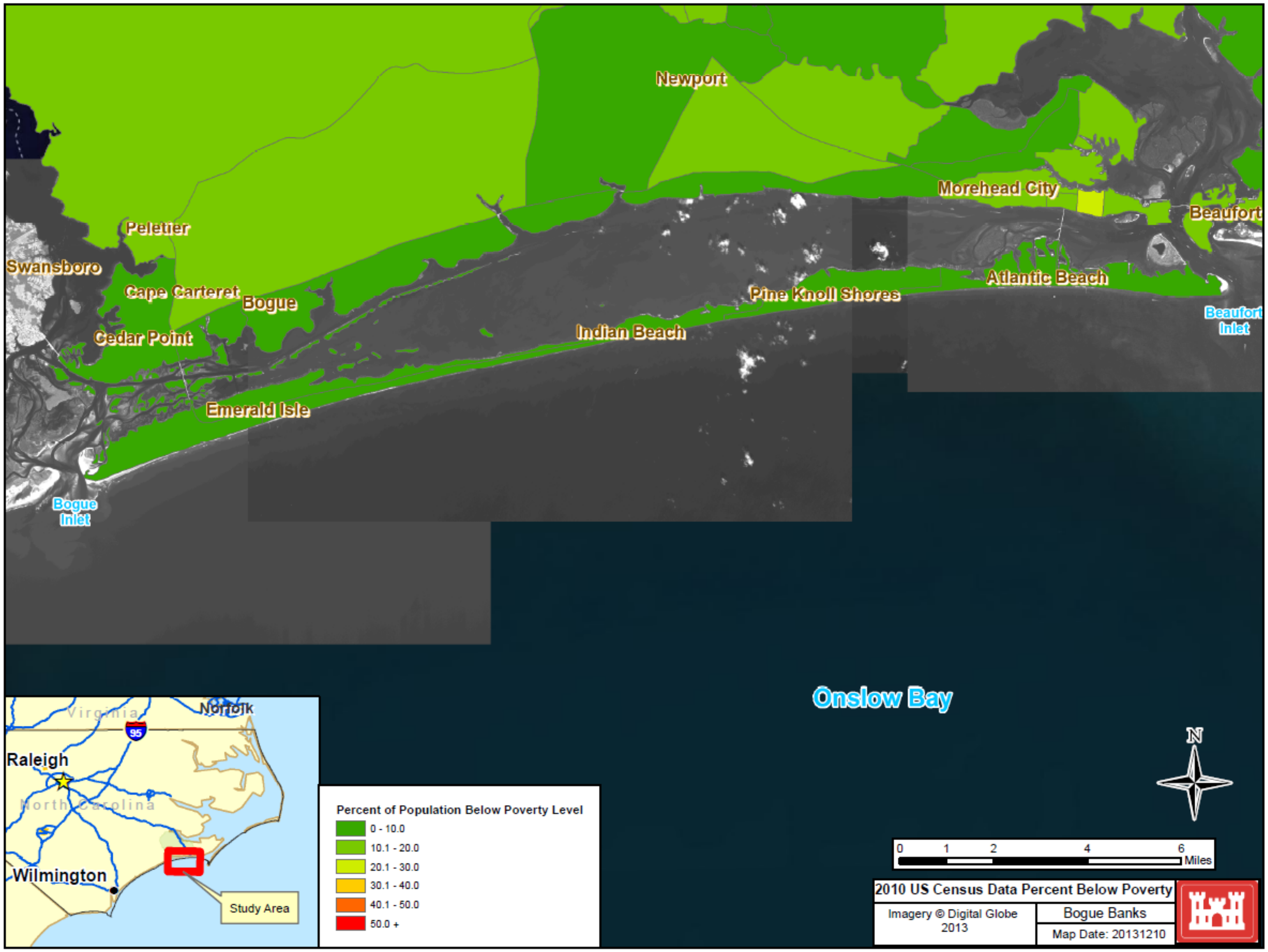



Figure 9.1 2010 Census Data Percent Below Poverty Line.

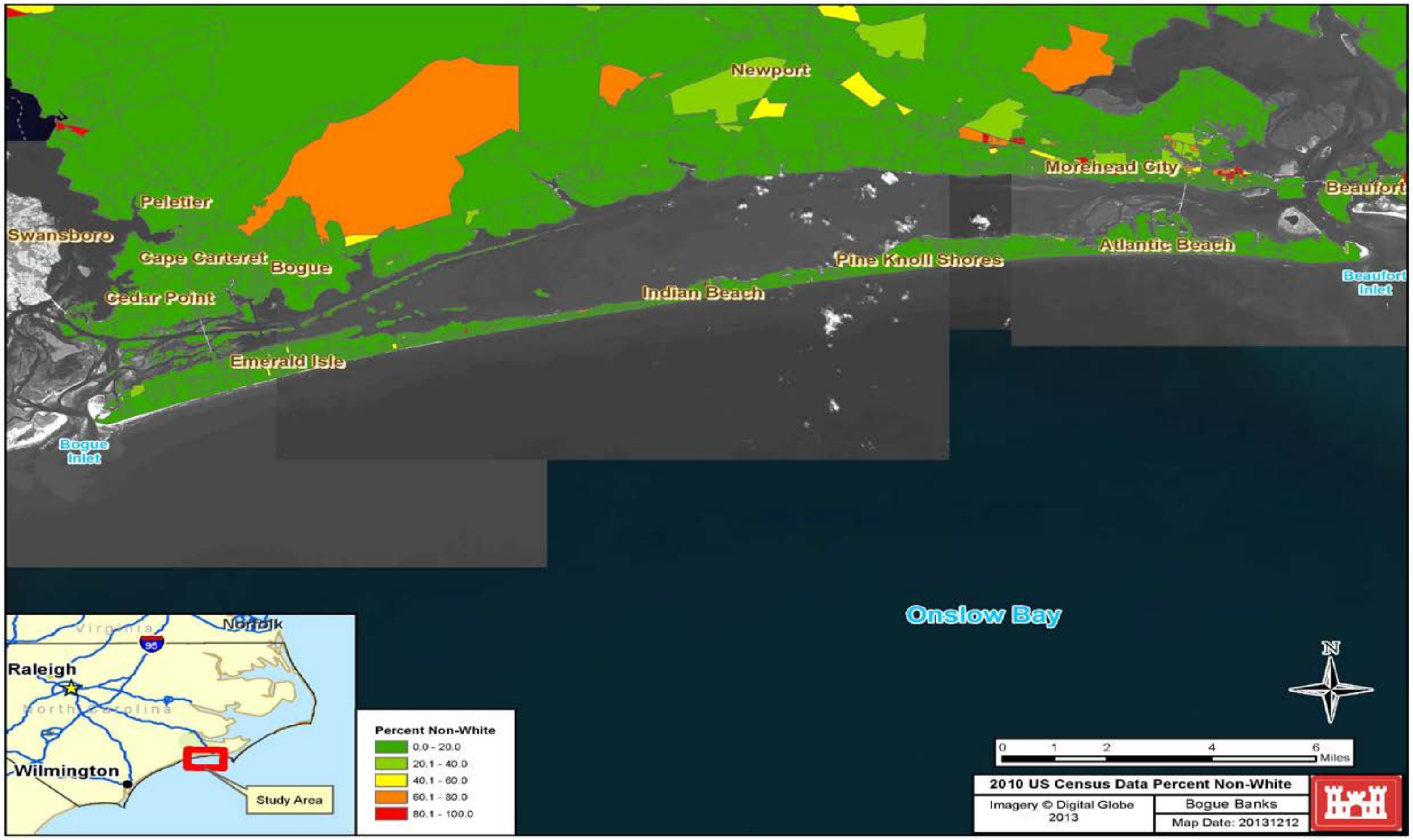



Figure 9.2 2010 US Census Data Percent Non-White

| Title of public law | U.S. Code | Compliance status |
|---|---|---|
| Abandoned Shipwreck Act of 1987 | 43 U.S.C. 2101 | Full Compliance |
| Anadromous Fish Conservation Act of 1965, As Amended | 16 U.S.C. 757 a et seq. | Full Compliance |
| Antiquities Act of 1906, As Amended | 16 U.S.C. 431 | Full Compliance |
| Archeological and Historic Preservation Act of 1974, As Amended | 16 U.S.C. 469 | Full Compliance |
| Archeological Resources Protection Act of 1979, As Amended | 16 U.S.C. 470 | Full Compliance |
| Clean Air Act of 1972, As Amended | 42 U.S.C. 7401 et seq. | Full Compliance |
| Clean Water Act of 1972, As Amended | 33 U.S.C. 1251 et seq. | Full Compliance |
| Coastal Barrier Resources Act of 1982 | 16 U.S.C. 3501-3510 | Full Compliance |
| Coastal Zone Management Act of 1972, As Amended | 16 U.S.C. 1451 et seq. | Full Compliance |
| Endangered Species Act of 1973 | 16 U.S.C. 1531 | Full Compliance |
| Estuary Program Act of 1968 | 16 U.S.C. 1221 et seq. | Full Compliance |
| Federal Water Project Recreation Act of 1965, As Amended | 16 U.S.C. 4601 | Full Compliance |
| Fish and Wildlife Coordination Act of 1958, As Amended | 16 U.S.C. 661 | Full Compliance |
| Flood Control Act of 1944, As Amended, Section 4 | 16 U.S.C. 460b | Full Compliance |
| Historic and Archeological Data Preservation | 16 U.S.C. 469 | Full Compliance |
| Historic Sites Act of 1935 | 16 U.S.C. 461 | Full Compliance |
| Magnuson Fishery Conservation and Management Act | 16 U.S.C. 1801 | Full Compliance |
| Marine Protection, Research and Sanctuaries Act of 1972 | 33 U.S.C. 1401 | Full Compliance |
| Migratory Bird Conservation Act of 1928, As Amended | 16 U.S.C. 715 | Full Compliance |
| Migratory Bird Treaty Act of 1918, As Amended | 16 U.S.C. 703 | Full Compliance |
| National Environmental Policy Act of 1969, As Amended | 42 U.S.C. 4321 et seq. | Full Compliance |
| National Historic Preservation Act of 1966, As Amended | 16 U.S.C. 470 | Full Compliance |
| National Historic Preservation Act Amendments of 1980 | 16 U.S.C. 469a | Full Compliance |
| Native American Graves Protection and Repatriation Act | 25 U.S.C. 3001 | Full Compliance |
| Noise Control Act of 1972, As Amended | 42 U.S.C. 4901 et seq. | Full Compliance |
| Outer Continental Shelf Lands Act 1953, as Amended | 43 U.S.C. 1331-1356 | Full Compliance |
| River and Harbor Act of 1899, Sections 9, 10, 13 | 33 U.S.C. 401-413 | Full Compliance |
| River and Harbor and Flood Control Act of 1970, Sections 122, 209 and 216 | 33 U.S.C. 426 et seq. | Full Compliance |
| Submerged Lands Act of 1953 | 43 U.S.C. 1301 et seq. | Full Compliance |
| Protection and Enhancement of Environmental Quality | 11514/11991 | Full Compliance |
| Protection and Enhancement of the Cultural Environment | 11593 | Full Compliance |
| Floodplain Management | 11988 | Full Compliance |
| Protection of Wetlands | 11990 | Full Compliance |
| Federal Compliance with Pollution Control Standards | 12088 | Full Compliance |
| Federal Compliance with Right-To-Know Laws and Pollution Prevention | 12856 | Full Compliance |
| Federal Actions to Address Environmental Justice and Minority and Low-Income Populations | 12898 | Full Compliance |
| Protection Of Children from Environmental Health Risks and Safety Risks | 13045 | Full Compliance |
| Coral Reef Protection | 13089 | Full Compliance |
| Invasive Species | 13112 | Full Compliance |
| Marine Protected Areas | 13158 | Full Compliance |
| Consultation and Coordination with Indian Tribal Governments | 13175 | Not Applicable |
| Responsibilities of Federal Agencies to Protect Migratory Birds | 13186 | Full Compliance |
| Executive Order Facilitation of Cooperative Conservation | 13352 | Full Compliance |

Table 9.1. The relationship of the proposed action to Federal laws and policies.

# 10. SUMMARY OF AGENCY AND PUBLIC INVOLVEMENT*

## 10.01 Scoping

A Notice of Intent (NOI) to prepare a Draft Environmental Impact Statement (DEIS) was published in the Federal Register on February 8, 2002. The NOI indicated that the DEIS is scheduled for distribution to the public in the spring of 2003. A new NOI was prepared and published in the Federal Register on March 23, 2012.

A scoping letter describing the proposed Bogue Banks Study and requesting public and agency participation was circulated in December 2003. Agency and public responses were received from: the US Department of Interior – US Fish and Wildlife Service, US National Oceanic and Atmospheric Administration, US Natural Resources Conservation Service, State of North Carolina (Division of Marine Fisheries, Division of Water Resources, Division of Environmental Health, Division of Coastal Management, Department of Cultural Resources, and Wildlife Resources Commission), North Carolina Coastal Federation, Bogue Banks Environmental Stewardship Corporation, Virginia Council on Indians, and residents of Emerald Isle. Another scoping letter was circulated in February 28, 2012. No further comments were received.

## 10.02 Cooperating Agencies

Pursuant to Section 1501.6 of the CEQ NEPA Regulations, eligible Federal, State, and local agencies, along with stakeholders interested in or affected by the Federal agency decision on this project have been requested to participate as a cooperating agency. The Bureau of Ocean Energy Management (BOEM) is the only Agency which has agreed to participate as a cooperating agency during the preparation of the Integrated Feasibility Report and Environmental Impact Statement. BOEM has assisted and will continue to assist in developing information and preparing environmental analyses in areas which the BOEM has special expertise. This assistance enhances the interdisciplinary capability of the study team.

Public Law 103-426 enacted 31 October 1994 gave BOEM the authority to convey, on a noncompetitive basis, the rights to Outer Continental Shelf (OCS) sand, gravel, or shell resources for shore protection; beach or wetlands restoration projects; or for use in construction projects funded in whole or part or authorized by the federal government. In implementing this authority, BOEM may issue a negotiated non-competitive lease agreement for the use of OCS sand to a qualifying entity. BOEM and the USACE are cooperating agencies having jurisdiction over different project facets and locations. OCS resources (beyond three miles) fall under BOEM's jurisdiction, as found in the OCS Land Act.

## 10.03 Fish and Wildlife Coordination

A Final Coordination Act Report (FCAR) was provided by the USFWS dated March 10, 2014, and is included as Appendix K to this report. USACE has considered these recommendations and factored them into the study when appropriate, as indicated in the responses below.

1. The beach fill template should concentrate on areas more than approximately one mile from Bogue and Beaufort Inlets. As stated in the Draft FWCA report (USFWS 2002), the preliminary findings of the North Carolina Coastal Resources Commission Science Panel on Coastal Hazards are that NC Inlets tend to influence oceanfront erosion and accretion for a mile or more on either side of the inlet. Beach fill placed in these areas is likely to be lost more quickly than in other areas and to alter the tidal currents and shoals in the adjacent inlet. While additional shoaling in some inlets may be beneficial to avian and fishery resources using the inlet, the subsequent increase in maintenance dredging and disposal may harm those resources more frequently and persistently.

*USACE Response. The proposed beach fill template is more than one mile from Beaufort Inlet. The project tapers off approximately ¼ mile from Bogue Inlet. The project is within a mile from Bogue Inlet in order to provide protection to the structures there which is a critical component of the project purpose.*

2. Direct impacts to fishery and avian resources can be avoided if no sediment dredging occurs within the natural habitats within Bogue Sound and Bogue Inlet. The integrity of the Bogue Inlet complex for migratory birds and larval fishery resources would be preserved if Bogue Inlet and natural areas within Bogue Sound are not used as a sediment source.

*USACE Response. No sediment dredging will occur within the natural habitats within Bogue Sound and Bogue Inlet.*

3. USACE should attempt to coordinate multiple dredging and sand disposal activities in the Bogue Banks area in order to avoid and minimize impacts to the extent practicable. The draft FWCA report recommended, for example, that dredged material disposal already occurring on the oceanfront beaches of Atlantic Beach should be modified to conform to the preferred design template instead of construction and maintenance of two separate projects in this area. The Service continues to recommend that USACE coordinate the beneficial placement of beach fill from maintenance dredging of the Morehead City Harbor navigation project with this project, in order to minimize the amount of new dredging needed, and also to minimize the cumulative impacts from nourishing the same stretch of beach more often than every 3 to 5 years. According to Page 7 of the DEIS, since 2004, approximately 3.2 million cubic yards (cy) of maintenance material dredged from Morehead City Harbor has been placed in various locations in Bogue Banks as part of the Section 933 project. Additionally, a Dredged Material Management Plan (DMMP) that is currently being developed for the area anticipates regular placement of material on Atlantic Beach in the future.

*USACE Response. This project is specifically designed for coastal storm damage reduction. Surveys will be performed prior to working to identify areas that lack coastal storm protection. Areas with no need will not be filled.*

4. Sediment dredged for placement on the beach should be compatible with the native sediments of Bogue Banks.

*USACE Response. Material placed on the beach will be compatible to native material, based on USACE compatibility criteria.*

5. Beach segments adjacent to each other should not be constructed consecutively, allowing for the quicker recovery of beach fauna because adjacent, undisturbed areas would be available for recruitment to the new fill. The 24-mile long Bogue Banks oceanfront shoreline could be divided into four sections that are constructed on a rotating schedule with adjacent sections constructed non-consecutively.

*USACE Response. Since the entire 24 miles is estimated to be able to be constructed in one season, "dividing" the project was not considered as that would increase project costs and decrease project benefits.*

6. The maintenance construction, or renourishment interval, should be greater than three years. We note that although USACE determined that a 3-year renourishment cycle provided the greatest net economic benefits, the Draft EIS states (on page 75) that "it is highly unlikely that the full project length would actually require renourishment every three years." The Service recognizes that a 3-year beach nourishment cycle may be needed for some portions of the project area. However, studies have shown that intertidal macrofauna can take one or two years to recolonize a nourished area. This is a concern of the Service, because as soon as the macrofauna are recovered (by the end of the second season), the proposed nourishment schedule would provide for beach disposal the very next season. The Service is concerned with the long-term impacts from frequent beach nourishment. The schedule of nourishing every three years or so results in a healthy macrofauna population for as little as one year out of every three. This, in turn, has a negative impact on shorebirds and surf fishes.

*USACE Response. Areas that do not need renourishment, will not receive sand every nourishment cycle, but much of the project beaches will need to be renourished every three years. Therefore, the recommended renourishment cycle is every 3 years. Also, Renourishment intervals that occurred more frequently than every 3years were not considered in order to allow adequate environmental recovery time of benthic resources. Because the material being used is compatible with the native beach we believe that recovery would occur within 3 years on the beach. Because of the striping pattern of hopper dredge operations, recruitment of benthic invertebrates from nearby unimpacted areas in the borrow area would occur allowing for quick recovery.*

7. This number was unintentionally left out of the FCAR and therefore no comment was provided.

*USACE Response. None*

8.  The ODMDS and nearshore disposal sites should be targeted for dredging before undisturbed marine areas, provided that the material is free of toxicants and is ecologically compatible with the native sediments of Bogue Banks' beaches.

*USACE Response. The ODMDS (borrow area Q2) is being used where economically practicable (based on dredge distance traveled). Other offshore borrow areas will also be utilized. Impacts to all proposed borrow sites are fully discussed in the EIS. All material placed on the beach whether from Q2 or not will be compatible to native material, based on USACE compatibility criteria.  Beach quality sand is generally free of toxins due to the geotechnical properties of those sediments.*

9.  The potential mitigative measures listed on pages 111 through 113 should be considered by USACE and/or by the local sponsors, particularly those that may lead to improved foraging or nesting habitat for shorebirds and sea turtles. These types of measures have been requested over the years for various projects, but several of the research or study type measures have never been implemented. The measures include:

a.  restoration of dredged material islands within or adjacent to the inlet complex.

b.  monitoring to determine if benthic intertidal invertebrates can be successfully collected ahead of the dredge pipeline and placed on new fill material after the material has been graded. This study would be fit nicely with the work being funded by Emerald Isle and North Topsail Beach and conducted by Carteret Community College on the potential to spawn *Donax* in an aquaculture lab and recolonize beaches with *Donax* spat.

c.  Determining if the introduction of higher carbonate content within fill material significantly delays recovery of the beach by invertebrates, birds, and fish as compared to beach fill without an increase in carbonate content.

d.  Determining the rate of bleaching of darker fill sediments on North Carolina beaches, and how deep the bleaching occurs within the substrate.

e.  Determining if nutrient cycling within the beach sediments is significant to filter feeding benthos, and if so, how a beach fill project may alter the nutrient cycle.

f.  Investigating the water depth and burial depth at which Donax and Emerita overwinter in offshore waters.

g.  Determining if the foraging efficiency of shorebirds is affected following a beach project, and if so, for how long.

*USACE Response. a. USACE will coordinate with USFWS to determine which islands they are most interested in and will determine USACE' or other Agencies capabilities and permits required to restore those islands.  b-g.  These are research related tasks that are not within the capabilities of the Wilmington District.  However, USACE' Engineering Research and Development Center (ERDC) located in Vicksburg Mississippi conducts numerous research efforts.  We will forward your suggestions to ERDC.*

## 10.04 Coordination of this Document

The USACE received 69 public and agency comments on the Draft EIS. All comments received are included in Appendix L and USACE responses to the comments are provided in Appendix M. Final EIS will be filed with the EPA and will also be posted to the Wilmington District's website.

## 10.05 Recipients of this Document

**Federal Agencies**

U.S. Environmental Protection Agency
Advisory Council on Historic Preservation
U.S. Department of Interior- Office of Environmental Policy and Compliance
National Marine Fisheries, Southeast Regional Office
National Marine Fisheries Service, Habitat Conservation Division
U.S. Fish and Wildlife Service – Raleigh Field Office
Federal Highway Administration
U.S. Department of Energy – Office of Environmental Policy & Compliance
US Department Of Agriculture - National Resources Conservation Service
Commander, Fifth Coast Guard District

**State Agencies**

North Carolina Department of Environment and Natural Resources
North Carolina Division of Water Resources
North Carolina Division of Parks and Recreation
North Carolina Wildlife Resources Commission
North Carolina Division of Archives and History
North Carolina Department of Cultural Resources
North Carolina Department of Transportation – Environmental Planning
North Carolina Department of Administration/State Clearinghouse
North Carolina Commission of Indian Affairs
South Carolina Indian Affairs Commission

**Local Governments**

Carteret County Board of Commissioners
Mayor, Town of Atlantic Beach
Mayor, Town of Emerald Isle
Mayor, Town of Pine Knoll Shores
Mayor, Town of Indian Beach
Town Manager, Atlantic Beach
Town Manager, Emerald Isle
Town Manager, Pine Knoll Shores
Town Manager, Indian Beach

**Elected Officials**
North Carolina United States Senators and Local District Congressmen
Local State Senators and Representatives

**Media**
Carteret County News-Times

**Conservation Groups/Recreation Groups**
The Nature Conservancy, NC Chapter
National Audubon Society
National Wildlife Federation
The Wilderness Society
Environmental Defense Fund of North Carolina
Conservation Trust for North Carolina
North Carolina Land Trust
North Carolina Coastal Federation
North Carolina Aquarium at Pine Knoll Shores
Fort Macon State Park

**Libraries**
N.C. Collection, Wilson Library, UNC-Chapel Hill
N.C. Dept. of Environment, Health, and Natural Resources Library
Randall Library, UNC-Wilmington
State Library of North Carolina
Joyner Library, East Carolina University
Carteret County Public Library

# 11. CONCLUSIONS

The coastal storm damage reduction problems and needs of the study area have been reviewed and evaluated with regard to the Federal and non-Federal interests and with consideration of engineering, economic, environmental, social, and cultural concerns. The conclusions of the study are summarized as follows:

a) The Bogue Banks shoreline is susceptible to major damage from future erosion and coastal storms.

b) The Recommended Plan is the NED plan, which consists of an 119,670 ft (22.7 miles) long main beach fill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beach fill is bordered on either side by a 1,000 ft tapered transition zone berm. Sand for the beach fill would be delivered from three offshore borrow areas by dredge. The project would be eligible to be renourished every three years following initial construction, in order to build the project back up to the authorized dimensions.

c) The Recommended Plan is feasible on the basis of engineering and economic criteria, and is acceptable by environmental, cultural, and social laws and standards.

d) The Recommended Plan is supported by the non-Federal sponsor, Carteret County. The sponsor has the capability to provide the necessary non-Federal requirements identified and described in section 8.02 of this report.

# 12. DISTRICT ENGINEER'S RECOMMENDATIONS

This study addresses the needs for coastal storm damage reduction for Bogue Banks, which includes the towns of Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach. The following recommendations include items for implementation by the Federal government, State of North Carolina, and local governments and agencies, including the structural coastal storm damage reduction project. In order for risks to life and safety to be reduced, any structural project should be accompanied by additional measures meant to assure that residents have sufficient warning, knowledge, and resources to evacuate the area well ahead of hurricane arrival. Recommendations for these types of measures are listed below. While many of these recommendations may already be in place, due to their importance they are being reinforced as a component of this project.

## 12.01 Coastal Storm Risk Education

Numerous people have died as a result of hurricanes and other coastal storms, primarily because of the failure to evacuate to an area of safety. Any loss of life is tragic, and any number of those deaths might have been prevented. Even one death prevented is sufficient reason to improve our methods of educating the public on hurricane and storm threats and to ensure that all is done to warn all those residents or visitors to the coastline of North Carolina as to the dual hazards of wind and surge/waves. It is particularly vital to inform the public as to the potential for hurricane occurrence, particularly in the dangerous hurricane season, so they pay continued attention to media reports on weather. Education needs to include articulation of effects related to the potential magnitude of the threat, the urgency to heed potential calls to evacuate, and providing the means by which to make wise choices on evacuation methods and route (see recommendations given below under Hurricane Evacuation Planning). The following are suggested guidelines for implementation by State and local government, in the interests of good education on hurricane storm threats:

- Provide good science and information to the residents and visitors to coastal North Carolina, so they can understand the nature of the threat, and its possibility of happening at any time, especially within the hurricane season. This information should be provided in both written form and as an initial graphic on televisions provided in visitor's housing, and also in a variety of venues, including the following:
    - Posted and televised education in supermarkets, libraries, and public buildings
    - Teacher-provided, posted, and televised education in schools and at public meetings and gatherings, at intervals not to exceed 1 year
    - Publicly posted and visitor-housing-posted information on evacuation routes, and procedures, on publicly accessible Web sites, updated regularly (minimum 1 yr.)

It is not possible to maintain the lives and safety of coastal North Carolina residents and visitors if they do not have sufficient warning and if they then do not use that knowledge to evacuate in a timely manner.

Education regarding coastal storm risks is an ongoing effort of multiple agencies and educational institutions and not a funded program under existing USACE authorities.

Updating Web sites containing evacuation routes and procedures should be done under existing programs implemented by State and local governments.

## 12.02 Hurricane and Storm Warning

Residents and visitors to the coast of North Carolina need to recognize that they live in, or visit, a high-hazard area. Although certain times of the year pose less risk than others, each year's hurricane season provides a strong possibility of hurricane impact somewhere along the coast of North Carolina. All residents and visitors need to be made aware of the current hurricane threat. But first, meteorological conditions must be evaluated, and any threat must be assessed and characterized by experts at NOAA's National Weather Service. That interpretation must then be passed to national and local media for dissemination. Continued support of NOAA's program, and the following supportive activities are critical to an adequate warning process:

- Ongoing efforts to upgrade the existing system of NOAA buoys, transmission capabilities, and advanced warning measures that provide data on the location and nature of weather conditions.
- Efforts directed at the interpretation of that data and its dissemination to the media and public, through the National Weather Service.
- Public appreciation for the need to be aware at all times of, and the need to listen to weather reports and advice given on various media. Television weather reports, radio, and the Internet all provide excellent, up-to-date information on weather conditions, and the development of threatening situations. Simply living in or visiting the barrier islands of North Carolina should be sufficient to create a consistent and ongoing process of being exceptionally aware of the weather and its potential consequences.
- The vital importance of heeding the advice of experts. One should know what needs to be done when a storm is approaching. Family members should conduct evacuation drills, keep needed phone numbers and travel supplies on hand, and be prepared to leave on short notice. One should be aware of evacuation routes, keep a full tank of gas during the hurricane season and have a plan for where one should go, how to maintain contact with other family members, and where one will relocate temporarily, particularly if the event turns out to be longer than expected.

## 12.03 Storm Evacuation Planning Upgrading

The critical need for adequate evacuation planning was borne out by Hurricanes Bertha, Fran, and Floyd, of the late 1990s, and brought even more to the forefront by the monumental impacts of Hurricane Katrina in 2005. An evacuation plan is an essential component of a comprehensive plan for ensuring the safety of residents of, and visitors, to the coast of North Carolina. The preservation of life is the single most important goal and objective of the recommendations. Joint FEMA/NOAA/USACE/North Carolina studies of evacuation routes and populations along the coastline has provided a tremendous amount of value to-date in aiding local government, individual, and family readiness in the face of approaching events. Support for that program is a critical element of the recommendations for the towns located on Bogue Banks in support of its residents and visitors.

The following are some recommendations in support of efforts to support Hurricane Evacuation Planning:

- Much can still be done to update this ongoing effort and to provide new and more widely disseminated data and tools for evacuation planning by the State and the towns, and also for use by individuals and families in their preparation for an impending event.
- Evacuation route signage is an important part of a successful evacuation campaign. Maintenance of hurricane evacuation route signage is viewed as a vital link in ensuring the safety of residents and visitors alike.
- The provision of additional signage illustrating surge height achieved during past events would be an added and continual link to ongoing education efforts. That could take the form of signs placed in locations in which there is significant traffic, such as major thoroughfares, where pedestrians walk, and particularly in those highest hazard zones according to elevation/depth data.

Evacuation Planning is an ongoing effort of multiple agencies, including the USACE, but its implementation is not a funded program under existing USACE authorities. Updating Web sites containing evacuation routes and procedures should be periodically updated under existing programs implemented by North Carolina.

## 12.04 Structural Damage Reduction Features and Items of Local Cooperation

On the basis of the conclusions of this study, I recommend the implementation of the Recommended Plan, identified as Alternative 9, which consists of a 22.7 mile long, 50-ft wide beach berm, with an elevation of 5.5 ft or 7 ft (NAVD 88) depending on location. Along portions of the 22.7 miles, the Recommended Plan also includes 5.9 miles of a dune system to be integrated into the existing dune constructed to an elevation of 15 ft to 20 ft, (NAVD 88) depending on location. Such modifications thereof as in the discretion of the Commander, USACE, may be advisable, at an initial first construction cost estimated at $37,327,000. The baseline cost estimate for construction in FY 2019 is $40,245,420.

As a result of the Feasibility study and EIS, I recommend that the project be authorized and implemented in accordance with the findings of this report.

Federal implementation of the Recommended Plan would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and as further specified below:

(1) Enter into an agreement which provides, prior to construction, 35 percent of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of design costs;

(3) Provide all lands, easements, and rights-of-ways, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

(4) Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;

b. Continue to maintain public access every ½ mile and adequate parking within the project limits in accordance with USACE requirements for participation in cost-sharing with the Federal Government for the project as follows:

(1) For so long as the project remains authorized, the non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

(2) Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

(3) At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

c. Shall not use funds from other Federal sources, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

d. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

e. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

f. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

g. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

h. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

i. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

j. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government. Completion of the OMRR&R by the federal government will not relieve the non-Federal Sponsors of responsibility to meet the non-Federal Sponsor's obligations or to preclude the federal government from pursuing any other remedy at law or in equity to ensure faithful performance;

k. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

l. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

m. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

n. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

o. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

p. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

q. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

r. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element;

s. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project.

t. Perform or provide for the performance, at no cost to the Government, of all operation, maintenance, repair, rehabilitation and replacement of existing dune features that are located throughout the project area but not part of the Recommended Plan or included as costs of the Federal project, in a manner allowing the proper functioning of the Federal project and consistent with the non-Federal interest's sole responsibility for implementation of other non-structural measures outside the Federal project, such as coastal storm risk education, hurricane and storm warning, and storm evacuation planning upgrading.

u. Take all necessary action to ensure that beaches protected by this project shall remain open and accessible to the public in accordance with Corps policy and in accordance with the terms of the Corps' standard Perpetual Beach Storm Damage Reduction Easement. Failure to maintain protected beaches as public shall result in an adjustment to future renourishment cost share to 100% non-Federal Sponsor cost at public beaches;

v. Protect and maintain the dune system from degradation, foot and vehicle traffic, development, and erosion by man-made or natural forces. Maintenance shall include both project construction areas and landward protective dunes and vegetated areas in accordance with ER 1110-2-2902, whether those protective features were constructed as part of the initial project or whether naturally existing at the time of design and construction;

(1) Rebuild and vegetate eroded or degraded dunes and vegetated areas landward of the construction limits after other than extraordinary storms, and after normal storm erosion, to assure project function and to prevent the expansion of private beach (or with Corps concurrence, provide Perpetual Beach Storm Damage Reduction Easements over such areas); and

(2) Conduct operation and maintenance (O&M) obligations through both direct activities as set forth in the O&M manual and ER 1110-2-2902, and through the enforcement of laws, ordinances, regulations, and federal policies which discourage unwise development, encroachments, and potential increased storm damages within the flood plain, protect the integrity of the foreshore vegetated high ground for proper project function, and preserve habitat. Such protection and maintenance may include the issuance and enforcement of zoning or other ordinances, or the purchase of perpetual easements in areas landward of the project construction limits; and

(3) Provide at least annually (as part of the biannual surveillance) a technical survey establishing berm and dune elevations in order to evaluate renourishment and maintenance requirements, and to establish pre-storm conditions in the event of an extraordinary storm request under PL 84-99.

The non-Federal Sponsor will submit financial plans and statements of financial capability and will request a letter from the State of North Carolina, which declares the state's financial capability and financing plan, to document their capability of providing the necessary funds to support the non-Federal share of the project first costs and periodic renourishment costs.

This recommendation is subject to the cost-sharing policies as outlined in this report and is endorsed, provided that, before construction, the non-Federal Sponsors enter into a written Project Partnership Agreement (PPA), as required by P.L. 91-611 section 221, as amended.

## 12.05 Recommended Plan Summary

The total first cost of the project, at Oct 2014 price levels, is $37,327,000. The Federal share of the total first project cost is estimated at $24,263,000. The non-Federal share of the total first project cost is estimated at $13,064,000. The estimated total nourishment cost, which includes the project first cost as well as the constant dollar cost at the current price level for all future periodic renourishment is $229,456,000. As previously indicated, the total project benefit-cost ratio is 2.45 to 1, meaning for every dollar spent on the project, approximately 2 dollars and 45 cents are realized in NED benefits.

Table 12.1 presents all applicable economic results at the FY2014 price level for the Recommended Plan at the interest rate of 3.5%. The Recommended Plan's benefit to cost ratio at 3.5% interest is 2.45 to 1.

| **Interest Rate** | **3.50%** |
|---|---|
| CSDR Benefit | $11,688,082 |
| CSDR BC-Ratio | 1.93 |
| Recreation Benefit | $3,148,607 |
| Combined Benefit | $14,836,689 |
| Combined BC-Ratio | 2.45 |
| CSDR Only Net Benefit | $5,623,082 |
| Combined Net Benefit | $8,771,688 |
| **Total Annual Cost** | **$6,065,000** |

Table 12.1. Applicable economic results at the FY2014 price level for the Recommended Plan at the interest rate of 3.5%.

The Recommended Plan contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the Recommended Plan may be modified before it is transmitted to Congress as a proposal for implementation funding. Prior to transmittal to Congress, the sponsor, State of North Carolina, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

COL, EN

STEVEN A. BAKER
Colonel, EN
Commanding

# 13. POINT OF CONTACT*

Any comments or questions regarding this Feasibility Report and EIS should be addressed to Bogue Banks Project Manager, U.S. Army Corps of Engineers, 69 Darlington Avenue, Wilmington, NC 28403.

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