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.

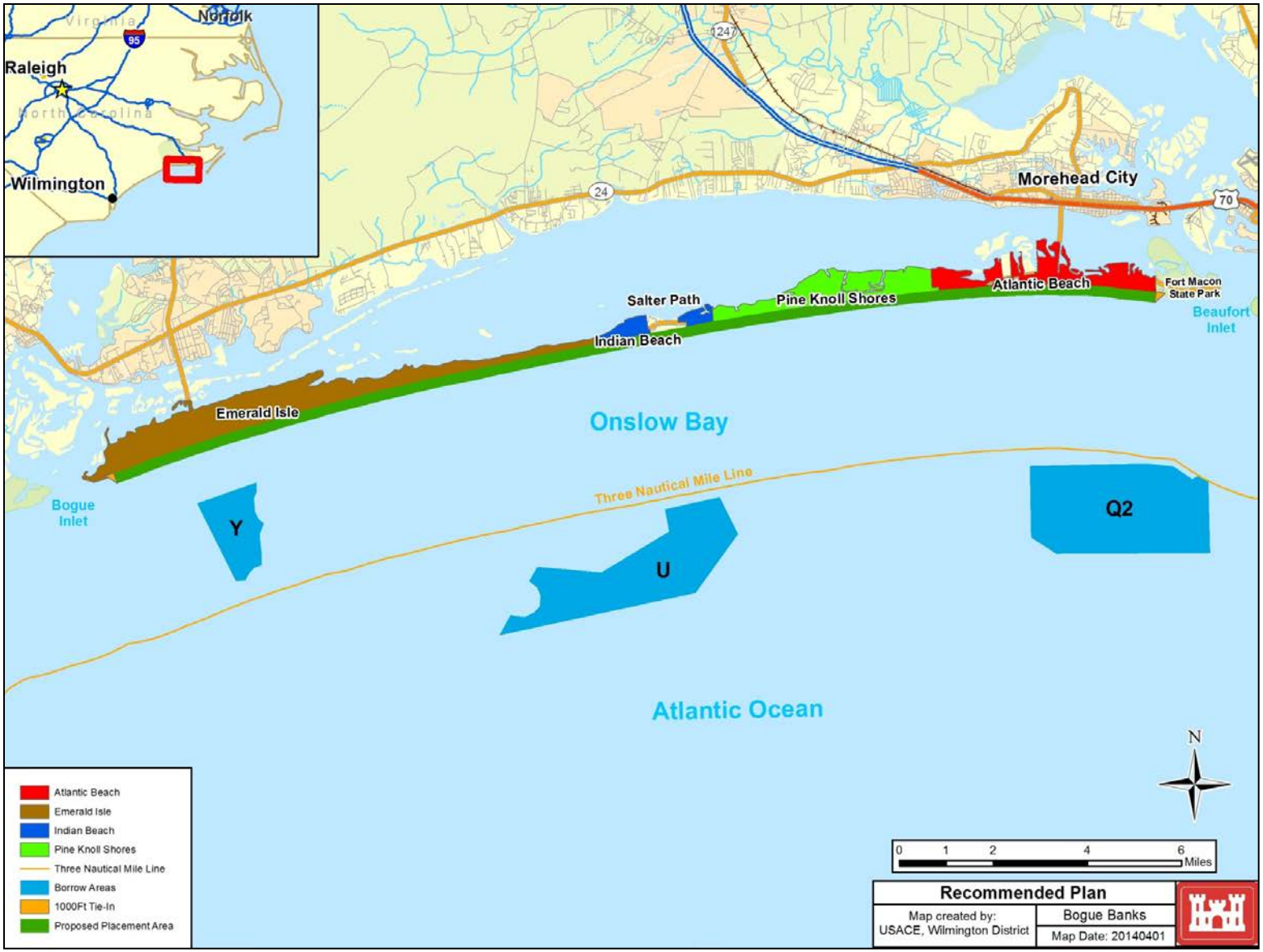
Table ES-1

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).



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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

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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.

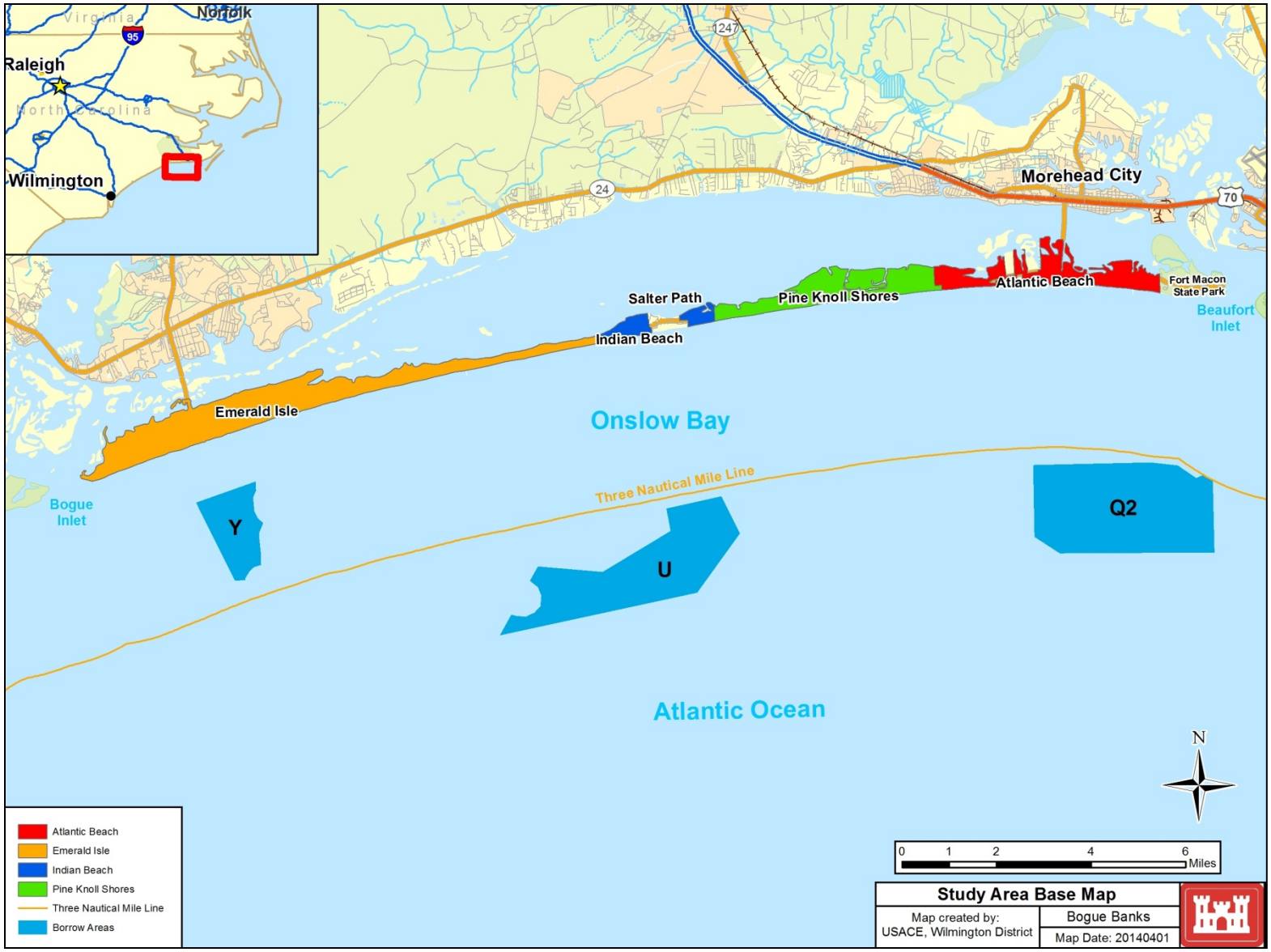


Figure 1.1. Bogue Banks Study Area Base Map, including potential offshore borrow locations (Y, U, and Q2).

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.

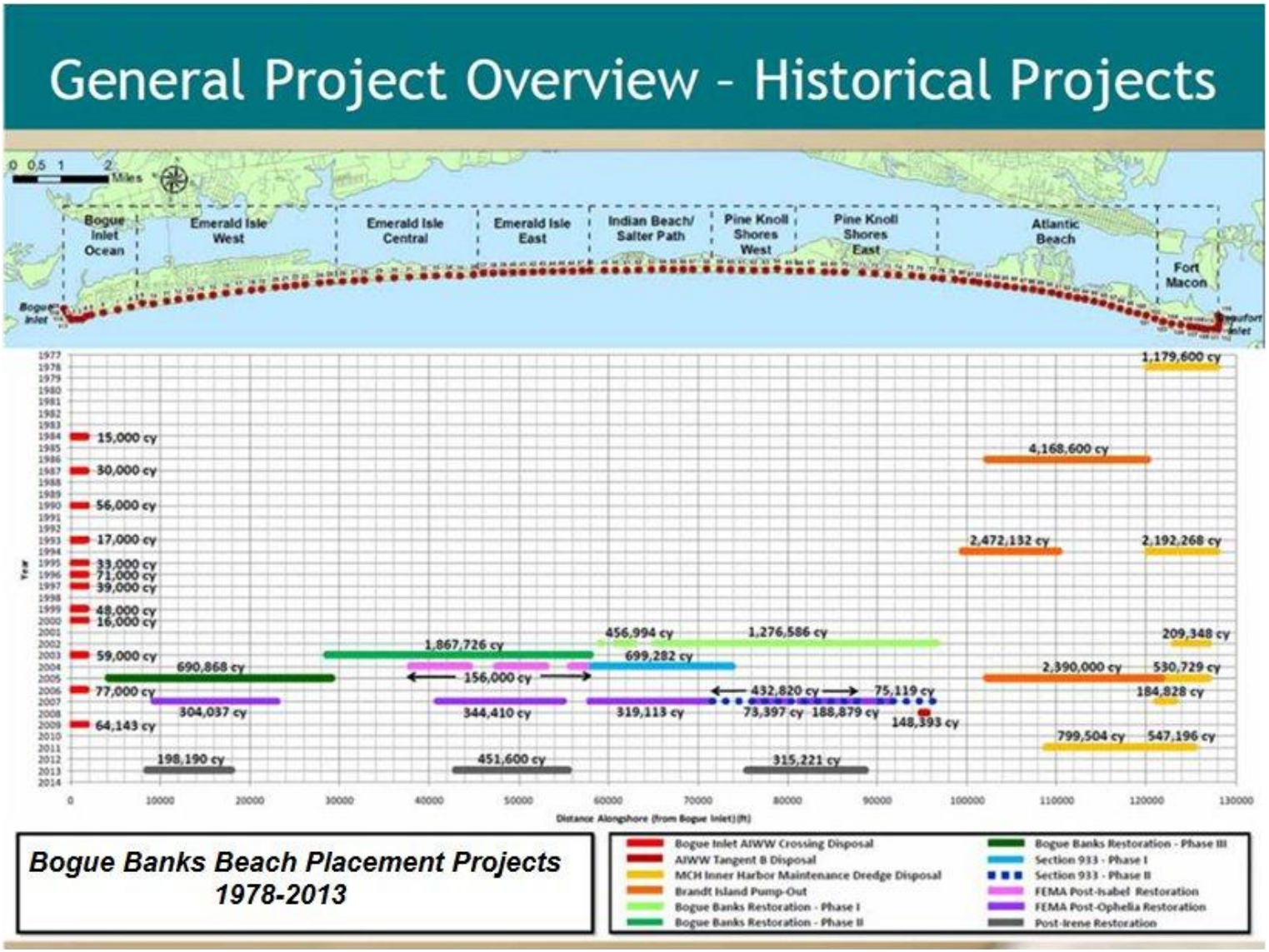


Figure 1.2. Historical placement of material on Bogue Banks Shoreline, 1978-2013.

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.

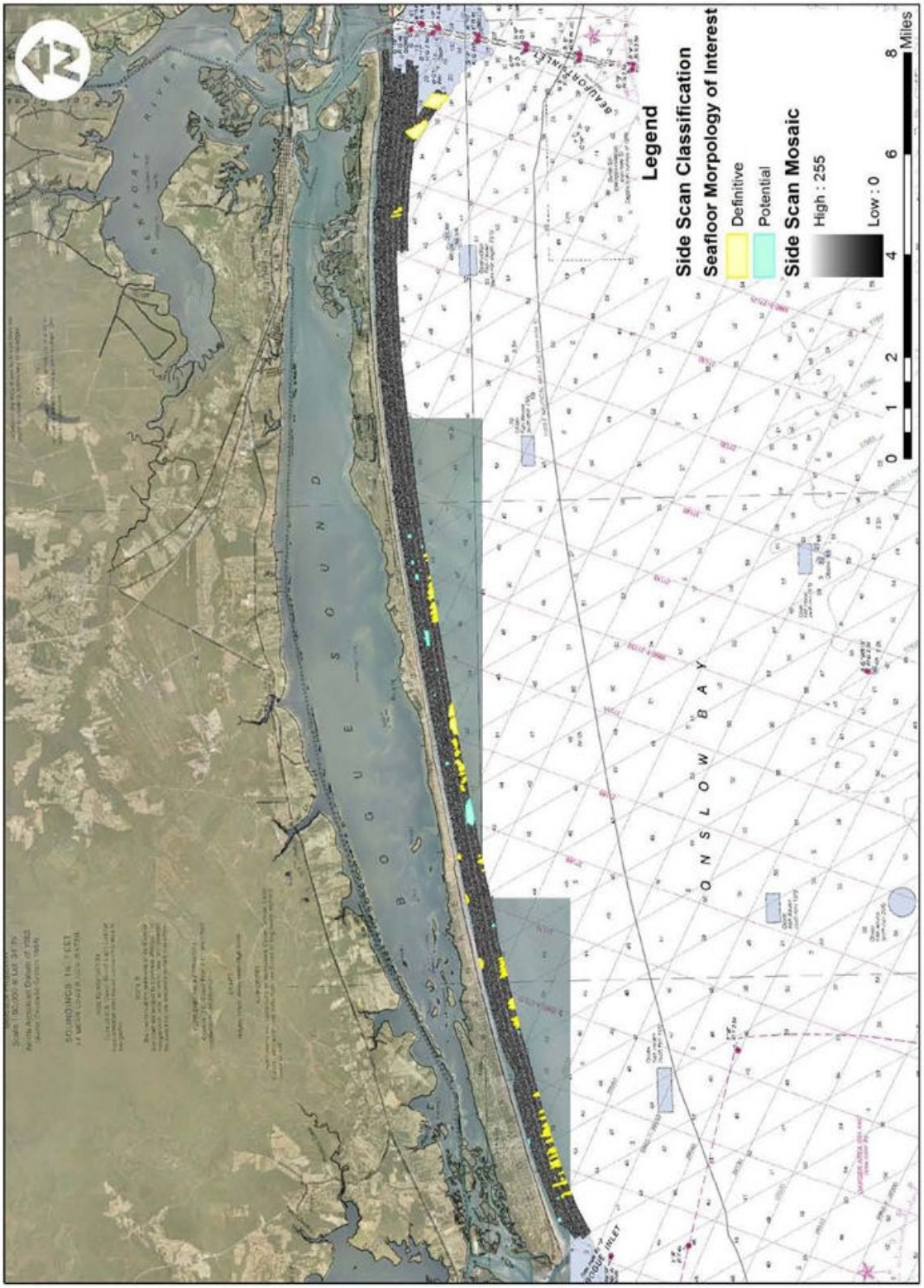


Figure 2.1 Mapping of potential hardbottom areas in the nearshore zone.

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	Hermatypic (reef-forming) Coral Habitat & Reefs
Mangroves	Hard Bottoms
Submerged Aquatic Vegetation (SAV)	
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 L-LARVAL J-JUVENILE A-ADULT 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 L-LARVAL J-JUVENILE A-ADULT 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 L-LARVAL J-JUVENILE A-ADULT 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.

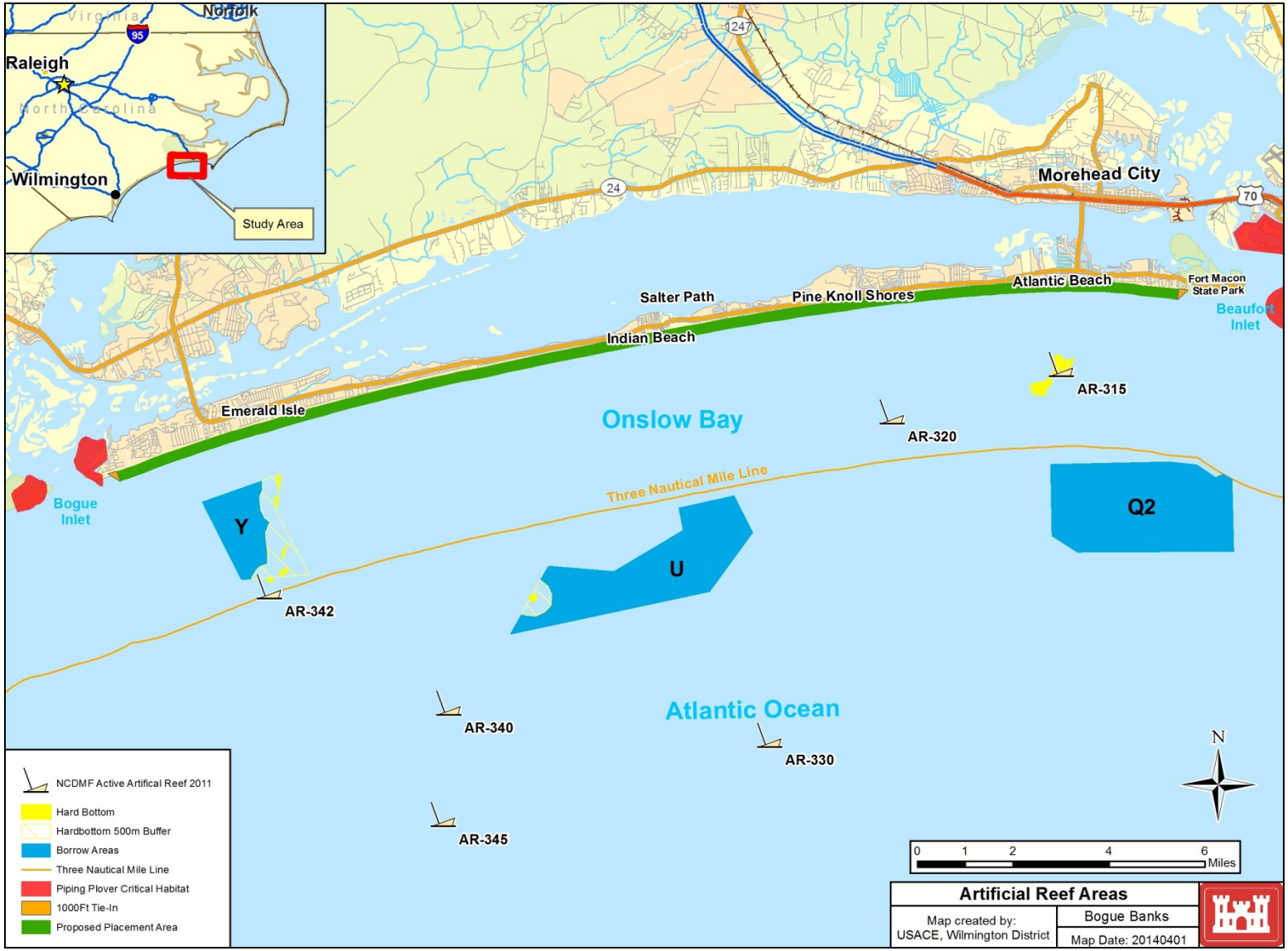


Figure 2.2. Location of artificial reefs in project vicinity.

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.

Some locations have been slightly enlarged for display purposes only.

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.

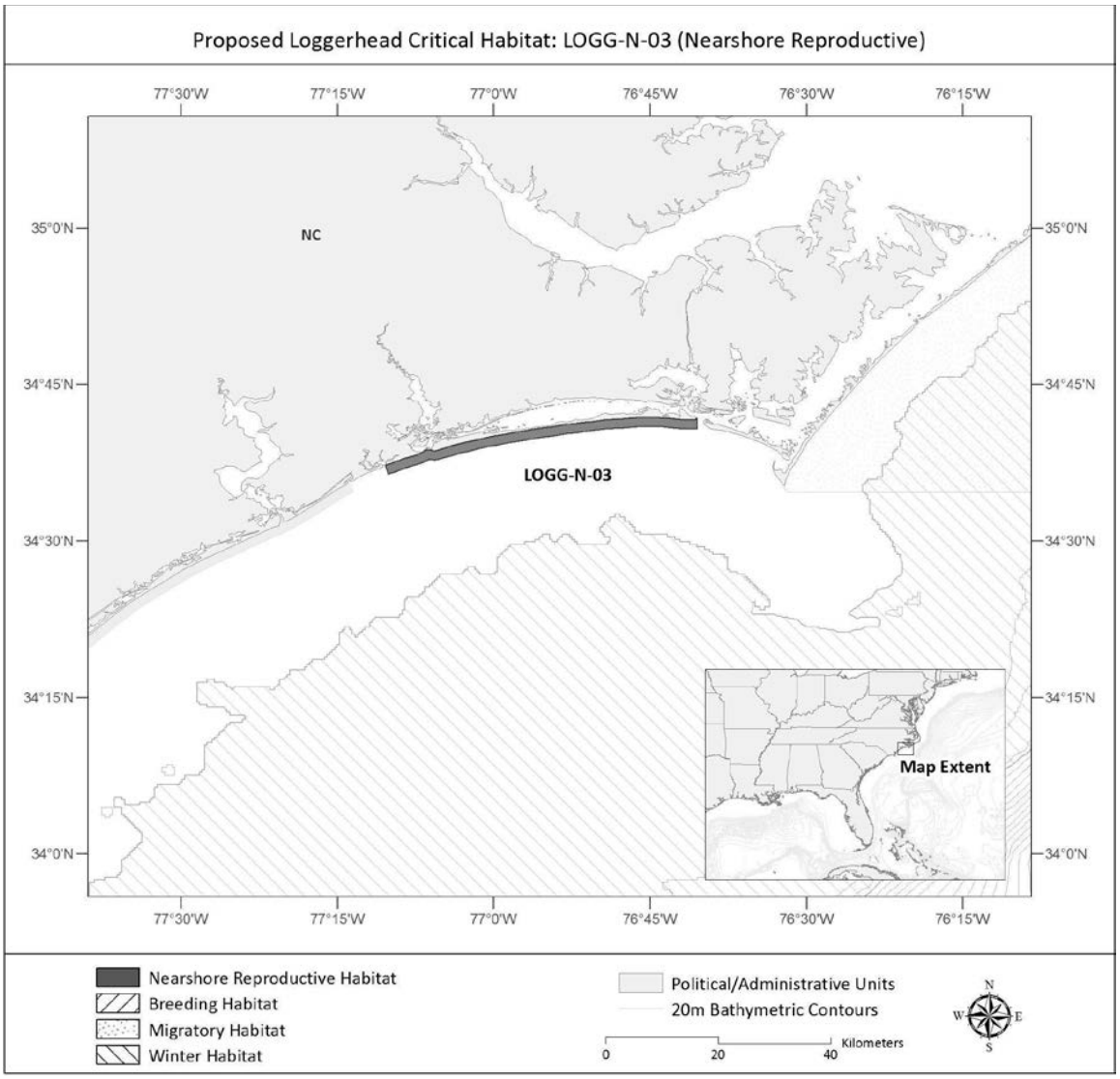


Figure 2.4 Proposed Loggerhead Critical Habitat

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.

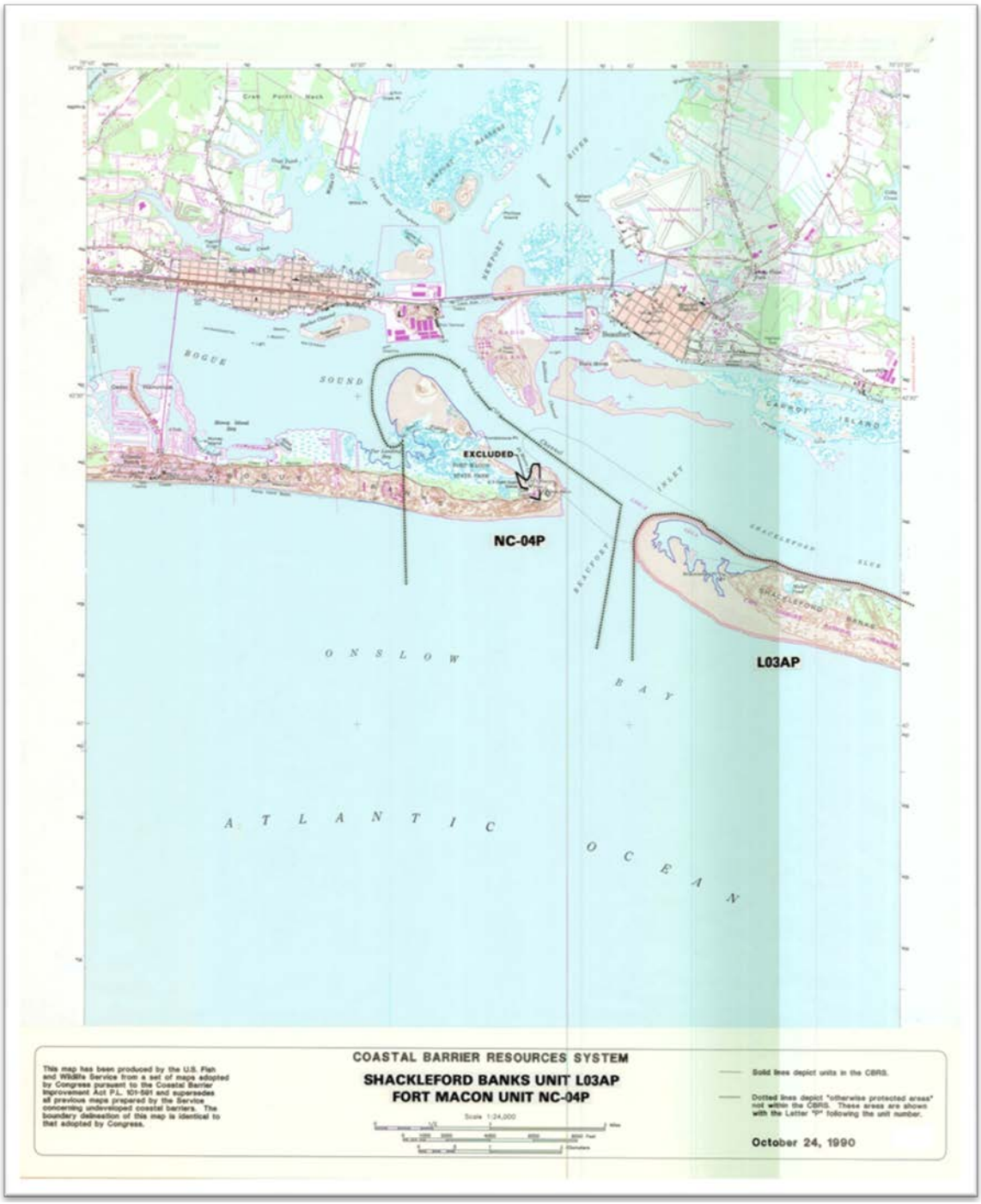


Figure 2.5. Location of CBRA unit NC-04P.

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.

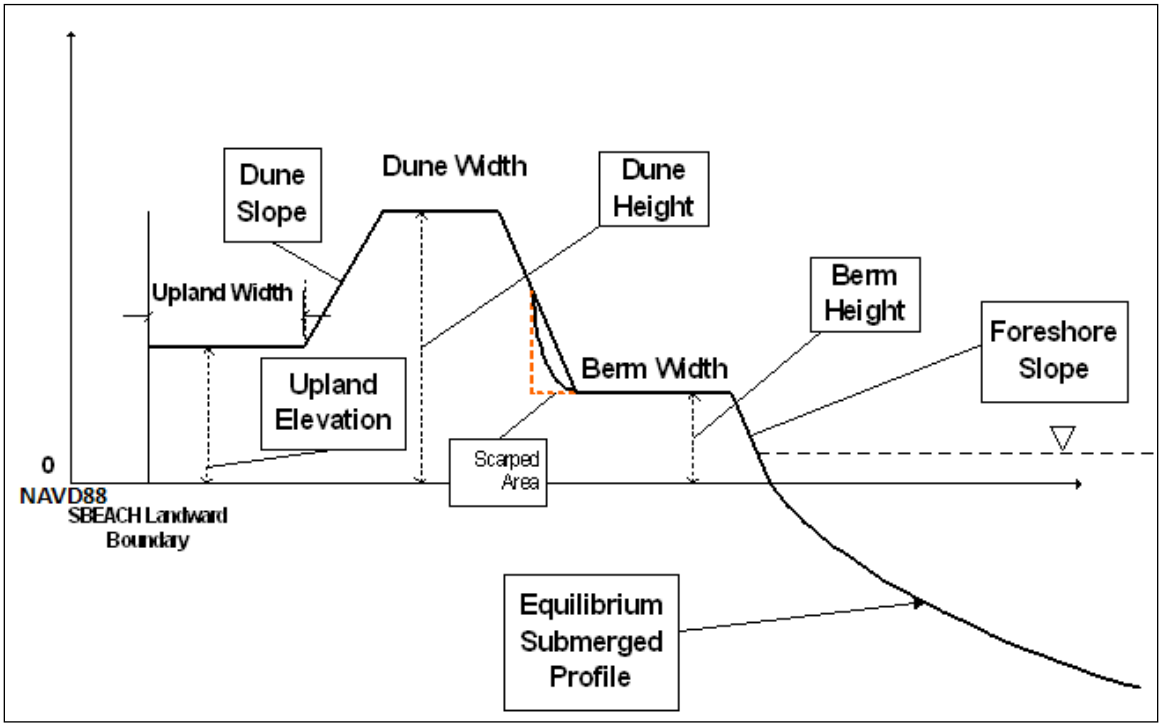


Figure 4.1. Features of an idealized shore profile cross-section.

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.

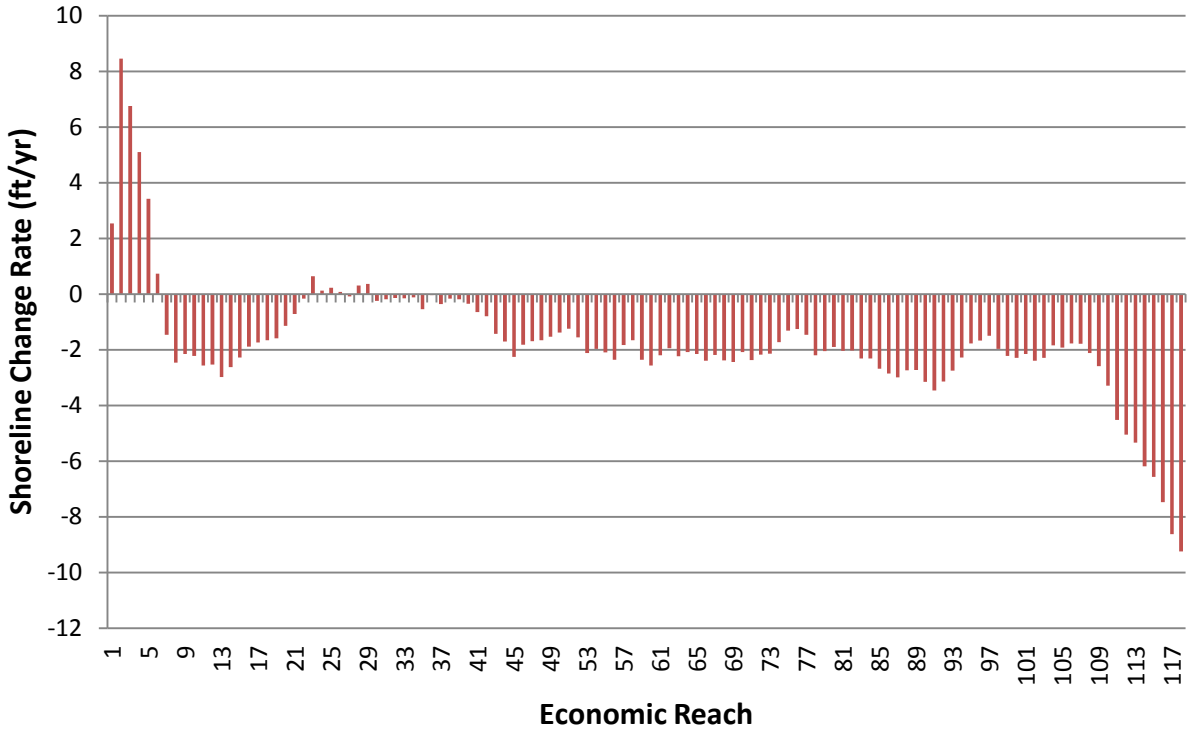


Figure 4.3. Average annual shoreline rates of change at each of the 118 economic reaches in the study area. A positive number indicates accretion, a negative number indicates erosion.

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)

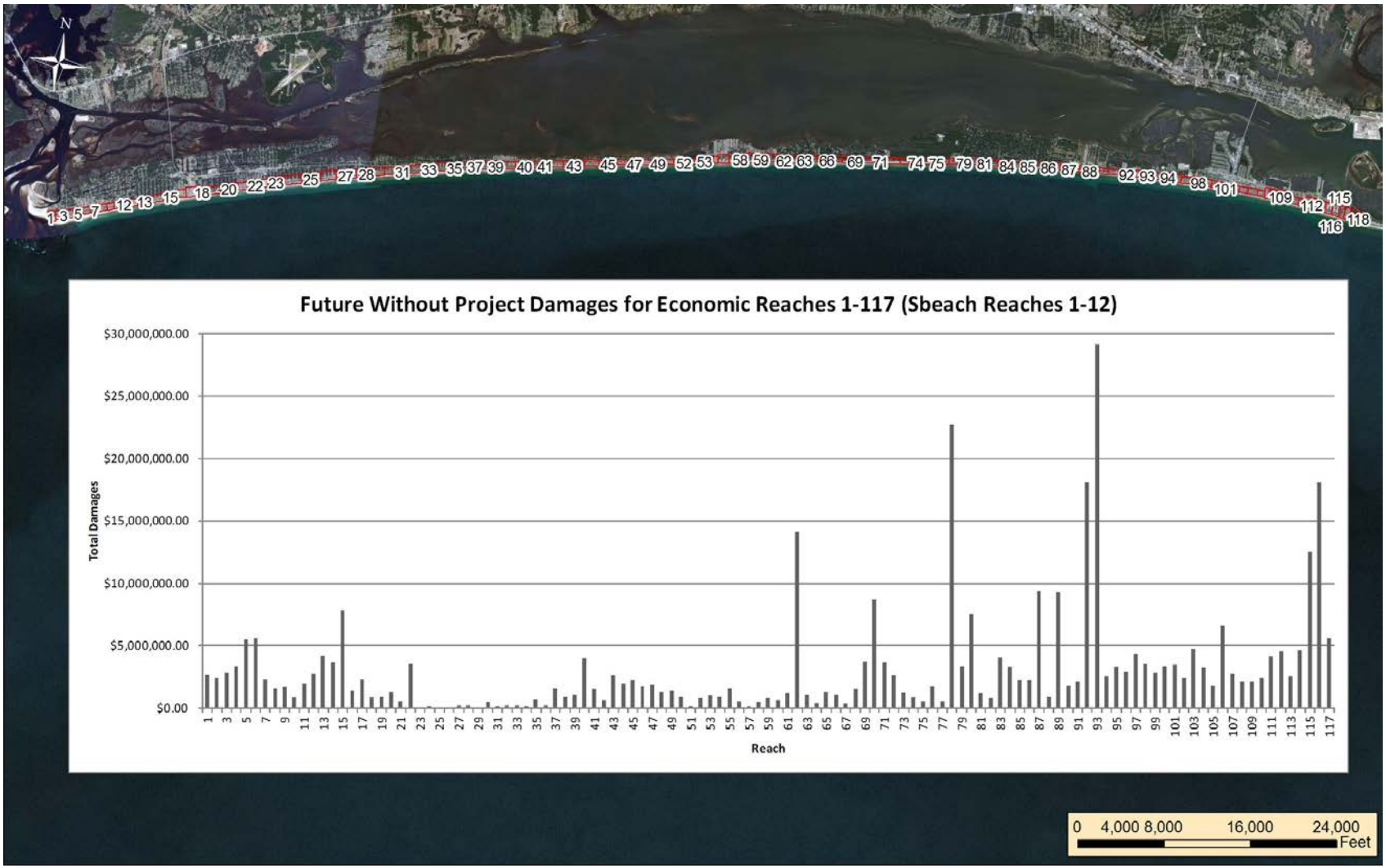


Figure 4.4. Total future without project damages (contents plus structures plus land loss) over 50 years by economic reach. Reach 1 is at the western end of the study area near Bogue Inlet and reach 118 is at the eastern end near Beaufort Inlet.

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 9th, "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)
1	$91,813	$42,934	$11,908	$122,839
2	$86,464	$30,638	$8,401	$108,701
3	$100,207	$50,453	$13,851	$136,809
4	$118,703	$39,651	$10,916	$147,438
5	$183,140	$67,147	$18,498	$231,789
6	$194,276	$54,137	$18,182	$230,231
7	$83,912	$60,399	$38,073	$106,237
8	$60,692	$50,051	$40,257	$70,487
9	$63,339	$49,161	$36,492	$76,007
10	$33,691	$30,950	$23,372	$41,269
11	$62,729	$40,225	$14,910	$88,044
12	$93,616	$65,765	$23,917	$135,464
13	$106,212	$76,842	$34,783	$148,271
14	$100,422	$65,629	$24,973	$141,078
15	$176,199	$84,412	$26,836	$233,774
16	$35,610	$35,358	$14,572	$56,395
17	$79,132	$50,938	$18,883	$111,187
18	$37,010	$58,163	$20,073	$75,101
19	$37,600	$56,167	$18,380	$75,387
20	$55,160	$84,702	$17,082	$122,780
21	$20,764	$12,705	$1,189	$32,280
22	$6,205	$13,811	$807	$19,209
23	$0	$0*	$671	($671)
24	$2,196	$14,247	$370	$16,073
25	$471	$17,622	$601	$17,492**
26	$530	$13,830	$351	$14,009
27	$2,432	$17,999	$1,157	$19,274
28	$1,213	$15,836	$642	$16,407
29	$478	$9,183	$390	$9,270
30	$15,577	$10,467	$3,884	$22,160
31	$7,188	$11,964	$3,816	$15,335
32	$10,433	$10,697	$3,950	$17,180
33	$9,618	$14,260	$4,278	$19,600
34	$5,848	$8,228	$3,017	$11,060
35	$28,155	$14,404	$6,700	$35,860
36	$5,846	$9,077	$2,716	$12,207
37	$15,319	$13,536	$5,262	$23,593
38	$14,580	$14,301	$4,519	$24,363
39	$20,291	$10,179	$3,386	$27,085
40	$117,555	$16,351	$6,203	$127,703
41	$20,814	$15,835	$5,849	$30,800
42	$19,179	$10,466	$5,536	$24,109
43	$79,577	$18,910	$46,300	$52,187
44	$61,648	$12,770	$38,781	$35,636
45	$98,045	$15,817	$64,646	$49,217
46	$61,964	$10,527	$34,024	$38,467
47	$55,570	$10,635	$31,580	$34,626
48	$44,442	$10,536	$30,642	$24,336
49	$45,484	$10,582	$27,881	$28,185
50	$27,827	$8,171	$19,186	$16,811
51	$9,083	$4,977	$10,172	$3,888**
52	$35,706	$15,132	$41,302	$9,536**
53	$50,068	$15,305	$55,050	$10,002**
54	$41,063	$4,097	$13,351	$31,809
55	$73,156	$9,704	$34,475	$48,385
56	$25,754	$8,356	$35,164	($1,053)
57	$8,899	$3,724	$11,203	$1,420**
58	$23,526	$10,852	$28,179	$6,199**
59	$38,874	$12,433	$34,806	$16,501

Reach	Total Benefits(AA) - Storm Damage Reduction Only	AA Recreation Benefits*	Total Cost (AA)	Total Net Benefits (AA)
60	$26,424	$7,086	$22,580	$10,930
61	$31,561	$8,773	$22,072	$18,262
62	$441,437	$10,014	$20,985	$430,466
63	$47,423	$13,754	$35,798	$25,380
64	$11,973	$4,140	$9,672	$6,442
65	$21,791	$1,808	$4,461	$19,138
66	$49,686	$14,409	$41,846	$22,250
67	$16,431	$5,242	$13,243	$8,430
68	$19,621	$5,526	$15,884	$9,262
69	$65,598	$13,335	$41,603	$37,329
70	$180,912	$10,708	$26,192	$165,427
71	$63,846	$11,373	$34,050	$41,169
72	$53,578	$11,388	$29,950	$35,016
73	$27,779	$7,842	$20,021	$15,600
74	$40,795	$12,395	$33,151	$20,040
75	$19,700	$9,611	$16,791	$12,520
76	$63,453	$3,851	$6,219	$61,085
77	$22,570	$9,864	$20,596	$11,838
78	$743,560	$8,375	$30,615	$721,320
79	$131,853	$9,988	$33,592	$108,249
80	$76,018	$6,163	$18,526	$63,654
81	$48,527	$9,988	$32,900	$25,616
82	$34,146	$8,841	$28,963	$14,023
83	$175,466	$14,092	$53,801	$135,757
84	$140,956	$13,749	$52,477	$102,228
85	$100,806	$14,061	$62,221	$52,646
86	$77,559	$13,613	$71,040	$20,132
87	$280,848	$17,271	$95,043	$203,076
88	$42,944	$9,935	$49,304	$3,575**
89	$227,147	$7,945	$37,376	$197,715
90	$81,587	$8,132	$45,337	$44,383
91	$82,521	$8,726	$54,305	$36,942
92	$269,274	$15,839	$87,901	$197,212
93	$1,102,082	$92,898	$72,959	$1,122,021
94	$91,095	$85,137	$55,560	$120,672
95	$108,336	$71,309	$37,487	$142,158
96	$93,600	$63,971	$31,881	$125,690
97	$129,465	$79,427	$36,389	$172,503
98	$112,838	$87,526	$50,436	$149,927
99	$100,416	$47,653	$30,454	$117,615
100	$121,390	$60,294	$39,076	$142,608
101	$131,636	$80,614	$50,005	$162,245
102	$83,403	$54,236	$36,390	$101,250
103	$160,850	$62,699	$40,608	$182,941
104	$116,709	$65,541	$35,181	$147,069
105	$65,305	$53,756	$29,963	$89,098
106	$254,736	$29,311	$15,163	$268,884
107	$108,172	$52,942	$27,664	$133,450
108	$72,544	$52,942	$32,242	$93,244
109	$79,193	$52,536	$38,112	$93,616
110	$88,402	$48,467	$42,493	$94,376
111	$73,347	$68,415	$45,049	$96,713
112	$88,947	$108,961	$78,752	$119,156
113	$66,276	$69,405	$53,121	$82,561
114	$142,422	$64,676	$56,506	$150,591
115	$414,591	$66,114	$61,187	$419,518
116	$679,570	$47,908	$50,326	$677,151
117	$140,906	$50,064	$60,787	$130,183

*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 Risk of demersal fish entrainment by dredging activities	Status quo maintained	Status quo maintained
	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 sustainability of dune habitat for nesting sea turtles and other dependent mammal and avian species	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
		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	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 sustainability of sea turtle nesting habitat due to preservation of the beach berm		
		Long term reduction of beach lighting impacts to sea turtles from constructed dune	Risk of increased beach lighting impacts to sea turtles as dune erodes	Risk of increased beach lighting impacts to sea turtles as dune erodes
		Risk of sea turtle entrainment from hopper dredge		
	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	
			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.

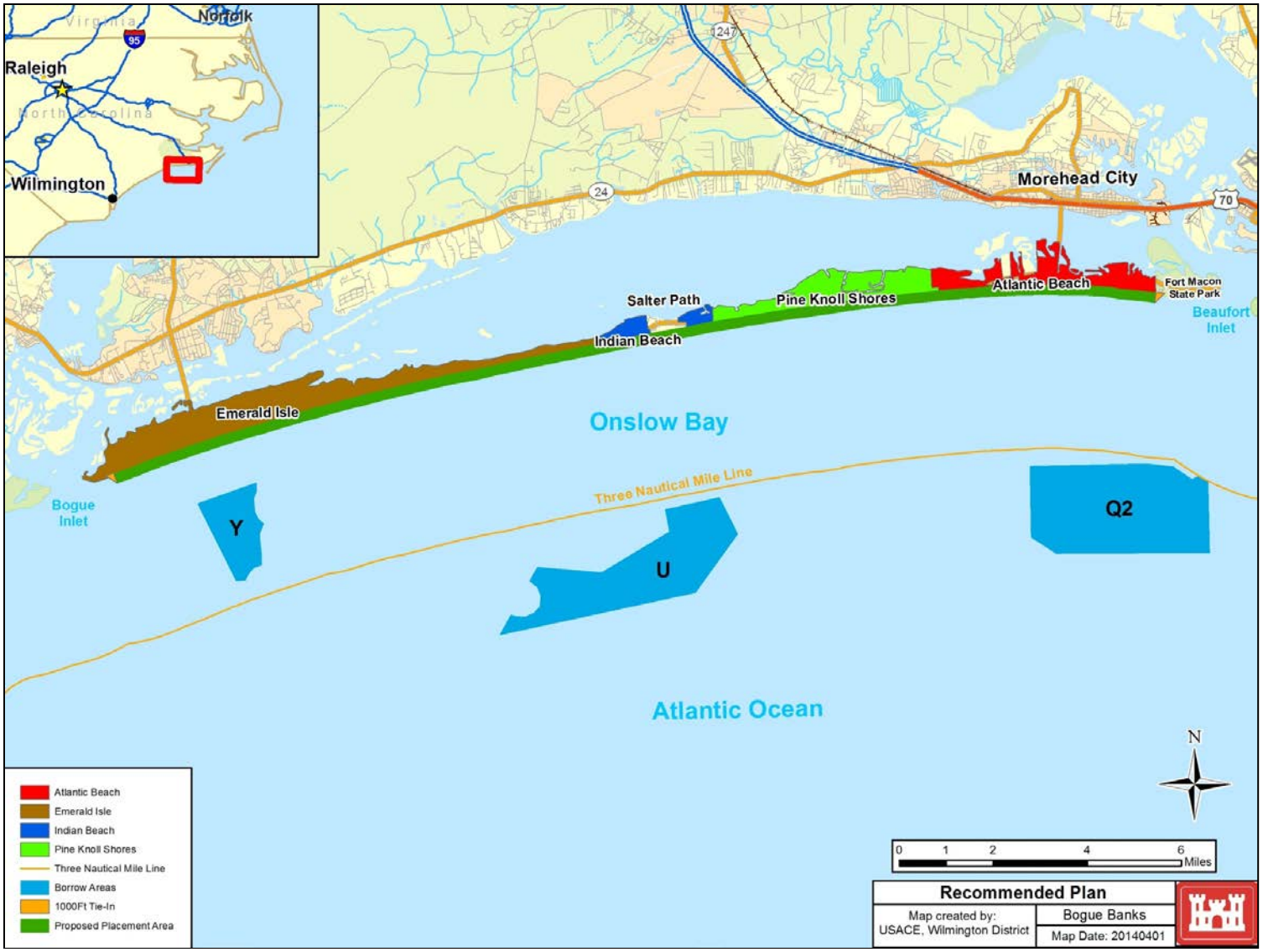


Figure 6.1 Recommended Plan

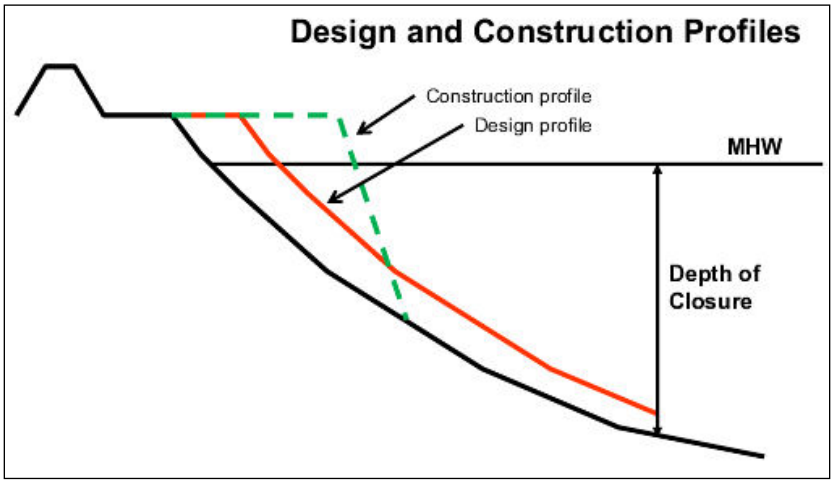


Figure 6.2. Representation of a berm construction vs. design profile.

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.

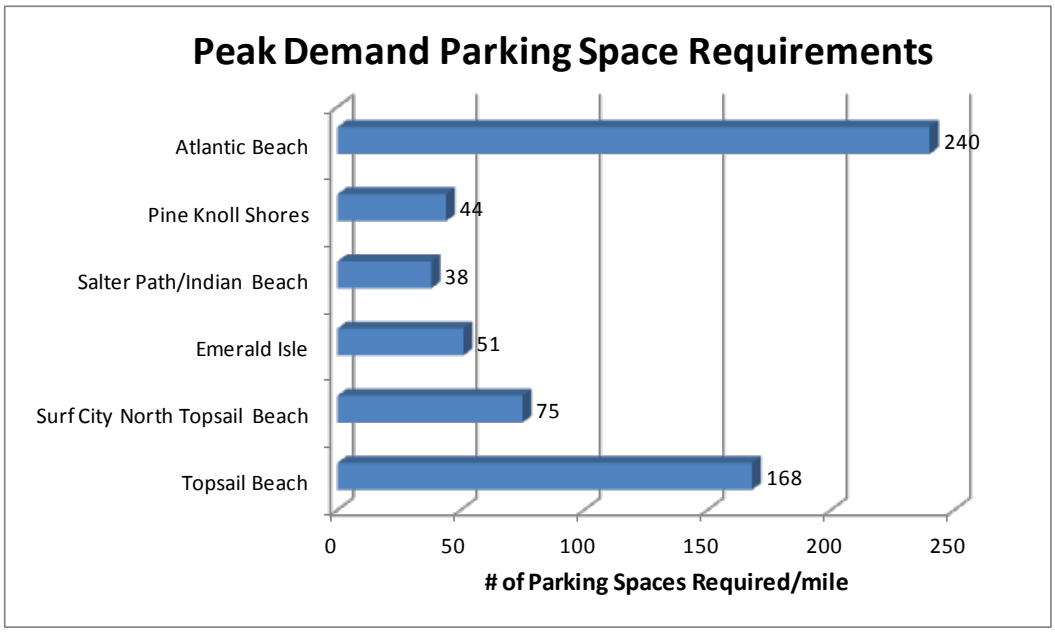


Figure 6.3. Projected peak parking demand parking space requirements per mile for towns within the Bogue Banks study area as well as two previously approved projects at Topsail Beach and Surf City, North Carolina.

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.

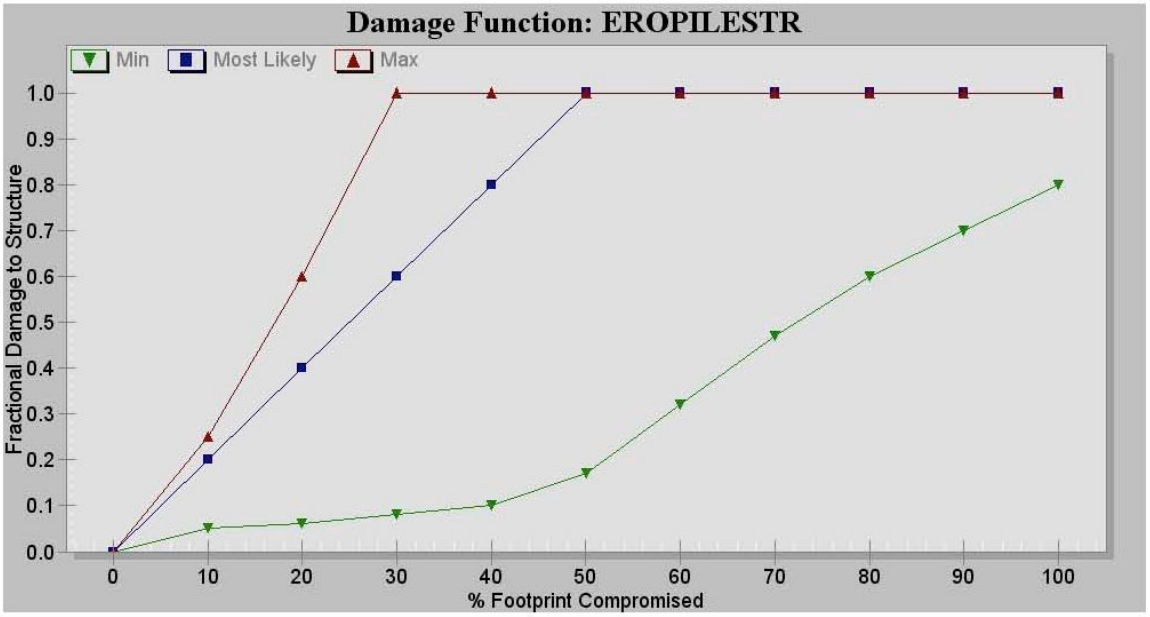


Figure 6.4. Damage functions used to measure erosion damage to structures on 8-ft pile.

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.

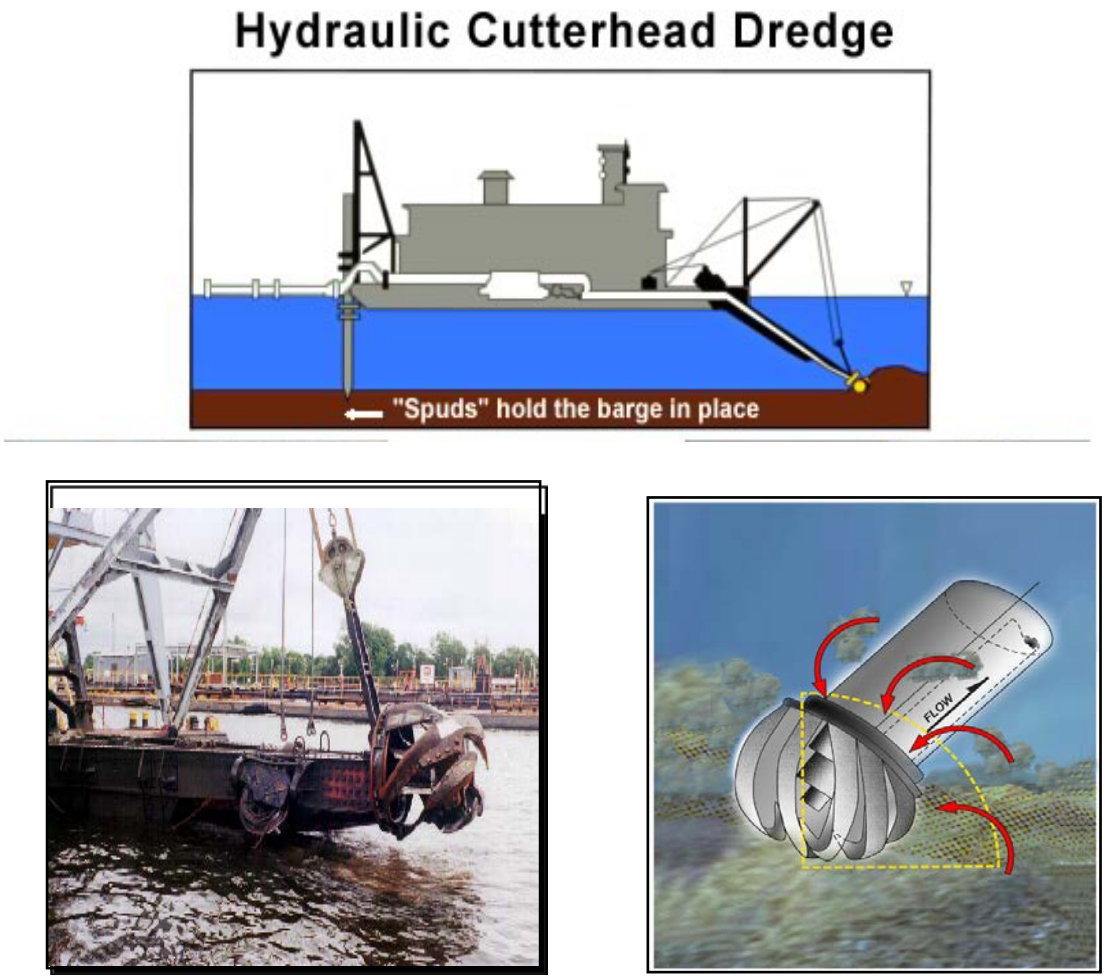


Figure 7.1. Cutterhead pipeline dredge schematic and representative close-up photographs.

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).

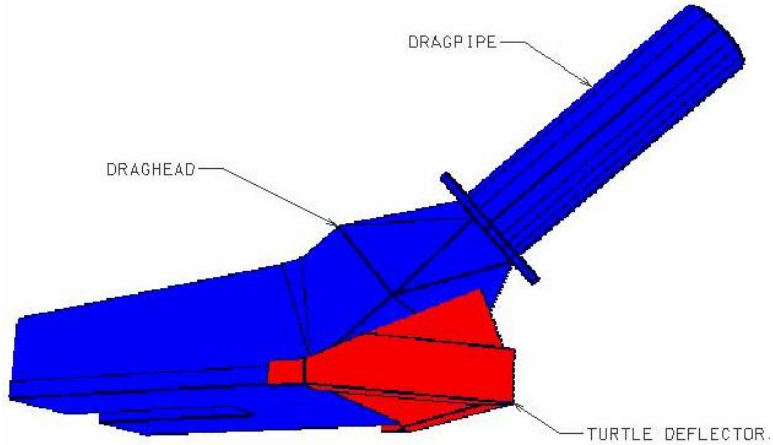


Figure 7.2. Hopper dredge and turtle deflecting draghead schematics.

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.

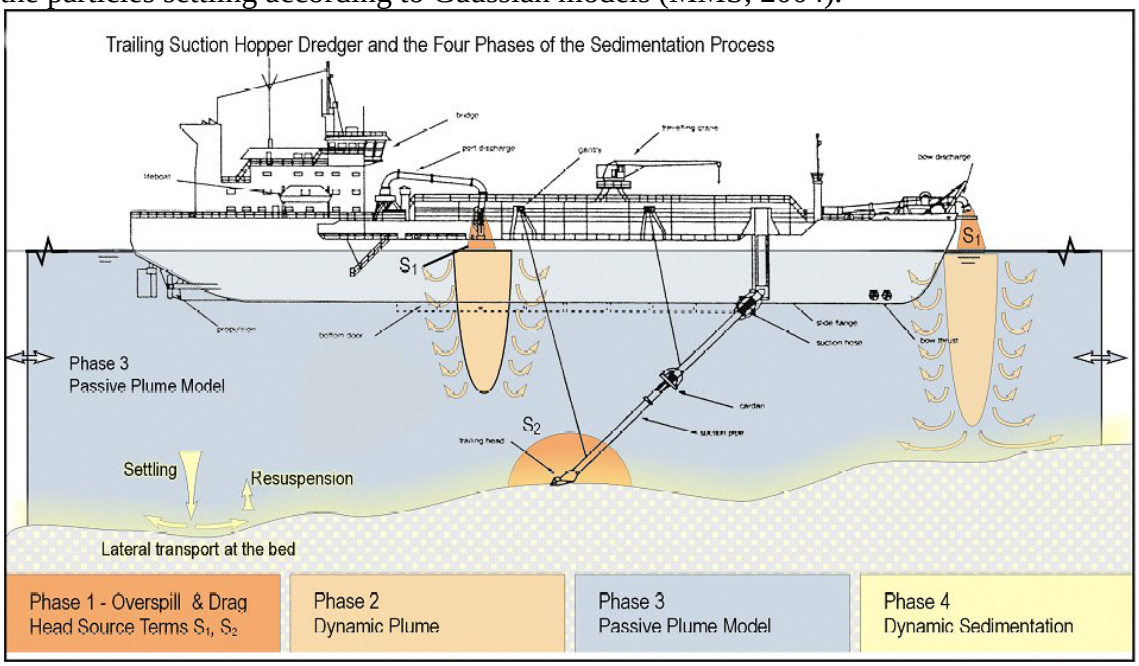
Past projects indicate that the extent of the sediment plume is generally limited to between 1,640 – 4,000 ft from the dredge and that elevated turbidity levels are generally short-lived, on the order of an hour or less (NASA 2013).

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 purpose	Project first cost	Apportionment %		Apportionment $	
		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 purpose	Project first cost	Apportionment %		Apportionment $	
		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					
Project purpose	Total Cost (16 renourishments)	Apportionment %		Apportionment $	
		Non-Federal	Federal	Non-Federal	Federal
Coastal storm damage reduction	$229,450,000	50%	50%	$114,725,000	$114,725,000
	Cost per year	Apportionment %		Apportionment $	
		Non-Federal	Federal	Non-Federal	Federal
Beach fill Monitoring (Annual)	$187,500	50%	50%	$93,750	$93,750
Annual OMRR&R costs					
	Cost per year	Apportionment %		Apportionment $	
		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:

<u>Coastal Wetlands</u>. 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:

North Carolina Mining Act. 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).

North Carolina Dredge and Fill Law (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.

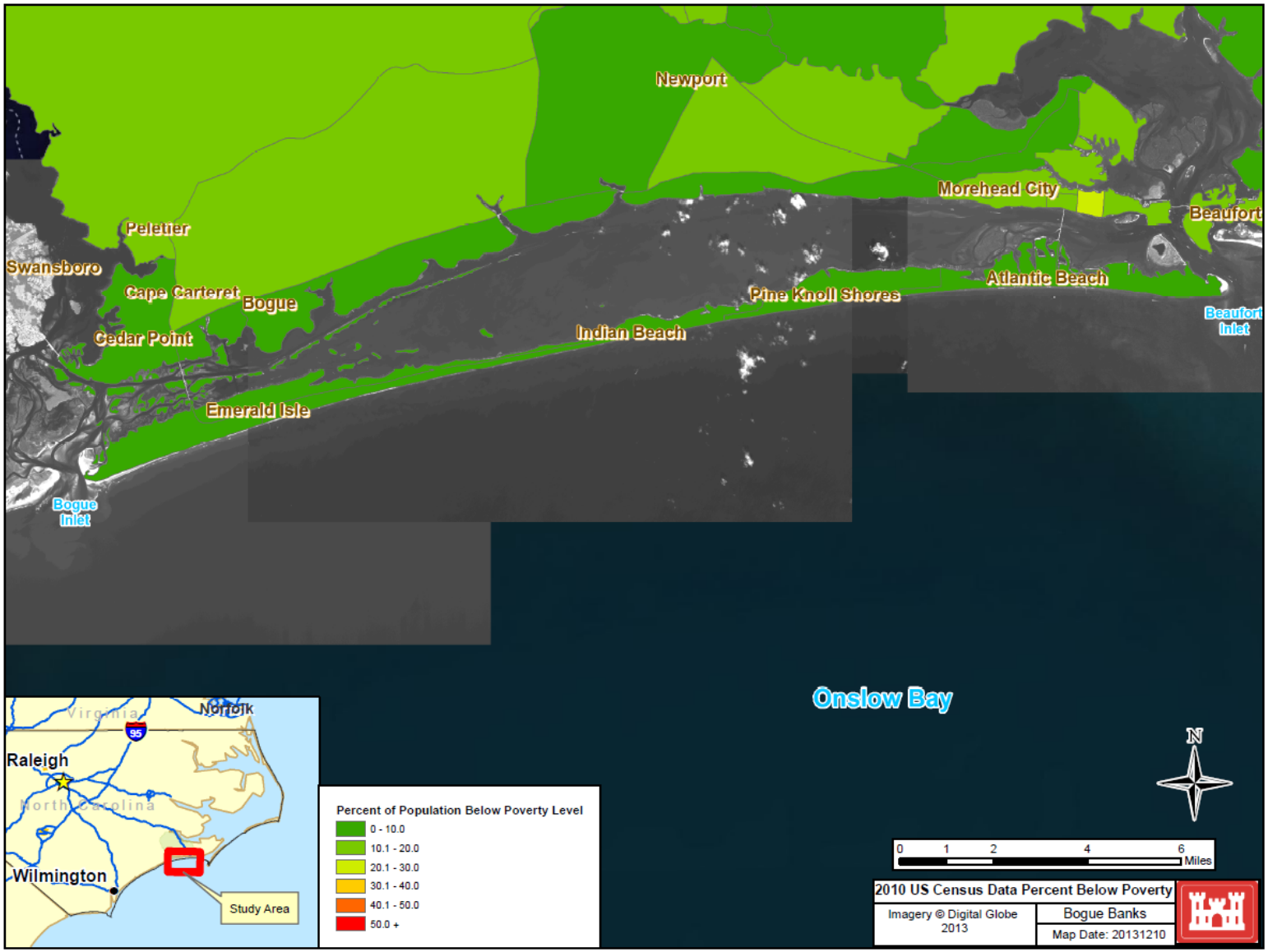


Figure 9.1 2010 Census Data Percent Below Poverty Line.

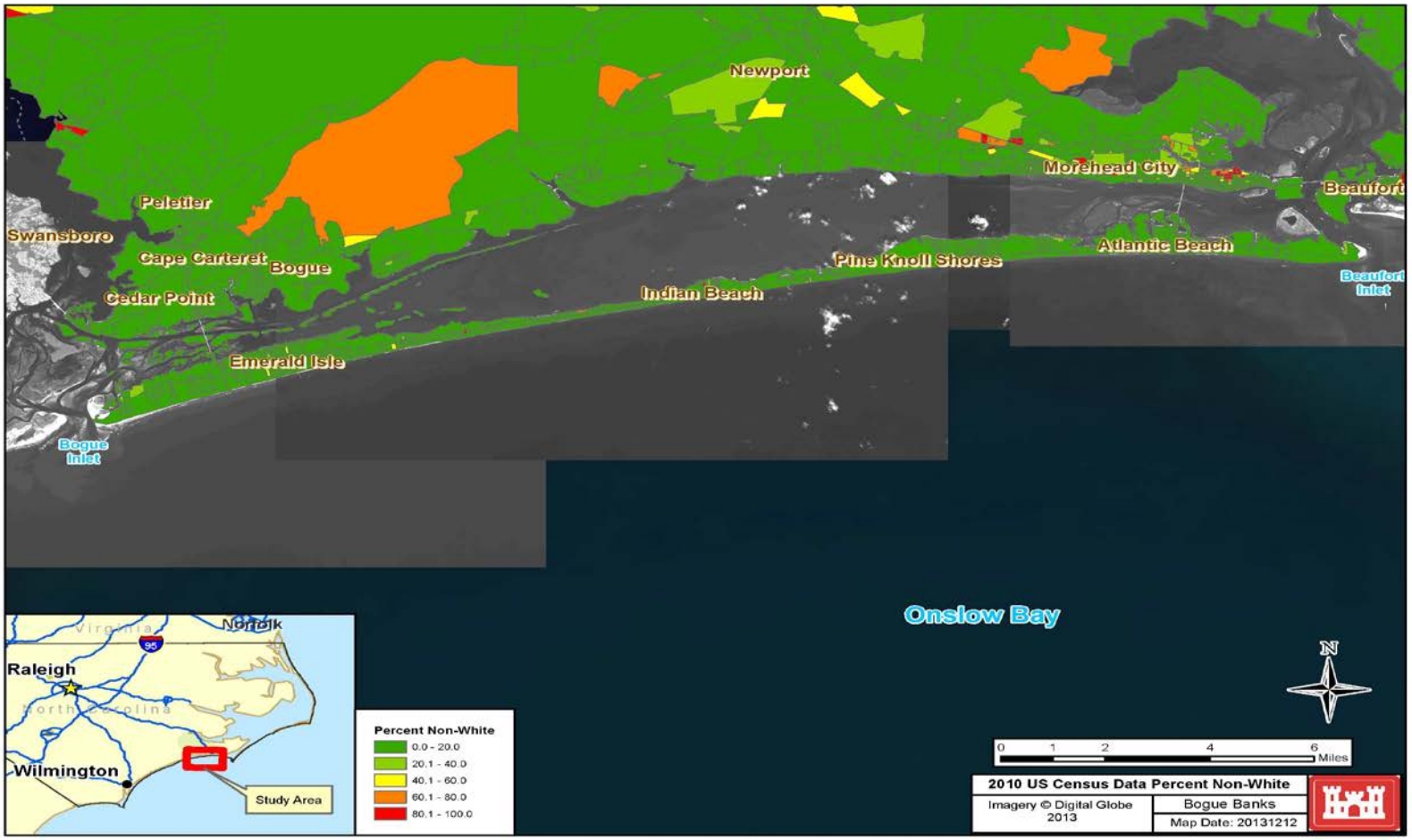


Figure 9.2 2010 US Census Data Percent Non-White

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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FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

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APPENDIX A

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Appendix A: Coastal Engineering

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1.1 Introduction

1.1.1 Project Overview

The U.S. Army Corps of Engineers (USACE) Wilmington District (District) is conducting a storm damage reduction study for the Bogue Banks (Carteret County) shoreline. The study area includes the majority of Bogue Banks, approximately 23 miles, from Bogue Inlet on the west to the western end of Fort Macon on the east (Figure 1). Communities included within the study area are Atlantic Beach, Pine Knoll Shores, Salter Path, Indian Beach and Emerald Isle. A portion of Fort Macon State Park on the eastern end of the barrier island is also included within the study area. The ultimate goal of the project is to formulate the beach maintenance plan for Bogue Banks over the next 50 years that maximizes net economic benefits and is feasible from both an environmental and constructability standpoint.

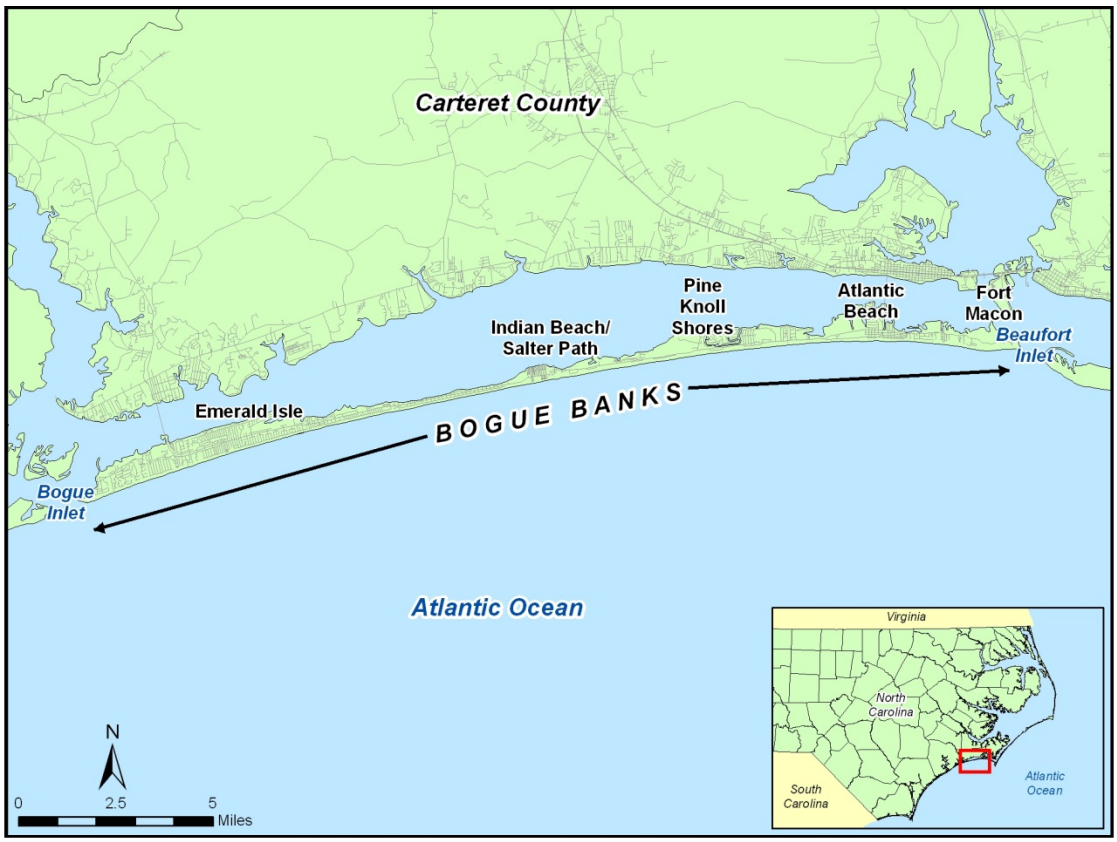

Figure 1: Project Location

The Beach-fx software was utilized to analyze the physical performance of storm damage reduction alternatives in the Bogue Banks study area as well as the economic benefits and costs. Beach-fx is an event-based, Monte Carlo life cycle simulation tool capable of estimating storm damage along coastal zones caused by erosion, flooding, and wave impact. The software also calculates the economic benefits and costs associated with the alternatives. Inputs are required from meteorology, coastal morphology, economics, and management processes. Within Beach-fx, data elements are stored in a relational database where rules for applying the data elements are inherent in the program (Gravens et. al. 2007). The data necessary to run a Beach-fx project provide a full description of the coastal area under study. The software requires an inventory of structures susceptible to damage, a set of historically-based possible storms that can impact the area, the estimated morphology response of the beach to each storm in the storm set, and damage-driving parameters for estimating inundation, erosion, and wave impact damages on the structures. The collection of beach profile responses to various historical storms

was developed using SBEACH (Storm induced BEAch CHange), a cross-shore beach morphology program within the CEDAS (Coastal Engineering Design & Analysis System) package.

The unit of analysis in a shoreline storm damage reduction project is the shoreline area. Within the Beach-fx planning context, the project is divided into reaches, which are defined as contiguous, morphologically homogeneous areas. Reaches are defined and grouped by profile, or cross sections of the beach which characterize the beach morphology. Each reach contains a given number of lots and each lot contains one or more damage element, such as a residential home or nonresidential structure.

The purpose of this appendix is to describe, in detail, the Coastal Engineering input driving the Beach-fx software for the Bogue Banks study area. This includes developing the representative reaches for the Bogue Banks study area, a historical storm suite, historic shoreline change conditions, and profile response to the array of storm events using SBEACH.

1.1.2 Longshore Sediment Transport

As part of the June 2001 Section 111 study (USACE, 2001) a sediment transport study was conducted for Bogue and Shackleford Banks. Results from the study show that the east end of Bogue Banks, between the east town limit of Atlantic beach and Beaufort Inlet, have a high degree of variability resulting from complex wave transformation across the ebb tide delta of Beaufort Inlet. The predominant direction of net littoral transport on Bogue Banks near Beaufort Inlet is to the east, while the remainder of the island experiences net transport to the west. The location of the reversal in net transport is located approximately 2.3 miles west from the shoulder of Beaufort Inlet. Sediment transport along Shackleford Banks is primarily toward the west, or Beaufort Inlet. Net transport is highest near the shoulder of the inlet flowing west. Transport rates decrease with increased distance from the inlet to a point 3.2 miles east of the inlet where potential transport is calculated to be nearly zero. East of this point the transport rates are lower and more erratic varying between easterly and westerly transport up to 6 miles east of the inlet. The remaining approximate half mile of the island experiences eastward net transport toward Barden Inlet.

2.1 Data Requirements

This section provides a description of the data collected to populate the Beach-fx databases and to execute the Bogue Banks Storm Damage Reduction Study as well as all assumptions inherent in the methodology.

2.1.1 Profiles

Coastal process models require a detailed characterization of the beach profile (distances vs. elevation). A simplified representation, or profile, is required for Beach-fx and depicts the following shore features: dune width, dune height, dune slope, foreshore slope, upland elevation, upland width, berm width, and berm height. For the Bogue Banks study area, the shoreline is defined by thirteen unique profile areas, grouped as shown in Figure 2. A schematic of the simplified Beach-fx profile is provided in Figure 3. Figures 4 through 16 provide the generalized representative cross shore for the existing condition (current conditions) for Profiles 1 to 13, respectively. The process for developing the idealized profiles is described in detail in Section 3 of this appendix.

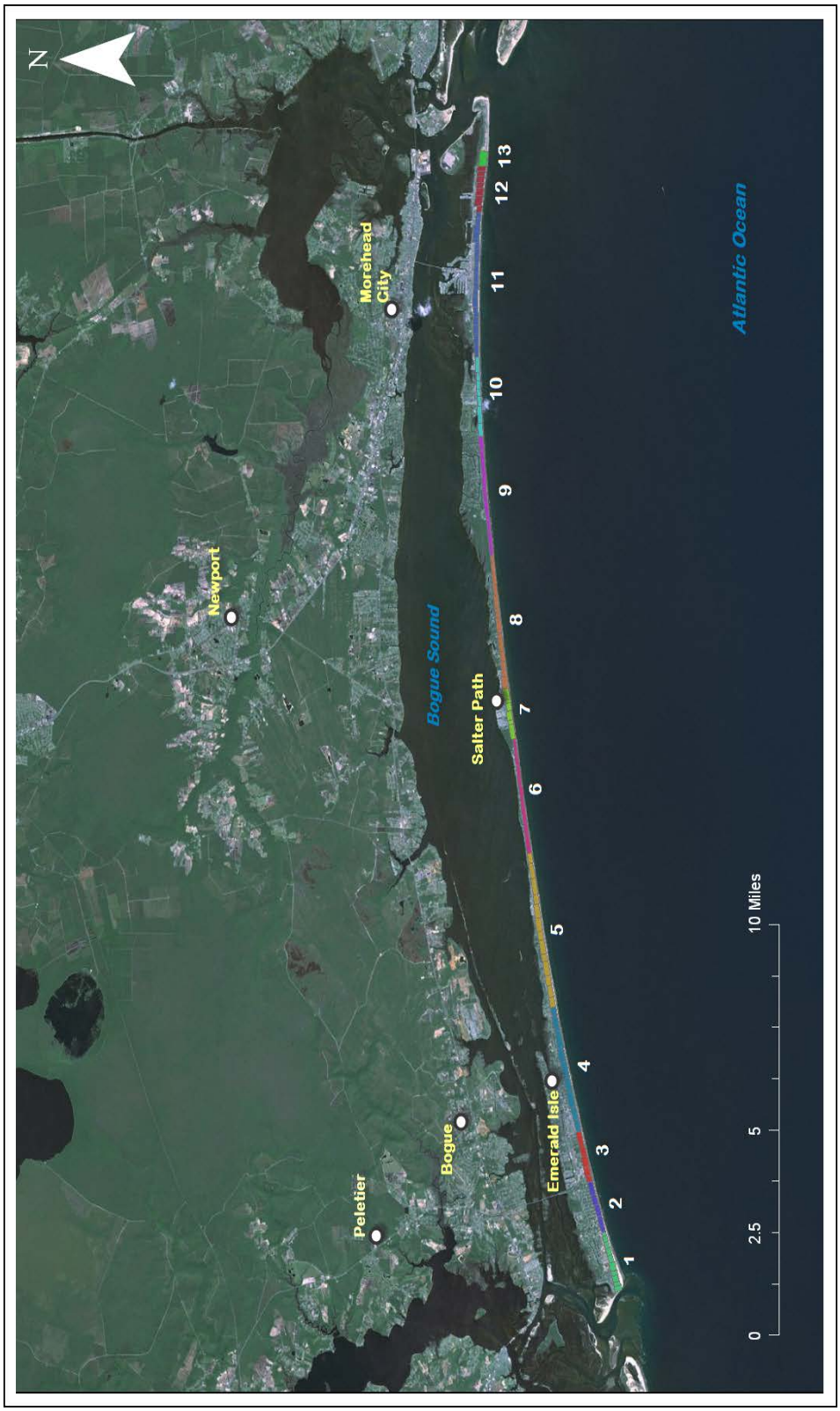

Figure 2: Representative profile areas 1 to 13 along the Bogue Banks study area

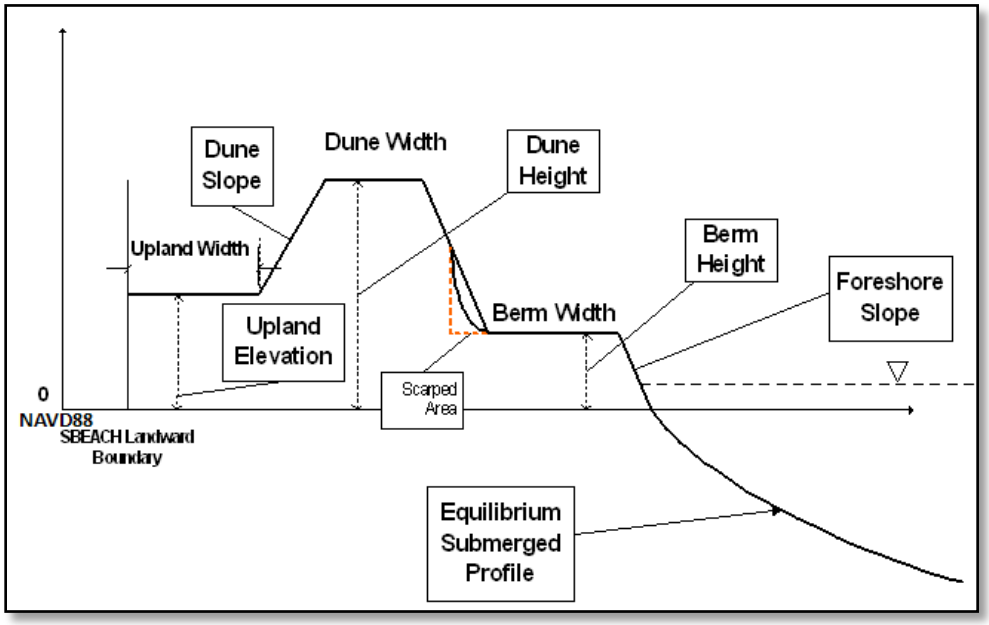

Figure 3: Simplified Beach Profile Required by Beach-fx

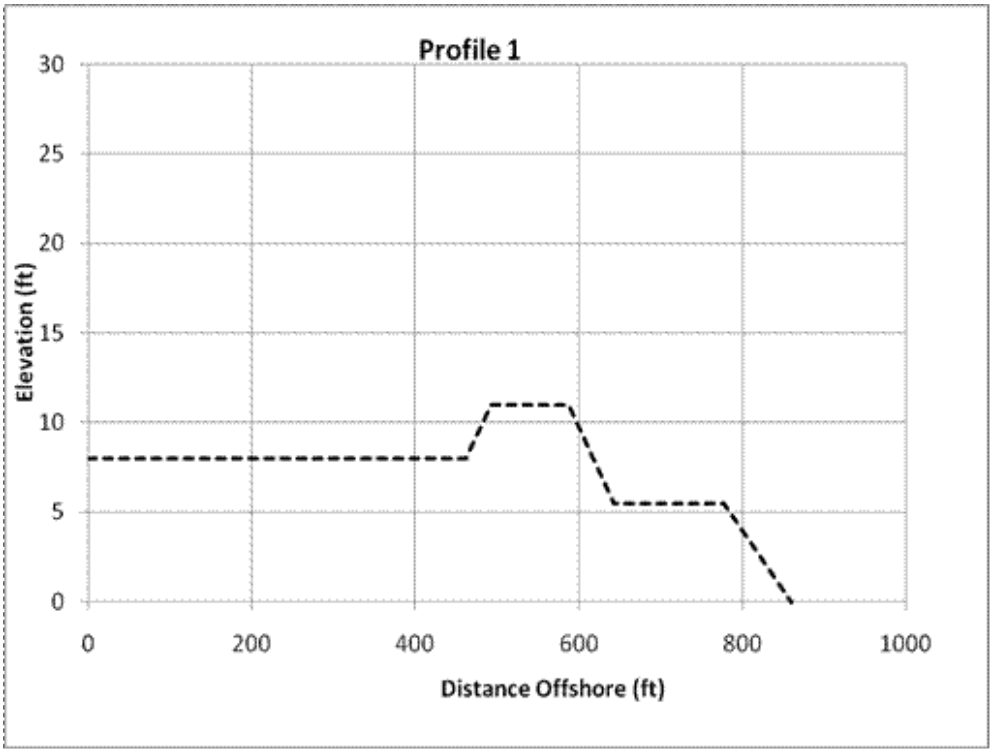

Figure 4: Generalized Cross Shore Morphology for Profile 1

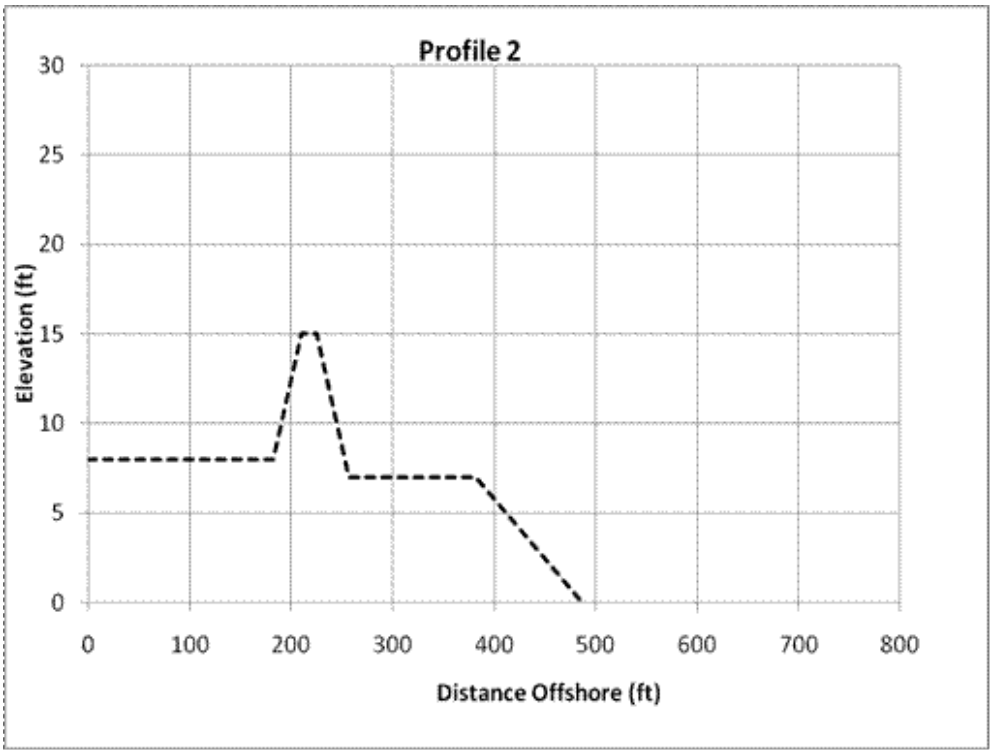

Figure 5: Generalized Cross Shore Morphology for Profile 2

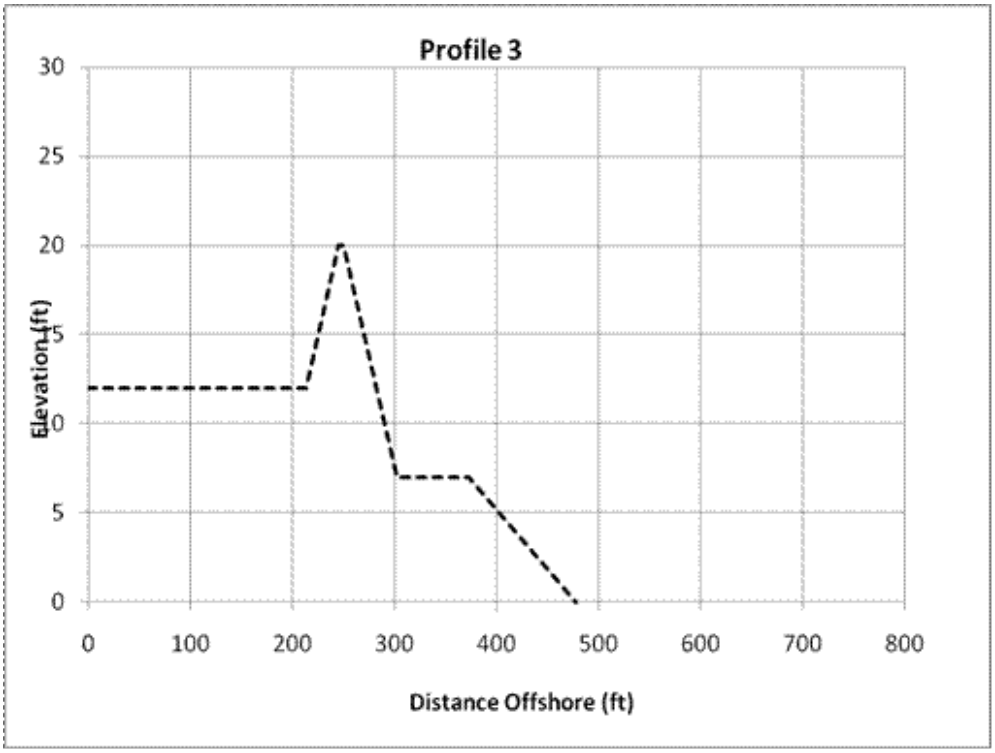

Figure 6: Generalized Cross Shore Morphology for Profile 3

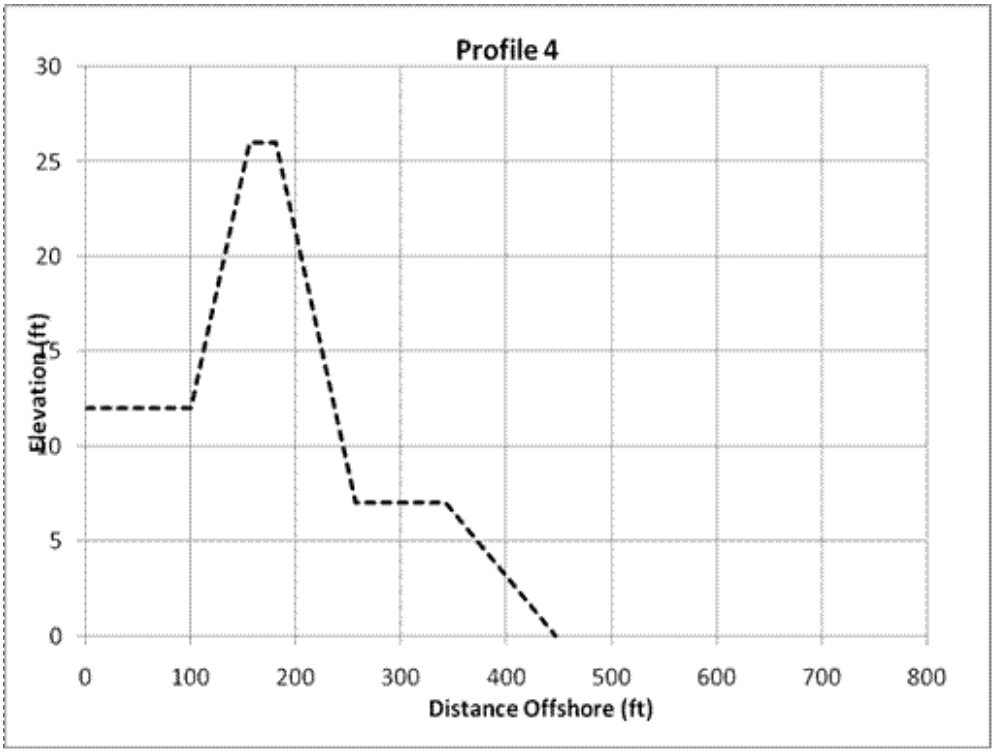

Figure 7: Generalized Cross Shore Morphology for Profile 4

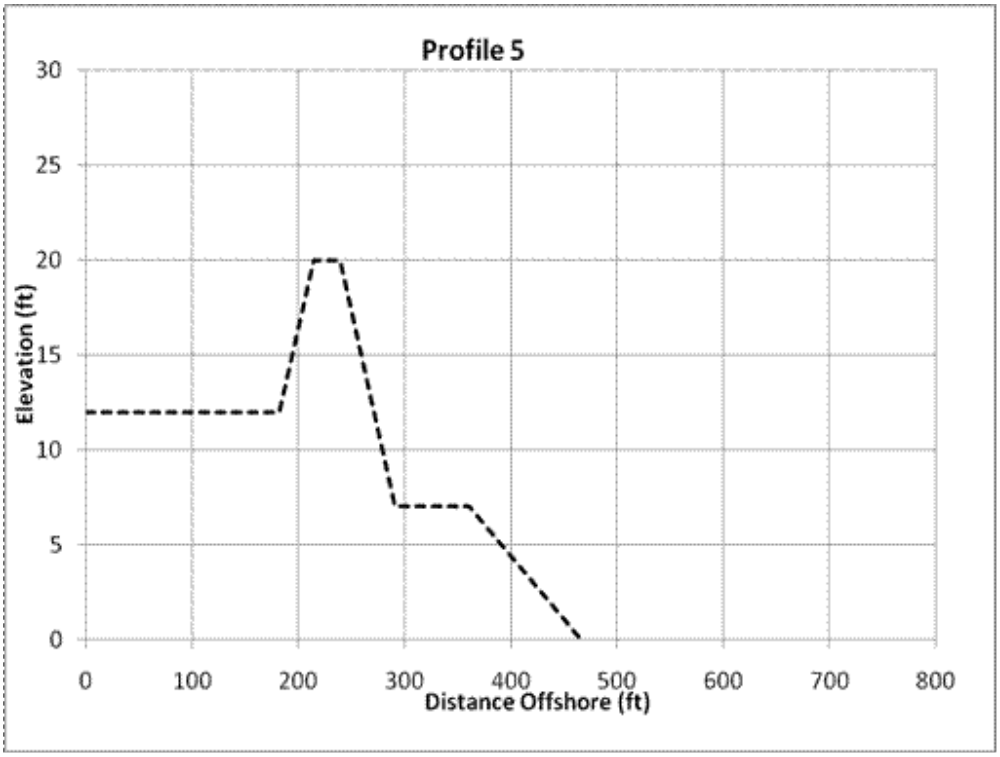

Figure 8: Generalized Cross Shore Morphology for Profile 5

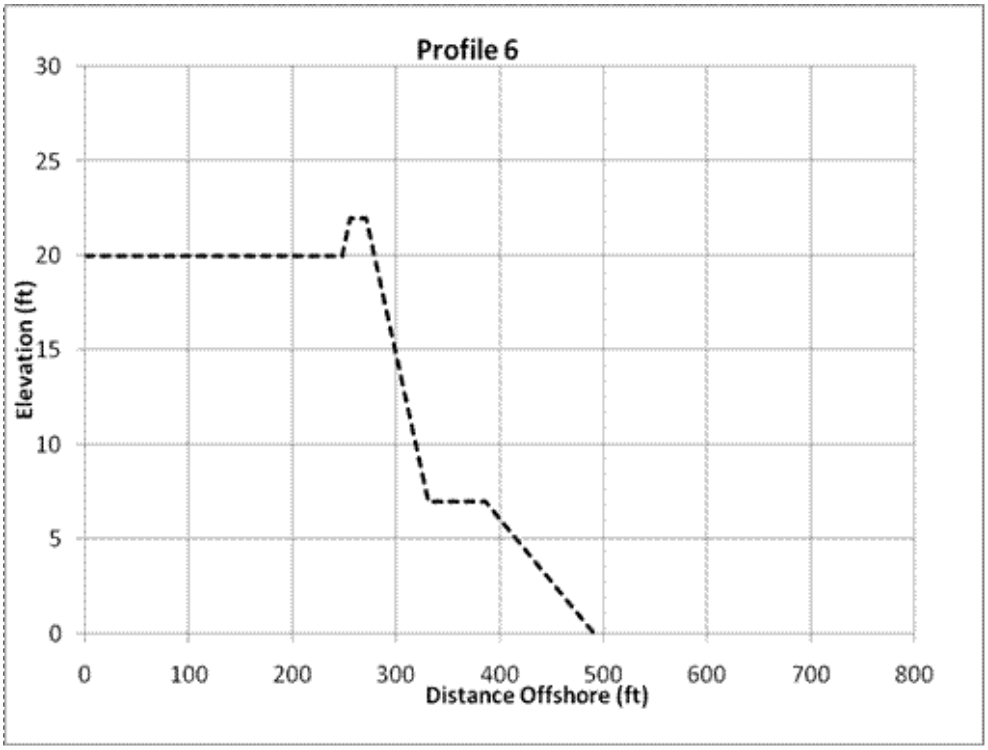

Figure 9: Generalized Cross Shore Morphology for Profile 6

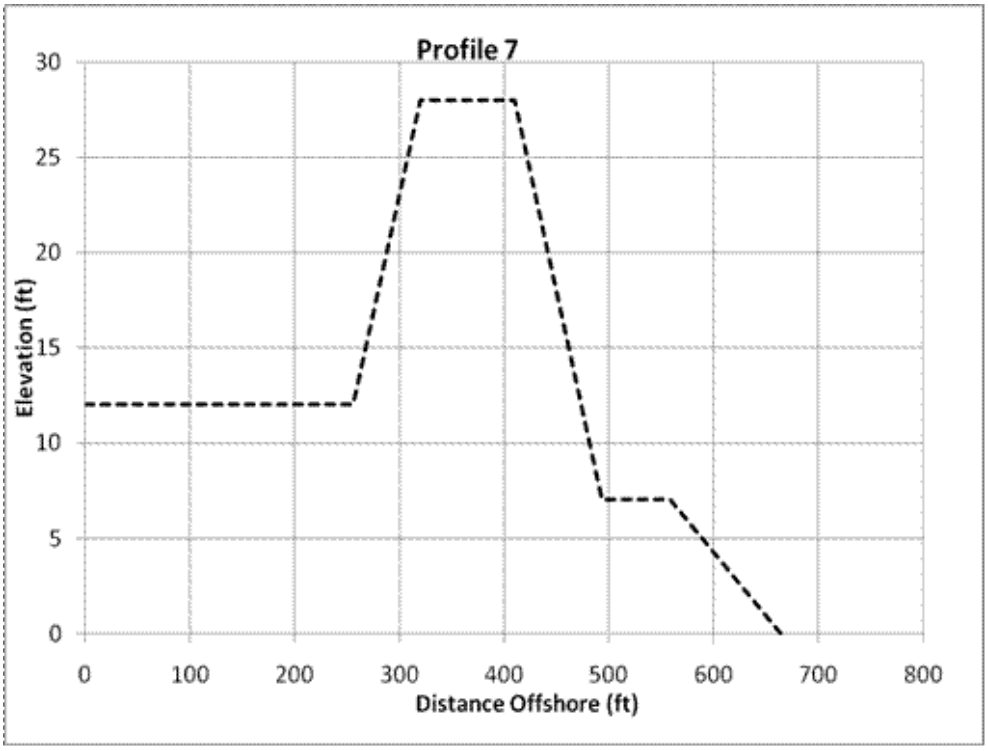

Figure 10: Generalized Cross Shore Morphology for Profile 7

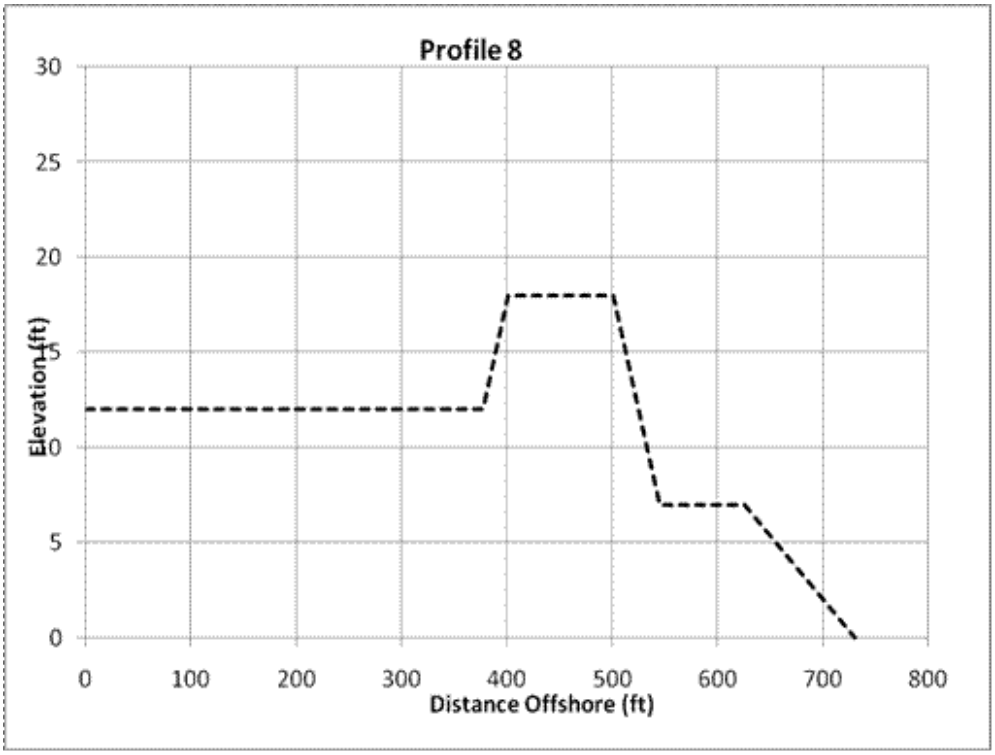

Figure 11: Generalized Cross Shore Morphology for Profile 8

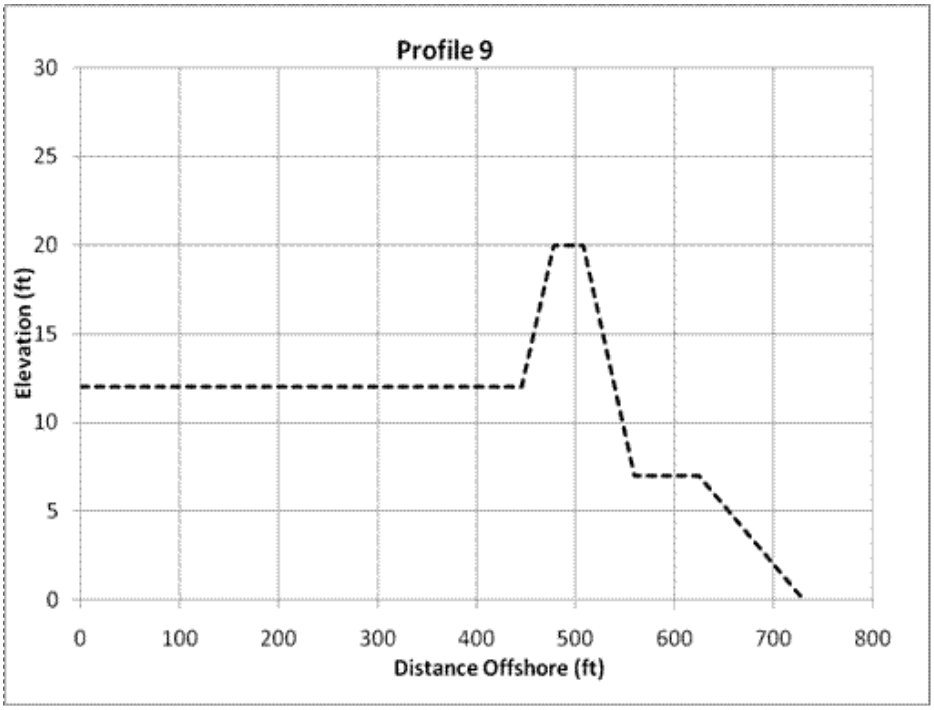

Figure 12: Generalized Cross Shore Morphology for Profile 9

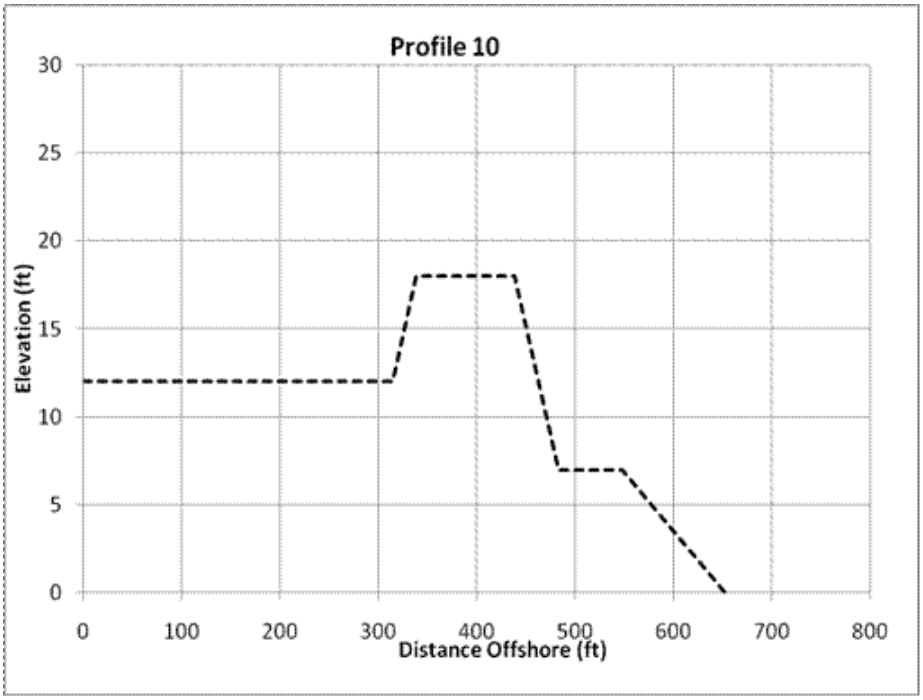

Figure 13: Generalized Cross Shore Morphology for Profile 10

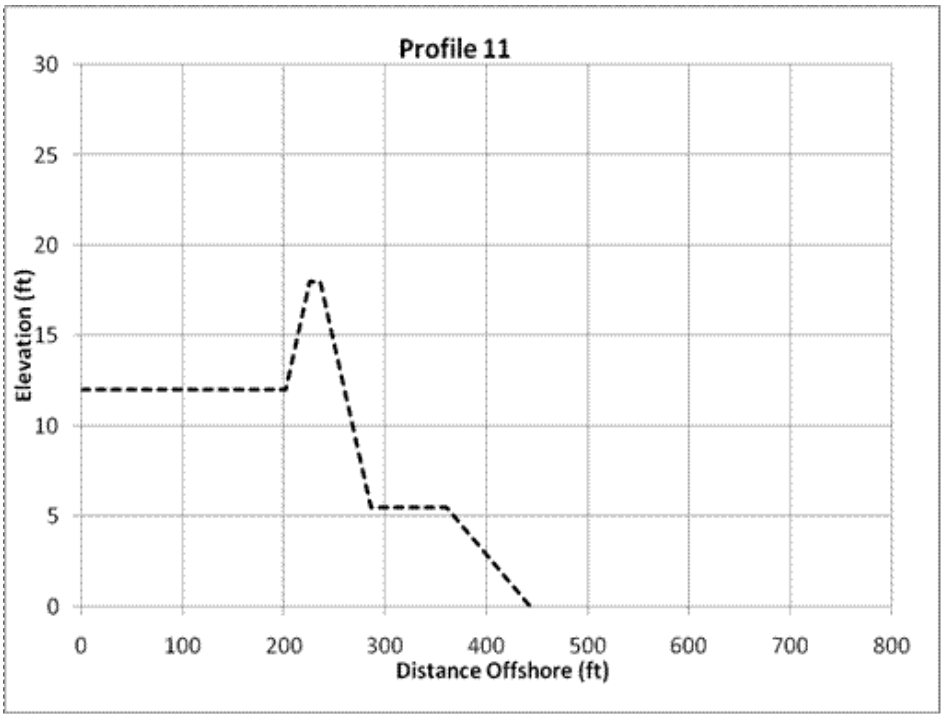

Figure 14: Generalized Cross Shore Morphology for Profile 11

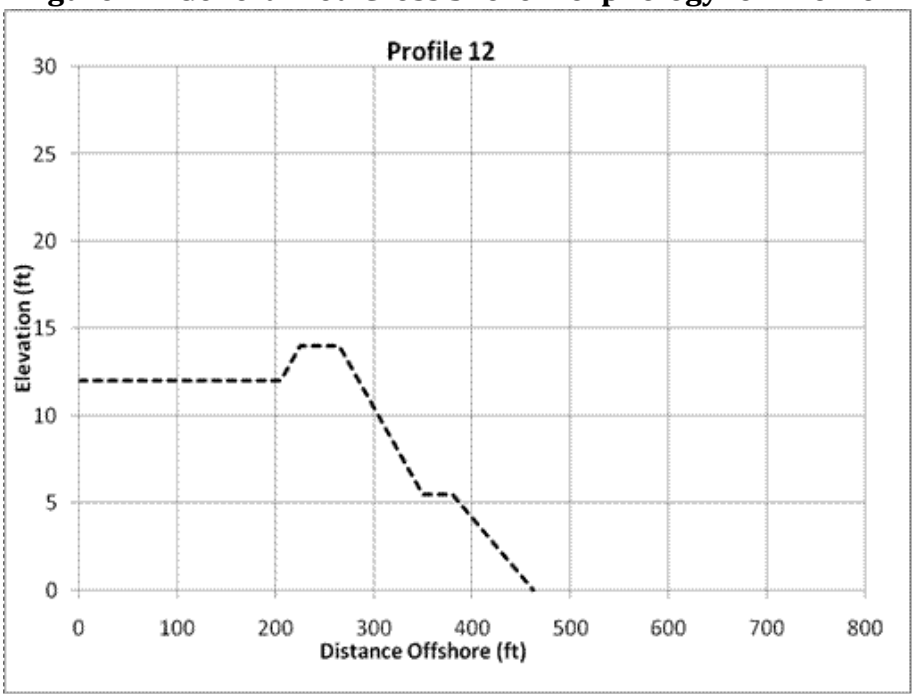

Figure 15: Generalized Cross Shore Morphology for Profile 12

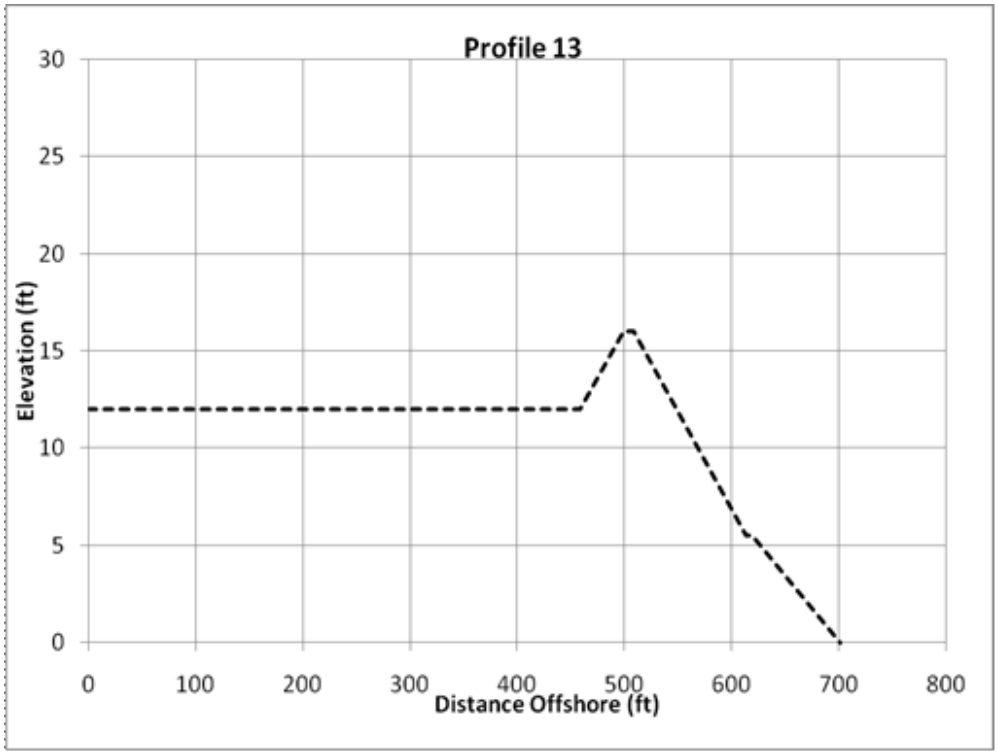

Figure 16: Generalized Cross Shore Morphology for Profile 13

2.1.2 Reaches

Reaches are contiguous stretches of the shoreline that share a common morphological makeup with a particular profile (Rogers et. al. 2009). The Bogue Banks study area is divided into 118 reaches that correspond with Profiles 1 to 13, as shown in Table 1. The following data are reach specific within Beach-fx: applied erosion rate, back-bay flooding, planned nourishment, emergency nourishment, flooding threshold, control line offset (threshold distance from the lot centroid to the seaward toe of the dune at which lots in the reach will be marked as condemned prohibiting the rebuilding of damage elements in that lot), and berm width recovery factor. For calibrating Beach-fx, reach-specific historic erosion rates are also needed, as discussed in Section 2.2.

No back-bay flooding or emergency nourishment is assumed in the study area. The berm width recovery factor is assumed at 95 percent for Reaches 1 to 117. The berm width recovery factor was adjusted to 99% for reach 118 during the calibration process.

Profile	Reaches
1	1-10
2	11-15
3	16-21
4	22-29
5	30-42
6	43-52
7	53-58
8	59-73
9	74-85
10	86-92
11	93-110
12	111-117
13	118

Table 1: Reach/Profile Cross Reference

Control line offsets differ in the study area depending upon structure square footage. According to the state legal requirements, structures less than 5,000 square feet (sq ft) have a minimum setback factor equal to 30 times the erosion rate from the vegetation line. Structures between 5,000 and 10,000 sq ft have a minimum setback factor equal to 60 times the erosion rate from the vegetation line. As structures increase in size to 100,000 sq ft or greater, the erosion standard increases incrementally, reaching a maximum setback of 90 times the erosion rate. The minimum erosion rate is set at 2 feet per year (ft/yr). Thus, it was necessary to analyze the weighted average control line offset for each reach. Assumptions were made regarding the average square footage of structure types in the study area. High rise hotels were assumed to fall within the 90 times erosion rate category. Club houses, apartments/condos, 1 to 2 story motels, warehouses, and large footprint single-family homes were assumed to fall within the 60 times erosion rate category. All other structures were assumed to fall within the 30 times erosion rate category. Given these assumptions, a weighted setback factor was calculated for each reach. This value was multiplied by the historical erosion rate in the reach (no less that 2) to determine the Reach specific weighted average control line offset input for Beach-fx.

2.1.3 Lots

In Beach-fx, a lot is an organizational container used by the software for damage elements and are designed in a way that best fits the specific study need. The following data are Lot specific: type (residential or vacant), lot description (typically address), armoring status and additional armoring specific data.

There were 1,847 lots created for the study area and no lot armoring is assumed within the study area. An example lot from Reach 1 is shown in Figure 17. The boundary of Reach 1 is red while lot boundaries within the reach are black. The blue dots represent damage elements.

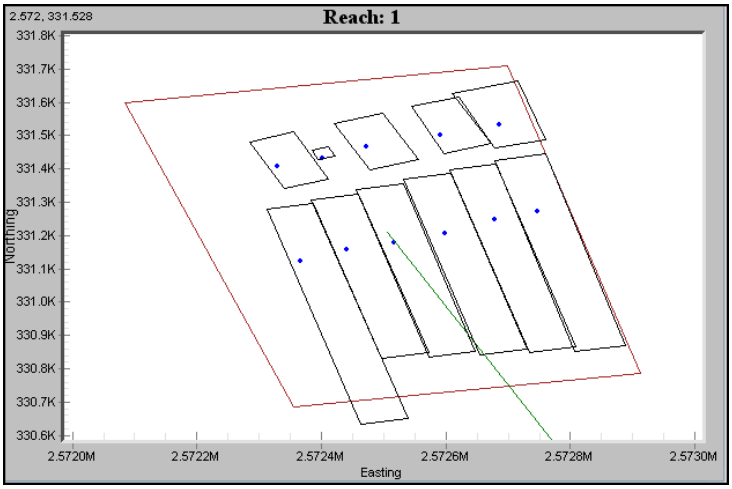

Figure 17: Lots within Reach 1

2.1.4 Damage Elements

A damage element is any physical structure that can endure storm damages, including a residential home, deck, pool, restaurant, pier house, etc. Damage elements are represented by X,Y coordinates in Beach-fx. Damage elements types, or categories, are defined by the user and are project specific. Foundation and construction categories for damage elements are also project specific and defined by the user. Critical vertical erosion amounts that compromise the structure are defined by foundation type. Damage element specific data include: type, description (typically address) foundation type, construction type, armor data, coordinates, number of rebuilds allowed, and triangular distributions of content value, structure value, rebuilding time, and first floor elevation.

For the Bogue Banks study area, the above mentioned data requirements were collected for nearly 2,000 damage elements by the Wilmington District. Construction types include wood or masonry, with all but one structure being built of wood. Foundation types include slab, 8-foot deep pile, or 16-foot pile with critical erosion amounts of 0.5, 4, and 8 feet, respectively. Nearly 80 percent of damage elements in the study area are built upon 8-foot deep piles. Damage element type codes cover the range of structures in the study area, as shown in Table 2.

Code	Description	Code	Description
SF1	1 story SF on slab	SF1_SM	SF 1 story on piles with small footprint
SF2	2 story SF on slab	SF2_SM	SF 2 story on piles with small footprint
MF1	apartments/condos	SF1_LG	SF 1 story on piles with large footprint
CondoHOA	condo, HOA	SF2_LG	SF 2 story on piles with large footprint
MOBHM	mobile home	POOLH	pool house, garage
HOTEL	hotel or hi-rise	STRT	street / highway
MOTEL	motel (1 to 2 stories)	PARK	parking lot
OFFIC	office Building	DECK	decks
POOL_TEN	swimming pool, tennis court	DUNE	dune walkovers
CLUB	private club	PU_ACC	public access--improved
RESTU	restaurant	WAREH	storage building / warehouse
BAR	tavern	PIERHOUSE	pier house or storage

Table 2: Damage Element Types

Quality checks were performed on the damage elements through the coordinate checking process in Beach-fx. Data discrepancies were investigated using GIS and resolved as appropriate. As a result of the coordinate checking process in Beach-fx, several errors were identified within the damage element database. Approximately 100 damage elements were reported by Beach-fx as not falling within the assigned lot and/or reach. These errors were investigated using GIS. The given damage element description (i.e. address) was compared to nearby lot addresses. In nearly all instances, the proper lot was located and the damage element coordinates were corrected accordingly. Three damage element locations could not be verified and were thus inactivated in the database. The coordinate checking process also reported incidents where the input first floor elevation was below the calculated profile elevation at that point for a given damage element. The cause of this error is likely due to the generalization of reach elevation. These errors were corrected by adjusting the given damage element elevation to be an appropriate distance above the profile elevation of the reach in which it falls. Additionally, the coordinate check revealed that 142 damage elements are located landward of the SBEACH line and thus never experience damage in the model. These damage elements were marked as inactive in the database.

After rectifying the damage element errors, the Bogue Banks study area has 1,764 active damage elements remaining. A summary of these damage elements by type are provided in Table 3. Large footprint single-family homes constitute the majority of the structures in the study area. Total structure values for all damage elements are estimated at $714.8 million and total contents are valued at $290.6 million for a total $1 billion in property that could potentially be damaged from incoming storms.

Damage Element Type	Count	Sum of Structure Value (ML*)	Sum of Contents Value (ML)	Sum of Total Value (ML)
BAR	1	123,600	51,418	175,018
CLUB	7	3,181,200	1,233,024	4,414,224
CondoHOA	2	1,200,000	480,000	1,680,000
HOTEL	3	3,435,600	3,698,654	7,134,254
MF1	12	44,882,400	17,952,960	62,835,360
MOBHM	4	1,290,000	620,040	1,910,040
MOTEL	14	8,824,800	3,991,560	12,816,360
OFFIC	4	353,700	355,723	709,423
PARK	13	7,044,100	3,039,400	10,083,500
PIERHOUSE	6	1,058,400	1,767,528	2,825,928
POOL_TEN	37	2,858,400	428,760	3,287,160
POOLH	2	2,526,000	444,576	2,970,576
RESTU	5	1,077,600	1,788,816	2,866,416
SF1	56	5,145,600	2,058,240	7,203,840
SF1_LG	451	71,716,920	28,686,768	100,403,688
SF1_SM	111	27,562,950	11,025,180	38,588,130
SF2	92	50,412,000	20,164,800	70,576,800
SF2_LG	802	367,432,848	146,923,790	514,356,638
SF2_SM	137	112,862,940	45,097,416	157,960,356
UA	2	1,200,000	480,000	1,680,000
WAREH	3	597,600	298,800	896,400
Grand Total	1,764	714,786,658	290,587,453	1,005,374,111

*ML = most likely

Table 3: Damage Element Summary Data

2.1.5 Meteorological Data

The project area is impacted by both tropical and extra-tropical (also called "nor'easter") storm events. An analysis of historical storm climatology resulted in identification of 35 tropical storms from 1893 to 1999 giving an annual probability of tropical storm occurrence of 0.33. Twenty-three extra-tropical storms occurred from 1978 to 1992 giving an annual probability of extra-tropical storm occurrence of 1.44. These 58 historical storms, shown by arrival date in Figure 18, were expanded to a plausible storm suite consisting of 696 storms by combining the historical storm surge hydrograph with three statistically defined tidal ranges (high, mean, and low) and combining the storm surge hydrograph at four phases of the astronomical tide such that peak surge is aligned at high tide, mid-tide rising, mid-tide falling, and low tide. In terms of relative probability of occurrence, those plausible storms associated with mean tidal ranges are given a relative probability of 2 whereas those storms associated with high and low tidal ranges are given a relative probability of 1.

Beach-fx requires specification of user defined storm seasons. Using the historical storms dataset, six seasons were defined and probabilities for tropical and extra-tropical storms were calculated. Minimum inter-storm arrival times

were also calculated and the maximum allowable tropical and extra-tropical storms within a season were set. These data are provided in Table 4.

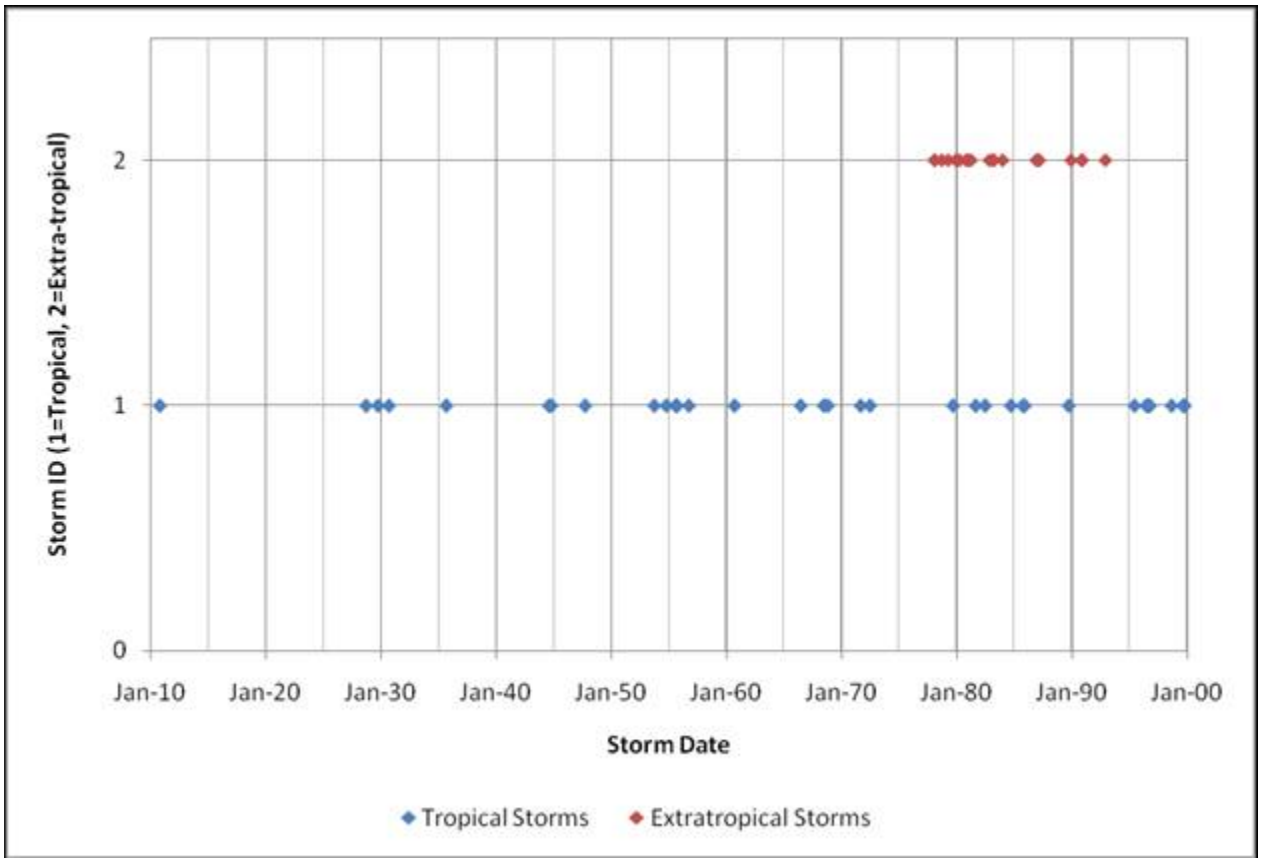

Figure 18: Historical Storm Dataset

Season	Probability Extra-Tropical	Probability Tropical	Min Storm Arrival	Max Extra-Tropical	Max Tropical
Jan-Mar	0.688	0.000	13	3	0
Apr-May	0.000	0.000	30	0	0
Jun-Aug	0.000	0.113	5	0	2
Sept	0.063	0.132	17	1	1
Oct	0.125	0.075	30	1	1
Nov-Dec	0.563	0.009	24	2	1

Table 4: Storm Seasons

2.1.6 Coastal Processes Model Data

A shoreline damage reduction study requires inputs from a coastal process model that captures how the beach responds to wave action and water levels caused by storms as well as long-term processes. For the Bogue Banks project, the Storm Induce Beach Change model (SBEACH) was executed external to the Beach-*fx* environment. The beach profile responses estimated in the SBEACH simulations are used to populate the Shore Response Database (SRD) in Beach-*fx*. Details on the SRD development are provided in Section 3.

2.1.7 Damage Functions

Damage functions are used within Beach-*fx* to estimate storm-induced damages sustained by the damage elements. Damages are estimated separately for the structure and contents of each impacted damage element. Damages are caused by three processes: erosion, inundation, and wave attack. Beach-*fx* has an inherent set of rules for combining damages when multiple damage processes produce damages to a structure or contents during a storm event (see Rogers et. al. 2009, page 47).

Damage functions are user-defined within Beach-*fx*. Damage function types and definitions are included but the specific functions must be developed and defined for each project. A specific damage function must be assigned to each combination of damage element type, foundation type, and construction type. These functions are expressed as a percent of the structure or content valuation compromised. In all, the Wilmington District developed 23 damage functions, as shown in Table 5. Triangular distributions were developed for each of the damage functions representing minimum, most likely, and maximum values at each point along the X-axis. These damage functions are where uncertainties of the model area accounted for using a Monte Carlo analysis. Illustration of each damage function developed for Bogue Banks can be found in the Economic Appendix, Appendix B.

Function	Function Description Group Description	X-axis	Y-axis
ERODP1MCON	Erosion - Pile 16 - MF - Contents	% Footprint compromised	Fractional damage to contents or structure
ERODP1SCON	Erosion - Pile 16 - SF - Contents		
EROPILECON	Erosion - Pile Foundations - Contents		
EROSHLCON	Erosion - Shallow Foundation - Contents		
ERODP1MSTR	Erosion - Deep Piles 1 Floor Medium - Structures		
ERODP1SSTR	Erosion - Deep Piles 1 Floor Small - Structures		
ERODP2LSTR	Erosion - Deep Piles 2 Floors Large - Structures		
ERODP2MSTR	Erosion - Deep Piles 2 Floors Medium - Structures		
ERODP2SSTR	Erosion - Deep Piles 2 Floors Small - Structures		
ERODP3MSTR	Erosion - Deep Piles 3 Floors Medium - Structures		
ERODP4LSTR	Erosion - Deep Piles 4 Floors Large - Structures		
ERODP4SSTR	Erosion - Deep Piles 4 Floors Small - Structures		
ERODP5LSTR	Erosion - Deep Piles 5 Floors Large - Structures		
EROPILESTR	Erosion - Pile Foundation - Structures		
EROSHLSTR	Erosion - Shallow Foundation - Structures	Water depth above 1st floor	
2SNBC	Innundation - 1 - 2 story - Contents		
4SNBC	Innundation - 4 story - Contents		
INUM4FL	Innundation - 4 - 5 floors - Structures		
INUNALLSTR	Innundation - All Structures up to 3 floors- Structures		
WAVENPC	Wave - Not On Piles - Contents		
WAVEPC	Wave - On Piles - Contents		
WAVENPS	Wave - Not On Piles - Structures		
WAVEPS	Wave - On Piles - Structures		

Table 5: Damage Functions for Bogue Banks

2.1.8 Existing Management Measures

Within the Bogue Banks area, no emergency nourishment is assumed to occur. No property is assumed to be armored. Thus, no existing management measures beyond existing regulatory requirements are assumed in the analysis.

2.1.9 Sea Level Rise

Beach-fx allows for sea level rise to be specified for a project. For the Bogue Banks project, sea level rise was set at 0.0084 ft/yr (2.57 mm/yr). This rate is based on the long term sea level rise measurement calculated at the Beaufort Inlet NOAA Tide gauge as shown in Figure 19.

In addition to the base model run using the historic sea level rise trend for the area, Beach-fx allows for relative sea level rise curves to be simulated in compliance with Engineering Circular 1165-2-212. This circular requires that "Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence". Relative sea level rise is a combination of the global sea level changes, due to thermal expansion and deglaciation, and local geologic changes in land elevation resulting in uplift or submergence. The relative sea level rise curves were calculated for NRC curves I and III and are displayed in Figure 20 along with the projected rise based on the measured historic rate at the Beaufort Inlet NOAA gauge. To incorporate these curves into the sea level rise analysis using Beach-FX a representative rate based on these curves was chosen. This rate was selected by calculating the projected sea level rise 30 years from the project base line year of 2010 and

computing an average of this rise by dividing by 30. The representative sea level rise rates used in Beach-FX were 0.0341 ft/yr for Curve III and 0.0145 ft/yr for Curve I.

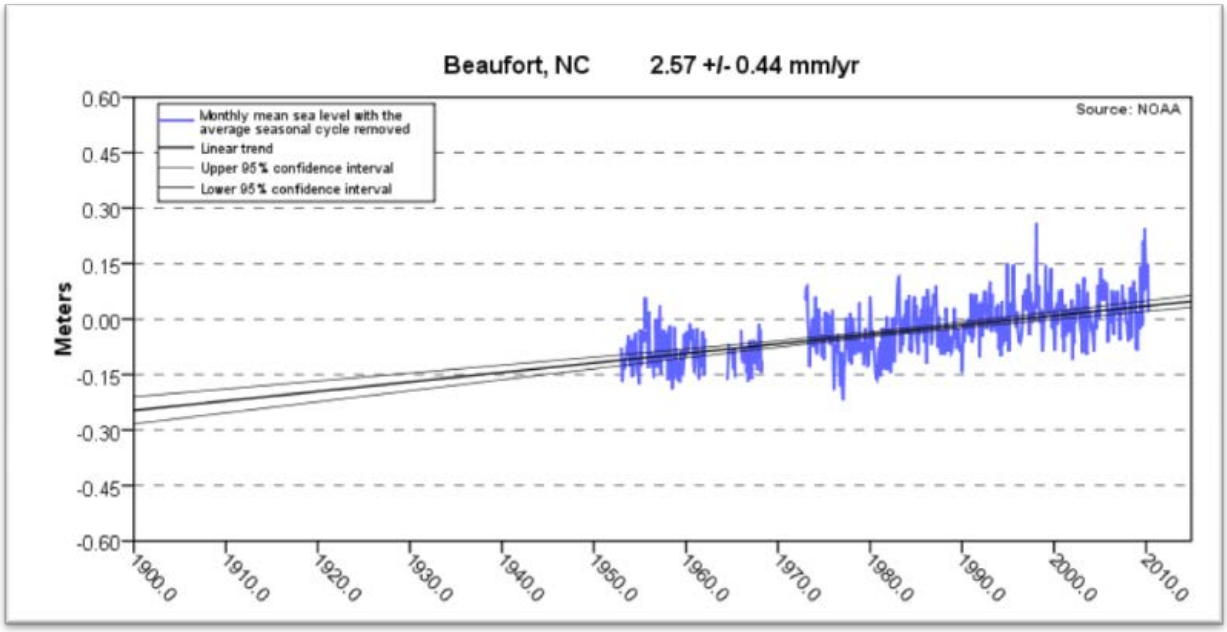

Figure 19 Long Term NOAA Tidal Gauge at Beaufort Inlet, NC

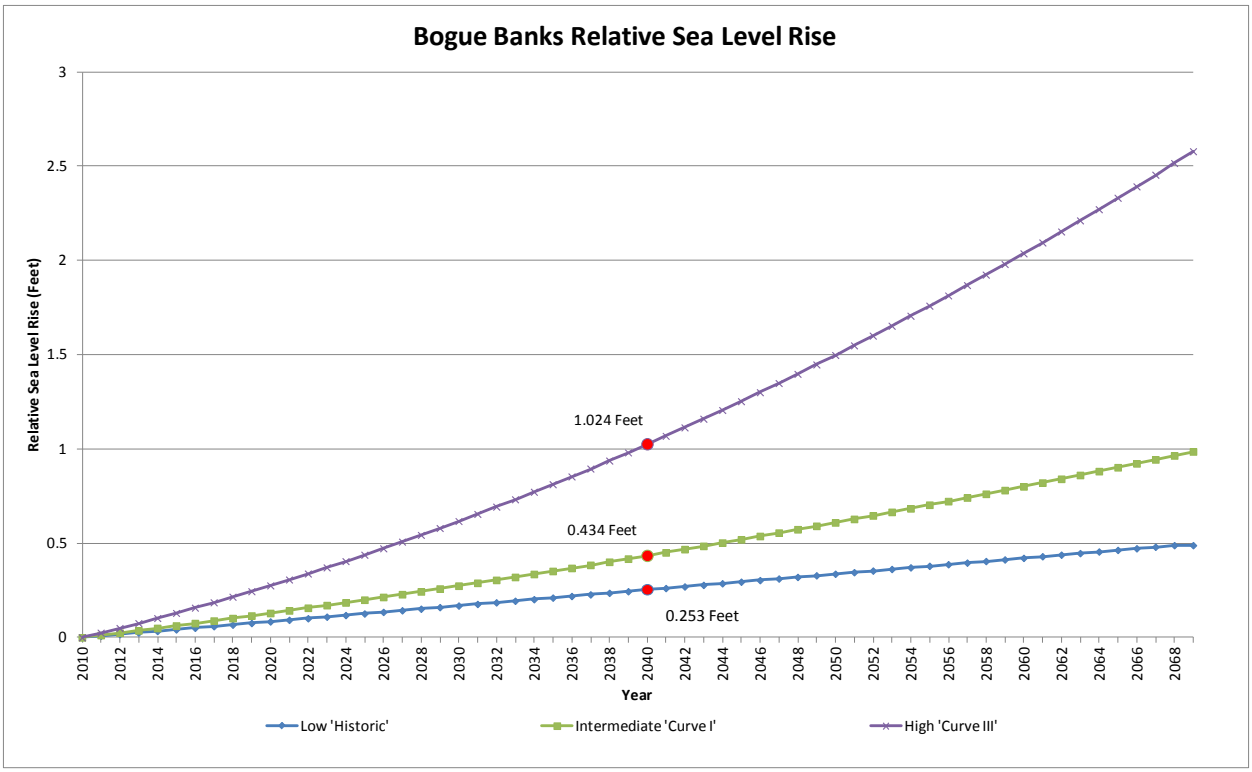

Figure 20 Bogue Banks Relative Sea Level Rise

2.1.10 Planned Nourishment

Development of planned nourishment alternatives requires data beyond the explanation of the existing conditions in the study area. The present implementation of planned nourishment within Beach-fx involves nourishment triggers expressed as a percent of specified nourishment template values along with a target nourishment interval, start date, mobilization threshold, and mobilization costs. Beach-fx requires inputs for these data as well as nourishment blackout windows, planform rate of change caused by the nourishment, production rate, borrow to placement ratio, and reach nourishment processing order. This section provides the planned nourishment assumption for the Bogue Banks study area.

The triggers used to initiate project nourishment were defined as 0.75 for berm width, 0.90 for dune width, and 0.85 for dune height. Model runs were completed with nourishment target intervals defined at 3, 4, and 5 years with a start date of January 1, 2019 and the mobilization threshold assumed at 1. Project-level mobilization costs are assumed for two hoppers at $3,200,000 and no mobilization costs are assumed at the reach level. Borrow to placement ratios for the study area are specified at the reach level and are shown in Table 6.

Due to the size of the storm response database file the project was divided into four roughly equal segments with the results summarized outside the Beach-fx environment. A summary of these data are provided in Table 6.

Reach Number	Planned Nourishment Alternative Name	Unit Placement Cost	Borrow To Placement Ratio	Production Rate	Berm Width Planned Nourishment Trigger	Dune Width Planned Nourishment Trigger	Dune Height Planned Nourishment Trigger
1	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
2	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
3	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
4	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
5	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
6	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
7	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
8	NED_3YRCYCLE	7.6	1.09603	27851.93	0.75	0.9	0.85
9	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
10	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
11	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
12	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
13	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
14	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
15	NED_3YRCYCLE	7.53	1.09603	28646.00	0.75	0.9	0.85
16	NED_3YRCYCLE	7.53	1.05324	28646.00	0.75	0.9	0.85
17	NED_3YRCYCLE	7.53	1.05324	28646.00	0.75	0.9	0.85
18	NED_3YRCYCLE	7.53	1.05324	28646.00	0.75	0.9	0.85
19	NED_3YRCYCLE	7.53	1.05324	28646.00	0.75	0.9	0.85
20	NED_3YRCYCLE	7.53	1.05324	28646.00	0.75	0.9	0.85
21	NED_3YRCYCLE	7.6	1.05324	27851.93	0.75	0.9	0.85
22	NED_3YRCYCLE	7.6	1.05324	27851.93	0.75	0.9	0.85
23	NED_3YRCYCLE	7.6	1.05324	27851.93	0.75	0.9	0.85
24	NED_3YRCYCLE	7.6	1.05324	27851.93	0.75	0.9	0.85
25	NED_3YRCYCLE	8.14	1.05324	26103.79	0.75	0.9	0.85
26	NED_3YRCYCLE	8.14	1.04802	26103.79	0.75	0.9	0.85
27	NED_3YRCYCLE	8.14	1.04802	26103.79	0.75	0.9	0.85
28	NED_3YRCYCLE	8.4	1.04802	24583.72	0.75	0.9	0.85
29	NED_3YRCYCLE	8.4	1.04802	24583.72	0.75	0.9	0.85
30	NED_3YRCYCLE	8.4	1.04802	24583.72	0.75	0.9	0.85
31	NED_3YRCYCLE	8.4	1.04802	24583.72	0.75	0.9	0.85
32	NED_3YRCYCLE	8.4	1.04802	24583.72	0.75	0.9	0.85
33	NED_3YRCYCLE	8.76	1.04802	23977.24	0.75	0.9	0.85
34	NED_3YRCYCLE	8.76	1.04802	23977.24	0.75	0.9	0.85
35	NED_3YRCYCLE	8.76	1.04802	23977.24	0.75	0.9	0.85
36	NED_3YRCYCLE	8.76	1.04802	23977.24	0.75	0.9	0.85
37	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
38	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
39	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
40	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
41	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
42	NED_3YRCYCLE	8.76	1.05042	24204.81	0.75	0.9	0.85
43	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
44	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
45	NED_3YRCYCLE	8.67	1.05252	24394.08	0.75	0.9	0.85
46	NED_3YRCYCLE	8.67	1.05252	24394.08	0.75	0.9	0.85
47	NED_3YRCYCLE	8.67	1.05252	24394.08	0.75	0.9	0.85
48	NED_3YRCYCLE	8.67	1.05252	24394.08	0.75	0.9	0.85
49	NED_3YRCYCLE	8.67	1.05252	24394.08	0.75	0.9	0.85
50	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
51	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
52	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
53	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
54	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
55	NED_3YRCYCLE	8.76	1.05252	24204.81	0.75	0.9	0.85
56	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85
57	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85
58	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85
59	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85
60	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85

Table 6: Reach Specific Planned Nourishment Assumptions

Reach Number	Planned Nourishment Alternative Name	Unit Placement Cost	Borrow To Placement Ratio	Production Rate	Berm Width Planned Nourishment Trigger	Dune Width Planned Nourishment Trigger	Dune Height Planned Nourishment Trigger
61	NED_3YRCYCLE	8.94	1.05252	23749.66	0.75	0.9	0.85
62	NED_3YRCYCLE	9.03	1.05252	23294.52	0.75	0.9	0.85
63	NED_3YRCYCLE	9.03	1.05252	23294.52	0.75	0.9	0.85
64	NED_3YRCYCLE	9.03	1.05252	23294.52	0.75	0.9	0.85
65	NED_3YRCYCLE	9.03	1.05252	23294.52	0.75	0.9	0.85
66	NED_3YRCYCLE	9.03	1.05252	23294.52	0.75	0.9	0.85
67	NED_3YRCYCLE	9.03	1.05042	23294.52	0.75	0.9	0.85
68	NED_3YRCYCLE	9.03	1.05042	23294.52	0.75	0.9	0.85
69	NED_3YRCYCLE	9.46	1.05042	22419.48	0.75	0.9	0.85
70	NED_3YRCYCLE	9.46	1.05042	22419.48	0.75	0.9	0.85
71	NED_3YRCYCLE	9.46	1.05042	22419.48	0.75	0.9	0.85
72	NED_3YRCYCLE	9.46	1.05042	22419.48	0.75	0.9	0.85
73	NED_3YRCYCLE	9.46	1.05042	22419.48	0.75	0.9	0.85
74	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
75	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
76	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
77	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
78	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
79	NED_3YRCYCLE	9.7	1.05042	21539.71	0.75	0.9	0.85
80	NED_3YRCYCLE	9.55	1.10707	22204.56	0.75	0.9	0.85
81	NED_3YRCYCLE	9.55	1.10707	22204.56	0.75	0.9	0.85
82	NED_3YRCYCLE	9.55	1.10707	22204.56	0.75	0.9	0.85
83	NED_3YRCYCLE	9.55	1.10707	22204.56	0.75	0.9	0.85
84	NED_3YRCYCLE	9.55	1.10707	22204.56	0.75	0.9	0.85
85	NED_3YRCYCLE	9.4	1.10707	22849.34	0.75	0.9	0.85
86	NED_3YRCYCLE	9.4	1.10707	22849.34	0.75	0.9	0.85
87	NED_3YRCYCLE	9.4	1.10707	22849.34	0.75	0.9	0.85
88	NED_3YRCYCLE	9.4	1.10707	22849.34	0.75	0.9	0.85
89	NED_3YRCYCLE	8.94	1.10707	23749.66	0.75	0.9	0.85
90	NED_3YRCYCLE	8.94	1.10707	23749.66	0.75	0.9	0.85
91	NED_3YRCYCLE	8.94	1.10707	23749.66	0.75	0.9	0.85
92	NED_3YRCYCLE	8.94	1.10707	23749.66	0.75	0.9	0.85
93	NED_3YRCYCLE	8.94	1.10707	23749.66	0.75	0.9	0.85
94	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
95	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
96	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
97	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
98	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
99	NED_3YRCYCLE	8.76	1.06965	24204.81	0.75	0.9	0.85
100	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
101	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
102	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
103	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
104	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
105	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
106	NED_3YRCYCLE	8.67	1.06965	24583.72	0.75	0.9	0.85
107	NED_3YRCYCLE	8.67	1.41164	24583.72	0.75	0.9	0.85
108	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
109	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
110	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
111	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
112	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
113	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
114	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
115	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
116	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
117	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85
118	NED_3YRCYCLE	8.67	1.41164	24394.08	0.75	0.9	0.85

Table 6: Reach Specific Planned Nourishment Assumptions (continued)

2.2 Beach-fx Calibration

Calibration of the Beach-*fx* model is essential to ensure that the morphology behavior is representative of the reaches of the study area (Rogers et. al. 2009). In the absence of nourishment activities, the simulated shoreline rate of change should, on average and over multiple iterations, equal the historical rate of shoreline change. Calibration of Beach-*fx* is achieved through an iterative simulation process in which a balance is reached between three interrelated model specifications: storm climatology, post-storm berm width recovery, and the applied erosion rate. It was found that convergence of the model outputs was achieved at approximately 275 iterations and based on this each of the model runs consisted of 300 iterations (Figure 21a). The goal of the calibration process is to determine the proper combination of these inputs that will result in the target historical erosion rate.

The Beach-*fx* calibration process involves two preliminary steps followed by third step that requires multiple simulation runs. These steps were successfully completed for the Bogue Banks study area. First, the role of the applied erosion rate was confirmed by creating a simulation in which there were no storms and the only process causing the shoreline to change was the applied erosion rate. In the second step, the estimated the shoreline rate of change due to storm processes only was determined. In this step, the combined effect of the post-storm berm width recovery and storm climatology on the erosion rate was identified by setting the applied erosion rate for all reaches to zero. The third step was to determine the applied erosion rate that will return the target historical erosion rate of change after a given number of iterations on a reach by reach basis. This was executed through a number of simulations where the input applied erosion rates were adjusted according to the output average annual erosion rate from the previous simulation.

Calibration was completed after the development of the Storm Damage Database which is discussed in detail in section three of this appendix. After a number of simulations, the proper combination of berm width recovery and applied erosion rate was determined for each reach. Berm width recovery was set at 95 percent for reaches 1 through 117 and 99 percent for reach 118. Reach 118 was initially included in the project scope; however, since there are no structures included within the reach limits it was not included in the final project layout. Figure 21 provides the calibrated average annual erosion rate compared to the target historical shoreline rate of change, thus confirming a successful calibration. Also included in Figure 21 is the data used as the applied erosion rate within Beach-fx during calibration.

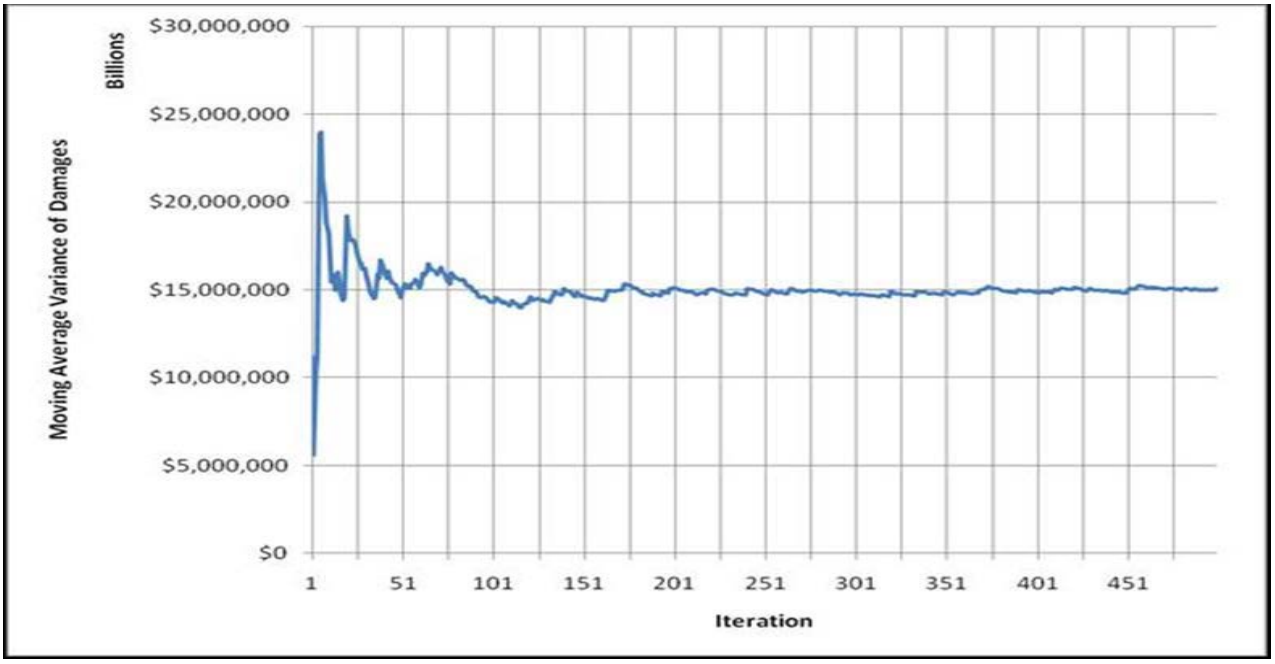

Figure 21a: Model Iterations for Convergence

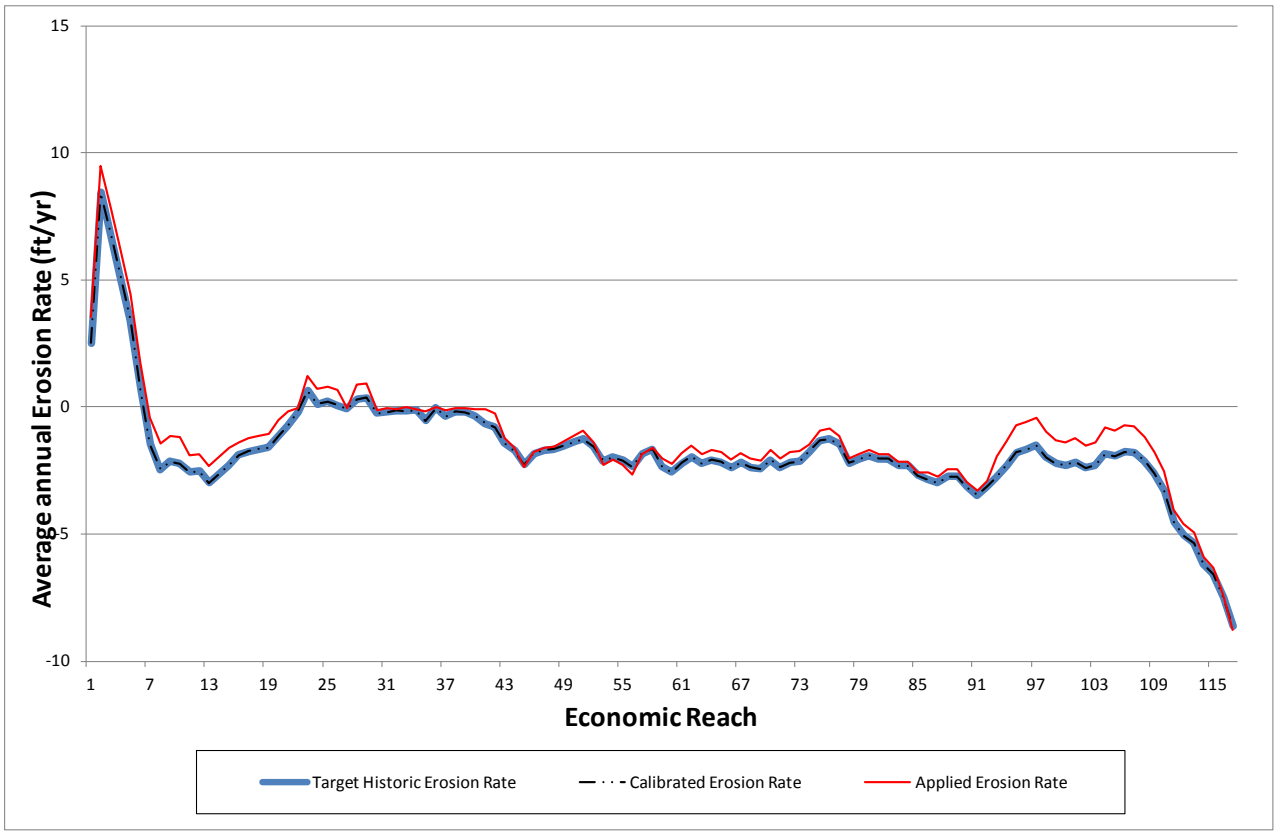

Figure 21: Confirmation of Beach-*fx* Calibration

3.1 SBEACH Data Requirements

This section provides details on the data collection and methodology employed to develop the storm response database (SRD) within the Beach-fx context that stores beach profile responses to various historical storms for lookup. Historical and current data sets applicable to Bogue Banks were collected, which would be necessary in the development of the storm response database as described here. These data include historical beach nourishment projects, historical erosion rates, current beach profile data, native beach sediment data, historical storm data, and economic data.

3.1.1 Historical Beach Nourishment Projects

Multiple data sources were consulted to develop a beach nourishment database for Bogue Banks, encompassing historical beach nourishment projects from 1978 to 2009. Sources included The Western Carolina Program for the Study of Developed Shorelines, North Carolina Sea Grant (Spencer Rogers), and the Carteret County Shore Protection Office. Table 7 shows the historical beach nourishment project locations, volumes, and descriptions. The historical beach nourishment projects were used to determine background erosion rates of the study area, which are required for calibration of Beach-fx and were used in discretization of the study area, as discussed in section 3.1.2 below.

3.1.2 Erosion Rates

The most recent set of erosion rates developed by the North Carolina Division of Coastal Management (DCM) was downloaded from the coastal hazards GIS data portion of the DCM website (http://dcm2.enr.state.nc.us/Maps/chdownload.htm). Using the digitized shorelines from a historical database compiled by DCM, long term erosion rates were calculated every 50 meters along the shoreline. Shoreline change was calculated based on the distance between the earliest shoreline archived (typically from the 1940s) and the 1998 shoreline. Raw erosion rates were then calculated by dividing the distance between the two shorelines by the numbers of years between them. The 1998 raw erosion rates calculated by DCM are presented in Figure 22.

Fiscal Year	Placement Location	Volume (cy)	Project Description
1978	Fort Macon	1,179,600	Dredge Disposal to Eastern Bogue Banks (MCH Inner Habor Maintenance)
1984	Western Emerald Isle	15,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1986	Atlantic Beach	4,168,600	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
1987	Western Emerald Isle	30,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1989	Emerald Isle	45,399	USACE Navigation Dredging
1990	Western Emerald Isle	56,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1993	Western Emerald Isle	17,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1994	Fort Macon	2,192,268	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
1994	Atlantic Beach	2,472,132	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
1995	Western Emerald Isle	33,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1996	Western Emerald Isle	71,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1997	Western Emerald Isle	39,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
1999	Western Emerald Isle	48,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
2000	Western Emerald Isle	16,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
2002	Fort Macon	209,348	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
2002	Indian Beach (reach 1)	456,994 (total)	Bogue Banks Restoration - Phase I -R1
2002	Indian Beach (reach 2)	456,994 (total)	Bogue Banks Restoration - Phase I -R2
2002	Pine Knoll Shores (reach 3)	1,276,586	Bogue Banks Restoration - Phase I -R3
2003	Western Emerald Isle	59,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
2003	Eastern Emerald Isle	1,867,726	Bogue Banks Restoration - Phase II
2004	Eastern Emerald Isle (east reach)	156,000 (total)	Isabel Sand Replenishment-East Reach
2004	Eastern Emerald Isle (mid reach)	156,000 (total)	Isabel Sand Replenishment-Mid Reach
2004	Eastern Emerald Isle (west reach)	156,000 (total)	Isabel Sand Replenishment-West Reach
2004	Indian Beach/Salter Path	699,282	Section 933 - Phase I
2005	Fort Macon	530,729	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
2005	Atlantic Beach	2,390,000	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
2005	Western Emerald Isle	690,868	Bogue Banks Restoration-Phase III
2006	Western Emerald Isle	77,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle
2007	Emerald Isle (reach 1)	262,080	Ophelia Sand Replenishment-Reach 1
2007	Emerald Isle (reach 2)	307,080	Ophelia Sand Replenishment-Reach 2
2007	Indian Beach/Salter Path (reach 3)	298,604	Ophelia Sand Replenishment-Reach 3
2007	Pine Knoll Shores (reach 4)	59,560	Ophelia Sand Replenishment-Reach 4
2007	Pine Knoll Shores (reach 5)	180,236	Ophelia Sand Replenishment-Reach 5
2007	Pine Knoll Shores	920,000	Section 933-Phase II
2007	Fort Macon	211,000	Dredge Disposal to Eastern Bogue Banks (MCH Inner Harbor Maintenance)
2009	Western Emerald Isle	74,000	Dredge Disposal from Bogue Inlet AIWW Crossing to Western Emerald Isle

Table 7 Historic Beach Nourishment Activities

The 1998 erosion rates calculated by DCM are influenced by multiple nourishment projects completed prior to 1998. Areas of Bogue Banks which may be affected are western Emerald Isle, Atlantic Beach, and Fort Macon. According to the beach nourishment database (Table 7) approximately 306,400 cy of material was used in beach nourishment projects along western Emerald Isle prior to 1998. Approximately 10,012,600 cy of material was placed along Atlantic Beach and Fort Macon prior to 1998 (3,371,868 cy along Fort Macon and 6,640,732 cy along Atlantic Beach). This nourishment material influences the rates calculated in these areas by creating artificial accretion or reduced apparent erosion. For the purposes of this project, erosion rates calculated by DCM were adjusted in these areas to account for accretion added by nourishment projects, resulting in the natural background erosion rate to be used in Beach-fx. Adjustments were made by dividing the total amount of material placed in each region prior to 1998 by the length over which it was placed and the number of years over which the original shoreline change was calculated. The resulting value, in cy/ft/yr, was then divided by a factor of 1.0 cy/ft which is an approximation of the relationship between the volume of material lost or gained (cy) and the corresponding response of the shoreline change (ft) in this region. Therefore, for every 1.0 cy of material lost (or gained), the shoreline erodes 1 ft (or accretes 1 ft). Using this coefficient allows for the volume of nourishment material (cy) prior to 1998 to be converted to shoreline accretion (ft). Since much of the nourishment material would have been spread along the beach, through natural littoral processes, by the time the 1998 shoreline was digitized, a diffusion factor was used to account for material from the nourishment projects being transported to the adjacent shoreline. It was calculated that the half life of each of the projects was reached before 1998. Therefore, 50 percent of the original nourishment amount for each project was spread along adjacent shorelines while the other 50 percent remained within the original project limits. The accretion provided by the nourishment projects at each 50 m transect was then subtracted from the DCM raw rates to get the background erosion rate.

The adjusted erosion rates are presented in Figure 23 and plotted against the original raw erosion rates in Figure 24. The adjusted erosion rates were used as a key basis for discretizing the study area for SBEACH modeling. They were also used as Beach-fx input and calibration information for each economic reach.

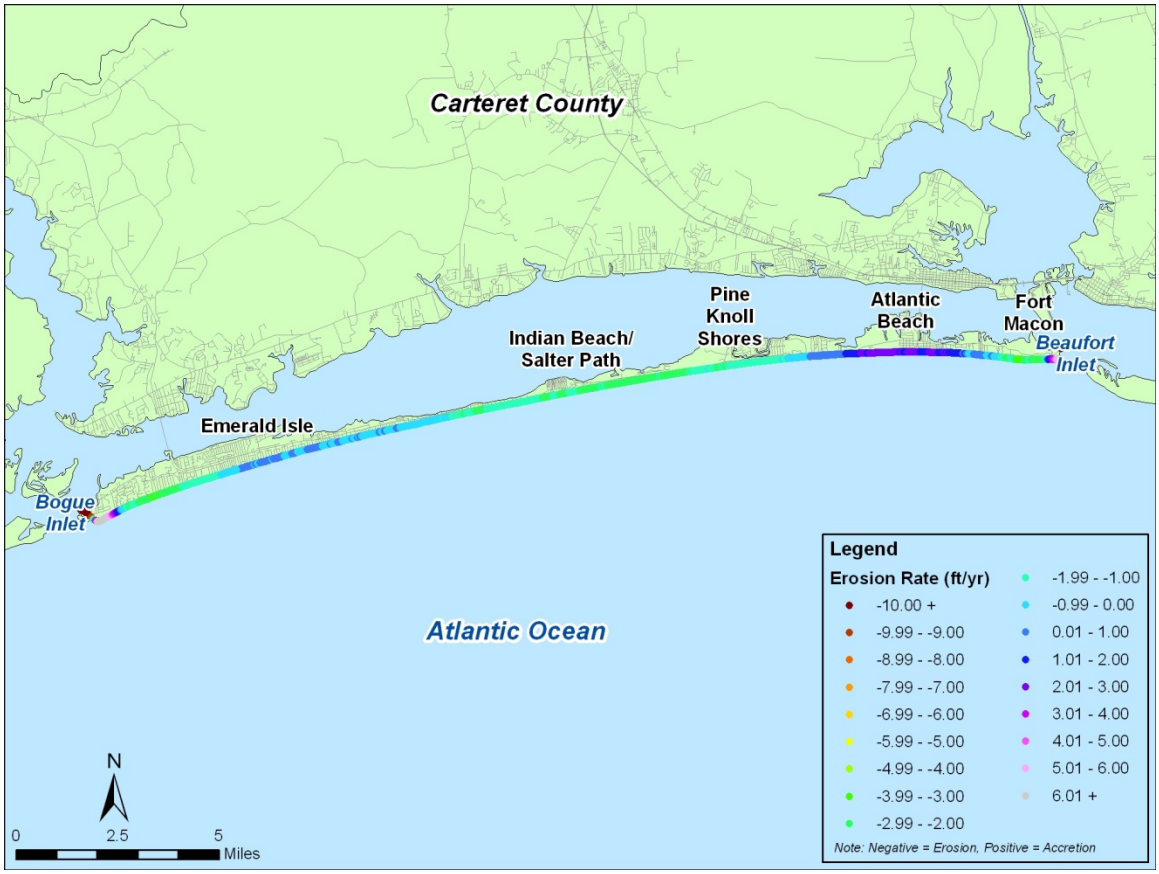

Figure 22: 1998 DCM Raw Erosion Rates

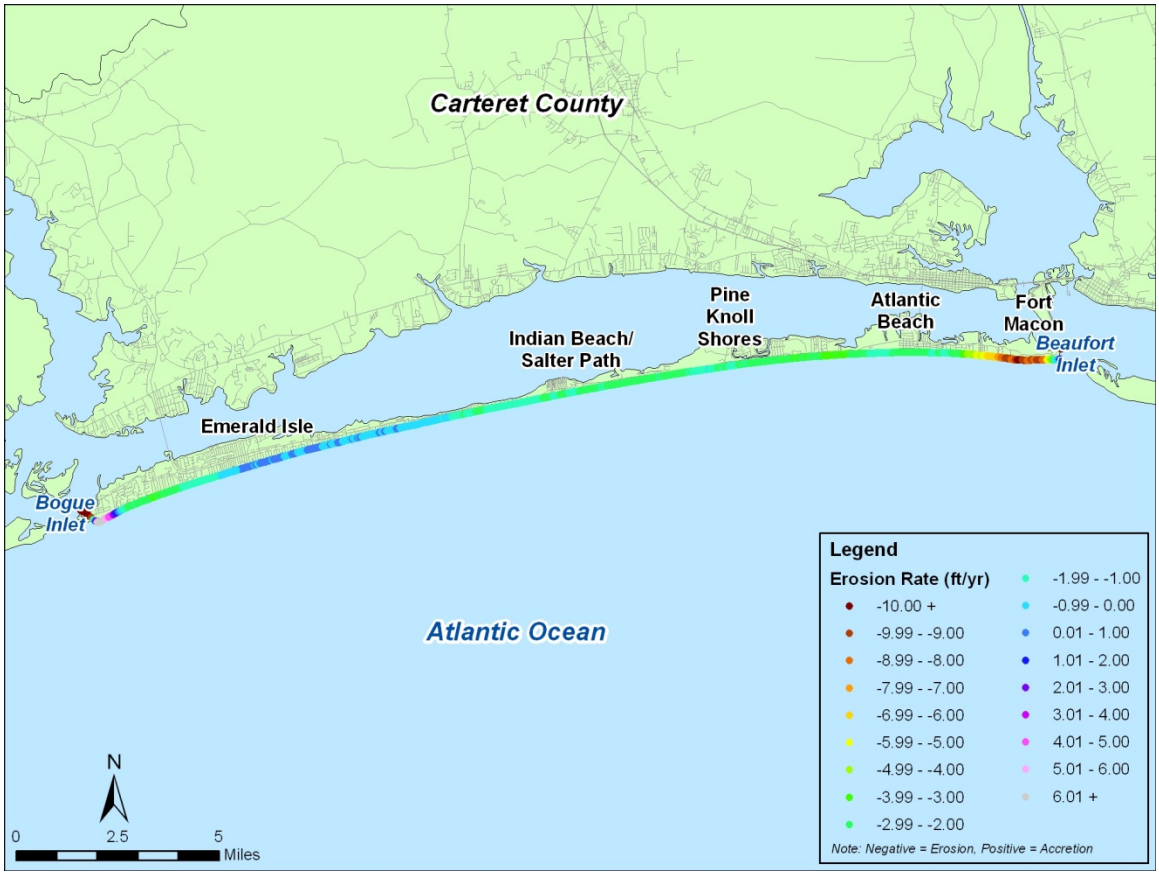

Figure 23: Adjusted Erosion Rates

Figure 24: Raw and Adjusted Erosion Rates

3.1.3 Survey Profile Data

As part of the Carteret County funded Bogue Banks Beach and Nearshore Mapping Program (BBBNMP), beach surveys are performed along Bogue Banks each spring/summer. Most recently, the beach was surveyed in June 2009 by Geodynamics. From Bogue Inlet to Beaufort Inlet, 112 transects were surveyed with a spacing of approximately 1000 ft. Both topographic and hydrographic data were collected at each transect. The survey was referenced in NAD 1983 State Plane North Carolina (ft), with a vertical datum of NAVD 1988. The location of the program transects and their associated regions are presented in Figure 25. The most recent set of data (June 2009) served as the basis from which representative profiles were developed for the existing conditions SBEACH model.

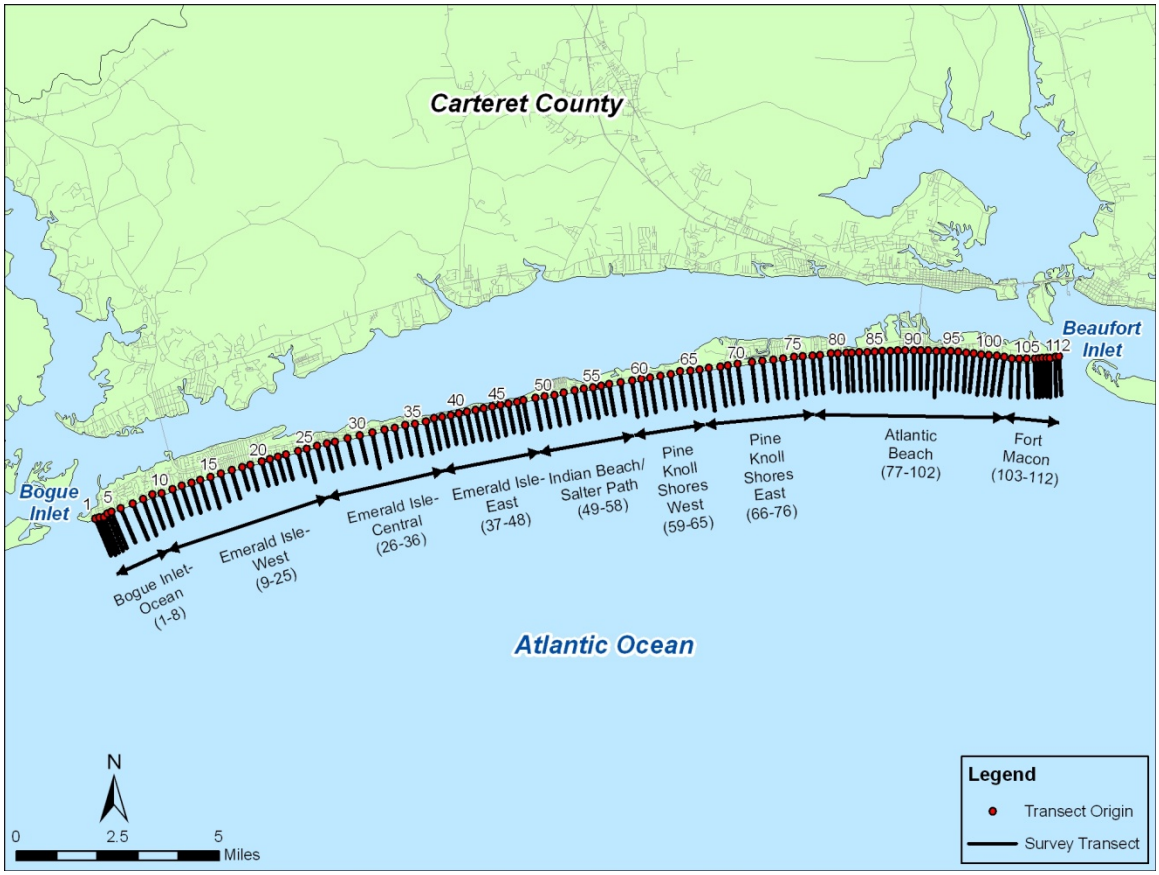

Figure 25: BBBNMP Survey Transect Locations and Regions

3.1.4 Sediment Data

In 2001, sediment along Bogue Banks was sampled by the USACE to determine native grain size. The results are presented in Table 8. This set of data served as the basis for determination of grain size input for SBEACH. Greater detail regarding sediment analysis is available within the Appendix C (Geotechnical Appendix) of this report.

Region	Native Grain Size (mm)
Bogue Inlet Area	0.19
West Emerlad Isle	0.19
East Emerald Isle	0.20
Indian Beach	0.20
Pine Knoll Shores	0.19
Atlantic Beach	0.19
Fort Macon	0.22

Table 8: Bogue Banks Native Mean Grain Size Data (2001)

3.1.5 Storm Data

The storm dataset used in this analysis was developed based on the storm surges identified by the Dredging Research Program (DRP-1-17, Scheffner, 1994). This research included all storm surge time-series from 1890 through 1990. These data were then supplemented with ADCIRC hindcast data to include hurricanes through 1999, including named hurricanes Bertha, Fran, Dennis, Floyd, Bonnie, and Irene. Storms within the database were selected based on the Peak Over Threshold method with the minimum wave height of 2 feet and minimum duration of 12 hours. The complete dataset contains 35 tropical storms occurring from 1893 to 1999 and 23 extratropical storms occurring from 1978 to 1992. Peak surges ranged from 0.3 ft to 16.2 ft for tropical storms and 0.4 ft to 1.4 ft for extratropical storms. Table 9 shows a list of the storms included in the dataset.

Tropical Storms		Extratropical Storms	
10/3/1893	8/27/1971	1/9/1978	3/1/1987
10/20/1910	6/21/1972	1/26/1978	12/8/1989
9/18/1928	9/5/1979 (David)	9/2/1978	11/10/1990
10/2/1929	8/20/1981	3/24/1979	12/4/1990
9/12/1930	6/19/1982	11/26/1979	12/10/1992
9/5/1935	9/12/1984 (Diana)	1/13/1980	
8/2/1944	9/27/1985 (Gloria)	3/13/1980	
10/19/1944	11/23/1985	10/24/1980	
9/24/1947	9/22/1989 (Hugo)	11/27/1980	
9/27/1953	6/6/1995	12/28/1980	
10/15/1954 (Hazel)	7/12/1996 (Bertha)	3/23/1981	
8/12/1955 (Connie)	9/6/1996 (Fran)	10/25/1982	
8/17/1955 (Diane)	10/8/1996	2/14/1983	
9/19/1955 (Lone)	8/26/1998 (Bonnie)	3/18/1983	
9/27/1956	8/30/1999 (Dennis)	12/21/1983	
9/11/1960 (Donna)	9/16/1999 (Floyd)	12/1/1986	
6/11/1966 (Alma)	10/18/1999 (Irene	1/1/1987	
10/19/1968 (Gladys)		2/16/1987	

Table 9: Storm Dataset

Wave heights and periods corresponding to the storm surge events discussed above were determined from WIS hindcast data. Combined with the water level time-series, these wave height and period time-series will serve as the storm input to SBEACH for the damage analysis.

Each storm surge hydrograph was combined with a cosine representation of the astronomical tide to generate a plausible total water level elevation. Each storm surge was combined with three representative tidal ranges (spring, mean and neap) and the peak surge elevation was aligned with four tidal phases (high tide, mid-tide falling, low tide and mid-tide rising) to create suite of 12 storms of each historical storm surge hydrograph. The result is a storm database that includes 696 storm cases used in the SBEACH modeling for the storm response database.

While this analysis does include plausible non-historical storm events in the Beach-FX analysis, it is possible for additional unforeseen extreme events to occur in the future. Extreme, non-historical storm events can have significant impacts to rubble mound coastal structures where armor unit stability is dependent of extreme wave events. Extreme events are also significant for inland flood control systems involving dams and levees. However,

beach systems and coastal storm damage reduction projects involving “soft” solutions like beach nourishment are flexible and able to adjust and withstand extreme events.

Current Corps policy as outlined in The Planning Guidance Notebook (ER 1105-2-100) specifies that CSDR damage relationships are developed using actual damage data from past storm events. This policy is embodied in the Beach-FX analysis which is aimed at developing a plausible storm suite that characterizes the storm climatology at the project site. Consistent with the Walton County CSDR project, for Bogue Banks no effort was made to define or characterize extreme events rather the effort was to characterize the expected storm climatology based on the plausible storm history for the project location.

In addition to the use of the storms in SBEACH, storm data was analyzed to determine various input parameters for Beach-*fx*, as discussed in Section 2.1.6.

3.2 SBEACH Methodology

The storm response database serves as an input to the Beach-fx program. It is essentially a “look-up” table of beach profile responses to storms, to be used by Beach-fx to determine the amount of damage a particular stretch of beach may endure during a particular storm. The response of beach profiles to storms was modeled using SBEACH, an empirically based numerical simulation model which was developed by the USACE Waterways Experiment Station (WES) Coastal & Hydraulics Laboratory (CHL). The purpose of the model is to calculate two-dimensional, cross-shore beach, berm, and dune erosion under single-storm surge, wave, and wind action. The SBEACH model is based on a fundamental assumption that profile change is produced only by cross-shore processes. Therefore, longshore processes are considered uniform and neglected in calculating profile change. The most recent version of SBEACH, version 4.03, operates under CEDAS, a suite of tools developed by Veri-Tech, based on various numerical models and codes developed by CHL, now a part of the Engineering Research and Development Center (ERDC), formally WES.

The SBEACH model has potential for many applications in the coastal environment, including evaluation of design beaches for erosion and/or flood protection, evaluation of short-term beach fill performance, and preliminary input for economic analyses of beach alternatives. The main inputs to the SBEACH model include:

- Profile Data – two-dimensional description of the shoreline extending from offshore to a landward point of interest,
- Sediment Data – characterization of the average sediment size and,
- Storm Data – time dependent description of water elevation, waves, and winds (if available).
- Model Calibration Parameters – various beach characteristic and sediment transport parameters which influence beach profile change.

3.2.1 Modeling Scope

The SBEACH model provides understanding of cross shore loss of sand in the berm and/or dune following storm activity. However, SBEACH must be calibrated to the specific site conditions at which it is to be applied. For this study Hurricane Ophelia data was used for calibration since both pre- and post-storm profiles were available in addition to wave hindcast data from Oceanweather Inc. The calibrated SBEACH model was then used to evaluate the existing conditions and future response if no projects were built (without project conditions). The calibrated SBEACH model was also used to evaluate the response of various nourishment alternatives (with project conditions). Results of the without project and with project conditions were then compiled into one database, housing the responses of each of the beach profiles to various storm conditions, to be used by Beach-fx to assess damages and determine the optimal project for Bogue Banks over a 50 year project duration.

3.2.2 SBEACH Calibration Model

The SBEACH model was calibrated to reflect the storm induced impacts which occurred between surveys in May 2005 and September 2005. During this time period, Hurricane Ophelia impacted the North Carolina coast from September 5, 2005 to September 18, 2005. This storm was selected as the basis of the SBEACH calibration based on the availability of quality measured survey data and measured storm data that was not available within the established storm database discussed in Section 3.1.5. This storm event is not included in the historical storm suite used to calculate storm induced damages within Beach-FX. Calibration of SBEACH occurred subsequent to the development of the storm suite and due to project funding and time limitations the storm database was not extended to include Hurricane Ophelia and other storms between 1999 and 2005.

SBEACH is typically calibrated by establishing known inputs such as profile data, storm data, and sediment data and then adjusting the model calibration parameters, which include a number of sediment transport characteristics and other beach characteristics that influence sediment transport. Sensitivity of the model response to changes in these parameters was tested and then they were adjusted to yield the appropriate model response.

3.2.3 SBEACH Calibration Survey Profile Data

The beach profile data used for calibration was obtained from the BBBNMP. In May 2005, the annual Bogue Banks survey was completed as part of the BBBNMP. In September 2005, an additional post-storm survey was performed immediately after Hurricane Ophelia impacted the coast. This profile data was readily available from the Carteret County Shore Protection Office. The post-storm survey was performed along 29 of the 112 transects used in the BBBNMP. The measured May 2005 profile data was used as the initial beach profile for the SBEACH model input. The post-storm measured September 2005 profile was also loaded into the model to serve as a reference profile position for the model calibration.

3.2.4 SBEACH Calibration Sediment Data

According to samples taken in 2001, the native grain size of the beach ranges from 0.19 mm to 0.22 mm. Most recently, the beach was nourished in 2007 at various locations with material from the Morehead City Harbor ODMDS as part of the post-Ophelia FEMA project. This material was shown in a 2004 study to have a grain size of 0.20 mm. Therefore, for this study, the effective grain size selected for use in the SBEACH model was 0.20 mm.

3.2.5 SBEACH Calibration Storm Data

Typical storm data input for SBEACH includes storm hydrographs of total water elevation, wave conditions, and wind conditions. For this analysis, the calibration simulation involved a 13 day time series over which Hurricane Ophelia impacted the coast. Storm data was available from Oceanweather Inc. (Oceanweather) as part of their Global Reanalysis of Ocean Waves (GROW) project along the east coast. Oceanweather has developed a global long term hindcast database which has been improved and enhanced over the years in various areas including the U.S. east coast (GROW-FINE EC28km). The GROW-FINE EC28km database contains a point offshore of Emerald Isle which was used for this study (grid point 2344). Data available from this site includes wind speed and direction, wave height and direction, peak period, surge height, and current speed and direction. Figure 26 shows the location of the data point and Figure 27 shows the data retrieved from the point which was used in the SBEACH calibration model.

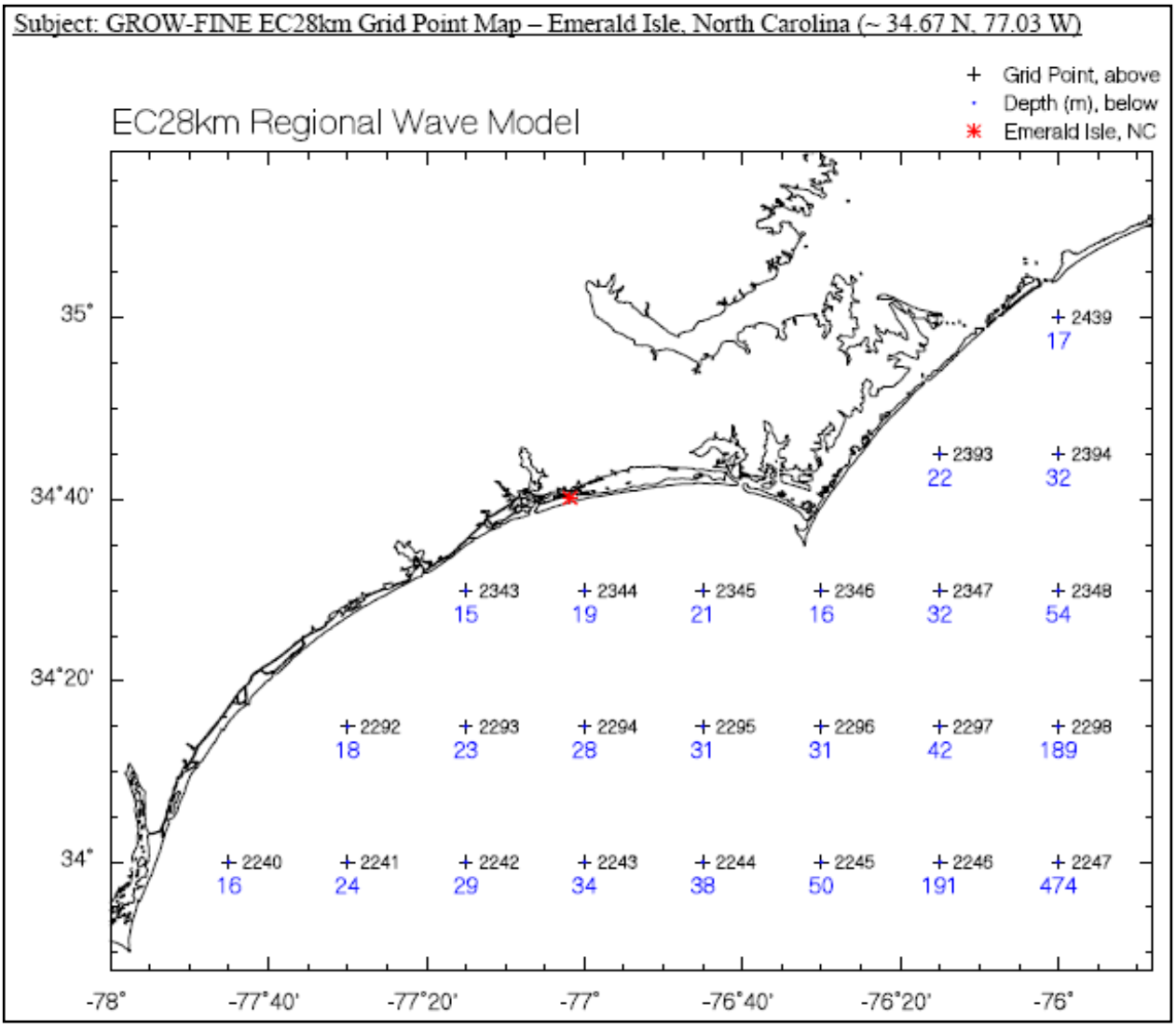

Figure 26: GROW-FINE EC28km Point Locations (Oceanweather Inc.)

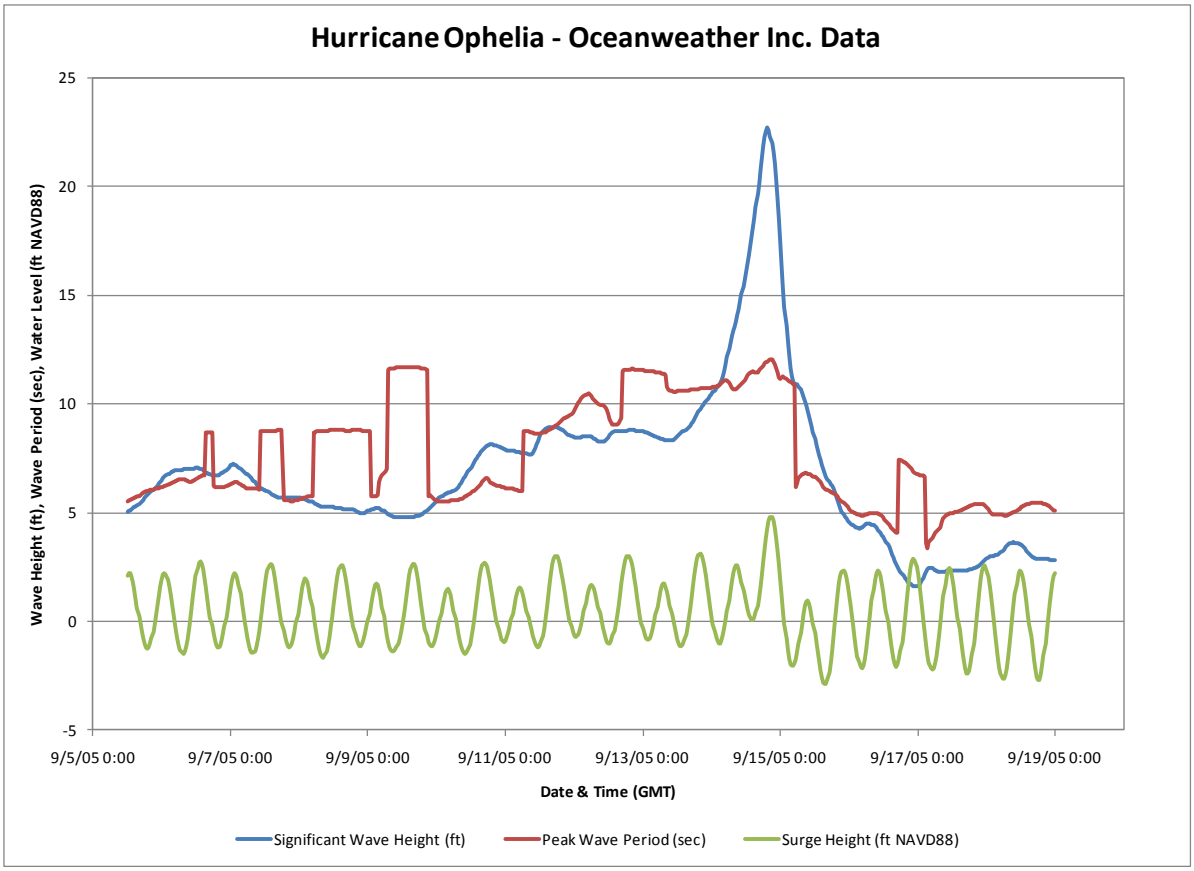

Figure 27: Grid Point 2344 Hurricane Ophelia Storm Data

3.2.6 SBEACH Calibration Parameters

SBEACH is typically calibrated by adjusting the sediment transport characteristics or beach characteristics. Sediment transport characteristics include Transport Rate Coefficient, K (m^4/N), Overwash Transport Parameter, Coefficient for Slope Dependent Term, Eps (m^2/s), Transport Rate Decay Coefficient Multiplier, and Water Temperature (°C). Beach characteristics include Landward Surf Zone Depth (ft) and Avalanche Angle (Deg).

Initially, the model was run with the default parameters. These were shown to create too much sediment transport, flattening out the beach and the outer bar. The main factor in this is the Transport Rate Coefficient, which was lowered to produce less transport of material. Other parameters changed from their defaults were the Transport Rate Decay Coefficient Multiplier, which was lowered to be in the middle of the acceptable range, and the Avalanche Angle which was set to 40 degrees and is considered a natural angle of internal friction for sand. The model calibration parameters decided on after running various model scenarios are presented in Table 10.

Beach Parameters:	Value	Units
Landward Surf Zone Depth	1	ft
Maximum Slope Prior to Avalanching	40	deg
Sediment Transport Parameters:	**Value**	**Units**
Transport Rate Coefficient	2.50E-07	m^4/N
Overwash Transport Parameter	0.005	
Coefficient for Slope-Dependent Term	0.002	m^2/S
Transport Rate Decay Coeffcient Multiplier	0.3	
Water Temperature	20	Deg C

Table 10: SBEACH Calibration Parameters

3.2.7 SBEACH Calibration Results

An example comparison of the initial profile (May 2005), final SBEACH model profile, and the measured final profile (September 2005) is shown in Figure 28 for one of the 29 transects containing pre- and post- storm profile data.

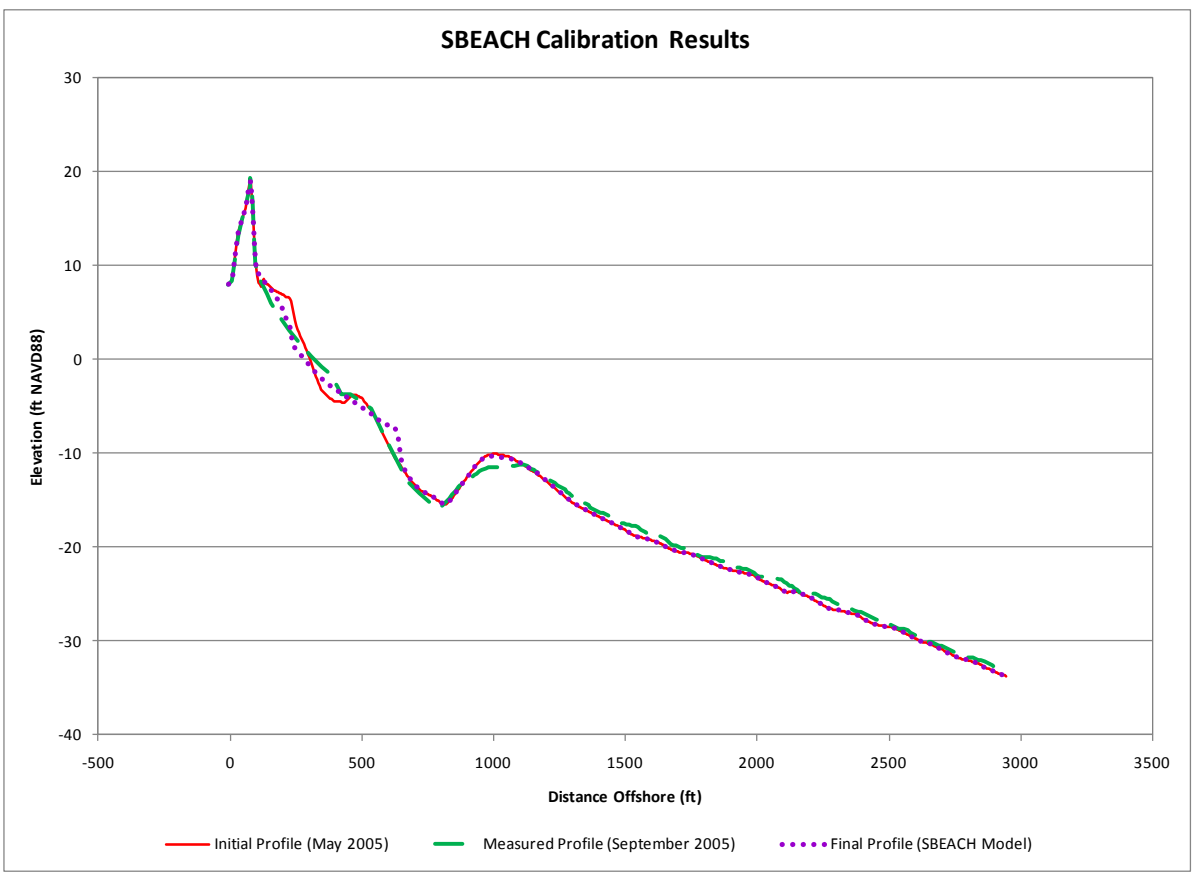

Figure 28: SBEACH Calibration Model Results

The amount of time between measured profiles (approximately 4 months) presented an issue with calibration which could only be run for Hurricane Ophelia (13 days) due to available data and the limits of SBEACH to only predict storm induced beach change. The offshore bar tends to move less in SBEACH simulations. Additionally, the SBEACH model does not account for longshore sediment transport, which may have been significant during the period modeled. However, the SBEACH model simulates change in the berm and dune region of the profile, holding offshore profiles fairly consistent over time.

3.3 SBEACH Results and Analysis

3.3.1 SBEACH Reach and Profile Development

After determining the SBEACH calibration coefficients, an existing conditions model was developed to estimate the initial cross shore beach change that Bogue Banks would experience from a variety of storms if no new projects were built. This process involved discretizing the study area into SBEACH analysis reaches, developing representative profiles for the existing conditions of each reach, idealizing the existing conditions profiles to fit within the Beach-*fx* framework, and creating an existing conditions matrix of profiles to be run in SBEACH. The corresponding results would encompass a range of beach responses that might take place over a 50 year period without any projects being built.

The study area was discretized primarily using long term erosion rates and beach profile shape. This resulted in 13 stretches of beach, known as SBEACH analysis reaches, with 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. The boundaries of each SBEACH analysis reach were made to coincide with the limits of the economic reaches provided by the USACE for ease of use in Beach-*fx*, allowing for each economic reach to be assigned to only one of the SBEACH analysis reach profiles. Figure 29 shows the limits of each SBEACH analysis reach plotted with the adjusted long term erosion rates. The survey transects from the BBBNMP located within each SBEACH analysis reach are also noted, as they will be used in development of the representative profiles for each SBEACH analysis reach as described in the following section.

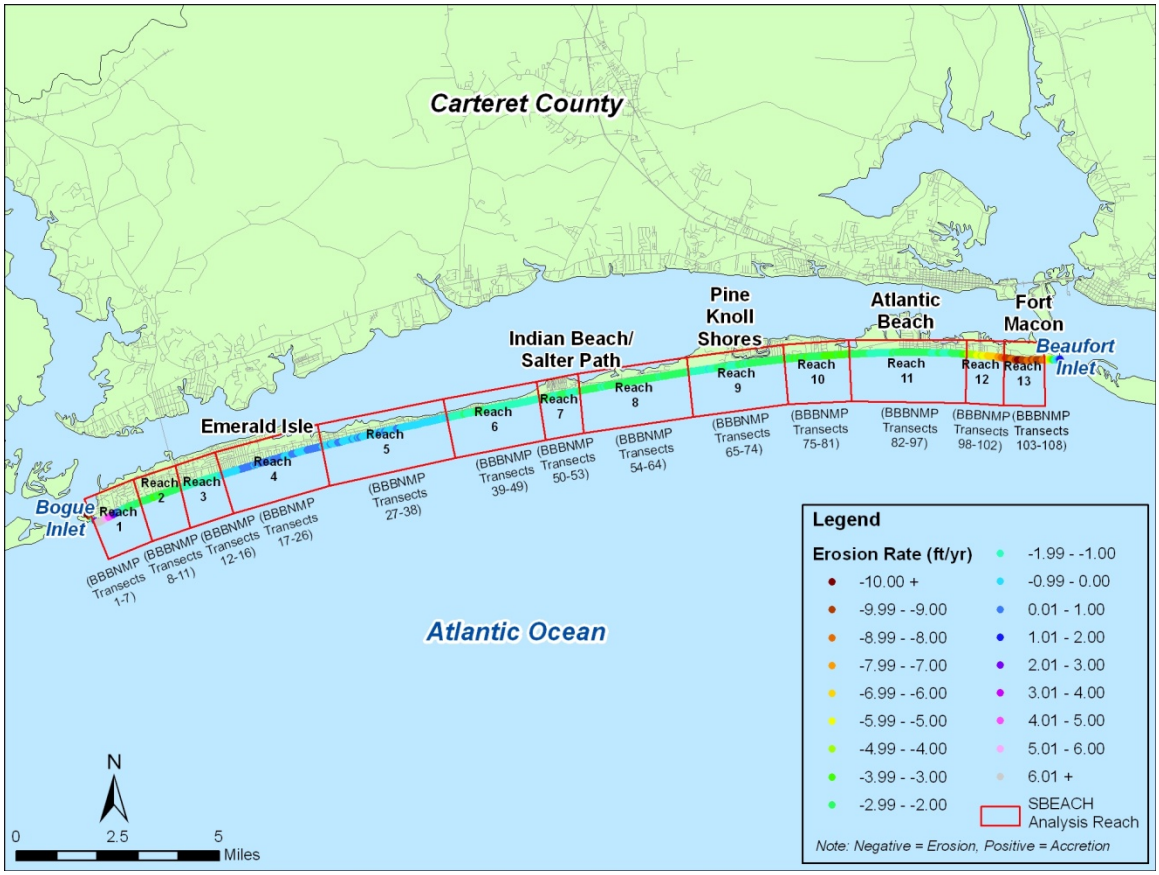

Figure 29: SBEACH Analysis Reaches

Overall average profiles were created for each of the 13 SBEACH analysis reaches using beach profile analysis tools in BMAP (Beach Morphology Analysis Package), located within the suite of CEDAS tools. BBBNMP survey profiles in each SBEACH analysis reach were split into 3 features (dune, berm/foreshore, and offshore bar) and averaged with respect to each component (Figure 30). The three components were then combined to form an overall average profile. Limitations of the survey data (not all transects went over the dune crest due to the presence of structures or dense vegetation) resulted in the averaged dune portion of the overall average profile not being representative of the dune features within each SBEACH analysis reach. Therefore, a visually inspected typical dune feature, within each SBEACH analysis reach, was selected from the raw survey data and combined with the overall average profile to create the final representative profile for each SBEACH analysis reach.

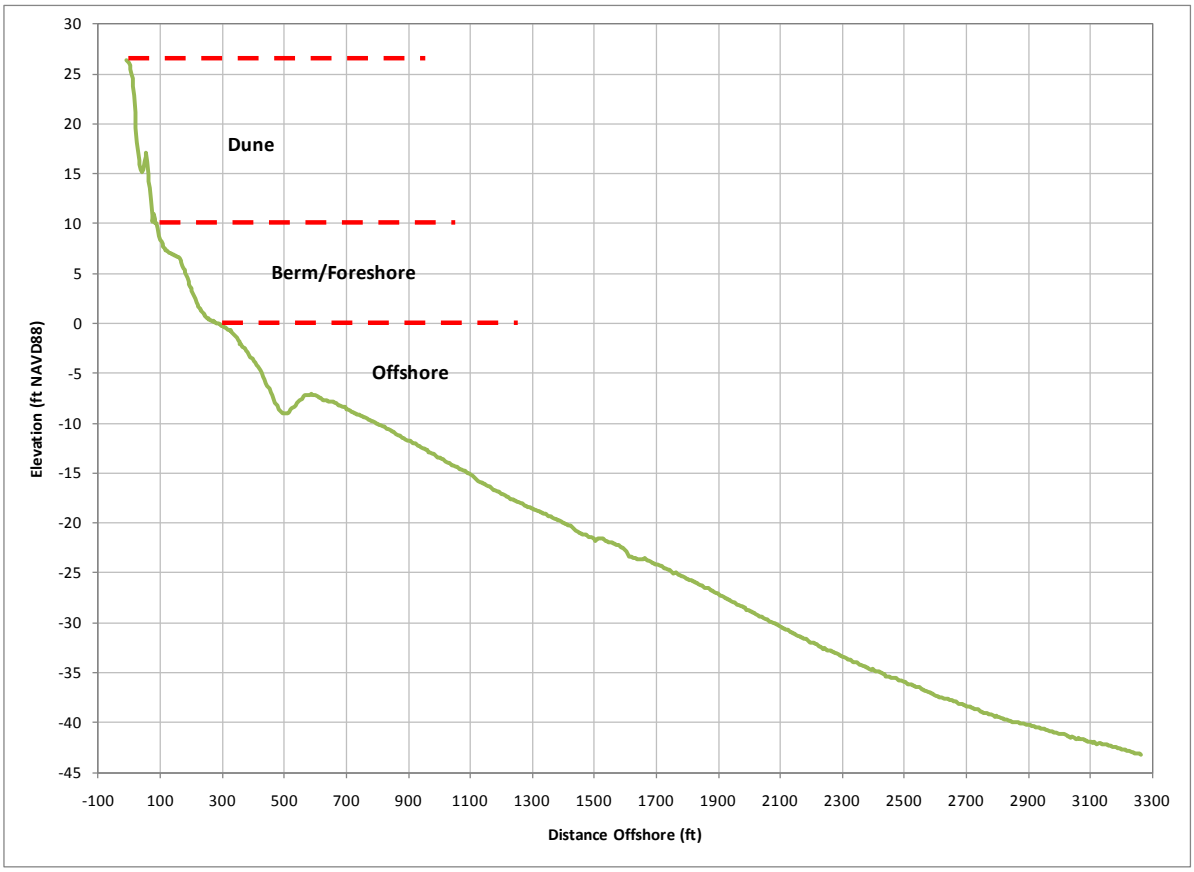

Figure 30: Profile Averaging Components

The following steps were taken to create an overall average profile and a finalized representative profile for each SBEACH analysis reach:

Step 1: Create average dune profile for each SBEACH analysis reach

- All profiles were aligned in space at an elevation representative of the dune face since not all survey profiles extended over the dune crest. This elevation ranged from +7 ft NAVD88 to +16 ft NAVD88 depending on the reach (see Table 11 for reach by reach values).
- An average was taken of the aligned profiles, creating the representative average dune feature for each reach.

Step 2: Create average berm/foreshore profile for each SBEACH analysis reach

- All profiles were aligned in space at an elevation representative of the berm/foreshore. This elevation was chosen to be +3 ft NAVD88 for all reaches.
- An average was taken of the aligned profiles, creating the representative average berm/foreshore feature for each reach.

Step 3: Create average offshore bar profile for each SBEACH analysis reach

- All profiles were aligned in space at an elevation on the seaward face of the offshore bar. This elevation ranged from -8 ft NAVD88 to -13 ft NAVD88 depending on the reach (see Table 11 for reach by reach values).
- An average was taken of the aligned profiles, creating the representative average offshore bar feature for each reach.

Step 4: Combine average profiles of all three features for each SBEACH analysis reach

- Average dune and average berm/foreshore profiles were aligned at an elevation ranging from 5.5 ft NAVD88 to 11 ft NAVD88 depending on the reach (see Table 11 for reach by reach values). A combination of the two profiles was created using everything above that elevation from the average dune profile and everything below that elevation from the average berm/foreshore profile to create "upper beach" profile.
- The "upper beach" profile was then aligned at 0 ft NAVD88 with the average offshore bar profile. A combination of the two profiles was created using everything above 0 from the "upper beach" profile and everything below 0 from the average offshore bar profile to create the "overall" average profile.

Step 5: Create a final representative profile for each SBEACH analysis reach

- Given the limitations of the survey data (landward survey extent), the dune portion of the "overall" average profile was not considered to be representative of the dune feature within many of the reaches.
- Therefore, a representative dune was selected from profiles within each reach. This dune was aligned and combined with the "overall" average profile at elevations ranging from 5.5 ft NAVD88 to 11 ft NAVD88, in accordance with the elevation previously used to combine the average dune profile with the average berm/foreshore profile (see Table 11 for reach by reach values), creating the final representative averaged profile for each analysis reach.

The average and representative profiles developed for Reaches 1 through 13 are shown in Figures 31 through 43.

Reach	Elevation Used to Align Profiles and Calculate Average Dune Profile	Elevation Used to Align Profiles and Calculate Average Berm/Foreshore Profile	Elevation Used to Align Profiles and Calculate Average Offshore Profile	Elevation Used to Combine Avg Dune & Average Berm/Foreshore (Upper Beach Profile)	Elevation Used to Combine Upper Beach Profile & Average Offshore Profile	Elevation Used to Combine Representative Dune with Overall Average Profile
Reach 1	7	3	-8.5	5.5	0	5.5
Reach 2	11	3	-8	6	0	6
Reach 3	16	3	-9	9	0	9
Reach 4	13	3	-9	10	0	10
Reach 5	14.5	3	-9	11	0	11
Reach 6	14.5	3	-11	10	0	10
Reach 7	11.5	3	-12	9	0	9
Reach 8	14.5	3	-10	9	0	9
Reach 9	13.5	3	-11	9	0	9
Reach 10	15	3	-10.5	9	0	9
Reach 11	11	3	-12	9	0	9
Reach 12	12	3	-10	9	0	9
Reach 13	14	3	-13	9	0	9

Table 11: Elevations Used to Develop Overall Average Profiles for Each Analysis Reach

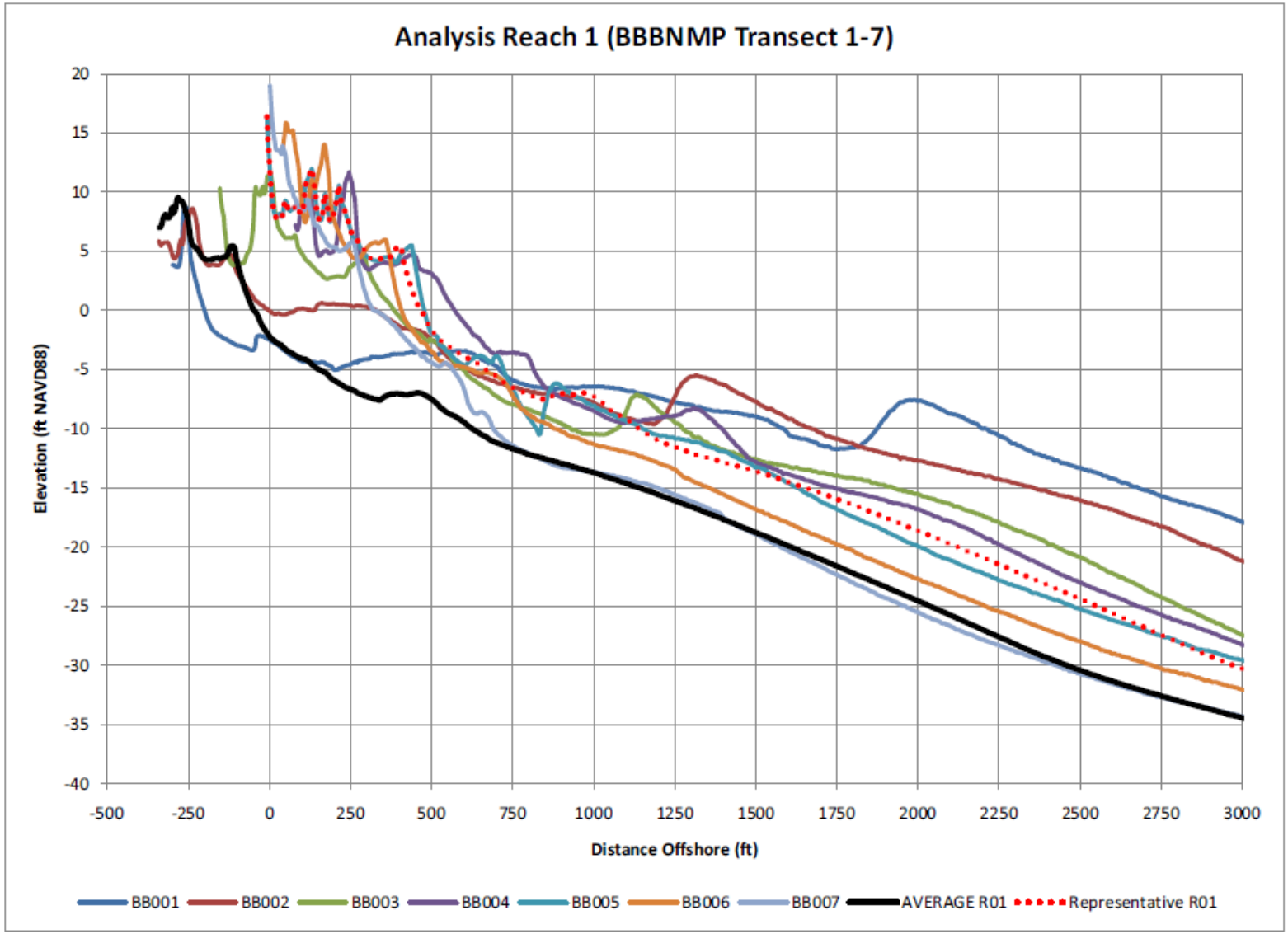

Figure 31 Reach 1 Representative Profile Development

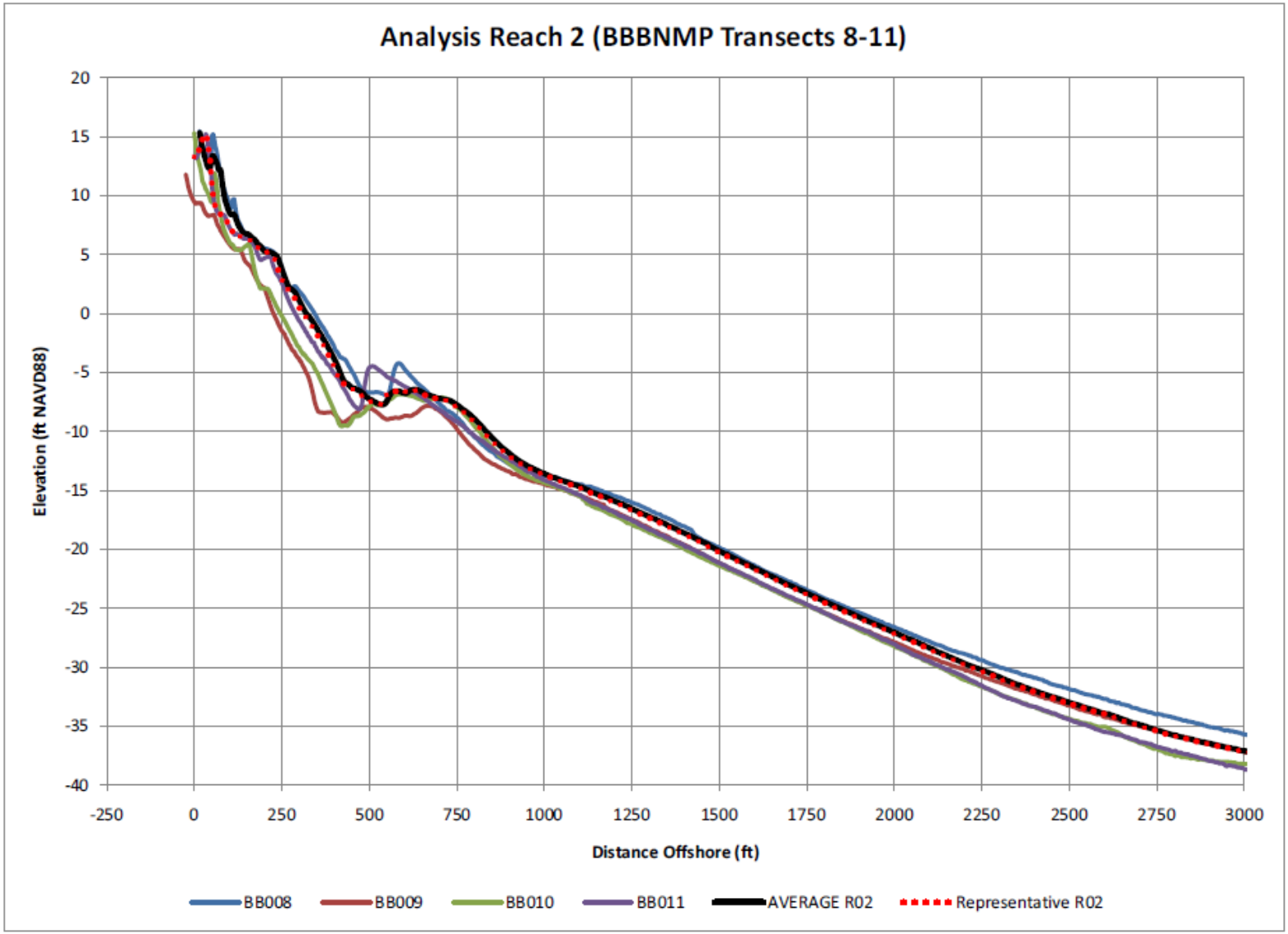

Figure 32 Reach 2 Representative Profile Development

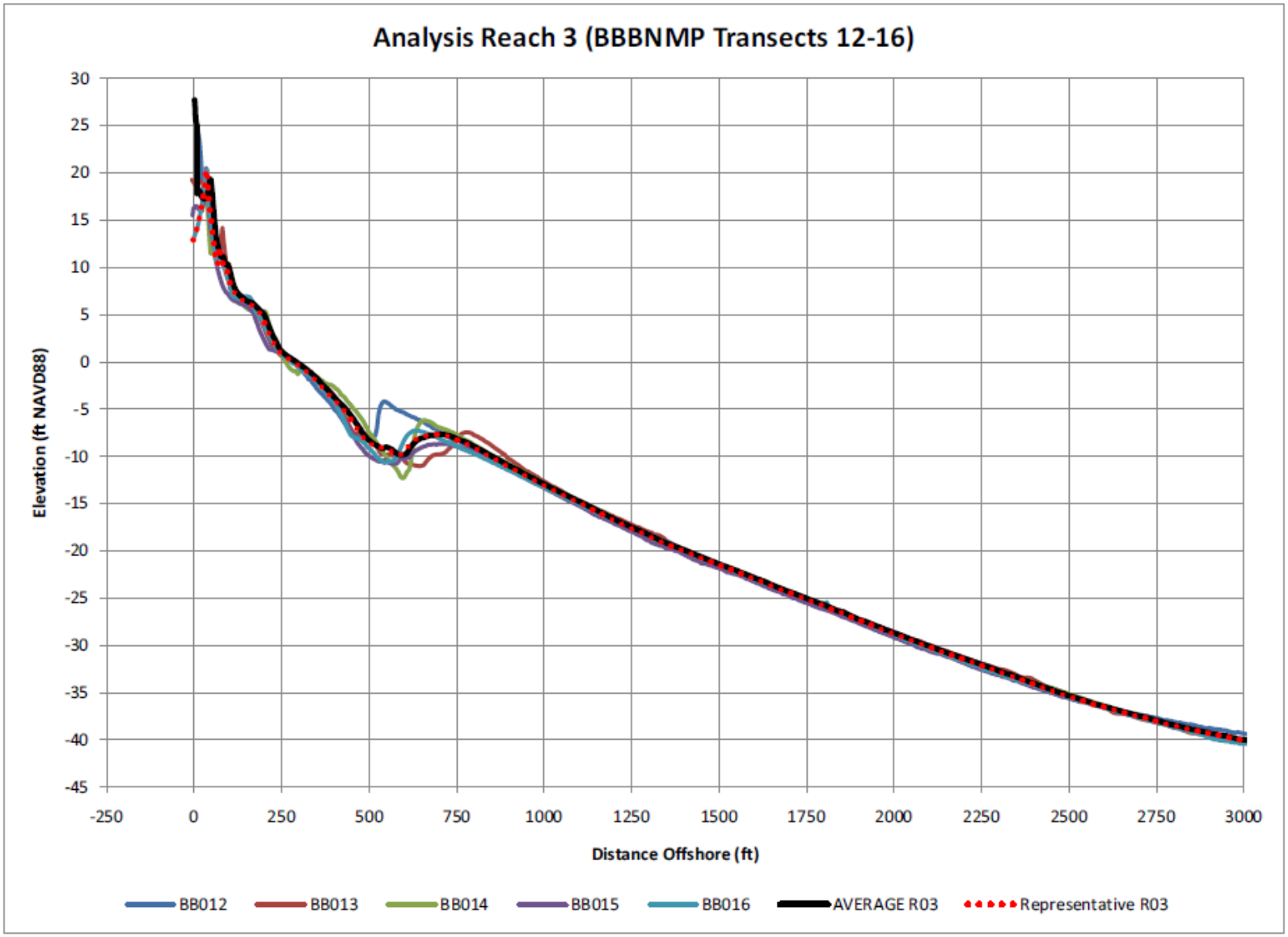

Figure 33 Reach 3 Representative Profile Development

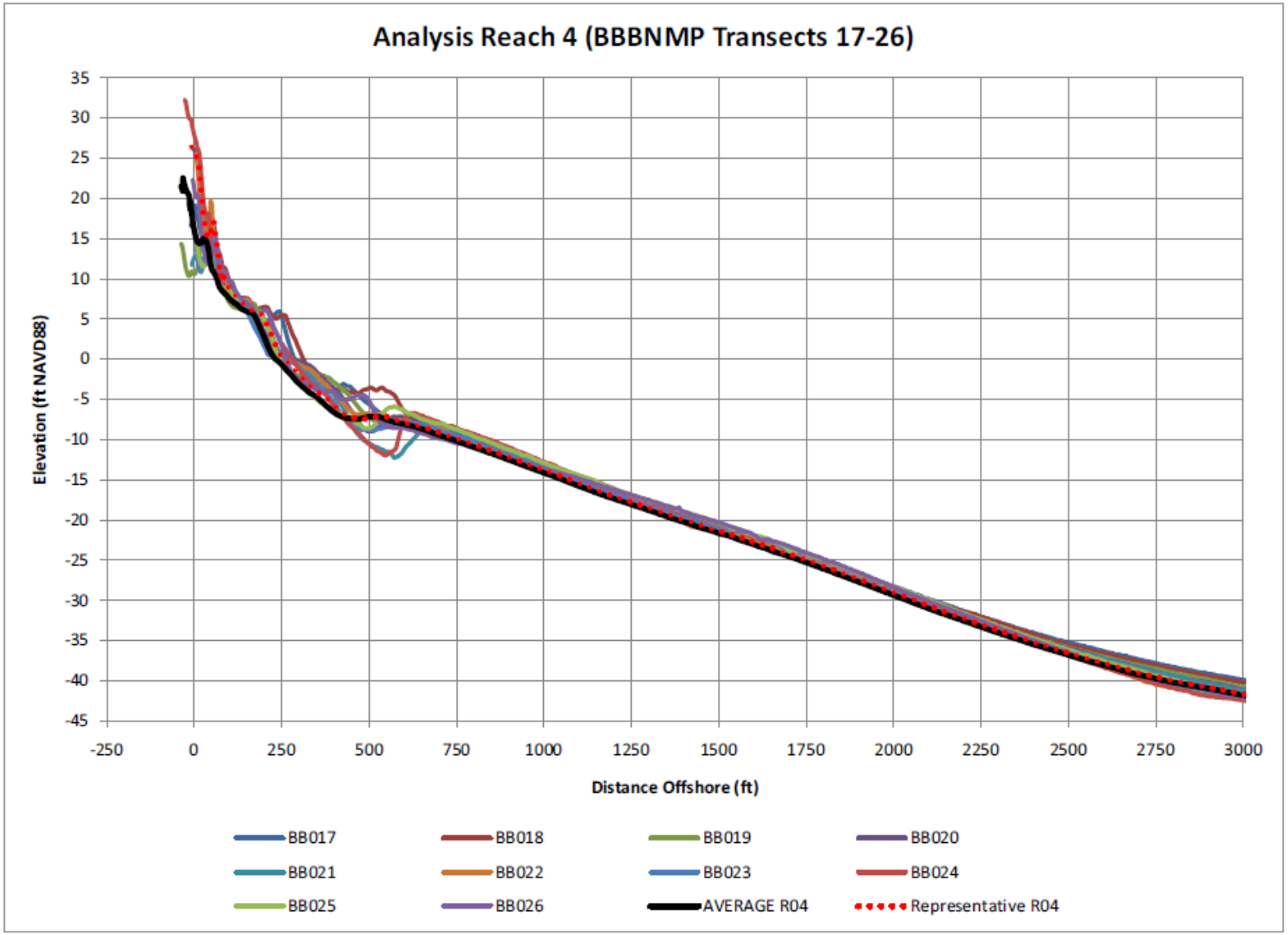

Figure 34 Reach 4 Representative Profile Development

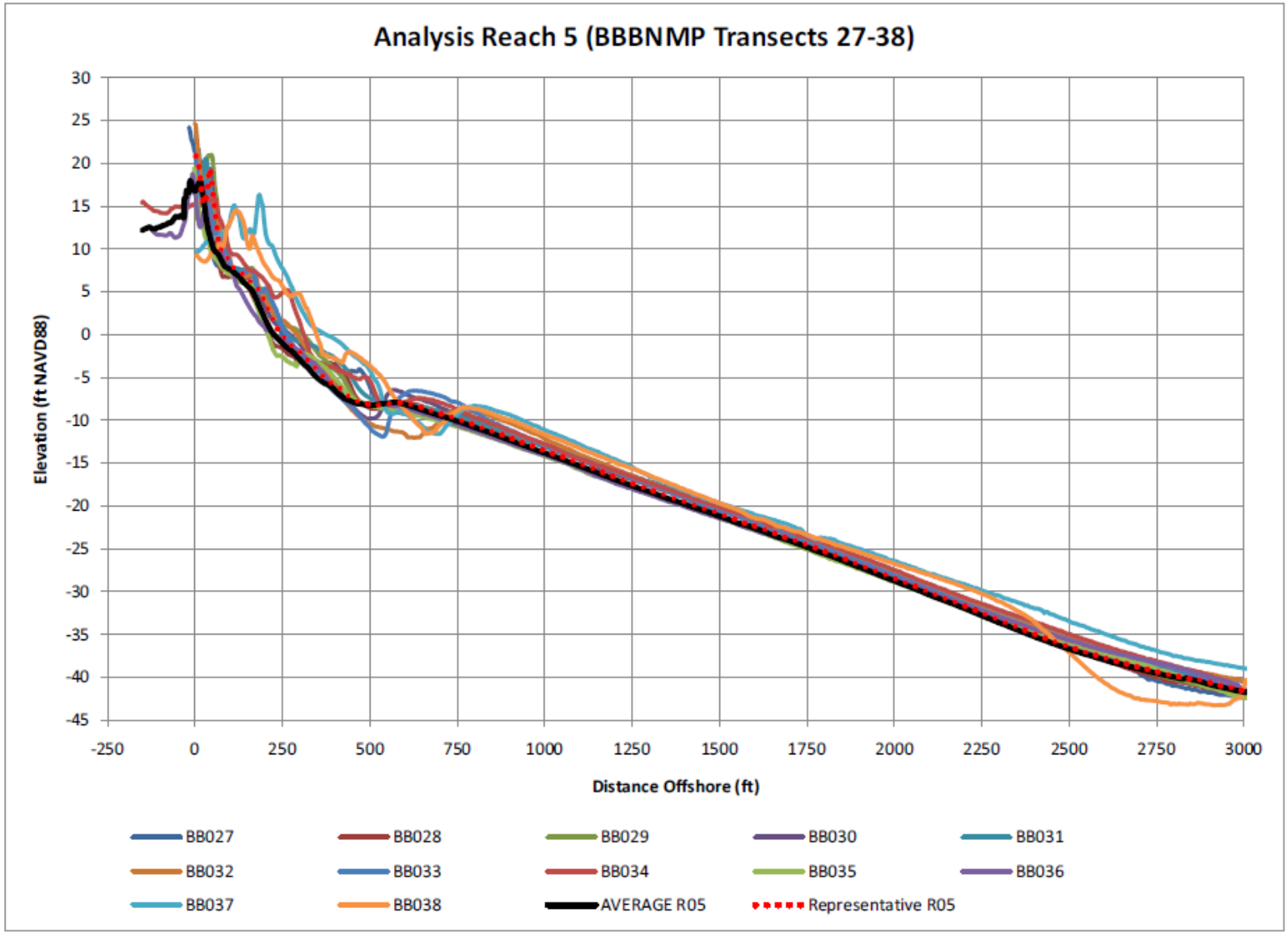

Figure 35 Reach 5 Representative Profile Development

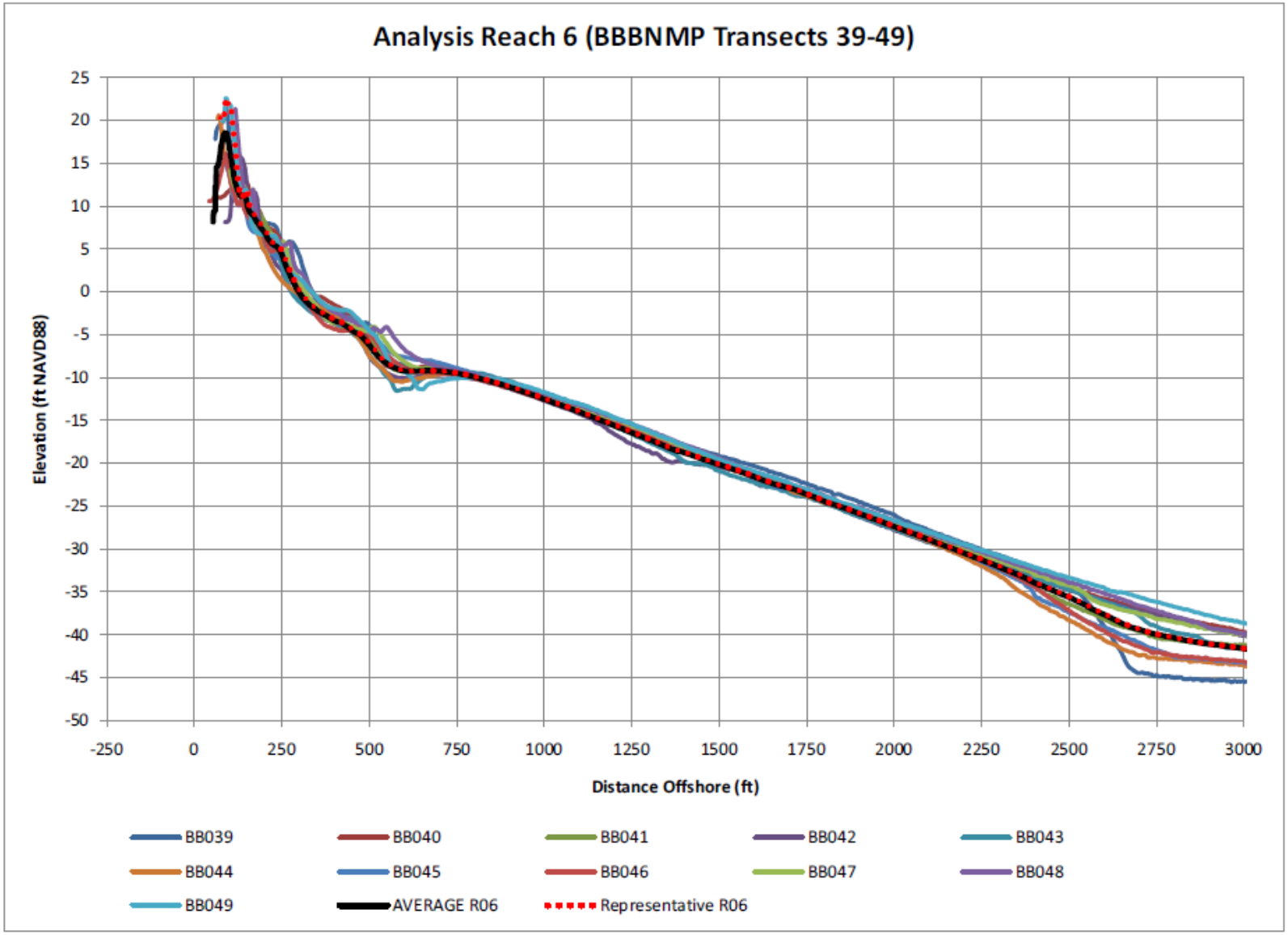

Figure 36 Reach 6 Representative Profile Development

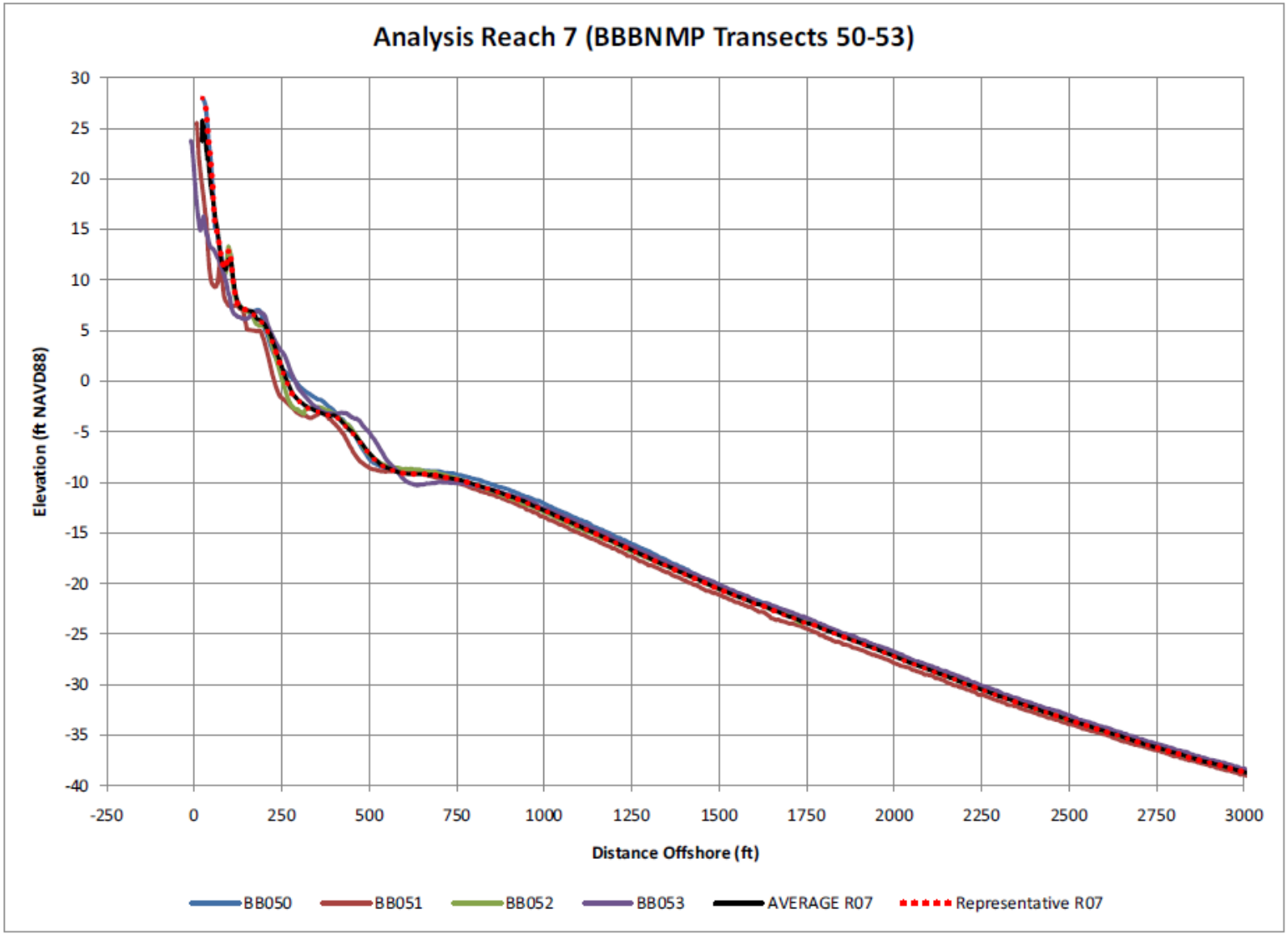

Figure 37 Reach 7 Representative Profile Development

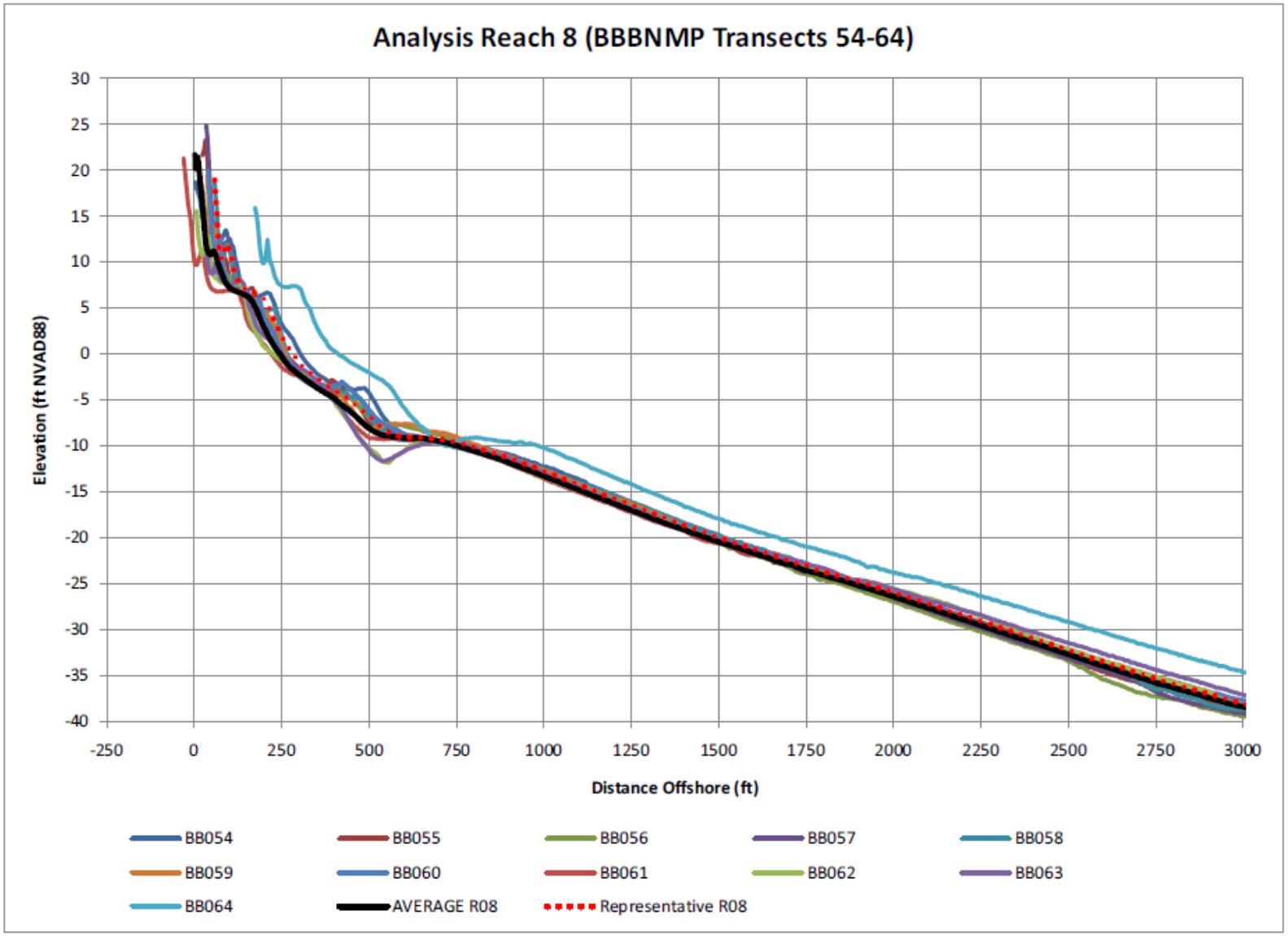

Figure 38 Reach 8 Representative Profile Development

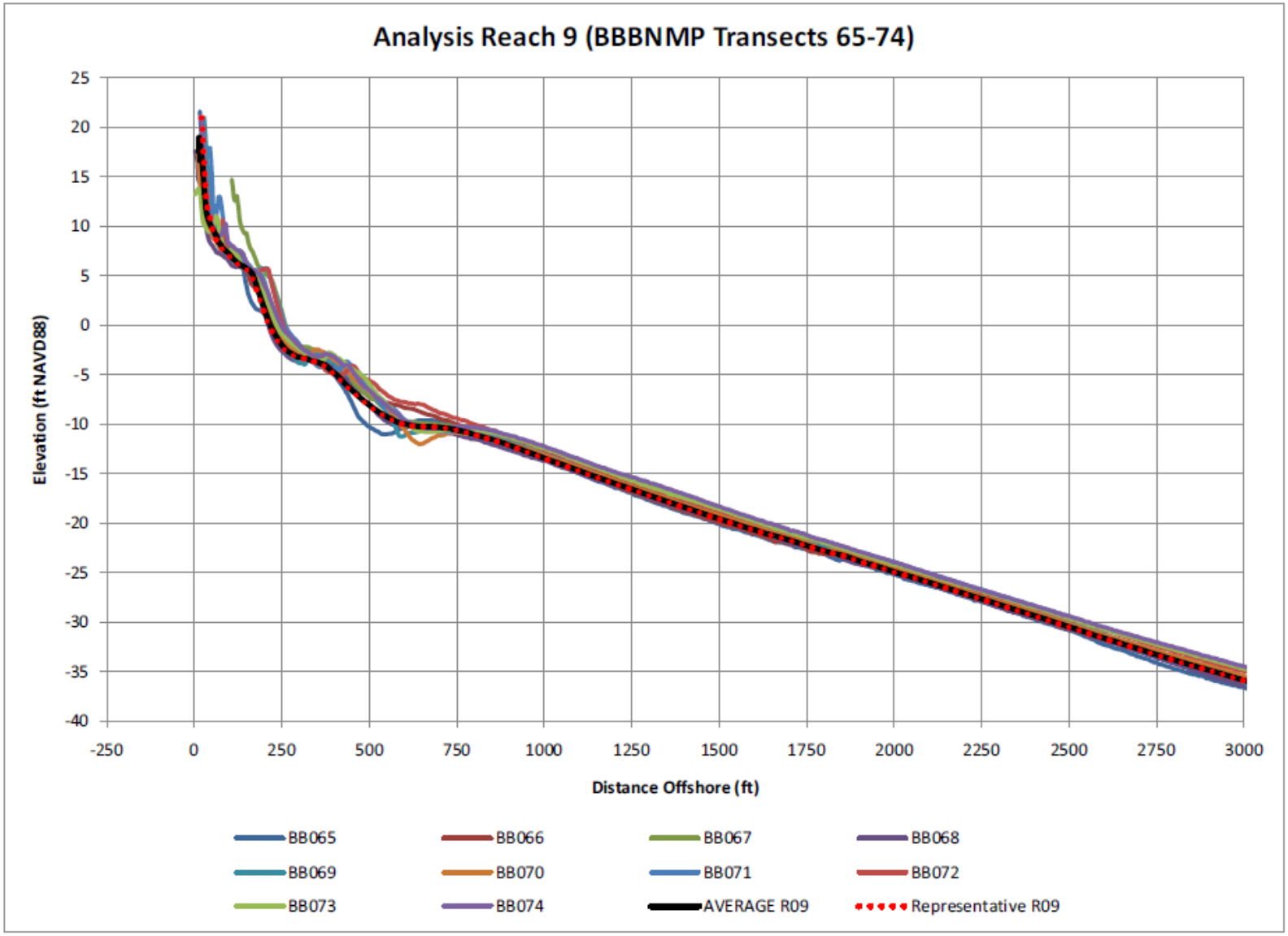

Figure 39 Reach 9 Representative Profile Development

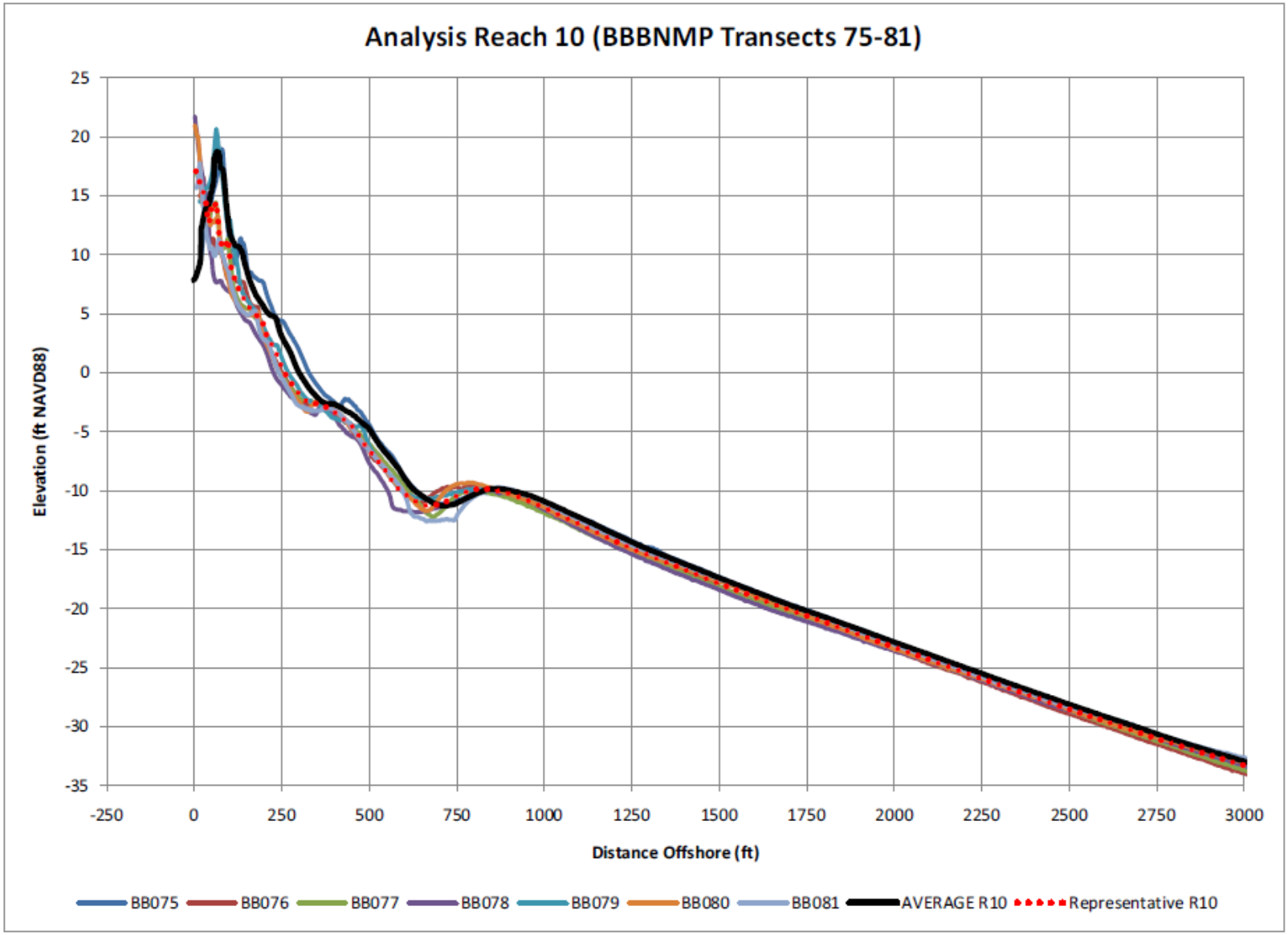

Figure 40 Reach 10 Representative Profile Development

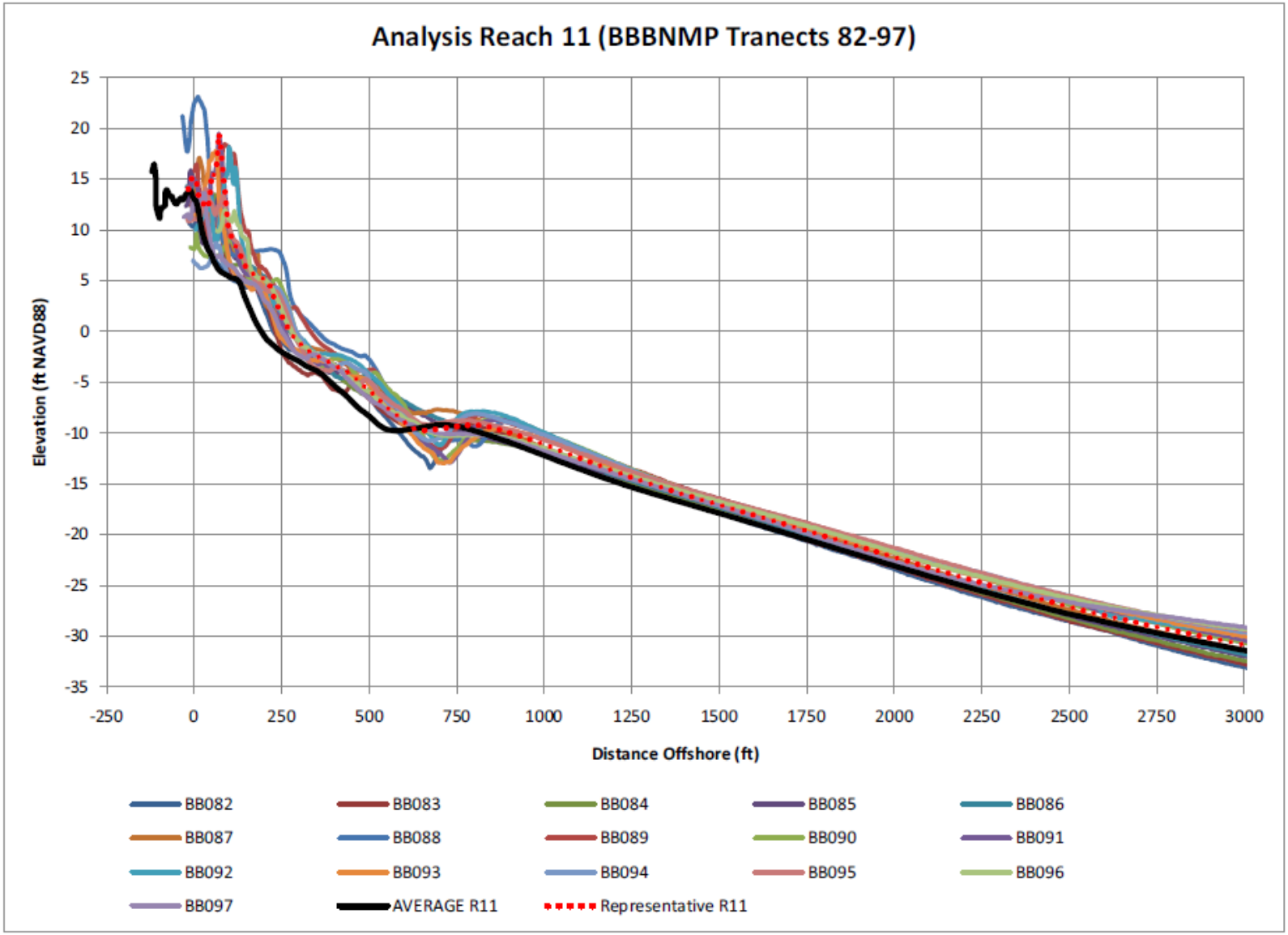

Figure 41 Reach 11 Representative Profile Development

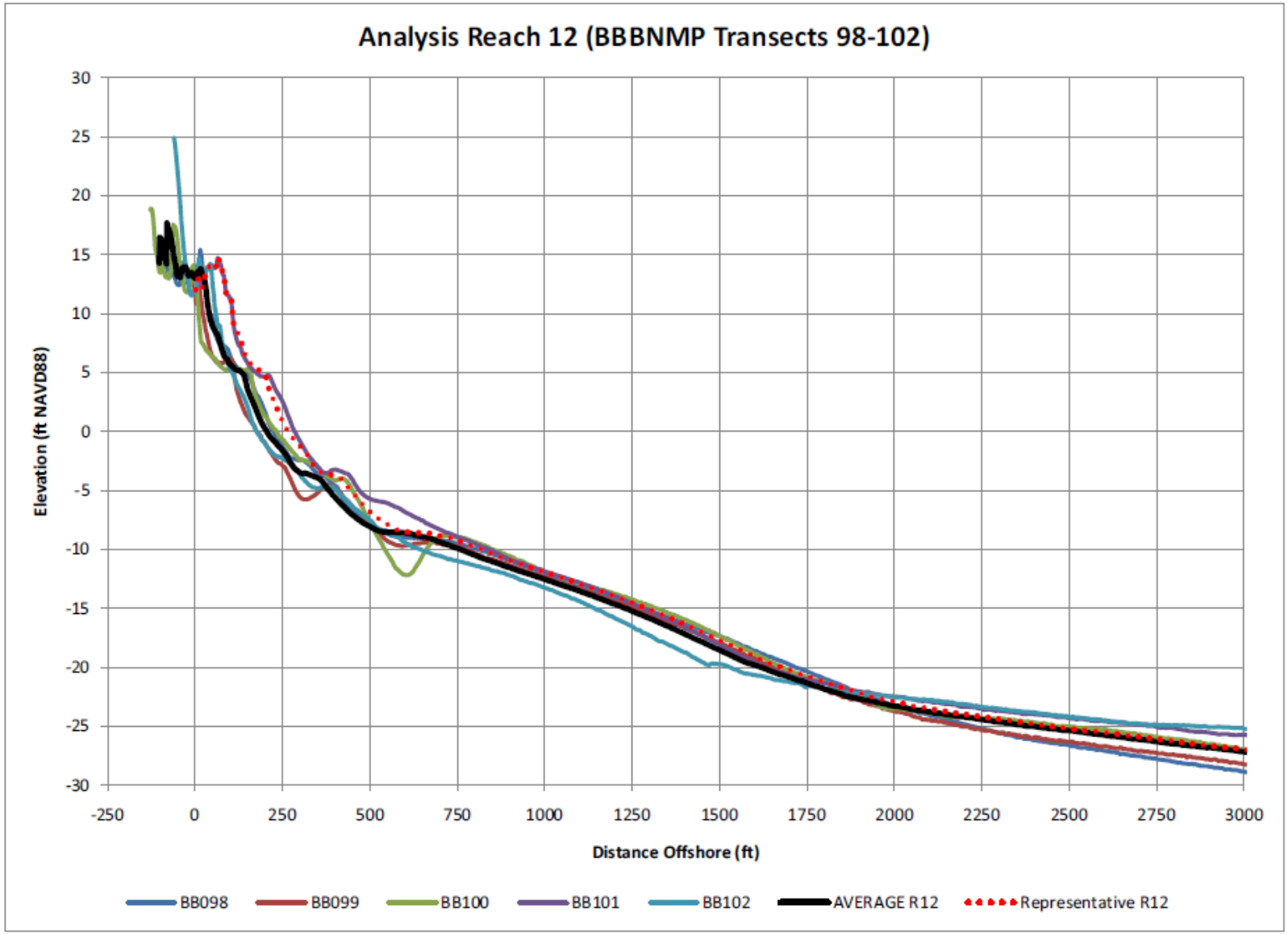

Figure 42 Reach 12 Representative Profile Development

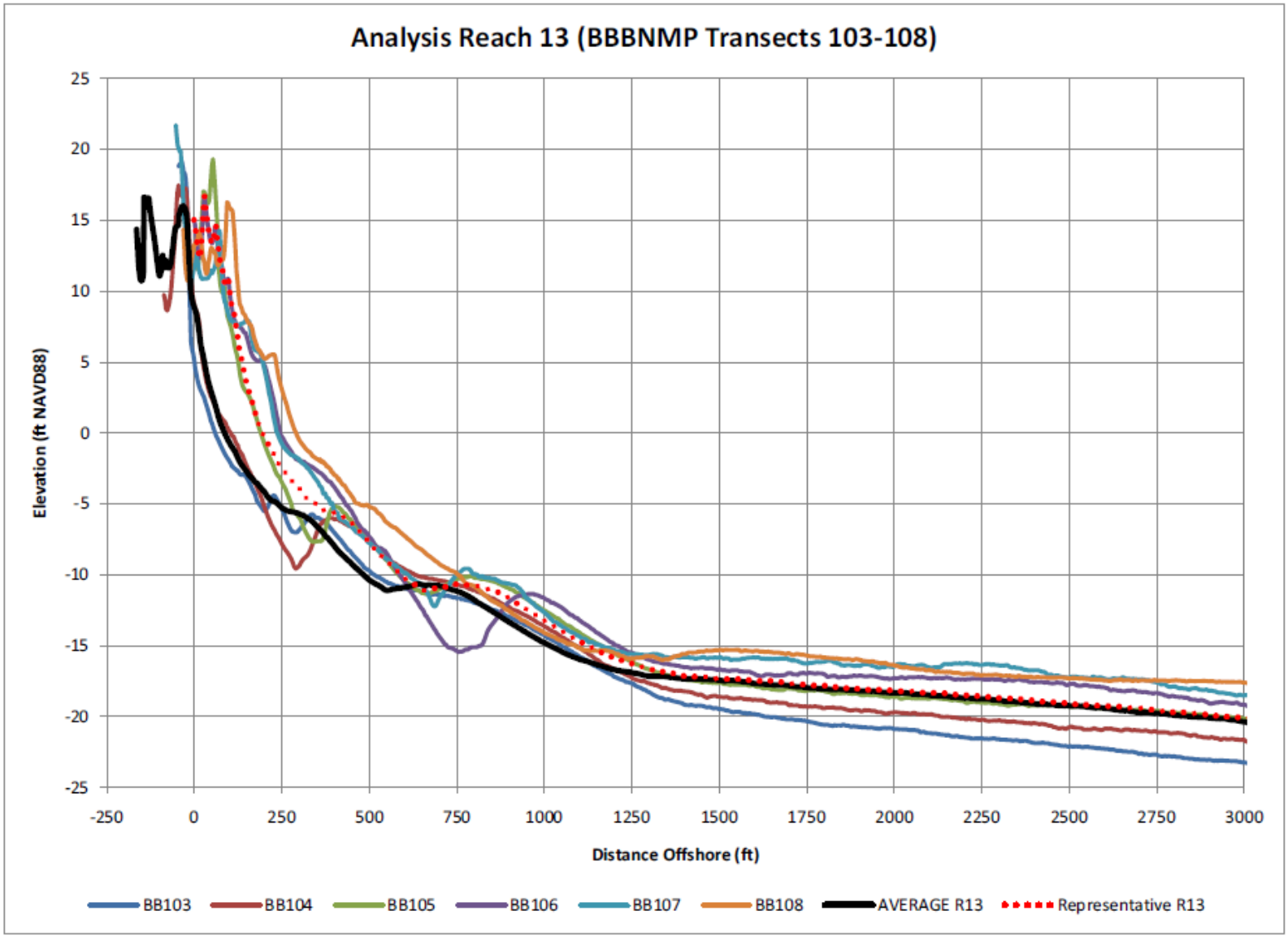

Figure 43 Reach 13 Representative Profile Development

The representative profiles for each reach were idealized to conform with the Beach-*fx* model framework, as seen earlier in this report in Figure 3. An effort was made to match dune slope, berm height, and foreshore slope across reaches to allow for ease in laying out project profiles later. However, survey data clearly shows that berm elevations and dune slopes are different near the inlets from the remainder of the beach. The idealized profile dimensions are tabulated for each SBEACH analysis reach in Table 12.

Reach	SBEACH Landward Boundary	Upland Elevation	Upland Width	Landward Dune Slope (X:1)	Dune Elevation	Dune Width	Seward Dune Slope (X:1)	Berm Height	Berm Width	Foreshore Slope (X:1)
1	-2000	8	2087.65	4	11	95	-4	5.5	135	-15
2	-2000	8	1992.50	4	15	15	-4	7	125	-15
3	-2000	12	1998.32	4	20	5	-4	7	70	-15
4	-2000	12	1928.27	4	26	25	-4	7	85	-15
5	-2000	12	1981.87	4	20	25	-4	7	70	-15
6	-2000	20	2077.96	4	22	15	-4	7	55	-15
7	-2000	12	1875.47	4	28	90	-4	7	65	-15
8	-2000	12	1937.00	4	18	100	-4	7	80	-15
9	-2000	12	1953.58	4	20	30	-4	7	65	-15
10	-2000	12	1919.61	4	18	100	-4	7	65	-15
11	-2000	12	2041.56	4	18	10	-4	5.5	75	-15
12	-2000	12	2014.62	4	14	40	-4	5.5	30	-15
13	-2000	12	1983.99	4	16	10	-4	5.5	5	-15

Table 12: Dimensions for Existing Idealized Profiles

In order to idealize the representative profiles developed for the existing conditions in each SBEACH analysis reach, contours created from 2007 LiDAR data were downloaded from the North Carolina Department of Transportation GIS website (http://www.ncdot.org/IT/gis/) to assess conditions landward of where the survey data ended. The LiDAR data was used to decide on the upland elevation and width landward of where the survey data ended. Figures 44 through 56 display the developed idealized conditions for Reaches 1 through 13.

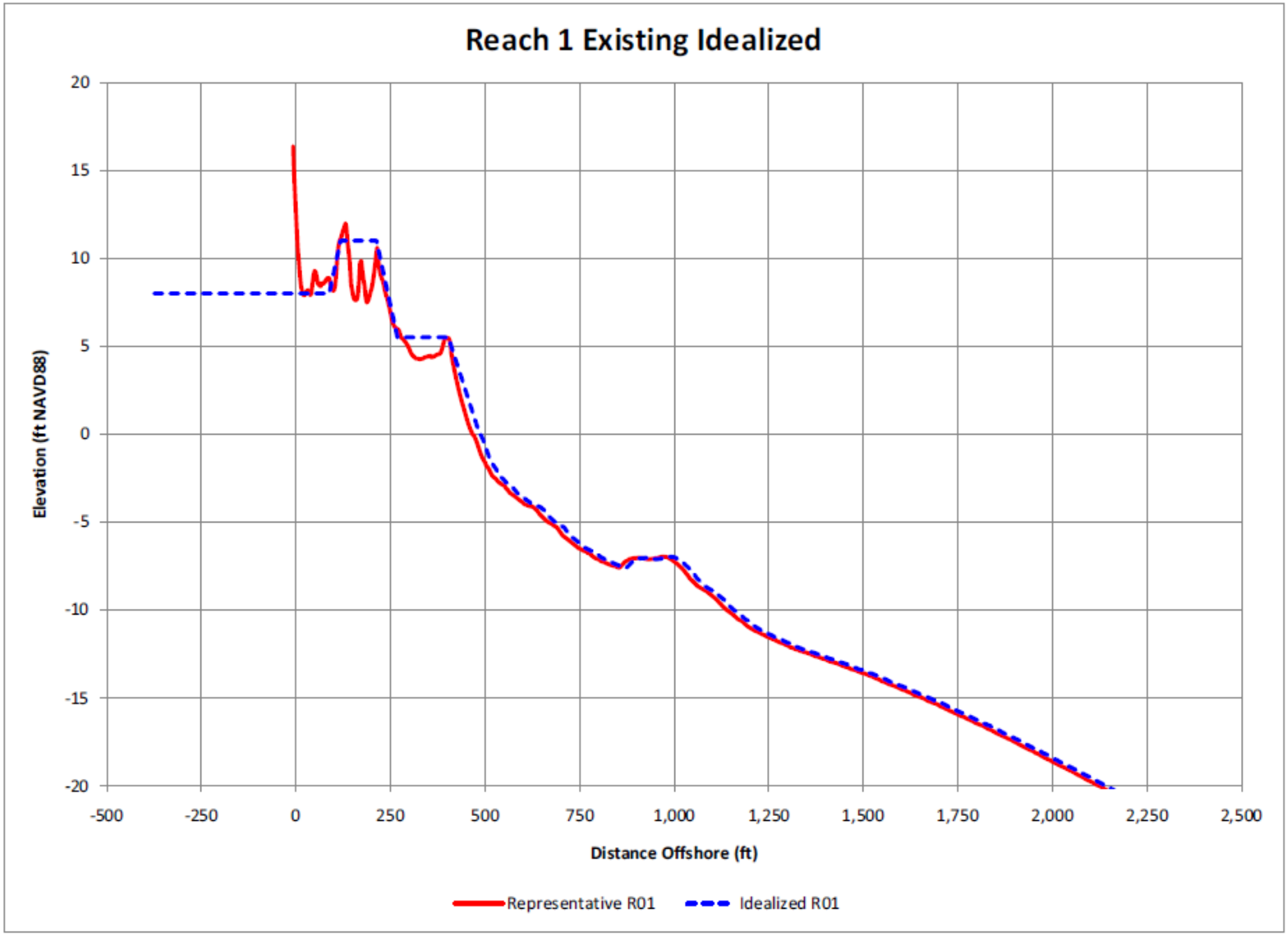

Figure 44 Reach 1 Idealized Existing Condition

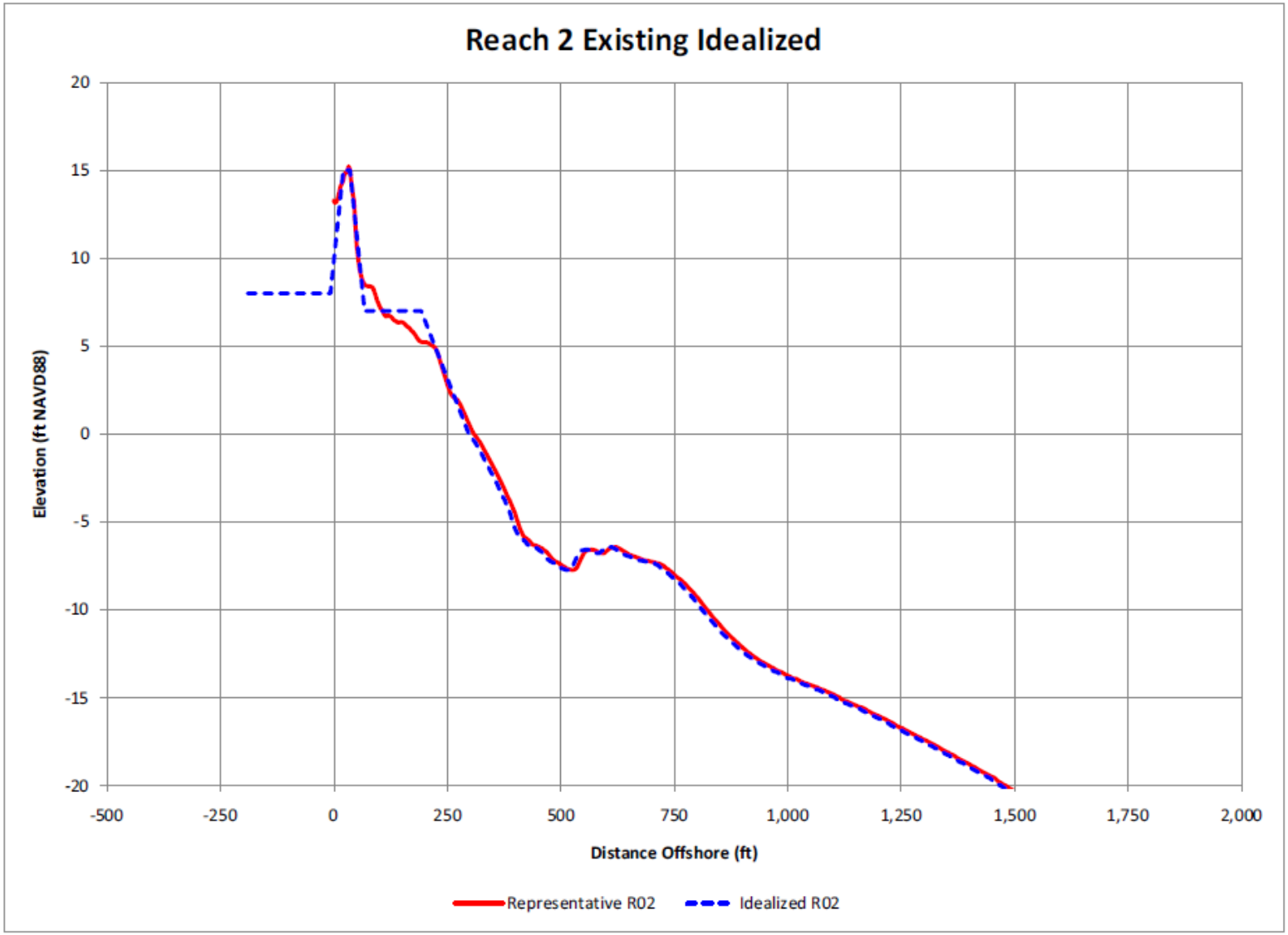

Figure 45 Reach 2 Idealized Existing Condition

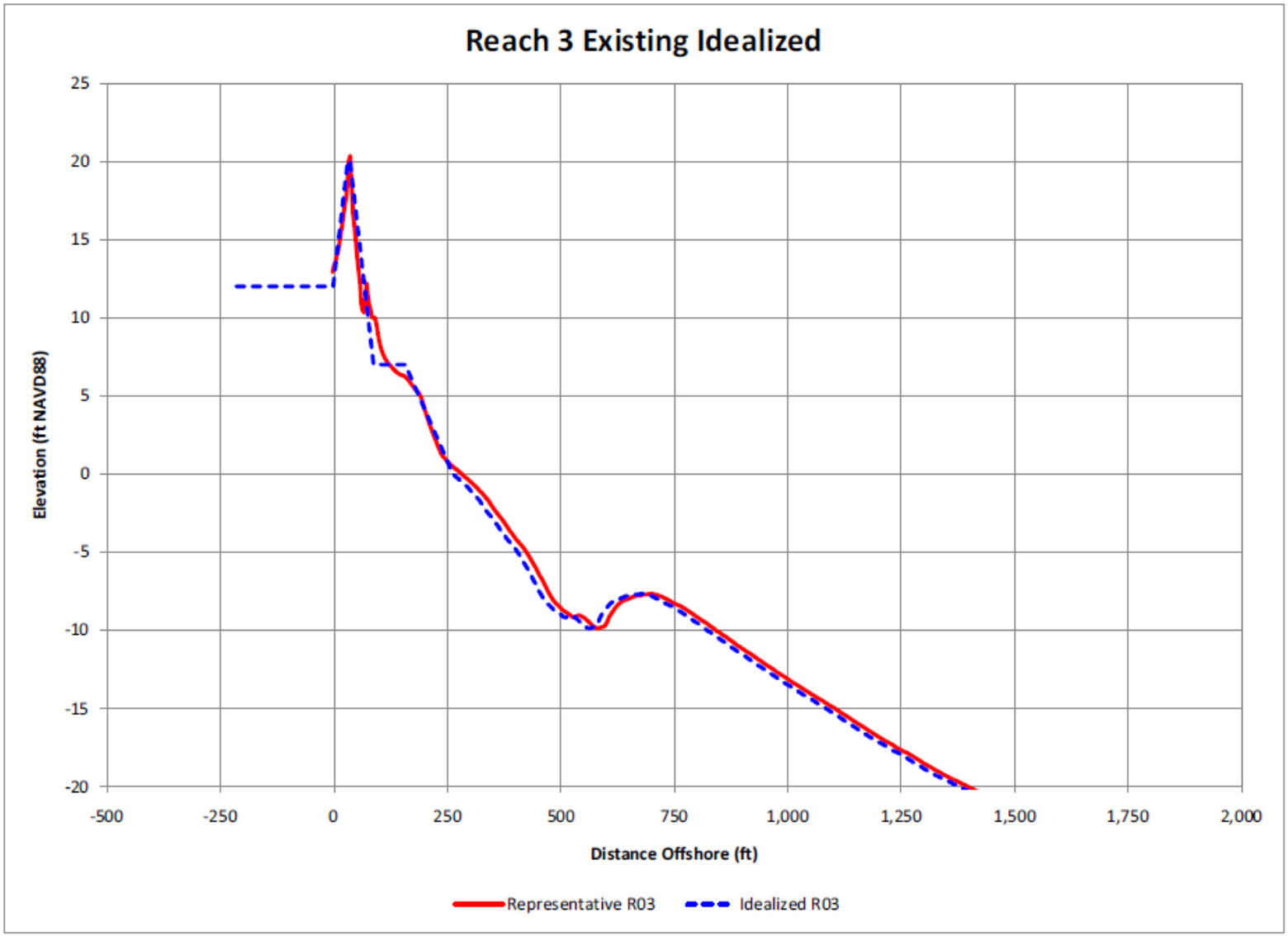

Figure 46 Reach 3 Idealized Existing Condition

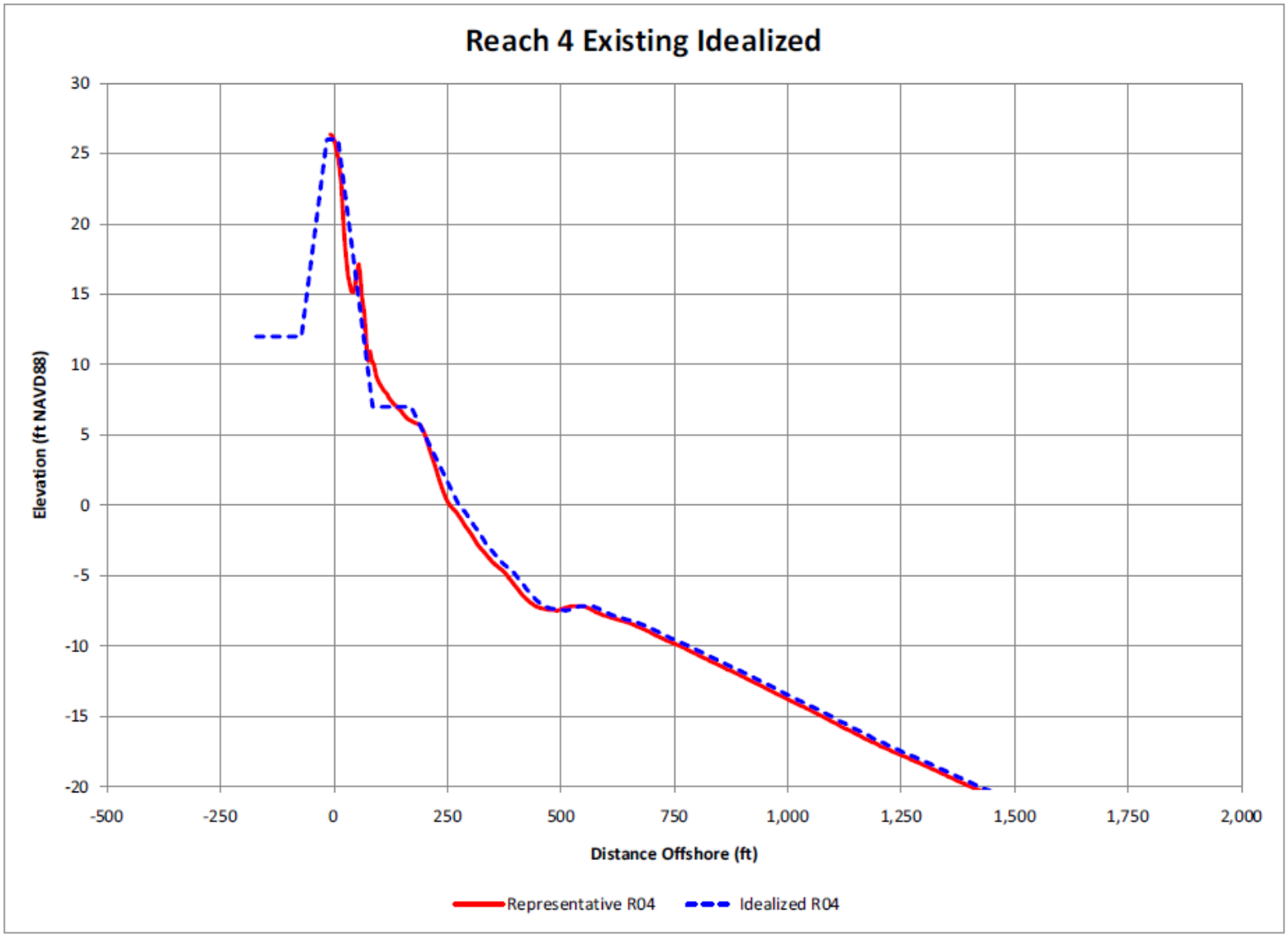

Figure 47 Reach 4 Idealized Existing Condition

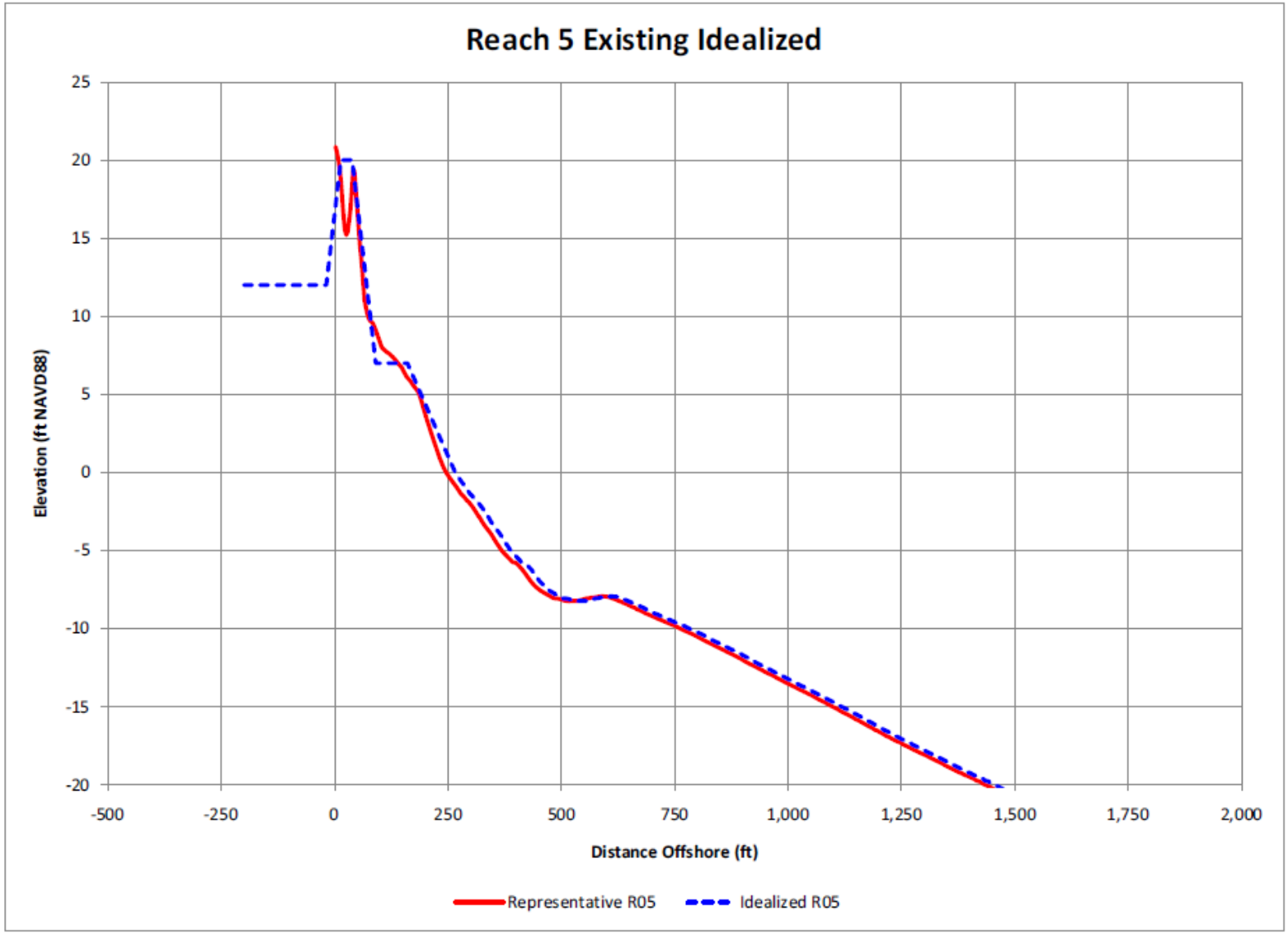

Figure 48 Reach 5 Idealized Existing Condition

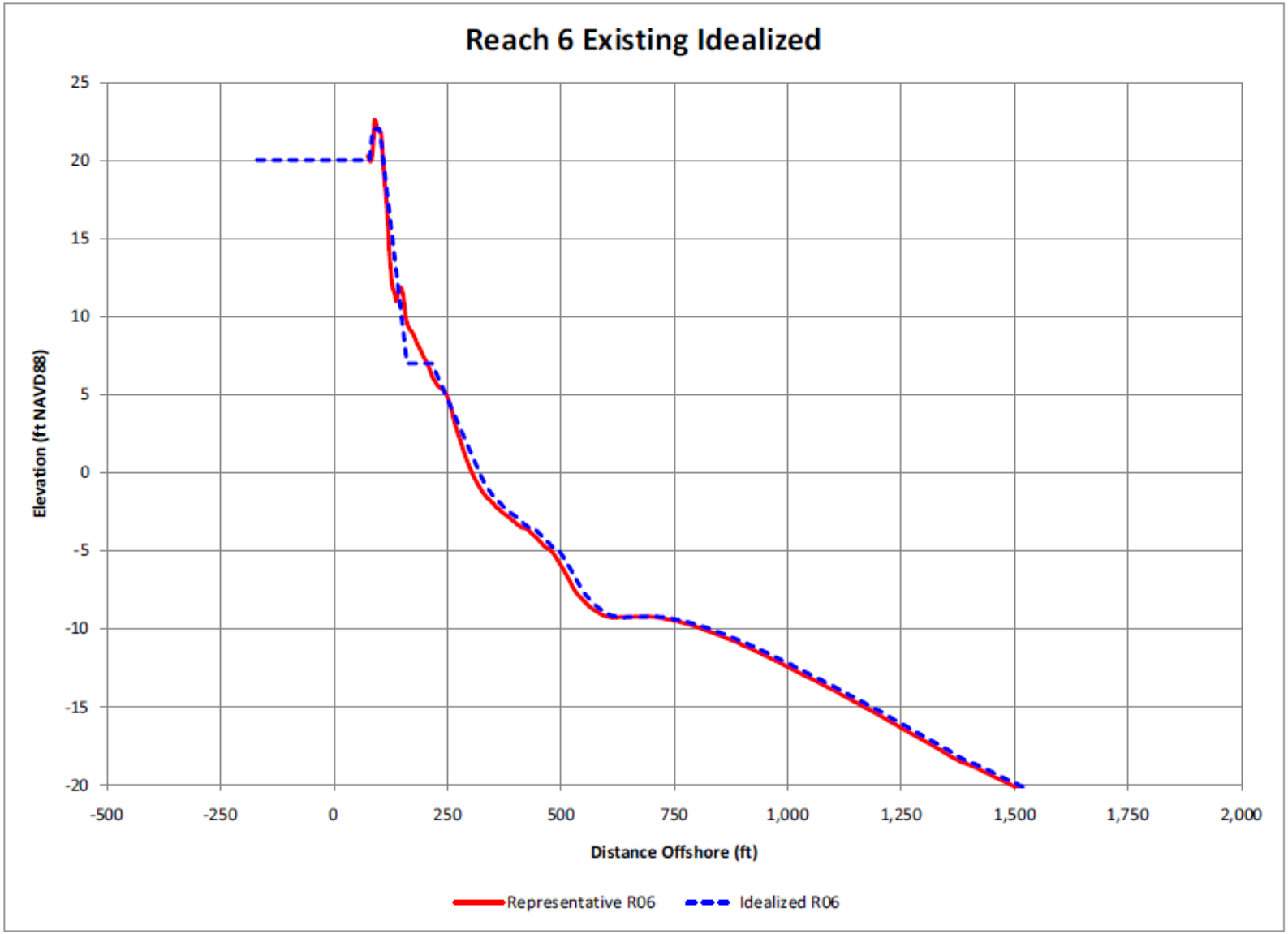

Figure 49 Reach 6 Idealized Existing Condition

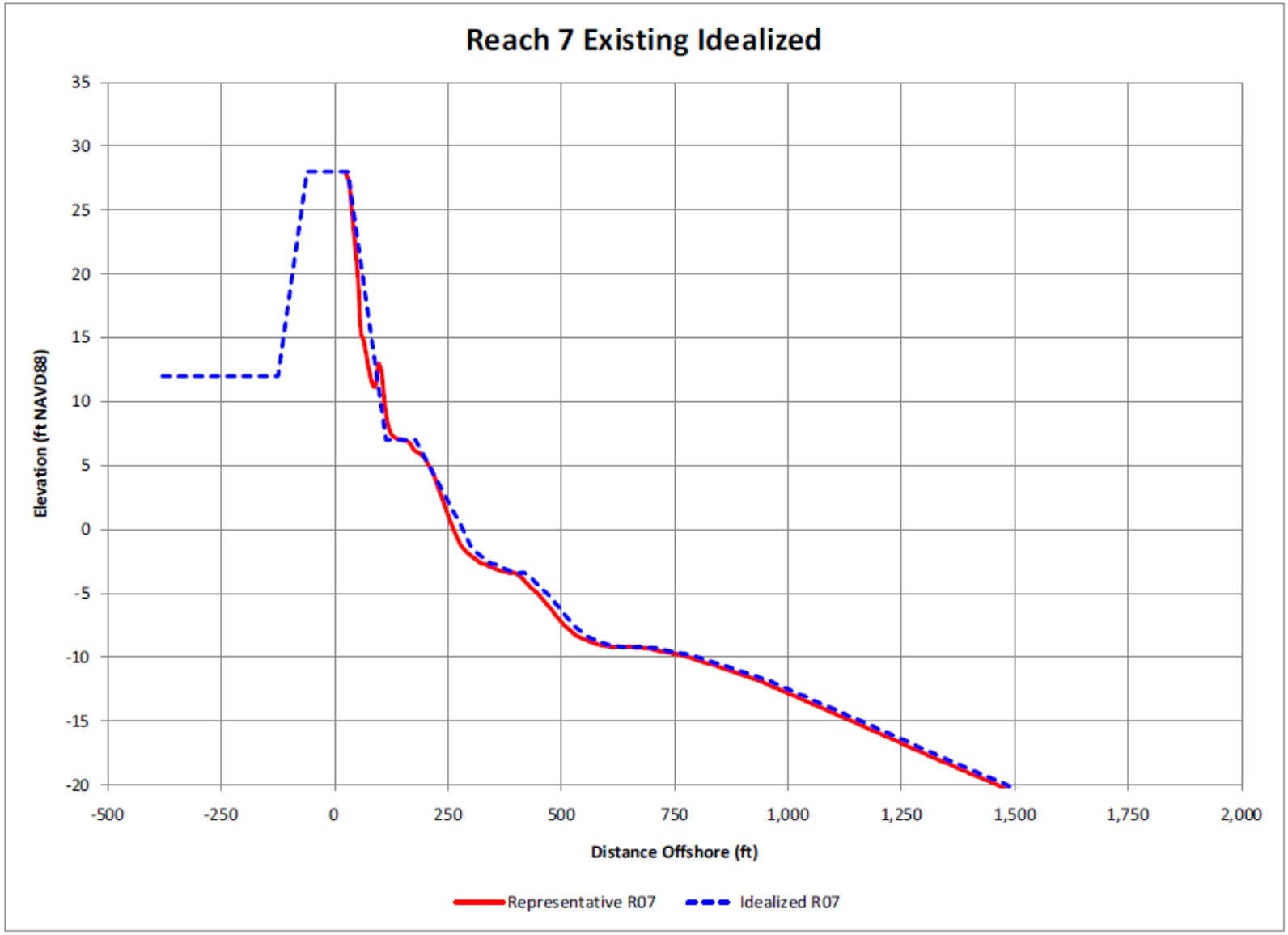

Figure 50 Reach 7 Idealized Existing Condition

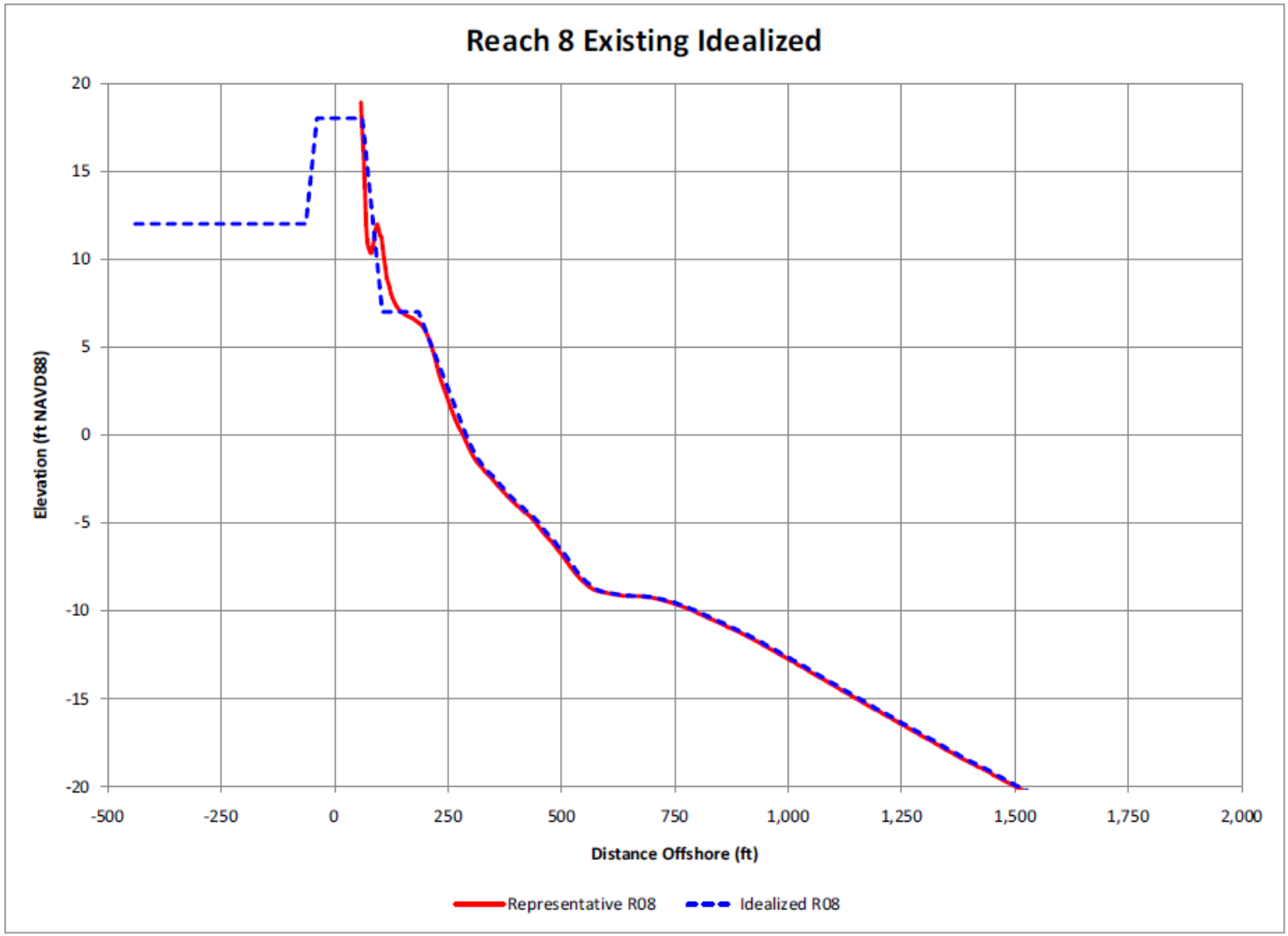

Figure 51 Reach 8 Idealized Existing Condition

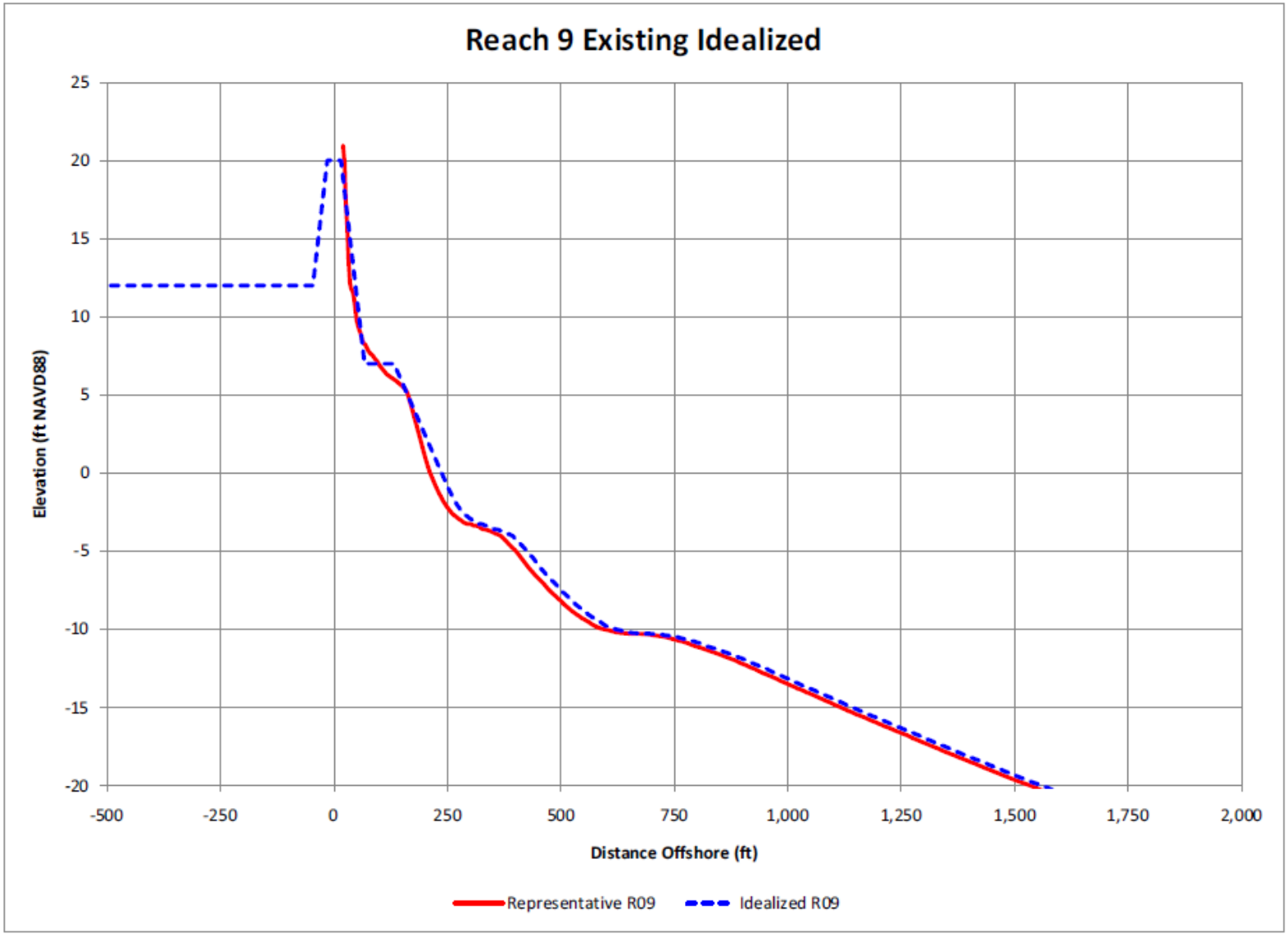

Figure 52 Reach 9 Idealized Existing Condition

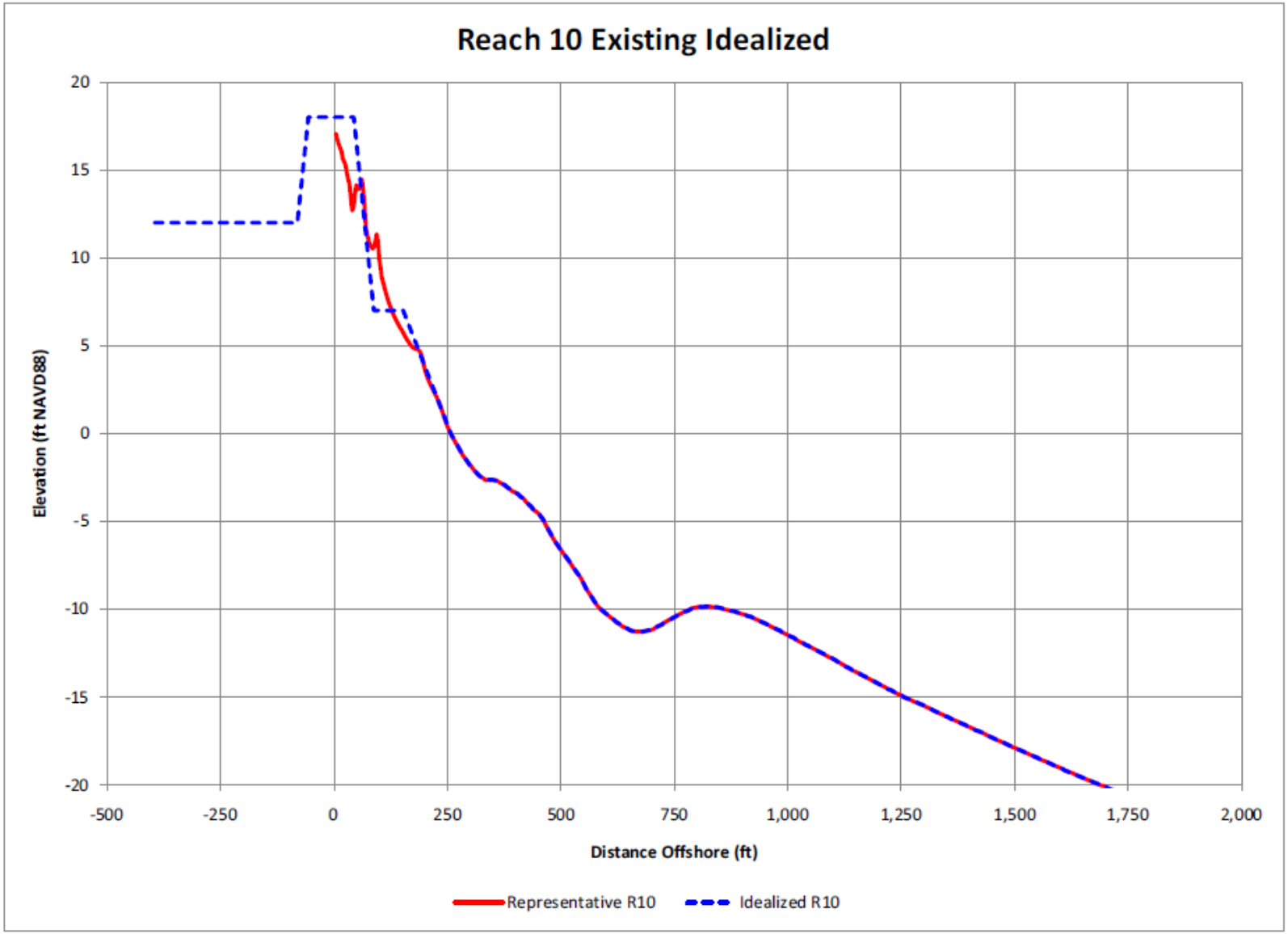

Figure 53 Reach 10 Idealized Existing Condition

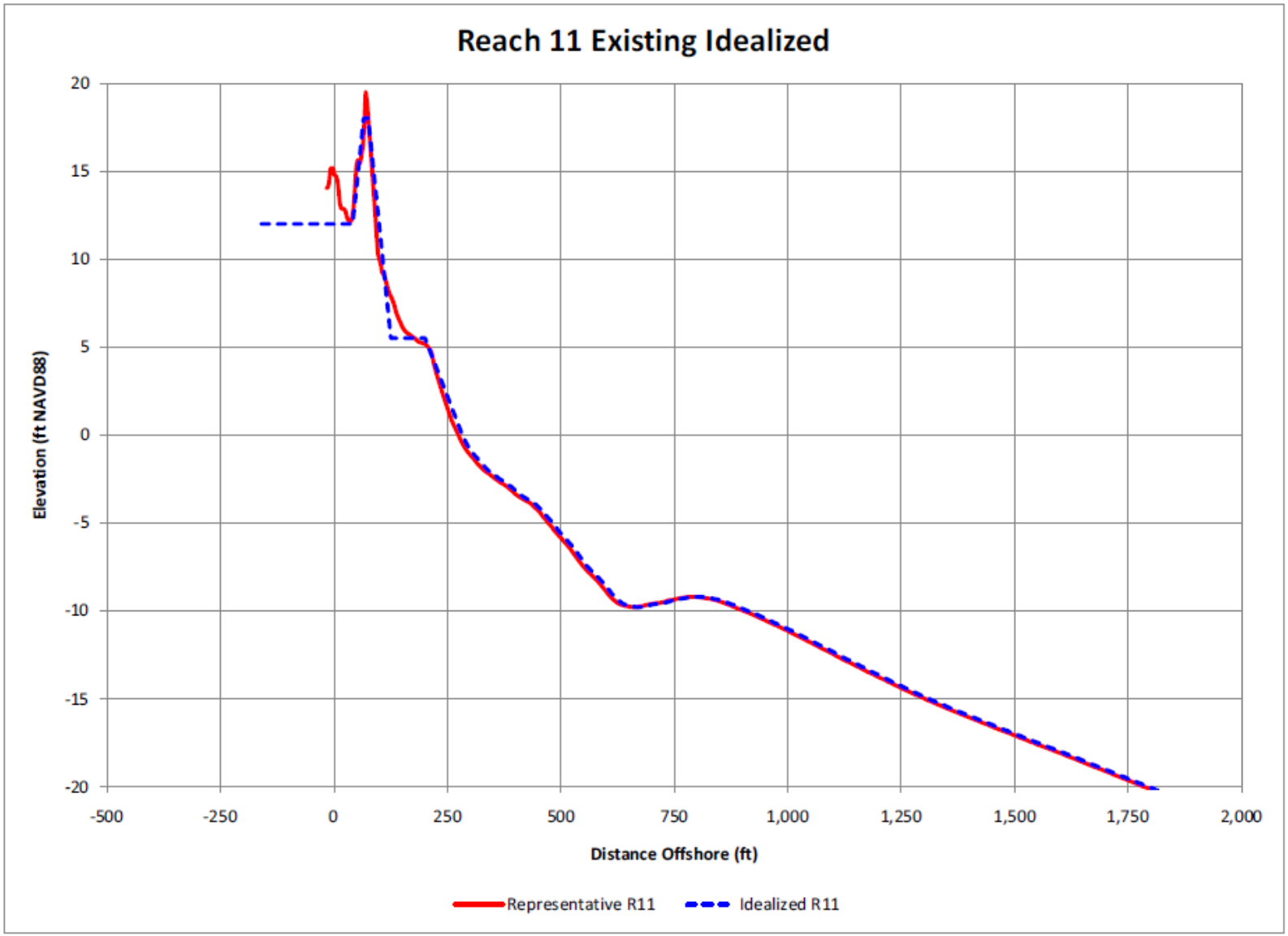

Figure 54 Reach 11 Idealized Existing Condition

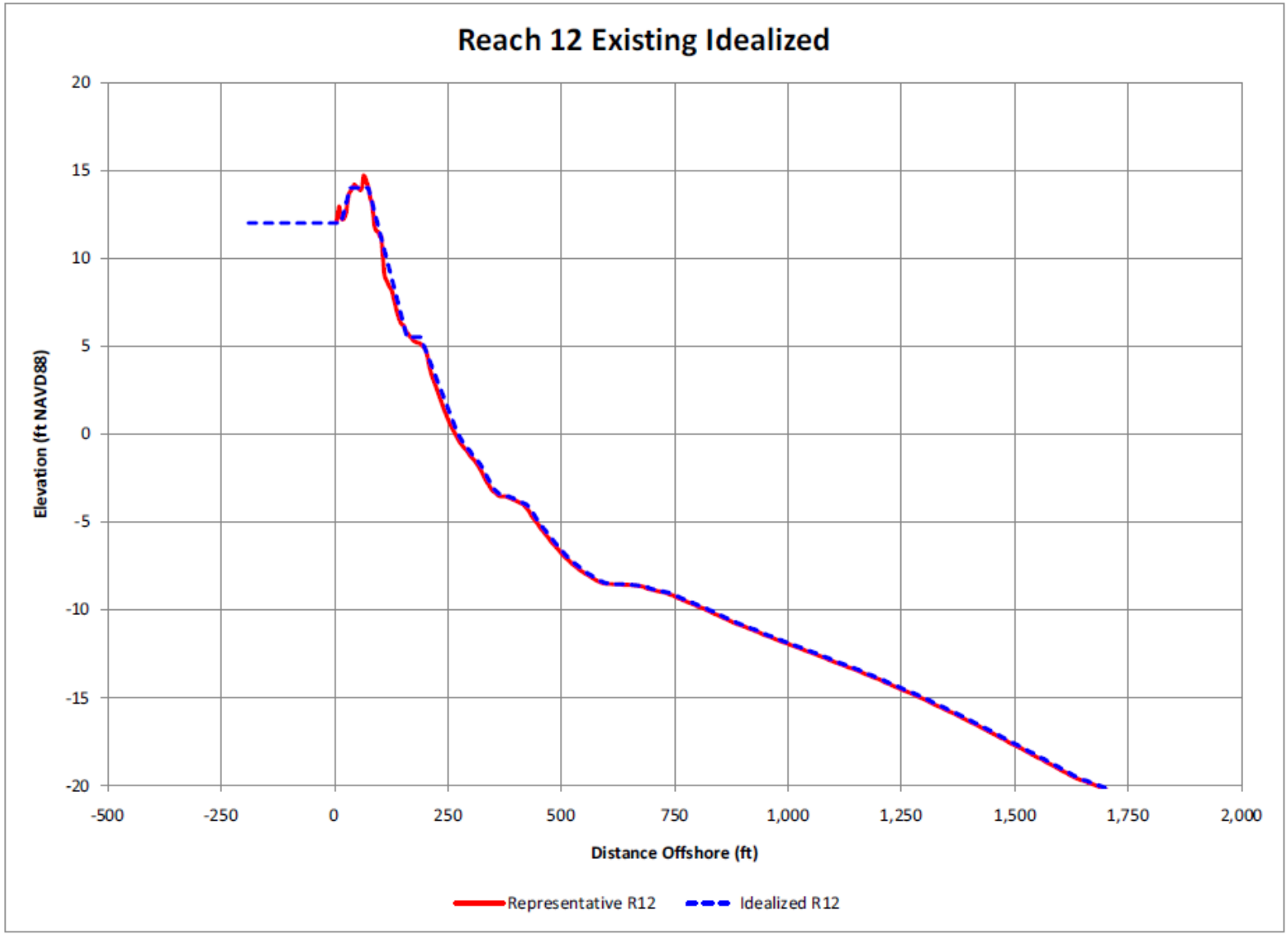

Figure 55 Reach 12 Idealized Existing Condition

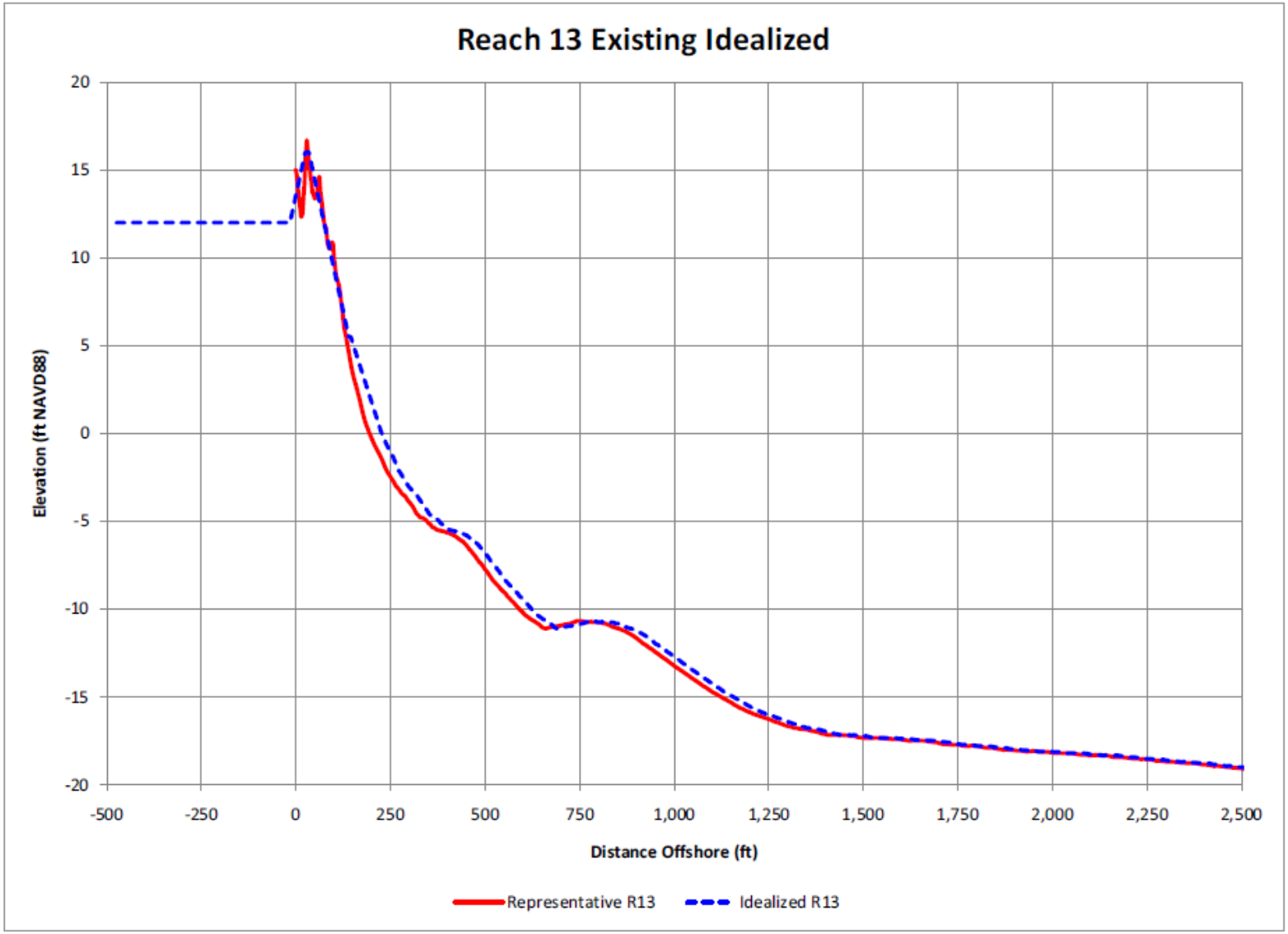

Figure 56 Reach 13 Idealized Existing Condition

3.3.2 SBEACH Project Alternatives

The idealized existing condition profiles were expanded to incorporate a wide array of alternative conditions that could possibly be encountered over a 50 year lifecycle. This expansion included potential project alternatives that could be used in various nourishment projects/templates within SBEACH. To stay within the idealized profile shape framework of Beach-*fx*, and given the fact that much of the shoreline contains structures on top of the existing dunes, it was decided that additions to the front of the existing dune (keeping dune height constant) coupled with a range of berm widths (keeping berm height constant) would be appropriate projects to consider for the island. The one exception to this was in reach 1 where there were no existing structures on the dune. As a result, this reach did include alternatives to increase the dune height. The dune and foreshore slopes were also kept constant from the existing conditions. To develop the matrix of SBEACH runs to be considered for the "with" project conditions, eroded cases of each of the projects were also run. The alternative matrix for Beach-fx is shown in Table 13 and represents 1,764,360 different iterations.

Reach	Upland Elevation	Project Dune Elevation	Project Dune Width	Project Berm Widths
1	8	8	5,15,25,35,50,75	0,25,50,75,100,125,150
		10	5,15,25,35,50,75	0,25,50,75,100,125,150
		11	5,15,25,35,50,75,95,105,115,135	0,25,50,75,100,125,135,150
		13	5,15,25,35,50,75	0,25,50,75,100,125,150
		15	5,15,25,35,50,75	0,25,50,75,100,125,150
2	8	8	5,15,25,35,50,75	0,25,50,75,100,125,150
		9	5,15,25,35,50,75	0,25,50,75,100,125,150
		11	5,15,25,35,50,75	0,25,50,75,100,125,150
		13	5,15,25,35,50,75	0,25,50,75,100,125,150
		15	5,15,25,30,35,40,50,75	0,25,50,75,100,125,150
3	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75	0,25,50,75,100,125,150
		20	5,10,15,20,25,30,35,50	0,25,50,70,75,100,125,150
4	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75	0,25,50,75,100,125,150
		20	5,15,25,35,50,75	0,25,50,75,100,125,150
		22	5,15,25,35,50,75	0,25,50,75,100,125,150
		24	5,15,25,35,50,75	0,25,50,75,100,125,150
		26	5,15,25,30,35,40,45,50	0,25,50,75,85,100,125,150
5	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75	0,25,50,75,100,125,150
		20	5,15,25,30,35,40,45,50,70	0,25,50,70,75,100,125,150
6	20	20	5,15,25,35,50,75	0,25,50,75,100,125,150
		22	5,15,20,25,30,35,40,50	0,25,50,55,75,100,125,150
7	12	26	5,15,25,35,50,75	0,25,50,75,100,125,150
		28	5,15,25,35,50,75,90,95,100,105,110,115	0,25,50,65,75,100,125,150
8	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75,95,100,105,110,115,120,125	0,25,50,75,80,100,125,150
9	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75	0,25,50,75,100,125,150
		20	5,15,25,30,35,40,45,50,55	0,25,50,65,75,100,125,150
10	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,15,25,35,50,75,95,100,105,110,115,120,125	0,25,50,65,75,100,125,150
11	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,50,75	0,25,50,75,100,125,150
		16	5,15,25,35,50,75	0,25,50,75,100,125,150
		18	5,10,15,20,25,30,35	0,25,50,75,100,125,150
12	12	12	5,15,25,35,50,75	0,25,50,75,100,125,150
		14	5,15,25,35,40,50,55,60,65	0,25,30,50,75,100,125,150

Table 13 Sbeach Alternative Matrix

4.1 Selected Plan

4.1.1 Planform Rates and Transition Evaluation

Once the optimum plan has been selected based on the economic output from Beach-fx a refinement to the selected plan must be run to account for the changing erosion rates induced by beach fills. The placement of large quantities of fill material on a beach as part of a beach nourishment program creates a shoreline perturbation on the natural shoreline. This perturbation of the natural shoreline creates changes in the historic sediment flow patterns that displace material from the fill and eventually create equilibrium in the shoreline. Although there are multiple complex models available to model the dispersion of beach fill, including the USACE Genesis model, the dispersion was modeled for the selected plan using the Plan Form Evolution model (PFE) within the Coastal Engineering Design and Analysis System (CEDAS) (Dean, 1989). This model was selected based on balancing project funding and time limitations with the uncertainties known to exist with all shoreline dispersion models near inlet areas.

For the selected plan dimensions, planform erosion rates were calculated for several different nourishment cycles in order to determine the cycle with the highest net benefit. Rates were calculated for 3, 4, and 5 year nourishment intervals based on a 50' berm width addition. Parameters representing local wave climatology were derived from data collected at station 276 of the Wave Information Studies (WIS) program. From this data the mean wave height was determined to be 3.22', mean wave period was 4.74 seconds, and wave direction is 165 degrees from north.

For each cycle time period evaluated the initial condition within the Beach Fill Module was set with the berm at 50' wide. The project includes transitions of 1000' length on both ends of the project that transition from the 50' wide placement to 0' where the project ties into the natural beach. After each simulation the initial condition was adjusted to reflect the ending shoreline position from the previous run. By doing this, each subsequent run included the influence of the material that was dispersed out of the placement areas in the previous run. Six iterations of the beach fill module were conducted in this way for each nourishment interval being considered. The results for the three year nourishment cycle are displayed in Figure 57 which shows how the rates converge by the sixth iteration of the model runs and are typical of the results observed for the 4 and 5 year cycle.

Once the planform erosion rates were calculated for each of the three considered nourishment intervals, the planform erosion rates were input into Beach-fx. The first six planform erosion rates input into Beach-fx corresponded to the six rates calculated within the Beach Fill Module. For planform erosion rates following the sixth nourishment cycle in Beach-fx the sixth cycle was assumed to be unchanged based on the convergence of rates observed in Figure 57. Based on the updated runs with planform erosion rates, a 3 year nourishment cycle was found to have the highest net benefits and is part of the selected plan as discussed in the main project report.

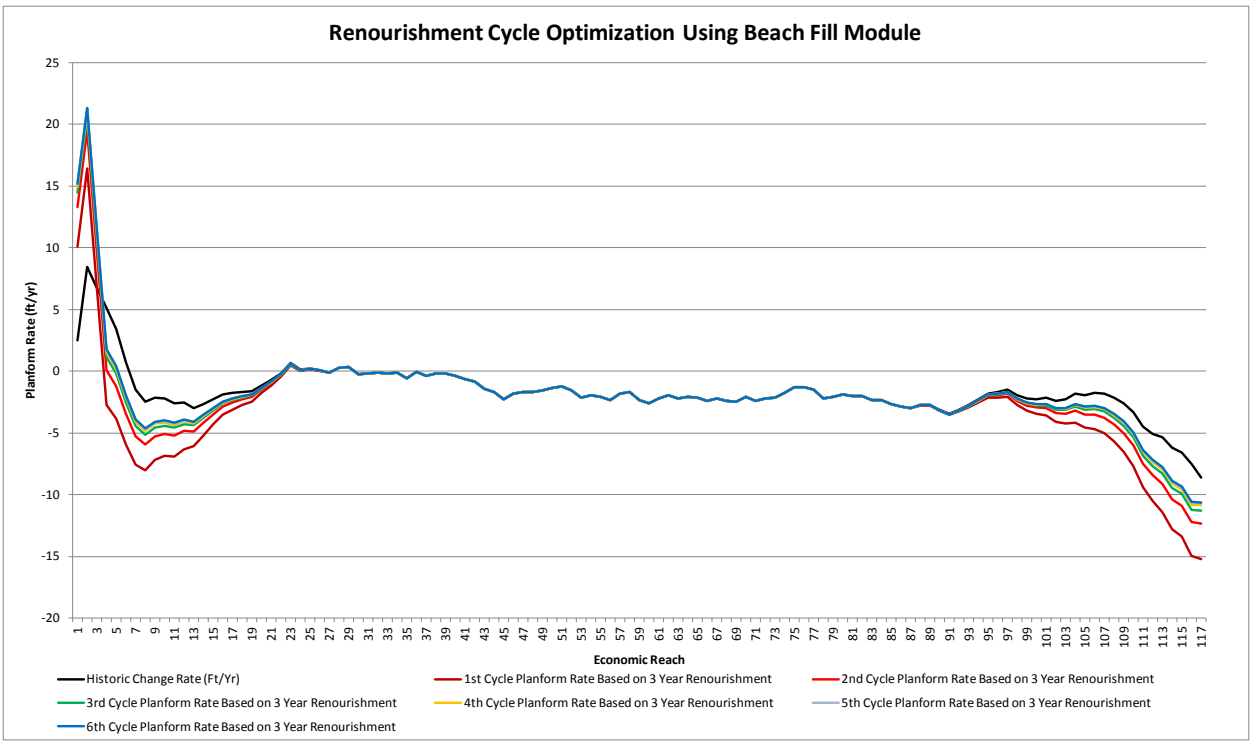

Figure 57 Planform Erosion Rates for the 3 Year Nourishment Interval

4.1.2 Description of Selected Plan

The recommended plan for Bogue Banks varies throughout the island between a combination of a dune/berm plan and a berm only plan. The dimensions representing the existing conditions in Beach-fx and the dimensions for the recommended plan are summarized in Table 14. The dune dimensions shown in this table integrate and are based on the existing idealized dune dimensions for those reaches. These dimensions represent the maximum size of the construction template. 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 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 TSP project template. While the recommended plan dune conditions vary the recommended berm for the plan is consistent at 50 feet throughout the project area. The typical layouts for a berm and dune plan are shown in Figures 58 and 59. Similar plots are displayed in Figures 60 and 61 for the berm only plan condition. While the conditions will vary through the island depending on existing dune heights and widths and berm widths, these plots give a graphical representation of the general placement locations for the dune and berm. The berm elevations for the recommended plan mirror the existing conditions and are +5.5 feet NAVD for reaches 1, 11, and 12. The remaining project area berm elevation is set at +7 feet NAVD. The project limits for the selected plan are shown in Figure 62.

Projected volumes for the selected plan are summarized in Table 15. These volumes were extracted from the output of the Beach-fx software. The table shows the initial volume required for each reach, as well as the average projected renourishment volume based on a 3 year cycle. The initial volume is the amount of material placed per reach during the initial construction of the project. This measurement was directly extracted from the Beach-fx data as the quantity from the first construction cycle. The average renourishment cycle quantity was not as straight forward to calculate due to the fact that each reach is not renourished during each renourishment cycle. To calculate the average volume placed for the 16 nourishment cycles following initial construction, the total

volume placed for these cycles was divided by 16*300, which represents 16 nourishment cycles and 300 iterations of the model for each cycle.

	Representative Existing Conditions			Recommended Plan Dimensions			
Reach	Dune Height	Dune Width	Berm Width	Dune Height	Dune Width	Berm Width	Berm Height
1(1)	11	95	135	16	95	50	5.5
2(2)	15	15	125	15	45	50	7
3(2)	20	5	70	20	10	50	7
4(3)	26	25	85	26	25	50	7
5(3)	20	25	70	20	25	50	7
6(3)	22	15	55	22	15	50	7
7(3)	28	90	65	28	90	50	7
8(3)	18	100	80	18	100	50	7
9(3)	20	30	65	20	30	50	7
10(3)	18	100	65	18	100	50	7
11(2)	18	10	75	18	40	50	5.5
12(3)	14	40	30	14	40	50	5.5
(1) Denotes plans with increased dune height							
(2) Denotes plans with increased dune width							
(3) Denotes reaches where dune dimensions are not federally maintained							

Table 14 Representative Existing and Recommended Plan Dimensions

Figure 58 Typical Dune and Berm Plan View

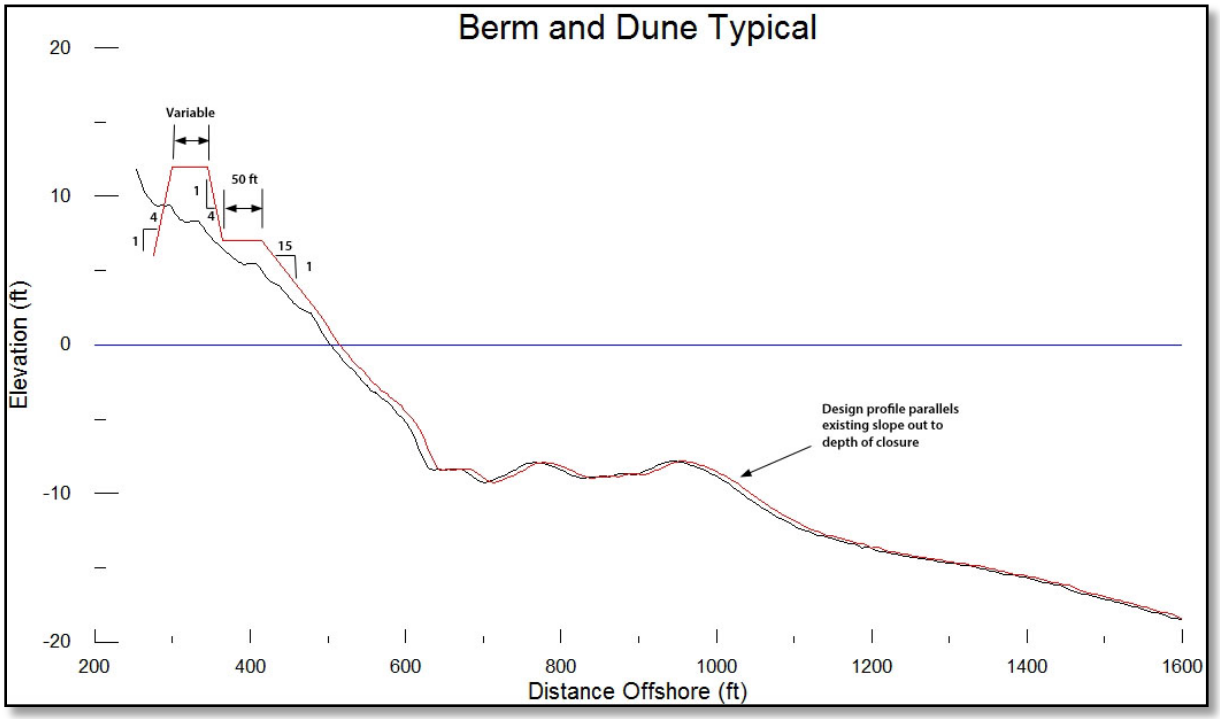

Figure 59 Typical Dune and Berm Cross Section

Figure 60 Typical Berm Only Plan View

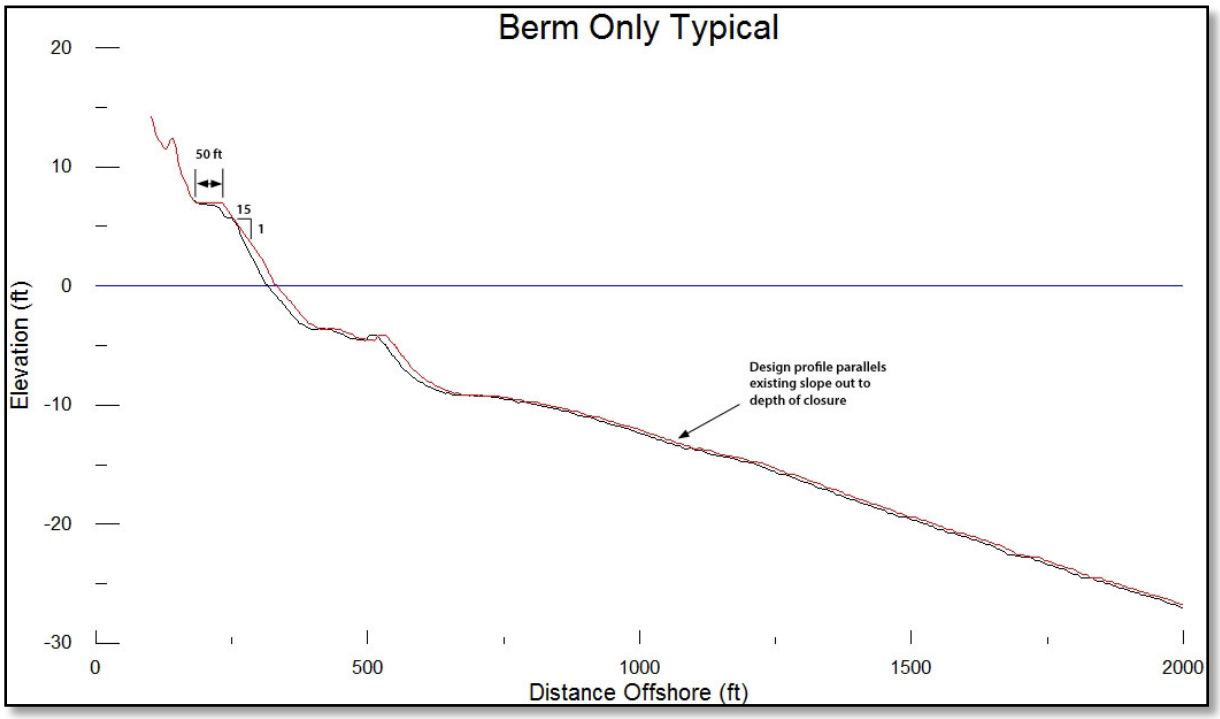

Figure 61 Typical Berm Only Cross Section

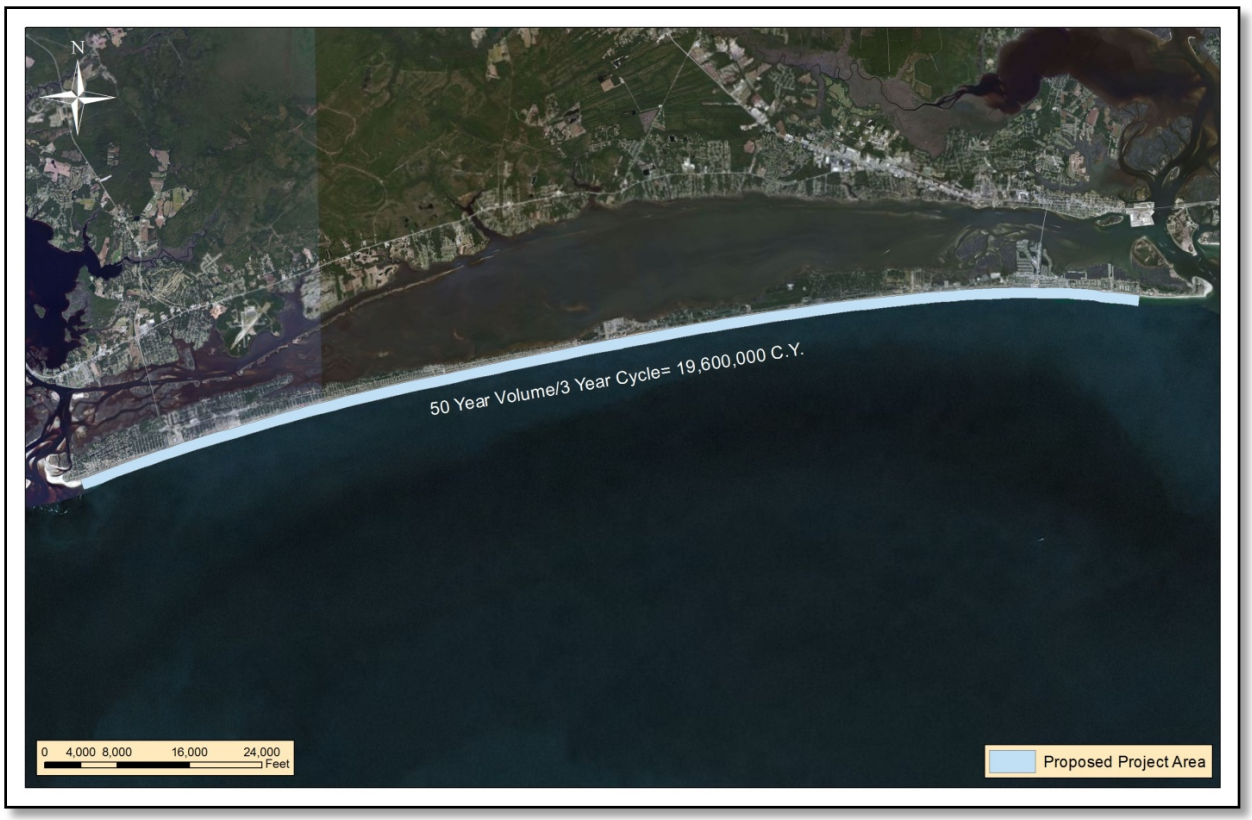

Figure 62 Project Area

Reach	Initial Placement Volume	Total Volume Placed (C.Y.) (300 iterations 16 cycles following initial placement)	Average Renourishment Cycle Placement (C.Y.)
1	28,583	2,884,442	601
2	20,377	2,026,296	422
3	33,555	3,364,436	701
4	26,383	2,748,498	573
5	44,697	6,063,027	1,263
6	44,073	35,296,346	7,353
7	71,044	68,598,638	14,291
8	66,926	6,597,064	1,374
9	63,255	57,581,444	11,996
10	40,203	35,332,759	7,361
11	6,811	56,393,927	11,749
12	11,133	85,918,378	17,900
13	13,024	106,321,672	22,150
14	11,111	76,138,414	15,862
15	14,336	80,467,438	16,764
16	5,250	36,497,311	7,604
17	5,878	47,125,388	9,818
18	5,802	48,995,517	10,207
19	5,109	43,630,524	9,090
20	5,618	43,020,576	8,963
21	200	7,883,461	1,642
22	160	3,333,081	694
23	148	1,281,210	267
24	133	615,272	128
25	164	1,070,930	223
26	129	609,735	127
27	208	2,747,081	572
28	148	1,191,811	248
29	86	728,668	152
30	1,174	8,996,101	1,874
31	1,339	8,600,387	1,792
32	1,200	9,152,144	1,907
33	1,593	8,924,113	1,859
34	922	6,656,653	1,387
35	1,620	15,089,073	3,144
36	1,014	5,664,846	1,180
37	1,518	11,706,672	2,439
38	1,599	9,625,679	2,005
39	1,139	7,320,954	1,525

Table 15 Selected Plan Projected Quantities

40	1,833	13,764,307	2,868
41	1,775	12,928,722	2,693
42	1,180	12,441,527	2,592
43	28,826	63,593,516	13,249
44	25,959	52,485,108	10,934
45	46,603	86,271,107	17,973
46	23,394	46,323,932	9,651
47	21,294	43,125,067	8,984
48	20,498	41,998,251	8,750
49	18,130	38,464,114	8,013
50	11,779	26,402,194	5,500
51	5,888	14,246,600	2,968
52	26,794	56,285,065	11,726
53	30,342	82,471,098	17,181
54	6,825	20,375,363	4,245
55	18,834	51,733,461	10,778
56	20,614	50,405,807	10,501
57	5,129	17,129,361	3,569
58	10,828	44,537,008	9,279
59	3,347	64,352,644	13,407
60	2,526	40,778,215	8,495
61	2,166	41,595,067	8,666
62	2,263	40,494,661	8,436
63	3,561	66,490,828	13,852
64	1,011	18,290,532	3,811
65	444	8,366,283	1,743
66	3,985	76,260,428	15,888
67	1,293	24,754,018	5,157
68	1,512	29,014,779	6,045
69	3,827	72,113,963	15,024
70	2,614	47,305,806	9,855
71	3,096	59,426,649	12,381
72	2,803	53,484,699	11,143
73	1,922	35,939,249	7,487
74	10,663	48,909,643	10,190
75	1,913	27,509,326	5,731
76	644	10,327,249	2,152
77	3,750	32,386,506	6,747
78	14,207	42,116,461	8,774
79	14,473	47,035,153	9,799
80	7,307	26,913,550	5,607

Table 15 Selected Plan Projected Quantities (Cont)

81	14,336	46,826,205	9,755
82	12,563	41,298,739	8,604
83	26,604	74,315,076	15,482
84	25,974	72,504,080	15,105
85	34,749	84,873,300	17,682
86	28,989	95,737,690	19,945
87	40,417	127,065,493	26,472
88	19,403	67,165,301	13,993
89	15,427	53,545,568	11,155
90	21,013	63,332,056	13,194
91	26,657	74,641,301	15,550
92	40,692	123,396,474	25,708
93	71,829	78,247,848	16,302
94	58,062	59,492,187	12,394
95	41,548	38,959,858	8,117
96	35,924	33,240,764	6,925
97	42,151	38,228,116	7,964
98	54,610	56,310,996	11,731
99	32,077	35,285,955	7,351
100	41,339	46,810,905	9,752
101	53,553	61,634,806	12,841
102	38,263	46,458,496	9,679
103	43,045	53,227,659	11,089
104	39,249	48,683,411	10,142
105	33,064	42,823,177	8,921
106	17,092	22,752,880	4,740
107	31,107	43,056,046	8,970
108	34,792	50,613,564	10,544
109	39,430	59,815,614	12,462
110	42,314	66,601,683	13,875
111	43,567	65,667,832	13,681
112	76,615	116,632,270	24,298
113	51,520	80,353,830	16,740
114	54,089	85,513,571	17,815
115	58,320	92,070,876	19,181
116	47,333	75,822,168	15,796
117	56,091	82,553,433	17,199
1000' Transition	53,934		16,536
Total Initial =	2,451,253.72	Average Renourishment=	1,068,745.69

Table 15 Selected Plan Projected Quantities (Cont)

5.1 Borrow Area Impacts

5.1.1 Introduction

Bogue Banks forms a 25.4-mile barrier island off the mainland of Carteret County (Figure 63). The offshore area of Bogue Banks was investigated to identify sites that may be appropriate as borrow material sources for the project. The potential offshore borrow areas that were identified are expected to provide an estimated volume of 42 Mcy of beach placement material.

Changing the bathymetry of the offshore area might affect the wave climate at the shorelines of Carteret County. The Coastal Modeling System CMS-WAVE was used to estimate wave transformation change in the study area and assess any adverse effects along the Bogue Banks and Shackleford Banks shorelines.

The Morehead City area is nationally ranked as number 38 with the amount of years between a Storm or Hurricane coming within 60 miles of the city. Therefore these simulations have been set-up to simulate both normal and extreme weather conditions.

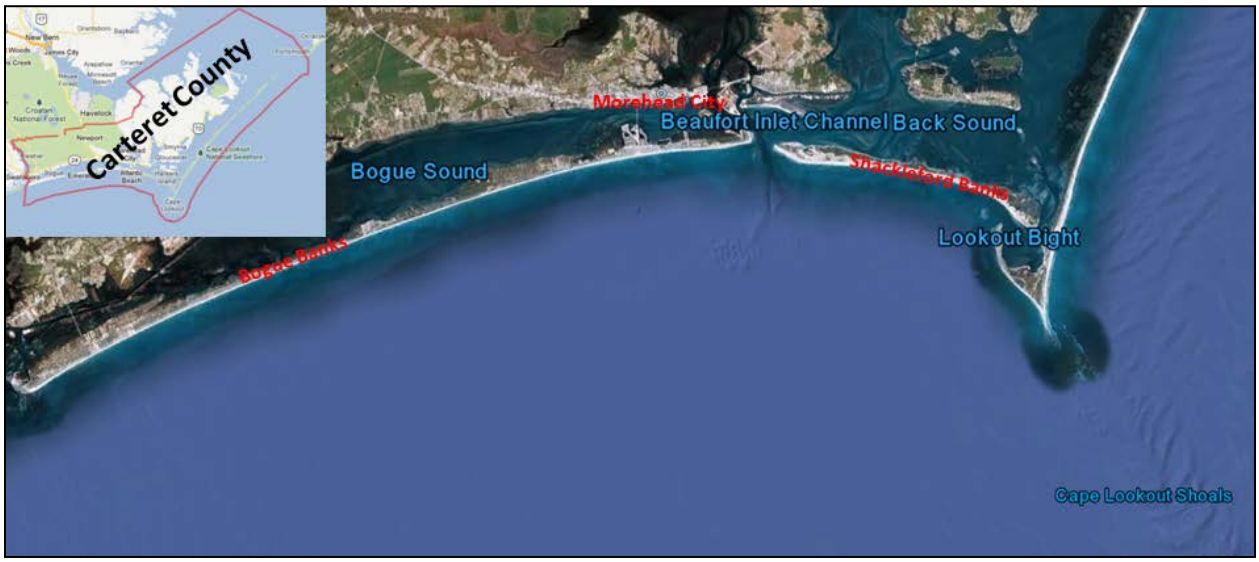

Figure 63- Bogue Banks location map

5.1.2 Grid Development

CMS-WAVE, previously called WABED (Wave-Action Balance Equation Diffraction), is a two dimensional (2D) spectral wave model formulated from a parabolic approximation equation (Mase et al. 2005a) with energy dissipation and diffraction terms. It simulates a steady-state spectral transformation of directional random waves co-existing with ambient currents in the coastal zone. The model operates on a coastal half-plane, implying waves can propagate only from the seaward boundary toward shore. The model includes features such as wave generation, wave reflection, and bottom frictional dissipation (Lin et al., 2008).

CMS-WAVE model requires accurate bathymetry data to construct computational grid over which waves propagate and transform. The bathymetry data for the CMS-WAVE grid was obtained from the existing ADvanced CIRculation model (ADCIRC) mesh of the Western North Atlantic, the Gulf of Mexico and the Caribbean Sea (Brian and Luettich, 2008). The ADCIRC grid has been designed to resolve major bathymetric and topographic features

such as inlets, dunes and river courses as identifiable on satellite images, NOAA charts, and various available Digital Elevation Model (DEM) and shoreline datasets (Figure 64). The ADCIRC bathymetry was updated with the following latest available surveys (Figure 64):

- April 2009 bathymetric survey of Beaufort Inlet.
- June 2010 beach profile of Bogue Banks.

The survey data was referenced to the horizontal State Plane Coordinate System (NAD83) in meters and to the vertical Mean Tidal Level (MTL) datum which represents the vertical datum of the model. The NOAA Beaufort, NC station (8656483) was used to reference the data to MTL.

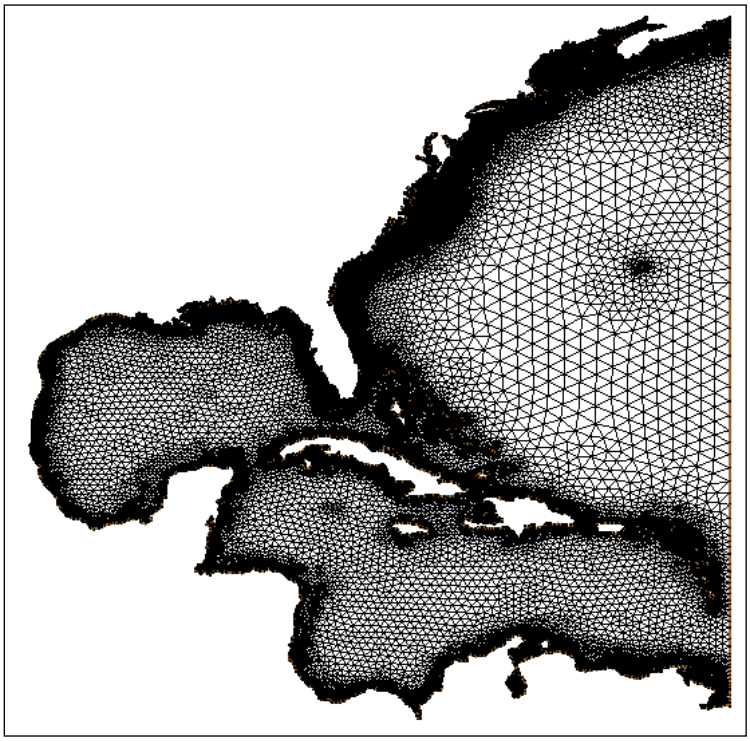

Figure 64- Western North Atlantic, the Gulf of Mexico and the Caribbean Sea ADCIRC grid (Brian and Luettich, 2008)

Figure 65- Survey data coverage

The CMS-WAVE grid was delineated such as to include the anticipated offshore borrow areas and the offshore Wave Information Studies (WIS) 63276 station. The grid orientation is 100 deg counterclockwise from East and extends about 87.7 KM along the shoreline and 23.3 KM offshore (Figure 66). The offshore grid boundary was extended seaward of WIS station 63276 to include more details of the Lookout Cape Shoal. The computational grid was constructed with 457861 cells and with resolution of 75 m in the offshore area. The resolution was increased to about 50 m in the nearshore area and in the offshore proposed borrow sites vicinity to adequately resolve wave energy transportation in the area. The bathymetry of the CMS-WAVE grid was obtained by interpolating the survey scatter data to the grid cells as shown in Figure 67.

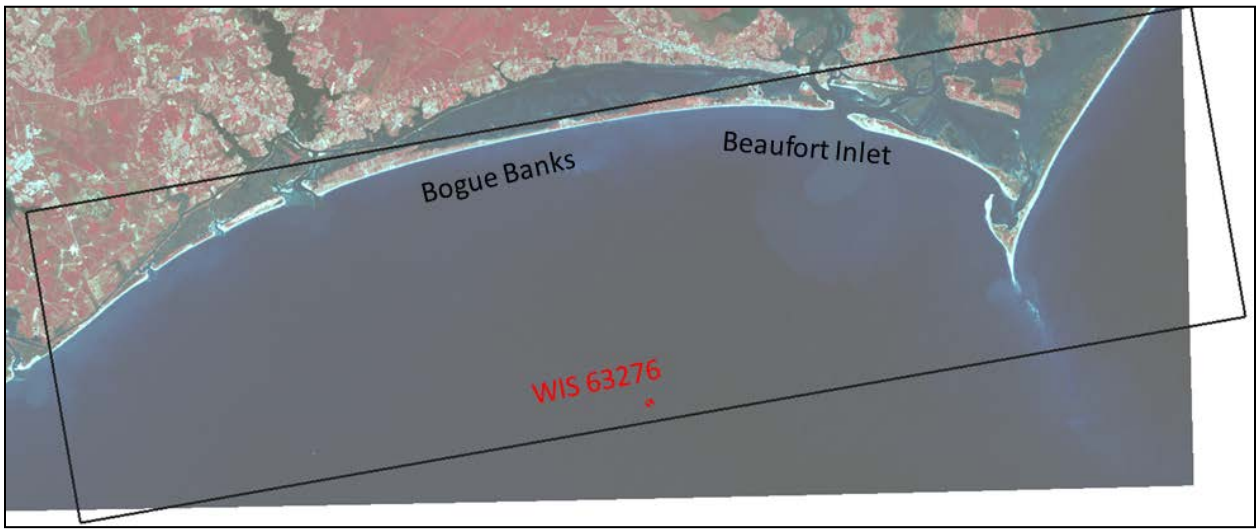

Figure 66- Extent of CMS-WAVE grid

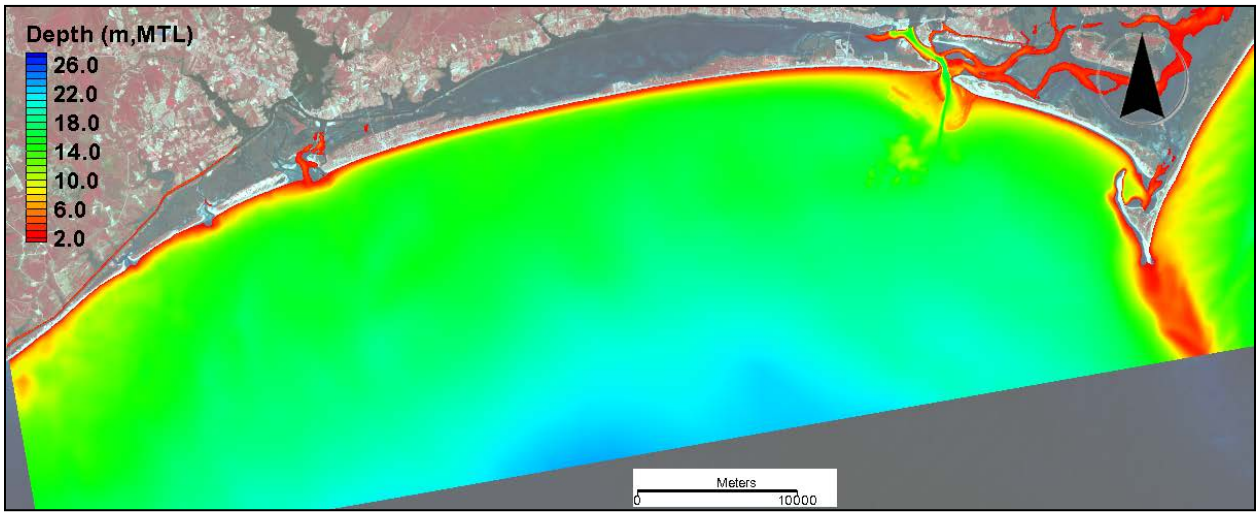

Figure 67- CMS-WAVE grid bathymetry

5.1.3 Model Forcing Conditions

CMS-WAVE was forced with directional wave spectra at the offshore grid boundary. The offshore wave climate provides representative wave boundary conditions. The model was not forced with wind or current fields which are optional.

Wave data used to determine the offshore wave conditions was obtained from the WIS Station 63276 located at Latitude of 34.5° N and Longitude of 76.833° W in 21 m depth. The WIS project produces a high quality online database of hindcast nearshore wave conditions from 1980-1999. The hindcast wave conditions were produced using the latest updated version of the numerical ocean wave generation and propagation model WISWAVE along with wind fields produced by Oceanweather Inc. Figure 68 shows the wave rose diagram of wave height versus wave direction percent occurrence at WIS station 63276 during 1980-1999. The figure shows that waves come mainly from the South East quadrant. Table 15 shows the percent occurrence of heights and periods of all directions at WIS station 63276. It can be seen from the table that wave heights generally range between 0.5-4 m and wave periods range between 5 -16 sec. Also the WIS station mean-maximum summary table (http://wis.usace.army.mil/products.html?staid=63276&lat=34.5&lon=-76.83&dep=21), which states the maximum monthly wave height and period during the 20 years of hindcast, was examined. The maximum wave height and period were 10.0 m and 16.21 s respectively. From these statistics, a set of discrete conditions were selected for simulations. The wave height range was defined at 0.5-m intervals from 0.0 m to 2.0 m and at 2 m interval to 10.0 m. The wave period range was 0 to 18 sec at a 3 sec interval. The wave directions were incremented every 22.5 deg. Significant wave height, peak wave period and vector mean wave direction (degrees clockwise from True north) were adopted in the analysis.

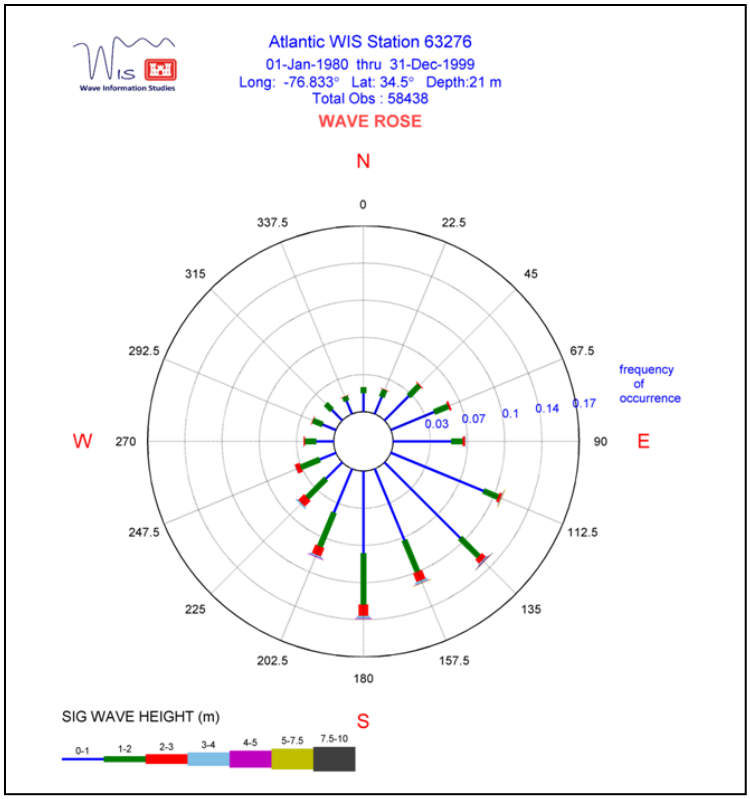

Figure 68- Waverose diagram at WIS station 63276

ATLANTIC WAVE HINDCAST ST: 63276
ALL MONTHS FOR YEARS PROCESSED : 1980 - 1999
STATION LOCATION : (-76.83 W / 34.50 N)
DEPTH : 21.0 m

PERCENT OCCURRENCE (X1000) OF HEIGHT AND PERIOD
FOR ALL DIRECTIONS

NO. CASES : 58437
NO. CALMS : 541

HEIGHT IN METERS	PARABOLIC FIT OF PEAK SPECTRAL WAVE PERIOD (IN SECONDS) <5.0	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 11.9	12.0- 13.9	14.0- 15.9	16.0- LONGER	TOTAL
0.00-0.10	.	.	.	.	.	.	.	.	.	.	925
0.10-0.49	8795	2186	2650	2039	1001	545	477	308	70	27	18098
0.50-0.99	33579	4823	2955	1540	997	562	545	391	124	49	45565
1.00-1.49	12567	4011	1841	1054	670	352	285	290	154	23	21247
1.50-1.99	1392	2597	1791	674	381	191	155	118	92	17	7408
2.00-2.49	107	698	1379	975	302	155	118	94	34	17	3879
2.50-2.99	.	63	263	544	362	148	71	47	29	18	1545
3.00-3.49	.	.	18	200	256	124	63	32	10	11	714
3.50-3.99	.	.	.	11	94	80	65	23	5	11	289
4.00-4.49	.	.	.	.	18	66	35	8	3	8	138
4.50-4.99	.	.	.	.	.	18	15	1	.	1	35
5.00-5.99	.	.	.	.	.	3	32	8	6	1	50
6.00-6.99	.	.	.	.	.	.	11	6	1	.	18
7.00-7.99	.	.	.	.	.	.	1	10	3	.	14
8.00-8.99	.	.	.	.	.	.	.	11	3	.	14
9.00-9.99	.	.	.	.	.	.	.	1	1	.	2
10.0-12.4	.	.	.	.	.	.	.	.	1	.	1
10.00+	.	.	.	.	.	.	.	.	1	.	1
TOTAL	56440	14378	10897	7037	4081	2244	1873	1348	536	183	

MEAN Hmo(M) = 1.0 LARGEST Hmo(M) = 10.0 MEAN TPP(SEC) = 5.3 FINITE

Table 16- Percent occurrence of wave heights and periods of all directions at WIS station 63276

The regional shore line adopted in the study is approximately oriented at 100 deg (azimuth) as shown in figure 65. Statistics were performed for onshore wave direction bands only (100 deg-290 deg) and other waves were considered as directed offshore and were not considered in the analysis. The wave data was analyzed between 100 deg and 290 deg directions in 22.5-deg bins.

The 20 years hindcast record was used to develop a binned approach based on joint probability of wave direction, period and height. A MATLAB routine was used to calculate the joint probability of wave direction, period and height. Table 16 shows the selected direction-period-height bins used to synthesize the wave climate. The total number of occurrences from the selected bins was 39588 which represent about 68% of the total waves (58438) at WIS station 63276.

Bin	Wave Direction (deg, from North)	Wave Period (sec)	Significant Wave Height (ft)
1	112.5 – 135.0	3.0 - 6.0	0.00 - 0.50
2	135.0 - 157.5	6.0 - 9.0	0.50 - 1.00
3	157.5 - 180.0	9.0 - 12.0	1.00 - 1.50
4	180.0 - 202.5	12.0 - 15.0	1.50 - 2.00
5	202.5 - 225.0	15.0 - 18.0	2.00 - 4.00
6	225.0 - 247.5		4.00 - 6.00
7	247.5 - 270.0		6.00 - 8.00
8	270.0 - 292.5		8.00 - 10.00

Table 17- Selected wave bins

The frequency of occurrence of all possible height-period-direction combinations was estimated. The total number of the combinations listed in table 16 is 188. For each wave direction bin, representative wave conditions with percent of occurrence more than 0.5 were selected to represent the normal or the most commonly occurring conditions in the wave climate for this study. Waves within bin 8 deviate by small angle from the shoreline and were considered as directed offshore and were excluded from the analysis. Accordingly, 36 wave conditions with total percent of occurrence of 54.5 were selected to represent the prevailing wave climate in the study area (Table 17). The Mean-Max summary table for WIS station 63276 was used to extract severe wave conditions. Four wave conditions with extreme wave height and period values were selected to represent storm conditions as shown in Table 17. Wave condition 39 occurred during September 1999 which represents Hurricane Floyd. Wave condition 40 occurred during September 1996 which represents Hurricane Fran. The selected extreme wave conditions had rare occurrences during the hindcast period of 20 years and consequently the percent of occurrence for the four

extreme conditions was negligible and was not listed in the table.

Wave Condition	Wave Direction (deg, from North)	Wave Period (sec)	Wave Height (m)	Percent Occurrence
1	123.75	4.5	0.75	4.38
2	123.75	7.5	0.25	2.63
3	123.75	4.5	0.25	2.13
4	123.75	7.5	0.75	1.49
5	123.75	4.5	1.25	0.86
6	146.25	4.5	0.75	4.37
7	146.25	4.5	0.25	1.44
8	146.25	4.5	1.25	1.14
9	146.25	7.5	0.25	1.1
10	146.25	7.5	0.75	0.76
11	146.25	7.5	3	0.61
12	168.75	4.5	0.75	4.95
13	168.75	4.5	1.25	2.04
14	168.75	4.5	0.25	1.2
15	168.75	7.5	3	1.01
16	168.75	7.5	1.75	0.88
17	168.75	7.5	1.25	0.81
18	168.75	7.5	0.75	0.73
19	168.75	4.5	1.75	0.51
20	191.25	4.5	0.75	4.38
21	191.25	4.5	1.25	2.25
22	191.25	4.5	0.25	1.14
23	191.25	7.5	3	0.98
24	191.25	7.5	1.25	0.69
25	191.25	7.5	1.75	0.61
26	191.25	4.5	1.75	0.57
27	191.25	7.5	0.75	0.54
28	213.75	4.5	0.75	2.17
29	213.75	4.5	1.25	1.41
30	213.75	7.5	3	0.74
31	213.75	4.5	1.75	0.62
32	236.25	4.5	0.75	1.24
33	236.25	4.5	1.25	1.17
34	236.25	4.5	1.75	0.67
35	258.75	4.5	0.75	1.48
36	258.75	4.5	1.25	0.81
37	133	16.21	4.3	
38	188	10.81	5.07	
39	146	13.4	8.57	
40	137	14.57	10	

Table 18 Representative wave conditions at WIS station 63276

The Surface-Water Modeling System (SMS) (Zundel, 2005) includes the capability to generate incident spectra using a TMA one dimensional shallow-water spectral shape (named for the three data sets used to develop the spectrum: TEXEL storm, MARSEN, and ARSLOE) (Bouws et al. 1985) and a $\cos^{nn}\alpha$. . To generate a TMA spectrum, the following parameters must be specified: peak wave period (*Tp*), wave height, water depth, and a spectral peakedness parameter (γ). The directional distribution of the spectrum is specified with a mean direction and a directional spreading coefficient (*nn*) . The energy in the frequency spectrum is spread proportional to $\cos^{nn}(\alpha-\alpha_m)$, where α is direction of the spectral component and α_m is the mean wave direction (Smith et al, 2001). For each of the selected 40 wave conditions, TMA wave spectra were implemented by SMS software.

5.1.4 Potential Borrow Areas

There are some limits on the lateral and vertical extent of borrow material sites. Lateral boundaries should be set far from shorelines to avoid adverse impacts on shorelines due to altering the wave energy in the nearshore area. Zones of rock and clay should be considered as undesirable areas when setting the lateral boundaries of the borrow areas. Boreholes were used in identifying the vertical boundaries of the potential borrow sources. The composition and thickness of overburden should be examined and borrow areas should be identified based on depth of suitable material. Buffers must be delineated between suitable and non suitable sediments, which cannot be included in the source's available volume. Buffer areas around sensitive environmental or cultural resources, or around known obstructions, must also be excluded from the source's available volume. Figure 69 shows the locations of boreholes offshore of Bogue Banks and the footprint of four proposed borrow areas. Borrow area Q1 will not be considered for use in the Bogue Banks 50 year nourishment project. If there is a shortage of material in the future it may be reconsidered. Therefore only three borrow areas (U, Y and Q2) will be considered in the wave analysis. The geotechnical analysis describing the details of developing the borrow areas limits are available in Appendix C.

Figure 70 shows an isopach map of the deposit to determine the volume of the borrow materials. An isopach map is a contour map showing the thickness of a deposit between two physical or arbitrary boundaries. In this case, the upper boundary of the deposit is defined by the surface of the sea bottom and can be delineated by bathymetric data. The lower boundary is the borehole depth which is created by interpolating the scatter borehole data to a uniform grid with a resolution of 50 m. The removal depth is to follow the borehole surface created from the borehole scatter data set.

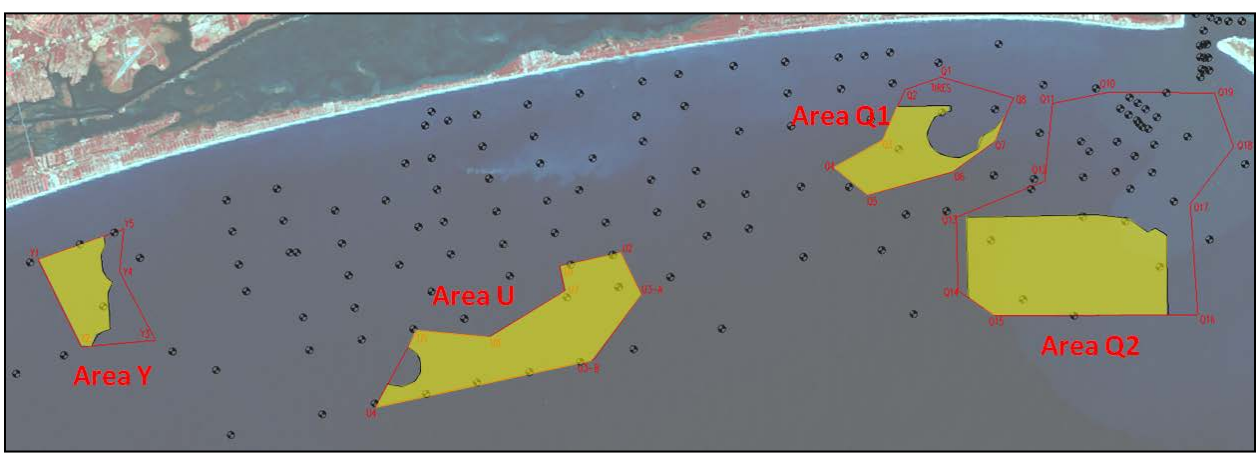

Figure 69- Proposed borrow areas and borehole locations

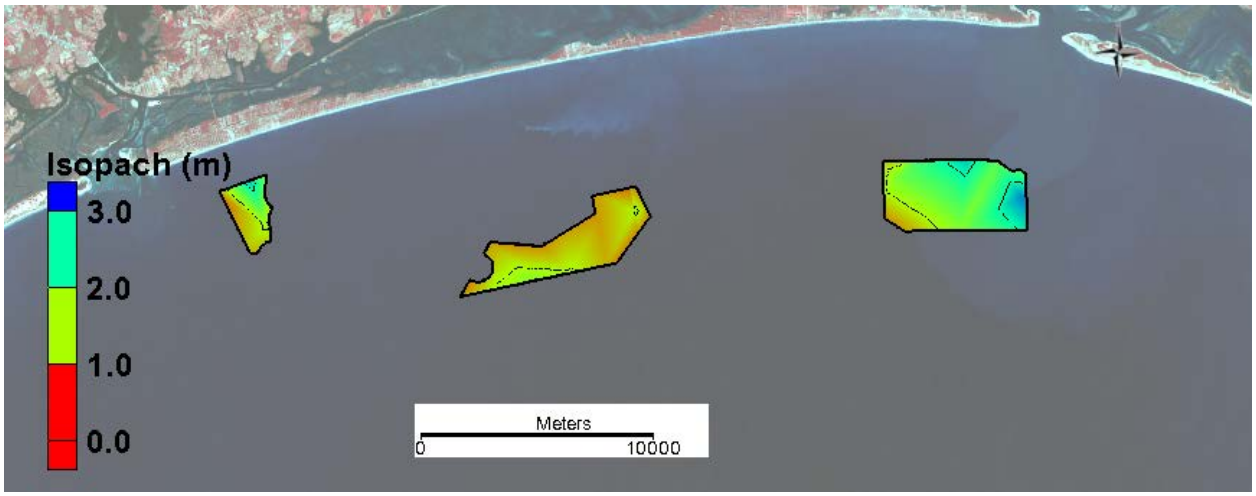

Figure 70- Borrow area isopach

The existing grid bathymetry was modified to incorporate the proposed dredged depths. Figure 71 shows the modified bathymetry of the CMS-WAVE grid at the proposed borrow sites. Therefore the only difference between the before- and the after-dredge CMS-WAVE grids was within the borrow area boxes shown in the figure.

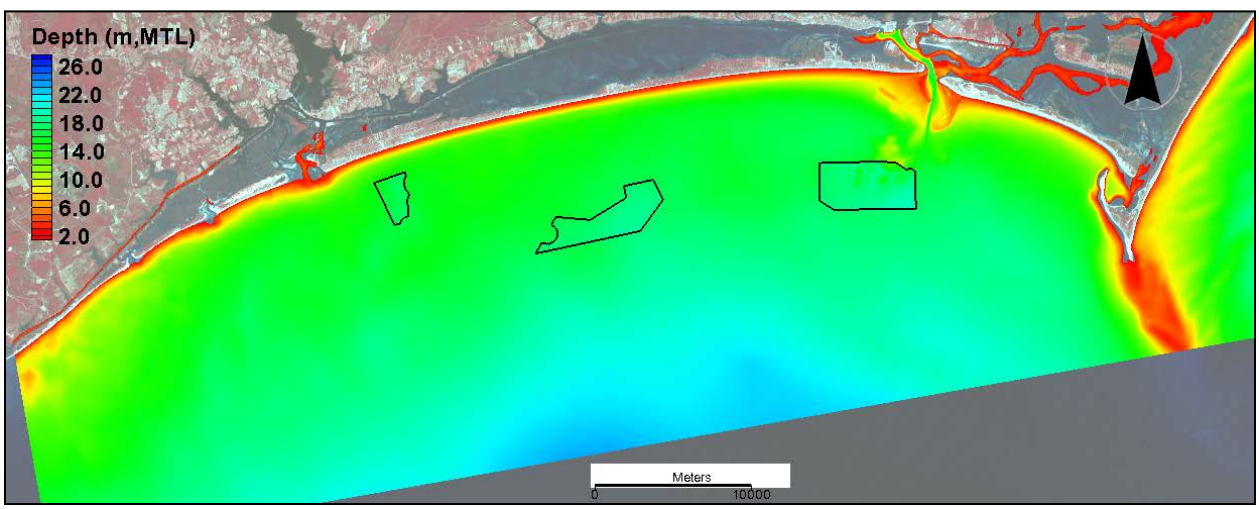

Figure 71- CMS-WAVE grid bathymetry after excavating the proposed borrow area

5.1.5 Wave Model Simulations

CMS-WAVE model simulations were conducted with and without the borrow areas excavation to investigate the adverse effect of mining on the wave climate along Shackleford Banks and Bogue Banks shorelines. CMS-WAVE simulations for the synthesized 40 wave conditions were conducted for the existing and after dredging the borrow areas grids to investigate the impact of dredging on wave climate in the study area.

This analysis was conducted based upon the assumption of fully excavating the entire borrow area. This extreme borrow area removal is an unlikely scenario because there is approximately 59 million cy of material available in these areas, and based on current estimates the project will need only about 22 million cy of material over 50 years. Therefore, the investigated scenario represents a worst case condition.

When wave angles deviate by about 60 deg or more from perpendicular to the seaward boundary, such model-induced energy losses are usually significant (Thompson, et. al., 1999). Wave conditions within Bin 1 deviate by 66.5 deg from perpendicular to the seaward boundary but since only qualitative comparison of wave height is being investigated in this study, the 123.5 deg cases were not rerun with rotated grid.

The four wave transformation processes associated with offshore bathymetric changes due to borrow pits can include wave refraction, diffraction, reflection and dissipation (Tang, 2002). Figure 72 shows the difference in wave height due to excavating the proposed borrow areas for wave case 12 which represents the most prevailing wave climate in the area with percent of occurrence of 4.95. The wave height difference was estimated by subtracting the existing wave height values from the excavated borrow area wave height values. The positive wave height difference (cool colors) indicates wave height increase and the negative wave height difference (warm colors) indicates wave height decrease. The arrows in the figure represent the after dredging wave direction only. The figure shows that dredging the borrow areas has minimal change on the wave climate with maximum wave height change of less than 2 cm. The change in wave height, due to the borrow areas excavation, for the 36 prevailing wave conditions was examined and the maximum increase of wave height was less than 10 cm. Figure 73 shows an example of the wave height change field for wave condition 11 with incident wave height of 3 m and wave period of 7.5 s.

Figure 74 shows the wave height change due to excavating the proposed borrow areas for wave case 40 which represents the most extreme weather condition during the 20 years with very rare occurrence (Hurricane Fran). Inclusion of the water level is important for the extreme wave events because if not included dissipation from depth-induced wave breaking would be overestimated. Therefore, the wave data might be overestimated since surge values were not included in the analysis. Maximum wave heights increase occurred at the eastern and western boundaries of borrow areas Y and Q2, mainly due to wave energy focusing at the borrow areas boundaries. The maximum observed wave height change in the borrow area vicinity was about 0.7 m. Wave transformation was governed by refraction and breaking in the nearshore shallow area in front of the shorelines.

Figures 75 and 76 show the change in wave height, before and after dredging the proposed borrow areas, along transects delineated in front of Shackleford and Bogue Banks shorelines respectively. CMS-WAVE estimated the breaker index at each cell. Grid cells with active breaking are specified with an index of 1 and nonbreaking cells with an index of 0 (Smith et al., 2001). The Transects were delineated just seaward of the breaker index of 1 for each cell. Also, the figures show the cumulative average wave height difference along the Transects (excluding the four extreme wave conditions). Maximum wave height increase of less than 1.5 cm was observed along Shackleford and Bogue Banks shorelines. Even during extreme weather conditions, maximum wave height increase due to the borrow area excavation was less than 1.5 cm along Bogue Banks shoreline. The cumulative average wave height increase was negligible along Shackleford and Bogue Banks shorelines. This is mainly due to wave dissipation at the nearshore shallow bathymetry in front of the shorelines.

Figure 77 shows the wave height change at four points in the vicinity of the borrow areas for the 40 wave conditions. It can be seen from the figure that the maximum increase of wave height, of less than 10 cm, was observed for wave conditions 1 thru 36. The maximum wave height increase, of about 0.7 m, occurred in the

borrow area vicinity only during storms. The magnitude of increase in wave height decrease as wave propagate shoreward due to dissipation of wave energy in the nearshore area.

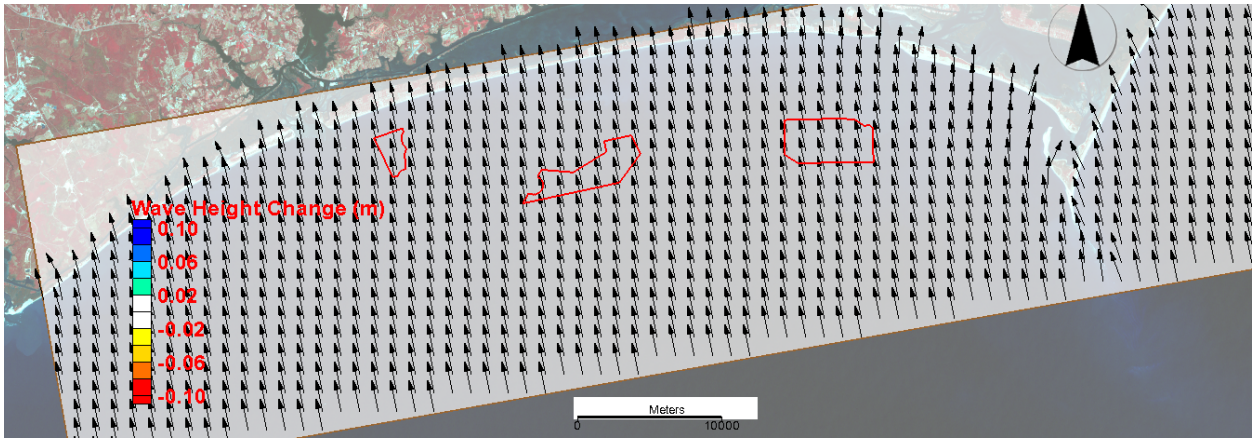

Figure 72- Wave height change for wave condition 12

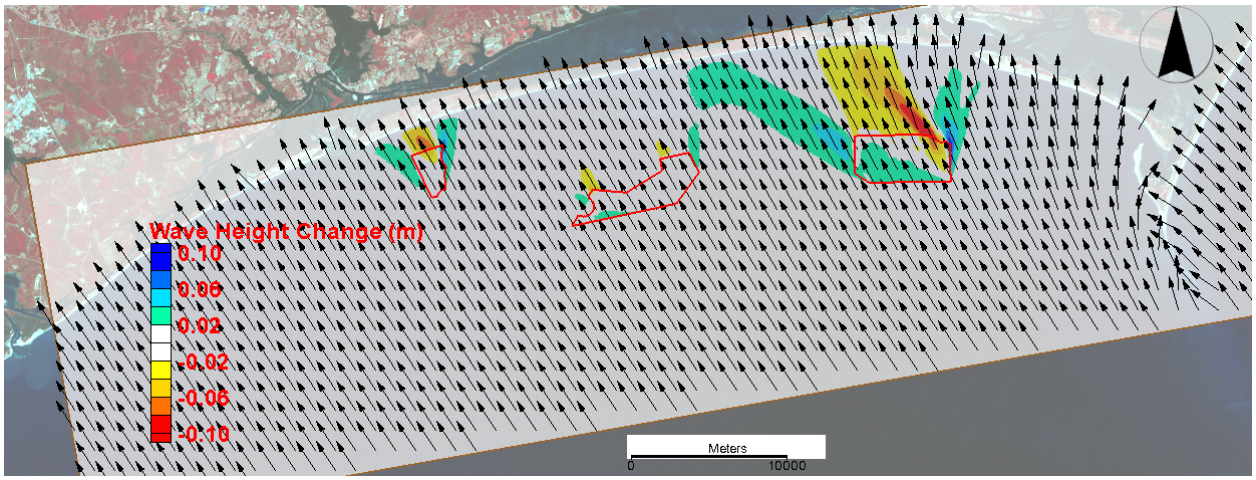

Figure 73- Wave height change for wave condition 11

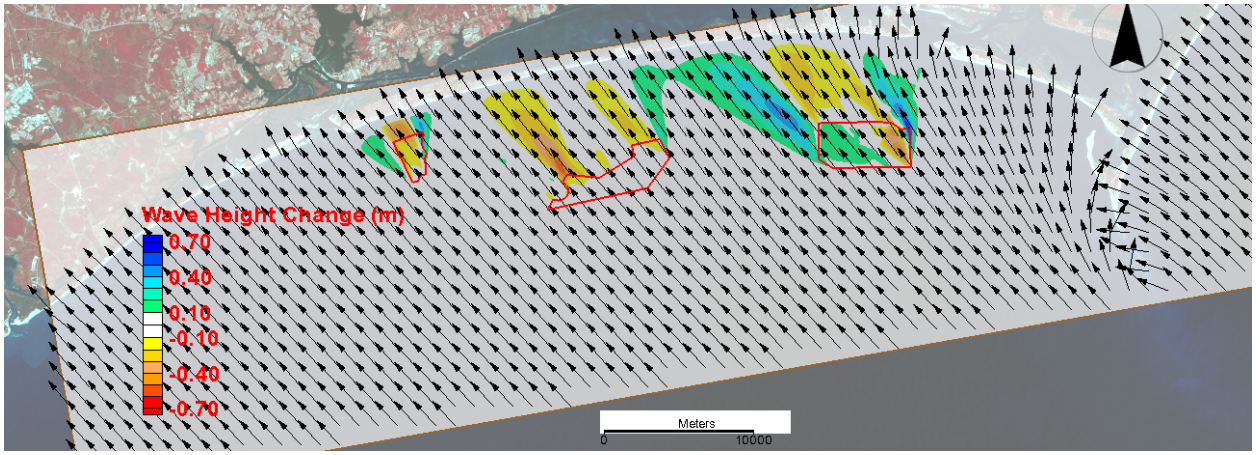

Figure 74- Wave height change for wave condition 40

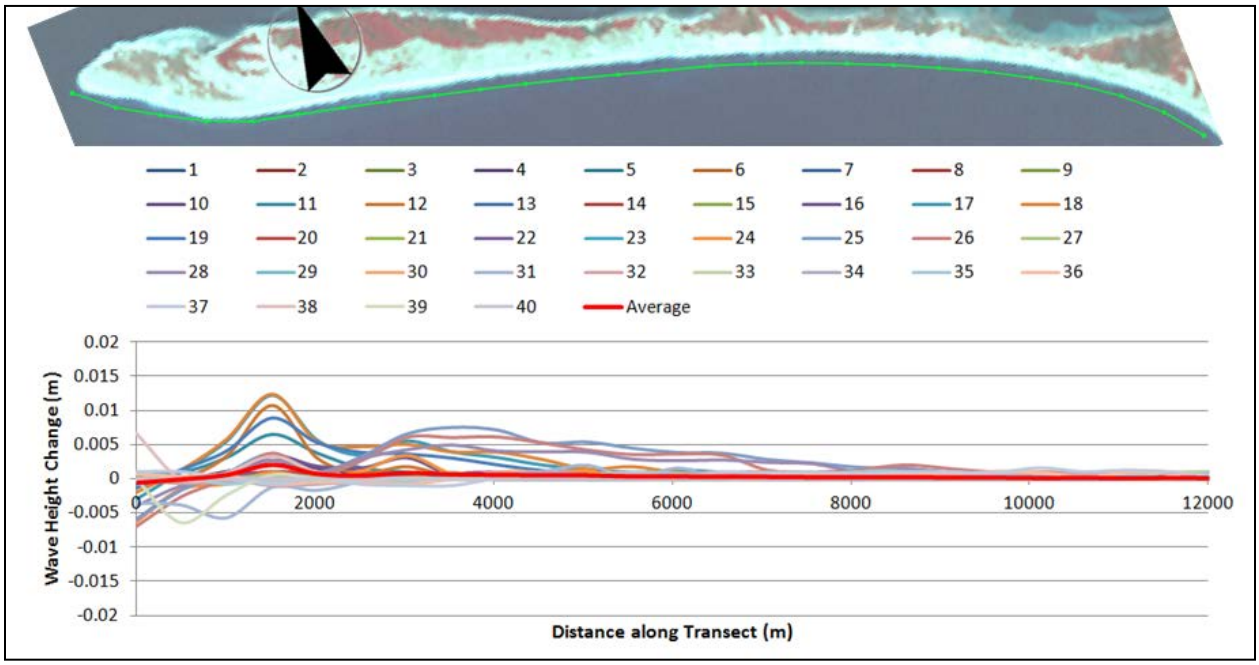

Figure 75-Wave height change along Shackleford Banks Transect

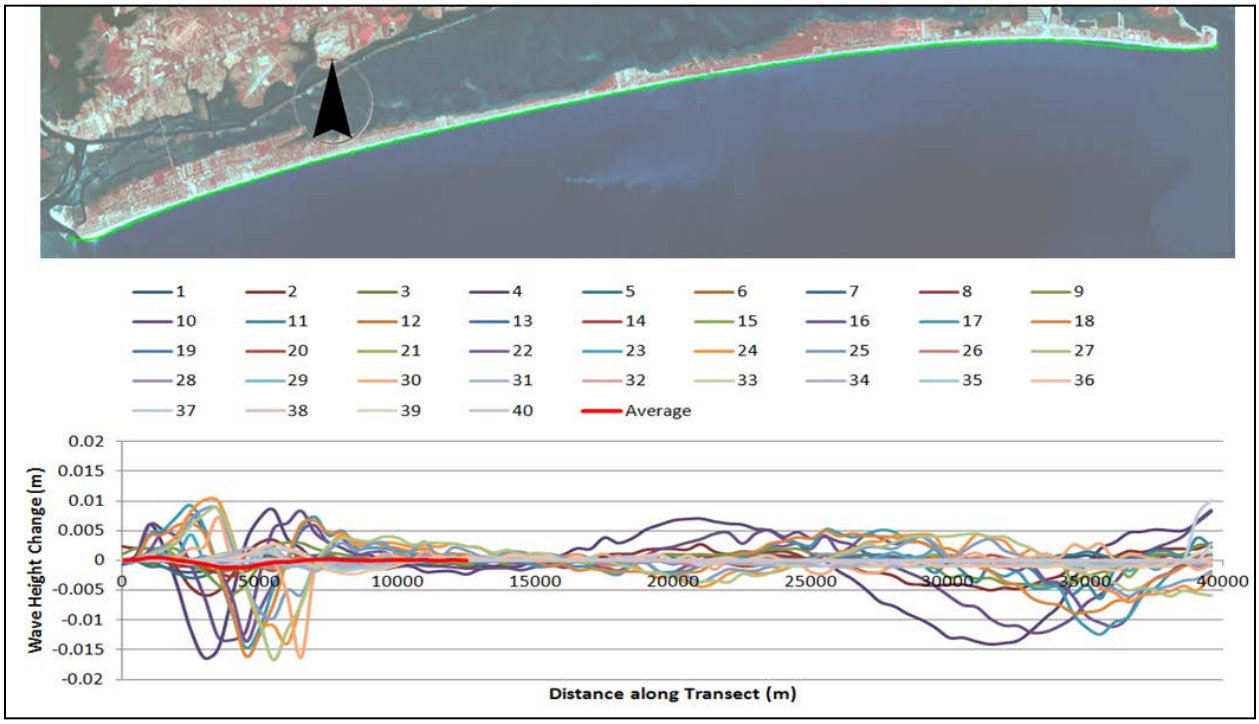

Figure 76-Wave height change along Bogue Banks Transect

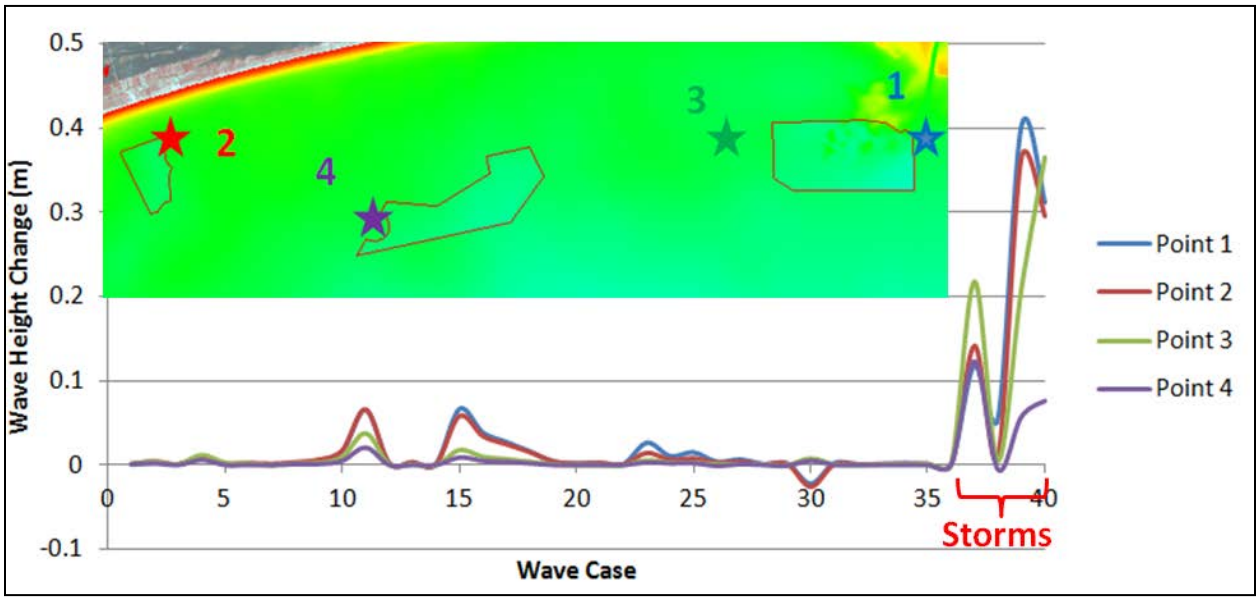

Figure 77-Wave height change at points in the borrow areas vicinity

5.1.6 Borrow Area Impact Analysis Conclusions

CMS-WAVE was used to estimate wave transformation change along Shackleford and Bogue Banks beaches due to the excavation of proposed borrow areas for the Bogue Banks 50 year nourishment project. WIS station 63276 was used to synthesize the offshore wave climate. Forty simulations were conducted to assess the impact of dredging the borrow areas on wave climate in the study area.

Maximum wave height increase of about 1.5 cm was observed along Shackleford and Bogue Banks shorelines for the forty wave conditions. Even during extreme weather conditions, maximum wave height increase due to the borrow area excavation was about 1.5 cm along Bogue Banks shoreline. The cumulative average wave height increase was negligible along Shackleford and Bogue Banks shorelines. This is mainly due to wave dissipation at the nearshore area in front of the shorelines.

Maximum increase of wave height of less than 10 cm was observed, in the offshore borrow areas vicinity, for wave conditions 1 thru 36. Maximum wave height increase, of about 0.7 m, occurred in the borrow area vicinity only during storms.

In general, the change in wave height along Bogue Banks shorelines from full excavation of the proposed borrow areas is negligible even during storms. This is mainly due to dissipating wave energy at the nearshore shallow bathymetry and due to the relatively offshore location of the borrow pits.

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FINAL

INTEGRATED

FEASIBILITY REPORT

AND

ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX B

Economics, Parking and Access

US Army Corps
of Engineers
Wilmington District

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1.0 INTRODUCTION.

The purpose and need for coastal storm damage reduction is to reduce damages and land loss resulting from beach erosion, wave attack, and flooding along the ocean shoreline of the study area. 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

1.01 Coastal Storm Damage Study Area.

The island of Bogue Banks is located in Carteret County near the center of North Carolina's coast. The island faces the Atlantic Ocean on the south and extends approximately 25.4 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 of the island, from west to east are 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 ½ mile wide.

Over the past 35 years Bogue Banks has developed rapidly as a family ocean resort community for outdoor recreation. Land use is primarily recreational, residential and a few 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. With the exception of some dune areas, the entire island is subject to hurricane storm surge flooding.

The study area is roughly the incorporated towns located on Bogue Banks in Carteret County, North Carolina. The study area extends from Bogue Inlet at the west end to Atlantic Beach on the east end, approximately 23 miles. For 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. From the ocean shoreline the study area extends landward approximately 500 feet. Seaward the study area extends from the shoreline approximately 1 mile. The study area also includes three offshore borrow sites lying 1 to 8 miles from the shoreline (shown in Figure B-1), including the Offshore Dredged Material Disposal Site (ODMDS).

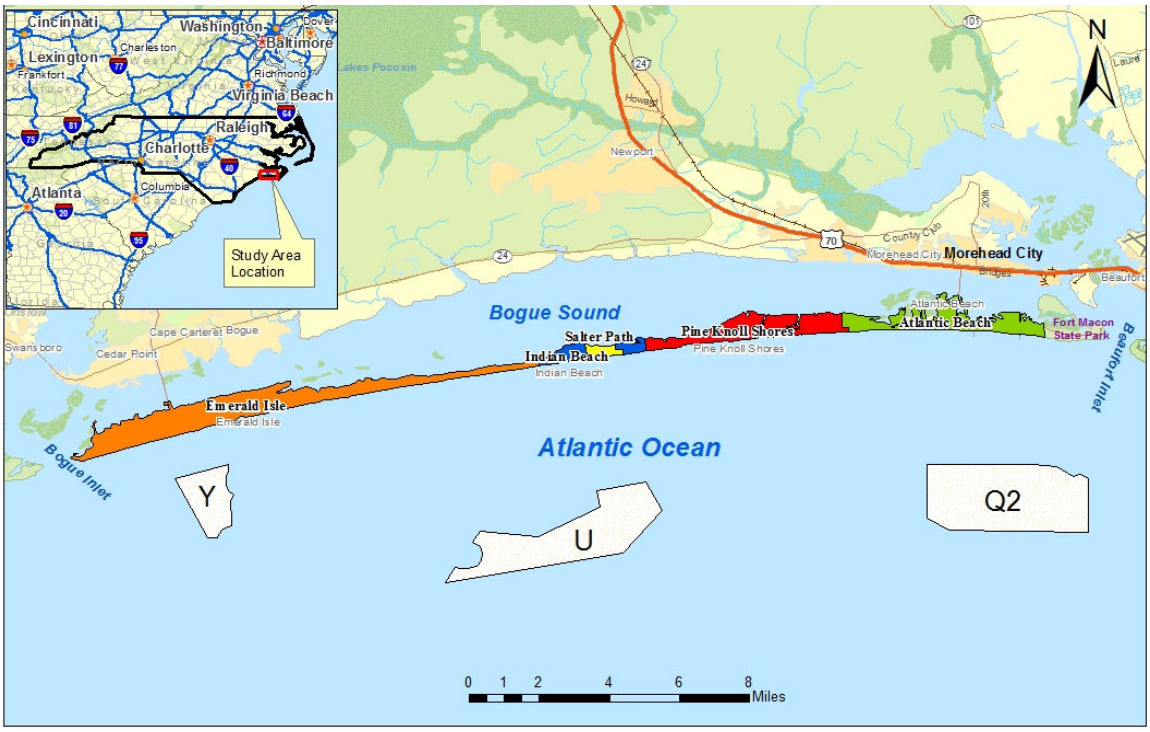


Figure B-1 Coastal Storm Damage Reduction Study Area

1.02 Recreation Day User Study Area

Overnight visitors come from as far away as 3,000 miles; however, the 46 counties listed in Table B-1 and shown in Figure B-2 were selected as being within a reasonable driving distance Bogue Banks. The purpose of the survey of potential day users was to collect data that will show the frequency of visits and the total number of trips to Bogue Banks. It is expected that the analysis will show that persons from nearby counties will visit more frequently than persons from the more distant counties.

Table B-1 - North Carolina Counties within Driving Distance of the Bogue Banks Study Area and Carteret County

Anson	Edgecombe	Martin	Robeson
Beaufort	Franklin	Montgomery	Sampson
Bertie	Granville	Moore	Scotland
Bladen	Greene	Nash	Stanly
Brunswick	Halifax	New Hanover	Vance
Carteret	Harnett	Northampton	Wake
Chatham	Hertford	Onslow	Warren
Columbus	Hoke	Orange	Washington
Craven	Johnston	Pamlico	Wayne
Cumberland	Jones	Pender	Wilson
Duplin	Lee	Pitt	
Durham	Lenoir	Richmond	

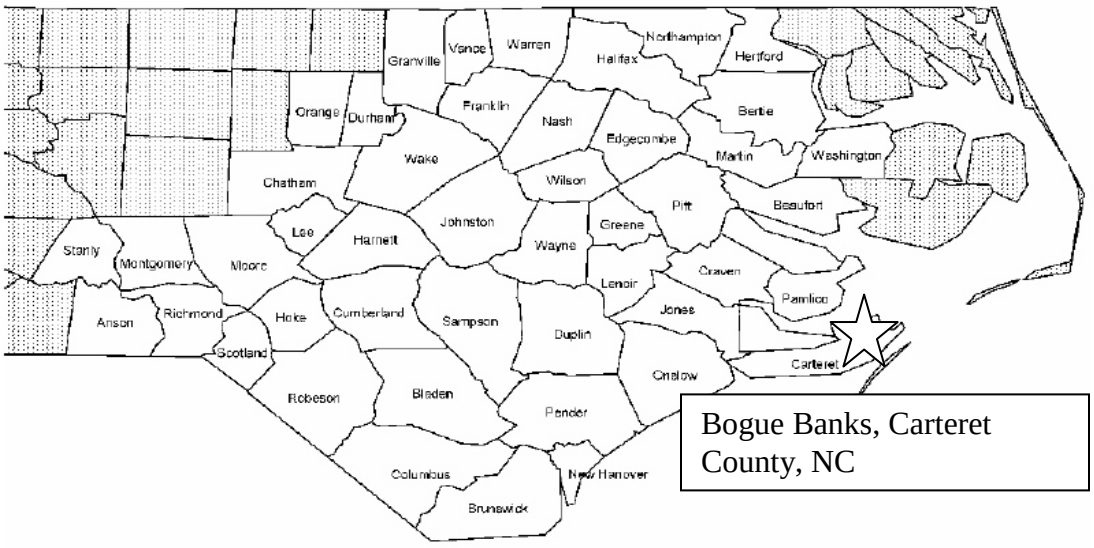


Figure B-2 – Recreation Demand Study Area

The recreation demand and methodology recommended for the beach user benefit analysis are presented later in this Appendix. According to the U.S. Census and the North Carolina Office of State Budget Management, the population of the forty-five-county area grew from 3,700,000 in 2000 to 4,400,000 in 2009, an increase of more than 20 percent in the decade.

1.03 Regional Economic Impact Area

The local economic impact area includes all of Bogue Banks and the nearby areas of Carteret County, North Carolina. Comprising the Bogue Banks study area are the towns of Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach

2.0 EXISTING ECONOMIC CONDITIONS:

2.01 Basic Economic Assumptions

This study is in compliance with the evaluation procedures outlined in the Water Resource Council's Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies, dated 10 March 1983, and Corps of Engineers policy guidance on Coastal Storm Damage Reduction, ER 1105-2-100, dated 22 April 2000. The following basic economic assumptions were used in the analysis of damages, benefits, and costs of the NED Plan

- **Interest rate.** The FY 2011 Federal interest rate used in the analysis of alternatives was 4.125 percent. Final cost updating and certification of the Recommended Plan used an Oct14 discount rate of 3.5%.

- **Price level**. October 2011 price levels were used in the analysis of alternatives, at 4.125 percent. Final cost updating and certification of the Recommended Plan used an Oct14 discount rate of 3.5%.

- **Period of Analysis.** The analysis is based on a 50-year period.

The economic comparison of alternatives was performed using the FY2011 interest rate of 4.125% (*appropriate at the time of that analysis*). It should be noted that the Recommended Plan was analyzed using the Oct 2014 discount rate of 3.5%

2.02 Demographics

Demographics for the existing economic conditions for the study area include census data for population, housing, and personal income, which are shown in Table B-2. The full-time resident population was estimated to be nearly 6,600 in 2010. Estimates of peak season population vary.

Table B-2 - Population, Income, Housing Summary

	Carteret County	Emerald Isle	Indian Beach*	Salter Path*	Pine Knoll Shores	Atlantic Beach
Population Year Round	66,469	3,655	112	N/A	1,339	1,495
Average Household Size	2.27	2.11	1.7	N/A	2.04	1.78
Housing Units	48,179	6,735	1,565	N/A	2,049	4,935
Occupied Year Round	28,870	1,732	66	N/A	653	840
Seasonal or Vacant	19,309	5,003	1,499	N/A	1,396	4,095
In Labor Force						
Civilian	32,504	1,784	52	N/A	578	1,016
Unemployed	2,780	207	0	N/A	30	110
Armed Forces	948	127	0	N/A	0	40
Employment By Leading Industry						
Construction	3,366	80	N/A	N/A	66	96
Arts, Entertainment, Food Service, Recreation, and Accommodation	1,936	189	N/A	N/A	108	199
Retail Trade	3,801	261	N/A	N/A	76	196
Education, Health & Social Services	5,631	340	N/A	N/A	93	199
Per Capita and Household Income						
Per Capita Money Income	$26,791	$34,279	$28,763	N/A	$43,068	$31,196
Median Household Income	$46,155	$50,380	$51,467	N/A	$60,521	$48,112

**Census Specific data is not available for Salter Path and is incomplete for Indian Beach*

Source: U.S. Census Bureau (http://factfinder.census.gov) and U.S. Dept. of Commerce – Bureau of Economic Analysis (http://bea.doc.gov/bea)

Office of State Budget and Management (2010 population estimates)

2.03 Shoreline Ownership

Public ownership of the shore in the towns of Bogue Banks includes dedicated roads and lands below mean high water (MHW) owned by the State of North Carolina. Other parcels are owned by the towns of Bogue Banks, including the Coastal Area Management Act (CAMA) public access points. The primary ownership of the oceanfront parcels is private. Privately-owned properties included in the Project area are considered to be in fee-simple ownership. Included within the project limits are single-family residential units, multi-family and condominium units, and commercial properties, including the fishing piers. Other information related to ownership of the shoreline is contained in the Real Estate Appendix.

2.04 Commercial and Recreational Fishing

The North Carolina Division of Marine Fisheries (NCDMF) reported nearly 600,000 pounds of commercial finfish and shellfish landings in the vicinity of Bogue Banks (including Carteret County) from 2009 and 2010. Total landings for commercial fish and shellfish were around 6 million pounds. The commercial value of these landings were reported to be over $9 million dollars.

Recreational fishing includes fishing from head boats, charter boats, private boats, piers, and the surf. Fishing from head boats is best in the winter months for snapper and grouper. Fishing from charter boats is excellent for King mackerel and bottomfish during the winter. Offshore, gulfstream species, like yellowfin tuna and Wahoo are present. Inside fishing has been successful for inshore species such as red drum, speckled trout, and flounder.

Private boat anglers can find bluefin tuna in the nearshore area, king mackerel and other bottomfish species in the offshore, and other species such as speckled trout, red drum, and flounder can be found in the inside areas of the creeks and Atlantic Intracoastal Waterway. NCDMF reports that shore fishing activity is limited in this area.

2.06 Storm-Related Emergency Costs

Information was collected from officials in nearby counties and municipalities sharing similar properties with the Bogue Banks study area, including: Pender and Onslow Counties, and also State, and Federal sources related to recent hurricanes and storms. At the time of this feasibility study, a study of emergency costs and benefits in the Bogue Banks study area had not been conducted. To demonstrate a reasonable equivalent for potential benefits for emergency activities, nearby Surf City and North Topsail beaches were used as proxies, at $99,000 for Surf City and $235,000 for North Topsail Beach, for a total of $334,000 over the associated area. This category of benefits is not very precise

and is relatively minor compared to CSDR benefits (1 to 2%) and so, was not included in the Bogue Banks economic analysis.

2.07 Determination of Structure Values

The value of residential structures is limited to replacement cost less depreciation. Replacement value is the cost to the owner if a structure is destroyed. If a significantly depreciated structure is destroyed and replaced, the difference between the old and new value is a betterment where the additional cost is offset by the additional utility and comfort of the new construction. Other measures of property value include fair market value and the income-producing value. These measures are not considered appropriate for National Economic Development benefits to protection of beach property. Fair market value is influenced by proximity to the ocean or sound, corresponding views of the beach and ocean, and short-term fluctuations in the local real estate market. Basing value on income can also produce significantly higher estimates. It is assumed that rental income lost to the owner will be transferred to some other owner in an alternate location. Therefore, the loss of income is considered a regional economic loss and not a loss to the National Economic Development account.

2.07.1 Cost of Residential Construction.

The average cost of residential construction on Emerald Isle was determined according to the quality of initial construction, at $193/ square foot (sf). Values for Indian Beach, Salter Path, Pine Knoll Shores and Atlantic Beach was determined to be $274/sf, $321/sf, $154/sf, and $137/sf, respectively. The “per square foot” structure values were determined by aggregating all structure values and square footage, then dividing that total value by total square footage. No structure was assigned a greater value regardless of the quality or construction type. The square footage areas for most structures were available at the Carteret County tax offices.

Structure values represent replacement value, less depreciation at the current price levels. In the case of Bogue Banks, depreciated replacement cost equals structure size multiplied by construction cost multiplied by a factor of depreciation (Depreciated Replacement Cost=Size x Unit Construction Cost x [1-% depreciation]).

2.07.2 Commercial Structure Values.

Values for commercial structures were based on visual surveys and talking to business managers and owners. Carteret County tax data was also used for comparison.

2.07.3 Value of Structures

Damage elements were not assigned a single structure or content value, but instead were give a low value, a most-likely value, and a high value. This is done to account for potential uncertainties in the assignment of these structure and content values..

The most likely structure value is based on the replacement cost less depreciation calculation. The low value is determined as 95% of the most likely value, while the high value is determined as 105% of the most likely value.

Total structure values for all damage elements (most-likely value) are estimated at $714.8 million and total contents are valued at $290.6 million for a total of about $1 billion in existing property (October 2011 price level at the time of analysis; re-verified in 2014 for Final Report) that could potentially be damaged from incoming storms.

2.08 Land Values

Land values in all North Carolina coastal counties are escalating in general due to increased population growth in the U.S. coastal regions. Lot sales in Carteret County are designated as ocean front, second row, and interior lots. To prevent the influence of water view or proximity to the ocean overriding the value, only the interior lot values are used in the analysis. A summary of values for ocean front lots, second row lots, and interior lots is presented below.

2.08.1 Ocean Front Lots

Ocean front lots are higher in risk for storm damage and erosion but continue to be highly desirable. These values were not used in the land loss estimates. The reason interior lots are used in this analysis versus oceanfront properties is defined in NED Manual for Coastal Storm Risk Management, and states “we use the nearshore market value to estimate the loss of private land from coastal storms. This represents the net loss assuming that the ocean front is the most valuable factor with a rent gradient declining as you move inshore. As the shoreline recedes, the extra ocean front differential value is transferred landward so the net economic loss is measured at nearshore value.”

2.08.2 Second Row Lots

These values were not used in the land loss estimates.

2.08.3 Interior Lots

The value and desirability of interior lots vary greatly; however, values based on sold prices continue to increase. Higher interior lot values may be due to the

limited number of all vacant lots in Bogue Banks and the fact that interior lots are less susceptible to storm and erosion damages. This data supports the estimated value of $12.55 per square foot in Pine Knoll Shores, Indian Beach, and Atlantic Beach. Emerald Isle data suggests $14.03 per square foot. Interior lot values are used to estimate the losses to land caused by long-term erosion.

3.0 FUTURE ECONOMIC CONDITIONS (WITHOUT PROJECT)

3.01 Projected Population Growth

Projected population growth for Carteret County is found at the North Carolina State Demographer's website. Figure B-3 shows both historical population from 1920 to 2000 and population projections for Carteret County through 2029.

According to the North Carolina demographics office, the population of this 45-county recreation day user demand area is expected to reach 4.3 million in 2010, 5.0 million in 2020, and over 5.6 million in 2029. Therefore it is reasonable to expect recreation visitation at Bogue Banks to increase over the next 25 to 50 years.

3.02 Assumed Conditions at Beginning of Period of Analysis: Without Project Condition

The period of analysis begins when the project improvement is in place and the benefits to the public begin to accrue. It is assumed that this condition could occur by FY2019. 15A NCAC 07H .2501 allows for a great deal of latitude for meeting rebuilding criteria following damages due to hurricanes or tropical storms. Issuing emergency permits for rebuilding on lots meeting a minimal setback restriction is generally the rule, not the exception in North Carolina. Common practice and historical evidence allow for rebuilding structures lost in storms provided setback restrictions are met, so the number of replacements is not limited in the analysis. However, after long-term erosion has claimed more distance on the oceanfront lot than the building requires to be put back, the model ceases to reinstate the same property. This assumption will prevent the overestimation of the without project coastal storm damages. Since all suitable lots are expected to be developed by the base year 2019, no additional growth in the number of residential or commercial structures is projected for the analysis. The assumptions used for structure replacement could result in fewer structures if storms destroyed a structure following its earlier replacement.

3.03 Summary of Future Without Project Economic Conditions

In summary, the future economic conditions are assumed to have the same distribution of residential use and commercial development as the existing

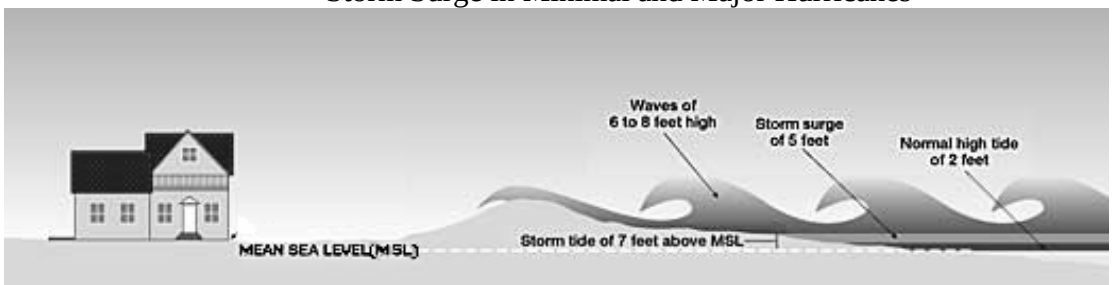
condition. Structures that are significantly damaged or destroyed are assumed to be replaced by an identical structure, and will continue to be replaced until rebuilding is no longer allowed per coastal regulations. All structures not damaged or destroyed are assumed to remain without any modification. No "teardowns" are built into the analysis where older structures are assumed to be torn down/demolished and replaced by more expensive units based on investment speculation related to the high demand for coastal real estate.

4.0 COASTAL STORM DAMAGES WITHOUT PROJECT

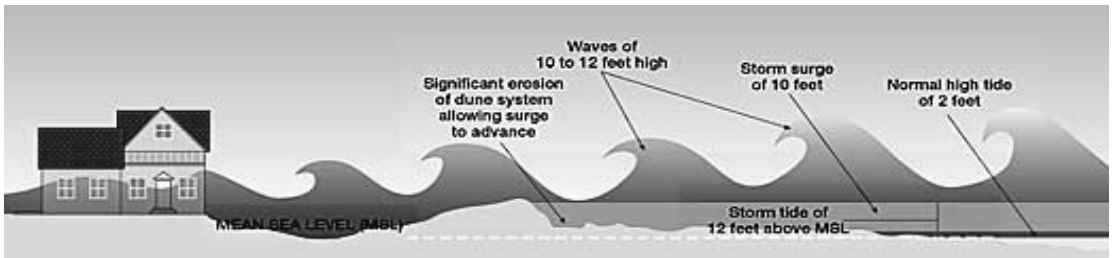
The average annual present value of coastal storm damages over the 50-year period of analysis without a damage reduction project totals $14,556,000 in October 2011 price levels. Average annual damages (average annual equivalent amounts, 50-yrs, 4.125%) were calculated by using the 50-year interest and amortization factor shown in Table B-7. These values were updated after screening and plan selection, to reflect October 2014 price levels, at 3.5% interest rate.

4.01 Damage Categories Defined: Figure B- 3 graphically shows the impact of tides, storm surge, and wave action that may occur during minimal and major hurricanes. (USACE, Mobile District, 1999). It should be noted that hurricane wind speed, the deciding factor in storm category by FEMA, does not determine the level of damages in the storm damage model. The impact of wind is not shown in the figure and wind damage is not estimated in the storm damage model. Coastal storm damages are calculated under with and without project conditions for damages to structures and contents, roadways, and land lost due to long-term erosion. In many cases damages are calculated for more than one category since storms frequently generate flood inundation, waves, and storm erosion simultaneously. The damage model, Beach-fx, calculates damages in all the appropriate categories and selects the category with the greatest damage and ignores the other damages. This technique prevents the overestimation or double counting of damages.

Storm Surge in Minimal and Major Hurricanes



In a Category I Hurricane, the storm surge will usually cause damage to beach dunes and structures placed on the seaward side of the dune line.



In a Category III Hurricane, the combined wave attack and storm surge erodes the dunes, exposing coastal structures to the most damaging effects of the surge. Although his wind speeds only placed Georges in Category II, the storm surge estimates were in line with Category III.

Courtesy of Escambia County Department of Public Safety.

Figure B- 3 Hurricane Surge and Wave Impacts

4.01_Damage Categories Defined (continued)

4.01.1 Storm Erosion

Storm erosion damages result from the undermining of structure pilings and foundations due to hurricane and tropical storms. Damages due to storm-induced erosion are the major damages that are generally computed by the economic damage model. The first element in determining the potential impact of storm induced erosion on the amount of damage to a coastal structure is how much of the protective beach (either existing or projected) remains in front of and under the structure during the storm. If the storm-induced erosion only reaches the front of the building, damage due to storm erosion is assumed to be zero and any damage to the structure would be that caused by either wave impact or inundation.

4.01.2 Flood

Flood damages are caused by inundation related to rises in tide and storm surge. Damages begin when flooding and overwash reaches the structure or enclosure.

4.01.3 Wave

Wave damages result from waves over and above the storm surge making contact with the structures. Waves impacting the structure three feet or more above the first living area elevation are expected to result in total loss of the structure. Figure B-3 illustrates the effect of both flood from storm surge and waves.

4.01.4 Land Lost or Long Term Erosion (LTE)

Land losses result from long-term erosion based on the analysis of historical erosion including rises in sea level. Land lost to long-term erosion is computed by multiplying the expected annual loss of land in acres by the value of nearshore interior lots. Fill material was also considered to reduce land losses due to long-term erosion. However, in the formulation of alternative plans, no suitable upland borrow sites were identified. Therefore, the cost of fill is not considered a practical limiting factor or substitute for the value of interior lots in the calculation of land lost or long-term erosion.

4.01.5 Summary of Damages

Examples of coastal storm erosion damage in coastal North Carolina are shown in Figure B-4 The present value of coastal storm damages by structure, content, and reach is shown in table B-3 for the without project condition.

Figure B-4- Coastal storm damage after Hurricane Fran 1996

Table B-3 – Present Value of Coastal Storm Damages (Without Project)

Average Annual Damages by Reach, Bogue Banks, Without Project, 4.125% Discount Rate			
Reach	Structure	Contents	Total Damages (AA)
1	$1,935,661	$749,793	$127,696
2	$1,749,783	$682,013	$115,634
3	$2,126,602	$751,788	$136,870
4	$2,410,341	$930,630	$158,866
5	$4,154,547	$1,312,800	$259,978
6	$4,066,477	$1,578,847	$268,441
7	$1,416,603	$527,251	$92,432
8	$781,007	$300,667	$51,435
9	$924,141	$316,398	$58,989
10	$432,924	$153,745	$27,897
11	$1,079,802	$369,595	$68,920
12	$1,431,991	$460,706	$90,000
13	$2,196,798	$833,313	$144,085
14	$2,016,075	$772,682	$132,608
15	$4,941,951	$1,912,575	$325,939
16	$735,421	$285,363	$48,539
17	$1,240,518	$547,922	$85,042
18	$217,445	$70,343	$13,685
19	$279,490	$101,813	$18,131
20	$549,592	$215,919	$36,401
21	$188,821	$75,529	$12,570
22	$2,397,056	$1,113,645	$166,937
23	$0	$0	$0
24	$106,045	$42,204	$7,049
25	$16,965	$6,779	$1,129
26	$18,612	$7,478	$1,241
27	$146,980	$57,757	$9,735
28	$171,789	$68,725	$11,437
29	$41,532	$16,610	$2,765
30	$296,704	$112,433	$19,455
31	$78,764	$31,198	$5,229
32	$155,245	$61,301	$10,297
33	$130,829	$52,048	$8,696
34	$85,251	$33,242	$5,634
35	$320,543	$127,851	$21,322
36	$176,060	$69,929	$11,697
37	$1,040,319	$407,278	$68,835
38	$590,433	$227,222	$38,880
39	$765,699	$300,566	$50,702
40	$3,581,398	$229,689	$181,221
41	$883,176	$353,370	$58,799

42	$263,760	$105,365	$17,552
43	$1,278,250	$491,945	$84,175
44	$965,062	$375,355	$63,738
45	$842,765	$317,032	$55,149
46	$820,944	$316,725	$54,097
47	$945,772	$369,359	$62,536
48	$546,847	$207,139	$35,853
49	$684,046	$264,899	$45,123
50	$419,402	$161,435	$27,619
51	$0	$0	$0
52	$74,252	$14,216	$4,207
53	$160,900	$1,323	$7,714
54	$501,435	$200,551	$33,380
55	$1,055,752	$0	$50,202
56	$0	$0	$0
57	$0	$0	$0
58	$0	$0	$0
59	$8,599	$3,208	$561
60	$77,975	$20,260	$4,671
61	$479,599	$189,354	$31,809
62	$9,769,852	$3,847,710	$647,529
63	$184,686	$57,731	$11,527
64	$136,070	$48,627	$8,782
65	$863,681	$342,326	$57,347
66	$110,032	$35,653	$6,927
67	$25,459	$9,213	$1,649
68	$834,944	$331,274	$55,455
69	$2,062,346	$810,363	$136,600
70	$5,769,607	$2,303,825	$383,900
71	$2,156,388	$769,697	$139,138
72	$1,415,978	$536,394	$92,837
73	$544,334	$209,655	$35,853
74	$196,797	$78,841	$13,107
75	$126,233	$48,421	$8,305
76	$1,592,634	$10,057	$76,210
77	$124,722	$49,106	$8,266
78	$15,870,116	$6,346,782	$1,056,436
79	$2,027,002	$798,765	$134,368
80	$5,152,032	$2,063,545	$343,108
81	$430,573	$155,858	$27,885
82	$238,362	$93,970	$15,803
83	$2,269,422	$899,029	$150,663
84	$1,733,096	$691,907	$115,311
85	$850,527	$329,632	$56,118
86	$842,519	$319,590	$55,259
87	$5,693,579	$2,276,103	$378,966
88	$121,245	$43,966	$7,856
89	$8,079,503	$654,784	$415,324

90	$830,882	$285,107	$53,066
91	$1,104,911	$184,361	$61,306
92	$11,930,665	$4,771,321	$794,196
93	$20,292,821	$7,964,599	$1,343,668
94	$1,341,348	$516,540	$88,344
95	$2,052,013	$815,240	$136,341
96	$1,832,484	$732,004	$121,944
97	$2,822,493	$1,126,713	$187,789
98	$2,098,514	$829,723	$139,241
99	$1,771,978	$702,204	$117,650
100	$2,044,206	$814,819	$135,949
101	$2,120,251	$765,535	$137,222
102	$1,401,517	$565,289	$93,524
103	$3,035,528	$1,214,735	$202,104
104	$2,016,834	$806,816	$134,267
105	$1,006,357	$428,186	$68,214
106	$5,914,066	$500,796	$305,033
107	$1,842,431	$566,597	$114,552
108	$1,236,379	$495,669	$82,361
109	$1,182,854	$468,921	$78,544
110	$1,313,205	$521,594	$87,247
111	$2,341,173	$912,179	$154,700
112	$1,806,727	$1,214,493	$143,662
113	$1,155,428	$388,934	$73,436
114	$2,539,300	$992,022	$167,918
115	$8,099,766	$3,188,903	$536,787
116	$12,291,266	$4,797,630	$812,594
117	$3,172,992	$1,249,638	$210,300
TOTAL	$224,824,875	$81,290,578	$14,556,093

Note: Addendum 1 to Appendix B (Attachment 4) provides additional information on structure types and building characteristics that constitute higher damages relative to other reaches.

5.0. ECONOMIC VARIABLES, ASSUMPTIONS, AND METHODOLOGY APPLIED IN COASTAL STORM DAMAGE MODEL

In Beach-fx the economic input includes a set of general global data that applies to the entire analysis, the estimated base year when damage reduction measures could be in place, flood damage curves, erosion damage curves, miscellaneous benefits to be included, and the variable inputs for each structure in the structure inventory data base or structure file. More information on the Beach-fx is presented in Appendix A, Coastal Engineering.

5.01 General Global Data

Based on the general economic assumptions, the global values are as follows:

- **Interest rate.** The FY 2011 Federal interest rate used in the analysis of alternatives was 4.125%. Final cost updating and certification of the Recommended Plan used an Oct14 discount rate of 3.5%.

- **Price level**. October 2011 price levels were used in the analysis of alternatives, at 4.125%. Final cost updating and certification of the Recommended Plan used an Oct14 discount rate of 3.5%.

- **Period of Analysis.** The analysis is based on a 50-year period.

The economic comparison of alternatives was performed using the FY2011 interest rate of 4.125% (*appropriate at the time of that analysis*). It should be noted that the Recommended Plan was analyzed using the Oct 2014 discount rate of 3.5%

5.02 Base Year

The Base Year is defined as the first year coastal storm damage reduction measures could be in effect. It is expected that damage reduction measures would be implemented by 2019.

5.03 Interior Lot Value per Square Foot

Long term erosion damages or land losses are based on the estimated value of interior lots. The data on lots actually sold support a value of $12.55 to $14.03 per square foot at the October 2011 price level, which was updated to 2014 values for the Final Report.

5.04 Initial Benefits

At the time of the scoping runs, the detailed construction schedule had not been developed. Therefore, no initial benefits were included in the analysis.

5.05 Update of Structure Benefits

The initial structure valuation was completed in 2009 -2010 time frame. USACE requires that a structure analysis be conducted to ensure that the initial benefits would remain adequate for use in the current (2014) iteration of the Bogue Banks study report. After consulting with MSC leadership on a proposed methodology, this was achieved by conducting a sample of first and second row structure values, using the Carteret County tax database, and comparing them to the same structure values in the existing project database. Of the 2,400 structures in the original database, a significant sample of 1,258 structures was taken. The resulting values indicate that the current structure values of those sampled are approximately 3% lower than those from the 2009-2010 structure databases. District leadership does not believe that the 3% difference in value is significant, and supports use of the existing database as a proxy for structure valuation.

5.06 Flood Damage Curves

Flood damages due to inundation are determined by the combined height of the storm still water level and a superimposed wave height. Based on the elevation of this combined height and the elevation of the structures first floor, the amount of inundation damage is determined from a standard set of inundation damage curves. Unless the predicted amount of storm induced erosion is sufficient to completely erode the ocean front dune, the residual height of the seaward edge of the beach is generally sufficient to limit the height of the wave that could be transmitted across the beach face without breaking. Accordingly, since the conditions necessary to cause a prediction of significant inundation related damages is rather severe, damages due to the inundation (combined storm still water level and wave height) rarely controls.

5.07 Damage Functions and Damage Curves

Damage functions are used within Beach-fx to estimate storm-induced damages sustained by the damage elements. Damages are estimated separately for the structure and contents of each impacted damage element. Damages are caused by three processes: erosion, inundation, and wave attack. Beach-fx has an inherent set of rules for combining damages when multiple damage processes produce damages to a structure or contents during a storm event.

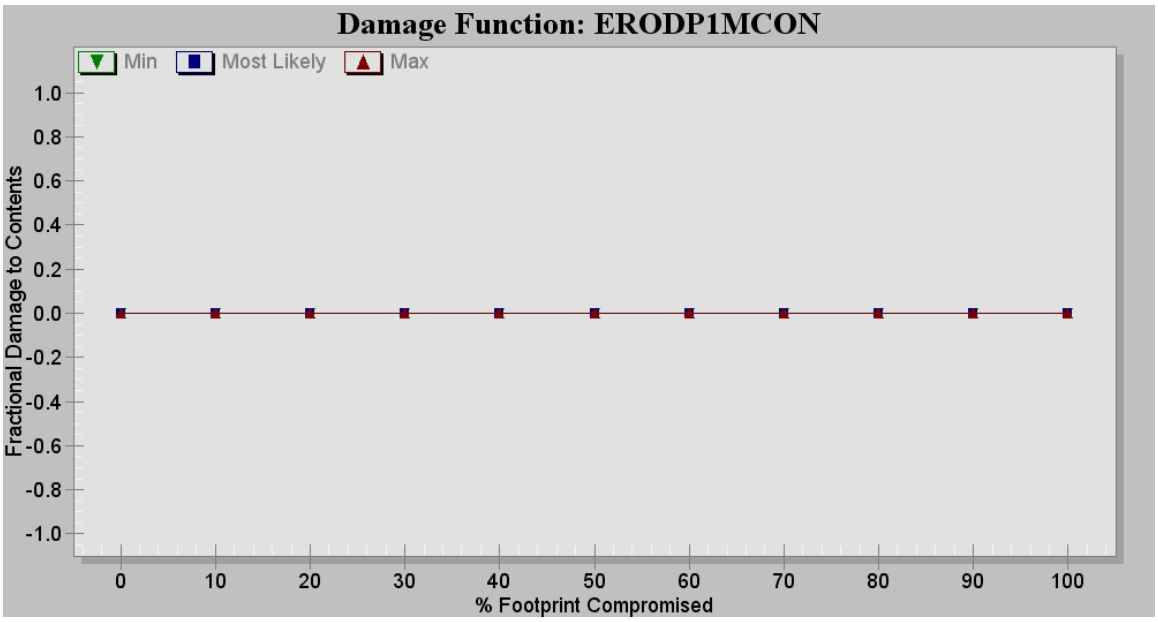
Damage functions are user-defined within Beach-fx. Damage function types and definitions are included, but the specific functions must be developed and defined for each project. A specific damage function must be assigned to each combination of damage element type, foundation type, and construction type. Damage functions are expressed as a percent of the structure or content valuation compromised. The damage functions utilized are listed in table B-7

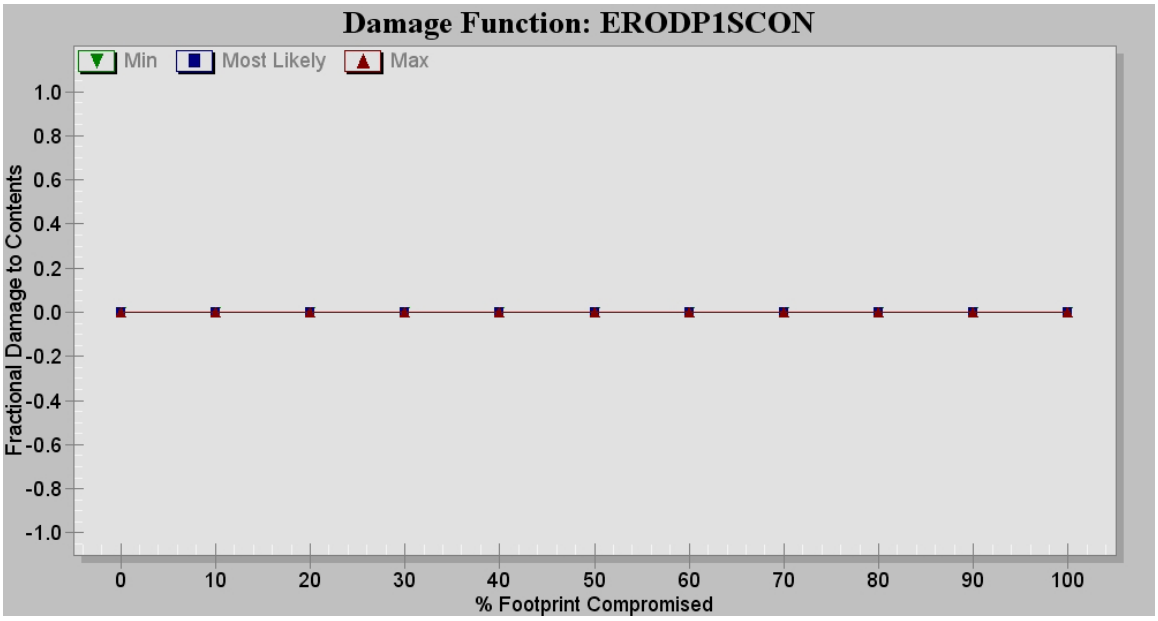
Damage functions were developed for the Bogue Banks project by the Wilmington District. In all, 23 damage functions were specified, as shown in Figures B5 to B25. Triangular distributions were developed for each of the damage functions representing minimum, most likely, and maximum values at each point along the X axis.

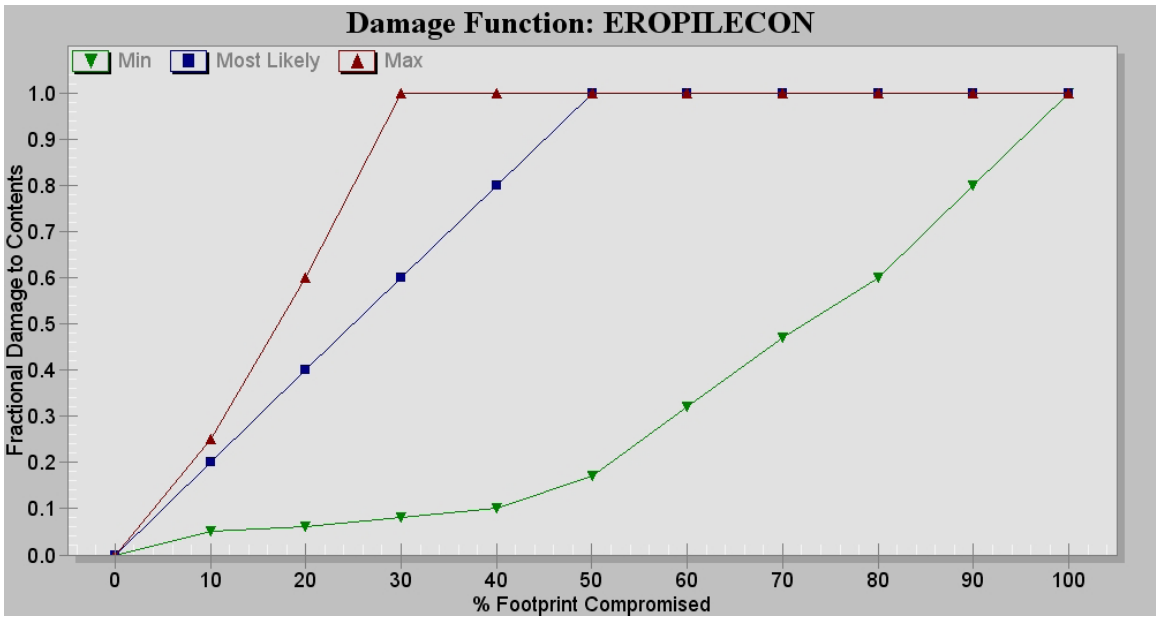
Table B-4 Damage Elements

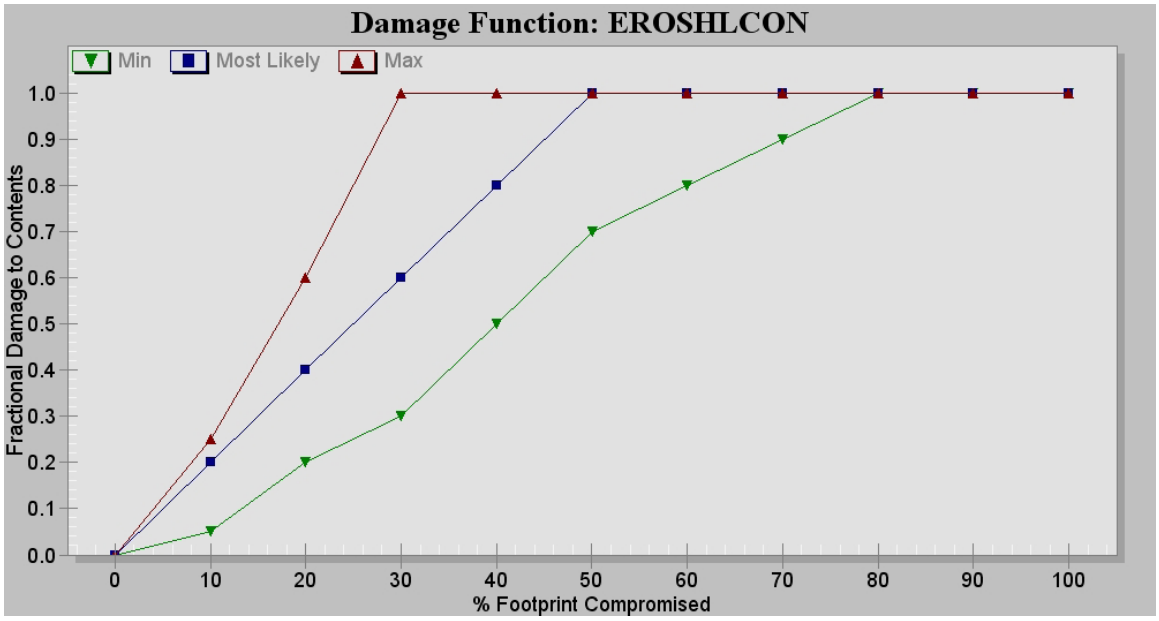
Damage Elements, Bogue Banks			
Function	**Function Description Group Description**	**X-axis**	**Y-axis**
ERODP1MCON	Erosion -Pile16 -MF -Contents	% Footprint com-promised	Fractional damage to contents or structure
ERODP1SCON	Erosion -Pile16 -SF -Contents		
EROPILECON	Erosion -Pile Foundation -Contents		
EROSHLCON	Erosion -Shallow Foundation -Contents		
ERODP2LSTR	Erosion -Deep Piles 2 Floors Large -Structure		
ERODP2MSTR	Erosion -Deep Piles 2 Floors Large -Structure		
ERODP2SSTR	Erosion -Deep Piles 2 Floors Large -Structure		
ERODP3MSTR	Erosion -Deep Piles 3 Floors Medium -Structure		
ERODP4LSTR	Erosion -Deep Piles 4 Floors Large -Structure		
ERODP4SSTR	Erosion -Deep Piles 4 Floors Small -Structure		
ERODP5LSTR	Erosion -Deep Piles 5 Floors Large -Structure		
ERODP1MSTR	Erosion -Pile16 -MF -Structure		
ERODP1SSTR	Erosion -Pile16 -SF -Structure		
EROPILESTR	Erosion -Pile Foundation -Structure		
EROSHLSTR	Erosion -Shallow Foundation -Structure		
4SNBC	Inundation -4 story -Contents	Water depth above 1st floor	
2SNBC	Inundation -1-2 story -Contents		
INUNALLSTR	Inundation -All Structures up to 3 floors -Structure		
INUM4FL	Inundation -4-5 floors -Structure		
WAVENPC	Wave -Not On Piles -Contents		
WAVEPC	Wave -On Piles -Contents		
WAVENPS	Wave -Not On Piles -Structure		
WAVEPS	Wave -On Piles -Structure		

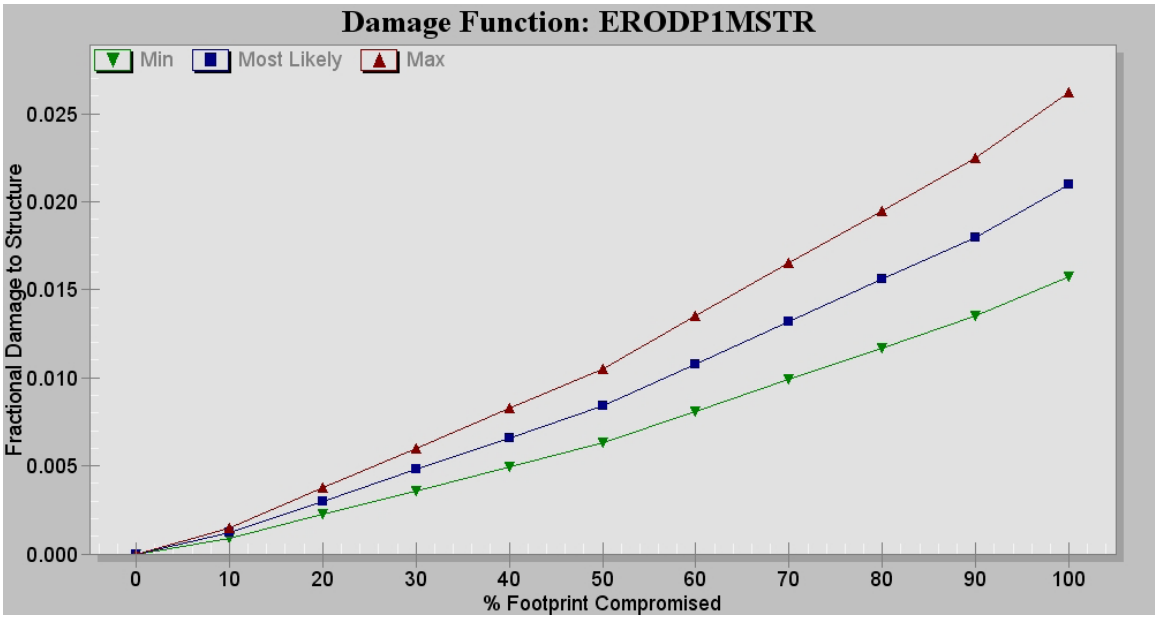
Figures B5-B25 - Composite Damage Curves

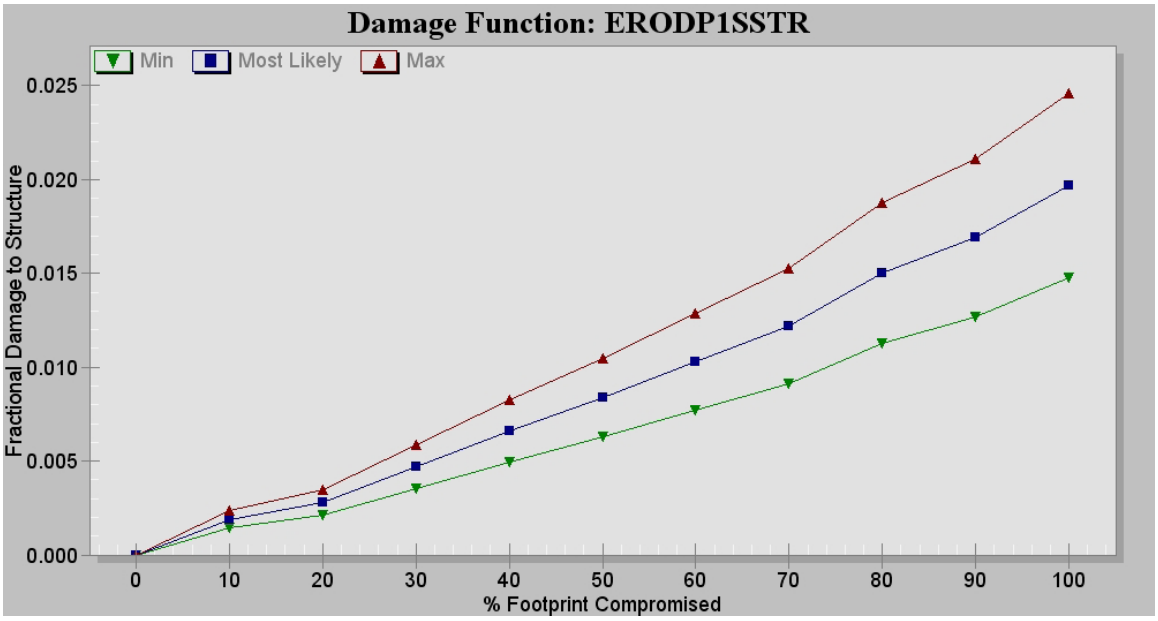


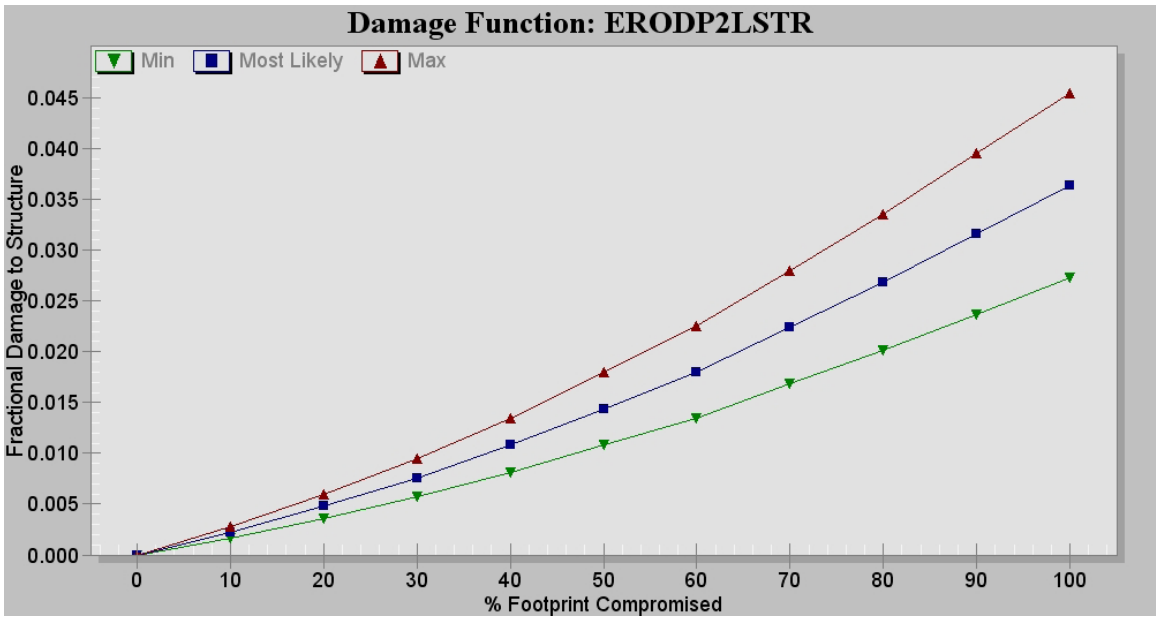


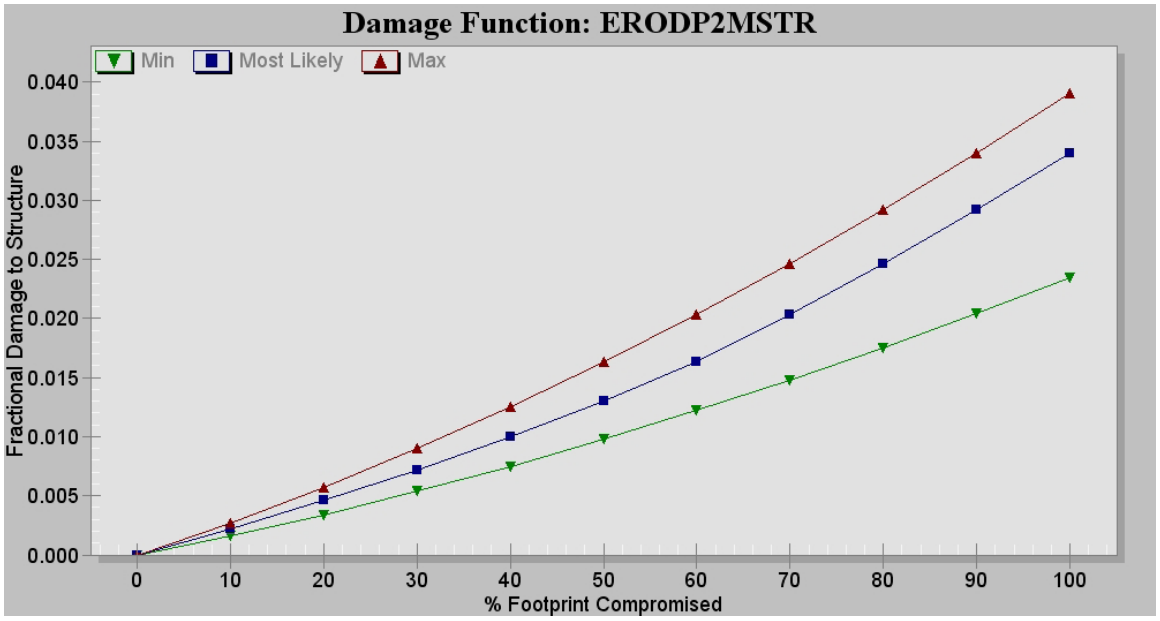

Damage Function: EROPILECON
Min
Most Likely
Max
Fractional Damage to Contents
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

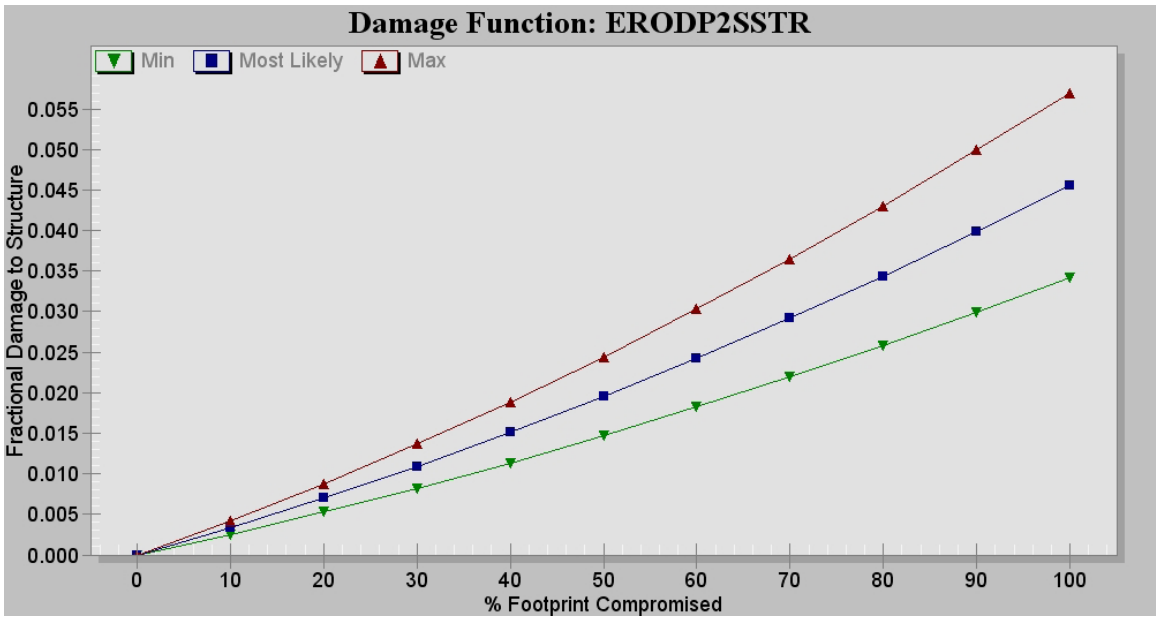

Damage Function: EROSHLCON
Min
Most Likely
Max
Fractional Damage to Contents
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

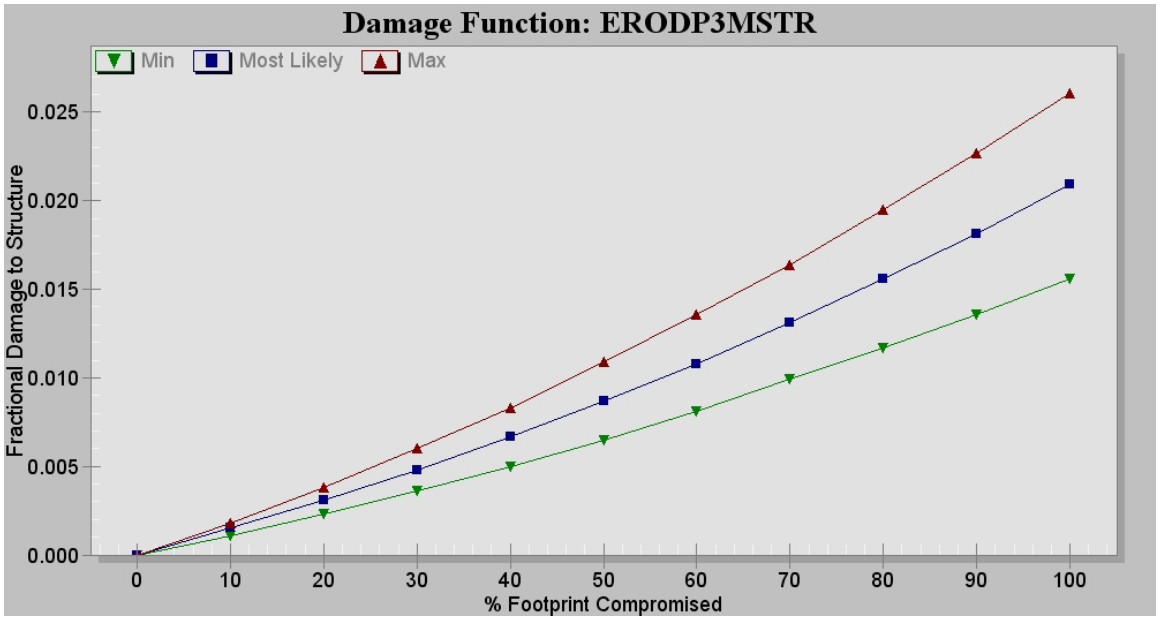

Damage Function: ERODP1MSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

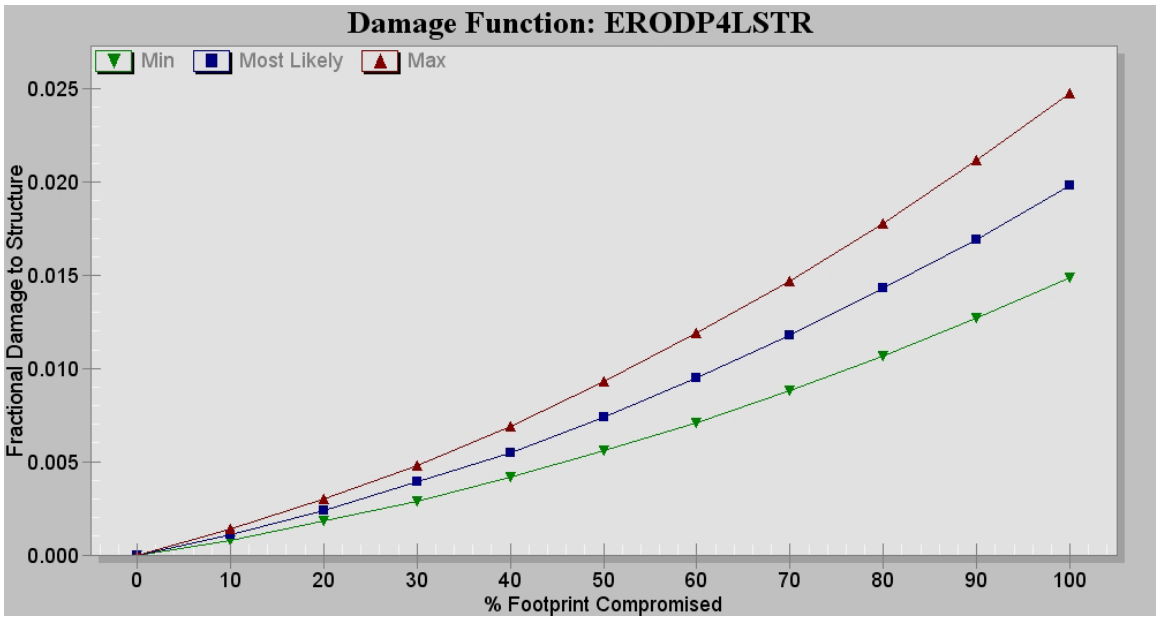

Damage Function: ERODP1SSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

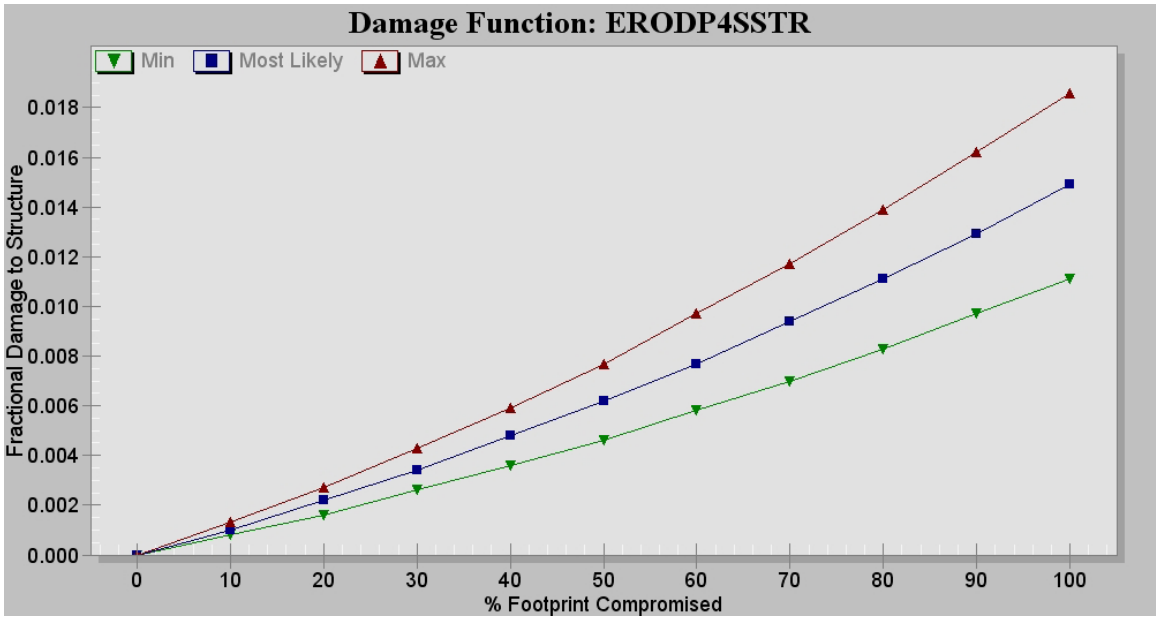

Damage Function: ERODP2LSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

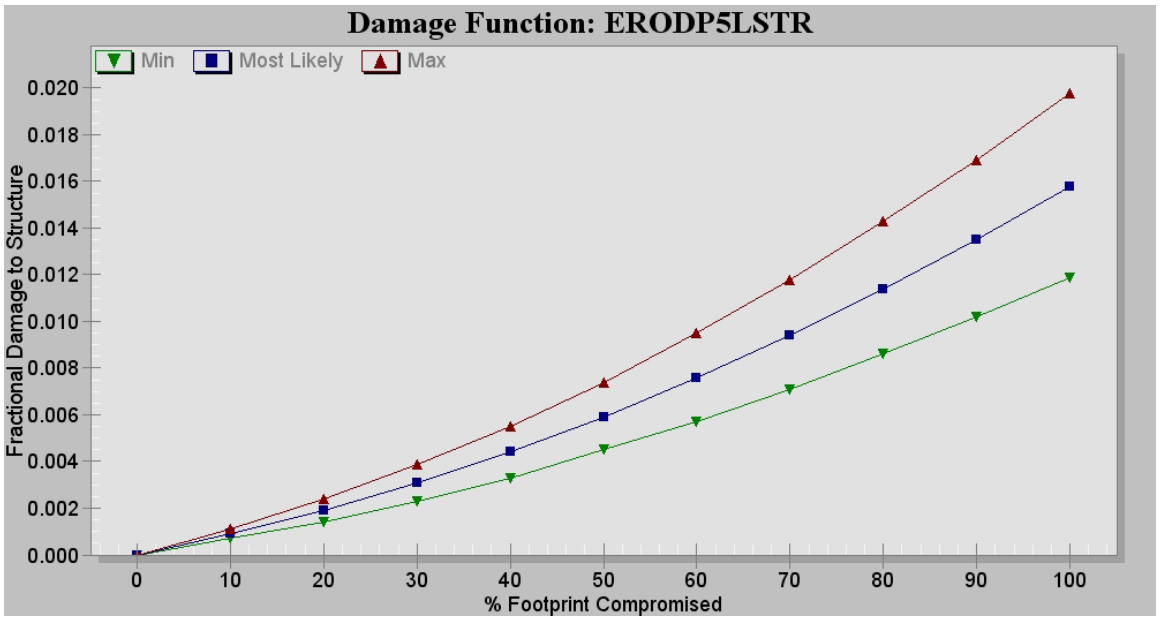

Damage Function: ERODP2MSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

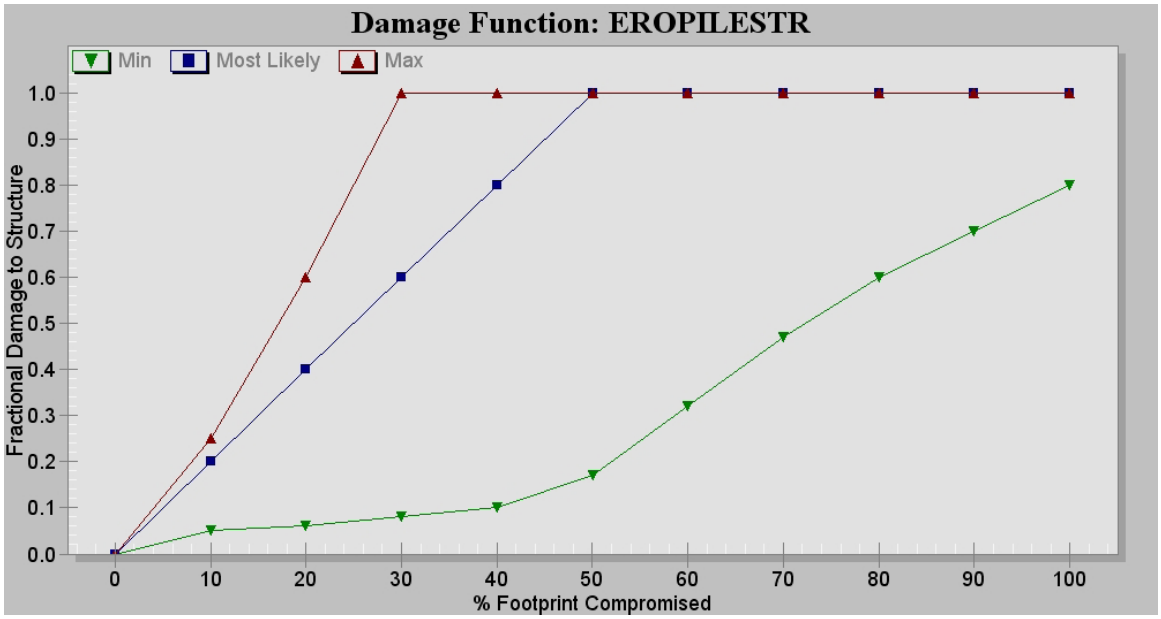

Damage Function: ERODP2SSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

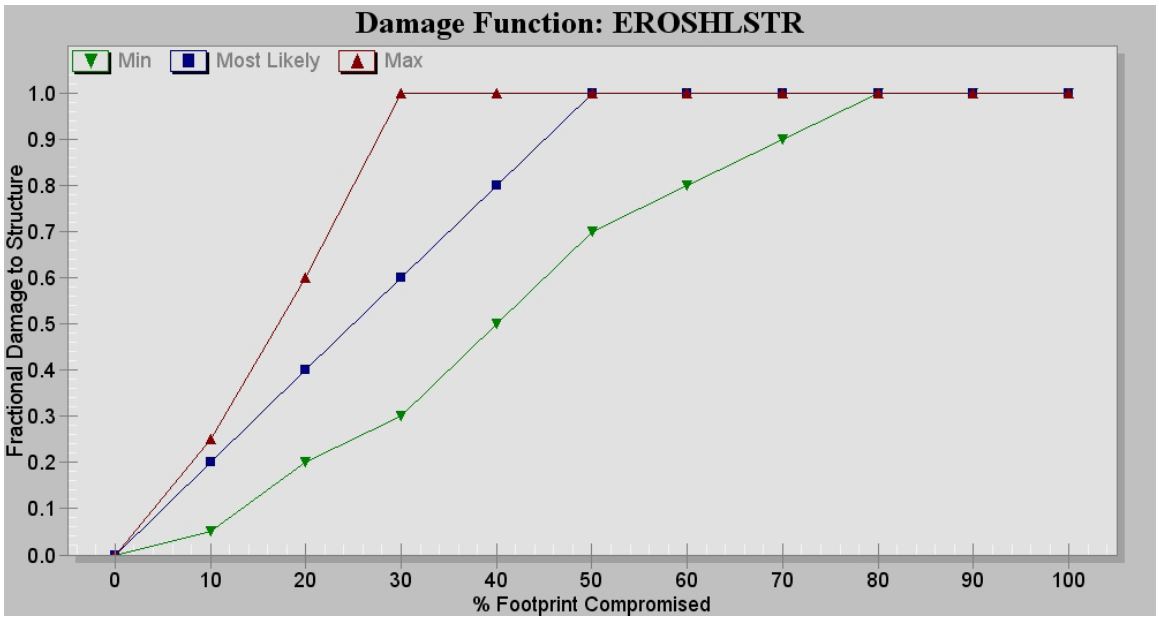

Damage Function: ERODP3MSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

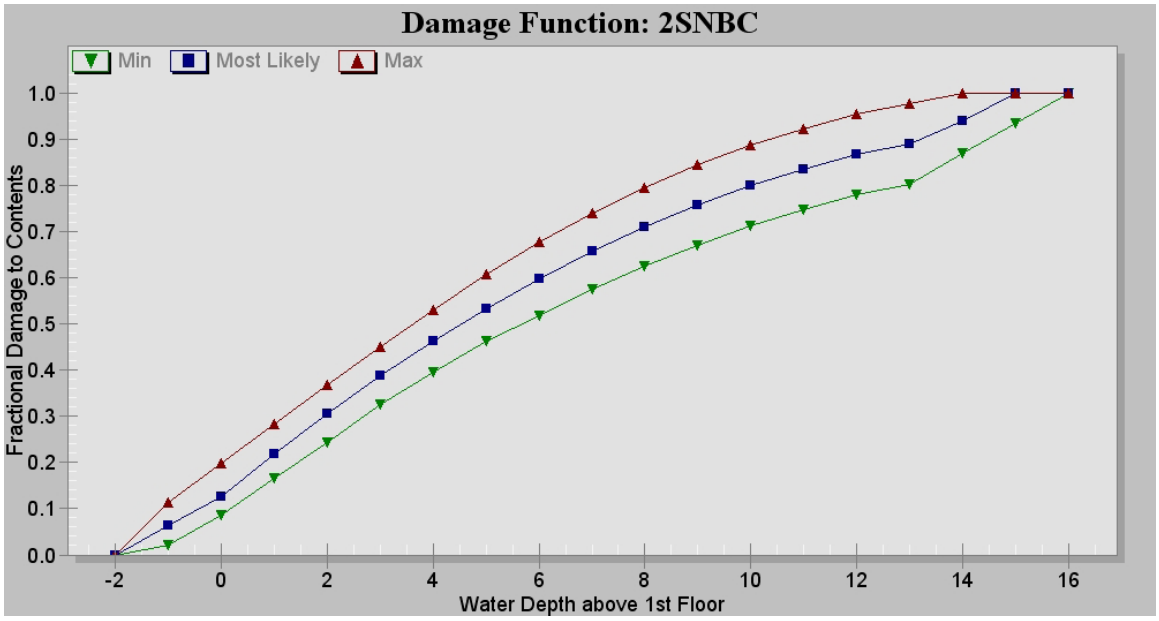

Damage Function: ERODP4LSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

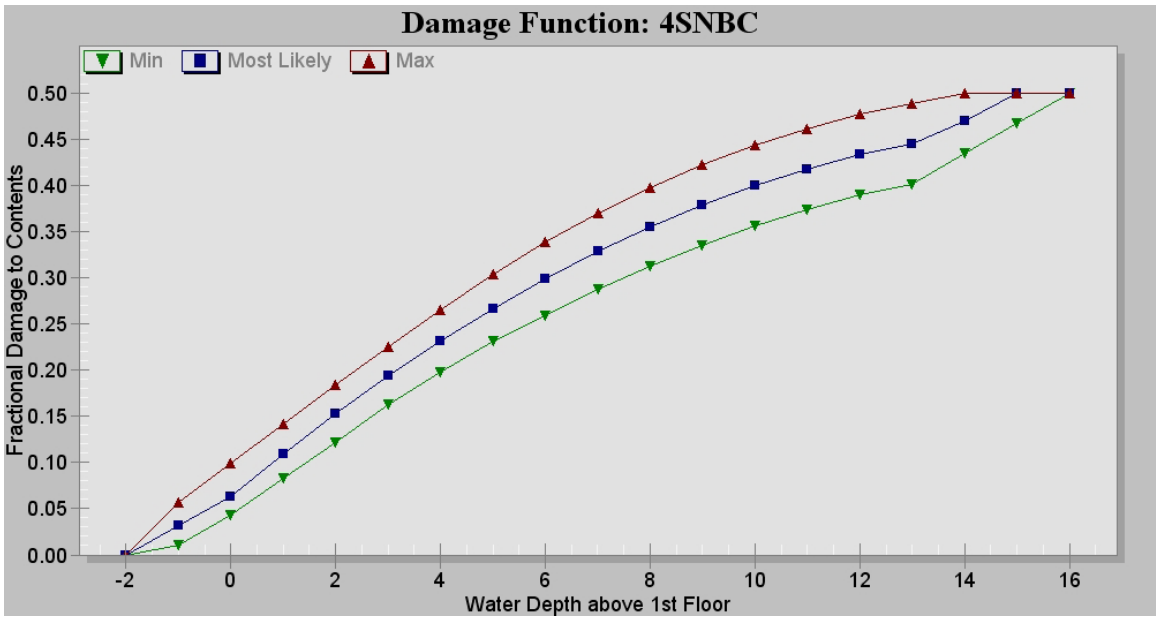

Damage Function: ERODP4SSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

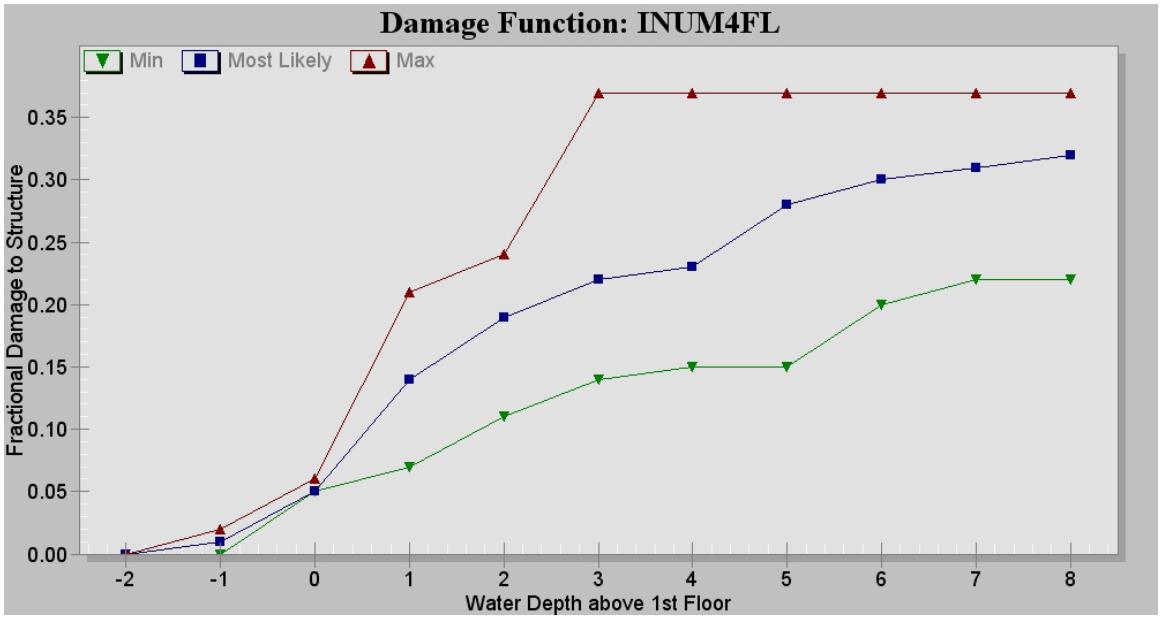

Damage Function: ERODP5LSTR
Min
Most Likely
Max
Fractional Damage to Structure
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised

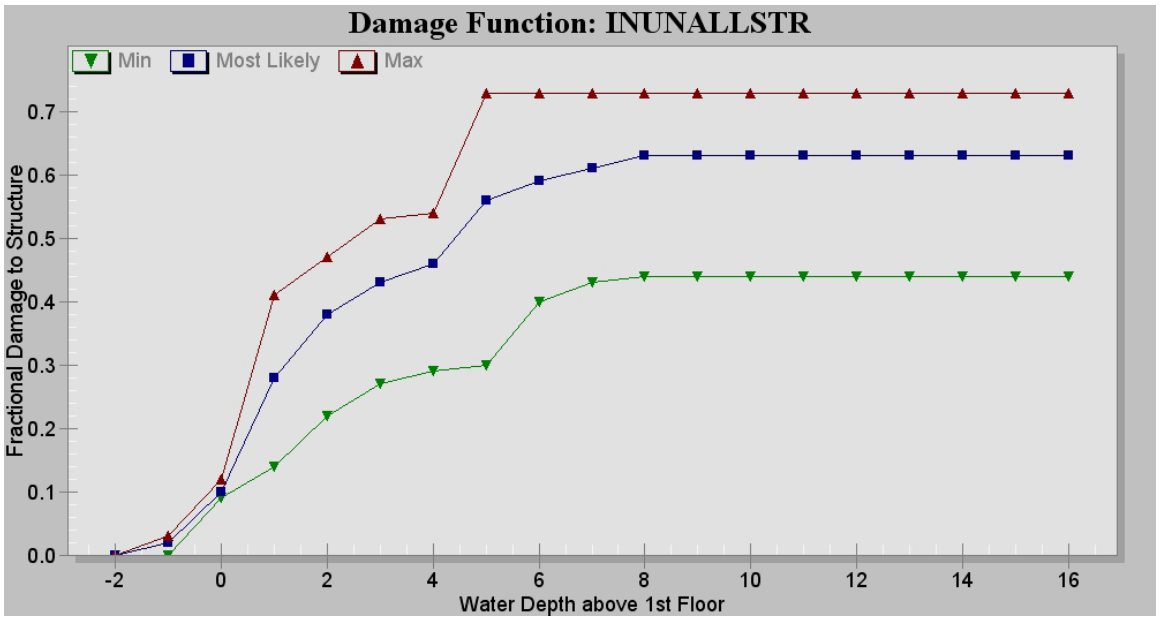

Damage Function: EROPILESTR
Min
Most Likely
Max
Fractional Damage to Structure
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised


Damage Function: EROSHLSTR
Min
Most Likely
Max
Fractional Damage to Structure
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
% Footprint Compromised


Damage Function: 2SNBC
Min
Most Likely
Max
Fractional Damage to Contents
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-2
0
2
4
6
8
10
12
14
16
Water Depth above 1st Floor


Damage Function: 4SNBC
Min
Most Likely
Max
Fractional Damage to Contents
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-2
0
2
4
6
8
10
12
14
16
Water Depth above 1st Floor


Damage Function: INUM4FL
Min
Most Likely
Max
Fractional Damage to Structure
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-2
-1
0
1
2
3
4
5
6
7
8
Water Depth above 1st Floor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Min
Most Likely
Max
Fractional Damage to Structure
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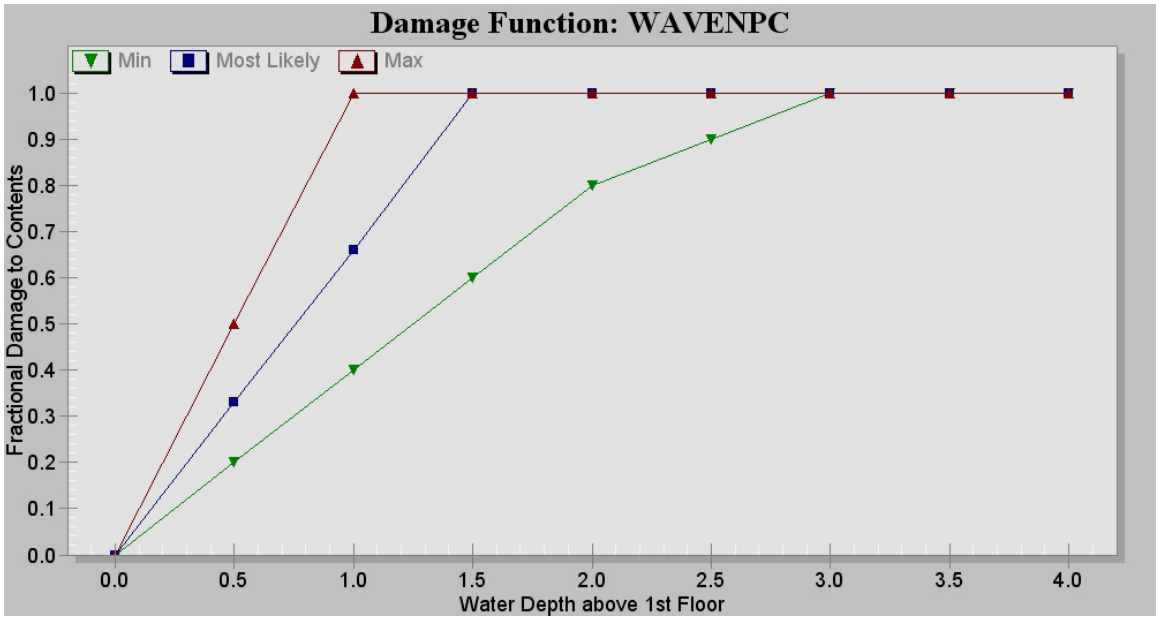
0.1
0.2
0.3
0.4
0.5
0.6
0.7
-2
0
2
4
6
8
10
12
14
16
Water Depth above 1st Floor


Damage Function: WAVENPC
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Most Likely
Max
Fractional Damage to Contents
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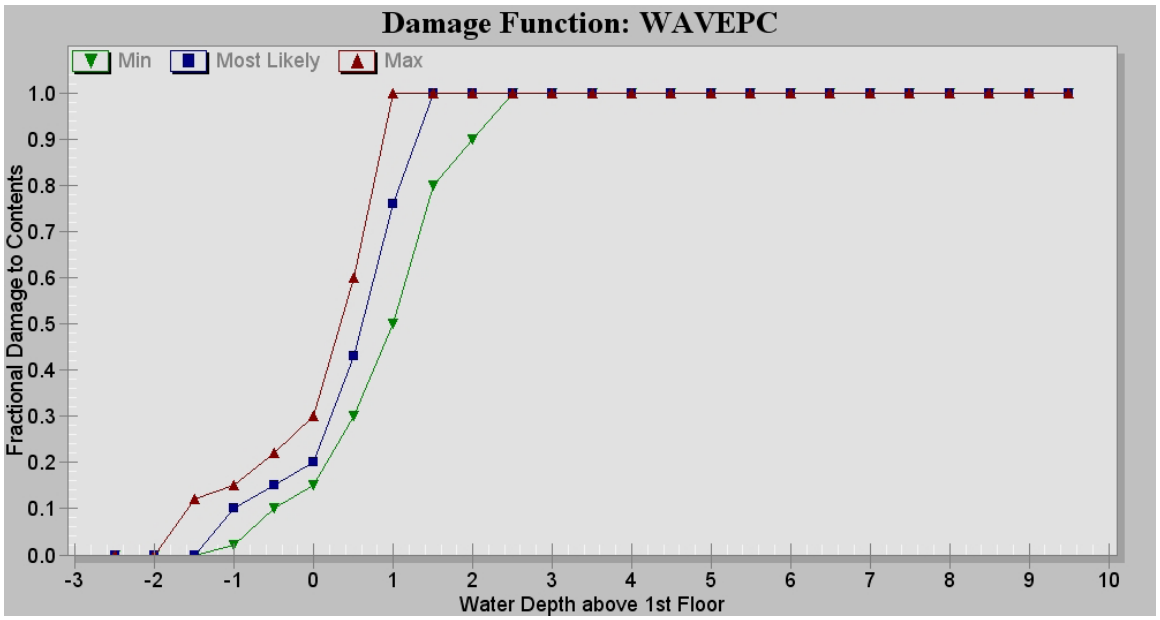
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Water Depth above 1st Floor


Damage Function: WAVEPC
Min
Most Likely
Max
Fractional Damage to Contents
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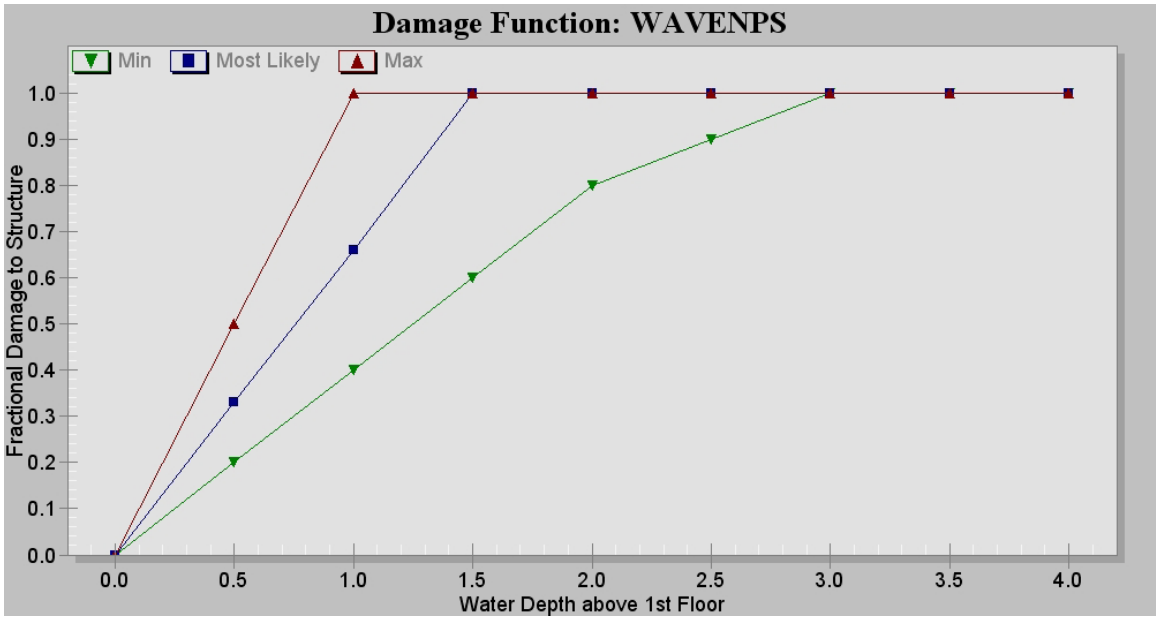
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
Water Depth above 1st Floor


Damage Function: WAVENPS
Min
Most Likely
Max
Fractional Damage to Structure
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0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Water Depth above 1st Floor

5.08 Variables Specific to Structure File

5.08.1 Structure Type/Damage Element – Flood Damage Curve

A damage element is any physical structure that can endure storm damages, including a residential home, deck, pool, restaurant, pier house, etc. Damage elements are represented by X,Y coordinates in Beach-fx. Damage element types, or categories, are defined by the user and are project specific. Foundation and construction categories for damage elements are also project specific and defined by the user. Critical vertical erosion amounts that compromise the structure are defined by foundation type. Damage element specific data include: type, description (typically address) foundation type, construction type, armor data, coordinates, number of rebuilds allowed, and triangular distributions of content value, structure value, rebuilding time, and first floor elevation.

For the Bogue Banks study area, the above mentioned data requirements were collected for nearly 2,000 damage elements. Construction types include wood or masonry, with all but one structure being built of wood. Foundation types include slab, 8-foot deep pile, or 16-foot pile. The majority of the structures within the study were built on 8-foot deep piles. Rebuilding was not limited over the project life cycle. Damage element type codes cover the range of structures in the study area, as shown in Table B-5

Table B-5 Damage Element Types

Damage Elements, Bogue Banks			
Code	**Description**	**Code**	**Description**
SF1	1 story SF on slab	SF1_SM	SF 1 story on piles with small footprint
SF2	2 story SF on slab	SF2_SM	SF 2 story on piles with small footprint
MF1	apartments/condos	SF1_LG	SF 1 story on piles with large footprint
Condo HOA	condo, HOA	SF2_LG	SF 2 story on piles with large footprint
MOBHM	mobile home	POOLH	pool house, garage
HOTEL	hotel or hi-rise	STRT	street / highway
MOTEL	motel (1 to 2 stories)	PARK	parking lot
OFFIC	office Building	DECK	decks
POOL_TEN	swimming pool, tennis court	DUNE	dune walkovers
CLUB	private club	PU_ACC	public access--improved
RESTU	restaurant	WAREH	storage building / warehouse
BAR	tavern	PIERHOUSE	pier house or storage

5.08.2 Structure Value

Structure values are entered in dollars based on the replacement cost less depreciation. Determinations of commercial structure values and description of the business type were made by district personnel with additional checking against tax records. Structure values represent the replacement value less depreciation at the current price levels. The district personnel consulted with local real estate agents, appraisers, business owners, and building contractors as needed.

5.08.3 Content Value

Contents to residential structures include personal possessions, including furniture, clothing, dishes, cooking utensils, linens, jewelry, stereo equipment, etc. For homeowners' insurance coverage, the standard coverage for contents is 50 percent of the dwelling coverage (consistent with a detailed Residential Flood Damage survey taken in the Northern Gulf Coast). For beach communities like the Bogue Banks communities, the estimated value of contents of an average residential structure would be up to 40 percent of the value of the structure. The main factor in this conclusion is that nearly 75 percent of the structures are not owner-occupied year round. Many of the seasonal 75 percent are rented to vacationers during the spring and summer beach season. Typical contents of rental properties include: beds, furniture, reclining chairs, color cable televisions, VCR's and DVD players, microwave ovens, clothes washers and dryers, and telephones, but do not typically contain higher-value personal possessions. Built-in appliances are included in the value of the structure. This percentage is consistent with a detailed Residential Flood Damage survey taken in the Northern Gulf Coast

It should be noted that elicitation from home owners (S. Greene, personal interview, 4 March, 2014), rental management companies, and real estate agents (R. Herring, personal interview, 1 March 2014) was sought and cited to back up the proxy claim of 40 percent content value. While this number may not be consistent with similar project's content value, the District feels that it is accurate given the nature of home ownership (many rentals) in the Bogue Banks study area.

5.08.4 Elevation at ground

Ground elevations for the vast majority of Bogue Banks structures were taken from FEMA elevation, established by surveys and in some cases were estimated from 2-foot contour maps.

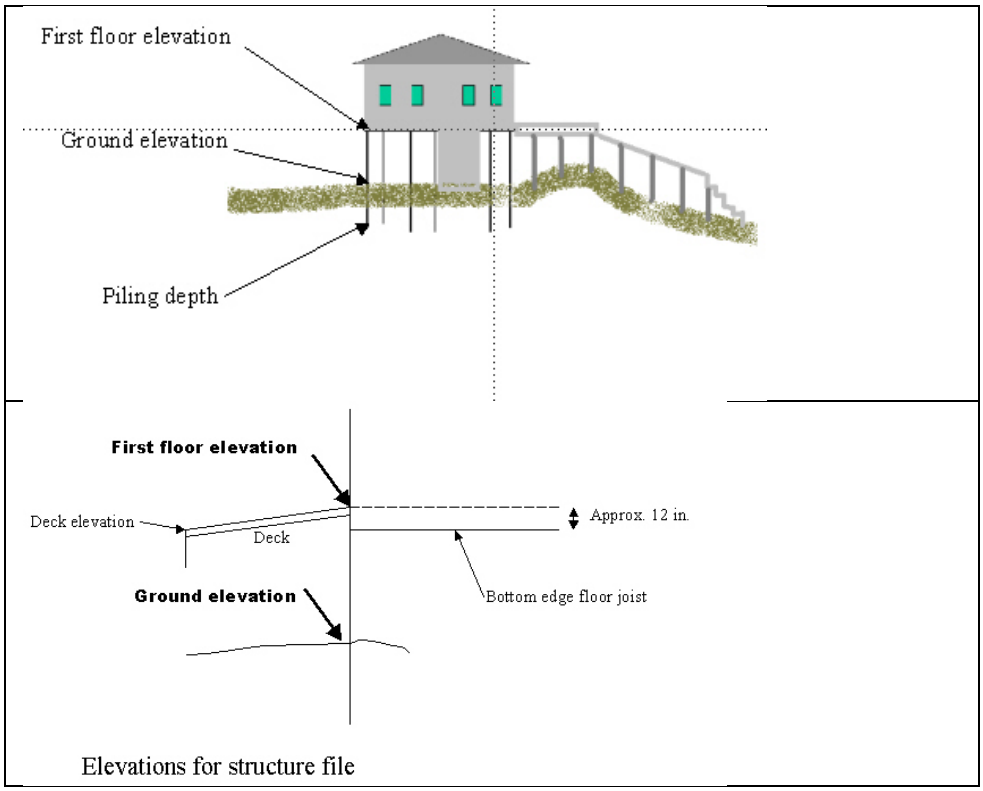


Figure B- 26 - Illustration of Residential Structure Elevations

5.08.5 Elevation at First Floor

The first-floor elevations were taken from FEMA elevation certificates or surveyed by the location of the front entry threshold as shown in Figure B-26. Data collected by North Carolina State University students for FEMA following Hurricane Fran in 1996 were also compared and used for missing structures. In these cases the first floor elevation was adjusted by one foot to get the top of the floor joist versus the bottom of floor joist measured by NCSU. In a few cases first floor elevations were estimated by adding 10 or 12 feet to the ground elevations. Likewise, this assumption was used to indicate the first floor elevation of all structures replaced during the period of analysis.

6.0. ALTERNATIVES TO REDUCE COASTAL STORM DAMAGES

6.01 Beachfill Alternatives Evaluation

Nine beachfill alternatives were economically evaluated in a sequential process using the Beach-fx model. The Beach-fx model was used to produce the actual 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 mobilization/de-mobilization and borrow placement costs, but not other miscellaneous costs (monitoring, tilling, walkway replacement, vegetation planting, real estate, administration, PED, etc). The miscellaneous costs were similar among the various beachfill 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. The final cost contained those additional elements, and thus, was higher than the costs presented during the alternatives comparison.

A four year renourishment cycle was specified for these initial comparative runs. Descriptions of each of these alternatives are presented in table B-6. Alternatives 1-5 were analyzed initially. These alternatives were chosen based on an assessment as to what general dimensions of a beachfill 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 of benefits at each of the 12 reaches. Bracketing is done to demonstrate that 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 prevention 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 Attachment 2 (Titled “Summary of Net Benefits, By Alternative”). Also, Net Benefits were used as the most cost effective criterion during the alternative screening process.

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. Therefore, a 9th, “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. 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.

		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 B-6. Descriptions of the 9 beachfill alternatives that were evaluated. An 'x' indicates no Federal maintenance of the dune feature.

6.02 Nonstructural Alternative Evaluation

As described in Section 5.05 (Identification, Examination, and Screening of Measures) of The Main Report, one non-structural alternative (alternative 10) was analyzed. 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 were not included in the analysis. Of the 1,764 active structures in the structure database, 1,071 were considered for the nonstructural 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. The goal of this screening 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. 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 comps from the Bogue Banks area.

6.03 Combined Structural/Non-Structural Alternative Evaluation

A combined structural/non-structural alternative would involve structure removal in parts of the study area, and beachfill in other parts. These structures are described in more detail in Addendum 1 to Appendix B (Attachment 4). 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. The non-structural analysis showed 5 reaches that had positive net benefits – reaches 78, 89, 93, 106 and 114. However, these reaches are all relatively short (average 1,000 feet) and are separated from one another by a good distance. For this reason, from an engineering perspective, it would be infeasible to transition into and out of these gap areas because

transition length areas would be longer than the gap lengths themselves. Additionally, the net benefits from the structural plans at these reaches are even higher. Therefore, there is not a viable combined structural/non-structural alternative, and such a plan was screened from further consideration. Further discussion of screening is included in Addendum 2 to Appendix B (Attachment 4).

6.04 NED Comparison of Alternatives

The average annual NED costs, benefits, and net benefits of each of the beachfill alternatives and the non-structural alternative analyzed are shown in table B-7. A detailed breakdown of costs and benefits for each alternative by each reach is contained in Attachment 2. The alternative with the highest net benefits is Alternative 9, the "hybrid" alternative. The costs and benefits used in table B-7 do not match the costs and benefits used in the description of the Recommended Plan, as these were used for plan selection, while a more detailed and USACE certified set of costs were produced for the Recommended Plan. Updated costs for the Recommended Plan are detailed in section 7.0.

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 B-7 Comparison of alternative costs and benefits, October 2010 price level, FY 2011 interest rate (4.125%). Costs and benefits shown here were used at the time of this analysis, but were updated to Oct 2014 price levels for the Final Report.

6.05 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 beachfill 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) need to come from coastal storm damage reduction benefits. Recreational benefits, however, are incidental to the provision of storm damage reduction (per USACE 1105-2-100) 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. The 117 economic reaches used in the alternatives analysis were used as the basis for demonstrating incremental justification. Table B-8 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, for the engineering reasons stated earlier, these single reaches should not be excluded from the project. Reaches 25, 51-53, 57, 58, and 88 are not justified on the basis of storm damage reduction benefits only, but are justified once recreation benefits are factored in. Hence, the entire length of beach analyzed (reaches 1-117) is incrementally justified and can be included as part of the Recommended Plan. By definition, residual damages are those damages that remain with the project in place. In Table B-8, the residual damages are represented in the Total Damage column, as these are “With Project” damages.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$35,883	$91,813	$11,908	$79,905
2	$29,170	$86,464	$8,401	$78,063
3	$36,663	$100,207	$13,851	$86,356
4	$40,163	$118,703	$10,916	$107,787
5	$76,838	$183,140	$18,498	$164,642
6	$74,165	$194,276	$18,182	$176,094
7	$25,677	$83,912	$38,073	$45,839
8	$14,697	$60,692	$40,257	$20,435
9	$16,214	$63,339	$36,492	$26,846
10	$7,574	$33,691	$23,372	$10,319
11	$30,737	$62,729	$14,910	$47,819
12	$35,889	$93,616	$23,917	$69,699
13	$92,242	$106,212	$34,783	$71,429
14	$73,169	$100,422	$24,973	$75,449
15	$195,437	$176,199	$26,836	$149,363
16	$31,230	$35,610	$14,572	$21,038
17	$30,183	$79,132	$18,883	$60,249
18	$3,116	$37,010	$20,073	$16,937
19	$4,988	$37,600	$18,380	$19,220
20	$7,685	$55,160	$17,082	$38,077
21	$5,162	$20,764	$1,189	$19,575
22	$164,160	$6,205	$807	$5,398
23	$0	$0	$671	($671)
24	$4,854	$2,196	$370	$1,826
25	$658	$471	$601	($130)
26	$711	$530	$351	$179
27	$9,405	$2,432	$1,157	$1,275
28	$10,224	$1,213	$642	$571
29	$2,287	$478	$390	$88
30	$7,698	$15,577	$3,884	$11,693
31	$1,360	$7,188	$3,816	$3,371
32	$2,050	$10,433	$3,950	$6,483
33	$2,201	$9,618	$4,278	$5,340
34	$1,228	$5,848	$3,017	$2,831
35	$4,522	$28,155	$6,700	$21,455
36	$6,381	$5,846	$2,716	$3,131
37	$60,629	$15,319	$5,262	$10,058
38	$27,850	$14,580	$4,519	$10,062
39	$33,234	$20,291	$3,386	$16,906
40	$72,020	$117,555	$6,203	$111,353
41	$53,012	$20,814	$5,849	$14,965
42	$10,598	$19,179	$5,536	$13,643
43	$44,076	$79,577	$46,300	$33,277
44	$33,971	$61,648	$38,781	$22,866
45	$9,293	$98,045	$64,646	$33,399
46	$20,104	$61,964	$34,024	$27,940
47	$33,206	$55,570	$31,580	$23,990
48	$16,945	$44,442	$30,642	$13,800
49	$23,277	$45,484	$27,881	$17,603
50	$16,254	$27,827	$19,186	$8,640
51	$0	$9,083	$10,172	($1,089)
52	$2,964	$35,706	$41,302	($5,596)
53	$18	$50,068	$55,050	($4,981)
54	$2,858	$41,063	$13,351	$27,712
55	$3,659	$73,156	$34,475	$38,681
56	$0	$25,754	$35,164	($9,410)
57	$0	$8,899	$11,203	($2,304)
58	$0	$23,526	$28,179	($4,653)
59	$7	$38,874	$34,806	$4,068

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$2,031	$26,424	$22,580	$3,843
61	$25,455	$31,561	$22,072	$9,488
62	$231,593	$441,437	$20,985	$420,452
63	$4,160	$47,423	$35,798	$11,625
64	$8,055	$11,973	$9,672	$2,302
65	$40,655	$21,791	$4,461	$17,330
66	$2,404	$49,686	$41,846	$7,841
67	$211	$16,431	$13,243	$3,188
68	$53,009	$19,621	$15,884	$3,736
69	$113,494	$65,598	$41,603	$23,994
70	$232,074	$180,912	$26,192	$154,720
71	$110,492	$63,846	$34,050	$29,796
72	$71,681	$53,578	$29,950	$23,628
73	$29,989	$27,779	$20,021	$7,758
74	$316	$40,795	$33,151	$7,645
75	$5,173	$19,700	$16,791	$2,909
76	$19,093	$63,453	$6,219	$57,234
77	$4,632	$22,570	$20,596	$1,974
78	$336,938	$743,560	$30,615	$712,945
79	$29,255	$131,853	$33,592	$98,261
80	$282,382	$76,018	$18,526	$57,491
81	$5,968	$48,527	$32,900	$15,628
82	$5,094	$34,146	$28,963	$5,182
83	$17,707	$175,466	$53,801	$121,665
84	$15,831	$140,956	$52,477	$88,479
85	$4,524	$100,806	$62,221	$38,585
86	$28,546	$77,559	$71,040	$6,519
87	$165,555	$280,848	$95,043	$185,805
88	$462	$42,944	$49,304	($6,360)
89	$216,501	$227,147	$37,376	$189,771
90	$4,931	$81,587	$45,337	$36,251
91	$18,216	$82,521	$54,305	$28,216
92	$589,873	$269,274	$87,901	$181,373
93	$284,497	$1,102,082	$72,959	$1,029,123
94	$29,854	$91,095	$55,560	$35,535
95	$49,325	$108,336	$37,487	$70,849
96	$46,342	$93,600	$31,881	$61,719
97	$78,336	$129,465	$36,389	$93,076
98	$55,365	$112,838	$50,436	$62,402
99	$35,004	$100,416	$30,454	$69,961
100	$37,751	$121,390	$39,076	$82,314
101	$34,833	$131,636	$50,005	$81,631
102	$31,893	$83,403	$36,390	$47,013
103	$65,371	$160,850	$40,608	$120,242
104	$37,815	$116,709	$35,181	$81,528
105	$20,245	$65,305	$29,963	$35,342
106	$59,011	$254,736	$15,163	$239,573
107	$22,298	$108,172	$27,664	$80,508
108	$28,669	$72,544	$32,242	$40,302
109	$22,205	$79,193	$38,112	$41,081
110	$25,628	$88,402	$42,493	$45,909
111	$121,696	$73,347	$45,049	$28,298
112	$126,501	$88,947	$78,752	$10,195
113	$55,511	$66,276	$53,121	$13,155
114	$77,724	$142,422	$56,506	$85,916
115	$178,864	$414,591	$61,187	$353,404
116	$179,774	$679,570	$50,326	$629,244
117	$125,759	$140,906	$60,787	$80,119
Total	$6,055,161	$11,249,325	$3,332,701	$7,916,625

Table B-8. Values used for incremental plan justification, Alternative 9. October 2010 price levels, FY 2011 interest rate (4.125%).

7.0 ECONOMICS OF NED PLAN

7.01 Recommended Plan— CSDR Benefits:

The total expected average annual coastal storm damage reduction benefits (at 4.125% interest rate) for the Recommended Plan were estimated from the Beach-fx model to be $11,511,000, or for October 2014 price levels, at a 3.5% interest rate, CSDR benefits are $11,688,082.

7.02 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 were 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 Attachment 1.

The average annual recreation benefit for the Recommended Plan (at 4.125% interest rate) was calculated at $3,432,000, or for October 2014 price levels, at a 3.5% interest rates, recreation benefits would be $3,148,607

7.03 Recommended Plan— Total Benefits

Combining the CSDR benefits and the recreation benefits yields a total average annual benefit for the Recommended Plan for October 2014 price levels, at a 3.5% interest rates of $14,836,688. Residual damages, at the 3.5% interest rate, are $127,994,713 or an average annual amount of $5,456,889.

7.04 Recommended Plan—Costs

Determining the economic costs of the Recommended 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 rights-of-way for initial project construction and periodic nourishment. Total First Costs are estimated to be $37,327,000 at October 2014 price levels. Details regarding determination of this cost are contained in the Cost Engineering Appendix.

Second, Interest during Construction was added to the project First Cost. Interest during Construction is computed from the start of construction through the 4 month initial construction period. Interest during Construction for the Recommended Plan, at a 3.5% interest rate, is estimated to be $161,051. The project First Cost plus Interest during Construction represents the Initial Investment Cost required to place the project into operation. Initial Investment Cost for the Recommended Plan is estimated to be $37,488,051.

Third, Scheduled Renourishment Costs were computed. Those costs are incurred in the future for each of the 16 planned renourishments. Discounting to present value is included in the determination of these costs. As detailed in Appendix D, the estimated cost is $14,341,000 for each renourishment.

Fourth, Expected Annual Costs were computed. Those costs consist of interest and amortization of the Total Investment Cost and the equivalent annual cost of project OMRR&R and beachfill monitoring. The Expected Annual Costs provide a basis for comparing project costs to expected annual benefits. Expected Annual Costs for the Recommended Plan are estimated to be $6,065,000. A summary of costs is presented in table B-9.

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	$14,341,000	$12,497,000
Renourishment, HB	2026	$14,341,000	$11,272,000
Renourishment, HB	2029	$14,341,000	$10,167,000
Renourishment, HB	2032	$14,341,000	$9,170,000
Renourishment, HB	2035	$14,341,000	$8,271,000
Renourishment, HB	2038	$14,341,000	$7,460,000
Renourishment, HB	2041	$14,341,000	$6,728,000
Renourishment, HB	2044	$14,341,000	$6,068,000
Renourishment, HB	2047	$14,341,000	$5,473,000
Renourishment, HB	2050	$14,341,000	$4,937,000
Renourishment, HB	2053	$14,341,000	$4,453,000
Renourishment, HB	2056	$14,341,000	$4,016,000
Renourishment, HB	2059	$14,341,000	$3,622,000
Renourishment, HB	2062	$14,341,000	$3,267,000
Renourishment, HB	2065	$14,341,000	$2,947,000
Renourishment, HB	2068	$14,341,000	$2,658,000
Subtotal, Renourishments		$229,456,000	$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 B-9. Recommended Plan annual costs (October 2014 price level).

7.05 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 Recommended Plan, is 2.45 to 1. The annual net benefits are $8,771,688.

8.0. REGIONAL ECONOMIC DEVELOPMENT (RED) IMPACTS

The following regional economic impacts will be addressed based on the interest of the local sponsor and the surrounding Jones, Onslow, Craven, and Pamlico counties. Local governments seek to preserve the tax base and encourage the growth in overall property values, to create stability in the labor force and the employment of the labor force. The steady growth of the local community and surrounding region is considered a worthy goal by the state and local governments. Displacement of people, businesses and farms in the study area is not a desirable outcome that sometimes may result from either continued storm damages or even some types of construction. Additionally, preservation of rental property will ensure that earning potential of these properties is preserved, keeping money in the region.

8.01 Preserve Tax Base and, Property Values

Real property, including land and structures, in the towns of Bogue Banks is subject to property tax by Carteret County and the towns. The tax base and property values will be preserved with implementation of a coastal storm damage reduction plan. Land loss and long-term erosion eventually renders lots unbuildable with a significantly lower economic value. Typically, the tax valuation of the ocean front lots is severely reduced to reflect the diminished utility of the land. Lower tax valuations may result in lower county and town tax revenues unless there is offsetting development in other areas**.**

8.02 Employment Stability

Tourism is highly valued as a source of employment and income. Employment related to recreation can be less than ideal because of the seasonal nature of recreation and tourism. Increased recreation visitation may improve the income of service industries in the two-county study area. It is unlikely that employment will be significantly impacted with or without storm damage reduction measures. Gains or losses in income or employment are considered regional impacts.

8.03 Community and Regional Growth

Implementation of effective damage reduction measures will ensure that the current growth trends in population and recreation visitation will continue. Protection of the

streets and highways in the study area preserve community cohesion and encourage the tourism industry on the island, including the towns of Bogue Banks.

8.04 Displacement of People, Businesses, and Farms

Implementation of damage reduction measures under consideration is not expected to displace people, businesses, or farms.

9.0. OTHER SOCIAL EFFECTS

9.01 Preservation of Life, Health, and Safety

Implementation of the effective damage reduction measures may produce a significant reduction in stress related to concern over the amount of damage and recovery during and after storm events

9.02 Community Cohesion

The proposed plan is anticipated to reduce periodic displacements of residents and visitors as a result of storm events

9.03 Community Growth

Growth trends in population and recreation visitation will continue with implementation of the proposed plan.

9.04 Traffic and Transportation

The proposed plan has the potential to reduce damage to streets and highways, through reduction in tidal over wash. However, water vessel traffic may see a short term increase as a result of dredging operations during initial construction and scheduled renourishments.

9.05 Environmental Justice

No impact to Environmental Justice is anticipated as a result of the proposed plan.

ATTACHMENT 1

RECREATION ANALYSIS

1.0 INTRODUCTION

In December of 2002 the Wilmington District United States Army Corps of Engineers (USACE) contracted with the University of North Carolina at Wilmington (UNCW) to collect data and develop methodologies for an in-depth and multi-faceted study of the recreation demand and benefits of visitors to four barrier islands on the North Carolina Coast: Bogue Banks, Topsail Island, Oak Island, and Holden Beach.

Planning and Guidance (P&G) describes recreation benefits as incidental benefits of the National Economic Development Account. As described in ER 1105-2-100: Single purpose shore protection projects are formulated exclusively for hurricane and storm damage reduction (HSDR) and recreation is an incidental benefit, but is typically predicated on beach width driven user utility. Recreation benefits can be included in the benefit/cost ratio for a project. However, HSDR benefits must account for at least half of the total benefits required to justify the project or the federal government will not share the project costs for that shoreline reach. Therefore, when calculating net benefits for a storm damage reduction project, recreation benefits are added into the net benefits after the storm damage reduction benefits have been estimated from coastal and economic models and after a plan has been selected.

The focus of this collaborative study effort was on day trip visitors who use public access and parking facilities. This study employed multiple methodologies that incorporated:

- An on-site field survey administered during the summer vacation season of 2003
- A telephone survey of residents living in eastern North Carolina within a 120 mile radius of each beach community incorporated into the survey instrument in the spring of 2004 (Office of Management and Budget approved, control number 0710-0001, Attachment 2)
- A focus group session with each municipality and representatives from its major business organizations
- A secondary data literature search, and aerial photography and parking counts of the project area on the days that the onsite surveys were conducted.

This study focused on four projects. These are:

- West Onslow Beach and New River Inlet GRR study
- Surf City/North Topsail Beach feasibility study
- Bogue Banks feasibility study
- Brunswick County Beaches feasibility study

The non-Federal sponsors for the four projects are, respectively, the Town of Topsail Beach; the Town of Surf City, the Town of North Topsail Beach; Carteret County; and the Town of Caswell Beach, the Town of Oak Island, and the Town of Holden Beach; Brunswick County.

A telephone survey instrument was used to gather comparative data for New Hanover County Beaches including Wrightsville Beach, Carolina Beach, Kure Beach, Masonboro Island, and Fort Fisher State Park; remaining Brunswick County beaches including Ocean Isle and Sunset Beach, and the Fort Macon State Park at Bogue Banks.

This report provided an outline methodology that will be used to analyze data collected from the on-site survey, telephone survey, parking counts, and aerial photography. The final analysis was be used to determine the peak recreation demand for each beach community under study in the without project condition, the latent and expected future demand in the with project condition, and the recreational benefits of the with and without project conditions that were calculated using the travel cost method (TCM) and the contingent valuation method (CVM).

This analysis answered the following key questions for the reader:

- What is an individual beach recreationist's willingness to pay (WTP) per day trip for each of the beaches in our study region?
- How would the number of beach trips made by an individual beach recreationist to each of the beaches change with a change in beach width?
- How would WTP for an individual beach recreationist change with a change in beach width?
- What would be the change in value in aggregate WTP across all recreationists visiting a particular beach should a change occur in beach width? For example, what would be the increase in recreation value (i.e., aggregate WTP) associated with a 50 foot increase in beach width on Bogue Banks?

Additionally, this report provided an overview of how the data will be used to establish baseline parking and access needs for Bogue Banks and project future parking needs in the with project condition.

As a note, on January 17, 2013, the District met with the Sponsor to provide them with an updated briefing on the NED plan and reiterate the specific 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 discussed. At the project Alternative Formulation Briefing on May 10, 2013, the Sponsor reiterated their awareness of these requirements and the importance of ensuring and maintaining public access for moving forward with the Federal project. Another meeting was held with the Sponsor and the Carteret County Beach Commission on June 24, 2013 to reiterate these requirements. In addition, the PDT met again with the Sponsor to review public access requirements on October 9, 2013. The District requested that the Sponsor acknowledge these requirements within their Letter of Intent and support for the project. Additional discussion pertaining to "Peak Demand" was added to the report.

2.0. METHODOLOGY

A multi-method approach was used to examine this study research questions. The primary methods included on-site and telephone surveys and econometric analyses to examine data within the framework of TCM and CVM. Historically, Wilmington District used the unit day value (UDV) method to determine recreation benefits for Hurricane and Storm Damage Reduction projects. The UDV method for estimating recreation benefits relies on expert or informed opinion and judgment to approximate the average willingness to pay of users of a particular project. However, given sufficient data, the UDV can be replaced with the TCM and the CVM estimates to provide a more valid and reliable monetary value of the recreation benefits for each project under feasibility study.

Questions on both the on-site survey and the telephone survey were specifically designed to generate data necessary to employ the TCM and the CVM. Survey data obtained from telephone and on-site survey invariably suffer from spurious records coming from missing values, outliers, and duplicate values, etc. Therefore, basic analysis methods for survey data required first and foremost cleaning data, filtering out unreliable answers from respondents whose answers lie distant from the most conceivable results. LIMDEP (2002)[i], a statistical software having specialized features for the statistical analysis of complex survey data, was employed to analyze the survey data. The analysis was accomplished by fitting nonlinear econometric models to observed data. These econometric models differ from standard regression models in that they can be adapted to handle the unique characteristics of survey data. In addition, the econometric models were developed to estimate economic values, such as a beach recreationist's willingness to pay, or the amount of money the recreationist would be willing to spend for a day of beach recreation.

One objective of this study is to estimate peak and latent demand of the beaches under study. Latent or potential demand is the number of individuals who would come to the beach if conditions were more conducive for recreation. This demand is modeled from the stated preference of the respondent versus their revealed preference. The recommended methodology and data collected from the surveys will be used to develop a model to estimate the number of trips taken to each beach in 2003 and the additional trips that the respondent would take if the width of the beach were increased. The model was also used to predict a decrease in trips with a decrease in beach width caused by erosion of the beach.

Table 1: 2003 Demographic Information

Variable	Demographic Areas		On Site Survey Models		Telephone Survey Models	
Name	North Carolina	Phone Sampling	WTP Simple	WTP Clogit	Analysis 1	Analysis 2
Mean Age	36*	37	Respondents over 18 years old		42	42
Mean Household Income	$42,536*	$36,072*	$54,255	$68,081	$58,833	$59,153
Sex						
Female	51%	51%	54%	57%	63%	62%
Male	49%*	49%*	46%	43%	37%	38%
Race						
White	72%	64%			81%	82%
Minority	28%*	36%*	Not used in model		19%	18%
Population / Observations	8,421,050	3,891,199	571	2,131	15	3,424

*All variables are in 2003 values except those notated with asterisks and described below (http://www.nist.gov/itl/div898/strd/).

North Carolina Demographics Age from July 2004 from NC State Demographics website.

North Carolina Demographics Sex and Race are from the 2000 US Census.

North Carolina Demographics Household Income was inflated to 2003 value from 1999 value from the 2000 US Census.

Telephone Sampling Area Demographics Sex and Race are from the 2000 US Census.

Telephone Sampling Area Demographics Household Income was inflated to 2003 value from 1999 value from the 2000 US Census.

The 2003 beach width will be used as a baseline for this study. The without project condition assumes that the baseline condition remains constant over an equivalent period of time to the expected life of the selected alternative for a hurricane and storm damage reduction project. The average annual benefits will be calculated for a 50 feet decrease in beach width to capture the effects of erosion on recreation. Long term erosion and hurricane impacts will be evaluated separately from the recreation analysis using coastal storm damage models.

Data collected from the aerial photography counts, parking counts and demographic data was employed in this model. Table 1 presents the demographic information of North Carolina and the sampling area.

3.0 ESTIMATING AVERAGE ANNUAL BENEFITS

This section of the appendix details the steps that were taken to derive average annual benefits (AAB) for Bogue Banks and the other beaches included in the surveys. Willingness to pay for beach improvement was used to calculate AAB. It was hypothesized that changes in beach characteristics such as beach width lead to an increase/decrease in the expected number of day user trips per household per year. Changes in the expected number of day user trips per household per year due to changes in beach characteristics can be found by calculating the difference between the expected number of trips per household under baseline conditions and the expected number of trips per household under alternative beach conditions. Since recreationists' responses to changes in beach improvement cannot be observed from market data, we used the contingent valuation method to estimate the WTP.

3.1 – Step 1 Estimating Willingness to Pay Using Contingent Valuation Method (CVM)

The first step in developing average annual benefits (AAB) was to determine a person's willingness to pay (WTP) for a visit to the beach and how certain factors will increase or decrease the likelihood that they pay more or less to visit a certain beach. Contingent valuation survey questions focused on specific environmental service(s) and the context that clearly defined and understood by survey respondents. To determine the average day-user's net willingness to pay (WTP) for beach recreation for each project, we used a binomial probit model (Haab and McConnell 2002, Chapter 2). In this study, we used the procedure to generate an equation that expresses willingness to pay (WTP) as a function of a set of socioeconomic and attitudinal variables. We specified WTP as a function of gender, age, income, beach width in feet, number of parking spaces per mile of beach length, weather condition and holiday.

3.2 – Step 2 – Estimating WTP for Site Access Using Travel Cost Method (TCM)

A conditional logit regression model was used to estimate the component of WTP that is beach-specific, known as "WTP for site access." In contrast, the WTP estimates for CVM measured the total of two components of beach recreation value: the value of visiting any beach in the study region and the WTP for site access to the particular beach on which the recreationist was surveyed. A conditional logit regression model was used to separately estimate WTP for site access alone (Haab and McConnell 2002, Chapter 8).

The conditional logit model attempts to explain the proportions of beach visitors visiting each beach as a function of beach characteristics such as beach length, beach width, the number of parking spaces at each beach, the weather forecast for each beach, and the cost of traveling to each beach per each respondent known as the 'access price.' WTP for site access may be estimated based on the estimated proportions. Because travel cost (access price) is used to predict beach choice, this model is a type of travel cost model (TCM).

Several alternative policy scenarios involving changes in beach quality characteristics can be evaluated using the conditional logit model results. This analysis focused only on the change in beach width effecting WTP. The purpose of developing project scenarios is to calculate WTP for specified changes in beach width compared to the 2003 base year. Beach width changes of –50ft, +50ft, +100ft, and +150ft were the selected scenarios. Econometric regression analyses will be performed for each beach separately, which allowed us to investigate the impact of changes in beach width of one town while assuming that the beach widths at the other towns remain constant at the 2003 base year levels.

The final requirement necessary to calculate the average annual benefits (AAB) was to determine the annual visitation for each beach. The telephone survey data was used to estimate an annual visitation model for each beach. For this analysis a Poisson

regression model was used to develop a trip index to establish how many trips individuals took to the beach in 2003. These estimated trips account only for trips originating from the geographic “area of influence” identified using the onsite survey data. The “area of influence” is the geographic area where seventy percent of the onsite survey day trips originated or a 120-mile radius of the beaches under study. The area of influence corresponds roughly to the eastern half of North Carolina. A random sample of telephone households in the area of influence was conducted in the spring of 2003. Of the 1,876 households surveyed, 1,187 (63 %,) reported taking a trip to one or more of the beaches included in this study in 2003. Survey questions gathered information on each respondent’s number of trips to each project beach in 2003. The 1,067 survey respondents who answered beach destination questions reported taking 9,002 trips to study area beaches in 2003.

Recreation Benefits, Bogue Banks, 3.5% Discount Rate								
				With Project		Without Project		
Reach	Length (ft)	Total Length	Percent	AA Rec Benefit	Benefit By Reach	AA Rec Benefit	Benefit By Reach	AA Net Benefit
1	595	6594	0.0902901	$ 6,437,690	$ 581,260	$ 6,011,353	$ 542,766	$ 38,494
2	425		0.064432		$ 414,793		$ 387,323	$ 27,470
3	700		0.1061037		$ 683,063		$ 637,827	$ 45,236
4	550		0.0833855		$ 536,810		$ 501,260	$ 35,550
5	931		0.1412107		$ 909,071		$ 848,867	$ 60,203
6	751		0.1138514		$ 732,940		$ 684,401	$ 48,539
7	838		0.1270184		$ 817,705		$ 763,552	$ 54,153
8	694		0.1052579		$ 677,618		$ 632,742	$ 44,875
9	682		0.1033856		$ 665,564		$ 621,487	$ 44,077
10	429		0.0650883		$ 419,018		$ 391,269	$ 27,750
11	681	5633	0.1208478	$ 5,755,551	$ 695,546	$ 5,457,115	$ 659,480	$ 36,065
12	1113		0.1975779		$ 1,137,170		$ 1,078,205	$ 58,964
13	1300		0.2308558		$ 1,328,702		$ 1,259,807	$ 68,896
14	1111		0.1971698		$ 1,134,821		$ 1,075,978	$ 58,843
15	1429		0.2535975		$ 1,459,593		$ 1,383,911	$ 75,683
16	690	5569	0.1239286	$ 2,302,220	$ 285,311	$ 2,046,418	$ 253,610	$ 31,701
17	994		0.1785378		$ 411,033		$ 365,363	$ 45,670
18	1135		0.2038628		$ 469,337		$ 417,189	$ 52,149
19	1096		0.1968649		$ 453,226		$ 402,868	$ 50,358
20	1653		0.2968828		$ 683,490		$ 607,546	$ 75,943
21	1322	83375	0.0158573	$ 7,782,784	$ 123,414	$ 7,064,406	$ 112,022	$ 11,392
22	1437		0.0172372		$ 134,153		$ 121,770	$ 12,383
23	1651		0.0198074		$ 154,157		$ 139,927	$ 14,229
24	1483		0.0177815		$ 138,390		$ 125,616	$ 12,774
25	1834		0.0219939		$ 171,173		$ 155,374	$ 15,800
26	1439		0.0172604		$ 134,334		$ 121,935	$ 12,400
27	1873		0.0224647		$ 174,838		$ 158,700	$ 16,138
28	1648		0.0197643		$ 153,821		$ 139,623	$ 14,198
29	956		0.0114606		$ 89,196		$ 80,962	$ 8,233
30	1089		0.013063		$ 101,667		$ 92,283	$ 9,384
31	1245		0.0149318		$ 116,211		$ 105,485	$ 10,727
32	1113		0.0133504		$ 103,903		$ 94,312	$ 9,591
33	1484		0.017797		$ 138,510		$ 125,725	$ 12,785
34	856		0.0102697		$ 79,927		$ 72,549	$ 7,378
35	1499		0.0179774		$ 139,914		$ 127,000	$ 12,915
36	945		0.0113285		$ 88,167		$ 80,029	$ 8,138

37	1408		0.0168934		$ 131,477		$ 119,342	$ 12,136
38	1488		0.0178493		$ 138,917		$ 126,095	$ 12,823
39	1059		0.0127047		$ 98,878		$ 89,751	$ 9,127
40	1701		0.0204069		$ 158,823		$ 144,163	$ 14,660
41	1648		0.0197636		$ 153,815		$ 139,618	$ 14,198
42	1089		0.0130626		$ 101,663		$ 92,279	$ 9,384
43	1968		0.0236013		$ 183,684		$ 166,729	$ 16,955
44	1329		0.0159379		$ 124,041		$ 112,592	$ 11,449
45	1646		0.0197413		$ 153,642		$ 139,461	$ 14,182
46	1095		0.0131385		$ 102,254		$ 92,816	$ 9,438
47	1107		0.0132738		$ 103,307		$ 93,771	$ 9,536
48	1096		0.0131501		$ 102,344		$ 92,897	$ 9,447
49	1101		0.0132071		$ 102,788		$ 93,300	$ 9,488
50	850		0.0101974		$ 79,364		$ 72,039	$ 7,326
51	518		0.0062118		$ 48,345		$ 43,883	$ 4,462
52	1575		0.0188859		$ 146,985		$ 133,418	$ 13,567
53	1593		0.0191017		$ 148,665		$ 134,942	$ 13,722
54	426		0.0051137		$ 39,799		$ 36,125	$ 3,674
55	1010		0.0121113		$ 94,260		$ 85,559	$ 8,700
56	870		0.0104294		$ 81,170		$ 73,677	$ 7,492
57	387		0.0046474		$ 36,170		$ 32,831	$ 3,339
58	1129		0.0135442		$ 105,412		$ 95,682	$ 9,730
59	1294		0.0155176		$ 120,770		$ 109,623	$ 11,148
60	737		0.0088445		$ 68,834		$ 62,481	$ 6,354
61	913		0.0109497		$ 85,219		$ 77,353	$ 7,866
62	1042		0.0124982		$ 97,271		$ 88,292	$ 8,978
63	1431		0.0171664		$ 133,602		$ 121,270	$ 12,332
64	431		0.0051671		$ 40,214		$ 36,502	$ 3,712
65	188		0.002256		$ 17,558		$ 15,937	$ 1,621
66	1499		0.017984		$ 139,966		$ 127,046	$ 12,919
67	546		0.0065428		$ 50,921		$ 46,221	$ 4,700
68	575		0.0068967		$ 53,676		$ 48,721	$ 4,954
69	1388		0.016643		$ 129,529		$ 117,573	$ 11,956
70	1114		0.0133639		$ 104,009		$ 94,408	$ 9,600
71	1183		0.0141941		$ 110,469		$ 100,273	$ 10,197
72	1185		0.0142133		$ 110,619		$ 100,409	$ 10,211
73	816		0.0097869		$ 76,169		$ 69,139	$ 7,031
74	1290		0.0154702		$ 120,401		$ 109,288	$ 11,113
75	1000		0.0119954		$ 93,358		$ 84,741	$ 8,617
76	401		0.0048057		$ 37,402		$ 33,950	$ 3,452
77	1026		0.0123109		$ 95,813		$ 86,969	$ 8,844
78	871		0.0104527		$ 81,351		$ 73,842	$ 7,509
79	1039		0.0124662		$ 97,022		$ 88,066	$ 8,955
80	641		0.0076917		$ 59,862		$ 54,337	$ 5,526
81	1039		0.0124662		$ 97,022		$ 88,066	$ 8,955
82	920		0.0110337		$ 85,873		$ 77,947	$ 7,926

83	1466		0.0175875		$ 136,880		$ 124,245	$ 12,634
84	1431		0.0171595		$ 133,549		$ 121,222	$ 12,327
85	1463		0.0175493		$ 136,582		$ 123,975	$ 12,607
86	1417		0.0169905		$ 132,233		$ 120,028	$ 12,206
87	1797		0.0215551		$ 167,758		$ 152,274	$ 15,485
88	1034		0.0123997		$ 96,504		$ 87,597	$ 8,908
89	827		0.0099154		$ 77,169		$ 70,046	$ 7,123
90	846		0.0101493		$ 78,989		$ 71,698	$ 7,291
91	908		0.0108912		$ 84,764		$ 76,940	$ 7,824
92	1648		0.0197687		$ 153,855		$ 139,654	$ 14,201
93	1243	15274	0.0814022	$ 2,387,488	$ 194,347	$ 1,364,279	$ 111,055	$ 83,291
94	1139		0.0746016		$ 178,110		$ 101,777	$ 76,333
95	954		0.0624849		$ 149,182		$ 85,247	$ 63,935
96	856		0.056055		$ 133,831		$ 76,475	$ 57,356
97	1063		0.0695982		$ 166,165		$ 94,951	$ 71,214
98	1171		0.0766946		$ 183,107		$ 104,633	$ 78,475
99	638		0.0417564		$ 99,693		$ 56,967	$ 42,726
100	807		0.0528326		$ 126,137		$ 72,078	$ 54,059
101	1079		0.0706379		$ 168,647		$ 96,370	$ 72,277
102	726		0.0475247		$ 113,465		$ 64,837	$ 48,628
103	839		0.0549398		$ 131,168		$ 74,953	$ 56,215
104	877		0.0574306		$ 137,115		$ 78,351	$ 58,763
105	719		0.0471039		$ 112,460		$ 64,263	$ 48,197
106	392		0.0256837		$ 61,320		$ 35,040	$ 26,280
107	709		0.0463909		$ 110,758		$ 63,290	$ 47,468
108	709		0.0463909		$ 110,758		$ 63,290	$ 47,468
109	703		0.0460344		$ 109,906		$ 62,804	$ 47,103
110	649		0.0424694		$ 101,395		$ 57,940	$ 43,455
111	711	4943	0.1438777	$ 895,308	$ 128,815	$ 468,971	$ 67,474	$ 61,340
112	1133		0.2291463		$ 205,157		$ 107,463	$ 97,694
113	721		0.1459598		$ 130,679		$ 68,451	$ 62,228
114	672		0.1360134		$ 121,774		$ 63,786	$ 57,988
115	687		0.1390387		$ 124,482		$ 65,205	$ 59,277
116	498		0.10075		$ 90,202		$ 47,249	$ 42,953
117	520		0.105284		$ 94,262		$ 49,375	$ 44,886
Total					$25,561,798		$22,413,192	$3,148,607

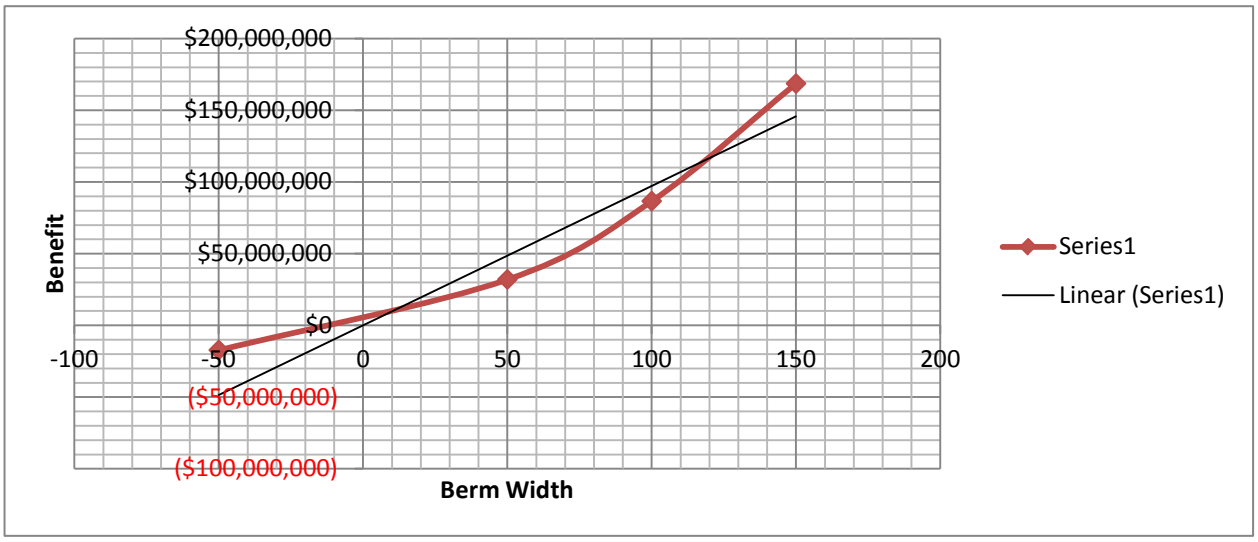
3.3. – Step 3 – Calculating Project Average Annual Benefits (AAB)

Finally the average annual benefits (AAB) for recreation under baseline 2003 conditions at each of the project beaches (updated to 2014 price levels for the Final Report) were calculated using estimates of annual trips to each beach in the study area, based on the telephone survey data, and estimates of recreation value per trip (net willingness to pay) based on the onsite survey data. Each of the models used to develop a demand curve of benefits is expressed in present worth.

Attachment 1, Recreation Curves by Sbeach Reach

Union of Coastal and Economic Reaches

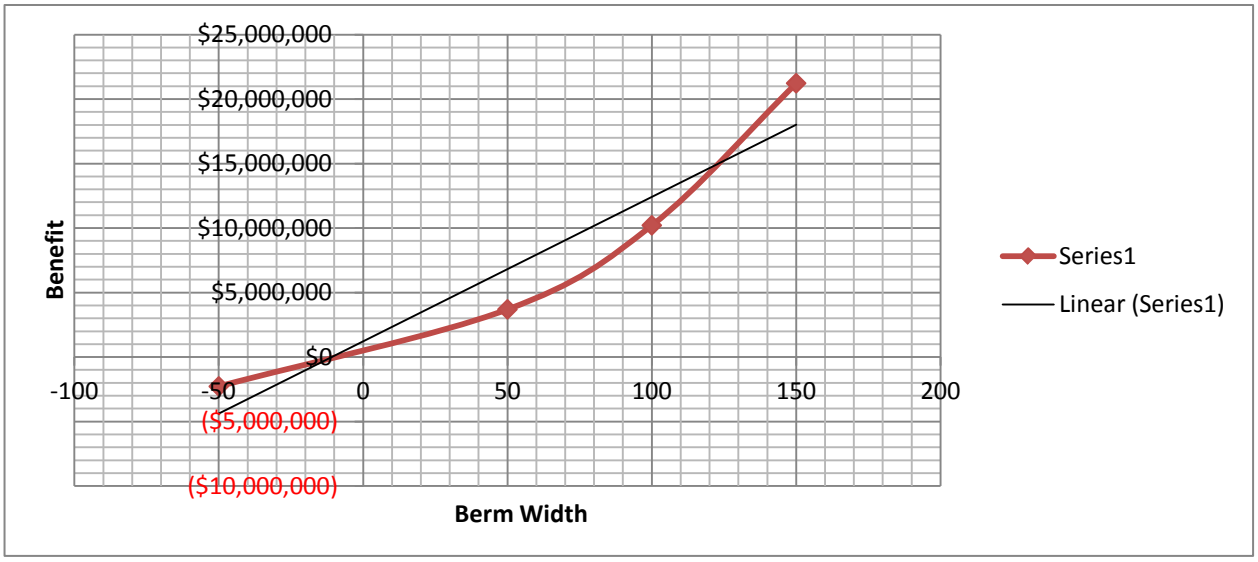
Coastal Reaches (SBeach)	Economic Reaches
1	1-10
2	11-15
3	16-20
4	21-29
5	30-42
6	43-52
7	53-58
8	59-73
9	74-85
10	86-92
11	93-110
12	111-117



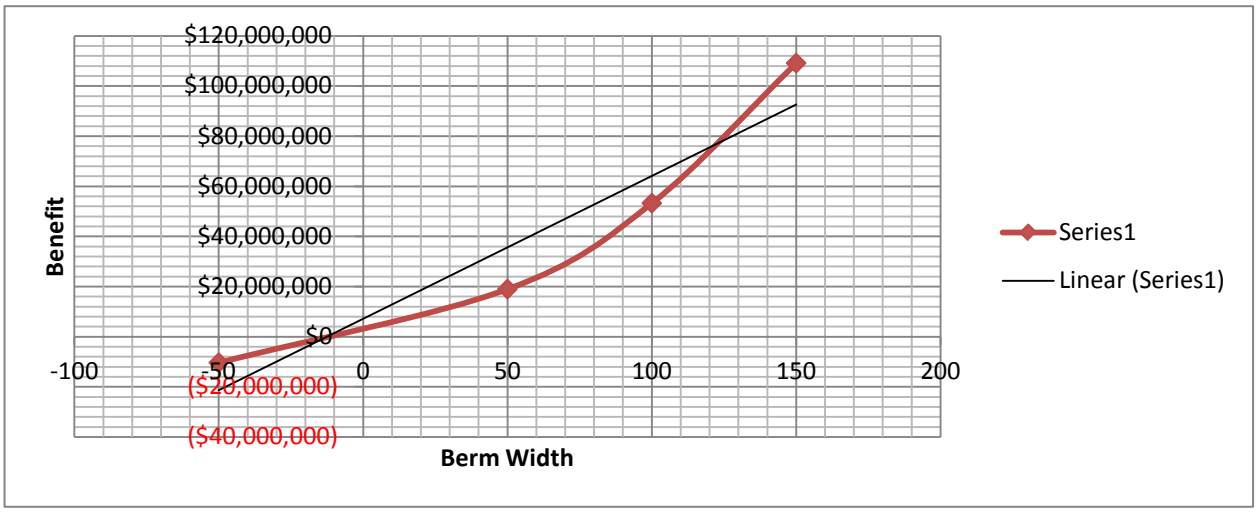
Emerald Isle, Sbeach Reaches 1-6

Salter Path, Sbeach Reach 7

Indian Beach, Sbeach Reach 7



Pine Knoll Shores, Sbeach Reaches 8-9



Atlantic Beach, Sbeach Reaches 10-12

ATTACHMENT 2

PARKING AND ACCESS

1.0 INTRODUCTION

The Army Corps of Engineers has several requirements that must be met in order to fully cost share in a coastal storm damage reduction project (see ER 1105-2-100 and ER 1165-2-130). These requirements include that the beaches must be available for public use and provide adequate parking and access. As described in ER 1165-2-130 (Federal Participation in Shore Protection, 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 Corps’ Wilmington District, additionally, has developed more specific public access and parking requirements for participation in coastal storm damage reduction projects within the District’s boundaries of North Carolina and Virginia. The Wilmington District requirement requires that a minimum of 10 public parking spaces be located within one-quarter mile of a public access point. The criteria for 10 spaces was based on using an average lot size along the shoreline area and determining how many parking spaces could be provided in that lot size (e.g. a 50’ x 95’ lot size can provide 10 spaces).

This Appendix contains an analysis of the current parking and access situation at Bogue Banks and how it relates to the distribution and peak demand requirements. The local sponsor will need to address any parking and access deficiencies prior to the signing of the PPA, otherwise project cost sharing would be adjusted. If the required number of parking spaces cannot be obtained, in some cases a public transportation system adequate for the needs of projected beach users may suffice instead (see ER 1165-2-130, section 6h(2)). Recognizing that circumstances can change between the time that this initial analysis was done and the PPA is signed, the parking and access needs as presented in this Appendix may be revisited at some point prior to the PPA signing.

As a note, on January 17, 2013, the District met with the Sponsor to provide them with an updated briefing on the NED plan and reiterate the specific 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 discussed. At the project Alternative Formulation Briefing on May 10, 2013, the Sponsor reiterated their awareness of these requirements and the importance of ensuring and maintaining public access for moving forward with the Federal project. Another meeting was held with the Sponsor and the Carteret County Beach Commission on June 24, 2013 to reiterate these requirements. In addition, the PDT met again with the Sponsor to review public access requirements on October 9, 2013. The District requested that the Sponsor acknowledge these requirements within their Letter of Intent and support for the project, which was provided in April 2014. Additional discussion pertaining to "Peak Demand" was added to the report.

2.0 Data

The spatial analysis of available public access and parking within the project areas was conducted using the following data:

Existing spatial data assembled for this analysis:

- Public Beach Access 2004 – Source: State of North Carolina CAMA Office
- Carteret County Tax Parcels 2010 – Source Carteret County Tax Office

New spatial data layers created for this analysis:

- Beach Access ½ Mile Diameter – ½ mile diameter buffers were created from the Public Beach Access Points. These circles represent the maximum distance allowed between Public Beach Access Points.
- Access Distance Greater than ½ Mile – Line segments were created between each Public Access Point. Data layer contains a definition query limiting display to only those segments that exceed ½ mile, or the maximum distance allowed between Public Access facilities per USACE Policy.
- Town Properties – Properties owned by the towns were derived from the Carteret County Tax Parcel Data to illustrate where potential Public Beach Access may be obtained if needed.

3.0 BEACH ACCESS

3.1 Methodology

Public Access Points were compared to the Project Area. Those Public Access Points adjacent to the given Project Area were selected for further analysis. Circular buffers with ½ mile diameter were generated from the selected Public Access Points. These circular features were given the layer name “Beach Access ½ Mile Diameter” and are

depicted as hollow blue circles in Maps 1-9 (all maps are contained at the end of this Appendix). These features, originating at each Public Access Point, must intersect with a Public Access Point on both east and west sides to meet the required maximum distance between public access points per USACE Policy. Instances where Public Access fails to meet this requirement are found on Access Maps (Attachment 3) 1, 2,5,6,7,8, and 9 within Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach.

Further analysis was conducted to determine the distance between those Public Beach Access Points that were more than ½ mile apart. The line feature "Access Distance Greater than ½ mile" was generated using the Public Beach Access Points. The lengths of these line segments were calculated and a definition query used to select those segments with a length exceeding ½ mile. These selected lines were then labeled with their calculated lengths to illustrate the magnitude of public access deficiencies within the project areas.

3.2 Results

There are 109 existing access points distributed throughout the study area.

Maps 1 and 2 define two instances within Emerald Isle that fail to meet the USACE public access density requirement. The distance between Public Access points located Wyndtree and Randy's Way has been calculated as .66 miles (see Map 1). To meet access density requirements, two additional Public Access Points are required between these two points. The distance between Public Access points located at Heavenly and Bogue Inlet Pier has been calculated as .35 miles (see Map 2). One additional Public Access Point is required between these two points to meet access density requirements.

Map 5 illustrates two instances of public beach access deficiency. The distance between the Indian Beach Regional Access and the Salter Path Regional Access has been calculated to be 0.09 miles. Technically, to meet access density requirements, an additional Public Access is required between these two points. Additionally, the distance between Salter Path Regional Access and the Sea Plantation West Access has been calculated to be 0.09 miles.

There are two instances of Public Beach Access deficiency in Pine Knoll Shores on Map 6. The distance between Beacon's Reach West Access and the Beacon's Reach East Access has been calculated to be 0.38 miles. One additional Public Beach Access points is required between these two points. Additionally, the distance between The Qualls Regional Access and the Iron Steamer Regional Access has been calculated to be 0.38 miles as well, requiring one additional Public Beach Access.

An additional two Public Beach Access deficiencies in Pine Knoll Shores can be found on Map 7. The distance between the Dogwood Regional Access and Memorial Park Regional Access has been calculated to be 0.06 miles, requiring an additional Public

Beach Access between these two points. The distance between Memorial Park Regional Access and the Knollwood Dr Regional Access has been calculated to be 0.14 miles. One additional Public Beach Access is required between these two points to meet the minimum access requirement.

Map 8 shows three Public Beach Access deficiencies of the project in Atlantic Beach. The distance between the Knollwood Dr Regional Access and the Coral Bay Club (west) Regional Access has been calculated to be 0.19 miles. One additional Public Beach Access is required between these two points. The distance between the Coral Bay Club (west) Regional Access and the Durham Avenue Regional Access has been calculated to be 0.84 miles, requiring two additional Public Beach Access points between these two points.

Map 9 shows a deficiency between the Commerce Way Regional Access and The Fort Macon Bathhouse Regional Access, with a distance of .07 miles outside of the ½ mile diameter.

In summary, at least 13 additional beach access points are needed throughout the project area to meet the USACE requirement for adequate distribution.

4.0 PARKING DISTRIBUTION

4.1 Methodology

Public Access Points and Parking Data were compared to the Project Areas. Those Public Access Points adjacent to the given Project Area were selected for further analysis. Circular buffers with ¼ Mile radii were generated from the selected Public Access Points. These circular features were given the layer name “Parking Radius ¼ Mile” and are depicted as hollow blue circles in Maps 1-9. These features, originating at each Public Access Point, must contain a minimum of 10 public parking spaces within ¼ mile per USACE Policy. Instances where Public Access Parking fails to meet this requirement are found on Parking Maps (Attachment 3) 1, 2, 3, 4, 8, and 9.

4.2 Results

There are an estimated 1,861 existing parking spots distributed throughout the study area (including Fort Macon). Beach Access Points were symbolized with a Green Filled Circle where the number of parking spaces met or exceeded the minimum of 10 spaces. Beach Access Points were symbolized with a Red Filled Circle where the number of parking spaces was less than the required 10 spaces. Each Beach Access was labeled with the number of known Parking Spaces.

The Beach Access Points Channel Drive, Inlet and Coast Guard Road (Station Street Park), and Wyndtree are all within ¼ mile of each other. Each Access point in this group has 10 Parking Spaces within ¼ mile. None of the other Beach Access Points on Map 1 meet the minimum requirement for parking.

The Beach Access Points Western Regional Access and Janell are located within ¼ mile of each other and both have 10 or more parking spaces available within ¼ mile. No other Beach Access Points on Map 2 meet the minimum requirement for parking.

Only Beach Access Point Dog Leg meets the minimum requirement for parking on Map 3. Dog Leg is located within ¼ mile of Old Pier Eastern Regional Access and has access to 10 or more parking spaces.

On Map 4, Beach Access Points at Old Pier Eastern Regional Access, 25th, 5th, 3rd, and 2nd all have 10 Parking Spaces within ¼ mile. None of the other Beach Access Points on Map 4 meet the minimum requirement for parking.

All Beach Access Points on Map 5 meet minimum parking requirements. Beach Access 1st, Baptist Church Gazebo, Ocean Club, Indian Beach Regional Access, Salter Path, Sea Plantation West, and Trinity Center Regional Access all meet the minimum parking requirements with access to 10 or parking spaces within ¼ mile.

Beacon's Reach West Regional Access, Beacon's Reach East/Clamdigger Inn/The Qualls Regional Access, Iron Steamer and Dayton Place located on Map 6 all meet or exceed the minimum parking requirement.

The Dayton Place, Dogwood, Memorial Park, Knollwood and the Amerisuites Regional Access and the Amerisuites Regional Access points on Map 7 meet the minimum requirement for parking, along with the Iron Steamer Regional Access also visible on Map 7. However, the Sheraton West Regional Access does not meet minimum parking requirements.

On Map 8, Durham Street Regional Access, Charlotte Avenue Regional Access, Raleigh Avenue Regional Access, Bath House Regional Access, The Circle Regional Access and Beaufort Avenue Regional Access all meet the minimum parking requirements by having 10 available parking spaces within ¼ mile.

New Bern Street Regional Access and Club Colony Drive Regional Access both meet required minimum of 10 Parking Spaces within ¼ mile, as do Tom Doe, Ocean Avenue , and Commerce Way Regional Access points. Of the remaining Beach Access Points On Map 9, only the Bathouse Regional Access meets the minimum requirement for parking.

4.0 PEAK PARKING

A study/survey was conducted by the University of North Carolina at Wilmington (UNCW) in 2003 was used as the basis for estimating potential peak hour parking demand in the area (this study can be made available upon request) at the time a project is constructed (currently estimated to be 2019 for the Bogue Banks Project). Peak hour demand is defined here as the average number of non-overnight visitors at

the beaches at 1 p.m. on July 4, 5, 12, 13 and Aug 2, 3, 9, 10, 30, and 31. Sufficient parking capacity is defined here as having enough parking spaces to accommodate peak hour demand on 60% of peak days. This means that on average, there would be enough public parking to accommodate all beach visitors year round, with the exception of at peak hour (1 p.m.) on four of the busiest (peak) days of the year.

The increase in peak demand is based on increases to the width of the beach. Because beach width will vary over the life of the project, an average annual change in beach width between the with and without project condition was calculated. This difference in beach width was measured for each of the individual towns in the project area (Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores, and Atlantic Beach) and used as the basis for determining project recreation benefits (see Appendix B – Economics) and the peak hour parking demand in each of these towns with a project in place in 2019. The number of parking spaces required to meet the peak hour parking demand requirement, as well as the current number of parking spaces in each of the towns is shown in Table 1 below.

Town	Total Parking Spaces Needed for Peak Demand	Current Parking Spaces	Additional Parking Spaces Needed
Emerald Isle	662	529	133
Salter Path/Indian Beach	96	141	0
Pine Knoll Shores	210	180	30
Atlantic Beach	1,100	1,011*	89
Total	**2,068**	**1,861**	**252**

*Includes 594 parking spots available at Fort Macon State Park

Table 1. Number of parking spaces needed to meet peak parking requirement, and estimated number of current parking spaces.

PUBLIC PARKING AND ACCESS MAPS

Are posted at the end of this appendix

Introduction to Methods and Procedures

This write-up provides an overview of the data and methodology that was used to determine the peak parking space requirements. The data on which the analysis is based comes the from telephone and onsite surveys conducted by the University of North Carolina at Wilmington in 2003 (the full report can be made available upon request). This data was used to establish parking requirements for Bogue Banks at the estimated start of project construction.

Methodology

The telephone survey asked respondents about trips taken in a 120-mile radius of the North Carolina coast during a typical peak summer season. The data was used to construct an index of the number of recreational day trip (TRIPINDX) to a beach. $TRIPINDX_i$ is the estimated number of recreational day trips taken to beach i per year by 1,067 households in the telephone survey sample. PC Miler, a Poisson/negative-binomial cluster regression model, was used to generate TRIPINDX. Other data collected for this study include stay time, STAYTIME, which is the average length of time in hours that a visitor remained at the beach. The duration of stay is assumed to affect parking demand. If the duration of stay is usually long, more parking spaces should be provided.

The on-site survey collected parking space data for ten beaches on peak (weekend) days in July and August 2003. For this analysis the variable $SPACES_,$ which gives the existing number of parking spaces at each beach, is used as a censoring variable by the Tobit regression procedure. Each beach has a separate censoring limit, as specified by the $SPACES_i$ variable. Two holidays were included in the survey effort: the Fourth of July weekend and the Labor Day Weekend. To test for the effect of holiday on parking demand, a dummy variable, $HOLIDAY_{d,}$ was generated equal to 1 if the day is July 4 or 5, or August 30 or 31, days corresponding to the Fourth of July and Labor Day holidays.

To account for fixed effects in the model, beach-specific dummy variables, DB00, DB09, that shift the intercept were generated for nine beaches. The dummy for beach 10 is omitted to avoid a dummy variable trap. Observe that beach 08 is omitted from the whole analysis. Dummy variables capturing time of day effects were constructed as follows: if t = 9am-11am, DMORN = 1, DMORN = 0 otherwise; if t = 3pm-5pm, DAFTN = 1, DAFTN = 0 otherwise. Note that potential dummy variable DMID = 1 when t = 12noon-2pm is omitted to avoid the dummy variable trap. Under this specification, with all dummy variables set to zero, the regression predicts uncensored FILLEDSP (dependent variable) at midday on a non-holiday weekend day on beach 10 (Atlantic Beach). Setting one of the various dummy variables to the value “1” adjusts the

regression predictions for an alternative time of day or an alternative beach destination. Table A1 summarizes key statistics for the survey data sample.

Variable	Description	Mean	Std.Dev.	Minimum	Maximum
FILLEDSP	Filled Parking Spaces	2.5666	2.2871	0	9.09
STAYTIME	Stay Time at beach	4.339445	1.318575	0.1875	9.5
HOLIDAY	Holiday {Fourth of July and Labor Day}	0.532934	0.49929	0	1
TRIPINDX	Trip index	428.956	255.16	146	924
DMORN	Day time dummy variable	0.377246	0.48506	0	1
DAFTN	Afternoon time dummy variable	0.211078	0.408379	0	1
DB00	Caswell Beach	0.0329	0.178598	0	1
DB01	Oak Island Beach	0.0449	0.207262	0	1
DB02	Holden Beach	0.0404	0.197088	0	1
DB03	North Topsail Beach	0.0449	0.207262	0	1
DB04	Surf City Beach	0.0404	0.197088	0	1
DB05	Topsail Beach	0.0404	0.197088	0	1
DB06	Pine Knoll Shores Beach	0.0389	0.193554	0	1
DB08	Indian Beach	0.0404	0.197088	0	1
DB09	Emerald Isle Beach	0.0434	0.203938	0	1

Notes: Only aggregate statistics are reported in table. The descriptive statistics for the 10 individual beaches are not presented to economize on space.

Table A1. Summary statistics of survey data.

It is likely that some visitors may not use the beach because parking capacity is limited. Suppose that out of 500 potential beach visitors, 200 are unable to use the beach because they cannot find parking space. One strategy of dealing with this difficulty is to ignore or drop these observations from the sample. However, by eliminating this subset from the sample not only do we lose degrees of freedom and therefore precision, we also risk biased estimates of the effects of independent variables. That is, important factors correlated with the dependent variable may characterize this group of visitors that has been dropped. In situations such as these, a better strategy that allows use of the entire sample is to assume that the dependent variable FILLEDSP (number of parking spaces filled at a give beach) has a censored distribution; that is, the dependent variable cannot be observed above or below some threshold value, and therefore is reported as this threshold value.

The underlying model of censored regression assumes that the true value of the dependent variable is unobservable. The basic form of the censored regression model is given by the latent variable formulation:

$$Y_i^* = X'_i\beta + \varepsilon_i \qquad (1)$$

Where y_i^* is the latent variable, X'_i is a vector of exogenous variables and ε_i is a normal error term with zero mean and standard deviation σ.

Define the censored random variable Y_i as

$$y_i = o \text{ if } y_i^* \leq 0$$
$$y_i = y^*_i \text{ if } y_i^* \succ 0$$

The dependent variable of the censored regression model is observed when $y_i^* \succ 0$. With the survey we can obtain the observable response (y_i) which represents the unobservable outcome of a particular range.

When the range of dependent variable is limited, censored regression methodology are used to analyze the data. Given the censored nature of the dependent variable, performing OLS on equation (1) will result in inconsistent coefficient estimates. To account for censored dependent variable and to obtain consistent estimates of the parameters, we estimate a censored regression within a maximum likelihood Tobit model.

The Tobit regression model (with upper and lower tail censoring) is specified as:

$$\begin{aligned} Ln(FILLEDSP_{idt}) &= \beta_o + \beta_1 DMORN + \beta_2 DAFTN + \beta_3 DB00 + ...\beta_{11} DB09 \\ &+ \beta_{12} STAYTIME_{id} + \beta_{13} HOLIDAY_d + \beta_{14} TRIPINDX_i + e_{idt} \end{aligned} \qquad (2)$$

If Ln$(FILLEDSP_{idt}) \leq 0$, then Ln$(FILLEDSP_{idt}) = 0$,
If Ln$(FILLEDSP_{idt}) \geq$ In$(SPACES_i)$, then In $((FILLEDSP_{idt}) = (SPACES_i)$,

where:

FILLEDSP, STAYTIME, SPACES, HOLIDAY, DMORN, DAFTN, DB00…DB9, and TRIPINDX are variables defined above, e_{idt} is a heteroskedastic error term. The error term is specified as $e_{idt} \sim N(0, \sigma^2.\exp(\alpha.TRIPIND_i))$, where σ (the standard deviation of the uncensored dependent variable in the absence of heteroskedasticity), α and $\beta_0 - \beta_{14}$ are the parameters to be estimated.

Parameters of the distribution of the latent dependent variable are estimated by maximum likelihood in LIMDEP (2002). The Tobit regression model estimates the probability distribution of FILLEDSP, including the number of FILLEDSP that would occur if the number of parking spaces were not constrained. The resulting probability distribution can be used to estimate parking requirements beyond current parking space capacity.

Results:

Projected Annual Visitation

As state population increases, the number of visitors to Bogue Banks is expected to increase, assuming that the number of trips per household remains constant. Table A1 shows baseline annual visitation to each of the towns in future years, as well as with various changes in beach width.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
NC State Gov't projections of households in telephone survey area	1,800,076	1,826,960	1,854,353	1,881,535	1,929,183	1,957,774	1,987,225	2,016,205	2,042,055	2,068,172	2,094,974
EMERALD ISLE											
Baseline Trips to this beach	986,726	1,001,463	1,016,478	1,031,378	1,057,497	1,073,169	1,089,314	1,105,199	1,119,369	1,133,685	1,148,377
Trips w. -50 width	875,400	888,474	901,796	915,015	938,186	952,091	966,413	980,506	993,078	1,005,779	1,018,813
Trips w. +50 width	1,112,210	1,128,820	1,145,745	1,162,540	1,191,980	1,209,646	1,227,843	1,245,749	1,261,721	1,277,858	1,294,417
Trips w. +100 width	1,253,651	1,272,374	1,291,452	1,310,382	1,343,566	1,363,478	1,383,990	1,404,172	1,422,176	1,440,365	1,459,030
Trips w. +150 width	1,413,080	1,434,184	1,455,687	1,477,026	1,514,430	1,536,874	1,559,994	1,582,743	1,603,036	1,623,538	1,644,578
INDIAN BEACH & SALTER PATH											
Baseline Trips to this beach	158,483	160,850	163,262	165,655	169,850	172,367	174,960	177,512	179,788	182,087	184,447
Trips w. -50 width	140,603	142,703	144,842	146,965	150,687	152,920	155,221	157,484	159,504	161,543	163,637
Trips w. +50 width	178,638	181,306	184,024	186,722	191,450	194,288	197,210	200,086	202,652	205,244	207,903
Trips w. +100 width	201,356	204,363	207,427	210,468	215,797	218,996	222,290	225,532	228,423	231,345	234,343
Trips w. +150 width	226,962	230,352	233,806	237,233	243,241	246,846	250,559	254,213	257,472	260,765	264,144
PINE KNOLL SHORES											
Baseline Trips to this beach	193,522	196,412	199,357	202,279	207,401	210,475	213,641	216,757	219,536	222,344	225,225
Trips w. -50 width	171,688	174,252	176,865	179,457	184,002	186,729	189,538	192,302	194,767	197,258	199,814
Trips w. +50 width	218,132	221,390	224,709	228,003	233,777	237,242	240,811	244,322	247,455	250,620	253,867
Trips w. +100 width	245,872	249,544	253,286	256,999	263,507	267,412	271,435	275,393	278,924	282,491	286,152
Trips w. +150 width	277,140	281,279	285,496	289,681	297,017	301,419	305,954	310,415	314,395	318,416	322,543
ATLANTIC BEACH											
Baseline Trips to this beach	871,446	884,461	897,722	910,881	933,949	947,790	962,048	976,077	988,592	1,001,236	1,014,211
Trips w. -50 width	773,126	784,673	796,438	808,113	828,577	840,857	853,506	865,953	877,055	888,273	899,784
Trips w. +50 width	982,269	996,939	1,011,887	1,026,720	1,052,720	1,068,322	1,084,393	1,100,207	1,114,313	1,128,564	1,143,189
Trips w. +100 width	1,107,186	1,123,722	1,140,570	1,157,289	1,186,596	1,204,182	1,222,297	1,240,122	1,256,021	1,272,085	1,288,571
Trips w. +150 width	1,247,988	1,266,627	1,285,618	1,304,463	1,337,497	1,357,319	1,377,738	1,397,830	1,415,752	1,433,858	1,452,440

Table A2. Projected annual visitation at Bogue Banks communities.

Total visits include both day and overnight visitors. For instance, about 52% of the visitation at Atlantic Beach is from day visitors, as compared to about 35% of the visitation at Emerald Isle. This leads to greater peak parking needs at Atlantic Beach, despite there being more overall visitation at Emerald Isle.

Projected Parking Needs

Estimates of the beach parking demand model using the two-limit Tobit regression estimation procedure is shown in Table A2.

Explanatory Variables	Coefficient	Std. Error.	t-ratio	P-value	Mean
Constant	4.557***	0.506	9.00	0	1
DMORN	-0.666	0.488	-1.36	0.1727	0.3772
DAFTN	-0.307	0.490	-0.63	0.5311	0.2111
DB00	-0.518	0.567	-0.92	0.3601	0.0329
DB01	0.699	0.512	1.37	0.1723	0.0449
DB02	-0.379	0.527	-0.719	0.4722	0.0404
DB03	0.166	0.595	0.279	0.7803	0.0449

DB04	-0.706	0.564	-1.252	0.2105	0.0404
DB05	-0.101	0.543	-0.186	0.8521	0.0404
DB06	-0.262	0.5577	-0.47	0.6383	0.0389
DB07	-0.946*	0.5378	-1.76	0.0785	0.0404
DB09	-1.271**	0.5544	-2.293	0.0218	0.0434
STAYTIME	0.008	0.0206	0.362	0.7175	4.339
HOLIDAY	0.364***	0.0536	6.78	0	0.5329
TRIPINDX	0.003***	0.00018	12.6	0	428.656
Sigma	0.451***	0.0161	28.023	0	----
Alpha	0.0007***	0.000067	10.992	0	----
Log-likelihood	-623.66				

Notes: ***,**, and * refer to significance at the 1%, 5%, and 10% levels, respectively. The chi-square and overall likelihood ratio statistics are 29.1 and 546.7, respectively. Number of observations =699. Dependent variable: FILLEDSP. D13 is the omitted time of day dummy variable.

Table A3. Tobit regression results - Dependent Variable: FILLEDSP

As expected the coefficient on the beach specific index of recreation demand, TRIPINDX, is positive and strongly significant. The large t statistic, 12.6, allows us to reject the null hypothesis of no trip demand at the 1% level of significance. This provides evidence that beach trip demand impacts the number of parking spaces. The heteroskedasticity parameter α is positive and strongly significant, indicating that larger values of TRIPINDX increase the variance of ln(FILLEDSP). There is evidence to indicate that HOLIDAY has a positive and significant effect on filled spaces. We also find evidence that STAYTIME has a positive but insignificant effect on filled spaces. Fixed effects dummy variables DB00…DB09 vary in sign, reflecting differences in the estimated value of filled parking spaces, ln(FILLEDSP), at midday across beaches. However, after controlling for other variables in the regression, only DB07 and DB09 are statistically significant at the 10% and 5% level, respectively. There is no evidence to indicate that this data suggests that time of day variables, DMORN and DAFTN, significantly impact beach-parking demand. In all, the explanatory power of the regression is reasonably good given the individual cross section data. The likelihood ratio test indicates that the overall regression is significant at $p<0.01$.

As mentioned earlier, an important component of this analysis was to determine parking spaces that would be required to accommodate all peak (weekend holiday) day beach visitors. With the estimated Tobit coefficients, it is possible to calculate the number of spaces that would be required to accommodate all peak (weekend holiday) day beach visitors 60% of the time, 95% of the time, etc. For each beach, ln(FILLEDSP) follows a normal distribution, with a beach-specific mean value given by the Tobit regression equation (with variables replaced by their mean values), and a beach-specific standard deviation given by $(\sigma^2 \cdot \exp[\alpha \cdot TRIPINDX_i])^{0.5}$. The unconditional mean of $\ln(FILLEDSP_i)$, denoted $\bar{\mu}$, is given by: $\bar{\mu} = \beta_0 + \beta_1 DMORN + \beta_2 DAFTN + \beta_3 DB00 + \ldots + \beta_{11} DB09 + \beta_{12} STAYTIME_{id} + \beta_{13} HOLIDAY_d + \beta_{14} TRIPINDX_i$,

where mean values are inserted for independent variables. The standard deviation of $\ln(FILLEDSP_i)$, denoted SD, is given by: $SD = \sigma^2 \cdot \exp[\alpha \cdot TRIPINDX_i])^{0.5}$. The unconditional 90 percentile, for example, of $FILLEDSP_i$ is then given by: 90 percentile $FILLEDSP_i$ = EXP(NORMINV(0.90, $\bar{\mu}$, SD)), where NORMINV is the inverse normal cumulative distribution function.

For each beach, the frequency of FILLEDSP can be graphed against FILLEDSP to determine the number of spaces that would be necessary to accommodate all peak (weekend holiday) day beach visitors 60% of the time, 95% of the time, etc. Furthermore, changes in beach conditions may shift the frequency distribution of FILLEDSP. An increase in beach width attracts additional beach visitation, which shifts the frequency distribution to the right. As the distribution shifts to the right, the current number of parking spaces accommodates all visitors less frequently.

Tables A3-A6 shows the number of parking spaces needed to meet peak demand at each of the Bogue Banks communities 60%, 70%, 80%, 90% and 95% of the time at future years with the various beach width increases associated with the Recommended Plan.

The average change in beach width at each of the communities, as compared to the without project condition, is as follows:

Emerald Isle: +6 ft

Salter Path and Indian Beach: +26 ft

Pine Knoll Shores: +21 ft

Atlantic Beach: +54 ft

The project year of project construction is 2019. Having sufficient parking to meet peak demand 60% of the time at the start of project construction is considered sufficient for satisfying the USACE requirement for accommodating peak demand.

	USACE									
	Telephone Survey			EMERALD ISLE Parking Space Requirements, with +6 ft beach width						
	Region									
	Population									
	Index		Mean	Std. Dev.	Mean	60%tile	70%tile	80%tile	90%tile	95%tile
Year	(2004 Base)	TRIPINDX	ln(FILLEDSP)	ln(FILLEDSP)	FILLEDSP	0.6	0.7	0.8	0.9	0.95
2013	1.142909226	1072	6.11E+00	0.674463107	448	532	638	791	1064	1359
2014	1.158993672	1087	6.14E+00	0.678298367	464	551	662	821	1106	1415
2015	1.175403086	1103	6.17E+00	0.682233588	480	571	687	853	1151	1475
2016	1.191880291	1118	6.21E+00	0.686208039	497	592	713	886	1198	1538
2017	1.208539311	1134	6.24E+00	0.690249885	515	614	740	921	1248	1604
2018	1.225643369	1150	6.28E+00	0.694424477	534	637	769	959	1301	1674
2019	1.243302456	1166	6.32E+00	0.698761028	555	662	800	999	1358	1751
2020	1.260632105	1182	6.36E+00	0.703043004	575	688	832	1040	1417	1829
2021	1.275861877	1197	6.39E+00	0.706827781	594	711	861	1077	1470	1901
2022	1.291205705	1211	6.42E+00	0.710661507	614	735	891	1117	1527	1976
2023	1.306920061	1226	6.45E+00	0.714609364	635	761	923	1158	1586	2057

Table A4. Peak parking demand requirements for +6 ft beach width at Emerald Isle.

	USACE									
	Telephone Survey			INDIAN BEACH & SALTEirements, with +26 ft beach width						
	Region									
	Population									
	Index		Mean	Std. Dev.	Mean	60%tile	70%tile	80%tile	90%tile	95%tile
Year	(2004 Base)	TRIPINDX	ln(FILLEDSP)	ln(FILLEDSP)	FILLEDSP	0.6	0.7	0.8	0.9	0.95
2013	1.142909226	181	4.41E+00	0.482447833	82	93	106	123	153	182
2014	1.158993672	183	4.42E+00	0.482908849	83	93	107	124	154	183
2015	1.175403086	186	4.42E+00	0.483379634	83	94	107	125	155	184
2016	1.191880291	188	4.43E+00	0.483852826	84	95	108	126	156	185
2017	1.208539311	191	4.43E+00	0.48433171	84	95	109	127	157	187
2018	1.225643369	194	4.44E+00	0.484823881	85	96	109	127	158	188
2019	1.243302456	196	4.45E+00	0.485332547	85	96	110	128	159	189
2020	1.260632105	199	4.45E+00	0.485832242	86	97	111	129	160	191
2021	1.275861877	202	4.46E+00	0.486271813	86	98	111	130	161	192
2022	1.291205705	204	4.46E+00	0.486715078	87	98	112	131	162	193
2023	1.306920061	206	4.47E+00	0.487169466	87	99	113	131	163	194

Table A4. Peak parking demand requirements for +26 ft beach width at Indian Beach and Salter Path.

	USACE Telephone Survey Region Population Index		PINE KNOLL SHORES Parking Space Requirements, with +21 ft beach width							
Year	(2004 Base)	TRIPINDX	Mean ln(FILLEDSP)	Std. Dev. ln(FILLEDSP)	Mean FILLEDSP	60%tile 0.6	70%tile 0.7	80%tile 0.8	90%tile 0.9	95%tile 0.95
2013	1.142909226	218	5.18E+00	0.489335203	178	201	230	268	333	398
2014	1.158993672	221	5.19E+00	0.489900521	179	203	232	270	335	401
2015	1.175403086	225	5.19E+00	0.490477933	180	204	233	273	338	404
2016	1.191880291	228	5.20E+00	0.491058415	182	206	235	275	341	407
2017	1.208539311	231	5.21E+00	0.491646001	183	207	237	277	344	411
2018	1.225643369	234	5.22E+00	0.492250016	184	209	239	279	346	414
2019	1.243302456	237	5.22E+00	0.492874409	186	210	240	281	349	418
2020	1.260632105	241	5.23E+00	0.493487925	187	212	242	283	352	421
2021	1.275861877	244	5.24E+00	0.494027729	188	213	244	285	355	424
2022	1.291205705	247	5.24E+00	0.494572173	190	215	246	287	357	428
2023	1.306920061	250	5.25E+00	0.495130387	191	216	247	290	360	431

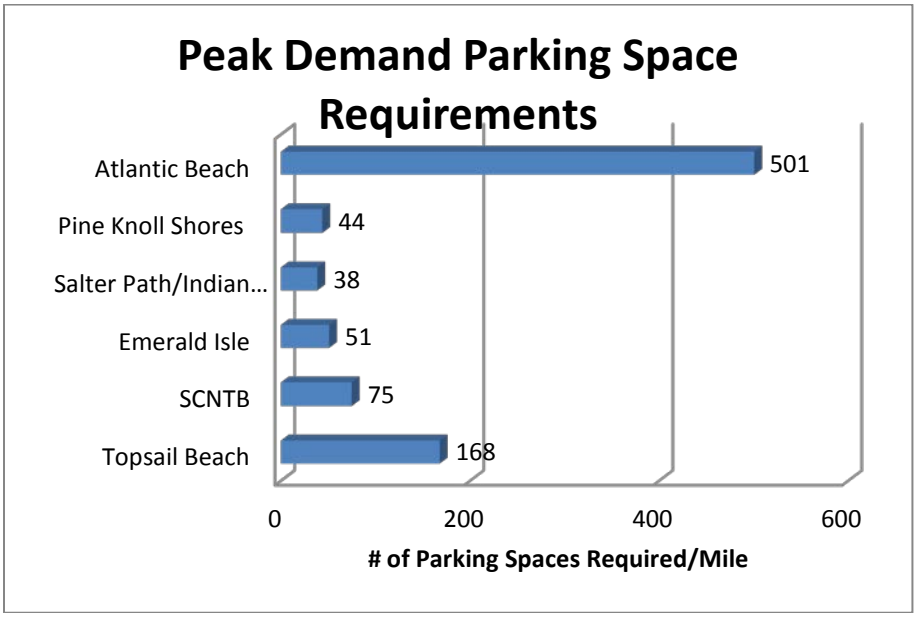
Table A5. Peak parking demand requirements for +21 ft beach width at Pine Knoll Shores.

	USACE Telephone Survey Region Population Index		ATLANTIC BEACH Parking Space Requirements, with +54 ft beach width							
Year	(2004 Base)	TRIPINDX	Mean ln(FILLEDSP)	Std. Dev. ln(FILLEDSP)	Mean FILLEDSP	60%tile 0.6	70%tile 0.7	80%tile 0.8	90%tile 0.9	95%tile 0.95
2013	1.142909226	1062	7.35E+00	0.671860737	1563	1854	2224	2752	3698	4721
2014	1.158993672	1077	7.39E+00	0.675644439	1617	1919	2305	2856	3844	4914
2015	1.175403086	1092	7.42E+00	0.679526545	1674	1988	2391	2966	3999	5119
2016	1.191880291	1107	7.46E+00	0.683447134	1733	2060	2480	3080	4161	5333
2017	1.208539311	1123	7.49E+00	0.68743398	1795	2136	2574	3201	4331	5560
2018	1.225643369	1139	7.53E+00	0.691551531	1860	2217	2674	3329	4513	5802
2019	1.243302456	1155	7.57E+00	0.695828576	1931	2303	2781	3468	4710	6064
2020	1.260632105	1171	7.60E+00	0.700051546	2002	2391	2890	3609	4911	6333
2021	1.275861877	1185	7.63E+00	0.703783963	2067	2471	2990	3738	5095	6579
2022	1.291205705	1200	7.67E+00	0.707564455	2135	2554	3094	3873	5287	6837
2023	1.306920061	1214	7.70E+00	0.71145729	2207	2643	3205	4016	5492	7112

Table A6. Peak parking demand requirements for +54 ft beach width at Atlantic Beach.

Review of the results for Atlantic Beach indicated the need to adjust these figures to a number more reasonable for this segment of the study area. Though the model makes valid assumptions to project parking demand, it is important to ground truth the results throughout the project area to assess whether the outputs are “reasonable” and implementable. As stated above, when comparing Atlantic Beach parking requirements to those projected for other towns, the total number of parking spaces required is not considered “reasonable.” As evident in Table A7, the peak demand parking space requirements (i.e. spaces/mile) for Atlantic Beach are significantly higher than estimates for other towns within and outside of the study area (i.e. 501 spaces per mile vs. an average of 75 per mile for five other beach communities in NC).

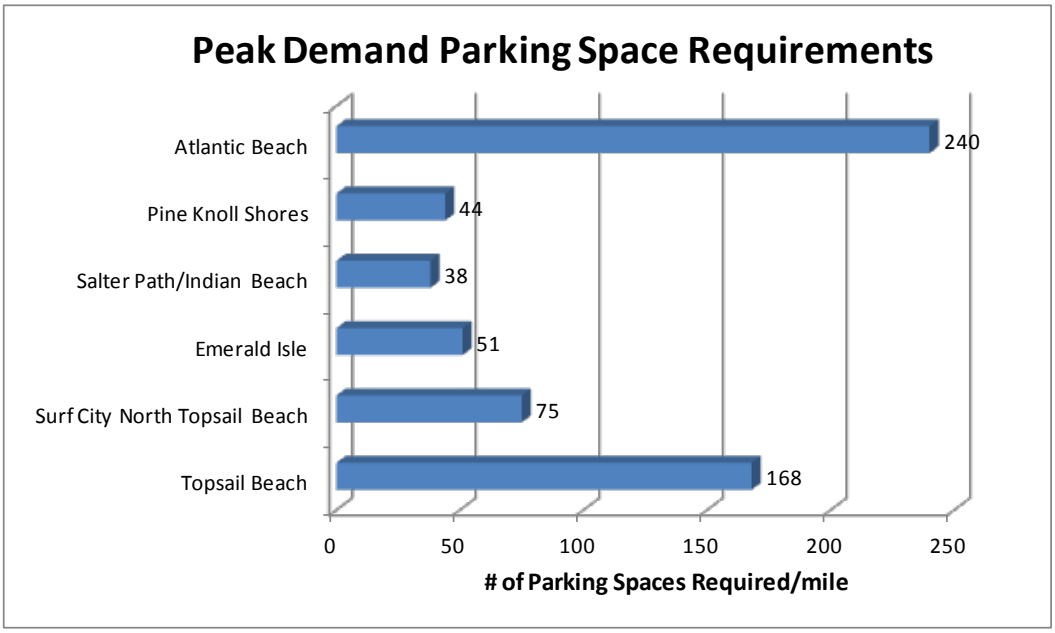
Table A7. Initially-projected peak demand parking space requirements for Atlantic Beach relative to adjacent towns within the Bogue Banks study area as well as two previously approved projects at Topsail Beach and SCNTB.



The Wilmington District then re-coordinated with the model developer regarding the high peak demand parking requirements at Atlantic Beach compared to other Towns. The discrepancy with Atlantic Beach parking numbers is based on the two main variables relative to the surveys that were conducted: STAY TIME and Percentage of overnight visitors relative to day trippers. The difference in STAYTIME across the beaches explained a small amount of the difference in parking space needs (Atlantic Beach has a longer average STAYTIME, and hence its parking spaces do not cycle as quickly as parking spaces in Emerald Isle, but the effect is relatively small). The primary difference is associated with the percentage of day users versus overnight visitors across beaches. From the on-site beach visitor survey data (as opposed to the telephone survey, which only collected day/overnight visitation data by county, rather than by beach), it was found that the percentage of beach visitors staying overnight at Atlantic Beach was only 48% whereas the percentage staying overnight at Emerald Isle was 65.4%. If one takes the predicted number of visits to Atlantic Beach in 2009 (1,084,000 visits) and multiplies by the percentage of day trips (1-0.48), you get 564,096 predicted day trips--these are the trips that need the public parking spaces, because the overnight trips use primarily private condo/cottage/hotel parking lots. Similarly, if one takes the predicted number of visits to Emerald Isle in 2009 (1,228,000 visits) and multiplies by the percentage of day trips (1-0.654), you get 424,753 predicted day trips. So, when one accounts for the difference in the percentages of overnight vs. day trips between the beaches, one finds more day trips taken to Atlantic Beach (even though fewer overall trips) compared to Emerald Isle and, therefore, a larger number of parking spaces needed at Atlantic Beach to accommodate the larger number of day trips.

Wilmington District found that a required geographical distribution of 10 parking spaces within ¼ mile of each ½ mile beach access in addition to the 1,011 spaces that already exist, results in a total of ~1100 (~240 spaces per mile) parking spaces to satisfy peak demand requirements. Though reduced from the originally projected total of 2,303 spaces required, this adjusted total number of spaces would still be over three times the average number of parking spaces per mile (~75) based on projections for other Towns. The Wilmington District believes that the Town of Atlantic Beach's commitment to meet the geographic distribution requirement coupled with the existing number of parking spaces would be consistent with requirements for "reasonable" public access and parking for federal participation in CSDR projects pursuant to ER 1105-2-100 and ER 1165-2-130. The Wilmington District will continue to coordinate with the Sponsor regarding parking and access requirements and update project files as additional parking spaces and accesses are obtained leading up to the signing of the PPA.

Table A8. Projected peak demand parking space requirements for Atlantic Beach relative to adjacent towns within the Bogue Banks study area as well as two previously approved projects at Topsail Beach and SCNTB.



To summarize, the number of spaces needed to meet peak demand with the project in place is as follows (previously indicated in Table 1):

Town	Total Parking Spaces Needed for Peak Demand	Current Parking Spaces	Additional Parking Spaces Needed
Emerald Isle	662	529	133
Salter Path/Indian Beach	96	141	0
Pine Knoll Shores	210	180	30
Atlantic Beach	1,100	1,011*	89
Total	**2,068**	**1,861**	**252**

*Includes 594 parking spots available at Fort Macon State Park

Number of parking spaces needed to meet peak parking requirement, and estimated number of current parking spaces.

Given the relative inordinate number of required spaces the Parking and Access model was producing in Atlantic Beach, the district adopted a 'willingness to pay' approach which employed area and user utility to determine requirements. As well, parameters used to define usage throughout Bogue were incorporated to maintain consistency in visitation accounting with other Bogue towns. The methodology used to determine parking and access requirements in Atlantic Beach is defined by the following:

-Optimized utility for beach use is achieved when the user has a 10 ft by 10 ft area, or 100 sq ft.

-Atlantic Beach has a length of 28,692 ft, multiplied by the design template of 50ft throughout the length of the project, producing a total of 1,435,000 square feet of beach. Additionally, Atlantic Beach will have 27 access points, and it is assumed that not all the area around these access points will be used as utilized beach area, as foot travel around them is assumed to be regular. A 30X30 area was assumed to not be utilized for this purpose. With the subtraction of 900 sq ft per access point, the total utilized beach area is 1,410,700 (900 x 27= 24,300, 1,435,000-24,300=1,410,700).

-This 1,410,700 total was then divided by the 100 sq ft area for optimized user utility, which produces the number of users, on Atlantic beach at any given time, which is 14,107.

-The beach recreation study produced by Dr Dumas et al. indicated that 48% of the users on Atlantic beach are overnight visitors and 52% day use visitors. This 52% usage translates to 7,336 day users on the beach (14,107 x .52=7,336) that would require parking and access.

-Peak usage is assumed to be weekend and holiday usage. At this time, it is assumed that beach day users with travel with family or friends, at an average of 4 occupants per vehicle. If it is assumed that 7,336 day users are traveling at an average of 4 per automobile, then it is assumed that 1,834 automobiles will be used to transport day users to Atlantic Beach.

-The assumption in the recreation study, and that which was applied to the other beaches on Bogue Banks, is that this value will be only met 60% during the peak demand times, producing a total of 1,100 (1,834x.6=1,100) automobiles used to transport day users on Atlantic Beach. Attachment II, Parking and Access of Appendix B demonstrates this as a consistent approach throughout the study, stating that “Having sufficient parking to meet peak demand 60% of the time at the start of project construction is considered sufficient for satisfying the USACE requirement for accommodating peak demand.”

ATTACHMENT 3

SUPPORTING DATA

Bogue Banks Interior Lot Comparisons			
	Structure	Land	
EI			
9807 Sandy Court	$644,219	$737,986	
9421 Ocean Drive	$329,111	$803,997	
9313 Ocean Drive	$169,732	$616,355	Average Price For Rebuild in 28594 is $193/sf
105 Janell LN	$577,853	$621,945	Lot values avg. $669,852
8619 Ocean View Dr	$667,872	$649,080	
7515 Ocean Dr	$230,871	$660,960	
7211 Ocean Dr	$183,327	$660,960	
6205 Ocean Drive	$170,030	$649,080	
5803 Ocean Drive	$1,000,923	$649,080	
3107 Ocean Drive	$1,564,822	$649,080	
Indian Beach			
1829 Salter Path Rd	$177,000	$705,280	Average Price For Rebuild in IB is $274/sf
713 Salter Path Rd	$300,317	$636,272	Lot Values avg $670,776
Salter Path			
193 Hoffman Beach Road	$212,972	$797,355	Average Price for Rebuild in SP is $321/sf
127 Sea Isle Dr	$1,179,847	$773,258	Lot Values avg $785,306
PKS			
607 Forest Dunes Dr	$778,136	$1,111,388	Average Price for Rebuild in PKS is $154/sf
461 Maritime Pl	$690,081	$832,200	Lot Values avg $812,442
105 Ocean Shore Ln	$527,878	$621,340	
115 Dogwood Circle	$265,510	$936,709	
215 Salter Path Rd	$1,052,502	$744,876	
13 Pinewood St	$225,531	$628,140	
AB			

1007 Ocean Ridge Dr	$679,285	$1,110,037	Average Price for Rebuild in AB is $137/sf
204 Club Colony Dr	$223,401	$642,813	Lot Values avg $791,513
200 Ocean Blvd	$493,389	$621,690	

Summary of Net Benefits, By Alternative, (For Alternative Screening) at 4.125%

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$94,053	$33,643	$5,524	$28,119
2	$75,627	$40,007	$3,892	$36,115
3	$106,873	$29,997	$6,408	$23,588
4	$108,457	$50,410	$5,040	$45,369
5	$231,654	$28,324	$8,668	$19,655
6	$194,152	$74,289	$7,311	$66,977
7	$83,838	$25,750	$11,340	$14,411
8	$34,277	$41,113	$15,745	$25,368
9	$51,665	$27,887	$13,145	$14,742
10	$24,965	$16,300	$8,582	$7,718
11	$49,311	$44,155	$9,396	$34,758
12	$56,341	$73,164	$14,939	$58,225
13	$114,164	$84,290	$23,531	$60,759
14	$93,926	$79,664	$15,878	$63,786
15	$247,896	$123,740	$15,920	$107,820
16	$31,230	$35,610	$14,572	$21,038
17	$30,183	$79,132	$18,883	$60,249
18	$3,116	$37,010	$20,073	$16,937
19	$4,988	$37,600	$18,380	$19,220
20	$7,685	$55,160	$17,082	$38,077
21	$1,181	$24,744	$3,463	$21,281
22	$166,848	$3,517	$2,990	$528
23	$0	$0	$2,645	($2,645)
24	$2,945	$4,105	$2,226	$1,879
25	$30	$1,099	$2,965	($1,866)
26	$293	$947	$2,304	($1,357)
27	$4,626	$7,211	$4,253	$2,958
28	$1,891	$9,546	$2,804	$6,742
29	$234	$2,531	$1,645	$886
30	$8,271	$15,004	$6,160	$8,843
31	$428	$8,120	$6,261	$1,858
32	$1,400	$11,083	$6,267	$4,816
33	$721	$11,098	$7,161	$3,937
34	$344	$6,732	$4,843	$1,889
35	$2,452	$30,225	$10,206	$20,019
36	$5,414	$6,813	$4,549	$2,265
37	$57,390	$18,559	$8,336	$10,223
38	$22,367	$20,063	$7,501	$12,562
39	$31,827	$21,699	$5,555	$16,144
40	$64,438	$125,138	$9,880	$115,257
41	$51,196	$22,629	$9,375	$13,254
42	$9,991	$19,785	$8,199	$11,586
43	$33,102	$90,552	$54,741	$35,811
44	$25,977	$69,641	$44,778	$24,863
45	$4,283	$103,055	$72,513	$30,542
46	$13,875	$68,193	$38,969	$29,224
47	$26,937	$61,839	$36,426	$25,413
48	$12,314	$49,073	$35,374	$13,700
49	$18,477	$50,283	$32,619	$17,664
50	$12,918	$31,163	$22,776	$8,386
51	$0	$9,083	$12,311	($3,228)
52	$1,406	$37,264	$48,123	($10,858)
53	$18	$50,068	$62,630	($12,562)
54	$1,656	$42,265	$15,341	$26,924
55	$2,965	$73,850	$39,238	$34,612
56	$0	$25,754	$39,489	($13,735)
57	$0	$8,899	$13,022	($4,123)
58	$0	$23,526	$33,383	($9,857)
59	$12	$38,868	$38,733	$135

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$1,891	$26,564	$24,948	$1,616
61	$22,799	$34,216	$24,804	$9,412
62	$218,802	$454,227	$24,015	$430,213
63	$3,829	$47,753	$40,161	$7,592
64	$5,803	$14,225	$10,954	$3,271
65	$39,412	$23,034	$5,028	$18,005
66	$1,932	$50,158	$46,422	$3,737
67	$204	$16,438	$14,891	$1,547
68	$53,109	$19,521	$17,648	$1,873
69	$117,845	$61,246	$46,121	$15,125
70	$225,447	$187,538	$29,666	$157,872
71	$100,327	$74,011	$37,855	$36,156
72	$65,677	$59,582	$33,702	$25,880
73	$27,884	$29,883	$22,591	$7,293
74	$238	$40,873	$38,591	$2,282
75	$3,783	$21,090	$20,778	$312
76	$15,633	$66,912	$7,782	$59,131
77	$9,524	$17,678	$24,815	($7,137)
78	$256,956	$823,541	$34,444	$789,097
79	$16,460	$144,648	$38,104	$106,544
80	$267,192	$91,208	$21,234	$69,974
81	$5,308	$49,187	$37,327	$11,861
82	$4,208	$35,032	$32,902	$2,130
83	$14,010	$179,163	$60,227	$118,936
84	$12,734	$144,054	$58,756	$85,298
85	$3,694	$101,636	$68,667	$32,969
86	$26,735	$79,370	$76,668	$2,702
87	$146,458	$299,945	$102,160	$197,785
88	$208	$43,198	$53,408	($10,209)
89	$216,996	$226,652	$40,492	$186,159
90	$3,691	$82,827	$48,522	$34,305
91	$15,785	$84,952	$57,715	$27,237
92	$587,952	$271,195	$94,080	$177,115
93	$393,343	$993,236	$50,056	$943,180
94	$73,221	$47,728	$34,696	$13,032
95	$131,660	$26,001	$19,985	$6,016
96	$115,749	$24,193	$16,245	$7,948
97	$174,293	$33,508	$17,120	$16,388
98	$128,270	$39,933	$29,000	$10,933
99	$106,891	$28,528	$18,777	$9,751
100	$108,541	$50,601	$24,471	$26,130
101	$84,097	$82,372	$30,451	$51,922
102	$82,107	$33,189	$23,345	$9,845
103	$175,400	$50,821	$25,420	$25,401
104	$115,803	$38,720	$19,320	$19,400
105	$61,269	$24,281	$16,927	$7,354
106	$119,705	$194,042	$8,062	$185,980
107	$57,053	$73,417	$14,839	$58,577
108	$73,586	$27,627	$19,422	$8,205
109	$65,211	$36,187	$25,517	$10,670
110	$68,964	$45,066	$31,067	$13,999
111	$121,794	$73,249	$49,676	$23,573
112	$121,259	$94,189	$86,146	$8,043
113	$55,102	$66,686	$57,885	$8,801
114	$77,765	$142,381	$61,030	$81,351
115	$168,827	$424,628	$65,836	$358,792
116	$176,006	$683,338	$53,686	$629,651
117	$123,238	$143,427	$64,334	$79,093
Total	$7,704,309	$9,600,177	$3,173,156	$6,427,021

Average annual remaining damages, costs and benefits by reach for Alternative 1.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$93,839	$33,857	$6,205	$27,653
2	$75,599	$40,035	$4,381	$35,654
3	$106,852	$30,018	$7,214	$22,803
4	$108,520	$50,346	$5,689	$44,657
5	$231,522	$28,456	$9,686	$18,770
6	$195,878	$72,563	$8,195	$64,367
7	$83,018	$26,570	$13,783	$12,787
8	$33,169	$42,221	$18,573	$23,648
9	$50,887	$28,666	$15,707	$12,959
10	$24,996	$16,269	$10,237	$6,032
11	$39,645	$53,821	$11,844	$41,977
12	$43,833	$85,672	$18,923	$66,749
13	$100,100	$98,354	$28,488	$69,866
14	$85,418	$88,172	$19,932	$68,240
15	$220,434	$151,201	$20,688	$130,513
16	$28,469	$38,371	$16,942	$21,428
17	$25,367	$83,948	$22,271	$61,677
18	$2,308	$37,818	$23,891	$13,926
19	$3,495	$39,093	$22,003	$17,090
20	$5,895	$56,950	$21,911	$35,039
21	$684	$25,241	$5,901	$19,340
22	$155,328	$15,037	$5,269	$9,769
23	$0	$0	$4,706	($4,706)
24	$3,885	$3,164	$4,360	($1,195)
25	$7	$1,122	$5,656	($4,534)
26	$534	$706	$4,584	($3,877)
27	$1,962	$9,876	$7,503	$2,373
28	$1,606	$9,831	$5,164	$4,667
29	$0	$2,765	$2,982	($218)
30	$3,975	$19,300	$8,873	$10,427
31	$0	$8,547	$9,208	($660)
32	$1,141	$11,343	$9,036	$2,307
33	$0	$11,819	$10,687	$1,132
34	$0	$7,076	$7,028	$48
35	$1,424	$31,254	$14,322	$16,932
36	$4,468	$7,759	$6,793	$966
37	$46,848	$29,100	$12,002	$17,098
38	$19,829	$22,601	$11,105	$11,495
39	$31,140	$22,386	$8,168	$14,218
40	$52,921	$136,655	$14,273	$122,382
41	$46,522	$27,304	$13,590	$13,713
42	$9,041	$20,735	$11,287	$9,448
43	$21,525	$102,128	$62,739	$39,389
44	$17,021	$78,597	$50,201	$28,396
45	$2,733	$104,606	$79,250	$25,356
46	$8,324	$73,745	$43,402	$30,343
47	$16,356	$72,420	$40,909	$31,511
48	$8,396	$52,992	$39,782	$13,210
49	$10,445	$58,316	$37,045	$21,270
50	$7,347	$36,734	$26,230	$10,504
51	$0	$9,083	$14,419	($5,336)
52	$941	$37,729	$54,548	($16,819)
53	$77	$50,009	$69,859	($19,850)
54	$1,212	$42,709	$17,274	$25,435
55	$2,575	$74,240	$43,829	$30,411
56	$0	$25,754	$43,529	($17,775)
57	$0	$8,899	$14,826	($5,927)
58	$0	$23,526	$38,635	($15,109)
59	$0	$38,881	$43,257	($4,377)
60	$1,827	$26,628	$27,674	($1,046)
61	$20,774	$36,241	$27,821	$8,421
62	$187,296	$485,733	$27,312	$458,421
63	$3,600	$47,983	$44,956	$3,027
64	$6,239	$13,790	$12,338	$1,452
65	$34,406	$28,039	$5,642	$22,397
66	$1,864	$50,226	$51,801	($1,575)
67	$149	$16,492	$16,691	($199)
68	$51,666	$20,964	$19,697	$1,268
69	$101,607	$77,485	$51,374	$26,111
70	$198,333	$214,652	$33,405	$181,247
71	$94,756	$79,582	$42,253	$37,329
72	$62,606	$62,653	$37,769	$24,884
73	$26,908	$30,860	$25,368	$5,492
74	$238	$40,873	$44,036	($3,163)
75	$2,443	$22,430	$24,986	($2,556)
76	$14,003	$68,543	$9,465	$59,078
77	$9,141	$18,061	$29,152	($11,091)
78	$232,430	$848,068	$38,145	$809,923
79	$11,880	$149,229	$42,482	$106,746
80	$253,059	$105,341	$23,910	$81,431
81	$4,777	$49,719	$41,666	$8,053
82	$3,181	$36,058	$36,733	($675)
83	$10,065	$183,108	$66,354	$116,754
84	$8,796	$147,991	$64,707	$83,284
85	$3,212	$102,118	$74,728	$27,390
86	$28,683	$77,421	$83,269	($5,848)
87	$121,419	$324,985	$110,474	$214,510
88	$364	$43,042	$58,238	($15,196)
89	$199,113	$244,534	$44,160	$200,374
90	$4,124	$82,394	$52,179	$30,215
91	$14,610	$86,126	$61,575	$24,551
92	$606,731	$252,416	$101,205	$151,211
93	$339,949	$1,046,630	$55,150	$991,480
94	$68,648	$52,301	$39,331	$12,969
95	$119,050	$38,611	$23,632	$14,979
96	$105,111	$34,831	$19,470	$15,360
97	$156,605	$51,195	$21,007	$30,188
98	$115,311	$52,891	$33,621	$19,270
99	$93,075	$42,345	$21,343	$21,001
100	$95,779	$63,362	$27,671	$35,691
101	$73,110	$93,359	$34,777	$58,582
102	$74,719	$40,578	$26,266	$14,312
103	$158,543	$67,678	$28,792	$38,887
104	$100,251	$54,273	$22,673	$31,600
105	$54,885	$30,665	$19,718	$10,947
106	$104,763	$208,984	$9,544	$199,441
107	$49,976	$80,494	$17,525	$62,969
108	$66,099	$35,113	$22,241	$12,873
109	$56,091	$45,308	$28,334	$16,973
110	$61,470	$52,560	$33,703	$18,857
111	$121,924	$73,119	$49,672	$23,447
112	$121,259	$94,189	$86,137	$8,052
113	$55,102	$66,686	$57,835	$8,851
114	$77,765	$142,381	$61,009	$81,372
115	$168,827	$424,628	$65,813	$358,814
116	$176,267	$683,077	$53,672	$629,405
117	$123,237	$143,429	$64,338	$79,091
Total	$7,095,623	$10,208,864	$3,563,636	$6,645,228

Average annual remaining damages, costs and benefits by reach for Alternative 2.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$43,528	$84,168	$9,705	$74,462
2	$34,970	$80,664	$6,818	$73,847
3	$46,606	$90,264	$11,222	$79,042
4	$49,241	$109,626	$8,859	$100,766
5	$102,480	$157,498	$15,105	$142,393
6	$95,037	$173,404	$12,561	$160,843
7	$39,268	$70,320	$27,394	$42,926
8	$18,980	$56,410	$31,436	$24,974
9	$24,422	$55,131	$27,875	$27,256
10	$11,245	$30,019	$17,941	$12,078
11	$30,737	$62,729	$14,910	$47,819
12	$35,889	$93,616	$23,917	$69,699
13	$92,242	$106,212	$34,783	$71,429
14	$73,169	$100,422	$24,973	$75,449
15	$195,437	$176,199	$26,836	$149,363
16	$24,249	$42,591	$21,542	$21,048
17	$18,792	$90,523	$28,897	$61,625
18	$1,682	$38,444	$31,441	$7,003
19	$2,711	$39,877	$29,302	$10,575
20	$4,449	$58,396	$32,690	$25,706
21	$667	$25,259	$11,717	$13,542
22	$164,052	$6,313	$10,874	($4,561)
23	$0	$0	$9,047	($9,047)
24	$0	$7,049	$8,356	($1,306)
25	$7	$1,122	$11,013	($9,892)
26	$0	$1,241	$8,707	($7,466)
27	$553	$11,285	$15,443	($4,158)
28	$784	$10,653	$10,117	$536
29	$0	$2,765	$5,837	($3,073)
30	$2,486	$20,789	$16,172	$4,617
31	$0	$8,547	$17,364	($8,817)
32	$493	$11,990	$16,492	($4,502)
33	$0	$11,819	$20,655	($8,837)
34	$0	$7,076	$12,964	($5,888)
35	$1,067	$31,610	$25,029	$6,581
36	$4,141	$8,087	$13,130	($5,044)
37	$42,852	$33,097	$21,841	$11,256
38	$17,945	$24,484	$21,186	$3,298
39	$32,148	$21,377	$15,396	$5,981
40	$45,563	$144,012	$26,093	$117,919
41	$45,528	$28,298	$25,000	$3,298
42	$8,714	$21,062	$19,162	$1,900
43	$21,145	$102,509	$78,203	$24,306
44	$15,649	$79,970	$60,628	$19,342
45	$2,802	$104,537	$92,044	$12,493
46	$7,570	$74,498	$51,912	$22,586
47	$13,817	$74,959	$49,482	$25,477
48	$7,676	$53,711	$48,290	$5,422
49	$9,192	$59,568	$45,571	$13,997
50	$6,511	$37,570	$32,888	$4,682
51	$0	$9,083	$18,477	($9,394)
52	$941	$37,729	$66,830	($29,100)
53	$18	$50,068	$83,911	($33,842)
54	$932	$42,989	$21,046	$21,943
55	$1,814	$75,000	$52,756	$22,245
56	$0	$25,754	$51,361	($25,607)
57	$0	$8,899	$18,299	($9,400)
58	$0	$23,526	$48,764	($25,238)
59	$39	$38,841	$53,222	($14,381)

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$1,805	$26,650	$33,388	($6,737)
61	$19,398	$37,618	$34,739	$2,878
62	$165,083	$507,947	$34,918	$473,029
63	$3,715	$47,868	$56,001	($8,133)
64	$5,817	$14,211	$15,559	($1,347)
65	$27,534	$34,911	$7,083	$27,829
66	$1,686	$50,404	$63,469	($13,065)
67	$168	$16,474	$20,879	($4,405)
68	$50,990	$21,640	$24,158	($2,518)
69	$89,825	$89,266	$62,725	$26,542
70	$177,451	$235,535	$42,145	$193,389
71	$89,666	$84,672	$51,885	$32,787
72	$62,202	$63,057	$47,271	$15,786
73	$25,453	$32,315	$31,853	$461
74	$238	$40,873	$54,971	($14,097)
75	$2,049	$22,824	$33,471	($10,647)
76	$9,948	$72,597	$12,861	$59,736
77	$7,599	$19,602	$37,835	($18,232)
78	$181,196	$899,302	$45,496	$853,805
79	$10,815	$150,294	$51,283	$99,011
80	$230,912	$127,488	$29,247	$98,240
81	$4,547	$49,948	$50,301	($353)
82	$2,653	$36,587	$44,385	($7,798)
83	$8,729	$184,444	$78,499	$105,945
84	$7,448	$149,339	$76,574	$72,765
85	$2,627	$102,703	$86,630	$16,073
86	$28,351	$77,754	$94,939	($17,185)
87	$116,775	$329,628	$125,343	$204,286
88	$364	$43,042	$66,741	($23,699)
89	$184,343	$259,305	$50,615	$208,690
90	$3,866	$82,652	$58,839	$23,813
91	$13,384	$87,353	$68,602	$18,750
92	$665,282	$193,865	$114,117	$79,748
93	$306,496	$1,080,083	$64,825	$1,015,258
94	$42,677	$78,272	$47,939	$30,333
95	$68,517	$89,144	$30,771	$58,373
96	$61,661	$78,281	$25,850	$52,431
97	$98,937	$108,864	$28,776	$80,088
98	$71,930	$96,272	$42,426	$53,847
99	$50,165	$85,254	$26,182	$59,072
100	$51,318	$107,824	$33,742	$74,082
101	$46,367	$120,102	$42,834	$77,268
102	$43,655	$71,642	$31,697	$39,945
103	$91,881	$134,340	$35,068	$99,272
104	$53,500	$101,023	$29,186	$71,838
105	$29,977	$55,574	$25,071	$30,502
106	$75,363	$238,384	$12,453	$225,931
107	$27,037	$103,432	$22,753	$80,680
108	$38,244	$62,969	$27,515	$35,454
109	$31,027	$70,371	$33,604	$36,767
110	$36,708	$77,322	$38,564	$38,759
111	$127,321	$67,722	$54,073	$13,650
112	$114,854	$100,594	$93,128	$7,465
113	$54,814	$66,974	$62,292	$4,682
114	$77,060	$143,086	$65,161	$77,925
115	$164,057	$429,398	$69,910	$359,487
116	$172,272	$687,072	$56,604	$630,468
117	$122,346	$144,319	$67,227	$77,092
Total	$119,037,322	$11,644,144	$4,427,958	$7,216,186

Average annual remaining damages, costs and benefits by reach for Alternative 3.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$94,018	$33,678	$7,421	$26,256
2	$75,627	$40,007	$3,896	$36,111
3	$106,873	$29,997	$6,415	$23,582
4	$108,457	$50,410	$5,046	$45,364
5	$231,654	$28,324	$9,031	$19,293
6	$189,173	$79,267	$15,445	$63,822
7	$76,818	$32,771	$34,947	($2,176)
8	$31,771	$43,618	$37,272	$6,346
9	$51,059	$28,494	$33,684	($5,191)
10	$23,625	$17,640	$21,566	($3,926)
11	$41,261	$52,205	$27,740	$24,465
12	$45,449	$84,056	$44,794	$39,262
13	$97,663	$100,791	$59,803	$40,989
14	$83,478	$90,112	$45,923	$44,189
15	$217,020	$154,616	$52,966	$101,650
16	$20,699	$46,141	$30,644	$15,498
17	$22,113	$87,202	$42,097	$45,104
18	$1,969	$38,157	$46,567	($8,410)
19	$3,003	$39,585	$43,945	($4,360)
20	$5,038	$57,807	$55,479	$2,328
21	$703	$25,222	$27,340	($2,118)
22	$161,978	$8,387	$27,268	($18,881)
23	$0	$0	$14,919	($14,919)
24	$5,962	$1,088	$16,760	($15,672)
25	$33	$1,096	$20,991	($19,895)
26	$847	$394	$17,835	($17,440)
27	$2,279	$9,559	$38,430	($28,872)
28	$4,809	$6,628	$18,521	($11,893)
29	$347	$2,417	$10,460	($8,042)
30	$5,429	$17,846	$33,555	($15,709)
31	$0	$8,547	$37,295	($28,748)
32	$493	$11,990	$34,245	($22,255)
33	$0	$11,819	$45,425	($33,606)
34	$0	$7,076	$27,211	($20,135)
35	$1,925	$30,752	$49,808	($19,056)
36	$3,770	$8,457	$28,898	($20,441)
37	$49,837	$26,111	$45,199	($19,088)
38	$18,882	$23,548	$45,952	($22,404)
39	$28,706	$24,819	$33,014	($8,195)
40	$57,074	$132,502	$54,296	$78,205
41	$44,253	$29,573	$52,309	($22,736)
42	$7,565	$22,211	$37,053	($14,842)
43	$22,551	$101,102	$108,552	($7,450)
44	$18,288	$77,330	$80,774	($3,443)
45	$2,802	$104,537	$115,881	($11,345)
46	$9,177	$72,891	$68,203	$4,688
47	$17,955	$70,822	$66,068	$4,753
48	$8,615	$52,773	$64,720	($11,947)
49	$11,779	$56,981	$62,193	($5,212)
50	$8,283	$35,798	$45,959	($10,162)
51	$0	$9,083	$26,518	($17,435)
52	$941	$37,729	$90,752	($53,023)
53	$18	$50,068	$105,421	($55,353)
54	$1,030	$42,891	$26,870	$16,021
55	$2,590	$74,225	$66,393	$7,832
56	$0	$25,754	$63,119	($37,365)
57	$0	$8,899	$23,746	($14,847)
58	$0	$23,526	$64,803	($41,277)
59	$0	$38,881	$72,724	($33,844)

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$1,288	$27,167	$44,308	($17,141)
61	$18,934	$38,082	$48,695	($10,614)
62	$171,356	$501,674	$51,317	$450,357
63	$2,687	$48,896	$77,996	($29,101)
64	$4,005	$16,024	$22,290	($6,266)
65	$31,919	$30,526	$9,987	$20,539
66	$1,246	$50,843	$86,165	($35,321)
67	$121	$16,521	$29,279	($12,758)
68	$37,331	$35,298	$32,881	$2,417
69	$89,609	$89,482	$84,570	$4,912
70	$187,743	$225,242	$60,288	$164,954
71	$83,606	$90,731	$70,653	$20,079
72	$50,037	$75,222	$66,359	$8,863
73	$23,444	$34,324	$45,059	($10,735)
74	$238	$40,873	$77,272	($36,399)
75	$2,789	$22,084	$51,180	($29,096)
76	$15,133	$67,413	$19,994	$47,419
77	$9,432	$17,769	$55,834	($38,064)
78	$248,703	$831,794	$60,221	$771,573
79	$12,022	$149,086	$68,945	$80,141
80	$231,325	$127,075	$40,034	$87,041
81	$4,397	$50,098	$67,679	($17,581)
82	$3,146	$36,093	$59,740	($23,647)
83	$10,944	$182,229	$102,639	$79,591
84	$10,019	$146,768	$100,108	$46,661
85	$3,093	$102,237	$109,862	($7,626)
86	$26,819	$79,286	$120,185	($40,899)
87	$128,456	$317,947	$157,272	$160,675
88	$239	$43,167	$85,078	($41,911)
89	$197,332	$246,316	$64,588	$181,727
90	$3,159	$83,360	$73,059	$10,301
91	$13,676	$87,060	$83,960	$3,100
92	$556,842	$302,306	$141,739	$160,566
93	$371,757	$1,014,822	$85,327	$929,495
94	$56,709	$64,240	$66,205	($1,965)
95	$108,635	$49,026	$46,127	$2,899
96	$97,478	$42,464	$39,588	$2,875
97	$148,669	$59,131	$45,857	$13,275
98	$108,762	$59,440	$61,219	($1,778)
99	$81,323	$54,097	$36,404	$17,693
100	$85,146	$73,995	$46,518	$27,477
101	$68,959	$97,510	$59,949	$37,561
102	$67,339	$47,957	$43,196	$4,761
103	$143,668	$82,553	$48,369	$34,184
104	$90,781	$63,743	$43,097	$20,646
105	$47,202	$38,349	$36,458	$1,891
106	$95,168	$218,580	$18,660	$199,920
107	$40,872	$89,598	$33,991	$55,606
108	$60,997	$40,216	$38,696	$1,520
109	$51,531	$49,868	$44,798	$5,070
110	$56,703	$57,328	$48,947	$8,381
111	$119,996	$75,047	$63,901	$11,146
112	$117,111	$98,337	$108,915	($10,577)
113	$54,276	$67,511	$72,393	($4,881)
114	$76,990	$143,157	$74,654	$68,503
115	$162,387	$431,068	$79,666	$351,402
116	$169,418	$689,926	$63,697	$626,229
117	$123,004	$143,661	$74,591	$69,070
Total	$6,811,659	$10,492,828	$6,144,620	$4,348,208

Average annual remaining damages, costs and benefits by reach for Alternative 4.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)		Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$128,995	($1,299)	$872	($2,171)		60	$2,031	$26,424	$22,580	$3,843
2	$114,527	$1,107	$619	$488		61	$25,455	$31,561	$22,072	$9,488
3	$131,901	$4,969	$1,019	$3,950		62	$231,593	$441,437	$20,985	$420,452
4	$150,507	$8,359	$805	$7,554		63	$4,160	$47,423	$35,798	$11,625
5	$255,070	$4,908	$1,362	$3,546		64	$8,055	$11,973	$9,672	$2,302
6	$268,949	($508)	$1,162	($1,669)		65	$40,655	$21,791	$4,461	$17,330
7	$93,982	$15,607	$1,932	$13,674		66	$2,404	$49,686	$41,846	$7,841
8	$50,169	$25,221	$5,403	$19,817		67	$211	$16,431	$13,243	$3,188
9	$57,916	$21,636	$3,690	$17,946		68	$53,009	$19,621	$15,884	$3,736
10	$27,130	$14,134	$2,538	$11,597		69	$113,494	$65,598	$41,603	$23,994
11	$67,808	$25,658	$6,796	$18,862		70	$232,074	$180,912	$26,192	$154,720
12	$82,745	$46,760	$10,701	$36,059		71	$110,492	$63,846	$34,050	$29,796
13	$135,657	$62,797	$18,246	$44,551		72	$71,681	$53,578	$29,950	$23,628
14	$115,699	$57,892	$11,592	$46,300		73	$29,989	$27,779	$20,021	$7,758
15	$309,467	$62,169	$10,838	$51,330		74	$316	$40,795	$33,151	$7,645
16	$35,314	$31,526	$12,522	$19,004		75	$5,173	$19,700	$16,791	$2,909
17	$50,531	$58,784	$16,116	$42,668		76	$19,093	$63,453	$6,219	$57,234
18	$5,531	$34,594	$16,979	$17,616		77	$4,632	$22,570	$20,596	$1,974
19	$7,935	$34,653	$15,443	$19,211		78	$336,938	$743,560	$30,615	$712,945
20	$16,319	$46,526	$13,042	$33,484		79	$29,255	$131,853	$33,592	$98,261
21	$5,162	$20,764	$1,189	$19,575		80	$282,382	$76,018	$18,526	$57,491
22	$164,160	$6,205	$807	$5,398		81	$5,968	$48,527	$32,900	$15,628
23	$0	$0	$671	($671)		82	$5,094	$34,146	$28,963	$5,182
24	$4,854	$2,196	$370	$1,826		83	$17,707	$175,466	$53,801	$121,665
25	$658	$471	$601	($130)		84	$15,831	$140,956	$52,477	$88,479
26	$711	$530	$351	$179		85	$4,524	$100,806	$62,221	$38,585
27	$9,405	$2,432	$1,157	$1,275		86	$28,546	$77,559	$71,040	$6,519
28	$10,224	$1,213	$642	$571		87	$165,555	$280,848	$95,043	$185,805
29	$2,287	$478	$390	$88		88	$462	$42,944	$49,304	($6,360)
30	$7,698	$15,577	$3,884	$11,693		89	$216,501	$227,147	$37,376	$189,771
31	$1,360	$7,188	$3,816	$3,371		90	$4,931	$81,587	$45,337	$36,251
32	$2,050	$10,433	$3,950	$6,483		91	$18,216	$82,521	$54,305	$28,216
33	$2,201	$9,618	$4,278	$5,340		92	$589,873	$269,274	$87,901	$181,373
34	$1,228	$5,848	$3,017	$2,831		93	$447,564	$939,015	$44,812	$894,203
35	$4,522	$28,155	$6,700	$21,455		94	$75,704	$45,245	$30,267	$14,978
36	$6,381	$5,846	$2,716	$3,131		95	$134,215	$23,446	$16,628	$6,819
37	$60,629	$15,319	$5,262	$10,058		96	$119,237	$20,705	$13,264	$7,441
38	$27,850	$14,580	$4,519	$10,062		97	$184,198	$23,603	$13,657	$9,946
39	$33,234	$20,291	$3,386	$16,906		98	$129,904	$38,299	$24,627	$13,672
40	$72,020	$117,555	$6,203	$111,353		99	$111,514	$23,905	$16,317	$7,588
41	$53,012	$20,814	$5,849	$14,965		100	$117,262	$41,880	$21,343	$20,537
42	$10,598	$19,179	$5,536	$13,643		101	$92,153	$74,317	$26,418	$47,899
43	$44,076	$79,577	$46,300	$33,277		102	$85,792	$29,504	$20,477	$9,027
44	$33,971	$61,648	$38,781	$22,866		103	$187,229	$38,992	$22,205	$16,787
45	$9,293	$98,045	$64,646	$33,399		104	$121,543	$32,981	$16,217	$16,764
46	$20,104	$61,964	$34,024	$27,940		105	$64,220	$21,330	$14,295	$7,035
47	$33,206	$55,570	$31,580	$23,990		106	$155,912	$157,835	$6,688	$151,147
48	$16,945	$44,442	$30,642	$13,800		107	$60,837	$69,633	$12,355	$57,278
49	$23,277	$45,484	$27,881	$17,603		108	$78,147	$23,066	$16,752	$6,314
50	$16,254	$27,827	$19,186	$8,640		109	$67,201	$34,198	$22,690	$11,507
51	$0	$9,083	$10,172	($1,089)		110	$69,928	$44,102	$28,444	$15,658
52	$2,964	$35,706	$41,302	($5,596)		111	$121,696	$73,347	$45,049	$28,298
53	$18	$50,068	$55,050	($4,981)		112	$126,501	$88,947	$78,752	$10,195
54	$2,858	$41,063	$13,351	$27,712		113	$55,511	$66,276	$53,121	$13,155
55	$3,659	$73,156	$34,475	$38,681		114	$77,724	$142,422	$56,506	$85,916
56	$0	$25,754	$35,164	($9,410)		115	$178,864	$414,591	$61,187	$353,404
57	$0	$8,899	$11,203	($2,304)		116	$179,774	$679,570	$50,326	$629,244
58	$0	$23,526	$28,179	($4,653)		117	$125,759	$140,906	$60,787	$80,119
59	$7	$38,874	$34,806	$4,068		Total	$8,637,710	$8,666,776	$2,715,409	$5,951,367

Average annual remaining damages, costs and benefits by reach for Alternative 5.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$128,993	($1,297)	$872	($2,169)
2	$114,615	$1,019	$619	$400
3	$131,899	$4,972	$1,020	$3,952
4	$150,501	$8,365	$806	$7,560
5	$255,070	$4,908	$1,363	$3,545
6	$268,694	($253)	$1,170	($1,423)
7	$93,741	$15,848	$3,306	$12,542
8	$49,034	$26,356	$8,476	$17,880
9	$57,995	$21,557	$6,236	$15,321
10	$27,117	$14,147	$4,216	$9,931
11	$65,245	$28,221	$10,825	$17,395
12	$80,083	$49,422	$17,207	$32,215
13	$132,344	$66,110	$26,860	$39,251
14	$112,137	$61,453	$18,296	$43,157
15	$299,631	$72,004	$18,401	$53,603
16	$27,373	$39,467	$20,686	$18,780
17	$41,673	$67,641	$27,659	$39,982
18	$3,573	$36,553	$30,002	$6,551
19	$5,840	$36,748	$27,925	$8,824
20	$9,621	$53,223	$30,828	$22,396
21	$4,584	$21,342	$7,211	$14,130
22	$163,538	$6,828	$5,553	$1,275
23	$0	$0	$675	($675)
24	$4,856	$2,193	$421	$1,773
25	$658	$471	$647	($176)
26	$712	$528	$411	$117
27	$9,182	$2,655	$8,093	($5,437)
28	$10,225	$1,212	$668	$544
29	$2,287	$478	$402	$76
30	$6,209	$17,066	$15,115	$1,951
31	$635	$7,913	$16,174	($8,261)
32	$1,533	$10,950	$15,414	($4,464)
33	$891	$10,927	$19,167	($8,240)
34	$495	$6,581	$12,104	($5,523)
35	$2,994	$29,684	$23,501	$6,183
36	$5,747	$6,480	$12,191	($5,711)
37	$57,471	$18,477	$20,421	($1,944)
38	$25,177	$17,253	$19,691	($2,438)
39	$31,301	$22,225	$14,337	$7,888
40	$68,427	$121,148	$24,404	$96,744
41	$50,382	$23,444	$23,356	$88
42	$9,690	$20,086	$18,053	$2,033
43	$38,820	$84,833	$75,106	$9,728
44	$29,078	$66,540	$58,642	$7,898
45	$6,305	$101,033	$89,631	$11,402
46	$17,494	$64,574	$50,304	$14,270
47	$29,308	$59,469	$47,837	$11,631
48	$14,297	$47,090	$46,670	$420
49	$21,125	$47,635	$43,869	$3,767
50	$14,341	$29,740	$31,563	($1,823)
51	$0	$9,083	$17,655	($8,572)
52	$1,974	$36,696	$64,464	($27,768)
53	$18	$50,068	$77,904	($27,835)
54	$2,101	$41,820	$19,449	$22,372
55	$3,381	$73,433	$48,959	$24,474
56	$0	$25,754	$48,013	($22,259)
57	$0	$8,899	$16,831	($7,932)
58	$0	$23,526	$44,471	($20,946)
59	$0	$38,881	$51,231	($12,350)
60	$1,713	$26,742	$32,234	($5,491)
61	$22,620	$34,395	$33,349	$1,047
62	$193,521	$479,509	$33,410	$446,099
63	$2,975	$48,607	$53,823	($5,216)
64	$4,984	$15,045	$14,943	$102
65	$36,503	$25,943	$6,790	$19,153
66	$1,726	$50,364	$61,158	($10,794)
67	$133	$16,509	$20,033	($3,524)
68	$52,806	$19,824	$23,284	($3,460)
69	$101,716	$77,376	$60,422	$16,954
70	$210,989	$201,997	$40,441	$161,556
71	$96,709	$77,628	$49,981	$27,647
72	$56,973	$68,286	$45,382	$22,904
73	$26,257	$31,511	$30,567	$944
74	$243	$40,868	$53,189	($12,321)
75	$4,841	$20,032	$32,145	($12,113)
76	$18,335	$64,210	$12,334	$51,876
77	$4,615	$22,587	$36,447	($13,860)
78	$319,321	$761,176	$44,332	$716,844
79	$23,906	$137,202	$49,885	$87,317
80	$263,448	$94,951	$28,393	$66,558
81	$5,578	$48,917	$48,934	($17)
82	$4,724	$34,515	$43,162	($8,646)
83	$15,753	$177,421	$76,545	$100,876
84	$14,795	$141,993	$74,681	$67,312
85	$4,069	$101,261	$84,682	$16,579
86	$27,750	$78,355	$93,013	($14,658)
87	$161,494	$284,909	$122,962	$161,948
88	$261	$43,145	$65,340	($22,196)
89	$221,132	$222,515	$49,552	$172,963
90	$4,142	$82,376	$57,725	$24,651
91	$16,867	$83,869	$67,517	$16,352
92	$578,584	$280,563	$111,981	$168,582
93	$425,120	$961,459	$63,308	$898,151
94	$74,266	$46,683	$46,577	$106
95	$132,977	$24,684	$29,554	($4,870)
96	$119,310	$20,632	$24,740	($4,108)
97	$179,295	$28,506	$27,493	$1,012
98	$128,576	$39,627	$40,925	($1,298)
99	$109,005	$26,415	$25,397	$1,017
100	$115,223	$43,918	$32,756	$11,162
101	$91,530	$74,939	$41,508	$33,431
102	$85,322	$29,975	$30,824	($849)
103	$185,763	$40,458	$34,034	$6,424
104	$121,108	$33,415	$28,120	$5,295
105	$64,820	$20,730	$24,165	($3,434)
106	$135,019	$178,728	$11,940	$166,788
107	$58,428	$72,041	$21,895	$50,146
108	$77,981	$23,232	$26,665	($3,433)
109	$65,240	$36,158	$32,804	$3,354
110	$69,995	$44,035	$37,779	$6,256
111	$116,654	$78,389	$53,116	$25,274
112	$124,397	$91,050	$91,648	($597)
113	$54,858	$66,930	$61,397	$5,532
114	$77,377	$142,769	$64,350	$78,419
115	$170,170	$423,285	$69,123	$354,162
116	$175,964	$683,380	$55,982	$627,398
117	$125,055	$141,610	$66,465	$75,145
Total	$8,273,352	$9,031,134	$4,048,578	$4,982,556

Average annual remaining damages, costs and benefits by reach for Alternative 6.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$35,883	$91,813	$11,908	$79,905
2	$29,170	$86,464	$8,401	$78,063
3	$36,663	$100,207	$13,851	$86,356
4	$40,163	$118,703	$10,916	$107,787
5	$76,838	$183,140	$18,498	$164,642
6	$74,165	$194,276	$18,182	$176,094
7	$25,677	$83,912	$38,073	$45,839
8	$14,697	$60,692	$40,257	$20,435
9	$16,214	$63,339	$36,492	$26,846
10	$7,574	$33,691	$23,372	$10,319
11	$30,065	$63,401	$16,433	$46,968
12	$35,238	$94,267	$26,346	$67,922
13	$88,727	$109,728	$37,873	$71,854
14	$72,171	$101,419	$27,459	$73,960
15	$192,937	$178,699	$29,751	$148,947
16	$24,249	$42,591	$21,542	$21,048
17	$18,792	$90,523	$28,897	$61,625
18	$1,682	$38,444	$31,441	$7,003
19	$2,711	$39,877	$29,302	$10,575
20	$4,449	$58,396	$32,690	$25,706
21	$667	$25,259	$11,717	$13,542
22	$164,052	$6,313	$10,874	($4,561)
23	$0	$0	$9,047	($9,047)
24	$0	$7,049	$8,356	($1,306)
25	$7	$1,122	$11,013	($9,892)
26	$0	$1,241	$8,707	($7,466)
27	$553	$11,285	$15,443	($4,158)
28	$784	$10,653	$10,117	$536
29	$0	$2,765	$5,837	($3,073)
30	$2,486	$20,789	$16,172	$4,617
31	$0	$8,547	$17,364	($8,817)
32	$493	$11,990	$16,492	($4,502)
33	$0	$11,819	$20,655	($8,837)
34	$0	$7,076	$12,964	($5,888)
35	$1,067	$31,610	$25,029	$6,581
36	$4,141	$8,087	$13,130	($5,044)
37	$42,852	$33,097	$21,841	$11,256
38	$17,945	$24,484	$21,186	$3,298
39	$32,148	$21,377	$15,396	$5,981
40	$45,563	$144,012	$26,093	$117,919
41	$45,528	$28,298	$25,000	$3,298
42	$8,714	$21,062	$19,162	$1,900
43	$21,145	$102,509	$78,203	$24,306
44	$15,649	$79,970	$60,628	$19,342
45	$2,802	$104,537	$92,044	$12,493
46	$7,570	$74,498	$51,912	$22,586
47	$13,817	$74,959	$49,482	$25,477
48	$7,676	$53,711	$48,290	$5,422
49	$9,192	$59,568	$45,571	$13,997
50	$6,511	$37,570	$32,888	$4,682
51	$0	$9,083	$18,477	($9,394)
52	$941	$37,729	$66,830	($29,100)
53	$18	$50,068	$83,911	($33,842)
54	$932	$42,989	$21,046	$21,943
55	$1,814	$75,000	$52,756	$22,245
56	$0	$25,754	$51,361	($25,607)
57	$0	$8,899	$18,299	($9,400)
58	$0	$23,526	$48,764	($25,238)
59	$39	$38,841	$53,222	($14,381)

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$1,805	$26,650	$33,388	($6,737)
61	$19,398	$37,618	$34,739	$2,878
62	$165,083	$507,947	$34,918	$473,029
63	$3,715	$47,868	$56,001	($8,133)
64	$5,817	$14,211	$15,559	($1,347)
65	$27,534	$34,911	$7,083	$27,829
66	$1,686	$50,404	$63,469	($13,065)
67	$168	$16,474	$20,879	($4,405)
68	$50,990	$21,640	$24,158	($2,518)
69	$89,825	$89,266	$62,725	$26,542
70	$177,451	$235,535	$42,145	$193,389
71	$89,666	$84,672	$51,885	$32,787
72	$62,202	$63,057	$47,271	$15,786
73	$25,453	$32,315	$31,853	$461
74	$238	$40,873	$54,971	($14,097)
75	$2,049	$22,824	$33,471	($10,647)
76	$9,948	$72,597	$12,861	$59,736
77	$7,599	$19,602	$37,835	($18,232)
78	$181,196	$899,302	$45,496	$853,805
79	$10,815	$150,294	$51,283	$99,011
80	$230,912	$127,488	$29,247	$98,240
81	$4,547	$49,948	$50,301	($353)
82	$2,653	$36,587	$44,385	($7,798)
83	$8,729	$184,444	$78,499	$105,945
84	$7,448	$149,339	$76,574	$72,765
85	$2,627	$102,703	$86,630	$16,073
86	$28,351	$77,754	$94,939	($17,185)
87	$116,775	$329,628	$125,343	$204,286
88	$364	$43,042	$66,741	($23,699)
89	$184,343	$259,305	$50,615	$208,690
90	$3,866	$82,652	$58,839	$23,813
91	$13,384	$87,353	$68,602	$18,750
92	$665,282	$193,865	$114,117	$79,748
93	$284,497	$1,102,082	$72,959	$1,029,123
94	$29,854	$91,095	$55,560	$35,535
95	$49,325	$108,336	$37,487	$70,849
96	$46,342	$93,600	$31,881	$61,719
97	$78,336	$129,465	$36,389	$93,076
98	$55,365	$112,838	$50,436	$62,402
99	$35,004	$100,416	$30,454	$69,961
100	$37,751	$121,390	$39,076	$82,314
101	$34,833	$131,636	$50,005	$81,631
102	$31,893	$83,403	$36,390	$47,013
103	$65,371	$160,850	$40,608	$120,242
104	$37,815	$116,709	$35,181	$81,528
105	$20,245	$65,305	$29,963	$35,342
106	$59,011	$254,736	$15,163	$239,573
107	$22,298	$108,172	$27,664	$80,508
108	$28,669	$72,544	$32,242	$40,302
109	$22,205	$79,193	$38,112	$41,081
110	$25,628	$88,402	$42,493	$45,909
111	$127,321	$67,722	$54,073	$13,650
112	$114,854	$100,594	$93,128	$7,465
113	$54,814	$66,974	$62,292	$4,682
114	$77,060	$143,086	$65,161	$77,925
115	$164,057	$429,398	$69,910	$359,487
116	$172,272	$687,072	$56,604	$630,468
117	$122,346	$144,319	$67,227	$77,092
Total	$5,282,257	$12,022,230	$4,594,244	$7,427,985

Average annual remaining damages, costs and benefits by reach for Alternative 7.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$35,545	$92,151	$17,518	$74,633
2	$29,377	$86,257	$10,064	$76,193
3	$36,679	$100,192	$16,593	$83,599
4	$40,081	$118,785	$13,076	$105,710
5	$76,430	$183,548	$23,833	$159,715
6	$73,436	$195,005	$28,084	$166,920
7	$25,163	$84,426	$48,696	$35,730
8	$14,356	$61,034	$48,965	$12,069
9	$16,069	$63,483	$45,015	$18,468
10	$7,569	$33,696	$28,732	$4,964
11	$30,065	$63,401	$16,433	$46,968
12	$35,238	$94,267	$26,346	$67,922
13	$88,727	$109,728	$37,873	$71,854
14	$72,171	$101,419	$27,459	$73,960
15	$192,937	$178,699	$29,751	$148,947
16	$24,249	$42,591	$21,542	$21,048
17	$18,792	$90,523	$28,897	$61,625
18	$1,682	$38,444	$31,441	$7,003
19	$2,711	$39,877	$29,302	$10,575
20	$4,449	$58,396	$32,690	$25,706
21	$667	$25,259	$11,717	$13,542
22	$164,052	$6,313	$10,874	($4,561)
23	$0	$0	$9,047	($9,047)
24	$0	$7,049	$8,356	($1,306)
25	$7	$1,122	$11,013	($9,892)
26	$0	$1,241	$8,707	($7,466)
27	$553	$11,285	$15,443	($4,158)
28	$784	$10,653	$10,117	$536
29	$0	$2,765	$5,837	($3,073)
30	$2,486	$20,789	$16,172	$4,617
31	$0	$8,547	$17,364	($8,817)
32	$493	$11,990	$16,492	($4,502)
33	$0	$11,819	$20,655	($8,837)
34	$0	$7,076	$12,964	($5,888)
35	$1,067	$31,610	$25,029	$6,581
36	$4,141	$8,087	$13,130	($5,044)
37	$42,852	$33,097	$21,841	$11,256
38	$17,945	$24,484	$21,186	$3,298
39	$32,148	$21,377	$15,396	$5,981
40	$45,563	$144,012	$26,093	$117,919
41	$45,528	$28,298	$25,000	$3,298
42	$8,714	$21,062	$19,162	$1,900
43	$21,145	$102,509	$78,203	$24,306
44	$15,649	$79,970	$60,628	$19,342
45	$2,802	$104,537	$92,044	$12,493
46	$7,570	$74,498	$51,912	$22,586
47	$13,817	$74,959	$49,482	$25,477
48	$7,676	$53,711	$48,290	$5,422
49	$9,192	$59,568	$45,571	$13,997
50	$6,511	$37,570	$32,888	$4,682
51	$0	$9,083	$18,477	($9,394)
52	$941	$37,729	$66,830	($29,100)
53	$18	$50,068	$83,911	($33,842)
54	$932	$42,989	$21,046	$21,943
55	$1,814	$75,000	$52,756	$22,245
56	$0	$25,754	$51,361	($25,607)
57	$0	$8,899	$18,299	($9,400)
58	$0	$23,526	$48,764	($25,238)
59	$39	$38,841	$53,222	($14,381)

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$1,805	$26,650	$33,388	($6,737)
61	$19,398	$37,618	$34,739	$2,878
62	$165,083	$507,947	$34,918	$473,029
63	$3,715	$47,868	$56,001	($8,133)
64	$5,817	$14,211	$15,559	($1,347)
65	$27,534	$34,911	$7,083	$27,829
66	$1,686	$50,404	$63,469	($13,065)
67	$168	$16,474	$20,879	($4,405)
68	$50,990	$21,640	$24,158	($2,518)
69	$89,825	$89,266	$62,725	$26,542
70	$177,451	$235,535	$42,145	$193,389
71	$89,666	$84,672	$51,885	$32,787
72	$62,202	$63,057	$47,271	$15,786
73	$25,453	$32,315	$31,853	$461
74	$238	$40,873	$54,971	($14,097)
75	$2,049	$22,824	$33,471	($10,647)
76	$9,948	$72,597	$12,861	$59,736
77	$7,599	$19,602	$37,835	($18,232)
78	$181,196	$899,302	$45,496	$853,805
79	$10,815	$150,294	$51,283	$99,011
80	$230,912	$127,488	$29,247	$98,240
81	$4,547	$49,948	$50,301	($353)
82	$2,653	$36,587	$44,385	($7,798)
83	$8,729	$184,444	$78,499	$105,945
84	$7,448	$149,339	$76,574	$72,765
85	$2,627	$102,703	$86,630	$16,073
86	$28,351	$77,754	$94,939	($17,185)
87	$116,775	$329,628	$125,343	$204,286
88	$364	$43,042	$66,741	($23,699)
89	$184,343	$259,305	$50,615	$208,690
90	$3,866	$82,652	$58,839	$23,813
91	$13,384	$87,353	$68,602	$18,750
92	$665,282	$193,865	$114,117	$79,748
93	$251,709	$1,134,870	$82,648	$1,052,222
94	$24,973	$95,976	$64,244	$31,732
95	$45,123	$112,538	$44,716	$67,822
96	$41,658	$98,284	$38,321	$59,963
97	$70,667	$137,134	$44,411	$92,723
98	$49,651	$118,551	$59,311	$59,240
99	$33,558	$101,862	$35,255	$66,607
100	$36,730	$122,412	$45,124	$77,287
101	$31,943	$134,526	$58,132	$76,394
102	$28,502	$86,795	$41,866	$44,929
103	$58,630	$167,591	$46,903	$120,688
104	$37,303	$117,220	$41,757	$75,463
105	$19,737	$65,813	$35,335	$30,478
106	$52,830	$260,918	$18,094	$242,824
107	$20,746	$109,724	$32,929	$76,795
108	$25,838	$75,375	$37,525	$37,850
109	$20,919	$80,480	$43,384	$37,095
110	$24,100	$89,930	$47,378	$42,552
111	$127,321	$67,722	$54,073	$13,650
112	$114,854	$100,594	$93,128	$7,465
113	$54,814	$66,974	$62,292	$4,682
114	$77,060	$143,086	$65,161	$77,925
115	$164,057	$429,398	$69,910	$359,487
116	$172,272	$687,072	$56,604	$630,468
117	$122,346	$144,319	$67,227	$77,092
Total	$5,190,090	$12,114,396	$4,770,137	$7,344,259

Average annual remaining damages, costs and benefits by reach for Alternative 8.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$35,883	$91,813	$11,908	$79,905
2	$29,170	$86,464	$8,401	$78,063
3	$36,663	$100,207	$13,851	$86,356
4	$40,163	$118,703	$10,916	$107,787
5	$76,838	$183,140	$18,498	$164,642
6	$74,165	$194,276	$18,182	$176,094
7	$25,677	$83,912	$38,073	$45,839
8	$14,697	$60,692	$40,257	$20,435
9	$16,214	$63,339	$36,492	$26,846
10	$7,574	$33,691	$23,372	$10,319
11	$30,737	$62,729	$14,910	$47,819
12	$35,889	$93,616	$23,917	$69,699
13	$92,242	$106,212	$34,783	$71,429
14	$73,169	$100,422	$24,973	$75,449
15	$195,437	$176,199	$26,836	$149,363
16	$31,230	$35,610	$14,572	$21,038
17	$30,183	$79,132	$18,883	$60,249
18	$3,116	$37,010	$20,073	$16,937
19	$4,988	$37,600	$18,380	$19,220
20	$7,685	$55,160	$17,082	$38,077
21	$5,162	$20,764	$1,189	$19,575
22	$164,160	$6,205	$807	$5,398
23	$0	$0	$671	($671)
24	$4,854	$2,196	$370	$1,826
25	$658	$471	$601	($130)
26	$711	$530	$351	$179
27	$9,405	$2,432	$1,157	$1,275
28	$10,224	$1,213	$642	$571
29	$2,287	$478	$390	$88
30	$7,698	$15,577	$3,884	$11,693
31	$1,360	$7,188	$3,816	$3,371
32	$2,050	$10,433	$3,950	$6,483
33	$2,201	$9,618	$4,278	$5,340
34	$1,228	$5,848	$3,017	$2,831
35	$4,522	$28,155	$6,700	$21,455
36	$6,381	$5,846	$2,716	$3,131
37	$60,629	$15,319	$5,262	$10,058
38	$27,850	$14,580	$4,519	$10,062
39	$33,234	$20,291	$3,386	$16,906
40	$72,020	$117,555	$6,203	$111,353
41	$53,012	$20,814	$5,849	$14,965
42	$10,598	$19,179	$5,536	$13,643
43	$44,076	$79,577	$46,300	$33,277
44	$33,971	$61,648	$38,781	$22,866
45	$9,293	$98,045	$64,646	$33,399
46	$20,104	$61,964	$34,024	$27,940
47	$33,206	$55,570	$31,580	$23,990
48	$16,945	$44,442	$30,642	$13,800
49	$23,277	$45,484	$27,881	$17,603
50	$16,254	$27,827	$19,186	$8,640
51	$0	$9,083	$10,172	($1,089)
52	$2,964	$35,706	$41,302	($5,596)
53	$18	$50,068	$55,050	($4,981)
54	$2,858	$41,063	$13,351	$27,712
55	$3,659	$73,156	$34,475	$38,681
56	$0	$25,754	$35,164	($9,410)
57	$0	$8,899	$11,203	($2,304)
58	$0	$23,526	$28,179	($4,653)
59	$7	$38,874	$34,806	$4,068

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$2,031	$26,424	$22,580	$3,843
61	$25,455	$31,561	$22,072	$9,488
62	$231,593	$441,437	$20,985	$420,452
63	$4,160	$47,423	$35,798	$11,625
64	$8,055	$11,973	$9,672	$2,302
65	$40,655	$21,791	$4,461	$17,330
66	$2,404	$49,686	$41,846	$7,841
67	$211	$16,431	$13,243	$3,188
68	$53,009	$19,621	$15,884	$3,736
69	$113,494	$65,598	$41,603	$23,994
70	$232,074	$180,912	$26,192	$154,720
71	$110,492	$63,846	$34,050	$29,796
72	$71,681	$53,578	$29,950	$23,628
73	$29,989	$27,779	$20,021	$7,758
74	$316	$40,795	$33,151	$7,645
75	$5,173	$19,700	$16,791	$2,909
76	$19,093	$63,453	$6,219	$57,234
77	$4,632	$22,570	$20,596	$1,974
78	$336,938	$743,560	$30,615	$712,945
79	$29,255	$131,853	$33,592	$98,261
80	$282,382	$76,018	$18,526	$57,491
81	$5,968	$48,527	$32,900	$15,628
82	$5,094	$34,146	$28,963	$5,182
83	$17,707	$175,466	$53,801	$121,665
84	$15,831	$140,956	$52,477	$88,479
85	$4,524	$100,806	$62,221	$38,585
86	$28,546	$77,559	$71,040	$6,519
87	$165,555	$280,848	$95,043	$185,805
88	$462	$42,944	$49,304	($6,360)
89	$216,501	$227,147	$37,376	$189,771
90	$4,931	$81,587	$45,337	$36,251
91	$18,216	$82,521	$54,305	$28,216
92	$589,873	$269,274	$87,901	$181,373
93	$284,497	$1,102,082	$72,959	$1,029,123
94	$29,854	$91,095	$55,560	$35,535
95	$49,325	$108,336	$37,487	$70,849
96	$46,342	$93,600	$31,881	$61,719
97	$78,336	$129,465	$36,389	$93,076
98	$55,365	$112,838	$50,436	$62,402
99	$35,004	$100,416	$30,454	$69,961
100	$37,751	$121,390	$39,076	$82,314
101	$34,833	$131,636	$50,005	$81,631
102	$31,893	$83,403	$36,390	$47,013
103	$65,371	$160,850	$40,608	$120,242
104	$37,815	$116,709	$35,181	$81,528
105	$20,245	$65,305	$29,963	$35,342
106	$59,011	$254,736	$15,163	$239,573
107	$22,298	$108,172	$27,664	$80,508
108	$28,669	$72,544	$32,242	$40,302
109	$22,205	$79,193	$38,112	$41,081
110	$25,628	$88,402	$42,493	$45,909
111	$121,696	$73,347	$45,049	$28,298
112	$126,501	$88,947	$78,752	$10,195
113	$55,511	$66,276	$53,121	$13,155
114	$77,724	$142,422	$56,506	$85,916
115	$178,864	$414,591	$61,187	$353,404
116	$179,774	$679,570	$50,326	$629,244
117	$125,759	$140,906	$60,787	$80,119
Total	$6,055,161	$11,249,325	$3,332,701	$7,916,625

Average annual remaining damages, costs and benefits by reach for Alternative 9.

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
1	$65,325	$62,371	$310,983	($248,613)
2	$40,550	$75,084	$221,112	($146,028)
3	$71,876	$64,994	$454,277	($389,283)
4	$60,463	$98,404	$334,379	($235,975)
5	$115,210	$144,768	$553,494	($408,726)
6	$50,764	$217,676	$497,859	($280,182)
7	$20,537	$71,895	$396,005	($324,109)
8	$10,142	$41,292	$125,535	($84,242)
9	$11,887	$47,102	$336,043	($288,941)
10	$17,817	$10,080	$175,463	($165,383)
11	$39,677	$29,243	$364,906	($335,663)
12	$24,784	$65,216	$552,067	($486,851)
13	$38,843	$105,242	$572,609	($467,367)
14	$54,006	$78,602	$730,954	($652,351)
15	$84,673	$241,266	$767,302	($526,035)
16	$0	$48,539	$102,710	($54,171)
17	$0	$85,042	$269,614	($184,572)
18	$0	$13,685	$226,191	($212,506)
19	$0	$18,131	$321,340	($303,209)
20	$0	$36,401	$911,767	($875,366)
21	$12,214	$356	$721,068	($720,712)
22	$0	$166,937	$412,253	($245,315)
23	$0	$0	$854,336	($854,336)
24	$0	$7,049	$777,366	($770,317)
25	$0	$1,129	$910,533	($909,403)
26	$0	$1,241	$718,229	($716,989)
27	$0	$9,735	$913,571	($903,836)
28	$0	$11,437	$946,417	($934,980)
29	$0	$2,765	$613,180	($610,415)
30	$532	$18,923	$641,368	($622,445)
31	$416	$4,812	$750,469	($745,656)
32	$1,580	$8,717	$622,309	($613,593)
33	$483	$8,213	$1,013,920	($1,005,707)
34	$48	$5,586	$571,354	($565,767)
35	$297	$21,025	$943,621	($922,596)
36	$447	$11,250	$473,608	($462,357)
37	$712	$68,123	$892,437	($824,314)
38	$789	$38,091	$862,746	($824,655)
39	$16,386	$34,316	$231,526	($197,210)
40	$4,058	$177,163	$1,015,689	($838,526)
41	$3,039	$55,760	$950,525	($894,765)
42	$2,276	$15,276	$570,327	($555,051)
43	$6,573	$77,601	$1,125,275	($1,047,674)
44	$10,855	$52,883	$723,798	($670,915)
45	$6,412	$48,738	$909,898	($861,160)
46	$2,261	$51,837	$540,769	($488,932)
47	$6,023	$56,513	$460,313	($403,800)
48	$5,936	$29,917	$539,742	($509,825)
49	$2,923	$42,200	$580,541	($538,341)
50	$1,329	$26,290	$398,230	($371,940)
51	$0	$0	$0	$0
52	$0	$4,207	$576,556	($572,349)
53	$0	$7,714	$722,109	($714,395)
54	$0	$33,380	$81,826	($48,446)
55	$0	$50,202	$1,502,706	($1,452,504)
56	$0	$0	$0	$0
57	$0	$0	$0	$0
58	$0	$0	$0	$0
59	$559	$2	$0	$2

Reach	Total Damages (AA)	Total Benefits (AA)	Total Cost (AA)	Net Benefits (AA)
60	$548	$4,123	$89,985	($85,863)
61	$186	$31,623	$341,454	($309,831)
62	$275	$647,254	$779,096	($131,843)
63	$0	$11,527	$463,451	($451,924)
64	$73	$8,709	$243,880	($235,170)
65	$792	$56,555	$202,624	($146,069)
66	$454	$6,474	$47,703	($41,229)
67	$126	$1,523	$217,574	($216,051)
68	$288	$55,167	$348,929	($293,762)
69	$506	$136,094	$647,102	($511,008)
70	$2,129	$381,771	$701,731	($319,961)
71	$50	$139,088	$714,897	($575,808)
72	$649	$92,189	$679,432	($587,244)
73	$0	$35,853	$316,690	($280,837)
74	$642	$12,465	$603,650	($591,185)
75	$587	$7,718	$330,841	($323,123)
76	$27	$76,183	$313,466	($237,283)
77	$70	$8,196	$561,767	($553,571)
78	$6,464	$1,049,971	$449,300	$600,672
79	$14,901	$119,467	$679,599	($560,131)
80	$12,557	$330,551	$569,699	($239,148)
81	$8,093	$19,792	$426,932	($407,140)
82	$844	$14,959	$362,396	($347,437)
83	$0	$150,663	$706,874	($556,211)
84	$0	$115,311	$547,616	($432,305)
85	$5,331	$50,787	$654,207	($603,419)
86	$18,098	$37,161	$268,701	($231,540)
87	$139	$378,827	$197,717	$181,110
88	$0	$7,856	$117,831	($109,975)
89	$0	$415,324	$358,725	$56,599
90	$7,028	$46,039	$410,638	($364,600)
91	$203	$61,104	$476,454	($415,350)
92	$0	$794,196	$1,499,568	($705,372)
93	$0	$1,343,668	$602,909	$740,760
94	$8,971	$79,374	$856,317	($776,943)
95	$36,334	$100,007	$662,937	($562,930)
96	$32,933	$89,011	$624,249	($535,238)
97	$49,823	$137,966	$827,216	($689,250)
98	$38,420	$100,821	$708,015	($607,194)
99	$25,127	$92,523	$516,404	($423,881)
100	$44,758	$91,192	$644,392	($553,200)
101	$16,155	$121,067	$509,713	($388,646)
102	$19,944	$73,580	$1,155,033	($1,081,453)
103	$70,627	$131,477	$677,060	($545,582)
104	$51,218	$83,050	$461,739	($378,690)
105	$21,075	$47,139	$293,694	($246,555)
106	$51,286	$253,747	$145,715	$108,031
107	$115,324	($772)	$0	($772)
108	$28,190	$54,170	$445,819	($391,649)
109	$28,255	$50,288	$435,206	($384,918)
110	$30,359	$56,888	$453,437	($396,549)
111	$50,837	$103,863	$488,387	($384,524)
112	$99,193	$44,469	$54,151	($9,682)
113	$53,781	$19,654	$186,590	($166,936)
114	$167,373	$545	$0	$545
115	$537,540	($753)	$0	($753)
116	$813,632	($1,038)	$0	($1,038)
117	$210,779	($478)	$0	($478)
Total	$3,475,692	$11,080,401	$58,872,734	($47,792,333)

Average annual remaining damages, costs and benefits by reach for Alternative 10 (Non-Structural).

Summary of Interest During Construction, NED Plan, 3.5%

Interest During Construction					
Input Data			Monthly Interest Rate (i_m)		
Construction Period (months)		4	$i_m = 1 - (1 + i)^{1/12}$		0.287%
Total Construction Cost		$37,327,000			
Middle of Month Uniform Payments		$9,331,750			
Annual Interest Rate(i)		3.500%			
Interest During Construction ($\sum P_m [(1+i)^{n-1} - 1]$)				Total IDC	$161,051
n= # of periods in months	Pm = the mth monthly payment		i_m = monthly interest rate		
Month	Payment	Interest Factor	Interest		
1	$9,331,750	0.008637	$80,602		
2	$9,331,750	0.005750	$53,658		
3	$9,331,750	0.002871	$26,791		
4	$9,331,750	0.000000	$0		

NED Plan Dimensions

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

PUBLIC PARKING AND ACCESS MAPS

ATTACHMENT 4

ADDENDUM 1 AND ADDENDUM 2

Addendum 1, Section 4.0-Coastal Storm Damages Without Project and Table B-3

The affected structures in reaches15, 70, 78, 87, 89, 92, 93, 106, 114, and 116 can be described as mostly multilevel multifamily structures that are mainly “slab on grade” construction. Also, included in this inventory are larger, “slab on grade” hotels, and commercial entities, which include a “second row” post office and church and large fishing pier.

By reach, the structures of note are as follows:
-Reach 15: High density condominiums on Pebble Beach Rd and Queen Ct.
-Reach 70: High density condominium developments (Forest Dunes and Coral Shores), Clam Digger Inn
-Reach 78: High density condominium developments and Whaler Inn Beach Club
-Reach 87: High density condominium development
-Reach 89: High density condominium development (Ocean Sands), Windjammer Inn and Seahawk Inn and Villas
-Reach 92: High density condominium development (Coral Bay Club)
-Reach 93: Post office and Bogue Banks Baptist Church, both on “second row” of inventory
-Reach 106: High density condominium development (Dunes Club), Oceana Fishing Pier
-Reach 114: High density condominium development (A Place at The Beach, phases I-III)
-Reach 116: High density condominium development (A Place at The Beach, phases I-III and Tar Landing)

Addendum 2, 6.03-Combined Structural/Non-Structural Alternative Evaluation

Nonstructural measures considered were regulatory (building codes, construction setbacks and floodplain regulations) and physical modifications to reduce damages (removal). Most regulatory measures have already been implanted at the local level. These measures were considered as part of the existing and future without project conditions, and are an integral part of any alternatives considered.

Based on an initial screening, no action, non-structural (regulatory measures and removal), and beach fill structural measure were forwarded in the plan formulation process and considered for more detailed evaluation.

The Economics Appendix (Section 6.03) and the Main Report (Section 5.07.2) discuss only one non-structural alternative which was the removal of all first row structures, but that is because it was the only non-structural alternative that made

it through the screening process. This screening process is further described in section 5.05 of the Main Report.

Section 5.07.3 of the Main Report describes the 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. Generally, in a combined plan, the non-structural aspects would be implemented at the “ends” of a project or within stretches of beach the structural alternative is implemented.

The non-structural analysis showed 5 reaches that had positive net benefits – reaches 78, 89, 93, 106 and 114. However, these reaches are all separated from one another by a good distance, plus the net benefits from the structural plans at these reaches are even higher. Therefore, there was not a viable combined structural/non-structural alternative, and such a plan was screened from further consideration.

A combined structural/non-structural plan where specific reaches are implemented as non-structural would have 1000 foot sections where the dune and berms would not be constructed and/or maintained. These gaps are unsustainable and would eventually permit erosion and flanking of the adjacent structural area and reduce benefits there.

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX C

Geotechnical Engineering

US Army Corps of Engineers
Wilmington District

Appendix C: Geotechnical Analyses

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Attachments

Attachment 1 Final Report Geophysical Survey of Sediment Deposits Offshore Bogue Island Onslow Bay, North Carolina prepared by Ocean Survey, Inc.
Attachment 2 Boring logs with Lab Data

1.0 INTRODUCTION

The results of the geotechnical investigation for the Feasibility Report for the Bogue Banks Coastal Storm Damage Reduction Project are presented in this appendix. A number of sites were investigated for the determination of quality and an adequate quantity of material appropriate for borrow and placement of sand for storm damage reduction. This appendix presents the results of the geotechnical investigation and the compatibility analysis for the Bogue Banks Shore Protection Project for Emerald Isle, Indian Beach, Pine Knoll Shores, Atlantic Beach, and Fort Macon, Carteret County, North Carolina. A number of sites were investigated for the determination of quality and quantity of material appropriate for the placement of sand on Bogue Banks. The sites investigated in this study are present in Figure C-1, and include the Beaufort Inlet Ebb Tide Delta, Bogue Inlet, and various sites offshore of Bogue Banks.

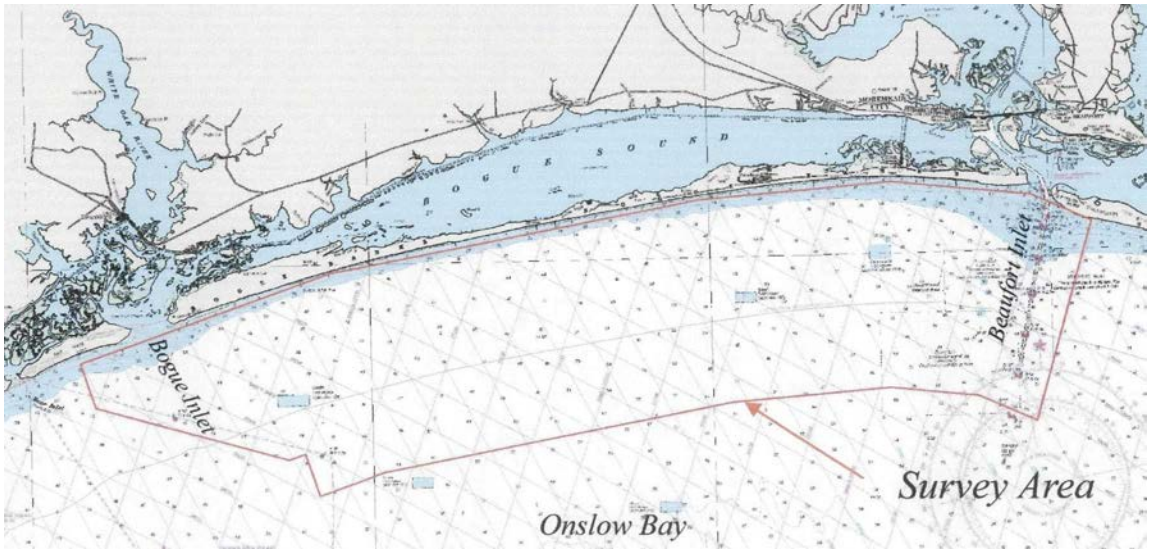

Figure C-1. Bogue Banks Site Map.

2.0 REGIONAL GEOLOGY

The study area encompasses Bogue Banks and nearshore Onslow Bay. Bogue Banks is a 25.4 miles long, south-facing barrier island located on the low-energy limb of the Cape Lookout foreland within Carteret County. The island is bound to the north by Bogue Sound, a relatively shallow water body through which the Atlantic Intracoastal Waterway passes. Present on Bogue Banks are beaches, dunes, and marshes, landforms typical of barrier island complexes. On the nearshore floor of Onslow Bay there are submarine scarps, shoals, and bars.

The Atlantic Coastal Plain and the inner continental shelf of Onslow Bay are both underlain by relatively flat-lying sedimentary units which gently dip and thicken to the southeast. This large sedimentary wedge includes both sediments, which have not been indurated or cemented and rock units. The deepest units were deposited during the Cretaceous Period, from 65 to 144 million years before present (ybp). The youngest

part of the wedge dates to the Quaternary Period, from 10,000 to 1.8 million ybp. This sediment and sedimentary rock wedge overlies pre-Mesozoic (older than 248 million years ago) crystalline basement rock (Horton and Zullo, 1991). A patchy veneer of Holocene (10,000 ybp to present) sand and gravel overlies the Quaternary strata in the project area.

Dynamic coastal processes have continually shape the barrier islands of southeastern North Carolina. The rivers and streams entering Onslow Bay are generally small with low gradients. Their continentally derived sediment loads are therefore not very large. In addition, much of this fluvial sediment becomes trapped within the river estuaries. This lack of significant sediment discharge into Onslow Bay limits the build-up of nearshore continental shelf sand deposits. In other areas along the Atlantic coast these nearshore deposits are an important source of sand. As in the case of Atlantic Beach, when deprived of this source of sand, seasonal storms and longshore currents can cause episodic severe shoreface erosion and migration (Cleary, 1968; Sarle, 1977; Riggs 1996).

3.0 SITE GEOLOGY

Bogue Banks (a Holocene age barrier island located in northern Onslow Bay) is bounded by Bogue Inlet to the west and Beaufort Inlet to the east and forms part of the southwest limb of the Cape Lookout cuspate forelands. This is a wave-dominated, microtidal (0.9 m tide range) shoreline. Although waves and storms represent the most significant coastal process affecting Holocene sedimentation (mean annual wave height is 1.7 m), the east-west orientation of Bogue Banks provides some shelter from the wave energy experienced along the northeast limb of Cape Lookout. Wide prominent beach ridges and extensive dune fields characterize the general morphology of Bogue Banks (Heron, et al, 1984).

Seaward of Bogue Banks, a complex Tertiary stratigraphic sequence crops out on much of the seafloor. On the inner shelf, close to the island, a relatively thin (less than ten feet) Pleistocene sequence unconformably overlies the Tertiary sediments. Numerous buried cut and fill stream channel structures occur within these units. The channels have been mostly in-filled with fluvial and estuarine sediments (mostly muds with some sand and shell) of mid-Pleistocene age. Generally, there is no evidence of Holocene barrier related sediment within these structures as they have been removed in response to the numerous sea-level fluctuations that have occurred during the Quaternary (Hine and Snyder, 1985).

Onslow Bay is a modern coastal embayment bordered by Cape Lookout to the north and by Cape Fear to the south. This embayment is underlain by sedimentary rock units that range in age from Upper Cretaceous through the Holocene and are associated with the Carolina Platform, a major tectonic component of the trailing-edge continental margin of North America (Snyder et al., 1982). Regional subsidence of this major structural ramp of pre-jurassic crust controlled lateral progradation of the coastal

margin. Seaward progradation of the continental shelf occurred primarily during the Tertiary via a succession of onlap and downlap acretional sequences at the shelf edge (Synder et al., 1982). The present outcrop pattern was produced by subsequent beveling in association with severe shoreface truncation during Neogene and Quaternary erosional transgressions (Synder et al., 1982; Popenoe, 1985).

The continental shelf in Onslow Bay consists of a relatively complex sequence of Tertiary strata, which crop out on the seafloor and dip gently seaward. These units are heavily dissected by relict fluvial channels and partially covered by a patchy veneer of Quaternary sands and gravels (Synder et al., 1988). Late Neogene to Quaternary mesa-like erosional remnants of indurated carbonates and calcareous sandstones (locally referred to as hard bottoms or live bottoms) also occur locally in the Onslow embayment (Riggs et al., 1985).

The oldest Tertiary rocks cropping out in Onslow Bay of Oligocene age. They are composed of two basic limestone units, the Belgrade and the Trent Formations, which consist of moldic biomicrudites limestones with interbedded calcarenite sands and grayish-green calcareous quartz sands (Riggs et al., 1985). A major unconformity separates these rocks from the overlying Miocene Pungo River Formation. Four regional unconformities subdivide the Pungo River formation into three major depositional sequences. Each of these sequences reflects deposition during sea-level cycles in excess of one million years duration. In turn, these stratigraphic sequences are comprised of at least sixteen smaller scales depositional sequences formed in response to sea-level cycles of 100,000 to 1 million-year duration (Riggs et al., 1985). All these depositional sequences are characterized by a lithology that grades upward from muddy, quartz sand or fine sandy and silty mud; to phosphatic, muddy quartz sand or muddy, sandy phosphorite, to cherty, dolosilty quartz sand, fossiliferous micrite, or shell hash. In general, the Miocene rocks that crop on the continental shelf in Onslow Bay; consist of interbedded phosphate sands, variably phosphatic silts and clays, diatomaceous clays, limestones, and dolomite (Snyder et al., 1988).

Patches of Pliocene and Quaternary sediments unconformably overlie the Miocene Pungo River Formation. The only Pliocene depositional record preserved on the inner-to-middle continental shelf of North Carolina is limited to a few calcarenite caprocks, which have become the seed for modern hard ground environments. In addition to this, and because of severe shoreface truncation Neogene and Quaternary erosional trangressions, the shelf stratigraphic record of multiple Quaternary glacioeustatic sea-level fluctuations is almost totally restricted to paleofluvial channel-fill sequences. These channels can be traced many miles; they are up to eighty feet in subsurface relief and up to six miles wide (Hine and Snyder, 1985). The channels in the inner shelf of Onslow Bay are lower coastal plain streams that were in-filled with estuarine and shelf fossiliferous muds and sands. Dates obtained from analyzing vibracore samples taken from these channels indicate that most of the infilling was completed during the mid-Pleistocene sea level transgressive flooding event (Belknap, 1982) and none of them have been associated with Holocene infilling.

4.0 SUBSURFACE INVESTIGATION

4.1 GEOPHYSICAL INVESTIGATION

Ocean Survey Inc. (OSI) performed a geophysical survey offshore of Bogue Banks. A search for suitable beach fill materials for this project was begun offshore in Onslow Bay. A marine geophysical investigation was conducted by OSI, January 8 to January 29, 2002, in order to locate and evaluate potential sand resource areas. Approximately 350 miles of bathymetric and subbottom data were collected along 40 tracklines. Five tracklines were shore-parallel and 35 tracklines were performed perpendicular to shore along with 5 diagonal tie lines to insure thorough coverage. For the trackline locations see Figure C-2.

Geophysical data was collected in the area between 1.0 nautical miles (30 foot isobath) to 6.0 nautical miles offshore of Bogue Banks. The site stretches nearly 24 nautical miles from Bogue Inlet to northeast of Beaufort Inlet. The survey limits were established to further resolve sand resource areas identified by earlier surveys.
Two types of sub-bottom methods were used: a “CHIRP Sonar” seismic reflection profiler, which generates a high frequency, short duration acoustic pulse providing high resolution of shallow sub-bottom strata; and a “Boomer” seismic reflection profiler which uses a low frequency pulse to achieve deeper penetration of the sub-bottom strata. These were run simultaneously to achieve the best possible resolution and penetration. Augmenting the seismic equipment was survey equipment that allowed real-time depth sounding, positioning, and motion (heave) corrections.

A differential global positioning system was used to determine position along the seismic lines. Equipment included a Trimble 4000 Global positioning System (GPS) and a Leica MX52R U.S. Coast Guard (USCG) Differential Beacon Receiver interfaced with HYPACK software. Navigation fixes were recorded by an onboard PC every second.

Bathymetric data was collected at a near continuous rate using an Innerspace Model 448 Digital Depth sounder, which operated at a frequency of 200 kHz. Tidal data from the NOAA station in Beaufort, North Carolina were used for tidal corrections.

The Contractor accomplished the high-resolution subbottom profiling utilizing an EdgeTech Xstar Full Spectrum “CHIRP” Subbottom Profiler system operating with frequencies of 0.5-12 kHz. The system has three components: a deck unit that is comprised of a PC system and amplifier, an underwater cable, and a Model 512 towed vehicle that houses the transducers. The tow fish vehicle emits a high frequency FM pulse over the full spectrum range of 0.5-12 kHz for a 20 millisecond period, and the acoustic return is received by a hydrophone array, which allows high resolution of the shallow subsurface. The higher frequency yields higher resolution with a tradeoff in lesser depth penetration.

Deeper sub-bottom penetration was accomplished using an Applied Acoustics 100-300 joule “boomer” system comprised of a boomer plate, power supply, hydrophone array,

TSS-model 360 filter and time-varied-gain system, and an EPC 1086 thermal paper recorder. The “boomer” employs a sound source that utilizes electrical energy discharged from a capacitor bank to rapidly move a metal plate in the transducer bed. The short duration motion of the metal plate creates a broad-band (500-8000 Hz) pressure wave capable of penetrating hundreds of feet of marine sediments under favorable site conditions.

The geophysical and bathymetric surveys showed that shallow rock scarps and outcrops dominate and control the submarine topography offshore of Bogue Banks. A surficial sand horizon was resolved. However, it is very discontinuous and broken by Oligocene rock outcrops. Erosion and reworking of this rock contributes coarse and fine-grained materials to the surficial sand. This decreases its aesthetic value as beach fill. The thickest sequence of unconsolidated sediment occurs in or adjacent to the paleochannels. These sediments tend to be dominated by estuarine muds and fine sands and thus unsuitable as beach fill. The borrow areas must generally be configured to avoid these channels.

OSI used the results of the geophysical survey to recommend boring locations. These locations were concentrated in areas that showed promise for use as borrow sources for sand. The boring locations were also sited in areas that may not contain sand suitable for use as beachfill to verify the interpretations from the geophysical survey.

Figure C-2. OSI Geophysical Tracklines.

4.2 VIBRACORE INVESTIGATION

The subsurface investigation was performed between April and July 2002. A total of 200 borings were performed in Bogue Inlet, offshore of Bogue Banks, Beaufort Inlet and the Bogue Sound area. The borings offshore of Bogue Banks were located between 1 and 6 miles from the beach, in water depths greater than 30 feet, and at changes in seismic profile which could represent differing soil types. The borings performed for the Bogue Banks Channel project is designated LB-02-V-1 through LB-02-V-200. For the vibracore boring locations see Figure C-3.

The borings were performed from the USACE Snagboat SNELL using a 3 7/8 inch diameter, 20-foot long, Alpine vibracore drill machine. The sampler consists of a metal barrel in which a plastic cylinder or tube is inserted. After the plastic tube was inserted, a metal shoe was screwed onto the plastic tube and then the metal barrel. The shoe provided a cutting edge for the sampler and retained the plastic tube. An air-powered vibrator was mounted at the upper-most end of the vibracore barrel, and the vibrator and the vibracore barrel was mounted to a stand. This stand was lowered to the ocean floor by the SNELL's crane; the vibrator was activated and vibrated the vibracore barrel into the ocean sediment. The sediment sample is retained in the plastic tube. All borings were drilled to a depth of 20 feet below the ocean floor, unless vibracore refusal was encountered. Vibracore refusal was defined as a penetration rate of less than 0.1 feet in 10 seconds.

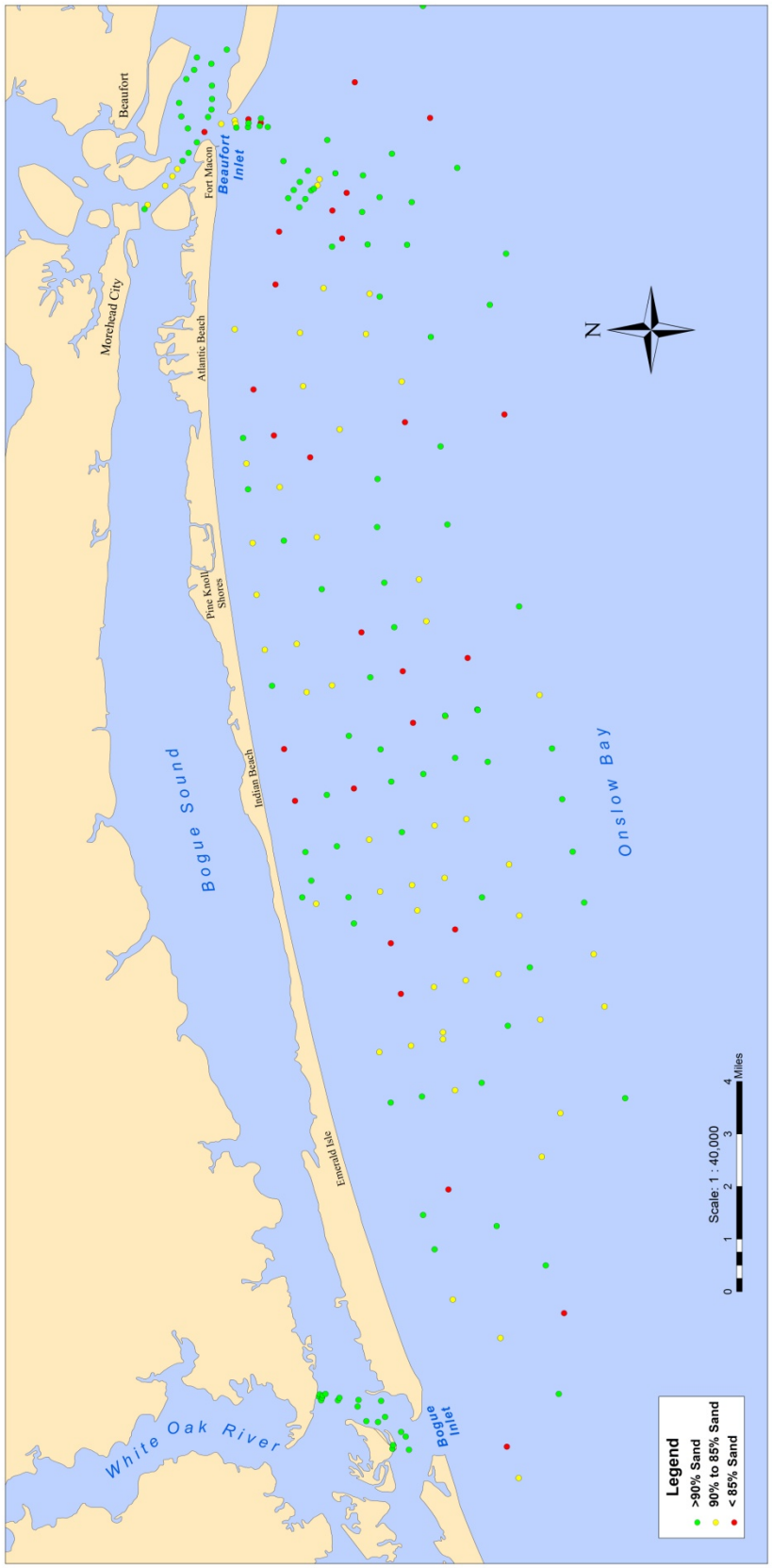

Figure C-3. Vibracore Boring Locations.

5.0 LABORATORY ANALYSIS

The recovered vibracore tubes were visually classified by Wilmington District personnel in accordance with the Unified Soils Classification System (USCS). Representative samples were taken at a minimum of every two feet or at each change of material. A total of 1400 samples were collected in the Bogue Banks area, of which 1369 samples were tested for this project. The grain size tests were performed in accordance with ASTM D-422 using a fifteen-sieve test and visual classifications were performed in accordance with ASTM D-2488, by Wolf Technologies, Inc. The sieves used in these tests were the 3/4, 3/8, #4, #7, #10, #14, #18, #25, #35, #45, #60, #80, #120, #170, and #200. The boring logs and the grain size test results are in Attachment 2.

6.0 NATIVE BEACH SAMPLING

The sampling locations consisted of a total of 25 transects, with 2 transects in Fort Macon, 5 transects in Atlantic Beach, 6 transects in Pine Knoll Shores, 2 transects in Indian Beach, 7 transects in Emerald Isle, and 3 transects in the Bogue Inlet area west of Emerald Isle. The sampling transects for Bogue Banks are presented in Figure C-4. The native beach was sampled in February, 2002. The sample locations are the toe of the dune, crest of the berm, mean high water (MHW) at an approximate elevation of +2.5 feet above mean sea level, mean low water (MLW) at an approximate elevation of -2.5 feet below MSL, and at 2-foot elevation increments from -2.0 feet below MSL to -24.0 feet below MSL as shown on Figure C-5. The samples were obtained with an ocean bottom grab sampler. The sieves used in the grain size testing were the 3/4”, 3/8”, #4, #7, #10, #14, #18, #25, #35, #45, #60, #80, #120, #170, and #200 sieves. The visual percent shell content of each sample was also determined.

Table C-1. Bogue Banks Native Beach Sampling Transect Coordinates.

Location	Grab Profile	2001 Station	Easting	Northing	Azimuth
Fort Macon	1	1019.94	2696659.50	352301.80	178.40
Fort Macon	2	4057.10	2693648.30	352128.90	176.10
Atlantic Beach	3	7048.38	2690763.10	352511.40	188.50
Atlantic Beach	4	11104.32	2686747.80	352878.60	184.60
Atlantic Beach	5	15125.70	2682742.30	353027.50	183.70
Atlantic Beach	6	20156.67	2677731.10	353015.20	181.70
Atlantic Beach	7	25178.11	2672728.60	352644.10	178.70
Pine Knoll Shores	8	30165.41	2667756.00	352529.50	175.80
Pine Knoll Shores	9	35207.09	2662729.70	352205.50	173.90
Pine Knoll Shores	10	40212.74	2657774.90	351517.50	173.30
Pine Knoll Shores	11	45209.95	2652859.20	350709.80	170.60
Pine Knoll Shores	12	50242.63	2647880.10	349992.10	171.00
Pine Knoll Shores	13	55247.85	2642927.40	349269.30	170.20
Indian Beach	14	60248.46	2638007.20	348388.50	170.20
Indian Beach	15	65251.23	2633113.80	347348.10	169.30
East Emerald Isle	16	70254.13	2628205.70	346384.90	168.80
East Emerald Isle	17	76295.50	2622268.00	345273.30	168.70
East Emerald Isle	18	82261.06	2616419.20	344102.30	167.40
West Emerald Isle	19	89262.34	2609535.80	342870.50	168.20
West Emerald Isle	20	96284.91	2602704.90	341242.10	166.40
West Emerald Isle	21	103359.23	2596043.40	338965.40	163.90
West Emerald Isle	22	110390.23	2589324.50	336992.00	164.10
Bogue Inlet Area	23	117403.30	2582665.30	334847.00	161.40
Bogue Inlet Area	24	123418.00	2576946.30	333040.50	159.70
Bogue Inlet Area	25	127403.67	2573233.50	331621.70	164.90

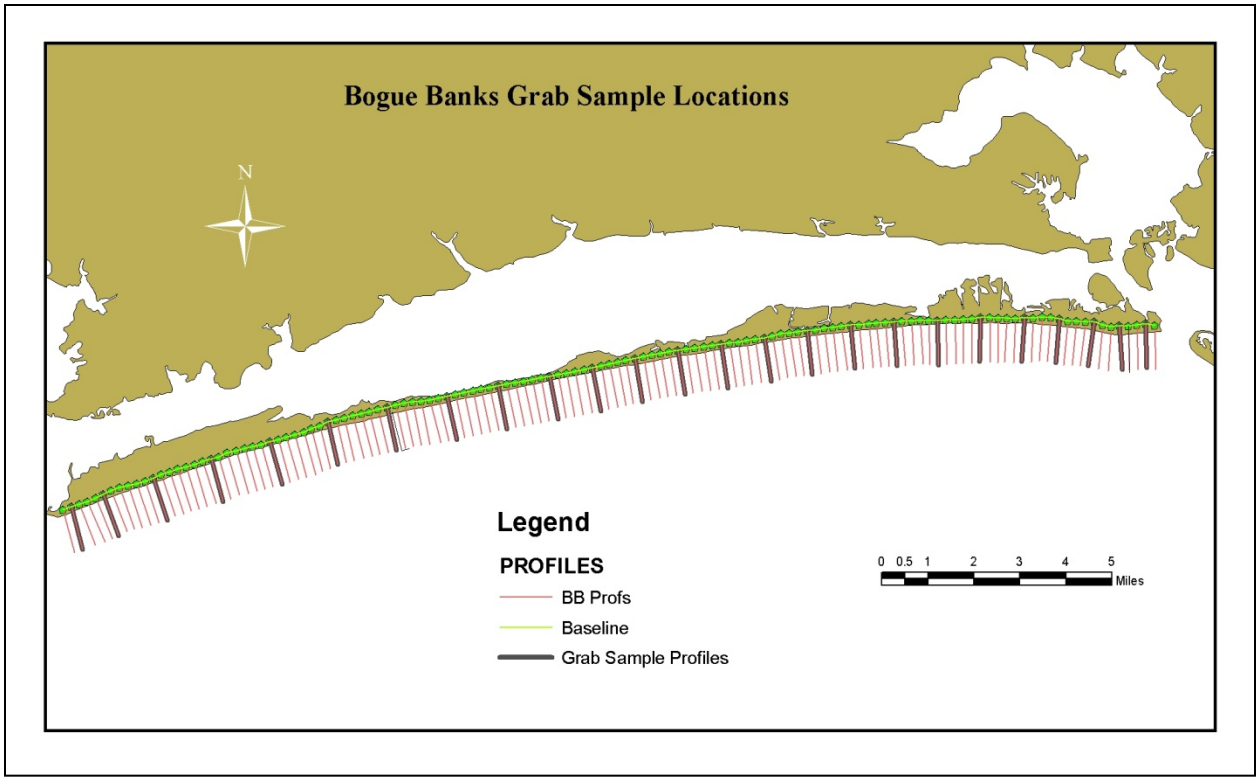

Figure C-4. Bogue Banks Native Beach Sampling Transects.

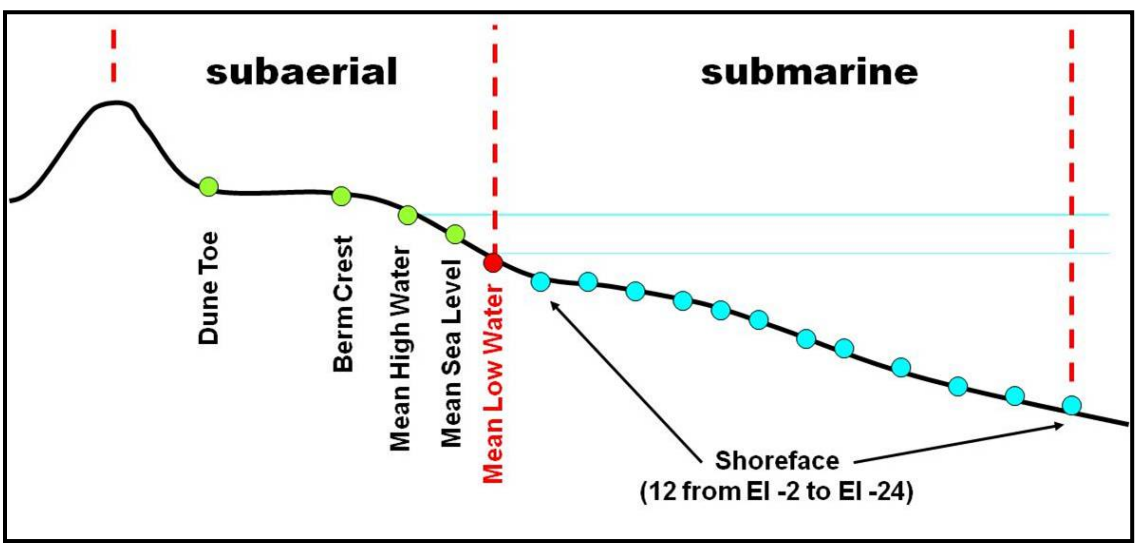

Figure C-5. Bogue Banks Beach Grab Sample Locations Along the Beach.

7.0 BORROW AREA SELECTION

The borrow sites for this project were selected through an iterative process to find the most economic and best quality material for use as borrow. After the completion of the vibracore borings, the usable sand thickness in each boring was estimated. The

thickness and location of the vibracore boring were plotted in the Bentley Microstation computer program. The program was then used to estimate contours of the approximated sand thickness over the entire area. For the sand thickness contours see Figure C-6.

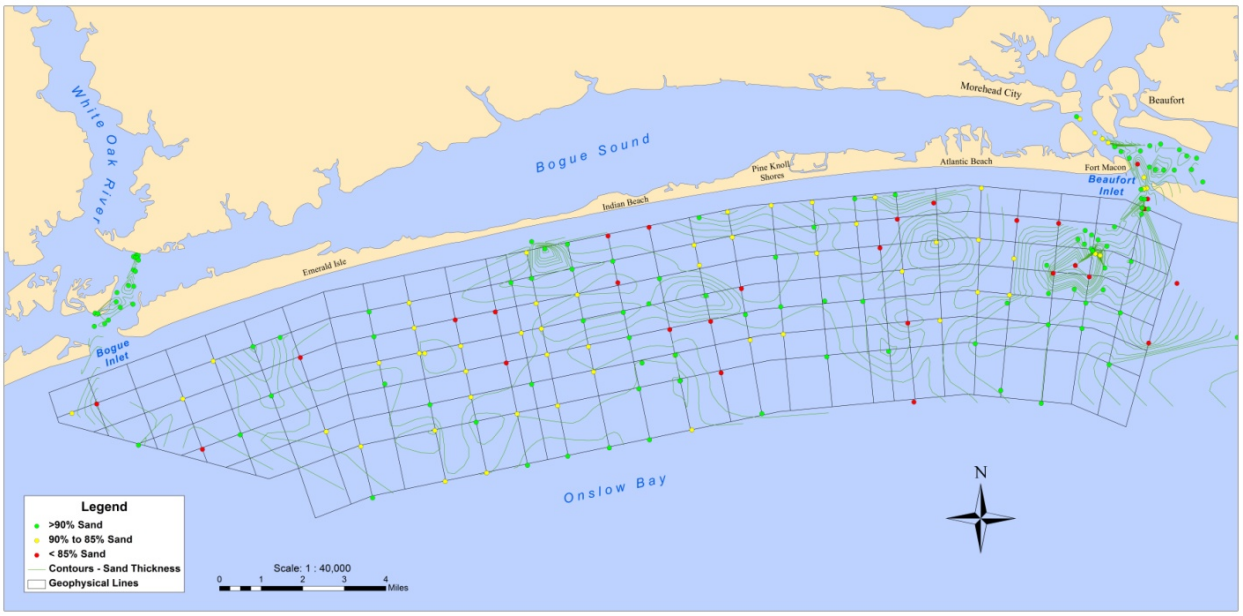

Figure C-6. Geophysical Tracklines and Boring Locations with Sand Thickness Contours.

The locations that appeared to contain a significant area and had usable depths of sand greater than 2 feet in thickness were identified. The preliminary areas identified for potential use for Bogue Banks Beach project borrow were Bogue Inlet, N, P, Q1, Q2, R, S, T, U, V, X, Y, Z, the Morehead City Harbor Channel, and Bogue Sound (see Figure C-7).

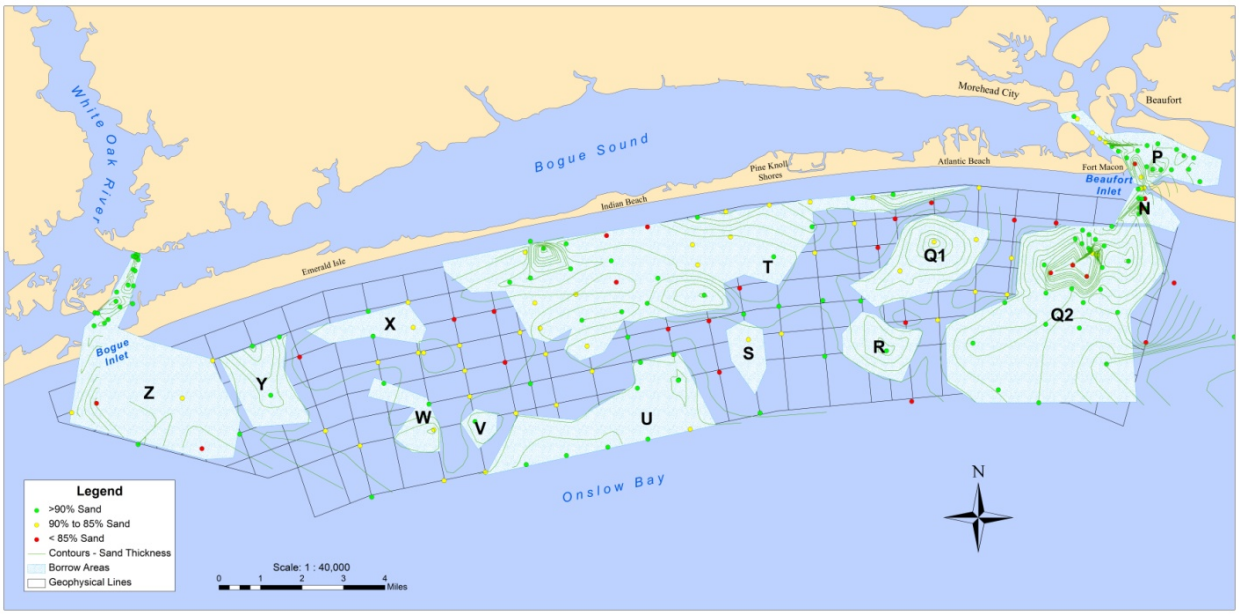

Figure C-7. Initial Proposed Borrow Areas.

Once the lab grain size testing of the vibracore samples was completed, the borrow areas were reassessed to determine the quality of the material in the proposed borrow areas. Some areas such as Area T contained too high a shell content and were eliminated. Other areas with higher silt content were also eliminated from consideration. Also, some other areas which no longer had a large enough quantity of suitable material to use for a full renourishment cycle were eliminated.

An assessment of environmental and archeological features of the remaining areas was performed. Area Q2 was greatly reduced due to the environmental features such as artificial reefs and archeological areas such as the Queen Anne's Revenge and other significant features along the ebb tide delta. Area Q2 was also reduced due to the exclusion of the Nearshore Placement Area.

A compatibility analysis was performed on the remaining potential borrow areas. The compatibility analysis is explained in the Compatibility Analysis section further below in this report. The potential borrow areas were again reduced if the material quality of the remaining material was not of beach quality. Area Q1 is one of these areas that after being reduced due to hardbottom and tire reefs, the remaining material volume and material quality was no longer as high as the remaining proposed borrow areas. The areas remaining as proposed borrow areas are Area Y, Area U, and the Morehead City Ocean Dredged Material Disposal Site (ODMDS) portion of Area Q2 (see Fig C-8).

Figure C-8. Selected Borrow Areas.

It should be noted that potential borrow areas eliminated at this time may not be unacceptable quality material for use as beach fill, they are just not as high a quality and as large a volume as selected areas. They may be reconsidered for use in the future is an increased volume of material is needed.

8.0 VOLUME CALCULATION

Bentley InRoads surface modeling software was used to develop surface models and estimate borrow volumes. Borehole data analysis resulted in a value for thickness of suitable material at each boring location. These material thickness values and their locations were input into InRoads for surface modeling. Bentley InRoads uses the Delaunay triangulation technique to interpolate data and create the surface models. Isopach lines were drawn to represent contours of material thickness. Initial borrow area limits were identified using a minimum estimate of 2 feet of usable material thickness. Other constraints such as locations of hardbottoms and cultural resources were applied to further refine the borrow limits. Final estimates of material volumes and surface areas were calculated using InRoads.

Due to the dredging process, it may not be practical to dredge the full depth of the borrow area. A vertical buffer of 1-foot was considered to accommodate the inaccuracies during dredging. The borrow area volumes were calculated for the full borrow depth and the borrow area with a 1-foot buffer. Based on previous experience with hopper dredges, the 1-foot buffer is reasonable to account for the dredging process. The 1-foot buffer was used to determine the quantities of borrow material available. The volumes of available material in each borrow area with the varying vertical buffers are shown in table C-2.

Table C-2. Bogue Banks Borrow Area Volumes.

Borrow Area	Volume (mcy)	
	No Buffer	1' Buffer
Borrow Area - Y	6.4	4.6
Borrow Area - U	14.4	8.9
Borrow Area - Q2	35.4	28.3

9.0 COMPATIBILITY ANALYSIS

A compatibility analysis involves the comparison of the grain size distribution characteristics of the material existing on the active profile of the native or reference beach and the material available from the proposed borrow area. The native beach and borrow sediments were analyzed using standard sieving techniques. Based on the size distributions of the two materials, estimates can be made of the amount of over-filling required to construct a given design beach profile.

Wave action tends to distribute the material across this active beach profile in discrete size increments. The active beach profile is that portion of the profile regularly affected by wave action and generally extends from the crest of the beach berm seaward to water depths of approximately 24 feet. Samples of the native beach material are collected at uniform depth intervals from the crest of the beach berm seaward to water depths of about 30 feet and the size characteristics of each sample determined by standard sieve analyses. The size characteristics of the individual samples are mathematically mixed to determine composite mean and composite standard deviation of the material that is on the active beach profile.

10.0 COMPATIBILITY REQUIREMENTS (CRITERIA)

The Wilmington District guideline with regard to the percentage of fine-grained sediments is that borrow areas containing more than 10 percent fines are generally considered to be incompatible for placement on the beach due to potential problems with turbidity and siltation during placement. Though the State of North Carolina has recently enacted sediment compatibility criteria, it is not a part of their Coastal Zone Management Program. Therefore, the Wilmington District will continue to follow the no more than 10 percent fines criteria for sediment compatibility.

11.0 NATIVE BEACH CALCULATIONS

The native beach composites were generated to reflect variations in sediment characteristics across the beach profile through varied energy zones, along the beach, at depths within the active profile. Surface samples were combined into one composite average grain-size distribution by summing the weights retained on each sieve interval and then dividing by the number of samples. The composite weight for a given size is:

$$w_{composite} = (w_{S1} + w_{S2} + w_{S3} + \ldots\ldots + w_{Sn})/n$$

where:

$w_{composite}$ = composite weight for a specific sieve
w_{Sn} = sediment weight retained on a specific sieve for each sample
n = number of samples

An analysis was performed with the grain size results of the samples taken to determine the native beach quality values. The values of key criteria was determined for the purpose of comparing potential sources of borrow material. The analysis determined the percent finer than then #4 sieve, the % finer than then #10 sieve, the percent finer than then #200 sieve, and the shell content.

12.0 OVERFILL RATIO

The suitability of the borrow material for placement on the beach is based on the overfill ratio. The overfill ratio is computed by numerically comparing the size distribution characteristics of the native beach sand with that in the borrow area and includes an adjustment for the percent of fines in the borrow area. The overfill ratio is primarily based on the assumption that the borrow material will undergo sorting and winnowing once exposed to waves and currents in the littoral zone, with the resulting sorted distribution approaching that of the native sand. Since borrow material will rarely match the native material exactly, the amount of borrow material needed to result in a net cubic yard of beach fill material will generally be greater than one cubic yard. The excess material needed to yield one net cubic yard of material in place on the beach profile is the overfill ratio. The overfill ratio is defined as the ratio of the volume of borrow material needed to yield one net cubic yard of fill material. For example, if 1.5 cubic yards of fill material is needed to yield one net yard in place, the overfill factor would equal 1.5.

The overfill criteria developed by James (1975) is the method used in the Automated Coastal Engineering System (ACES). The procedure is also described in the U.S. Army Coastal Engineering Manual EM-1110-2-1100 Part V (July 2003).

The overfill ratio for the Native or Reference Beach was compared to the borrow area material was calculated by the Aces Method. Based on the Aces Method, the overfill ratio for is varied between 1.05 and 1.41. Any overfill ratio value of less that 1.5 with a fine content of less than 10% is considered acceptable for use as beach renourishment. For the beach segments for the overfill ratios see Figure C-9. The overfill ratio for each borrow is shown in table C-3.

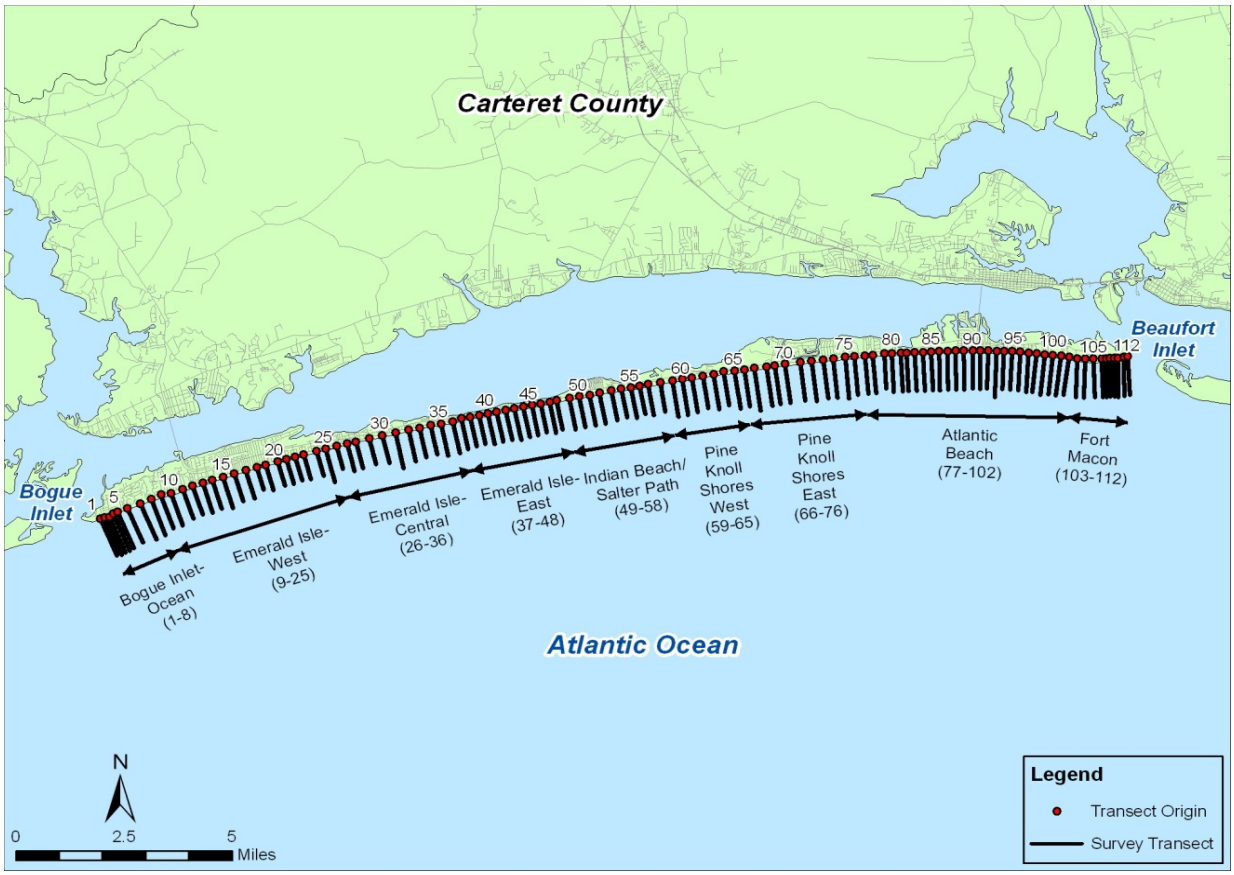

Figure C-9. Bogue Banks Beach Segments for Overfill Ratios.

Table C-3. Bogue Banks Overfill Ratios.

LOCATION	OVERFILL RATIO
Bogue Inlet - Ocean	1.10
Emerald Isle - West	1.05
Emerald Isle - Central	1.05
Emerald Isle - East	1.05
Indian Beach/Salter Path	1.05
Pine Knoll Shores - West	1.05
Pine Knoll Shores - East	1.11
Atlantic Beach	1.07
Fort Macon	1.41

NOTE: The overfill ratio is calculated using the James Method.

13.0 RESULTS

Based on the analysis of the overfill ratio and the grain size analysis borrow areas Q2 (ODMDS), U, and Y were selected as the source of borrow material. The percent passing the #200 sieve is less than 10 percent for all the proposed borrow areas. The grain size distributions for the native beaches and the borrow areas are shown in Table C-4. A total of 41.8 million cubic yards of material is available within the 3 proposed borrow areas. The volume of available material and the footprint area of each borrow area is shown in table C-5.

Table C-4. Bogue Banks Grain Size Comparison.

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

* % Passing #200 is comparable to % silt

Table C-5. Bogue Banks Borrow Area Footprint and Volumes.

Borrow Area	Borrow Depth (ft)			Footprint Area (acres)	Volume (mcy) 1' Buffer
	Min	Max	Avg		
Borrow Area - Y	2.2	7.6	4.4	1100	4.6
Borrow Area - U	1.4	4.0	2.8	3450	8.9
Borrow Area - Q2	3.1	8.1	5.3	4400	28.3

14.0 CONCLUSION

Based on the total estimated volume in the borrow areas, including the 1-foot vertical buffer, there is an adequate quantity of suitable beach quality material to complete the full 50-year life of the project. There is approximately 41.8 million cubic yards of suitable borrow material available in the 3 proposed borrow areas, Area Y, Area U, and Q2. These volumes do not include any recharge of these areas. Areas to be used for borrow will be further defined during the Preconstruction, Engineering, and Design phase of this project. Additional borings and/or geophysical surveys will be performed to better delineate the borrow area boundaries and material types.

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Attachment 1

Final Report Geophysical Survey of Sediment Deposits Offshore Bogue Island Onslow Bay, North Carolina prepared by Ocean Survey, Inc.

Attachment 2

Boring logs with Lab Data

Both Available Upon Request

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX D

Cost Engineering

US Army Corps of Engineers
Wilmington District

Appendix D: Cost Engineering

BOGUE BANKS BEACHES
Feasibility Report
Carteret County, North Carolina

1. The Cost Engineering Appendix project costs were prepared to describe the Current Working Estimate (CWE) for the National Economic Development (NED) Plan for the Bogue Banks Beaches, North Carolina – Feasibility Report.

The NED Plan is the alternative selected plan which has the greatest net benefits. The NED for Bogue Banks includes the beaches from Bogue Banks Inlet to Beaufort Inlet approximately 22.7 miles from Reaches 1 thru 117. The two essential features of the selected plan are the varying dune heights and a 50 foot design berm based on Alternative 9 as shown in main report Table 5.3 of all alternative comparisons evaluated.

Alternatives were evaluated using SBEACH and Beach-*fx* modeling. Coastal analysis and characterizing the physical characteristics of the shoreline was used for modeling with the Storm-induced Beach Change (SBEACH) model. The SBEACH model output of shoreline responses was 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. Costs plus a contingency from each borrow area were used in the model of alternatives.

The NED, Alternative 9, consists of sand dunes constructed to elevations ranging from 15 to 20 feet above the National Geodetic Vertical Datum (NGVD), fronted by a 50-foot wide beach berm (elevation of 5.5 or 7-ft).

Material for placement on the beach will come from three (3) offshore borrows areas (see Figure 1) located approximately 2.3 to 5.5 miles offshore from the beach (measurement is average distance from pumpout location to center of the borrow area). These borrow areas are labeled Y, U, and Q2. Quantities of borrow areas and depths are shown in Table 1. It was assumed Hopper dredges would be the most economical method (vs. cutterhead suction pipeline which would have very long pumping distances) to excavate material, travel to pump out stations, and pump material onto the beach.

The current borrow use plan involves placing material from Borrow Area Y on reaches 1-36, material from Borrow Area U on reaches 37-79, and material from the Q2 on reaches 80-117. There is sufficient material in the borrow areas to allow periodic nourishments to continue throughout the 50-year project life without each borrow area being depleted of material.

2. The TOTAL CURRENT WORKING ESTIMATE (CWE) for NED Initial Construction of beach nourishment is $29,495,000 October 2013 pricing ($36,574,000 with 24 percent contingency). Initial Construction will take 3.5 months for 2,451,000 cy. Hopper dredging will only be performed during the periods (seasons) December 15 thru March 31 during Initial construction because of environmental windows for turtles. The CWE for Initial Construction fully funded to midpoint of construction FEB 2020 is $33,341,000 ($41,343,000 with 24% contingency).

Future or subsequent Periodic Nourishments each are estimated to be 1,070,000 cy for each cycle at $10,960,000 OCT 2013 pricing ($14,029,000 with 28% contingencies). The periodic nourishment years occur every 3 years after completion of Initial Construction beginning year 2023 for 50 years until 2070. The periodic nourishments assume 1 season using 1-hopper medium class dredge. The CWE for Periodic Construction fully funded to midpoint of construction is $441,346,000 ($564,923,000 with 28% contingency).

All quantities are dredge volumes and not beach template quantities.

The CWE costs, for construction and non-construction items, were established to be the most likely Baseline Cost Estimate at October 2013 price levels.

3. Baseline most likely CWE's are shown in the attached MCACES (Microcomputer Aided Cost Engineering System) summary sheets. The summary sheets are formatted into a Code of Accounts framework for reporting. The costs included under each Code of Accounts are described below.

The Cost Estimates were prepared under guidance given in the Corps of Engineers Regulation ER 1110-2-1302, CIVIL WORKS COST ENGINEERING; ER 1110-1-300, Cost Engineering Policy and General Requirements; and ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works.

4. CODE OF ACCOUNTS

CODE OF ACCOUNT 01 – LANDS AND DAMAGES: The detail estimated costs were prepared and furnished by the Real Estate Division, Savannah District as discussed in the Real Estate Appendix H. Contingencies were developed during the formal Cost Schedule Risk Analysis and resulted in 24% contingency.

CODE OF ACCOUNT 17 – BEACH REPLENISHMENT: This account includes project costs for mobilization and demobilization, dredging, beach fill shaping, beach tilling, dune vegetation, and dune walkover structures.

Emphasis was placed on accuracy of dredging costs during evaluation of alternative plans to develop the NED Plan. The location and features of borrow areas in relation to the project, as well as historical production of dredges for similar projects, were used in conjunction with the Corps of Engineers Dredge Estimating Program (CEDEP).

CEDEP considers details of borrow area characteristics, depth of borrow, effective production time, distances from borrow sites, costs of dredge plant ownership, operating and repair, fuel consumption/prices, and other economic adjustments for labor and equipment at OCT 2013 price levels.

a. For Initial Construction it was determined two(2) medium class size hopper dredges would be used to place sand on the beach from pump out locations about 3,000 to 3,500 feet from the shoreline. The average travel distance 1-way to the pump out stations from the 3 borrow areas varies from 2.3 miles to 5.5 miles on average. The one way distance depends on which project segment is receiving beach sand.

The initial construction time for placement of sand on project is estimated to be 3.5 months (dependent on medium to large Hoppers) for 2.45 million cubic yards (borrow area quantity) based on using 2 hopper dredges throughout the environmental window. The environmental window for hopper dredges is December 15 through March 31 or about 3.5 months for a season.

Additional time for mob/demob and pipe set up on the beach needs to be added for each seasonal contract. Mobilization is typically estimated at approximately 30 days prior to beginning initial placement and 30 days demobilization of pipe and equipment off the beach, as well as beach tilling, dune vegetation and new wooden walkover structures.

Two hoppers were considered to be typical of past project equipment availability that would be used for construction. Although Pipeline suction cutterhead dredges were considered, pipeline lengths from the borrow areas and beach were not considered as economical as the use of hopper dredges. However, the solicitation for construction will not limit the type of equipment to construct the project.

b. For Periodic Nourishments it was determined that one hopper dredge with pump out would continue to be the most suitable method to place sand on the beach. This was based on the same overall borrow proximity to the beach. Pump out stations located approximately 3,000 to 3,500 feet from shore were assumed.

The Periodic Nourishment construction time for placement of sand on project is estimated to be 3 months for 1.07 million cubic yards (borrow area quantity) based on using 1 hopper dredge throughout the environmental windows. The environmental window for hopper dredges during periodic nourishment is January 1 through March 31 or about 3 months for a season.

Beach fill placement costs are included as part of the hopper dredging unit price. Beach fill consists of shaping the dredged material with dozers to the required cross section while the dredge is pumping material onto the beach.

c. The costs for Beach Tilling were based on historical costs for similar projects. The costs for Dune Vegetation were based on historical pricing and discussions with North Carolina extension services. The price for Dune Walkover Structures was based on

detailed cost estimates used for similar structures and historical costs on similar projects. There will be no Dune vegetation or walkover structures for periodic nourishments.

d. For Initial and Periodic nourishments, a contingency of 24% and 28%, respectively, were included to represent unanticipated conditions and uncertainties not known at the time the estimate was developed. There is a better than average level of confidence in the dredge pricing, because of the detailed geotechnical investigations of borrows areas, similarities of other beach nourishment projects, and the historical costs for similar projects. A contingency of 24% for Initial construction & 28% contingency for Periodic nourishments were developed in a detailed Cost Schedule and Risk Analysis (CSRA) through the Cost Center of Expertise in Walla Walla, Washington.

CODE OF ACCOUNT 30 – PLANNING, ENGINEERING AND DESIGN: The costs included in this account were furnished by those responsible for performing each activity. This account includes plans and specifications, field investigations and surveys, cost estimates, engineering during construction, environmental monitoring, and project management. A 24% Initial & 28% periodic contingency assigned to ACCOUNT 30.

CODE OF ACCOUNT 31 – CONSTRUCTION MANAGEMENT – This account includes supervision and administration of the contracts by construction management, hydrologic surveys during construction, environmental/coastal monitoring after construction, and contracting personnel during construction. A 24% Initial & 28% Periodic contingency was assigned to ACCOUNT 31.

Figure 1. Vicinity map, including potential offshore borrow locations (Y,U, and Q2).

Borrow Area	Depth (ft)			Footprint (acres)	Volume (cy)
	Min	Max	Avg		
Y	2.2	7.6	4.4	1,100	6,400,000
U	1.4	4.0	2.8	3,600	14,400,000
Q2	3.1	8.1	5.3	4,400	35,900,000

Table 1. Depth, area, and volume of material at each of the three borrow sites.

The plan has a main fill length of 119,670 ft, starting 1,000 ft 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 main fill are shown in Table 2 below. The constructed dune feature dimensions listed are inclusive of the existing dune.

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 2. Main beachfill dimensions. A “x” indicates that a federally maintained dune feature is not part of the selected plan in those reaches.

Example 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 (mlw).

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.

Table 3 shows the current project schedule following authorization 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
Project Authorization (WRDA)	Dec 2014
Sign PPA	Dec 2017
Complete Real Estate Acquisition	Sept 2019
Complete Final Plans and Specs	Sept 2019
Award Construction Contract	Nov 2019
Begin Initial Construction	Dec 2019
Complete Initial Construction	Mar 2020
Begin First Renourishment	Dec 2022
Complete First Renourishment	Mar 2023

Table 3. Project schedule following authorization.

Bogue-INITIAL_LS_OCT_1_2013--FEB-2014
BOGUE BEACHES - FEASIBILITY REPORT - CURRENT WORKING ESTIMATE (CWE)

Estimated by	CESAW-TS-EE
Designed by	USACE - WILMINGTON DISTRICT
Prepared by	John C. Caldwell
Preparation Date	2/7/2014
Effective Date of Pricing	10/1/2013
Estimated Construction Time	110 Days

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1a Real Estate Analy/Docs 2
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B DREDGING - HOPPER 2
C DUNE PLANTINGS 2
D TILLING 2
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2a Beach Surveys 2
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1 Supervision and Administration 2
1a Supervn and Adminstn 2
31_27 --Monitoring - pipeline route, Dredge, Nest Monitoring, Compaction Assessment 2
2 Construction Monitoring 2
2a Construction Monitoring 2

Date	Author	Note
6/22/2012	CESAW-TS-EE	New Project Note - SEE APPNDIX D NARRATIVE FOR OVERALL DESCRIPTION OF PROJECT SPECIFICS.

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Project Cost Summary Report			**29,495,000**	**0**	**29,495,000**
01 --LANDS and DAMAGES - REAL ESTATE -	**1**	**LS**	**3,517,000**	**0**	**3,517,000**
17 --BEACH REPLENISHMENT -	**1**	**LS**	**24,068,000**	**0**	**24,068,000**
30 --PLANNING, ENGINEERING & DESIGN -	**1**	**LS**	**1,600,000**	**0**	**1,600,000**
31 --S&A-CONST MGT & MONITORING -	**1**	**LS**	**310,000**	**0**	**310,000**

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Contract Cost Summary Report			**29,495,000**	**0**	**29,495,000**
01 --LANDS and DAMAGES - REAL ESTATE -	**1.00**	**LS**	**3,517,000**	**0**	**3,517,000**
01_01 --Real Estate Analysis Documents	**1.00**	**LS**	**3,517,000**	**0**	**3,517,000**
1 Real Estate Analysis Documents	**1.00**	**LS**	**3,517,000**	**0**	**3,517,000**
1a Real Estate Analy/Docs	**1.00**	**LS**	**3,517,000**	**0**	**3,517,000**
17 --BEACH REPLENISHMENT -	**1.00**	**LS**	**24,068,000**	**0**	**24,068,000**
17_02 --BEACH NOURISHMENT - PLANTINGS - WALKOVERS	**1.00**	**LS**	**24,068,000**	**0**	**24,068,000**
1 BOGUE BANKS	**1.00**	**LS**	**24,068,000**	**0**	**24,068,000**
A MOB & DEMOB	**1.00**	**LS**	**1,600,000**	**0**	**1,600,000**
B DREDGING - HOPPER	**1.00**	**LS**	**18,384,000**	**0**	**18,384,000**
C DUNE PLANTINGS	**1.00**	**LS**	**3,825,000**	**0**	**3,825,000**
D TILLING	**1.00**	**LS**	**84,000**	**0**	**84,000**
E WALKOVERS	**1.00**	**LS**	**175,000**	**0**	**175,000**
30 --PLANNING, ENGINEERING & DESIGN -	**1.00**	**LS**	**1,600,000**	**0**	**1,600,000**
30_23 --Construction Contracts Documnts	**1.00**	**LS**	**1,600,000**	**0**	**1,600,000**
1 Plans and Specifications (P&S)	**1.00**	**LS**	**1,150,000**	**0**	**1,150,000**
1a P & S Documents	**1.00**	**LS**	**1,150,000**	**0**	**1,150,000**
2 Beach Surveys	**1.00**	**LS**	**450,000**	**0**	**450,000**
2a Beach Surveys	**1.00**	**LS**	**450,000**	**0**	**450,000**
31 --S&A-CONST MGT & MONITORING -	**1.00**	**LS**	**310,000**	**0**	**310,000**
31_12 --Construction Contracts	**1.00**	**LS**	**220,000**	**0**	**220,000**
1 Supervision and Administration	**1.00**	**LS**	**220,000**	**0**	**220,000**
1a Supervn and Adminstn	**1.00**	**LS**	**220,000**	**0**	**220,000**
31_27 --Monitoring - pipeline route, Dredge, Nest Monitoring, Compaction Assessment	**1.00**	**LS**	**90,000**	**0**	**90,000**
2 Construction Monitoring	**1.00**	**LS**	**90,000**	**0**	**90,000**
2a Construction Monitoring	**1.00**	**LS**	**90,000**	**0**	**90,000**

Bogue-PERIODIC LS_OCT_1_2013 Price Level --FEB_2014
BOGUE BEACHES - FEASIBILITY REPORT - CURRENT WORKING ESTIMATE (CWE)

Estimated by	CESAW-TS-DE
Designed by	USACE - WILMINGTON DISTRICT
Prepared by	John C. Caldwell
Preparation Date	2/7/2014
Effective Date of Pricing	10/1/2013
Estimated Construction Time	90 Days

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Date	Author	Note
6/22/2012	CESAW-TS-EE	New Project Note - SEE APPENDIX D NARRATIVE -FEBRUARY 2014 FOR OVERALL DESCRIPTION OF PROJECT SPECIFICS.

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Project Cost Summary Report			**10,959,861**	**0**	**10,959,861**
17 --BEACH REPLENISHMENT - Periodic Nourishment -	**1**	**LS**	**9,209,861**	**0**	**9,209,861**
30 --PLANNING, ENGINEERING & DESIGN -	**1**	**LS**	**1,000,000**	**0**	**1,000,000**
31 --S&A-CONST MGT & MONITORING -	**1**	**LS**	**750,000**	**0**	**750,000**

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Contract Cost Summary Report			**10,959,861**	**0**	**10,959,861**
17 --BEACH REPLENISHMENT - Periodic Nourishment - - - - - - - - - - - - - - - - - - -	**1.00**	**LS**	**9,209,861**	**0**	**9,209,861**
17_02 --BEACH NOURISHMENT	**1.00**	**LS**	**9,209,861**	**0**	**9,209,861**
1 BOGUE BANKS	**1.00**	**LS**	**9,209,861**	**0**	**9,209,861**
MOB & DEMOB	**1.00**	**LS**	**950,000**	**0**	**950,000**
DREDGING - HOPPER	**1.00**	**LS**	**8,175,861**	**0**	**8,175,861**
TILLING	**1.00**	**LS**	**84,000**	**0**	**84,000**
30 --PLANNING, ENGINEERING & DESIGN -	**1.00**	**LS**	**1,000,000**	**0**	**1,000,000**
30_23 --Construction Contracts Documnts	**1.00**	**LS**	**1,000,000**	**0**	**1,000,000**
1 Plans and Specifications (P&S)	**1.00**	**LS**	**1,000,000**	**0**	**1,000,000**
1a P & S Documents	**1.00**	**LS**	**1,000,000**	**0**	**1,000,000**
31 --S&A-CONST MGT & MONITORING -	**1.00**	**LS**	**750,000**	**0**	**750,000**
31_12 --Construction Contracts	**1.00**	**LS**	**220,000**	**0**	**220,000**
1 Supervision and Administration	**1.00**	**LS**	**220,000**	**0**	**220,000**
1a Supervn and Adminstn	**1.00**	**LS**	**220,000**	**0**	**220,000**
31_27 --Monitoring - pipeline route, Dredge, Nest Monitoring, Compaction Assessment	**1.00**	**LS**	**80,000**	**0**	**80,000**
2 Construction Monitoring	**1.00**	**LS**	**80,000**	**0**	**80,000**
2a Construction Monitoring	**1.00**	**LS**	**80,000**	**0**	**80,000**
31_27 --Beach Survey Monitoring by Coastal Eng	**1.00**	**LS**	**450,000**	**0**	**450,000**
2 Beach Survey Monitoring by Coastal Eng	**1.00**	**LS**	**450,000**	**0**	**450,000**
2a Beach Survey Monitoring by Coastal Eng	**1.00**	**LS**	**450,000**	**0**	**450,000**

Bogue-PERIODIC-TOTALS LS_OCT_1_2013--FEB_2014
BOGUE BEACHES - FEASIBILITY REPORT - CURRENT WORKING ESTIMATE (CWE)

Estimated by	CESAW-TS-DE
Designed by	USACE - WILMINGTON DISTRICT
Prepared by	John C. Caldwell
Preparation Date	2/13/2014
Effective Date of Pricing	10/1/2013
Estimated Construction Time	90 Days

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Date	Author	Note
6/22/2012	CESAW-TS-EE	New Project Note - SEE APPENDIX D NARRATIVE -FEBRUARY 2014 FOR OVERALL DESCRIPTION OF PROJECT SPECIFICS.

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Project Cost Summary Report			**175,357,776**	**0**	**175,357,776**
Periodic Nourishment 2023	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2026	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2029	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2032	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2035	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2038	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2041	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2044	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2047	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2050	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2053	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2056	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2059	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2062	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2065	**1**	**LS**	**10,959,861**	**0**	**10,959,861**
Periodic Nourishment 2068	**1**	**LS**	**10,959,861**	**0**	**10,959,861**

US Army Corps
of Engineers®

BOGUE BANKS, CARTERET COUNTY, NORTH CAROLINA COASTAL STORM DAMAGE REDUCTION FEASABILITY REPORT RISK ANALYSIS

Prepared by:
U.S. Army Corps of Engineers,
Wilmington District

Supported by:
U.S. Army Corps of Engineer
Walla Walla Cost MCX

Date: June 21, 2013

Updated: February 5, 2014

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APPENDIX A Detailed Risk Register

Report Purpose

February 5, 2014 UPDATE: The June 2013 cost estimate was updated to OCT 2013 costs and the revisions were negligible mostly due to a reduction in fuel price from $3.50/gallon to $3.35/gallon off-road diesel fuel. Therefore the CSRA was virtually unchanged except for revisions to first cost of OCT 2014 (FY-15) and fully funded costs.

The US Army Corps of Engineers (USACE), Wilmington District, presents this cost and schedule risk analysis (CSRA) report for the Bogue Banks Coastal Storm Damage Reduction Feasibility Report. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on the first cost as well as the periodic renourishment costs of the project. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion.

Project Scope

The project area includes approximately a 25 mile long barrier island on North Carolina's central coasts in Carteret County. The plan calls for an initial placement of then a periodic renourishment every three years for (16 total). Material for the project comes from several offshore borrows locations.

Risk Analysis Results

A Cost and Schedule Risk Analysis (CSRA) update was performed on June 21 2013 on this project to identify the 80% confidence level contingencies for the initial construction and renourishments. The study was performed on the Federal NED plan. The contingencies considered both cost and schedule with the schedule risk being converted to an additional cost risk. The risks for the initial construction were reexamined and adjusted based on the reduced quantities for a renourishment. The midpoint of the 50 year renourishment period was utilized to analysis time sensitive risks. The results are that the examination of the of the risks for the first cost result in a 24% contingency at the 80% confidence level and the renourishments risk result in a slightly higher 28% contingency at the 80% level. These contingencies are applied to the remaining project activities such as Lands and Damages, Design and Construction Management as applicable. The following results were observed based on the MCACES Cost Estimate:

Construction Results	Contingency Amount ($k)	Contingency %
Initial Construction	$6,918	24%
Periodic Renourishments	$49,101	28%

High Risk Items

The following were high risk items affecting cost. The complete risk register and analysis can be viewed in Appendix A.

- Market Conditions

Discussion: Dredging is a highly competitive industry and there are limited windows when dredging can be performed in this area. The PDT has planned (and currently has adequate time in the project schedule) to advertise the project early in order to ensure the largest number of potential bidders. This represents an opportunity to reduce costs on the initial construction but may not be as likely to be recognized on the renourishments.

- Dredge number and size

Discussion: The choice of dredge size can affect efficiency and productivity, causing a difference between the government estimate and the bid price of the contract. The estimate assumed two medium-sized hopper dredges will be utilized, but the actual equipment is not restrictive within the proposed contract. A large hopper dredge could result in greater efficiency as compared to two smaller hoppers, but are less available and may be impacted by speed restrictions and may cause variations in the bid pricing.

Contract Modifications/Claims:

Discussion- Contract modifications are always a risk in dredging. This work has proscriptive work windows and any environmental impacts in the region could potentially stop or delay the work that season resulting in remobilization costs.

- Other risks- Fuel, Quantities, and Borrow assumptions

Discussion- With dredging work the price of fuel is a significant cost and is usually a high risk factor along with the quantities and borrow assumptions. Overall this is a relatively straightforward project and many of the risks are typical of similar projects.

Mitigation Recommendations

A positive outcome of the CSRA was a thorough discussion of the risks and their mitigation measures. PDT members worked through each risk item and how the risks would affect the overall project. Most could not be mitigated such as adverse weather and funding issues

Major recommendations are as follows for high risk items:

- Modifications/Claims during Project Construction Execution – Research into specific risk events which cause modification or claim during previous construction periods. Identify potential risk mitigation efforts from results.

- For the periodic renourishments, the quantities of remaining borrow should be evaluated each year to ensure that the necessary materials are available as the project progresses.

Total Project Cost Summary

The following tables portray the first cost of the initial construction and the 16 periodic renourishments features based on the anticipated contracts. The costs are intended to address the necessary costs at authorization of the project. Costs are in thousands of dollars. The contingency is based on an 80% confidence level, as per USACE Civil Works guidance. The most likely cost of the project INITIAL NOURISHMENT at OCT 2013 price levels is $29,495,000 and $36,574,000 with 24% contingency. Project First Costs are in FY15 dollars are summarized below.

Table 1 - Project First Cost Summary

		FIRST COSTS			FULLY FUNDED COSTS		
ACCT	DESCRIPTION	COST ($k)	CONTG ($k)	TOTALS ($k)	COST ($k)	CONTG ($k)	TOTALS ($k)
1	Lands & Damages	$3,586	$861	$4,446	$3,830	$919	$4,749
17	Beach Replenishment	$24,537	$5,889	$30,426	$27,088	$6,501	$33,589
Construction Costs		**$28,123**	**$6,750**	**$34,872**	**$30,918**	**$7,420**	**$38,338**
30	Planning, Engineering & Design**	$1,659	$398	$2,057	$2,023	$486	$2,509
31	Supervision & Administration**	$321	$77	$398	$400	$96	$496
	Summary 30 & 31 Account	**$1,980**	**$475**	**$2,455**	**$2,423**	**$582**	**$3,005**
	Total	**$30,103**	**$7,225**	**$37,327**	**$33,341**	**$8,002**	**$41,343**

The most likely cost of the project Periodic Nourishments at OCT 2013 price levels is $175,360,000 and $224,461,000 with 28% contingency. Project First Costs are in FY15 dollars are summarized below.

Table2 - Project Renourishment Cost Summary (16 renourishments)

		Renourishment First Cost			RENORISHMENT FULLY FUNDED COST		
ACCT	DESCRIPTION	COST ($k)	CONTG ($k)	TOTALS ($k)	COST ($k)	CONTG ($k)	TOTALS ($k)
17	Beach Replenishment	$150,233	$42,065	$192,299	$277,182	$77,611	$354,794
Construction Costs							
30	Planning, Engineering & Design**	$16,585	$4,644	$21,229	$93,286	$26,120	$119,406
31	Supervision & Administration**	$12,439	$3,483	$15,922	$70,878	$19,846	$90,724
	Total O&M Cost	**$179,258**	**$50,192**	**$229,450**	**$441,346**	**$123,577**	**$564,923**

PURPOSE/BACKGROUND

The US Army Corps of Engineers (USACE), Wilmington District, presents this cost and schedule risk analysis (CSRA) report for the Bogue Banks Coastal Storm Damage Reduction Feasibility Report. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on the costs to implement the selected alternative. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion

REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for both the first cost and the renourishments risks for all project features. The project schedule was examined and schedule risks for the initial construction are only considered as the schedule risks for the long term renourishments are primarily limited by the funding received and are beyond the team to influence. The schedule risk for the initial construction is generally minor and is converted to costs and added to the cost risk model. It is assumed that after the initial construction is complete that the project would receive the necessary funding to renourish the beach segments. The study and presentation can include or exclude consideration for operation and maintenance or life cycle costs, depending upon the program or decision document intended for funding.

Project Scope

Major Project Features studied from the civil works work breakdown structure (CWWBS) for this project includes:

01 – Lands & Damages

17 – Beach Replenishment

30 - Planning, Engineering & Design

31 - Construction Management

USACE Risk Analysis Process

The risk analysis process follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Directory of Expertise for Civil Works (Cost Engineering MCX). The risk analysis process reflected within the risk analysis report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. The risk analysis results are intended to serve several functions, one being the establishment of reasonable contingencies reflective of an 80 percent confidence level to successfully accomplish the project work within that established contingency amount. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted. The risk study utilizes the MCACES cost estimate amount for all features then applies the resultant percentage of risk/contingency to the project first and fully funded costs.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analyses should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting, and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, the risk analysis is performed to meet the requirements and recommendations of the following documents and sources:

- ER 1110-2-1150, Engineering and Design for Civil Works Projects.
- ER 1110-2-1302, Civil Works Cost Engineering.
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works.
- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Memorandum from Major General Don T. Riley (U.S. Army Director of Civil Works), dated July 3, 2007.
- Engineering and Construction Bulletin issued by James C. Dalton, P.E. (Chief, Engineering and Construction, Directorate of Civil Works), dated September 10, 2007.

METHODOLOGY/PROCESS

The initial CSRA meeting was held via teleconference on May 01 2013 for the purposes of identifying and assessing risk factors. Participants include the following PDT members:

Mike Jacobs, NWW – Cost DX

Pamela Castens, SAW – Project Mgt

John Caldwell, SAW – Cost Engineering

Jeffrey Lin, SAW - Planning

Christopher Graham, SAW - Economics

Eric Gasch, SAW - Environmental

Kevin Conner, SAW – Coastal Engineering

Belinda Eastbrook, SAS – Real Estate

Ben Lackey, SAW – Geotechnical Engineering

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. A parallel process is also used to determine the probability of various project schedule duration outcomes and quantify the required schedule contingency (float) needed in the schedule to achieve any desired level of schedule confidence.

In simple terms, contingency is an amount added to an estimate (cost or schedule) to allow for items, conditions, or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project

leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Engineering MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk adverse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. Because Crystal Ball is an Excel add-in, the schedules for each option are recreated in an Excel format from their native format. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results would be provided in section 6.

Identify and Assess Risk Factors

Identifying the risk factors via the PDT are considered a qualitative process that results in establishing a risk register that serves as the document for the further study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT is obtained using creative processes such as brainstorming or other facilitated risk assessment meetings. In practice, a combination of professional judgment from the PDT and empirical data from similar projects is desirable and is considered.

The initial formal meeting focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Discussions focused primarily on risk factor assessment and quantification.

Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans are analyzed using a combination of professional judgment, empirical data, and analytical techniques. Risk factor impacts are quantified using probability distributions (density functions), because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involves multiple project team disciplines and functions. However, the quantification process relies more extensively on collaboration between cost engineering, designers, and risk analysis team members with lesser inputs from other functions and disciplines.

The following is an example of the PDT quantifying risk factor impacts by using an iterative, consensus-building approach to estimate the elements of each risk factor:

- Maximum possible value for the risk factor.
- Minimum possible value for the risk factor.

- Most likely value (the statistical mode), if applicable.
- Nature of the probability density function used to approximate risk factor uncertainty.
- Mathematical correlations between risk factors.
- Affected cost estimate and schedule elements.

Risk discussions focused on the various project features as presented within the USACE Civil Works Work Breakdown Structure for cost accounting purposes. It was recognized that the various features carry differing degrees of risk as related to cost, schedule, design complexity, and design progress.

The resulting product from the PDT discussions is captured within a risk register as presented in Appendix A, for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions are meant to support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the base cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

For schedule contingency analysis, the option schedule contingency is calculated as the difference between the P80 option duration forecast and the base schedule duration. These contingencies are then used to calculate the time value of money impact of project delays that are included in the presentation of total cost contingency in section 6. The resulting time value of money, or added risk escalation, is then added into the contingency amount to reflect the USACE standard for presenting the "total project cost" for the fully funded project amount.

Schedule contingency is analyzed only on the basis of each option and not allocated to specific tasks. Based on Cost Engineering MCX guidance, only critical path and near critical path tasks are considered to be uncertain for the purposes of contingency analysis.

KEY CONSIDERATIONS AND ASSUMPTIONS

Key assumptions include the following:

- Adequate Borrow currently exists for the project in the three well defined borrow areas.
- Life Cycle costs have not been included in this cost estimate.
- Contract acquisition strategy will be full and open.

- The initial contract will be awarded earlier than other competing dredging contracts for the winter work window.

RISK ANALYSIS RESULTS

Risk Register

Risk is unforeseen or unknown factors that can affect a project's cost or schedule. Time and money have a direct relationship due to the time value of money. A risk register is a tool commonly used in project planning and risk analysis and serves as the basis for the risk studies and Crystal Ball risk models. The risk register describes risks in terms of cost and schedule. A summary risk register that includes typical risk events studied (high and moderate levels) is presented in this section. The risk register reflects the results of risk factor identification and assessment, risk factor quantification, and contingency analysis. A more detailed risk register is provided in Appendix A. The detailed risk registers of Appendix A include low level and unrated risks, as well as additional information regarding the specific nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing and communicating identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting risk analysis feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

A correlation is a dependency that exists between two risks and may be direct or indirect. An indirect correlation is one in which large values of one risk are associated with small values of the other. Indirect correlations have correlation coefficients between 0 and -1. A direct correlation is one in which large values of one risk are associated with large values of the other. Direct correlations have correlation coefficients between 0 and 1. Correlations were not identified in this analysis.

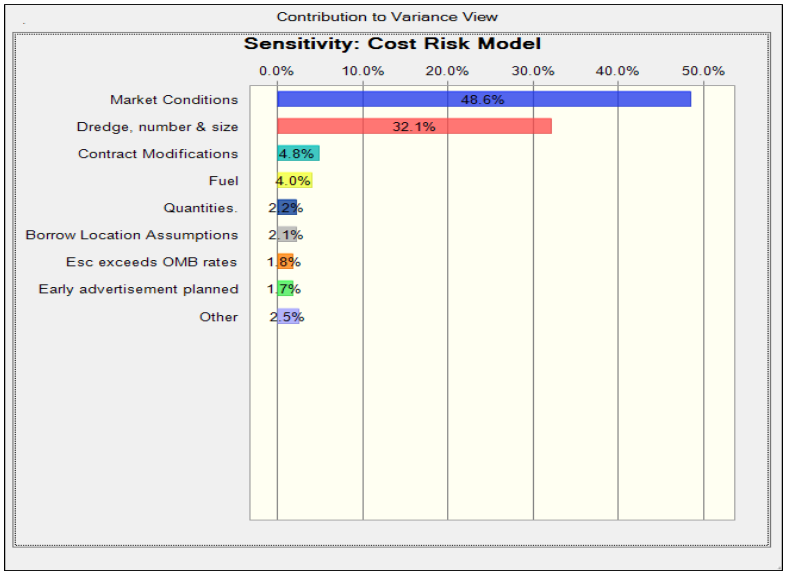
The risk register identifies thirty five different risks. There are twelve are either moderate or high risks. An abridged version of the risk register is presented below.

Table 2 - Risk Register (Short)

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
PROJECT & PROGRAM MGMT									
PPM-2	Congressional Funding - PED	Concern is that the PED Congressional funding is uncertain, post feasibility.	Need a chiefs report by Sept 13 by new program EC. Request for PED funding is not able to be go in until FY16 which could delay start of final design. Design would move to FY16-17. There is approximately a year of float in the schedule.	Likely	Negligible	LOW	Likely	Marginal	MODERATE
PPM-3	Congressional Funding Construction	Concern is that construction funding is incremental or delayed by not getting the initial project.	Relatively small overall dollar project most likely would get construction dollars.	Very Likely	Negligible	LOW	Very Likely	Marginal	MODERATE
PPM-8	Public Access Requirements	Sponsor must complete construction parking and facilities to support use of beach.	Sponsor must construct significant parking and associated facilities prior to construction project to set the conditions that benefits are received from the project. Failure to complete would stop or delay project. This is not part of the total project cost.	Unlikely	Crisis	HIGH	Unlikely	Crisis	HIGH
	RISKS								
CA-2	Early advertisement planned	Plan to award in July to get ahead of other districts.	optimizes timeline to get best dredge bidding competition and minimize.	likely	marginal	MODERATE	Unlikely	Negligible	LOW
	TECHNICAL RISKS								
T-2	Quantities.	change over time due to beach erosion during the PED phase and geotechnical overfill ratios--additionally funding delays may increase quantities.	Overall quantities are based on average volumes. There could be variation over time over the models .	Likely	marginal	MODERATE	Likely	Marginal	MODERATE
	CONSTRUCTION RISKS								
CON-1	Contract Modifications	There may be modification issues that have not been captured in current risks.	quantities. This is considered elsewhere. Each contract will likely carry the intended quantities per contract, but is restricted by the work window. Competing work, loss of dredger, quantity assumption can cause modifications such as remobilizations and delays. Other modification potentials could	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE
CON-2	Pipeline Dredge	The estimate assumes a hopper dredge because of longer pipeline distances and depth to borrow.	Pipeline dredge not likely due to ratio of beach length.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW
	RISKS								
EST-1	Dredge, number & size	Estimate choice can effect efficiency and productivity, causing a change to the estimate.	dredges but equipment is not restrictive w/in contract. The chosen estimate hopper size and number can affect the cost and productivity. Hopper dredges accommodate poor weather better than pipeline dredges. A large hopper results in greater efficiency as compared to two smaller hoppers, but less available and may be impacted by speed	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
EST-3	Fuel	Fuel fluctuations can impact dredging costs.	driver for equipment. Fuel has fluctuated drastically in the past 18 months. It is now back on the upswing. Study should be for time of funding date estimate.	Likely	Significant	HIGH	Unlikely	Marginal	LOW
EST-4	Two Dredge Productivity	The estimate assumes a certain productivity based on two medium sized dredge. Productivity may vary.	the size and productivity for two medium sized hopper dredges with a 2.3-5.5 mile haul mile haul. Those estimate assumptions establish the schedule. Productivity of two hopper dredges can vary due to various possibilities. And conditions. Productivity	Likely	Marginal	MODERATE	Likely	Negligible	LOW
EST-5	Borrow Location Assumptions	borrow areas will be used to support the beach locations.	Borrow areas well defined and have excess material so low risk.	Likely	Marginal	MODERATE	Likely	Negligible	LOW
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)							
EXT-1	Market Conditions	Market conditions and competing projects may impact bid competition.	when considering the number of dredges available. It is a tough bidding climate based on environmental time-line restrictions.	Likely	Significant	HIGH	Likely	Negligible	LOW
EXT-5	Esc exceeds OMB rates	Over longer periods of time, the actual market may be greater than the OMB rates, impacting contract costs.	Volatile fuel, being a larger risk on dredging projects, may not correlate with the OMB rates and may be higher as time passes.	Likely	Marginal	MODERATE	Unlikely	Negligible	LOW

Cost Risk Analysis - Cost Contingency Results

The project Cost Contingency at the 80% confidence level is 24%. This level was established by analyzing the different cost risk factors that affect the project. Cost contingencies can be either positive or negative. The cost sensitivity chart demonstrates relative cost contingency of individual risks for the initial construction. The chart for the renourishments is similar with long term variables such as escalation, fuel, and the borrow sources having slightly higher rankings. The sensitivity chart for the first cost is depicted below.



- Market Conditions

Discussion: Dredging is a highly competitive industry and there are limited windows when dredging can be performed in this area. The PDT has planned (and currently has adequate time in the project schedule) to advertise the project early in order to ensure the largest number of potential bidders. This represents an opportunity to reduce costs on the initial construction but may not be as likely to be recognized on the renourishments.

- Dredge number and size

Discussion: The choice of dredge size can affect efficiency and productivity, causing a difference between the government estimate and the bid price of the contract. The estimate assumed two medium-sized hopper dredges will be utilized, but the actual equipment is not restrictive within the proposed contract. A large hopper dredge could result in greater efficiency as compared to two smaller hoppers, but are less available and may be impacted by speed restrictions and may cause variations in the bid pricing.

- Contract Modifications/Claims:

Discussion- Contract modifications are always a risk in dredging the largest risk being the quantity assumptions and or borrow source competition/depletion over a long period of time.

Schedule Risk Analysis - Schedule Contingency Results

No specific schedule risk was derived from team's analysis. Schedule risks for the construction window were assessed for their impacts to cost and added to the cost contingency for both the first and the nourishment costs. The cost contingency analysis results are in the table below.

Table 3 - Contingency Analysis Results

Estimate of First Costs	$29,495,000		
Confidence Level	Value	Contingency	%
0%	$28,571,673	$ (1,179,800)	-4%
5%	$30,446,256	$ 1,179,800	4%
10%	$31,271,327	$ 2,064,650	7%
15%	$31,798,503	$ 2,359,600	8%
20%	$32,313,720	$ 2,949,500	10%
25%	$32,752,657	$ 3,539,400	12%
30%	$33,116,801	$ 3,834,350	13%
35%	$33,395,832	$ 4,129,300	14%
40%	$33,691,159	$ 4,424,250	15%
45%	$34,033,013	$ 4,719,200	16%
50%	$34,331,307	$ 5,014,150	17%
55%	$34,626,209	$ 5,309,100	18%
60%	$34,913,961	$ 5,604,050	19%
65%	$35,216,561	$ 5,899,000	20%
70%	$35,600,623	$ 6,193,950	21%
75%	$36,023,845	$ 6,783,850	23%
80%	$36,412,519	$ 7,078,800	24%
85%	$36,835,665	$ 7,373,750	25%
90%	$37,718,512	$ 8,258,600	28%
95%	$38,574,091	$ 9,143,450	31%
100%	$41,927,605	$ 12,682,850	43%

Estimate of Renourishment First Costs	$175,360,000		
Confidence Level	Value	Contingency	%
0%	$159,577,600	$ (15,782,400)	-9%
5%	$184,128,000	$ 8,768,000	5%
10%	$189,388,800	$ 14,028,800	8%
15%	$192,896,000	$ 17,536,000	10%
20%	$196,403,200	$ 21,043,200	12%
25%	$199,910,400	$ 24,550,400	14%
30%	$201,664,000	$ 26,304,000	15%
35%	$203,417,600	$ 28,057,600	16%
40%	$206,924,800	$ 31,564,800	18%
45%	$208,678,400	$ 33,318,400	19%
50%	$210,432,000	$ 35,072,000	20%
55%	$212,185,600	$ 36,825,600	21%
60%	$213,939,200	$ 38,579,200	22%
65%	$217,446,400	$ 42,086,400	24%
70%	$219,200,000	$ 43,840,000	25%
75%	$220,953,600	$ 45,593,600	26%
80%	$224,460,800	$ 49,100,800	28%
85%	$227,968,000	$ 52,608,000	30%
90%	$231,475,200	$ 56,115,200	32%
95%	$238,489,600	$ 63,129,600	36%
100%	$261,286,400	$ 85,926,400	49%

APPENDIX A
DETAILED RISK ANALYSIS RESULTS AND MODEL

Contingency on Base Estimate	80% Confidence Project Cost
MCACES Estimate First Cost (Most Likely) ->	**$29,495,000**
Baseline Estimate Cost Contingency Amount ->	$7,078,800
Baseline Estimate First Costs (80% Confidence) ->	**$36,573,800**

Contingency on Renourishments	80% Confidence Project Cost
MCACES Renourishment Estimate First Cost (Most Likely) ->	**$175,360,000**
Renourishment Estimate Cost Contingency Amount ->	$49,100,800
Renourishment Estimate First Costs (80% Confidence) ->	**$224,460,800**

- PROJECT CONTINGENCY DEVELOPMENT -

Contingency Analysis

MCACEs Estimate of First Costs	$29,495,000			
Confidence Level	Value	Contingency	%	
0%	$28,571,673	$ (1,179,800)	-4%	#
5%	$30,446,256	$ 1,179,800	4%	#
10%	$31,271,327	$ 2,064,650	7%	#
15%	$31,798,503	$ 2,359,600	8%	#
20%	$32,313,720	$ 2,949,500	10%	#
25%	$32,752,657	$ 3,539,400	12%	#
30%	$33,116,801	$ 3,834,350	13%	#
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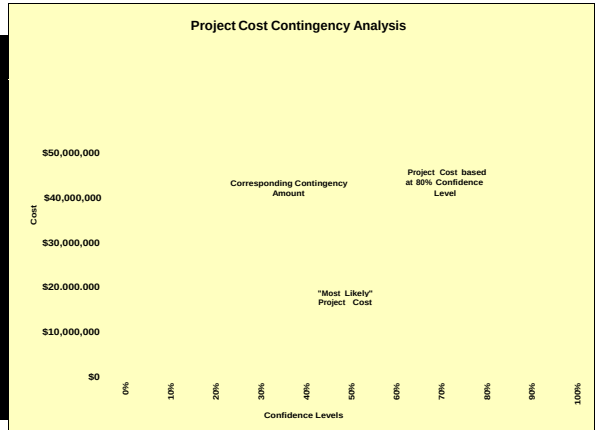
60%	$34,913,961	$ 5,604,050	19%	#
65%	$35,216,561	$ 5,899,000	20%	#
70%	$35,600,623	$ 6,193,950	21%	#
75%	$36,023,845	$ 6,783,850	23%	#
80%	$36,412,519	$ 7,078,800	24%	#
85%	$36,835,665	$ 7,373,750	25%	#
90%	$37,718,512	$ 8,258,600	28%	#
95%	$38,574,091	$ 9,143,450	31%	#
100%	$41,927,605	$ 12,682,850	43%	#



Contingency Analysis

MCACES Estimate of Renourishment First Costs	$175,360,000			
Confidence Level	Value	Contingency	%	
0%	$159,577,600	$ (15,782,400)	-9%	#
5%	$184,128,000	$ 8,768,000	5%	#
10%	$189,388,800	$ 14,028,800	8%	#
15%	$192,896,000	$ 17,536,000	10%	#
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25%	$199,910,400	$ 24,550,400	14%	#
30%	$201,664,000	$ 26,304,000	15%	#
35%	$203,417,600	$ 28,057,600	16%	#
40%	$206,924,800	$ 31,564,800	18%	#
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65%	$217,446,400	$ 42,086,400	24%	#
70%	$219,200,000	$ 43,840,000	25%	#
75%	$220,953,600	$ 45,593,600	26%	#
80%	$224,460,800	$ 49,100,800	28%	#
85%	$227,968,000	$ 52,608,000	30%	#
90%	$231,475,200	$ 56,115,200	32%	#
95%	$238,489,600	$ 63,129,600	36%	#
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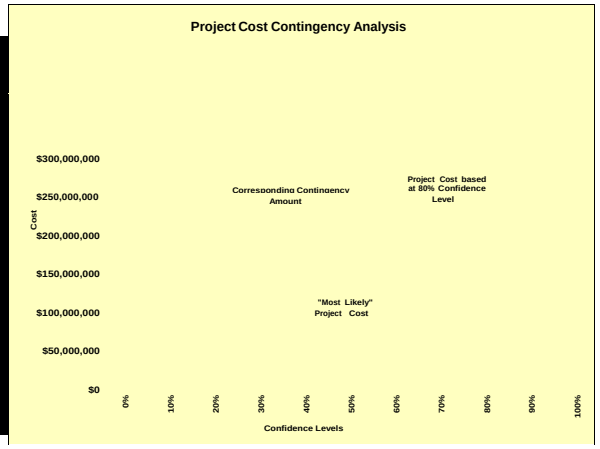


Bogue Banks Feasability Study 2013 CSRA

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Project Scope Narrative:

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost Likelihood*	Project Cost Impact*	Project Cost Risk Level*	Project Schedule Likelihood*	Project Schedule Impact*	Project Schedule Risk Level*	Responsibility/POC	Affected Project Component
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)											
PROJECT & PROGRAM MGMT											
PPM-1	Congressional Funding - Feasibility	Adequate Congressional funding to complete the feasibility study	Funding is in place to complete feasibility study.	Very Unlikely	Marginal	LOW	Very Unlikely	Marginal	LOW		Project Cost & Schedule
PPM-2	Congressional Funding - PED	Concern is that the PED Congressional funding is uncertain, post feasibility.	PED funding is not able to be go in until FY16 which could delay start of final design. Design would move to FY16-17. There is approximately a year of float in the schedule.	Likely	Negligible	LOW	Likely	Marginal	MODERATE		Project Cost & Schedule
PPM-3	Congressional Funding Construction	Concern is that construction funding is incremental or delayed by not getting the initial project.	Relatively small overall dollar project most likely would get construction dollars.	Very Likely	Negligible	LOW	Very Likely	Marginal	MODERATE		Project Cost & Schedule
PPM-4	Stakeholder funding capability	Sponsor has large tax base and is likely to be able to meet requirements.	Sponsors must fund portion of 50% feasibility, 25% PED and 35% initial construction plus 100% real estate acquisition. Sponsors feel confident that their budget shares are not a critical constraint and that the Federal shares and funding are a greater concern.	Very Unlikely	Negligible	LOW	Very Unlikely	Marginal	LOW		Project Cost & Schedule
PPM-5	Adequate PDT Resources	Stable long term PDT.	The District feels that there is adequate District support and team development for future efforts.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
PPM-6	Sponsor Support	Sponsor support and agreement with the project plan.	Sponsor coordination and support is healthy, alleviated with monthly meetings that include PDT and sponsors.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
PPM-7	Schedule quality	Concern whether current schedule is realistic, optimistic.	c. The PED is confident of the schedule for PED and construction durations. The construction durations reflect a conservative estimate approach and establish the construction schedule. Extra 30 days in initially	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
PPM-8	Public Access Requirements	Sponsor must complete construction parking and facilities to support use of beach.	Sponsor must construct significant parking and associated facilities prior to construction project to set the conditions that benefits are received from the project. Failure to complete would stop or delay project. This is not part of the total project cost.	Unlikely	Crisis	HIGH	Unlikely	Crisis	HIGH		Project Cost & Schedule
CONTRACT ACQUISITION RISKS											
CA-1	Contract Acquisition Strategy	The acquisition strategy could impact the construction cost and schedule.	Work type is not complicated. It is likely that it will be a FFP large business, based on historical and small business does not have capability. The contract packages will consider the estimate schedule projections related to productivity.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
CA-2	Early advertisement planned	Plan to award in July to get ahead of other districts.	Plan is to award in July for Dec start which optimizes timeline to get best dredge bidding competition and minimize.	likely	marginal	MODERATE	Unlikely	Negligible	LOW		Project Cost & Schedule
TECHNICAL RISKS											
T-1	Soil Quality	Limited borings done on borrow sources. However there is a pretty good data set from previous projects.	There may be pockets of material that are not suitable but overall we have enough material to complete the project. More data will be obtained in PED phase but generally thought to be a low risk.	Unlikely	Marginal	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
T-2	Quantities.	Scope definition is excellent, but quantities can change over time due to beach erosion during the PED phase and geotechnical overfill ratios--additionally funding delays may increase quantities.	Overall quantities are based on average volumes. There could be variation over time over the models .	Likely	marginal	MODERATE	Likely	Marginal	MODERATE		Project Cost & Schedule
T-4	Hard Bottom Encounter	Hard bottoms may be uncovered later in out years .	Sand bottom may be covering hard bottoms, leaving a risk in the borrow quantity available at each site. It could damage the hopper dredge. Risk is increased in the out years, because in the near term the dredge can simply relocate. Better clarification should occur during PED phase with better surveys.	Very Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
T-5	Work window	Work window is in winter when storms can occur.	Seasonal weather patterns utilized for window. South facing beaches are generally less impacted by weather. Average productivities from historical data are used.	Likely	Negligible	LOW	Likely	Negligible	LOW		Project Cost & Schedule
LANDS AND DAMAGES RISKS											
RE-1	Acquire real estate	Concern that RE cannot acquire real estate timely to support the construction contracts.	Historically, a good track record and relocations are minor.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
RE-2	Real Estate Estimate	Real Estate estimate may cause cost impact.	Historical information is good. The estimate currently includes a 25% contingency. This should be re-evaluated within the risk analysis outcome.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
RISKS											
ENV-1	UXO	Area is near Camp Lejune ranges west of project.	Area surveyed. Mitigation will be required if encountered.	Very Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
ENV-2	Critical Habitat Designation Sea Turtle Site Take	Designation of area as critical habitat could change work window.	Area could be designated as a "critical habitat" and have more restrictions on work window, sand quality, etc.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule

ENV-3	SAD Turtle Incidental Take	Other projects encountering sea turtles	Other SAD impacts or "takes" can impact this project. Time frame shut down could occur (standby time based in days). Takes in this area could shut down project. About a 1 in 15 year experience.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
ENV-4	Bird Nesting	Bird nesting impacts construction.	Winter work window is also based on bird nesting concerns. Risk is minimized, but such an encounter may shut down work activity for a period of time.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
ENV-5	Wright Whale Restrictions	Encounter potential impacts dredge fleet speed.	10 knot speed restriction if you encounter whales. Larger hopper dredges have a higher speed that could be impacted. Feds may not require this restriction on a federal project and the current estimate assumes smaller dredges with slower speed capability. Feds also monitor whale movement. Estimate must accommodate speed restrictions, affecting the productivity. The estimate is developed to accommodate the speed restrictions.	Likely	Negligible	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
ENV-6	Environmental Monitoring	Environmental monitoring required during dredging.	impacts are found. Environmental group will have a separate monitoring contract. The monitoring costs have been considered within PED.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
ENV-7	Dune Revalidation	Dune Revegetation required	Estimate includes first vegetation. Dune Revegetation may be required on renourishments but is not included..	Likely	Negligible	LOW	Likely	Negligible	LOW		Project Cost & Schedule
ENV-8	Archeological	Concern that there may be uncovered archeological finds during the underwater excavations.	Borrow areas have been well established with adequate investigation to determine this is not a concern. If anything was discovered, another available nearby borrow source, already identified and studied, would be the next source.	Very Unlikely	Marginal	LOW	Very Unlikely	Marginal	LOW		Project Cost & Schedule
	CONSTRUCTION RISKS										
CON-1	Contract Modifications	There may be modification issues that have not been captured in current risks.	considered elsewhere. Each contract will likely carry the intended quantities per contract, but is restricted by the work window. Competing work, loss of dredger, quantity assumption can cause modifications such as remobilizations and delays. Other modification potentials could include borrow source remobilization resulting from environmental impacts.	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE		Project Cost & Schedule
CON-2	Pipeline Dredge	The estimate assumes a hopper dredge because of longer pipeline distances and depth to borrow.	Pipeline dredge not likely due to ratio of beach length.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
	ESTIMATE AND SCHEDULE RISKS										
EST-1	Dredge, number & size	Estimate choice can effect efficiency and productivity, causing a change to the estimate.	Estimate assumed two medium-sized hopper dredges but equipment is not restrictive w/in contract. The chosen estimate hopper size and number can affect the cost and productivity. Hopper dredges accommodate poor weather better than pipeline dredges. A large hopper results in greater efficiency as compared to two smaller hoppers, but less available and may be impacted by speed restrictions. productivity is generally conservative at 77%.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE		Project Cost & Schedule
EST-3	Fuel	Fuel fluctuations can impact dredging costs.	Fuel has fluctuated drastically in the past 18 months. It is now back on the upswing. Study should be for time of funding date estimate.	Likely	Significant	HIGH	Unlikely	Marginal	LOW		Project Cost & Schedule
EST-4	Two Dredge Productivity	The estimate assumes a certain productivity based on two medium sized dredge. Productivity may vary.	The current estimate makes assumptions in the size and productivity for two medium sized hopper dredges with a 2.3-5.5 mile haul mile haul. Those estimate assumptions establish the schedule. Productivity of two hopper dredges can vary due to various possibilities. And conditions. Productivity could be 70-85%.	Likely	Marginal	MODERATE	Likely	Negligible	LOW		Project Cost & Schedule
EST-5	Borrow Location Assumptions	The estimate makes assumptions as to which borrow areas will be used to support the beach locations.	Borrow areas well defined and have excess material so low risk.	Likely	Marginal	MODERATE	Likely	Negligible	LOW		Project Cost & Schedule
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)									
EXT-1	Market Conditions	Market conditions and competing projects may impact bid competition.	Currently, there are a lot of projects planned when considering the number of dredges available. It is a tough bidding climate based on environmental time-line restrictions.	Likely	Significant	HIGH	Likely	Negligible	LOW		Project Cost & Schedule
EXT-2	External Opposition	External opposition may cause scope or schedule change.	Feds adhering to the environmental requirements. Sponsor's in favor of project. No serious historical intervention because it is a beach renourishment project.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
EXT-3	Acts of God	Severe weather may impact cost or schedule.	Nor easter storms or hurricanes could impact construction as well as beach profile. Construction occurs in low period of weather risks; however, storms are still a potential. As long as the estimate and schedules assume some inefficiency, it should not be a serious issue.	Likely	Negligible	LOW	Likely	Negligible	LOW		Project Cost & Schedule
EXT-4	Borrow Competition	External entities may compete for the borrow sources.	For initial construction this is unlikely. Long term competition is unknown. The long term competition does not impact initial appropriation needs and feasibility funding request. Future projects must consider this potential as it occurs in future contracts.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
EXT-5	Esc exceeds OMB rates	Over longer periods of time, the actual market may be greater than the OMB rates, impacting contract costs.	Volatile fuel, being a larger risk on dredging projects, may not correlate with the OMB rates and may be higher as time passes.	Likely	Marginal	MODERATE	Unlikely	Negligible	LOW		Project Cost & Schedule

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

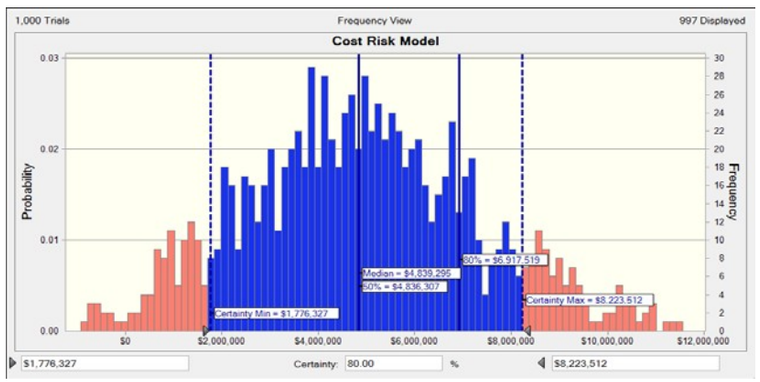
Bogue Banks 2013 CSRA First Cost of Construction

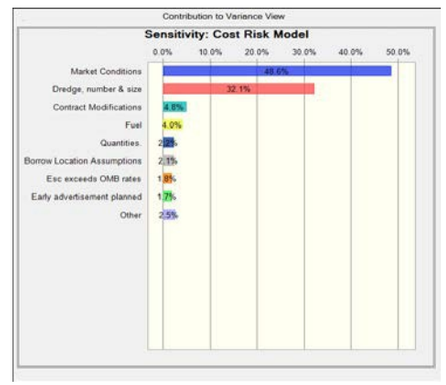
Risk No.	Risk/Opportunity Event	Project Cost: Likelihood*	Project Cost: Impact*	Project Cost: Risk Level*	Variance Distribution	Correlation to Other(s)	Probability of Occurrence	Crystal Ball Simulation: Expected Values ($$$): Low	Most Likely	High	Contingency Model	Notes
Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)												
	PROJECT & PROGRAM MGMT											
PPM-2	Congressional Funding - PED	Likely	Negligible	LOW	Custom			$ -	$ -	$88,695	0	
PPM-3	Congressional Funding Construction	Very Likely	Negligible	LOW	Custom			$ -	$ -	$295,100	0	
	CONTRACT ACQUISITION RISKS											
CA-2	Early advertisement planned	likely	marginal	MODERATE	Triangular			$ (1,203,400)	$ -	$0	0	
	TECHNICAL RISKS											
T-2	Quantities.	Likely	marginal	MODERATE	Uniform			$ (1,203,400)	$ -	$3,610,200	0	
	LANDS AND DAMAGES RISKS											
	REGULATORY AND ENVIRONMENTAL RISKS											
	CONSTRUCTION RISKS											
CON-1	Contract Modifications	Unlikely	Marginal	LOW	Triangular			$ -	$ -	$1,684,760	0	
	ESTIMATE AND SCHEDULE RISKS											
EST-1	Dredge, number & size	Likely	Marginal	MODERATE	BetaP			($1,112,746)	$ -	$3,338,237	0	
EST-3	Fuel	Likely	Significant	HIGH	BetaP			$0	$ -	$2,000,000	0	
EST-5	Borrow Location Assumptions	Likely	Marginal	MODERATE	Triangular			$0	$ -	$1,390,932	0	
	ECONOMICS RISKS											
	Programmatic Risks											
EXT-1	Market Conditions	Likely	Significant	HIGH	Triangular			($1,390,932)	$ -	$4,172,796	0	
EXT-5	Esc exceeds OMB rates	Likely	Marginal	MODERATE	Uniform			$ -	$ -	$1,179,800	0	
											$ -	

Sum Values to Here

USE ROUNDED DATA FOR REPORT

PROJECT CONTINGENCY	Percentile	MCACES First Costs	Contingency	Baseline w/ Contingency	Contingency %	Rounded %	Rounded $
	0%	$29,495,000	($923,327)	$28,571,673	-3.13%	-4%	$ (1,179,800)
	5%	$29,495,000	$951,256	$30,446,256	3.23%	4%	$ 1,179,800
	10%	$29,495,000	$1,776,327	$31,271,327	6.02%	7%	$ 2,064,650
	15%	$29,495,000	$2,303,503	$31,798,503	7.81%	8%	$ 2,359,600
	20%	$29,495,000	$2,818,720	$32,313,720	9.56%	10%	$ 2,949,500
	25%	$29,495,000	$3,257,657	$32,752,657	11.04%	12%	$ 3,539,400
	30%	$29,495,000	$3,621,801	$33,116,801	12.28%	13%	$ 3,834,350
	35%	$29,495,000	$3,900,832	$33,395,832	13.23%	14%	$ 4,129,300
	40%	$29,495,000	$4,196,159	$33,691,159	14.23%	15%	$ 4,424,250
	45%	$29,495,000	$4,538,013	$34,033,013	15.39%	16%	$ 4,719,200
	50%	$29,495,000	$4,836,307	$34,331,307	16.40%	17%	$ 5,014,150
	55%	$29,495,000	$5,131,209	$34,626,209	17.40%	18%	$ 5,309,100
	60%	$29,495,000	$5,418,961	$34,913,961	18.37%	19%	$ 5,604,050
	65%	$29,495,000	$5,721,361	$35,216,361	19.40%	20%	$ 5,899,000
	70%	$29,495,000	$6,105,623	$35,600,623	20.70%	21%	$ 6,193,950
	75%	$29,495,000	$6,528,845	$36,023,845	22.14%	23%	$ 6,783,850
	80%	$29,495,000	$6,917,519	$36,412,519	23.45%	24%	$ 7,078,800
	85%	$29,495,000	$7,340,665	$36,835,665	24.89%	25%	$ 7,373,750
	90%	$29,495,000	$8,223,512	$37,718,512	27.88%	28%	$ 8,258,600
	95%	$29,495,000	$9,079,091	$38,574,091	30.78%	31%	$ 9,143,450
	100%	$29,495,000	$12,432,605	$41,927,605	42.15%	43%	$ 12,682,850





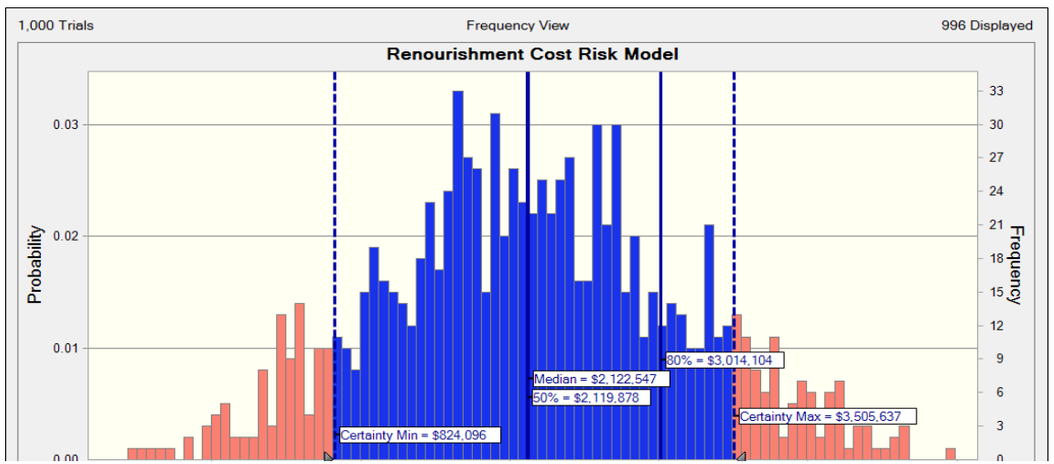
Bogue Banks CSRA - Renourishments

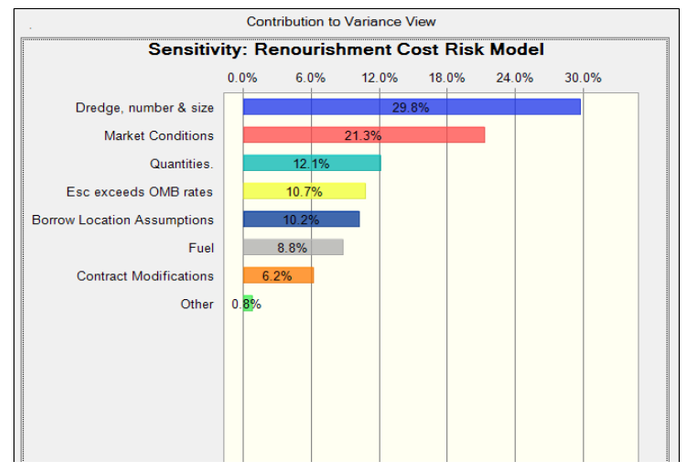
Risk No.	Risk/Opportunity Event	Project Cost: Likelihood*	Project Cost: Impact*	Project Cost: Risk Level*	Variance Distribution	Correlation to Other(s)	Probability of Occurrence	Crystal Ball Simulation: Expected Values ($$$): Low	Most Likely	High	Contingency Model	Notes
Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)												
	PROJECT & PROGRAM MGMT											
	CONTRACT ACQUISITION RISKS											
	TECHNICAL RISKS											
T-2	Quantities.	Likely	marginal	MODERATE	Uniform			$ (524,691)	$ -	$1,574,072	0	
	LANDS AND DAMAGES RISKS											
	REGULATORY AND ENVIRONMENTAL RISKS											
	CONSTRUCTION RISKS											
CON-1	Contract Modifications	Unlikely	Marginal	LOW	Triangular			$ -	$ -	$734,567	0	
	ESTIMATE AND SCHEDULE RISKS											
EST-1	Dredge, number & size	Likely	Marginal	MODERATE	Uniform			($485,165)	$ -	$1,455,494	0	
EST-3	Fuel	Likely	Significant	HIGH	Beta			$0	$ -	$872,014	0	
EST-5	Borrow Location Assumptions	Likely	Marginal	MODERATE	Beta			$0	$ -	$1,212,912	0	
	ECONOMICS RISKS											
	Programmatic Risks											
EXT-1	Market Conditions	Likely	Significant	HIGH	Triangular			($606,456)	$ -	$1,819,368	0	
EXT-5	Esc exceeds OMB rates	Likely	Marginal	MODERATE	Uniform			$ -	$ -	$1,028,802	0	
											$ -	

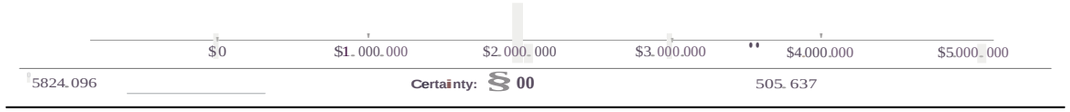
Sum Values to Here

USE ROUNDED DATA FOR REPORT

PROJECT CONTINGENCY	Percentile	MCACES ESTIMATE of One nourishment cost	Contingency	Baseline w/ Contingency	Contingency %	Rounded %	Rounded $
	0%	$10,960,000	($938,487)	$10,021,513	-8.56%	-9%	$ (986,400)
	5%	$10,960,000	$498,076	$11,458,076	4.54%	5%	$ 548,000
	10%	$10,960,000	$824,096	$11,784,096	7.52%	8%	$ 876,800
	15%	$10,960,000	$1,084,728	$12,044,728	9.90%	10%	$ 1,096,000
	20%	$10,960,000	$1,275,532	$12,235,532	11.64%	12%	$ 1,315,200
	25%	$10,960,000	$1,470,333	$12,430,333	13.42%	14%	$ 1,534,400
	30%	$10,960,000	$1,624,645	$12,584,645	14.82%	15%	$ 1,644,000
	35%	$10,960,000	$1,723,431	$12,683,431	15.72%	16%	$ 1,753,600
	40%	$10,960,000	$1,869,987	$12,829,987	17.06%	18%	$ 1,972,800
	45%	$10,960,000	$1,993,128	$12,953,128	18.19%	19%	$ 2,082,400
	50%	$10,960,000	$2,119,878	$13,079,878	19.34%	20%	$ 2,192,000
	55%	$10,960,000	$2,250,800	$13,210,800	20.54%	21%	$ 2,301,600
	60%	$10,960,000	$2,385,306	$13,345,306	21.76%	22%	$ 2,411,200
	65%	$10,960,000	$2,543,521	$13,503,521	23.21%	24%	$ 2,630,400
	70%	$10,960,000	$2,661,520	$13,621,520	24.28%	25%	$ 2,740,000
	75%	$10,960,000	$2,807,572	$13,767,572	25.62%	26%	$ 2,849,600
	80%	$10,960,000	$3,014,104	$13,974,104	27.50%	28%	$ 3,068,800
	85%	$10,960,000	$3,279,229	$14,239,229	29.92%	30%	$ 3,288,000
	90%	$10,960,000	$3,505,637	$14,465,637	31.99%	32%	$ 3,507,200
	95%	$10,960,000	$3,901,877	$14,861,877	35.60%	36%	$ 3,945,600
	100%	$10,960,000	$5,262,897	$16,222,897	48.02%	49%	$ 5,370,400



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Bogue Banks Feasability Study 2013 CSRA

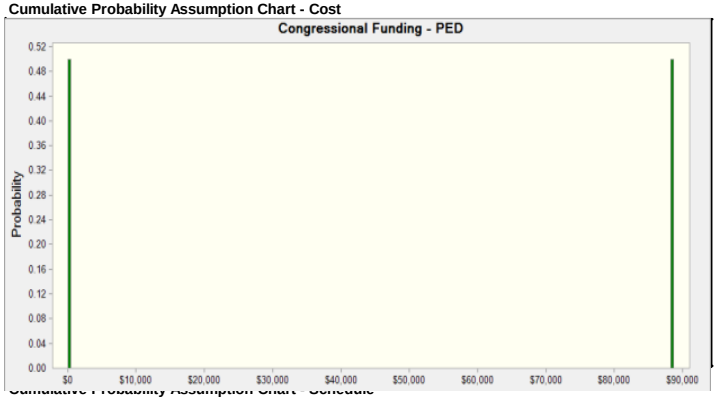
Co	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
	PPM-2	Congressional Funding - PED	Likely	Negligible	LOW	Custom			$0	$0	$88,695	

sche	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
	PPM-2	Congressional Funding - PED	Likely	Marginal	MODERATE	#N/A	#N/A	#N/A	0.0 Months	0.0 Months	0.0 Months	

Description	Concern is that the PED Congressional funding is uncertain, post feasibility. Need a chiefs report by Sept 13 by new program EC. Request for PED funding is not able to be go in until FY16 which could delay start of final design. Design would move to FY16-17. There is approximately a year of float in the schedule.
Development of Low Values	The best case scenario is that the project proceeds on schedule and there is no change to the construction schedule.
Development of High Values	The worst case scenario is that the PED Phase costs would increase approximately 5% or 90k. There is 1 year of float in the PED phase schedule so this would not effect the construction schedule but would change when the PED funds are expended. Not applicable to O&M portion.

Confidence Percentile	Assumption values (in dollars)	Assumption values (in months)
0%	$0	#N/A
10%	$0	#N/A
20%	$0	#N/A
30%	$0	#N/A
40%	$0	#N/A
50%	$0	#N/A
60%	$88,695	#N/A
70%	$88,695	#N/A
80%	$88,695	#N/A
90%	$88,695	#N/A
100%	$88,695	#N/A

Cumulative Probability Assumption Chart - Cost



Cumulative Probability Assumption Chart - Schedule

Bogue Banks Feasability Study 2013 CSRA

Co	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
	PPM-8	Public Access Requirements	Unlikely	Crisis	HIGH	#N/A	#N/A	#N/A		$0		

sche	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
	PPM-8	Public Access Requirements	Unlikely	Crisis	HIGH	#N/A	#N/A	#N/A		0.0 Months		

Description	Sponsor must complete construction parking and facilities to support use of beach. Sponsor must construct significant parking and associated facilities prior to construction project to set the conditions that benefits are received from the project. Failure to complete would stop or delay project. This is not part of the total project cost.
Development of Low Values	This is not modeled as it would stop the project. It is on the risk register as a watch list item only
Development of High Values	

Confidence Percentile	Assumption values (in dollars)	Assumption values (in months)
0%	#N/A	#N/A
10%	#N/A	#N/A
20%	#N/A	#N/A
30%	#N/A	#N/A
40%	#N/A	#N/A
50%	#N/A	#N/A
60%	#N/A	#N/A
70%	#N/A	#N/A
80%	#N/A	#N/A
90%	#N/A	#N/A
100%	#N/A	#N/A

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

17 ACCT BEACH NOURISHMT																																				
		oct 11	2014	2014	2014	2014	2014	2014	2015	2015	2015	2016	2016	2017	2017	2017	2017	2017	2018	2018	2019	2019	2019	2019	2019	2019	2019	2020	2020	2020	2020	2020	2020	2020	2020	2020
			FEB		APR	OCT		DEC		SEPT	OCT		DEC		FEB		APR		OCT			JUNE		AUG	SEPT	OCT		DEC		FEB		APR		JUNE		AUG	SEPT
			0			15	0				16	0			0			0	19	0	0															
					0	0			0		0			0			0		0				0													
PRINTS BEST USING ANSI E - 33" X 44"																																				
CHIEF'S REPORT		**OCTOBER 2014**				CHIEFS						AUTHORIZATION			OCT 2017 GET CONSTRUCTION FUNDS																						
						REPORT																														
PPA		**DECEMBER 2017**													DEC 2017 SIGN PPA																					
	OCT 13																																			
REAL ESTATE	**$3,516,750**	$4,360,770.00														REAL ESTATE		JAN 2018 REAL ESTATE ACQUISITION (26 mos)																		
		MidPoint APRIL 2018														1		19			26															
	w/24% contingency																HIDDEN MONTHS																			
	$4,360,770																																			
INITIAL CONST	**$1,600,000**	PED																				x														
	OCT 13	MidPoint JULY 2019									**PED INITIAL INVESTIGATIONS**										**FINAL PLANS-SPECS**															
	w/24% contingency																									**Advertise-Bid Open-Award-NTP**										
	$1,984,000																																			
CONTRACT 1 of 1																												2 HOPPERS 1 SEASON								
BOGUE BANKS	**$24,068,000**	**CONSTRUCTION**																										Contract 1 -								
	OCT 13	**MidPoint FEB 2020**																									MOB and Demob = $1,600,000									
	w/24% contingency																										2,451,200 CY * $ 7.50/CY = $18,384,000									
	$29,844,320																												0							
INITIAL NOURISHMENT																											**mob**	**CONTRACT 1**		**x**		**dmob**				$19,984,000
	$310,000	**S&A**																											TILLING							$84,000
	OCT 13	**MidPoint FEB 2020**																											**DUNE VEGETATIO**		**x**					$3,825,000
	w/24% contingency																																			
	$384,400																												**WALKOVER STRU**		**x**					$175,000
$25,978,000																																				**$24,068,000**
																												CONST MGT AND MONITOR		**x**					**$310,000**

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 113670

SAW – Bogue Banks Feasibility Study

The Bogue Banks Feasibility Study, as presented by Wilmington District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of March 20, 2014, the Cost MCX certifies the estimated total project cost of:

Initial Construction:
FY 2015 Price Level: $37,327,000
Fully Funded Amount: $41,343,000

Periodic Replenishments (2023-2068 16 Total)
FY 2015 Price Level: $229,450,000
Fully Funded Amount: $564,923,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
PROJECT NO: P2 - 113670
LOCATION: CARTERET COUNTY, NORTH CAROLINA

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/6/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5 FEB 14				Program Year (Budget EC): 2015								
		Effective Price Level: 1 OCT 13				Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-13 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
17	BEACH REPLENISHMENT	$24,068	$5,776	24%	$29,844	1.9%	$24,537	$5,889	$30,426	$0		$27,088	$6,501	$33,589
	INITIAL NOURISHMENT													
	CONSTRUCTION ESTIMATE TOTALS:	$24,068	$5,776		$29,844	1.9%	$24,537	$5,889	$30,426	$0		$27,088	$6,501	$33,589
01	LANDS AND DAMAGES	$3,517	$844	24%	$4,361	2.0%	$3,586	$861	$4,446	$0		$3,830	$919	$4,749
30	PLANNING, ENGINEERING & DESIGN	$1,600	$384	24%	$1,984	3.7%	$1,659	$398	$2,057	$0		$2,023	$486	$2,509
31	CONSTRUCTION MANAGEMENT	$310	$74	24%	$384	3.7%	$321	$77	$398	$0		$400	$96	$496
	PROJECT COST TOTALS:	$29,495	$7,079	24%	$36,574		$30,103	$7,225	**$37,327**	$0		$33,341	$8,002	$41,343

CHIEF, COST ENGINEERING, Lee Danley, PE

PROJECT MANAGER, Pam Castens

CHIEF, REAL ESTATE, Ralph Werthmann SAS

CHIEF, PLANNING, Elden Gatwood

CHIEF, ENGINEERING, Greg Williams, PE

CHIEF, OPERATIONS, Bob Sattin, PE

CHIEF, CONSTRUCTION, Dennis Lynch, PE

CHIEF, CONTRACTING, Jon Mayo

CHIEF, PM-PB, Sam Colella

CHIEF, DPM, Christine Brayman

ESTIMATED FEDERAL COST:	**65%**	**$26,873**
ESTIMATED NON-FEDERAL COST:	**35%**	**$14,470**
INITIAL NOURISHMENT ESTIMATED TOTAL PROJECT COST:		**$41,343**
Periodic Nourishments for 50-year project		**$564,923**
ESTIMATED FEDERAL COST - Periodics Nourishments :	**50%**	**$282,462**
ESTIMATED NON-FEDERAL COST - Periodic Nourishments :	**50%**	**$282,462**
ESTIMATED TOTAL PERIODIC PROJECT COST:		**$564,923**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
LOCATION: CARTERET COUNTY, NORTH CAROLINA
This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/6/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5 FEB 14 Effective Price Level: 1 OCT 13				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	INITIAL NOURISHMENT													
17	BEACH REPLENISHMENT	$24,068	$5,776	24%	$29,844	1.9%	$24,537	$5,889	$30,426	2020Q2	10.4%	$27,088	$6,501	$33,589
	CONSTRUCTION ESTIMATE TOTALS:	$24,068	$5,776	24%	**$29,844**		$24,537	$5,889	$30,426			$27,088	$6,501	$33,589
01	LANDS AND DAMAGES	$3,517	$844	24%	$4,361	2.0%	$3,586	$861	$4,446	2018Q3	6.8%	$3,830	$919	$4,749
30	PLANNING, ENGINEERING & DESIGN PED	$1,600	$384	24%	$1,984	3.7%	$1,659	$398	$2,057	2019Q4	22.0%	$2,023	$486	$2,509
31	CONSTRUCTION MANAGEMENT Construction Management	$310	$74	24%	$384	3.7%	$321	$77	$398	2020Q2	24.6%	$400	$96	$496
	CONTRACT COST TOTALS:	$29,495	$7,079		**$36,574**		$30,103	$7,225	$37,327			$33,341	$8,002	**$41,343**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
PROJECT NO: P2 - 113670
LOCATION: CARTERET COUNTY, NORTH CAROLINA

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/20/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			5 FEB 14	Program Year (Budget EC):			2015					
		Effective Price Level:			1 OCT 13	Effective Price Level Date:			1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-13 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
17	BEACH REPLENISHMENT													
	Periodic Nourishments - 16 years													
	CONSTRUCTION ESTIMATE TOTALS:	$147,360	$41,261		$188,621	1.9%	$150,233	$42,065	$192,299	$0		$277,182	$77,611	$354,794
01	LANDS AND DAMAGES	$0	$0 -		$0	-	$0	$0	$0	$0		$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN	$16,000	$4,480	28%	$20,480	3.7%	$16,585	$4,644	$21,229	$0		$93,286	$26,120	$119,406
31	CONSTRUCTION MANAGEMENT	$12,000	$3,360	28%	$15,360	3.7%	$12,439	$3,483	$15,922	$0		$70,878	$19,846	$90,724
	PROJECT COST TOTALS:	$175,360	$49,101	28%	$224,461		$179,258	$50,192	**$229,450**	$0		$441,346	$123,577	$564,923

CHIEF, COST ENGINEERING, Lee Danley, PE

PROJECT MANAGER, Pam Castens

CHIEF, REAL ESTATE, Ralph Werthmann SAS

CHIEF, PLANNING, Elden Gatwood

CHIEF, ENGINEERING, Greg Williams, PE

CHIEF, OPERATIONS, Bob Sattin, PE

CHIEF, CONSTRUCTION, Dennis Lynch, PE

CHIEF, CONTRACTING, Jon Mayo

CHIEF, PM-PB, Sam Colella

CHIEF, DPM, Christine Brayman

ESTIMATED FEDERAL COST:	**50%**	**$282,462**
ESTIMATED NON-FEDERAL COST:	**50%**	**$282,462**
ESTIMATED TOTAL PROJECT COST:		**$564,923**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
LOCATION: CARTERET COUNTY, NORTH CAROLINA
This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/20/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5 FEB 14 Effective Price Level: 1 OCT 13				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PERIODIC Nourishments 2023 to Year 2035													
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2023Q2	16.8%	$10,968	$3,071	$14,039
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2026Q2	23.6%	$11,605	$3,249	$14,854
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2029Q2	30.8%	$12,279	$3,438	$15,717
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2032Q2	38.4%	$12,992	$3,638	$16,630
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2035Q2	46.4%	$13,747	$3,849	$17,596
	Periodic Nourishments every 3 years													
	PERIODIC Nourishments 2023 to Year 2035													
	CONSTRUCTION ESTIMATE TOTALS:	$46,050	$12,894	28%	$58,944		$46,948	$13,145	$60,093			$61,590	$17,245	$78,836
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
	PED, PM, Life Cycle Updates, E&D, Contracts	$5,000	$1,400	28%	$6,400	3.7%	$5,183	$1,451	$6,634	2029Q1	84.9%	$9,583	$2,683	$12,266
31	CONSTRUCTION MANAGEMENT													
	Construction Management, PM, Contracting	$3,750	$1,050	28%	$4,800	3.7%	$3,887	$1,088	$4,976	2029Q2	87.1%	$7,272	$2,036	$9,308
	CONTRACT COST TOTALS:	$54,800	$15,344		**$70,144**		$56,018	$15,685	$71,703			$78,445	$21,965	**$100,409**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
LOCATION: CARTERET COUNTY, NORTH CAROLINA
This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/20/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			5 FEB 14	Program Year (Budget EC):			2015					
		Effective Price Level:			1 OCT 13	Effective Price Level Date:			1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PERIODIC Nourishments 2038 to Year 2050													
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2038Q2	54.9%	$14,545	$4,073	$18,618
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2041Q2	63.9%	$15,390	$4,309	$19,700
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2044Q2	73.4%	$16,284	$4,560	$20,844
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2047Q2	83.5%	$17,230	$4,824	$22,055
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2050Q2	94.2%	$18,231	$5,105	$23,336
	Periodic Nourishments every 3 years						$0							
	PERIODIC Nourishments 2038 to Year 2050													
	CONSTRUCTION ESTIMATE TOTALS:	$46,050	$12,894	28%	**$58,944**		$46,948	$13,145	$60,093			$81,682	$22,871	$104,553
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
	PED, PM, Life Cycle Updates, E&D, Contracts	$5,000	$1,400	28%	$6,400	3.7%	$5,183	$1,451	$6,634	2044Q1	308.3%	$21,162	$5,925	$27,087
31	CONSTRUCTION MANAGEMENT													
	Construction Management, PM, Contracting	$3,750	$1,050	28%	$4,800	3.7%	$3,887	$1,088	$4,976	2044Q2	313.7%	$16,081	$4,503	$20,584
	CONTRACT COST TOTALS:	$54,800	$15,344		**$70,144**		$56,018	$15,685	$71,703			$118,924	$33,299	**$152,223**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
LOCATION: CARTERET COUNTY, NORTH CAROLINA
This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/20/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5 FEB 14 Effective Price Level: 1 OCT 13				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PERIODIC Nourishments 2053 to Year 2065													
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2053Q2	105.4%	$19,290	$5,401	$24,692
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2056Q2	117.4%	$20,411	$5,715	$26,126
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2059Q2	130.0%	$21,597	$6,047	$27,644
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2062Q2	143.4%	$22,851	$6,398	$29,249
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2065Q2	157.5%	$24,179	$6,770	$30,948
	Periodic Nourishments every 3 years						$0							
	PERIODIC Nourishments 2053 to Year 2065													
	CONSTRUCTION ESTIMATE TOTALS:	$46,050	$12,894	28%	**$58,944**		$46,948	$13,145	$60,093			$108,327	$30,332	$138,659
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
	PED, PM, Life Cycle Updates, E&D, Contracts	$5,000	$1,400	28%	$6,400	3.7%	$5,183	$1,451	$6,634	2059Q1	811.5%	$47,243	$13,228	$60,471
31	CONSTRUCTION MANAGEMENT													
	Construction Management, PM, Contracting	$3,750	$1,050	28%	$4,800	3.7%	$3,887	$1,088	$4,976	2059Q2	823.6%	$35,900	$10,052	$45,952
	CONTRACT COST TOTALS:	$54,800	$15,344		**$70,144**		$56,018	$15,685	$71,703			$191,471	$53,612	**$245,083**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: BOGUE BANKS FEASIBILITY STUDY REPORT
LOCATION: CARTERET COUNTY, NORTH CAROLINA
This Estimate reflects the scope and schedule in report; BOGUE BANKS FEASIBILITY STUDY - FEBRUARY 2014

DISTRICT: CESAW WILMINGTON DISTRICT PREPARED: 3/20/2014
POC: CHIEF, COST ENGINEERING, Lee Danley, PE

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5 FEB 14 Effective Price Level: 1 OCT 13				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PERIODIC Nourishment 2068													
17	BEACH REPLENISHMENT	$9,210	$2,579	28%	$11,789	1.9%	$9,390	$2,629	$12,019	2068Q2	172.5%	$25,583	$7,163	$32,746
	Periodic Nourishments every 3 years						$0							
	PERIODIC Nourishment 2068													
	CONSTRUCTION ESTIMATE TOTALS:	$9,210	$2,579	28%	**$11,789**		$9,390	$2,629	$12,019			$25,583	$7,163	$32,746
01	LANDS AND DAMAGES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
	PED, PM, Life Cycle Updates, E&D, Contracts	$1,000	$280	28%	$1,280	3.7%	$1,037	$290	$1,327	2068Q1	1375.8%	$15,298	$4,284	$19,582
31	CONSTRUCTION MANAGEMENT													
	Construction Management, PM, Contracting	$750	$210	28%	$960	3.7%	$777	$218	$995	2068Q2	1395.3%	$11,625	$3,255	$14,880
	CONTRACT COST TOTALS:	$10,960	$3,069		**$14,029**		$11,204	$3,137	$14,341			$52,506	$14,702	**$67,208**

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

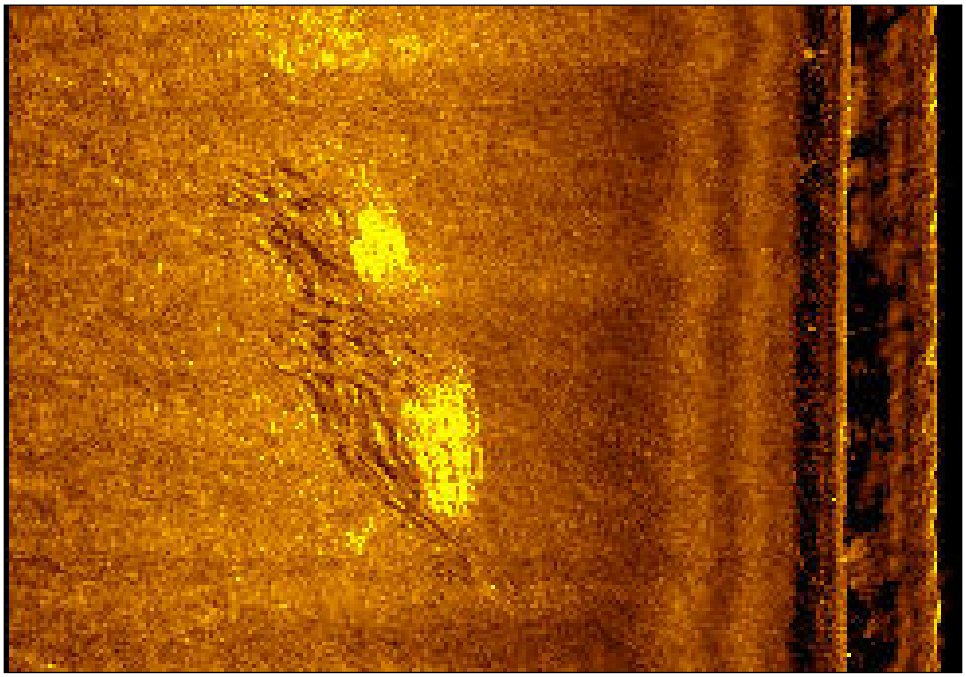
APPENDIX E

ARCHAEOLOGICAL SURVEY

US Army Corps of Engineers
Wilmington District

An Archaeological Remote Sensing Survey of Bogue Banks Offshore Borrow Areas, Carteret County, North Carolina

Contract Number: DACW54-03-D-0002 Delivery Order: CV04



Side Scan Sonar Image of a Possible Shipwreck Borrow Area Q2

Submitted to:
U.S. Army Corps of Engineers
Wilmington District

Submitted by:
Mid-Atlantic Technology and Environmental Research, Inc.

An Archaeological Remote Sensing Survey of Bogue Banks Offshore Borrow Areas, Carteret County, North Carolina

Contract Number: DACW54-03-D-0002 Delivery Order Number: CV04

Submitted To:

U.S. Army Corps of Engineers
Wilmington District
69 Darlington Avenue
Wilmington, North Carolina 28403

Submitted By:

Mid-Atlantic Technology and Environmental Research, Inc.
441 Blossom Ferry Road
Castle Hayne, North Carolina 28429

Principal Investigator:

_____
Wes Hall

20 December 2008

ABSTRACT

The U.S. Army Corps of Engineers Wilmington District (USACE) is conducting preliminary investigations of four proposed sand borrow areas totaling +/- 18,500 acres, for beach re-nourishment projects at the communities of Emerald Isle, Indian Beach, Pine Knoll Shores, and Atlantic Beach, in Carteret County, North Carolina. As a part of these investigations, Mid-Atlantic Technology and Environmental Research, Inc. (M-AT/ER) of Castle Hayne, North Carolina, conducted marine magnetometer and side-scan sonar surveys of the proposed borrow areas for the purpose of identifying any potential archaeological resources that might be impacted by the offshore dredging activities during the sand mining process.

In addition to archaeological resources, M-AT/ER conducted a search to identify hard bottom/marine habitat areas, using side-scan sonar record analysis as part of the remote sensing investigations. M-AT/ER conducted historical research and field investigations for the project between 15 December 2006 and 10 July 2007.

A total of 33 magnetic and or acoustic anomalies were selected as targets or target clusters in Borrow Area Q2. One target was identified within Borrow Area Y. No unidentified remote sensing targets were identified within Borrow Area Q1 or U. Of the total 34 selected targets in Borrow Areas Q2 and Y, ten (10) did not demonstrate characteristics that have the potential to be associated with a significant submerged cultural resource such as a historic shipwreck. No addition investigations or mitigation has been recommended for these targets.

The remaining twenty four (24) targets or target clusters in Borrow Area Q2 and Y do have characteristic that could be associated with a significant submerged cultural resource. These targets are recommended for either additional underwater investigations to identify and access the target's cultural resource potential, or avoidance of potential impact by the creation of a no-impact buffer zone that surrounds the anomaly or cluster of anomalies.

No natural hard bottom was identified within Borrow Areas Q1 or Q2. However, Borrow Area Q1 does have large areas that are part of the North Carolina Artificial Reef Program including an area of widely scatter tires.

Relatively small areas of hard bottom were identified and mapped within Borrow Areas U and Y.

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INTRODUCTION

The U.S. Army Corps of Engineers Wilmington District (USACE) is conducting preliminary investigations of four proposed sand borrow areas totaling +/- 18,500 acres, for beach re-nourishment projects at the communities of Emerald Isle, Indian Beach, Pine Knoll Shores, and Atlantic Beach, in Carteret County, North Carolina. As a part of these investigations, Mid-Atlantic Technology and Environmental Research, Inc. (M-AT/ER) of Castle Hayne, North Carolina, conducted marine magnetometer and side-scan sonar surveys of the proposed borrow areas for the purpose of identifying any potential archaeological resources that might be impacted by the offshore dredging activities during the sand mining process. This work was conducted pursuant to provisions of Section 106 of the National Preservation Act of 1966 (36 CFR 800, Protection of Historic Properties) and the Abandon Shipwreck Act of 1987 (Abandon Shipwreck Guidelines, National Park Service, Federal Register, Vol. 55, No. 3, 4 December 1990, pages 50116-50145) [1].

In addition to archaeological resources, M-AT/ER conducted a search to identify hard bottom/marine habitat areas, using side-scan sonar record analysis as part of the remote sensing investigations. M-AT/ER conducted historical research and field investigations for the project between 15 December 2006 and 10 July 2007.

PROJECT LOCATION

The four survey areas are located between 2 and 5 nautical miles offshore of Bogue Banks and the towns Emerald Isle, Indian Beach, Pine Knoll Shores, and Atlantic Beach, North Carolina. Figures 1 and 2 show the project location and the relative position of each borrow area, followed by Figures 3 through 6 that provide detail of each survey area. North Carolina State Plane coordinates (NAD 83) are included for reference.

---

[1] **A national policy for historic preservation has been established in accordance with authorization contained in Sections 106 and 110 (formerly E.O. 11593) of the National Historic Preservation Act of 1966, as amended following the Advisory Council on Historic Preservation Regulations (36 CFR 800). Executive Order 11593 and the Historic Preservation Act Amendments of 1980 specified that the Federal Government shall provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the nation. In 1988, the Abandoned Shipwreck Act (Public Law 100-298) declared that the states (or territories of the U.S.) are to manage shipwrecks in state waters. As a result of these acts and other legislation, state and federal agencies are required to administer cultural properties under their control in a spirit of stewardship and trusteeship. Each agency is required to initiate such measures as are necessary to insure that policies, plans, and programs will preserve sites, structures, and objects of historical or archaeological significance that exist on properties owned by the Federal Government or that are subject to federal regulation.**

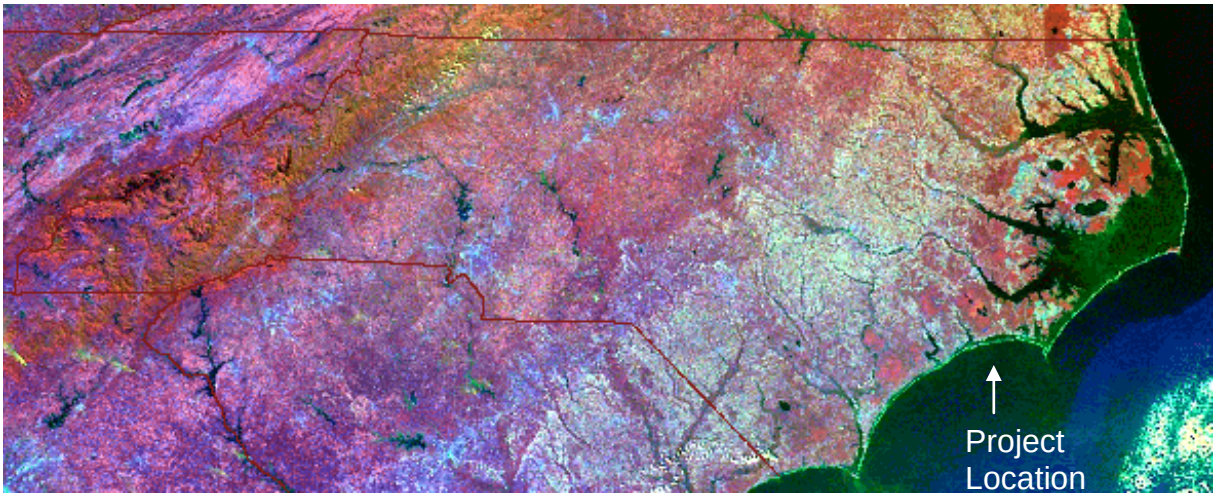

Figure 1. Project Location Map.

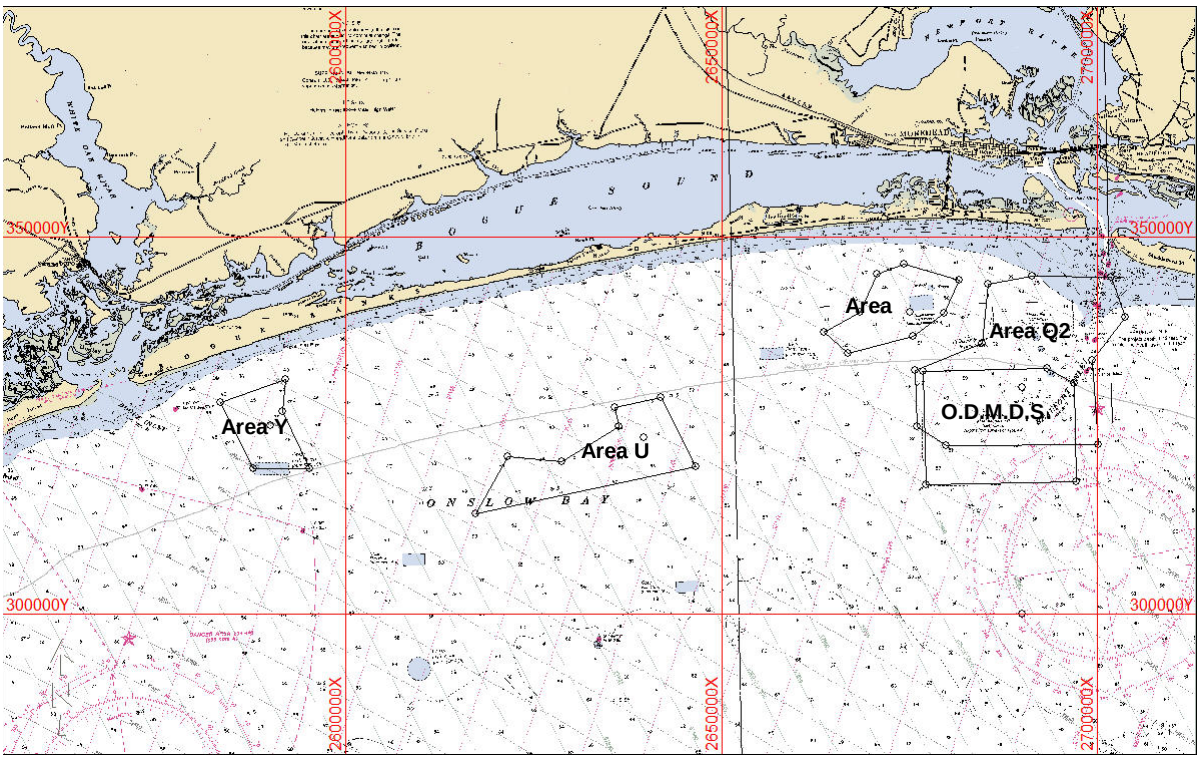

Figure 2. Relative Position of Borrow Areas.

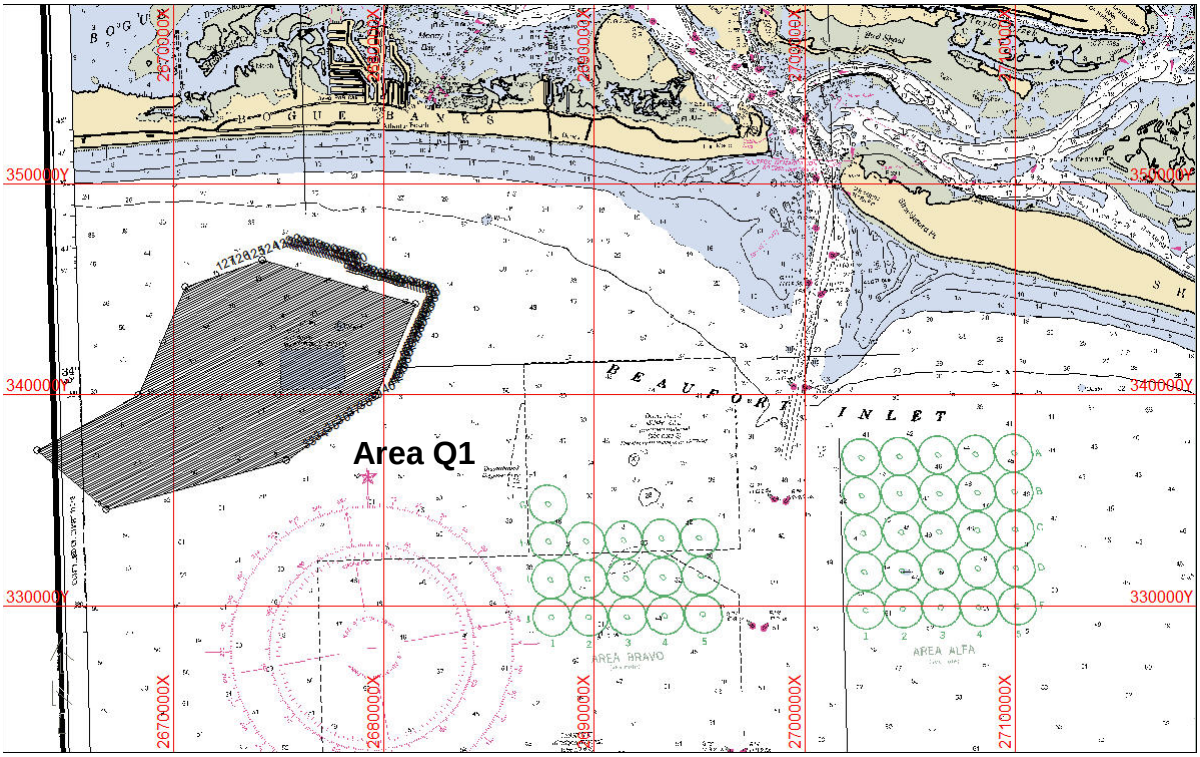

Figure 3. Borrow Area Q1.

The Borrow Area Q1 survey consisted of 127 lines @ 100ft/30m spacing, totaling more than 1,119,998 linear ft/302 nautical miles with water depths of 45 to 50 ft.

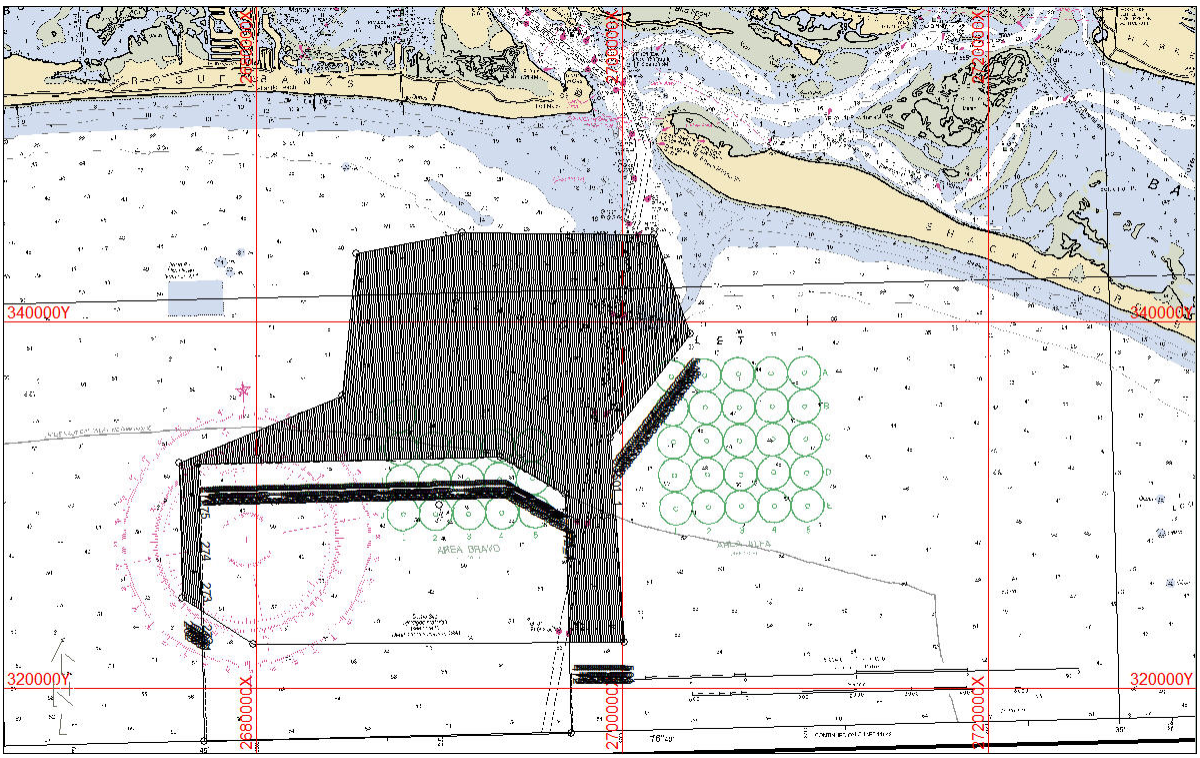

Figure 4. Borrow Area Q2.

The Borrow Area Q2 survey consisted of 480 lines @ 65ft/20m spacing, totaling 4,001,421 linear ft/658 nautical miles with water depths of 15 to 53 ft.

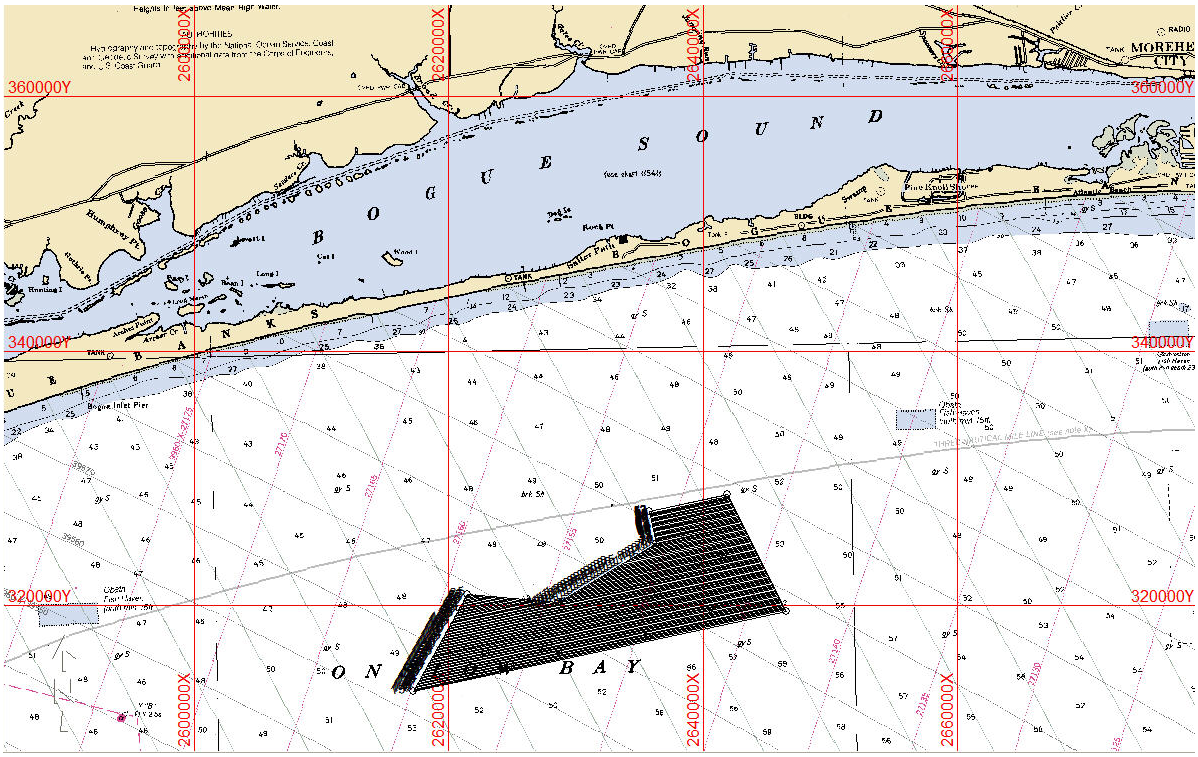

Figure 5. Borrow Area U.

The Borrow Area U survey consisted of 141 lines @ 100ft/30m spacing, totaling 1,839,554 linear ft/302 nautical miles with water depths of 51 to 57 ft.

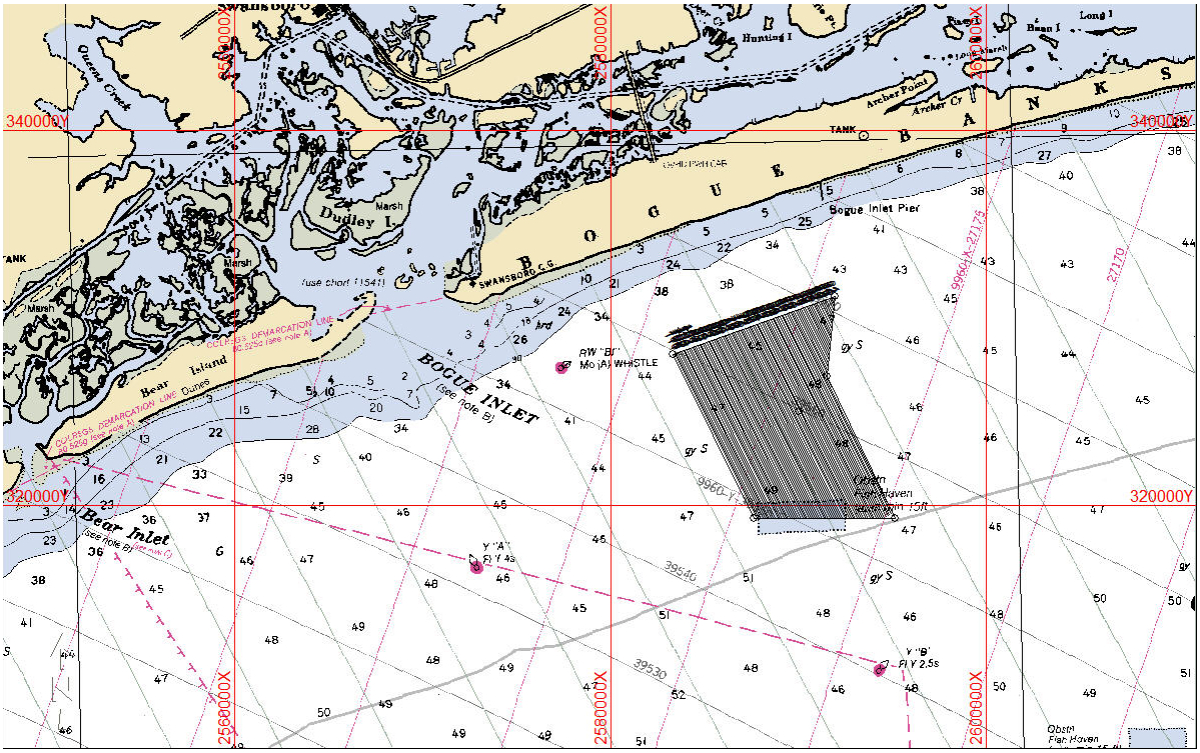

Figure 6. Borrow Area Y.

The Borrow Area Y survey consisted of 111 lines @ 100ft/30m spacing, totaling 795,834 linear ft/131 nautical miles with water depths of 44 to 49 ft.

HISTORICAL BACKGROUND

North Carolina's barrier islands formed nearly 18,000 years ago when coastal areas submerged during the Holocene epoch. High sand ridges built up along the mainland beaches by wind and water action, during the last period of glaciations. As the sea level rose, the ridge system failed, causing low-lying areas behind to flood. As a result, lagoons and shallow sounds were formed, leaving the existing dune ridges as barrier islands.

Inlets are formed by the wave action and shifting sands. Most of the inlets are temporary, either migrating along the coast or closing altogether as near shore currents transport sand parallel to the coastline. Permanent inlets occur along the southern coast where the mouths of significant rivers provide enough force to maintain stable inlets (Tubby 2000:59).

In the late seventeenth century, the region particularly around Cape Lookout was commonly visited by New England whalers where they set temporary camps among the dunes (Angley 1982:5). Permanent settlement of the Bogue Banks began in the early eighteenth century. In 1720 Cristopher Gale received a patent for 9,461 acres, "being on the banks and Marshes adjacent betwixt Topsail and Bogue Inlet and is commonly called Bogue Banks and Bogue Island" (Angley 1984:1).

In 1722, Beaufort was appointed as "a port for the unloading and discharging [of] vessels," it was clear that development and growth would depend on trade entering and clearing through Beaufort Inlet (Paul 1970:370373; Angley 1982:8). Unlike many of the inlets along the North Carolina coast, Beaufort Inlet was relatively stable and open and offered a safe and deep channel for ship traffic (Stick 1958:312).

Throughout the eighteenth century Beaufort and Bogue Inlets were of only local importance to trade and travel. As in most of eastern North Carolina, early trade centered around lumber products. Beaufort Inlet served the rich Newport River area plantations and the Bogue Inlet served the White Oak River and its tributaries. Naval stores, lumber, and agricultural goods from both these areas were exported to the West Indies in exchange for glassware, cloth, furniture, coffee and rum (Angley 1984:1).

Beaufort supported a strong, though small, shipbuilding industry (Tatham 1806). In 1810, Jacob Henry, a former representative from Carteret County to the North Carolina House of Commons, commented upon the local shipbuilding industry at Beaufort:

> The principal trade carried on here is ship building in which they have acquired a very considerable reputation. Live oak and Cedar are the timbers principally used but the stock is by no means so abundant as it has been. Some of the swiftest sailors and best built Vessels in the United States have been launch'd here, particularly the Ship Minerva, a well known Packet between Charleston and New York. There are at present five Vessels at the Stocks, two of which are ready to be launch'd (Newsome 1929:399 Watts 1997:5).

In 1815, a hurricane struck the Bogue Banks area and devastated Beaufort. The storm was described as "being one of the most violent and disastrous ever known upon the coast." Because of the storm Beaufort Inlet changed significantly; the bar was "injured so that but 12 feet could be brought over it at low water." Fortunately the channel eventually recovered from the storm's damage and by 1830 depth on the bar had increased to eighteen feet at mean low water. By 1854, the bar channel had decreased slightly to a depth of 15 1/2 feet and had migrated slightly to the south (Watts 1997:5).

The development of the railroad in the mid-nineteenth century brought significant changes to Beaufort and the development of a new port facility at Sheppard's Point creating a decline in commerce through Beaufort. In 1841, John Motley Morehead, then governor of North Carolina, began to promote the idea of the establishment of a port facility at the eastern terminus of the Atlantic and North Carolina Railroad. By 1858 the port and rail facility had become a reality. The editor of the Greensboro *Patriot* described the conditions and natural advantages which he believed would benefit maritime traffic through Beaufort Inlet to the new port facility at Morehead City in September 1858:

> Beaufort, is about three miles, this being about the widest part of the harbor. The channel is in the form of a half-moon, one horn running eastwardly along the Shackleford banks, called Core Sound, and the other westwardly by Morehead and Carolina cities, which are situated on Bogue Sound. The deepest water is along Newport River, which runs in nearly a north direction between Morehead City and Beaufort, touching the railroad wharf in the former place. The main channel is about one mile wide, so that the inside of the channel would be some two miles from Beaufort, though vessels drawing from nine to ten feet water can approach the Beaufort wharves at full tide. Running up the channel about three miles from the bar, we come to the railroad wharf at Morehead City, where vessels drawing eighteen feet can approach with ease, and unload and take in lading with the greatest safety (Konkle 1922:341-342).

Within six months the rail and port facility at Morehead City was prospering. Ships were continually calling at the wharfs and being loaded with cargoes directly from train cars (Konkle 1922:360-361).

The Civil War closed Beaufort Inlet to trade and disrupted the lives of the inhabitants of Morehead City and Beaufort. Union forces took Morehead City on March 22, 1862. Just days later Union troops crossed the Newport River and took control of Beaufort. Confederate forces still controlled Fort Macon, however. On April 22, several Union vessels anchored near Harker's Island to the east of Beaufort, including the steamer *Alice Price* which served as General Burnside's temporary headquarters. A Union gunboat and one or two smaller vessels were positioned inside Beaufort Inlet, controlling the approaches and exits to Bogue and Core Sounds. By April 25 a fierce battle ensued and the fall of Fort Macon was imminent, Confederate forces burned the bark *Glen* on April 25 to keep it out of Union hands.

On April 26, Colonel Moses J. White, commander of Fort Macon, surrendered to Generals Parks and Burnside on Shackleford Banks (Angley 1982:34; Stick 1958:148-153).

The occupation of Fort Macon and the surrounding vicinity provided Union naval forces with access to a deep-water port and place of rendezvous that was used to support the blockading squadron throughout the remainder of the war. During December 1864 and January 1865, a fleet under the command of Admiral David Porter massed at Beaufort Harbor in preparation for their assault on Fort Fisher in Wilmington, the last major stronghold of the Confederacy in North Carolina. During the Civil War at least five Confederate vessels were captured at sea in the Cape Lookout area: the schooners *Edwin, Julia, Revere,* and *Louisa Agnes,* captured in 1861; and the steamer *Banshee,* taken on November 21, 1863 (Angley 1982:35; Price 1948:n.p.). One Confederate vessel was totally lost in the vicinity as a result of enemy action. On July 9, 1864, the side-wheel steamer *Pevensey* was chased ashore and blown up on Bogue Banks, approximately nine miles west of Beaufort Inlet (Hill 1975:11-13). Not all known shipwrecks near Beaufort were a result of enemy action. On June 12, 1863, while en route from the Delaware Capes to Charleston, the U.S.S. *Lavender* ran aground in heavy seas near Cape Lookout Shoals. The *Lavender* was a screw tug of 173 tons. On July 20, 1865, the 186-ton Union screw steamer *Quinnebaugh* went ashore on Beaufort bar in rough weather after her machinery failed. The *Quinnebaugh* was transporting Union troops, refugees, and civilians north at the time of her loss (Shomette 1973:88-89; Berman 1972:141; Lytle and Holdcamper 1975:291).

Although of lesser importance, Bogue Inlet was also blockaded by Union forces. Because of ongoing concerns that the Confederates were using Bogue Inlet to supply the Confederate war effort, the U.S.S. *Ellis* under the command of William B. Cushing was sent to maintain the blockade in mid-October 1862. Use of Bogue Inlet to run the blockade appears to have been somewhat limited. Only a single schooner was reported lost at the inlet during the war years. The schooner was reported “ashore on the west breaker” at Bogue Inlet in mid-November 1863 (Angley 1984:6).

Just six years after the Civil War, the federal government began measures to reduce the severity of maritime disasters along the coast by establishing the United States Life Saving Service. In 1874, seven stations were established along the North Carolina coast. In 1875 a similar station was authorized by Congress for Cape Lookout. However, was not until ten years later that the station was finally built. Over the following years three other live saving stations were established on Core Banks, and a station was also established near Fort Macon (Angley 1982:35-36; Stick 1958:169-170, 310-313). It was not until the early twentieth century that Congress also recognized the need for a life saving station at Bogue Inlet (Angley 1984:11).

In the latter years of the nineteenth century the U.S. Army Corps of Engineers conducted several investigations on the feasibility of improvements to navigation of the White Oak River and Bogue Inlet. During that time produce including naval stores, cotton, peanuts, lumber, and fish from the White Oak River and Swansboro were transported to Beaufort Harbor by small boats that navigated the sound. After several studies, the various proposed projects including a jetty to help stabilize the inlet were disapproved as being at a cost that exceeded demand (Angley 1984:8-10).

Commerce on the White Oak River in 1906 was determined to be 21,532 tons most of which was timber and sawn lumber. The remaining tonnage consisted of seafood, agricultural commodities and some general merchandise. Almost all of the cargo passed from Swansboro through the inland channel to Morehead City or Beaufort (Angley 1984;13). Until the 1920s Beaufort was the southern terminus of of the Intracoastal Waterway along the Atlantic Seaboard. In 1932, the Intracoastal Waterway was extended from Beaufort to the Cape Fear River south of Wilmington. By 1938, traffic on the waterway consisted of 8,500 motor vessels, 200 barges, and 300 tugs conducting 9,000 trips. Intracoastal Waterway became a primary artery for cargo including seafood, fertilizer, agricultural products, lumber, petroleum product and other merchandise (Angley 1984;14).

Following the Civil War at Morehead City and Beaufort the fishing industry became an important source of income. Menhaden fishing was of particular importance. From 1865 to 1873, the State of North Carolina’s first menhaden processing plant was in operation on Harker's Island. By 1900 several menhaden plants were in operation at various locations on Bogue and Core Sounds including Beaufort (Hill 1975:16-18 Watts 1997:7).

Although the fishing industry was growing, the port at Morehead City developed slowly. Limited traffic through the port was mostly attributed to the depth of water over the bar of the entrance channel to Beaufort Inlet. The size of the shoals related to the bar was also increasing in size. By the 1880s the Federal government began to make improvements to the inlet in an attempt to increase maritime trade to port. Over the next eight years five jetties were constructed on Shackleford Point and another six jetties were constructed on Fort Macon Point. By 1889 the deterioration of the inlet had been halted (Angley 1982:40). To further improve the inlet the entrance channel across the Beaufort Inlet bar was dredged to a depth of 20 feet at mean low water in 1905 and 1907. A 20-foot channel, 200 feet wide, was also established between the inlet and the wharves at Morehead City. A smaller channel, seven feet deep and 100 feet wide, was created to serve the wharves along the Beaufort waterfront (Angley 1982:40).

In 1912 federal records indicate 12 sailing vessels and 35 gasoline powered vessels were registered at Morehead City. At Beaufort 175 sailing vessels, 240 gasoline powered vessels, and six barges were registered. Between 1 July 1898 and 3 June 1908, 82 vessels were reported lost off the North Carolina coast (Angely 1982:42).

In 1923 the tugboat *Juno* sank in the Beaufort Inlet channel creating a hazard to navigation and caused great difficulty to vessels attempting to use the inlet. The wreck of the *Juno* was eventually leveled with explosives but the need for channel improvements was clear. Beginning in 1926 the federal government made considerable improvements to the use of the Port of Morehead City by increasing the depth of the channel from Beaufort Inlet from 20-feet to 30-feet (Stick 1952:237-238 Watt 1997:9-10).

During World War Two German submarines brought war within sight of coastal communities. On one night, March 18, 1942, German submarines sank three tankers in the Cape Lookout area: the *Papoose,* the *W. E. Hutton,* and the *E. M. Clark.* Just five days later another tanker, the *Naeco* was sunk in the same vicinity (Stick 1952:234). Following the attacks, coastal communities of North Carolina were developed "black out" system along with coastal watches. In addition, a more efficient convoy system for tankers and other commercial vessels was devised. Additional planes and patrol vessels were also put into service particularly for the Cape Lookout area (Stick 1952:237-239 Watts 1997:10).

The value of deepwater ports was recognized by the North Carolina State Legislature in 1945 with the creation of the NC State Ports Authority. In 1949 the General Assembly approved the issue of $7.5 million in bonds for construction and improvement of seaports to promote trade throughout the state. Terminals equipped to handle oceangoing vessels were completed at Wilmington and Morehead City in 1952. Their positions nearly midway between major competing ports in Virginia and South Carolina made them more accessible to North Carolina traders. Morehead City has become a major port for products including phosphate, scrap metal, sulfur, rubber asphalt and other bulk products. At Morehead City, planning continues for expansion onto Ports Authority property on Radio Island and preparing for the larger ships of the future (ncstateport.com).

PRE-SURVEY CONSULTATION AND DOCUMENTATION

As part of the investigative effort, M-AT/ER first conducted a literature search to help document man's activities in the vicinity and to provide a historical context for the assessment of potential cultural resources discovered offshore. The search helped to determine the extent and type of commercial and naval activity offshore, which further assisted in the assessment of targets identified during field investigations. This research focused on primary and secondary materials, as compiled by environmental and archeological agencies responsible for managing the State's cultural resources and depositories, such as libraries and museums. In addition, research included consultation with local historians and the State Underwater Archaeologist at Fort Fisher.

The following offices and/or institutions were contacted:

- Underwater Archaeology Unit, Division of Archives and History, Fort Fisher, NC
- North Carolina Maritime Museum, Beaufort, NC
- NC State Archives
- Office of the Historian, U.S. Coast Guard, Washington, D.C.
- Marine Casualty Branch, U.S. Coast Guard
- Maritime Historian, Sanctuaries and Reserves Division, National Oceanic and Atmospheric Administration

Preliminary secondary sources examined:

- The Encyclopedia of American Shipwrecks
- Merchant Steam Vessels of the United States 1807 - 1868
- Shipwrecks of the Western Hemisphere
- Shipwrecks of the Civil War
- Official Records of the Union and Confederate Navies in the War of the Rebellion
- Automated Wreck and Obstruction Information System of the National Oceanic and Atmospheric Administration
- Web Site Review of http://anchor.ncd.noaa.gov/awois/search.cfm
- Historical Maps and Charts

Researchers reviewed source materials at each institution and conducted interviews with librarians/technical staff to determine the best potential sources for background information. A list of known or potential shipwrecks has been developed for the vicinity.

DESCRIPTION OF INVESTIGATIONS

Remote Sensing Survey

M-AT/ER's underwater archaeology team conducted the survey from two equally equipped survey vessels. One vessel was 25-feet in length and the other was 36-feet in length. Two primary remote sensing devices were used: a Geometrics 881 cesium marine magnetometer and a Marine Sonic 600 kHz digital, side-scan sonar. Each instrument was interfaced with a Starlink Differential Global Positioning System.

For each vessel, data was collected along parallel lines spaced at 100-foot intervals in Borrow Areas Q1, U, and Y and at 65-foot intervals in Borrow Area Q2. Magnetic data, along with corresponding positioning data, was recorded at .5-second sample intervals (or approximately every 5 feet along a track line at 6 knots) using HYPACK™ data acquisition software. A 50 pound tri-wing depressor was utilized to maintain the magnetometer tow sensor at a depth of 10 to 20 feet above the bottom within each survey area. The 881 sensor was trailed behind the depressor. At 6 knots the depressor's tow-line traveled at approximately a 40 degree angle to the transom of the survey vessel. Beginning at the offshore or deeper portion of each borrow area the magnetometer height was set. Using the angle of the depressor's tow line and its length, the height of the magnetometer sensor was adjusted to achieve a maximum of a 20-foot sensor height above the bottom.

Side scan sonar data was recorded with Marine Sonic Sea Scan® acoustic data acquisition software using an onboard PC computer system. Side Scan Sonar data was recorded at a scale of 164 feet (50 meters) per channel. The height of sonar fish was adjusted to achieve the best records for the conditions.

Magnetic Background Variation

Artificial induced variation in magnetic data or background noise was maintained at less than .1 nanoteslas at a sample rate of ½ second. Noise spikes, such as those produced by sharp turns or rapid changes in speed, were easily identified and removed during the data editing process. Once the data had been reduced to pole, the magnetic background was represented by the "zero value data" depicted in the magnetic contour maps.

Data Analysis / Cultural Resources

During field investigations, data being produced by the magnetometer, side-scan sonar and sub-bottom profiler were closely monitored. Targets (magnetic or acoustic) were identified and recorded as they were generated. Also noted on field records was information about the local environment, which included man-made features such as pipelines, channel markers, crab traps, and conditions that could influence magnetic or acoustic data.

After a survey area had been completed, archaeologists edited the magnetic data for detailed analysis and comparison to acoustic data. Editing was performed in three phases. The initial phase consisted of using HYPACK's single-beam editing program to review raw data (of individual survey lines) and to delete any artificially induced noise or data spikes. While editing survey lines, a preliminary target table was developed that included individual target coordinates, signature characteristics, intensity, and duration. Once all survey lines for an area were edited, the edited data was converted to an XYZ file (Easting and Northing State Plane Coordinates, and magnetometer data – measured in gamma), also using HYPACK. Next, the XYZ files were imported into a Triangular Irregular Network (TIN) modeling program (HYPACK) that was used to contour the data in 10-gamma intervals. Once the data was contoured, the contour graphic was converted to a DXF file and imported into AutoCAD in order to clearly view individual magnetic anomalies and their association with acoustic target signatures. Once in AutoCAD, additional editing of the total magnetic intensity was performed without affecting individual magnetic anomalies. For example, dramatic or pronounced diurnal changes that frequently will create a "striped," "zigzag," or "herring bone" pattern in the contour lines can be edited out and averaged across a survey area to create a more realistic and accurate contour map.

A second major analytical technique employed included the subtraction of general background from each successive data sample to develop the actual field gradient. The gradient is the vertical difference (z) between samples. By subtracting

successive data samples one from the other the effects of diurnal change is completely eliminated. The resulting data represents only the localized changes in the magnetic background created by ferrous object(s) (i.e. anomalies). When graphically represented by contouring (using the same method described above), only the intensity of variation is represented.

During the analysis process, magnetic anomalies were categorized using the anomaly intensity, duration and/or extent, and signature characteristics. In addition, the anomaly's geographic location was taken into consideration, as well as its association with acoustic target signatures.

After magnetic data was developed into a target list, acoustic data was examined using SeaScan™ acoustic data review software to identify any unnatural or man-made features in the records. Once identified, acoustic features were described using visible length, width, and height from the bottom surface. The coordinates of the acoustic features also were recorded.

Data Assessment (General)

Target signatures were evaluated using the National Register of Historic Places criteria[2] as a basis for the assessment. For example, although a historic object might produce a remote sensing target signature, it is unlikely that a single object (such as a cannon ball) has the potential to meet the criteria for nomination to the National Register of Historic Places.

Target assessment was based primarily on the nature and characteristics of the acoustic and magnetic signatures. Shipwrecks – large or small – often have distinctive acoustic signatures, which are characterized by geometrical features typically found only in a floating craft. Most geometrical features identified on the bottom (in open water) are manmade objects. Often an acoustic signature will have an associated magnetic signature. Generally, if the acoustic signature demonstrates geometric forms or intersecting lines with some relief above the bottom surface and have a magnetic signature of any sort; it can be categorized as a potentially significant target. Often, modern debris near docks, bridges, or an anchorage is easily identified solely based on the characteristics of its acoustic signature. However, it is more common to find material partially exposed. Frequently, these objects produce a record that obviously indicates a man-made object, but the object

2 To qualify for the National Register, a historic shipwreck must "meet one or more of the National Register criteria A, B, C, and D. Determining the significance of a historic vessel depends on establishing whether the vessel is 1) the sole, best, or a good representative of a specific vessel type; 2) is associated with a significant designer or builder; or 3) was involved in important maritime trade, naval, recreational, government, or commercial activities" The criteria is described thusly:

A. [B]e associated with events that have made a significant contribution to the broad patterns of our history; or

B. be associated with the lives of persons significant in our past;

C. embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. have yielded, or may be likely to yield, information important in prehistory or history.

(National Register Bulletin, U.S. Department of the Interior, National Park Service, Interagency Resources Division).

is impossible to identify or date. In making an archaeological assessment of any sonogram record, the history and modern use of the waterway must be taken into consideration. Naturally, historically active areas tend to have greater potential for submerged cultural resources. The assessment process prioritizes targets for further underwater archaeological investigations.

Magnetic target signatures alone are more difficult to assess. Without any supporting sonogram record, the nature of the bottom sediments and the water currents become more important to the assessment process. A small, single-source magnetic signature has the least potential to be a significant cultural resource. Although it might represent a cannon ball or historic anchor, this type of signature has little potential to meet National Register criteria.

A more complex magnetic anomaly, represented by a broad monopolar or dipolar type signature, has a greater potential to be a significant cultural resource, depending on bottom type. Shipwrecks that occur in regions with hard bottoms, with little migrating sand, tend to remain exposed and are often visible on sonogram records. A magnetic anomaly that is identified in a hard bottom area and has no associated acoustic signature frequently can be discounted as being a historic shipwreck. Most likely, such an anomaly is modern debris, such as wire rope, chain, or other ferrous material.

Soft migrating sand or mud can bury large wrecks, leaving little or no indication of their presence on the bottom surface. The types of magnetic signatures that a boat or ship might produce are infinite, because of the large number of variables including location, position, chemical environment, other metals, vessel type, cargo, sea state, etc. These variables are what determine the characteristics of every magnetic target signature. Since shipwrecks occur in a dynamic environment, many of the variables are subject to constant change. Thus, in making an assessment of a magnetic anomaly's potential to represent a significant cultural resource, investigators must be circumspect in their predictions.

Broad, multi-component signatures (again, depending on bottom characteristics and other factors) often have the greatest potential to represent a shipwreck. On the other hand, high-intensity, multi-component, magnetic signatures (without an accompanying acoustic signature) in areas of relatively high velocity currents can be discounted as a historic resource. Eddies created by the high-velocity currents almost always keep some portion of a wreck exposed. Generally, wire rope or some other low-profile ferrous debris produces this type of signature in these circumstances. Many types of magnetic anomalies display characteristics that are not easily interpreted. The only definitive method of determining the nature of the object creating these anomalies is by physical examination.

DESCRIPTION OF FINDINGS

Identification of Submerged Cultural Resource

Investigations to identify documented shipwrecks near the project area revealed that numerous ships have wrecked in the vicinity of Bogue Banks, Beaufort Inlet and Bogue Inlet (see Historic Shipwrecks in the Vicinity of Bogue Banks - Appendix A). The historic shipwreck tentatively identified as the *Queen Anne's Revenge* and currently undergoing investigation immediately north of Borrow Area Q2 helps to demonstrate the potential for other historic shipwrecks in the vicinity of Beaufort Inlet. Several targets were identified within Borrow Area Q2 that have similar remote sensing characteristic to the Queen Anne's Revenge shipwreck site.

Borrow Areas Q1 and U

No magnetic or acoustic anomalies that could be attributed to potential submerged cultural resources were found in Borrow Area Q1 or U. All magnetic and acoustic targets identified within these two borrow areas were found to be associated with either the North Carolina Artificial Reef Program or a single pipeline or cable.

Borrow Areas Y and Q2

Only one magnetic anomaly with an associated acoustic signature was identified in Borrow Area Y. It has been recommended for additional investigations or avoidance. In contrast, hundreds of magnetic anomalies were identified within Borrow Area Q2. Many of these magnetic anomalies are isolated low intensity targets with little potential to be associated with a significant submerged cultural resource. Some of the magnetic anomalies are clustered together suggesting they may be related and could be associated with the scattered remains of historic shipwrecks. These were grouped into target clusters.

Borrow Area Q1

Although there were numerous magnetic and acoustic target signatures in Borrow Area Q1 none were found to be associated with historic submerged cultural resources. All target signatures were associated with a variety of purposely sunken vessels, craft, tires and debris associated with the North Carolina Division of Marine Fisheries – Atlantic Beach Reef AR-315 (Figures 7, 8, 9, 10, and 11).

The following is a list of vessels, craft, and materials deposited at the reef since 1974 (source: www.ncfisheries.net/reefs/ar315a.htm):

Material	Deployment Date	Position (Decimal min.)
440' liberty ship *Theodore Parker*	4-Jun-74	34° 40.350' / 076° 44.717' to 34° 40.350' / 076° 44.767'
Tires: 177,168	1974-1984	Throughout area N of Lib. Ship
Steel Hull Sportfishing Vessel *Finest Kind*	02-Aug-77	Unverified
40' Coast Guard launch	1980	Unverified
Trawler *Helen May*	6-Jan-83	Unverified
60' lash barge #1, with 450 tons of concrete rubble on both	9-Jun-89	34° 40.233' / 076° 44.600'
60' lash barge #2	9-Jun-89	34° 40.400' / 076° 44.483'
Aircraft F-4	1992	34° 40.350' / 076° 44.650'
Aircraft A-4 (2)	1992	34° 40.367' / 076° 44.650'
Concrete Rubble	1991, 1992	34° 40.383' / 076° 44.650' to 34° 40.383' / 076° 44.667'
Bridge Rubble	1989	34° 39.983' / 076° 45.033'
Steel bridge framing	1989	34° 40.350' / 076° 44.583'
		34° 40.383' / 076° 44.583'
Reef Balls	21-Feb-00	34° 40.383' / 076° 44.500' to
		34° 40.400' / 076° 44.500'
		34° 40.400' / 076° 44.483'
104' Navy tug *Takos*	2-Nov-00	34° 40.320' / 076° 44.806'
Newport DOT Concrete Pipe	2002	34° 40.316' / 076° 44.820'
Newport DOT Concrete Pipe, Misc. Concrete, Radio Island Pilings	2003	34° 40.330' / 076° 44.793'
T.D. Eure Const. Radio Island Ramp Pilings (6-12' length, ~500 pieces)	2003	34° 40.280' / 076° 44.534'
T.D. Eure Const. Radio Island Ramp Pilings (6-12' length, ~500 pieces)	2003	34° 40.217' / 076° 44.617'
Carteret County Sportfishing Association Concrete Pipe (Heavy Concentration)	2003	34° 40.243' / 076° 44.600'
Carteret County Sportfishing Association Pilings (Round Disperse Pattern)	2003	34° 39.908' / 076° 45.189'
Carteret County Sportfishing Association and T.D. Eure Const. Broadcast of pilings and concrete pipe: (Quadrate Area Coord.) This area is ideal for casual drift bottom fishing that is away from the heaviest reef trolling and diving activity.	2003	34° 39.957 / 076° 45.129'
		34° 39.925' / 076° 45.062'
		34° 39.863' / 076° 45.085'
		34° 39.839' / 076° 45.156'
Reef Balls: 50, Ultra Ball: 1,	19-Mar-04	34° 40.200' / 076° 44.800'

DELETED

Figure 7. Magnetic Contour and Target Location Map Borrow Area Q1.

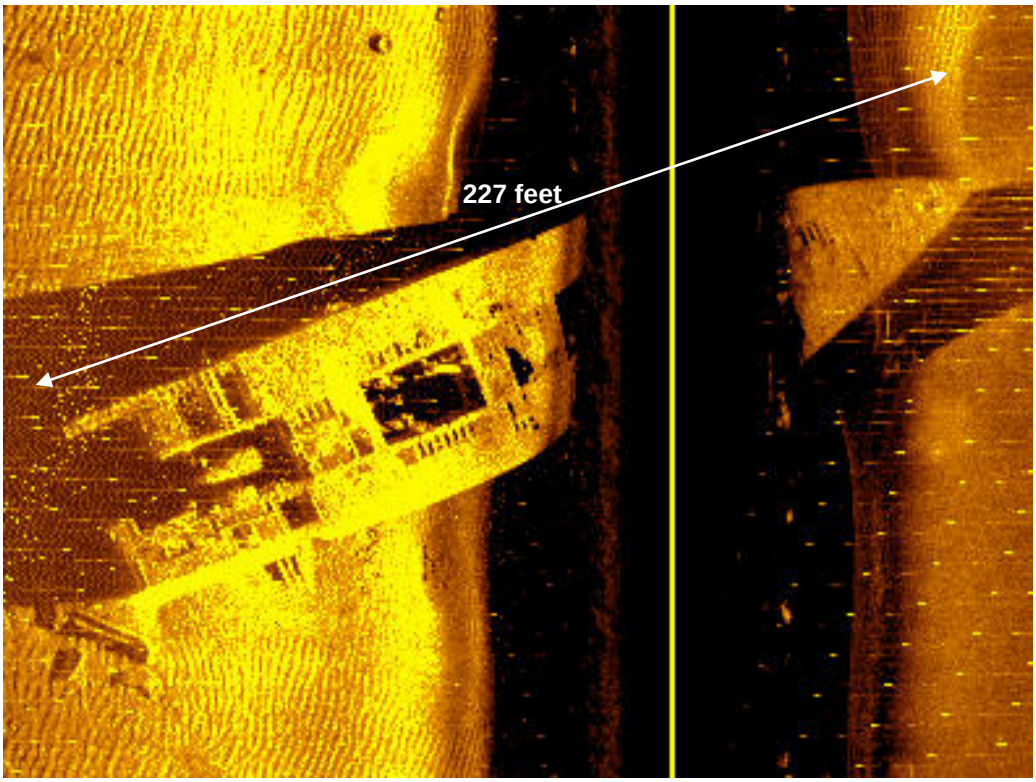

Figure 8. AR-315 Liberty Ship *Theodore Parker.*

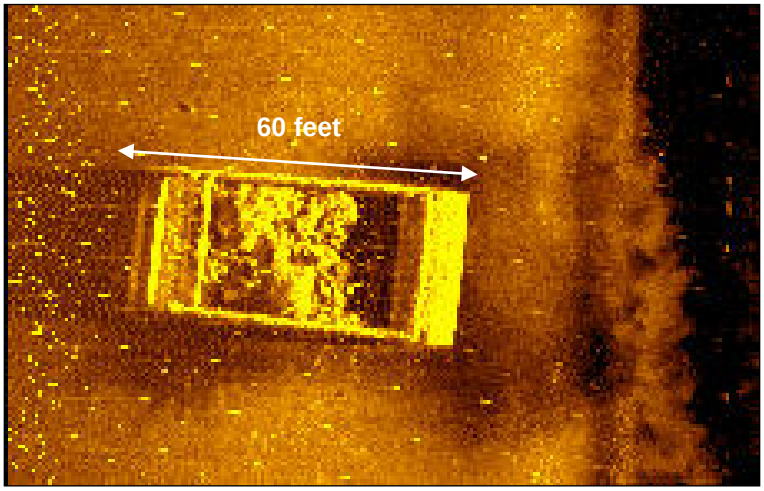

Figure 9. AR-315 Lash Barge.

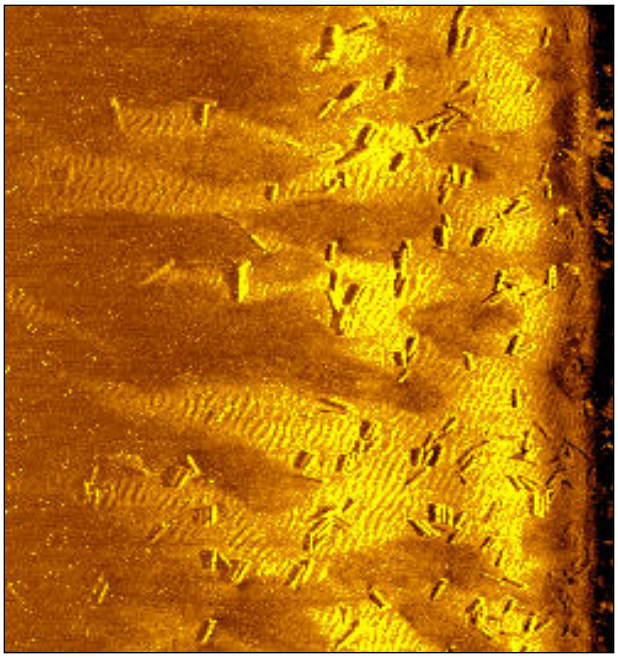

Figure 10. AR-315 Concrete Pipe.

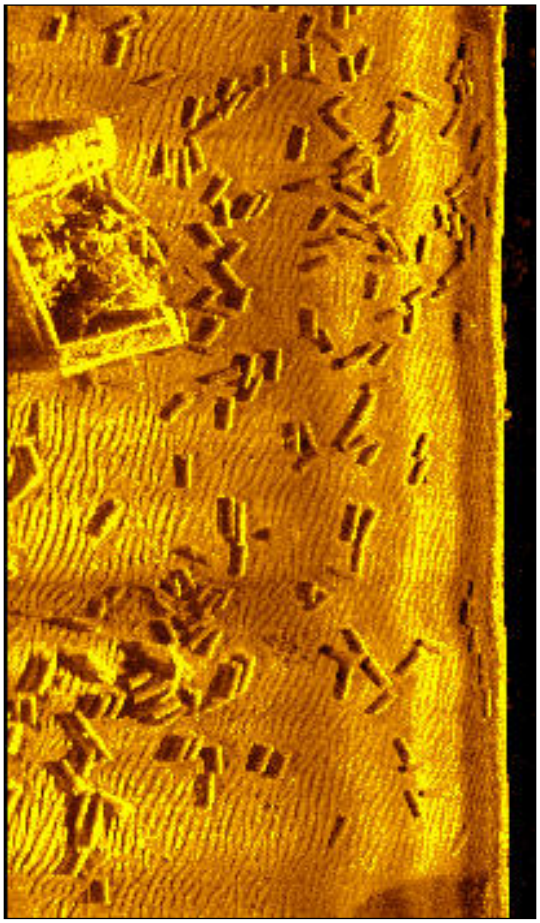

Figure 11. AR-315 Concrete Pipe and Lash Barge.

Borrow Area Q2

Borrow Area Q2 is positioned directly offshore to the South and West of historic Beaufort Inlet (Old Topsail Inlet). The eastern portion of Borrow Area Q2 includes the Beaufort Inlet entrance channel. There are numerous magnetic anomalies in Borrow Area Q2. Many of the anomalies are relatively low intensity as well as widely and randomly dispersed. Some of the magnetic anomalies are clustered together suggesting they may be related (Figure 13).

Rather than selecting and describing each individual magnetic anomaly as a target, most have been grouped into clusters based on proximity or relation to a corresponding acoustic signature. Isolated low intensity (less than 20 nT) magnetic signatures without a corresponding acoustic signature are not generally included in target signature descriptions. This is because isolated targets have minimum potential to be associated with a significant cultural resource based on National Register Criteria.

A total of 33 targets and target clusters are describe below:

Q2-1 - Cluster
NC State Plane x=2691236 y=343661

Target Cluster Q2-1 consisted of at least three dipolar magnetic anomalies on three survey lines with a maximum magnetic intensity of 18 nT. No acoustic target signature was identified in association with the magnetic anomalies. The low intensity, proximity, and characteristics of the targets signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least three single source objects with similar magnetic characteristics or one linear object such as a wire rope over 300 feet in length. The nature of the target cluster suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 12).

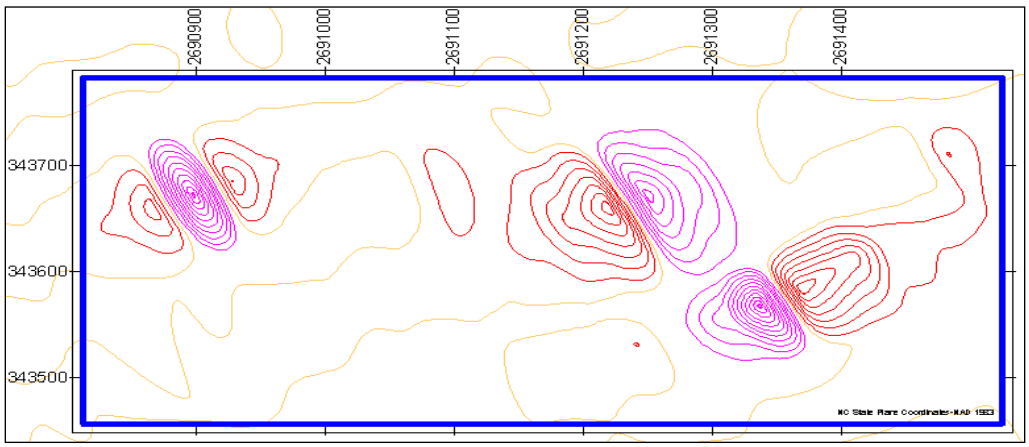

Figure 12. Target Cluster Q2-1 Magnetic Contour Signature.

DELETED

Figure 13. Magnetic Contour and Target Location Map Borrow Area Q2.

Q2-2 - Cluster
NC State Plane x=2693713 y=343620

Target Cluster Q2-2 consisted of at least two dipolar magnetic anomalies on three survey lines with a maximum magnetic intensity of 15 nT. No acoustic target signature was identified in association with the magnetic anomalies. The low intensity, proximity, and characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least two single source objects with similar magnetic characteristics or one linear object such as a wire rope over 200 feet in length. The nature of the target cluster suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 14).

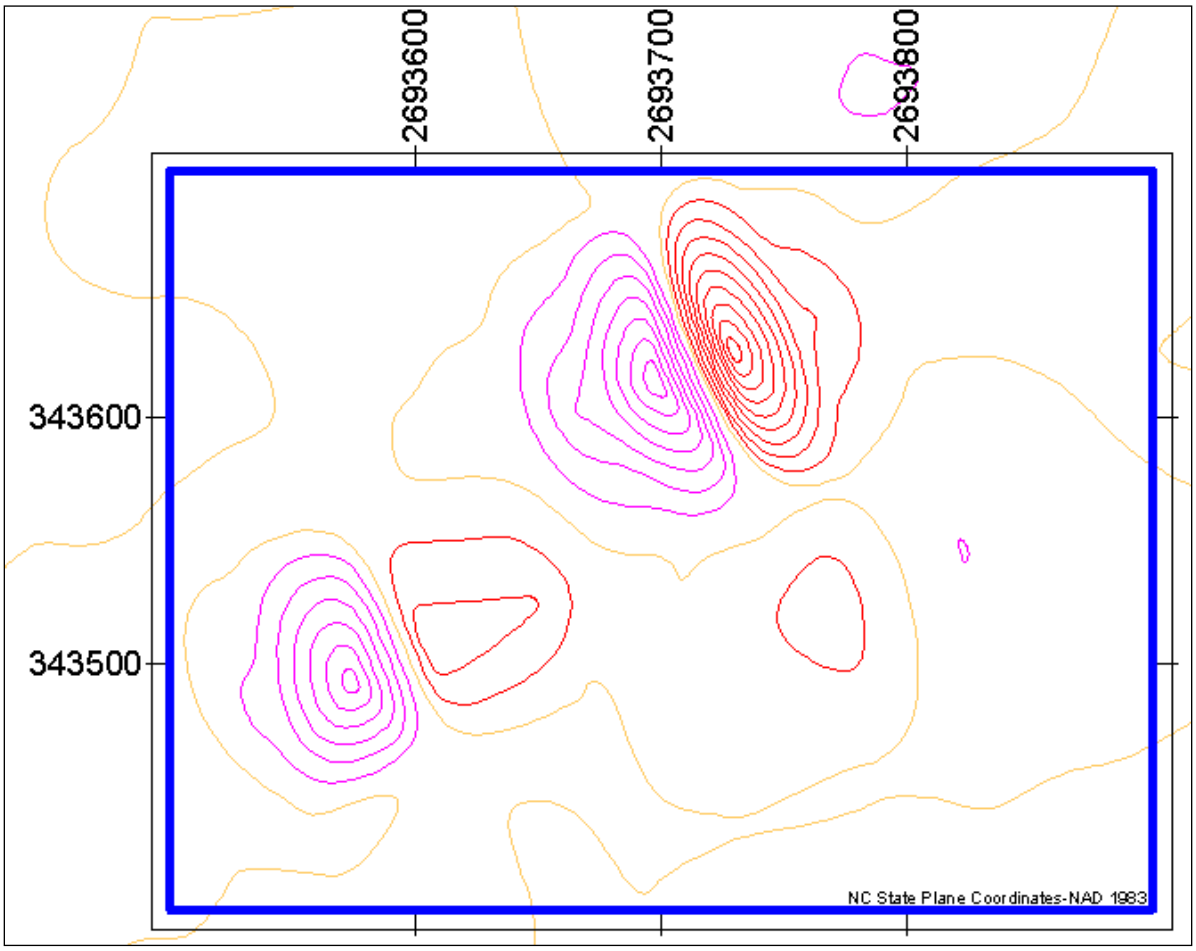

Figure 14. Target Cluster Q2-2 Magnetic Contour Signature.

Q2-3
NC State Plane x= y=

Target Q2-3 has a multi-component magnetic signature with an intensity of more than 51 nT measuring 72 feet between poles. No acoustic target signature was found in association with the magnetic signature. Q2-3 appears to be one or two single source anomalies in close proximity. The target is approximately 600 feet south of the known QAR (*Queen Anne's Revenge*) shipwreck site. The proximity to the historic shipwreck site in combination with the magnetic intensity and characteristics suggests the anomaly has the potential to be associated with a significant submerged cultural resource. Underwater investigations to identify the nature of the material producing the magnetic signature are recommended prior potential construction impacts. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The impact zone should include an area at least 600 feet to the north of Q2-3 and 200 to the south (Figure 15).

DELETED

Figure 15. Target Q2-3 Magnetic Contour Signature.

Q2-4
NC State Plane x= y=

Target Q2-4 has a multi-component magnetic signature with an intensity of more than 109 nT measuring 64 feet between poles. No acoustic target signature was found in association with the magnetic signature. Target Q2-4 appears to be a multiple source anomaly. The target has the potential to be associated with a significant cultural resource. Underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The impact zone should include an area at least 300 feet in diameter around the target coordinates (Figure 16).

DELETED

Figure 16. Target Q2-4 Magnetic Contour Signature.

Q2-5 - Cluster
NC State Plane x=2699997 y=344355

Target Cluster Q2-5 consisted of at least three dipolar magnetic anomalies on two survey lines with a maximum magnetic intensity of 5 nT. No acoustic target signature was identified in association with the magnetic anomalies. The low intensity, proximity, and characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least three single source objects with similar magnetic characteristics or one linear object such as a wire rope over 300 feet in length. The nature of the target cluster suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 17).

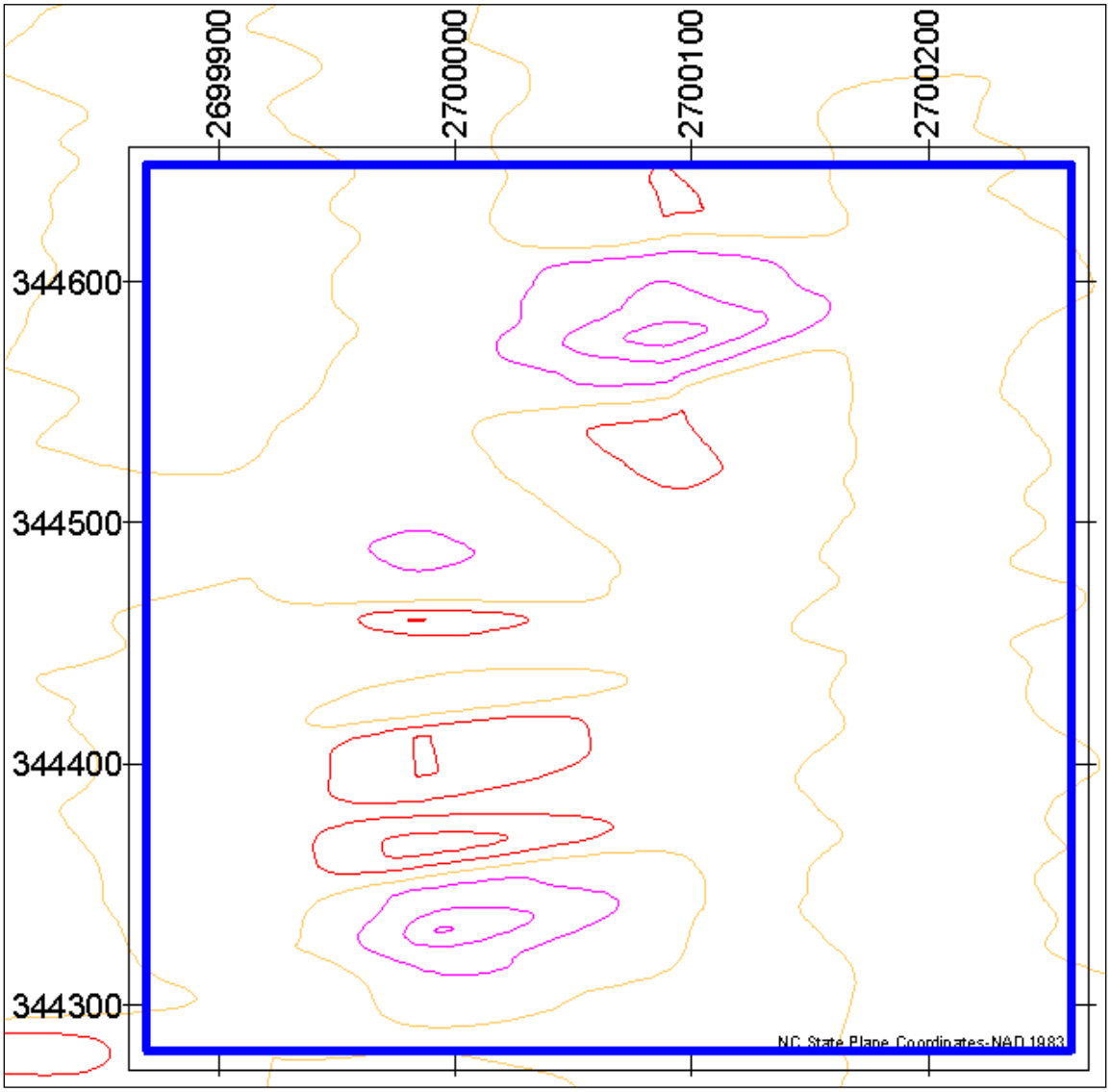

Figure 17. Target Cluster Q2-5 Magnetic Contour Signature.

Q2-6-Cluster
NC State Plane x=2700968 y=344019

Target Cluster Q2-6 consisted of at least two dipolar magnetic anomalies on two survey lines with a maximum magnetic intensity of 6 nT. A sonar image of 150 – foot long wire rope and 4 by 4 foot block buoy sinker was identified in association with the magnetic anomaly.

No additional underwater archaeological investigations are recommended (Figure 18 and 19).

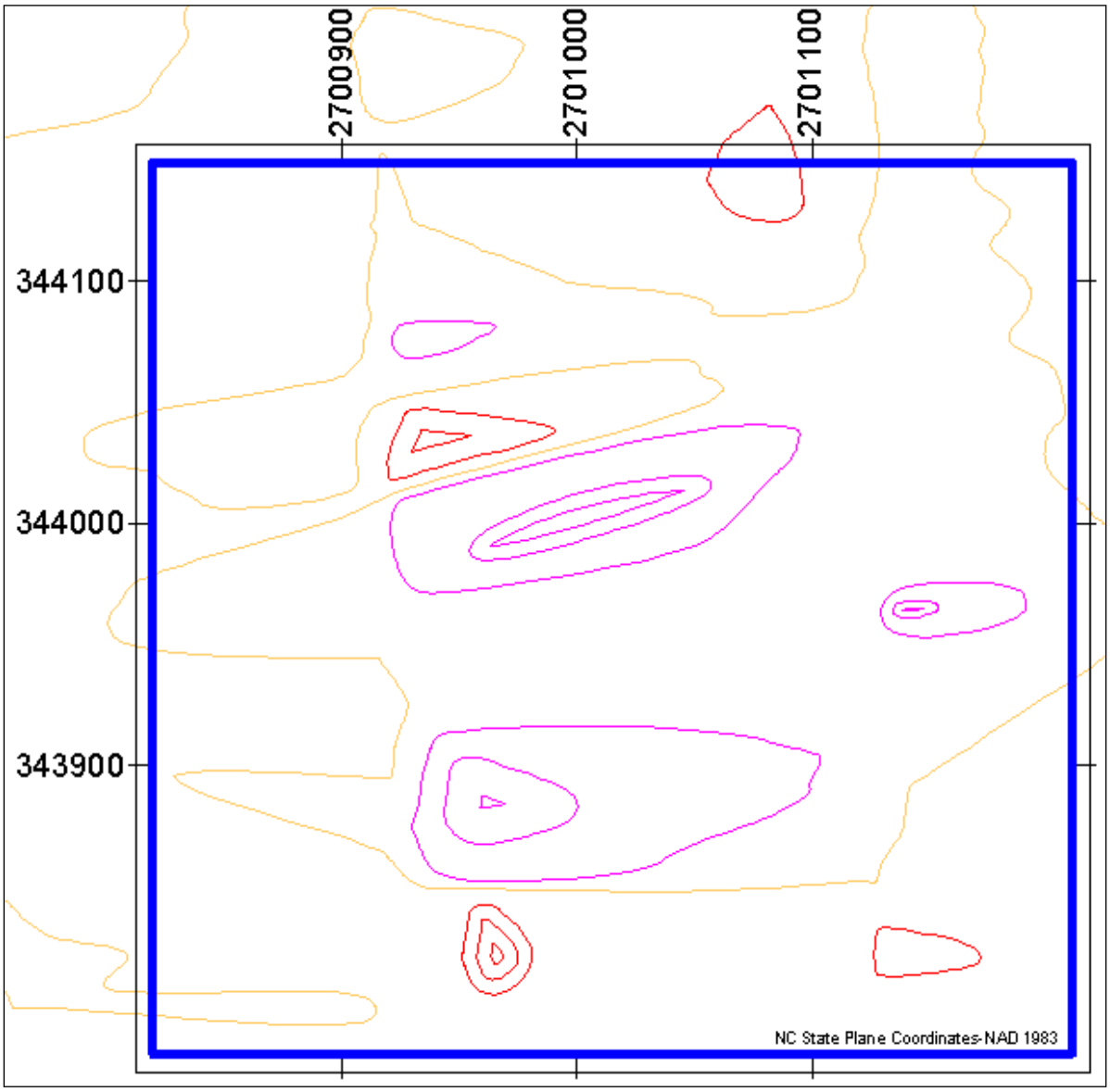

Figure 18. Target Cluster Q2-6 Magnetic Contour Signature.

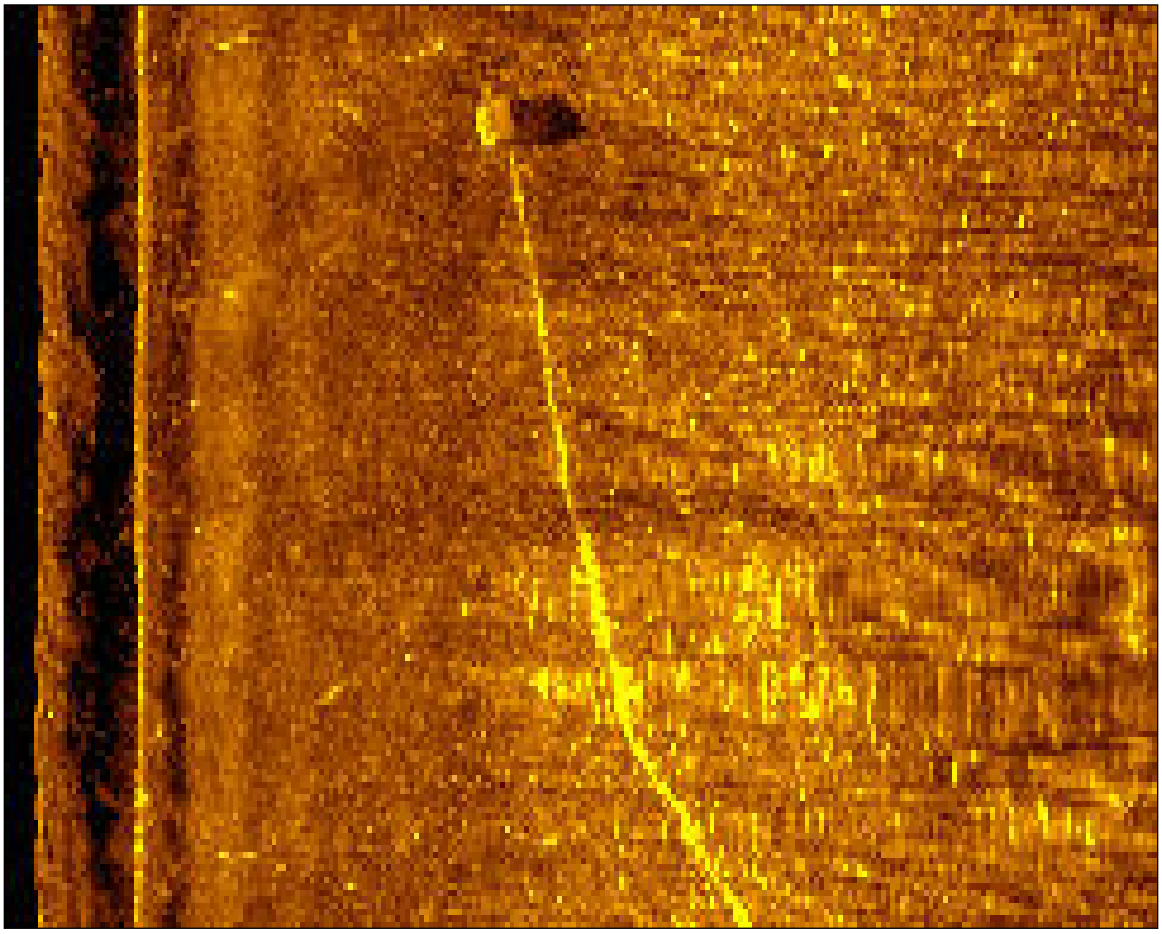

Figure 19. Acoustic Target Signature Q2-6.

Q2-7-Cluster
NC State Plane x= y=

Target Cluster Q2-7 consisted of at least seven multi-component and dipolar magnetic anomalies on four to six survey lines with a maximum magnetic intensity of 106 nT. The low intensity, proximity, and characteristics of the targets' signatures suggest they may be related. No acoustic target signature was found in association with the magnetic signature.

The target cluster has the potential to be associated with a significant cultural resource. Underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The impact zone should include an area at least 1200 feet in diameter around the target coordinates (Figure 20).

DELETED

Figure 20. Target Cluster Q2-7 Magnetic Contour Signature.

Q2-8 - Cluster
NC State Plane x=2698151 y=343529

Target Cluster Q2-8 consisted of at least three dipolar magnetic anomalies on three survey lines with a maximum magnetic intensity of 33 nT. The low intensity, proximity, and characteristics of the targets signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least two single source objects with similar magnetic characteristics or one linear object such as a wire rope over 150 feet in length. The nature of the target cluster suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 21).

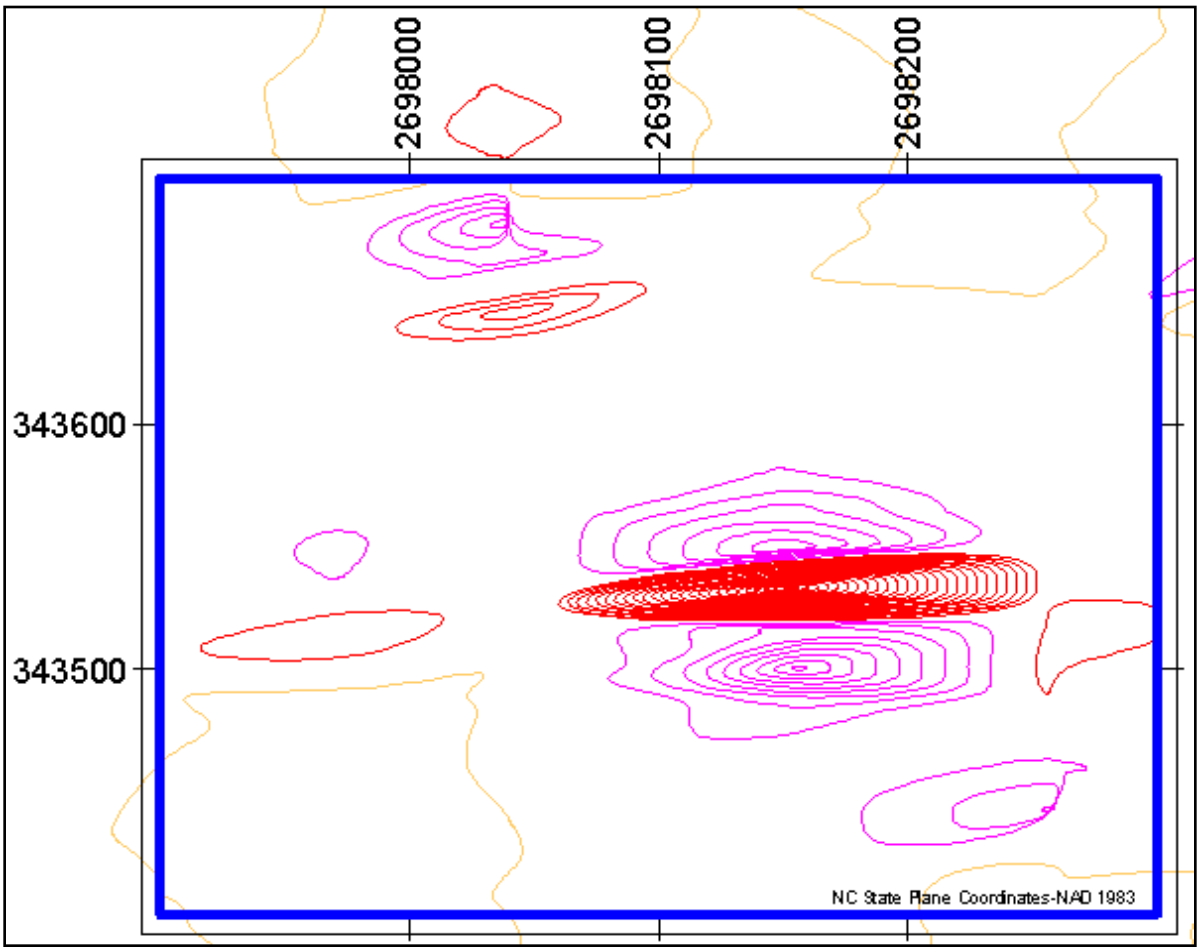

Figure 21. Target Cluster Q2-8 Magnetic Contour Signature.

Q2-9-Cluster
NC State Plane x= y=

Target Cluster Q2-9 consisted of at least five multi-component and dipolar magnetic anomalies on four to six survey lines with a maximum magnetic intensity of 266 nT. Acoustic records associated with the anomalies demonstrate materials over 60 feet in length by 15 feet in width exposed within a depression. Based on the acoustic signature the site appears to be a shipwreck.

The target has the potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 900 feet in diameter around the target coordinates (Figures 22, 23, and 24).

DELETED

Figure 22. Target Cluster Q2-9 Magnetic Contour Signature.

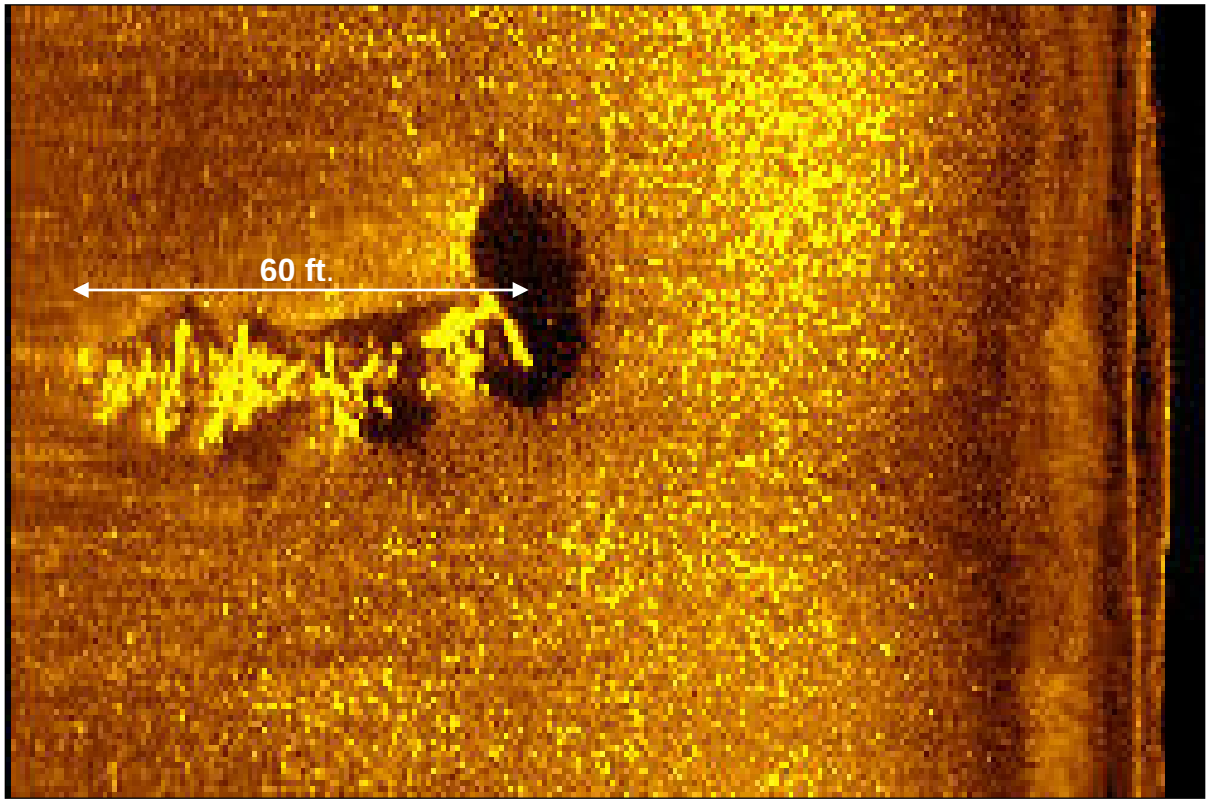

Figure 23. Acoustic image of Target Q2-9.

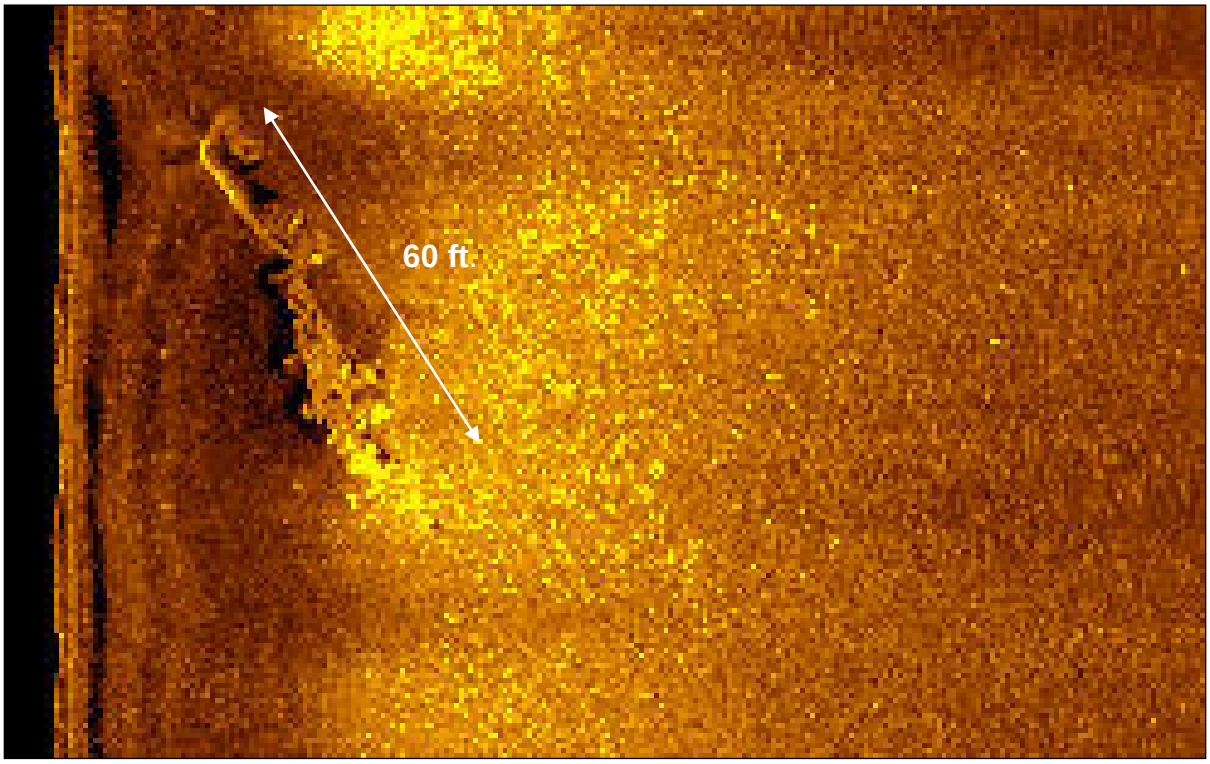

Figure 24. Acoustic image of Target Q2-9.

Q2-10-Cluster
NC State Plane x= y=

Target Cluster Q2-10 consisted of at least two dipolar magnetic anomalies on two survey lines with a maximum magnetic intensity of 86 nT. The relatively high intensity, proximity, and characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least two single source objects with similar magnetic characteristics. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 300 feet in diameter around the target coordinates (Figure 25).

DELETED

Figure 25. Target Cluster Q2-10 Magnetic Contour Signature.

Q2-11-Cluster
NC State Plane x= y=

Target Cluster Q2-11 consisted of at least three magnetic anomalies on two survey lines with a maximum magnetic intensity of 34 nT. The relatively high intensity, proximity, and similar characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest that there are at least three single source objects with similar magnetic characteristics. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 400 feet in diameter around the target coordinates (Figure 26).

DELETED

Figure 26. Target Cluster Q2-11 Magnetic Contour Signature.

Q2-12-Cluster
NC State Plane x= y=

Target Cluster Q2-12 consisted of at least three multi-component magnetic anomalies on four survey lines with a maximum magnetic intensity of 146 nT. The relatively high intensity, proximity, and characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 800 feet in diameter around the target coordinates (Figure 27).

DELETED

Figure 27. Target Cluster Q2-12 Magnetic Contour Signature.

Q2-13-Cluster
NC State Plane x= y=

Target Cluster Q2-13 consisted of at least three multi-component magnetic anomalies on four survey lines with a maximum magnetic intensity of 38 nT. Sonar images associated with the site show a single object approximately 8 feet wide and 8 feet long protruding over 6 feet above the bottom. The acoustic image is complex

and although it may be associated with a large modern anchor it may also be associated with historic material such as steam machinery. An underwater investigation to identify the nature of the material producing the magnetic and acoustic signatures is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 200 feet in diameter around the target coordinates (Figure 28 and 29).

DELETED

Figure 28. Target Cluster Q2-13 Magnetic Contour Signature.

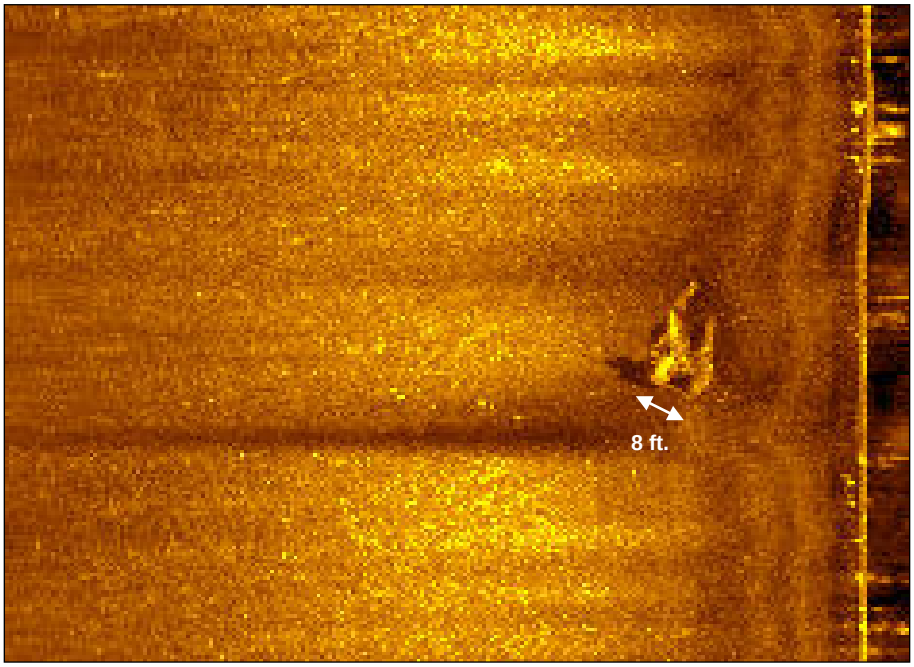

Figure 29. Sonar image associated with Q2-13.

Q2-14-Cluster
NC State Plane x=2702312 y=341477

Target Cluster Q2-14 consisted of multi-component and dipolar magnetic anomalies on four survey lines with a maximum magnetic intensity of 15 nT. No acoustic target signature was identified in association with the magnetic anomalies. The low intensity, proximity, and characteristics of the targets' signatures suggest they may be related.

The characteristics of the cluster suggest the material producing the magnetic signature is a linear object such as a wire rope over 300 feet in length. The nature of the target cluster suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 30).

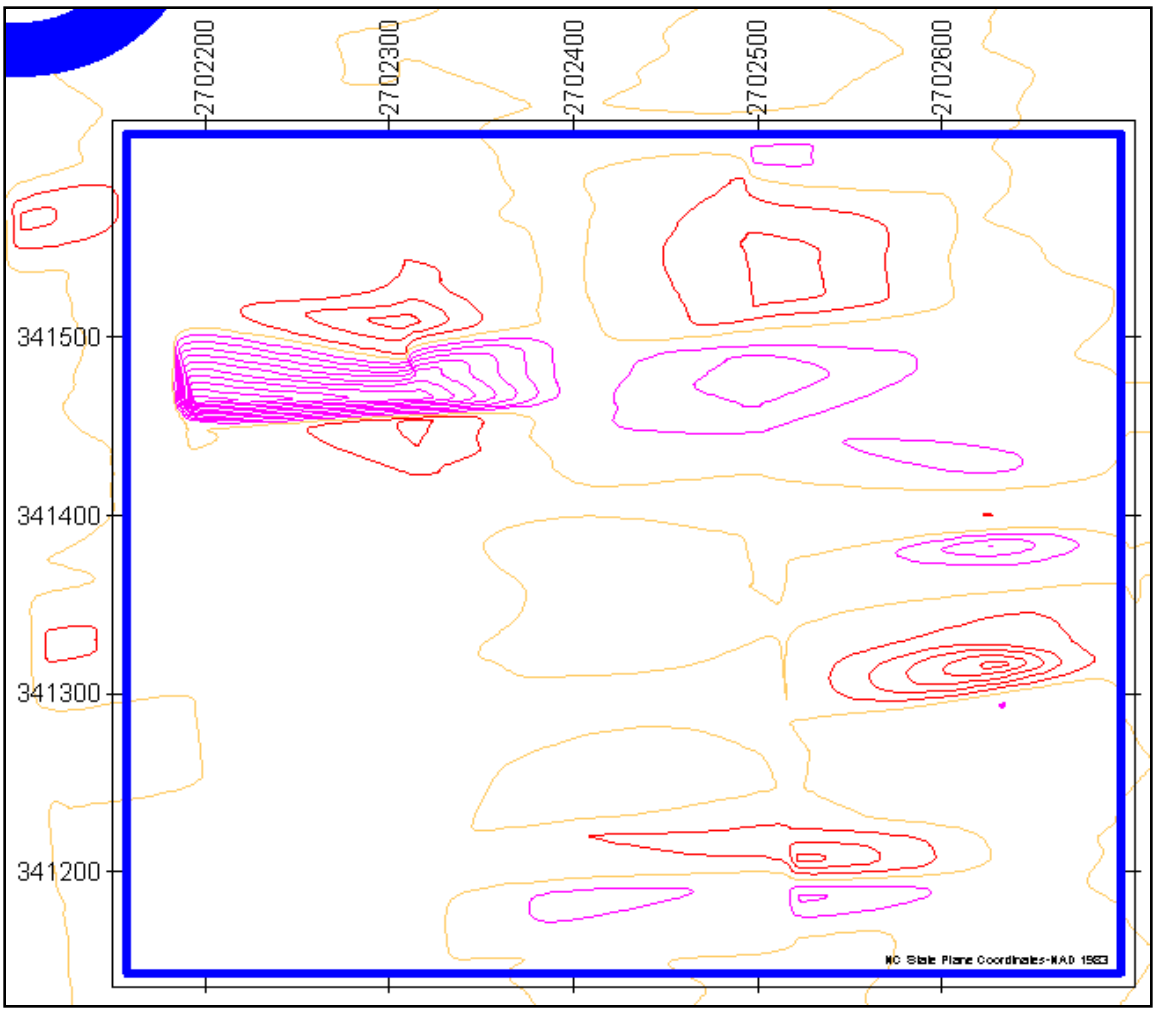

Figure 30. Target Cluster Q2-14 Magnetic Contour Signature.

Q2-15-Cluster
NC State Plane x= y=

Target Cluster Q2-15 consisted of large multi-component and associated smaller anomalies on four survey lines with a maximum magnetic intensity of 57 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 600 feet in diameter around the target coordinates (Figure 31).

DELETED

Figure 31. Target Cluster Q2-15 Magnetic Contour Signature.

Q2-16-Cluster
NC State Plane x= y=

Target Cluster Q2-16 consisted of multi-component and associated smaller anomalies on five survey lines with a maximum magnetic intensity of 24 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 900 feet in diameter around the target coordinates (Figure 32).

DELETED

Figure 32. Target Cluster Q2-16 Magnetic Contour Signature.

Q2-17-Cluster
NC State Plane x= y=

Target Cluster Q2-17 consisted of multi-component and associated smaller dipolar anomalies on five survey lines with a maximum magnetic intensity of 24 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 900 feet in diameter around the target coordinates (Figure 33).

DELETED

Figure 33. Target Cluster Q2-17 Magnetic Contour Signature.

Q2-18
NC State Plane x=2690513 y=338750

Target Q2-18 consisted of relatively small multi-component anomaly on two survey lines with a maximum magnetic intensity of 18 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the target signature is created by a single source object with similar magnetic characteristics or one linear object such as a wire rope over 200 feet in length. The nature of the target suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations are recommended (Figure 34).

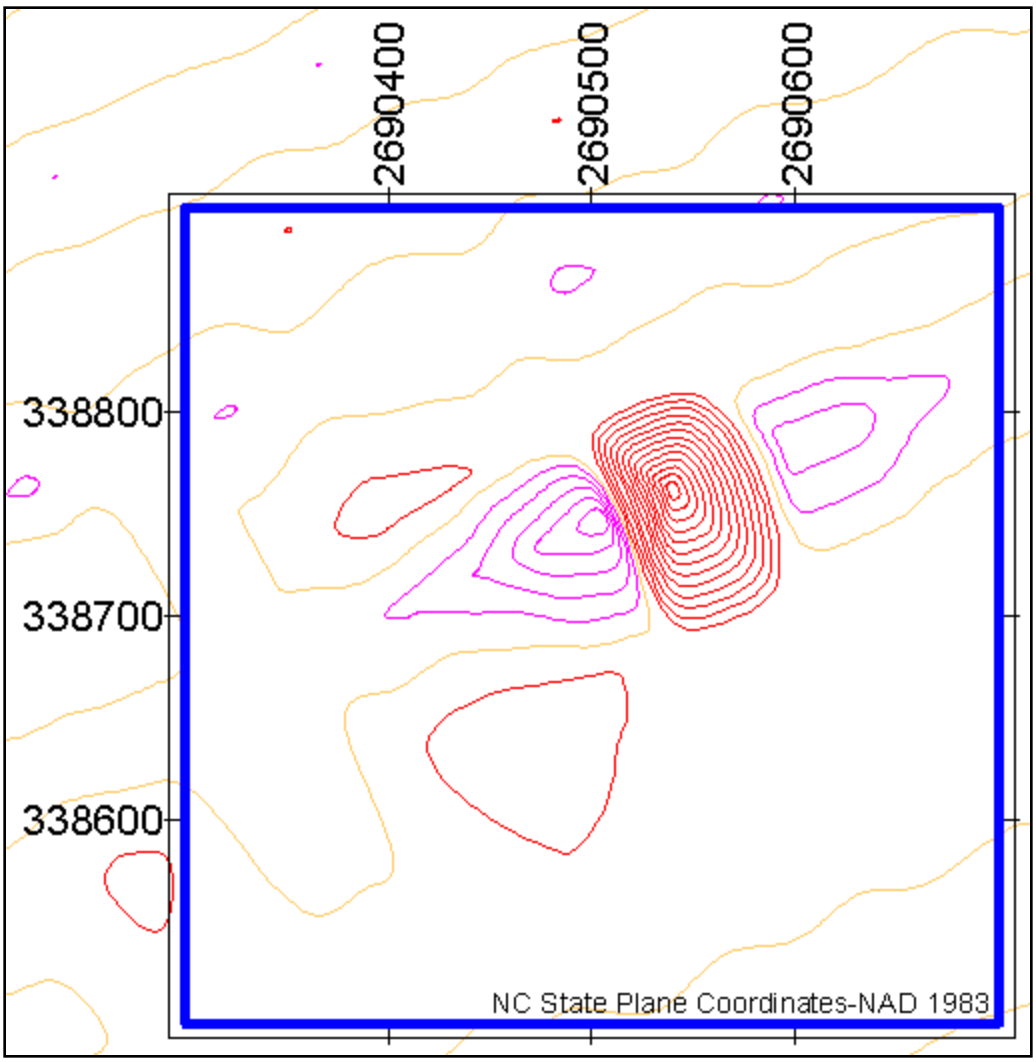

Figure 34. Target Q2-18 Magnetic Contour Signature.

Q2-19-Cluster
NC State Plane x= y=

Target Cluster Q2-19 consisted of large multi-component anomaly on three survey lines with a maximum magnetic intensity of 440 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 600 feet in diameter around the target coordinates (Figure 35).

DELETED

Figure 35. Target Cluster Q2-19 Magnetic Contour Signature.

Q2-20-Cluster
NC State Plane x= y=

Target Cluster Q2-20 consisted of multi-component and associated smaller dipolar anomalies on five survey lines with a maximum magnetic intensity of 145 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 1200 feet in diameter around the target coordinates (Figure 36).

DELETED

Figure 36. Target Cluster Q2-20 Magnetic Contour Signature.

Q2-21-Cluster
NC State Plane x= y=

Target Cluster Q2-21 consisted of several small widely scattered dipolar magnetic anomalies on 8 survey lines with a maximum magnetic intensity of 10 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 1200 feet in diameter around the target coordinates (Figure 37).

DELETED

Figure 37. Target Cluster Q2-21 Magnetic Contour Signature.

Q2-22
NC State Plane x= y=

Target Q2-22 consisted of multi-component magnetic anomaly encountered on three survey lines with a maximum magnetic intensity of 145 nT. No acoustic target signature was identified in association with the magnetic anomaly.

The characteristics of the target suggest that there are one to two objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 300 feet in diameter around the target coordinates (Figure 38).

DELETED

Figure 38. Target Cluster Q2-22 Magnetic Contour Signature.

Q2-23-Cluster
NC State Plane x= y=

Target Cluster Q2-23 consisted of widely scattered small multi-component and dipolar magnetic anomalies on 12 survey lines with a maximum magnetic intensity of 48 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 2000 feet in diameter around the target coordinates (Figure 39).

DELETED

Figure 39. Target Cluster Q2-23 Magnetic Contour Signature.

Q2-24-Cluster
NC State Plane x= y=

Target Cluster Q2-24 consisted of widely scattered small multi-component and dipolar magnetic anomalies on 13 survey lines with a maximum magnetic intensity of 44 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster suggests it has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 2000 feet in diameter around the target coordinates (Figure 40).

DELETED

Figure 40. Target Cluster Q2-24 Magnetic Contour Signature.

Q2-25
NC State Plane x= y=

Target Q2-25 consisted of multi-component anomaly over two survey lines with a maximum magnetic intensity of 8 nT. A scatter of material including linear features approximately 40-feet-long by 15-feet-wide was identified in association with the anomaly.

The characteristics of the target strongly suggest that the target is a shipwreck site. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 400 feet in diameter around the target coordinates (Figure 41).

DELETED

Figure 41. Target Cluster Q2-25 Magnetic Contour Signature.

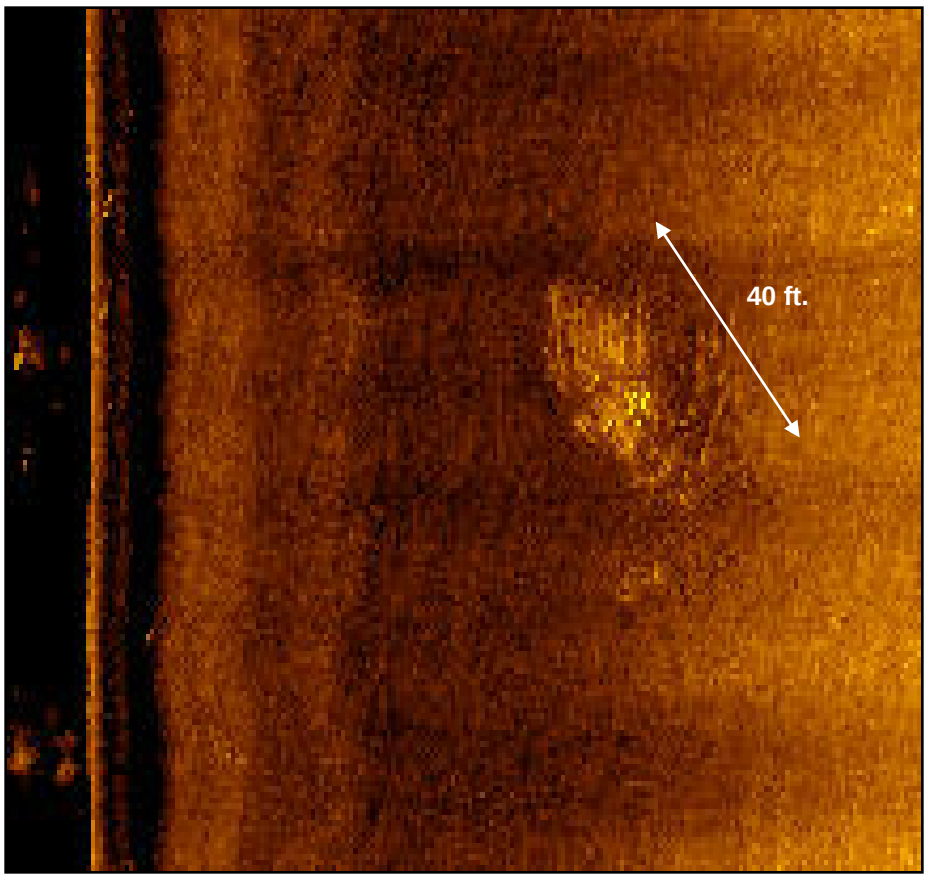

Figure 42. Target 25 - Acoustic Target Signature.

Q2-26-Cluster
NC State Plane x=2685058 y=334046

Target Cluster Q2-26 consisted of three low intensity dipolar anomalies on two survey lines with a maximum magnetic intensity of 7 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that the material producing the low intensity anomalies in over 400 feet in length and linear. The target is most likely wire rope and has low potential to be associated with a significant submerged cultural resource. No additional investigations are recommended (Figure 43).

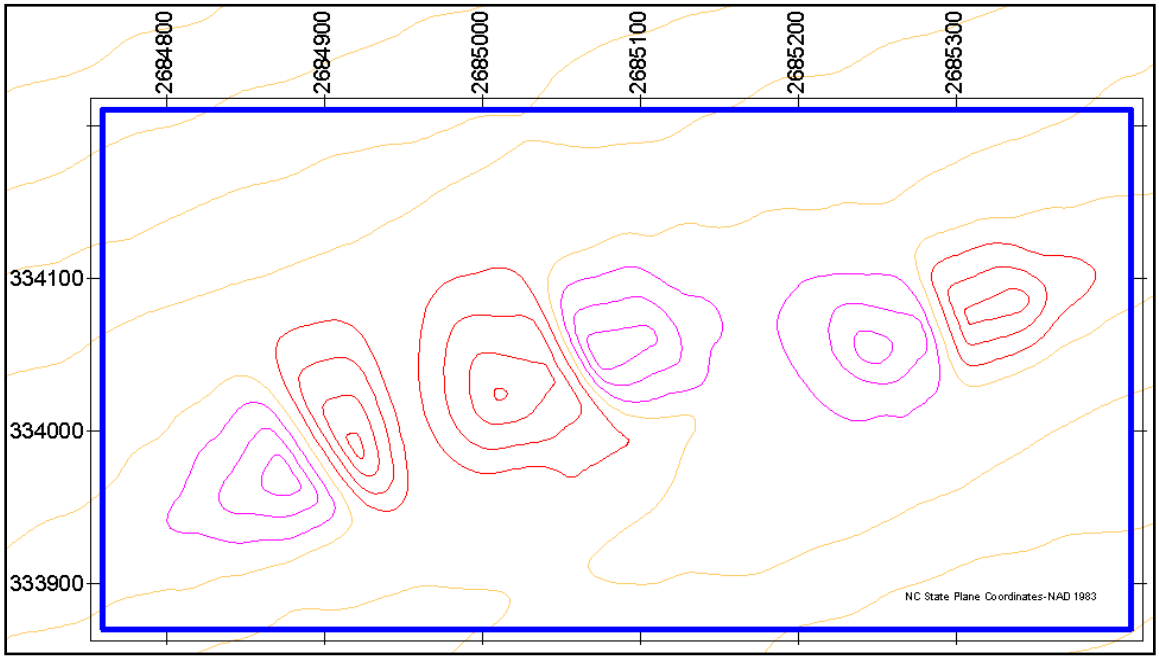

Figure 43. Target Cluster Q2-26 Magnetic Contour Signature.

Q2-27
NC State Plane x=2689273 y=334323

Target Q2-27 had no magnetic signature. The acoustic image suggested the target was a disk or dome-shaped object 16 feet in diameter with associated structural mountings still attached. The object appears to be of modern origin.

The nature of the target suggests it has little potential to be associated with a significant cultural resource. No additional underwater archaeological investigations or mitigation are recommended (Figure 44).

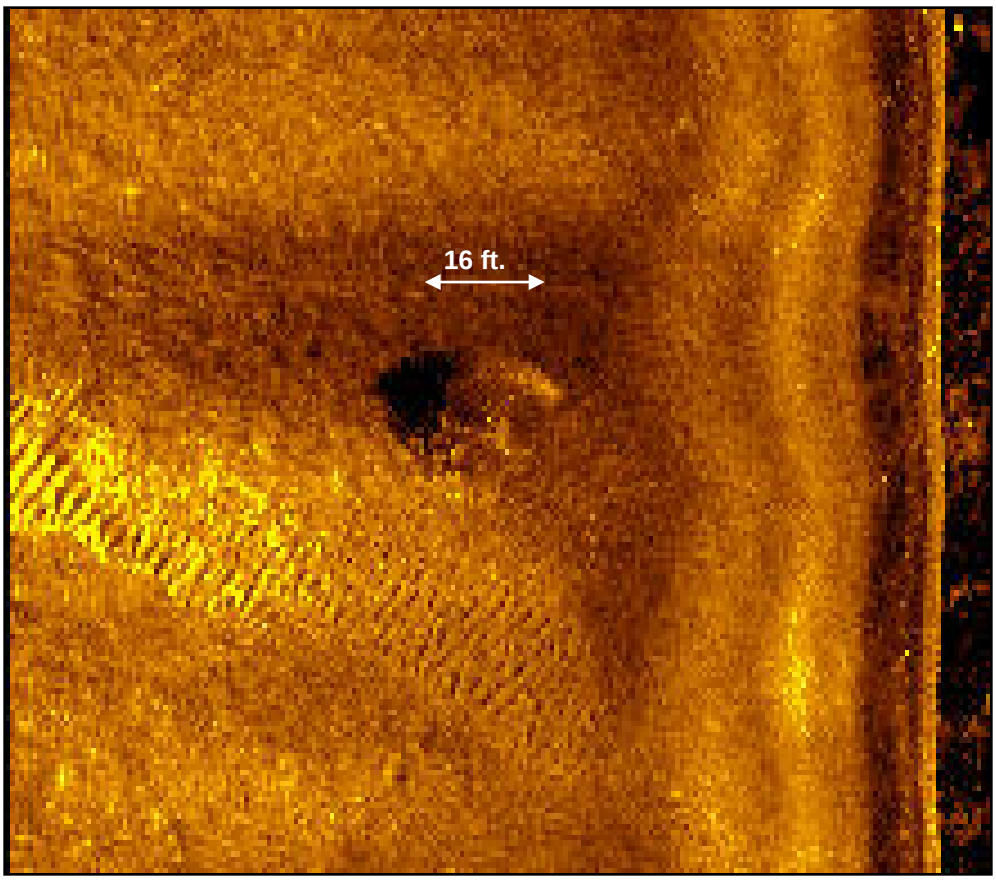

Figure 44. Target 27 – Acoustic Target Signature.

Q2-28-Cluster
NC State Plane x= y=

Target Cluster Q2-28 consisted of multi-component anomaly on three survey lines with a maximum magnetic intensity of 20 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that there are several objects associated with the site. The nature of the target cluster indicates sit has some potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 400 feet in diameter around the target coordinates (Figure 45).

DELETED

Figure 45. Target Cluster Q2-28 Magnetic Contour Signature.

Q2-29-Cluster
NC State Plane x=2688551 y=333005

Target Cluster Q2-29 consisted of two low intensity dipolar anomalies on two survey lines with a maximum magnetic intensity of 12 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The characteristics of the cluster suggest that the material producing the low intensity anomalies is over 300 feet in length and linear. The target is most likely wire rope and has low potential to be associated with a significant submerged cultural resource. No additional investigations are recommended (Figure 46).

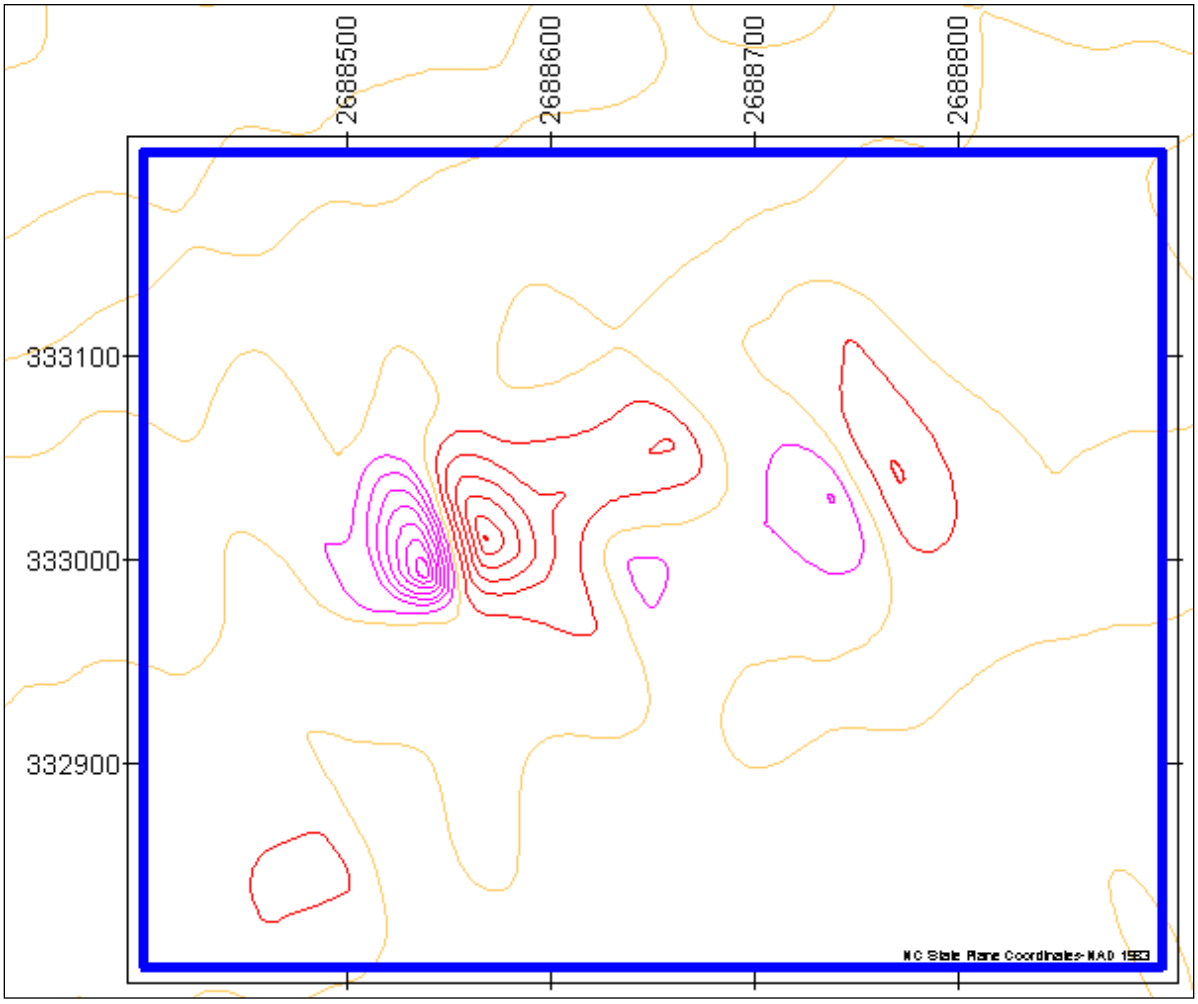

Figure 46. Target Cluster Q2-29 Magnetic Contour Signature.

Q2-30-Cluster
NC State Plane x= y=

Target Cluster Q2-30 consisted of multi-component and dipolar magnetic anomalies on six to eight survey lines with a maximum magnetic intensity of 16 nT. Acoustic records associated with the anomalies show a pile of linear objects over 70 feet in length by 20 feet wide exposed just above the bottom.

The target has the potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 700 feet in diameter around the target coordinates (Figures 47 and 48).

DELETED

Figure 47. Target Cluster Q2-30 Magnetic Contour Signature.

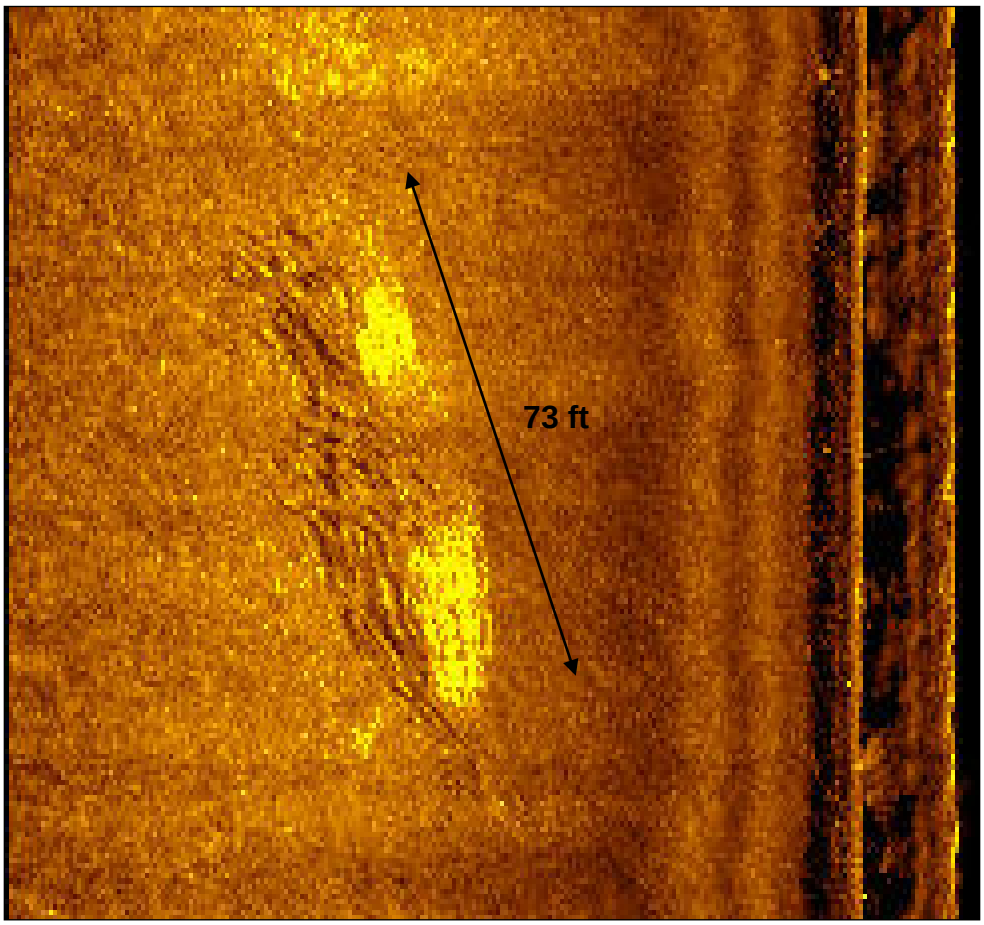

Figure 48. Target 30 – Acoustic Target Signature.

Q2-31-Cluster
NC State Plane x= y=

Target Cluster Q2-31 consisted of multi-component and dipolar magnetic anomalies on four to six survey lines with a maximum magnetic intensity of 24 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The target has the potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 900 feet in diameter around the target coordinates (Figure 49).

DELETED

Figure 49. Target Cluster Q2-31 Magnetic Contour Signature.

Q2-32-Cluster
NC State Plane x=2695255 y=332311

Target Cluster Q2-32 consisted of multi-component and dipolar magnetic anomalies on 12 to 14 survey lines with a maximum magnetic intensity of 38 nT. No acoustic target signature was identified in association with the magnetic anomalies.

The target has the potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 2000 feet in diameter around the target coordinates (Figure 50).

DELETED

Figure 50. Target Cluster Q2-32 Magnetic Contour Signature.

Q2-33-Cluster
NC State Plane x=2698949 y=331513

Target Cluster Q2-33 consisted of at least three multi-component magnetic anomalies on four survey lines with a maximum magnetic intensity of 11 nT. Sonar images associated with the site show a single object approximately 8 feet wide and a second circular object a short distance away. The acoustic image has characteristics that suggest the object is a large modern anchor. No addition investigations or mitigation is recommended (51 and 52).

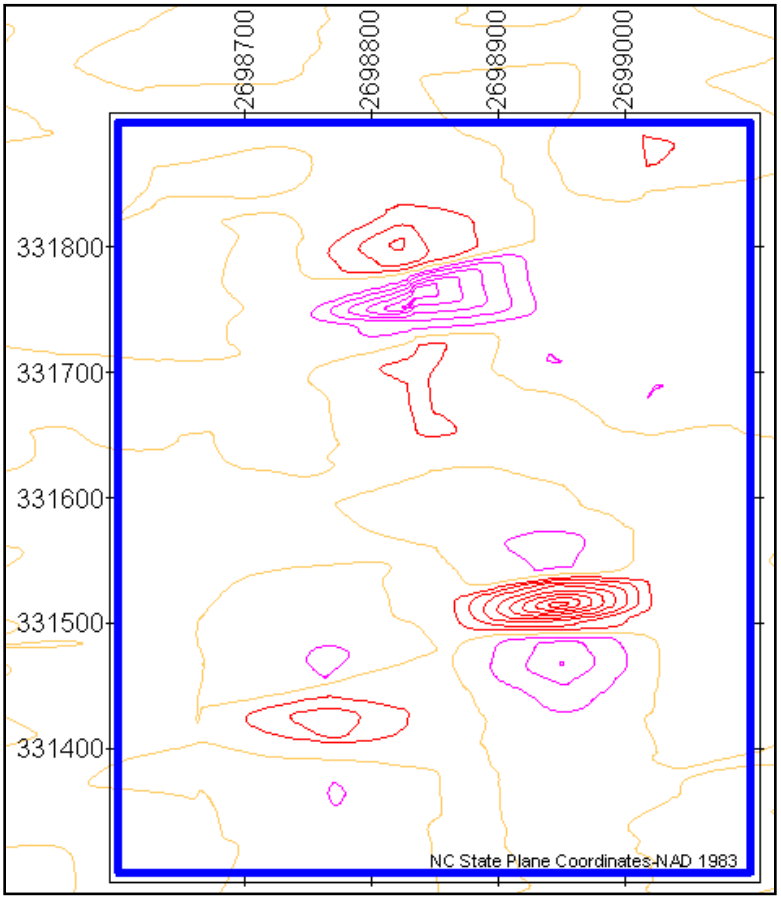

Figure 51. Target Cluster Q2-33 Magnetic Contour Signature.

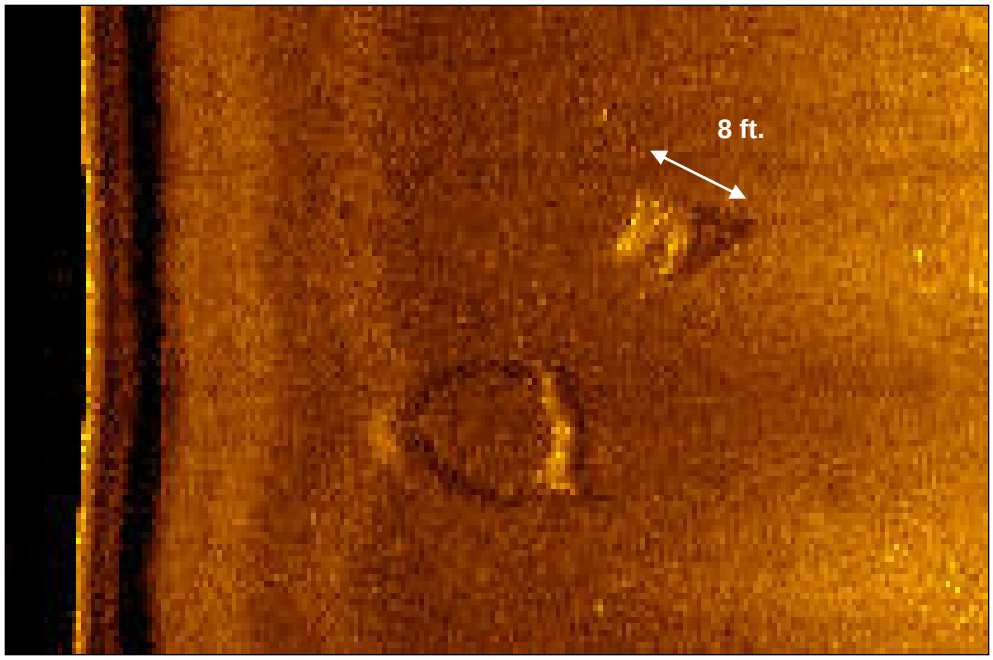

Figure 52. Target 33 - Acoustic Target Signature.

Borrow Area U

Borrow Area U is positioned well offshore and approximately half way between Bogue and Beaufort inlets. No magnetic or acoustic anomalies were identified that could be associated with potential submerged cultural resources within Borrow Area U. A linear series of magnetic anomalies were identified that are obviously associated with an over 1800-feet-long pipe or cable that extends into the borrow area from the north (Figure 53). No additional investigations or mitigation are recommend for the borrow area.

Figure 53. Magnetic Contour and Target Location Map Borrow Area U.

Borrow Area Y

Borrow Area Y is positioned offshore and east southeast of the Bogue Inlet. One magnetic anomaly with an associated acoustic target signature was identified within the borrow area (Figure 55)

Y-1
NC State Plane x= y=

Target Target Y-1 consisted of multi-component magnetic anomaly with maximum magnetic intensity of 16 nT. Acoustic records associated with the anomaly identified an unusually shaped object (much like an historic steam boiler) approximately 16 feet long by 7 feet wide.

The target has the potential to be associated with a significant cultural resource. An underwater investigation to identify the nature of the material producing the magnetic signature is recommended. If underwater investigations are not an option, a no impact buffer zone should be created around the target signature. The no-impact zone should include an area at least 300 feet in diameter around the target coordinates (Figures 54 and 56).

DELETED

Figure 54. Target Y-1 Magnetic Contour Signature.

Figure 55. Magnetic Contour and Target Location Map Borrow Area Y.

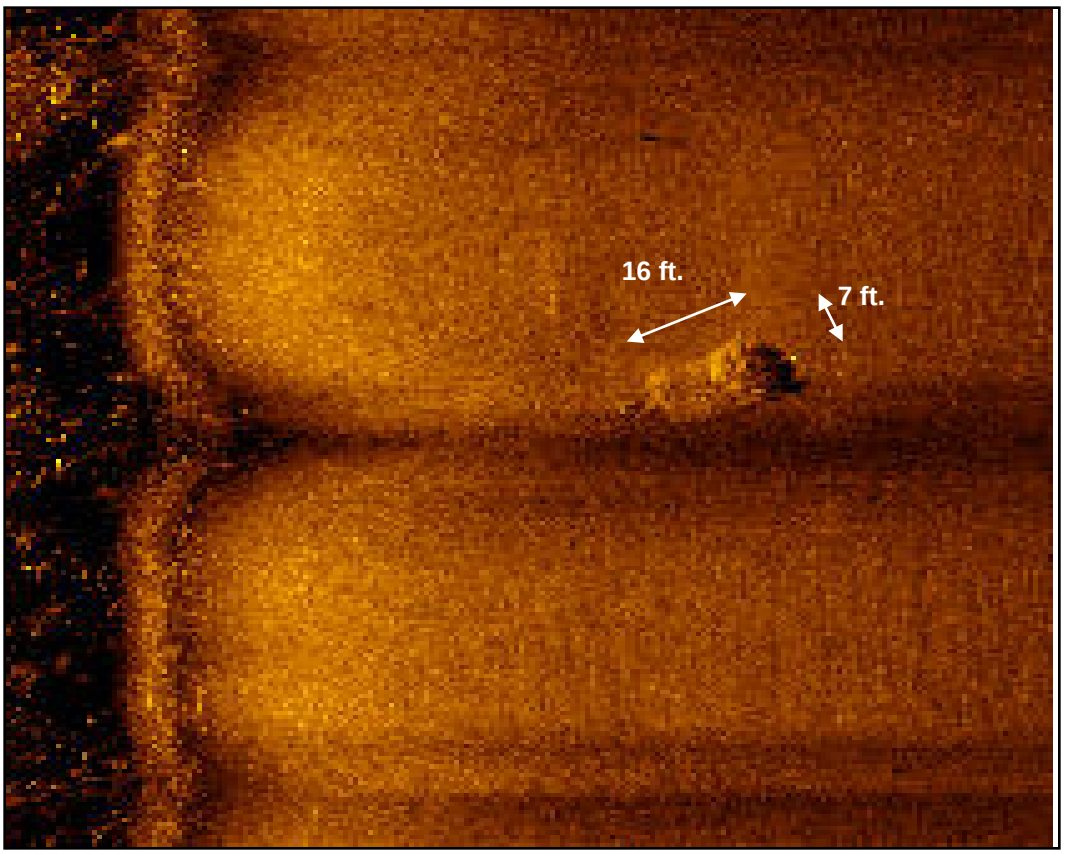

Figure 56. Target Y-1 Acoustic Target Signature.

IDENTIFICATION OF HARD BOTTOM AREAS

M-AT/ER reviewed acoustic records (side-scan sonar and depth) to identify and define areas that were hard bottom or habitats for marine animals. Hard bottom areas were defined as areas larger than 1,800 square meters. Other characteristics include low protrusions – the majority of the area less than .5-meters above the bottom; moderate protrusions – the majority of the area 1 to 2 meters above the bottom; and high protrusions – more than 2 meters above the bottom.

Borrow Area Q1

No hard bottom was identified in within Borrow Area Q1 however large areas of Q1 have been utilized as part of North Carolina's Artificial Reef Program. A list of vessels and materials deposited within the artificial reef as well as representative sonar images of the material has been previously presented on pages 16 through 20 (see figures 7,8,9 10, 57, 58 and 59).

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Figure 57. Hard Bottom Map – Borrow Area Q1.

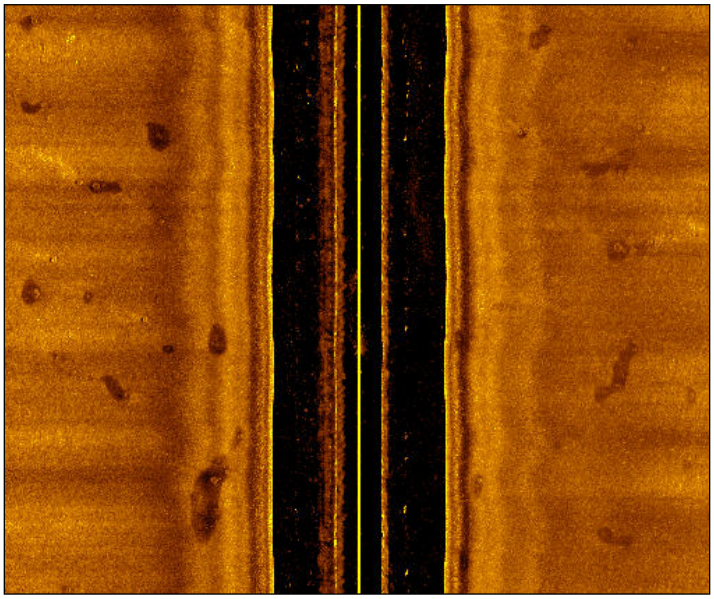

Figure 58. Example of Tire Scatter Borrow Area Q1.

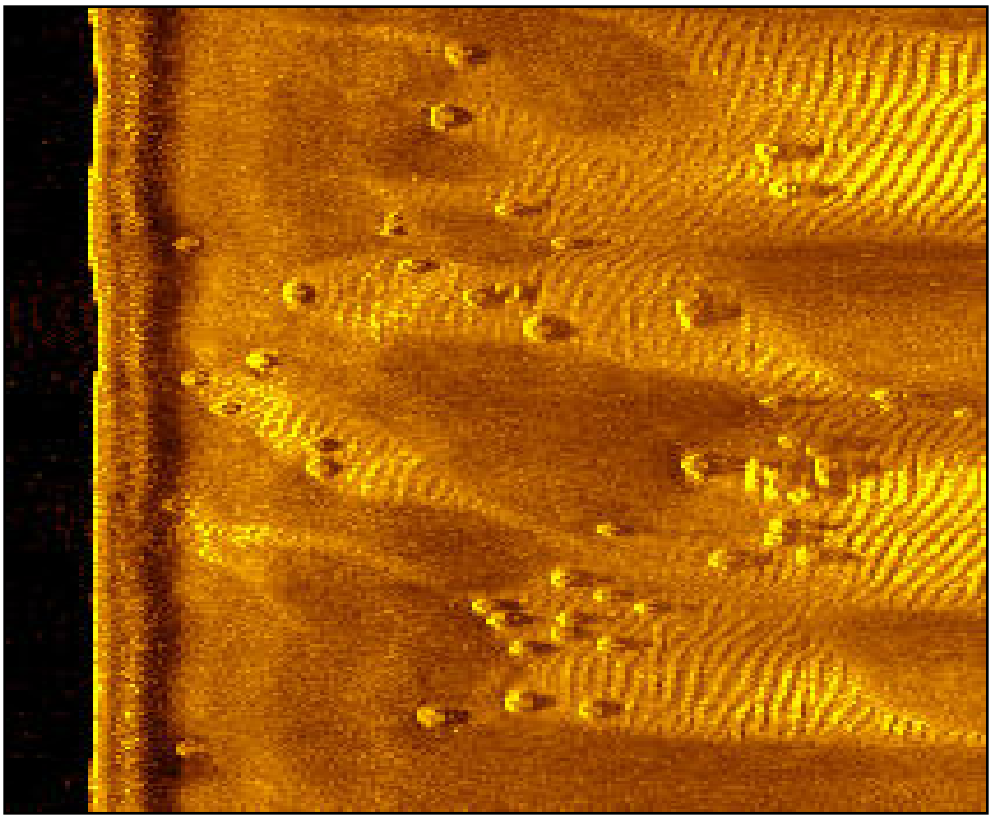

Figure 59. Example of Tire Scatter Borrow Area Q1.

Borrow Area Q2

No hard bottom was identified within Borrow Area Q2 (Figure 60).

Borrow Area U

A small area (9 acres) of low relief hard bottom was identified in the western portion of Borrow Area U (Figures 62, 63 and 64).

Borrow Area Y

Areas of hard bottom totaling about 22 acres were identified along the eastern side and within Borrow Area Y. All of the hard bottom areas identified were of low relief. Just outside the borrow area to the south investigators also noted artificial reef material (Figures 61, 65, 66, 67 and 68).

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Figure 60. Hard Bottom Map – Borrow Area Q2.

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Figure 61. Hard Bottom Map – Borrow Area U.

DELETED

Figure 62. Hard Bottom Map – Borrow Area Y.

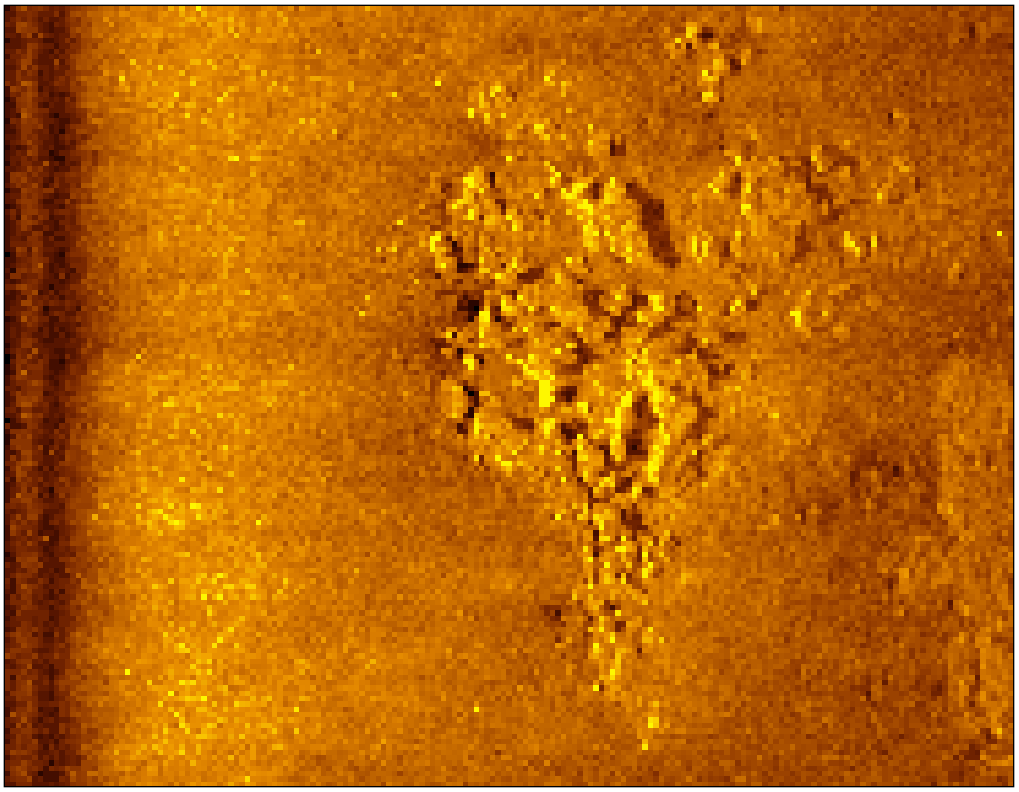

Figure 63. Example of Hard Bottom Borrow Area U.

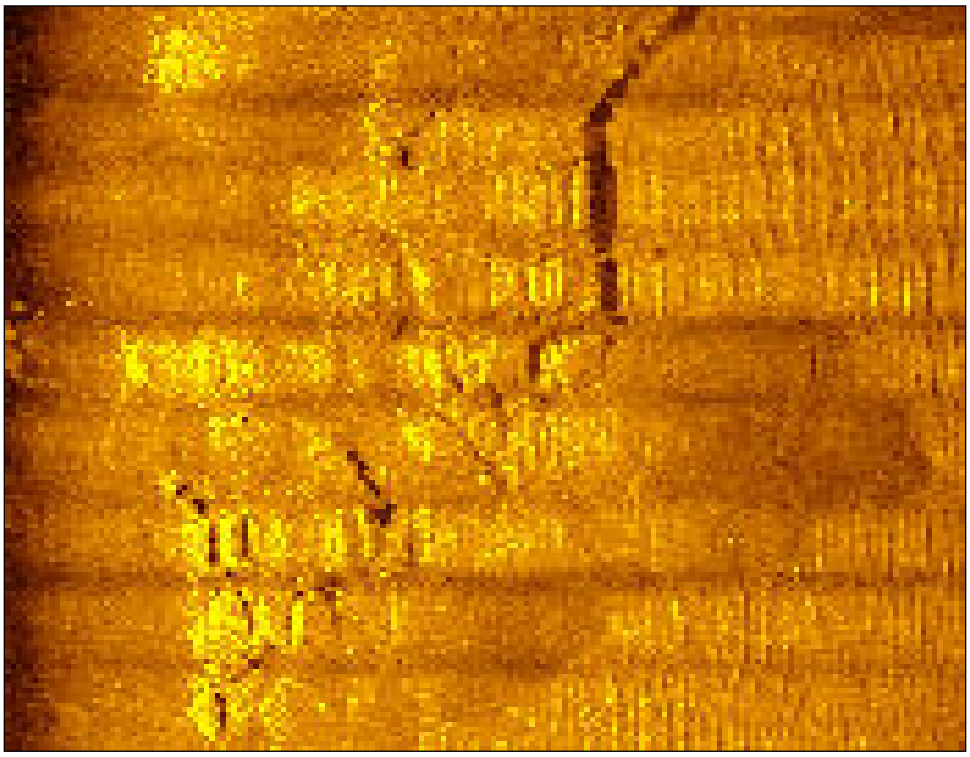

Figure 64. Example of Hard Bottom Borrow Area U.

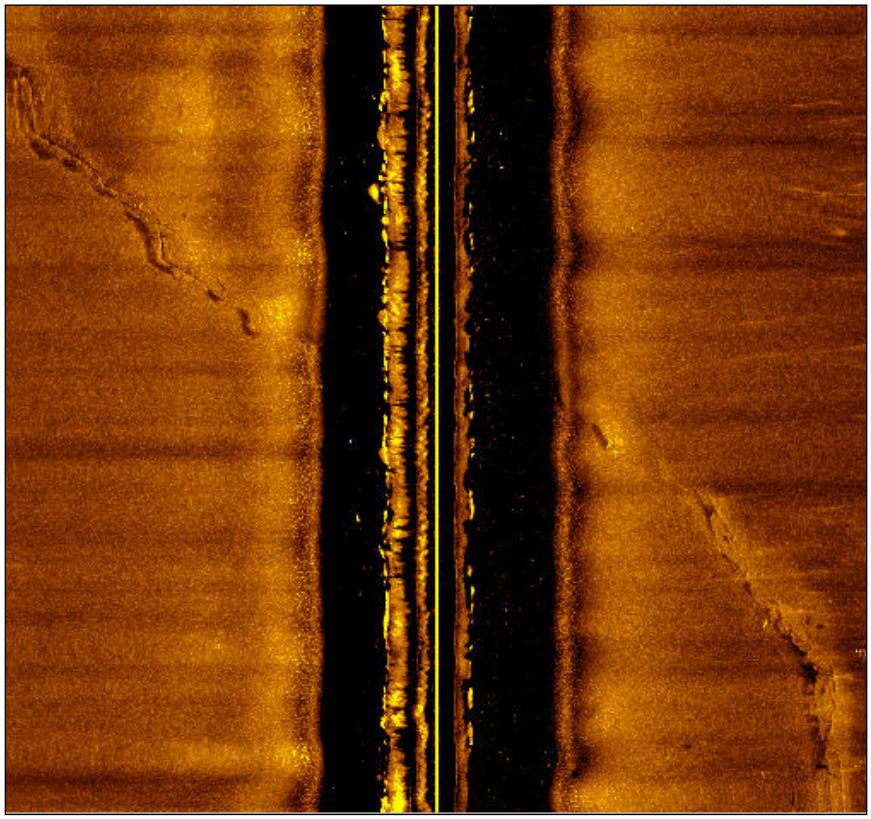

Figure 65. Example of Hard Bottom Borrow Area Y.

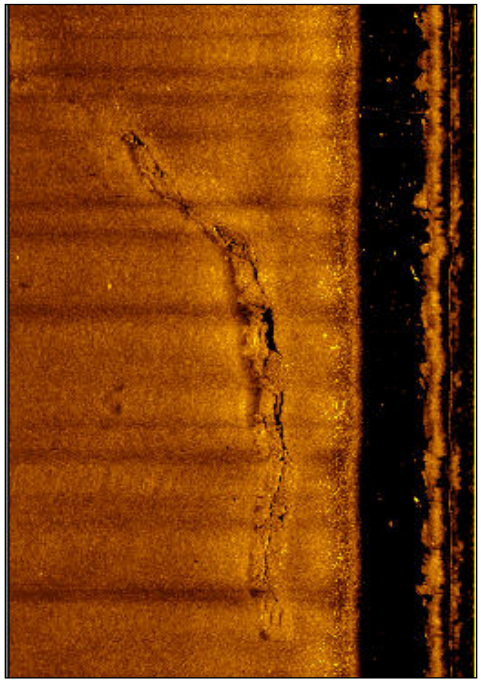

Figure 66. Example of Hard Bottom Borrow Area Y.

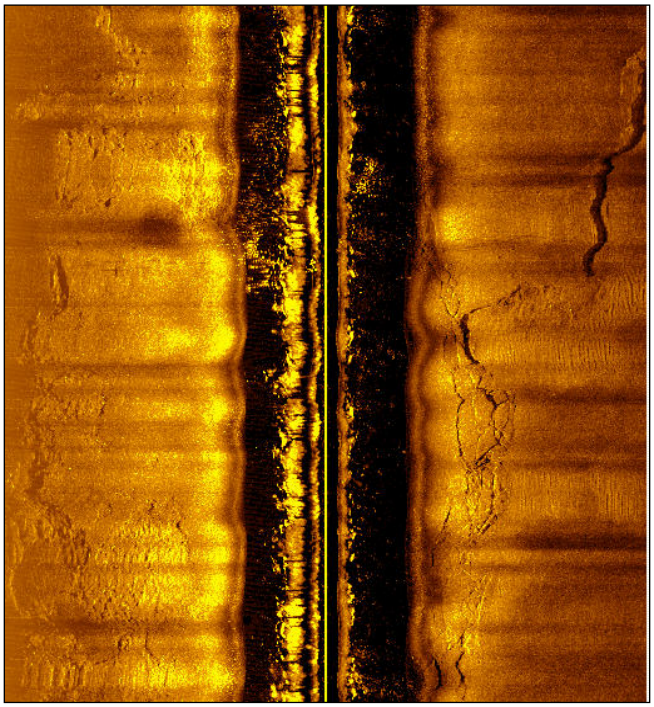

Figure 67. Example of Hard Bottom Borrow Area Y.

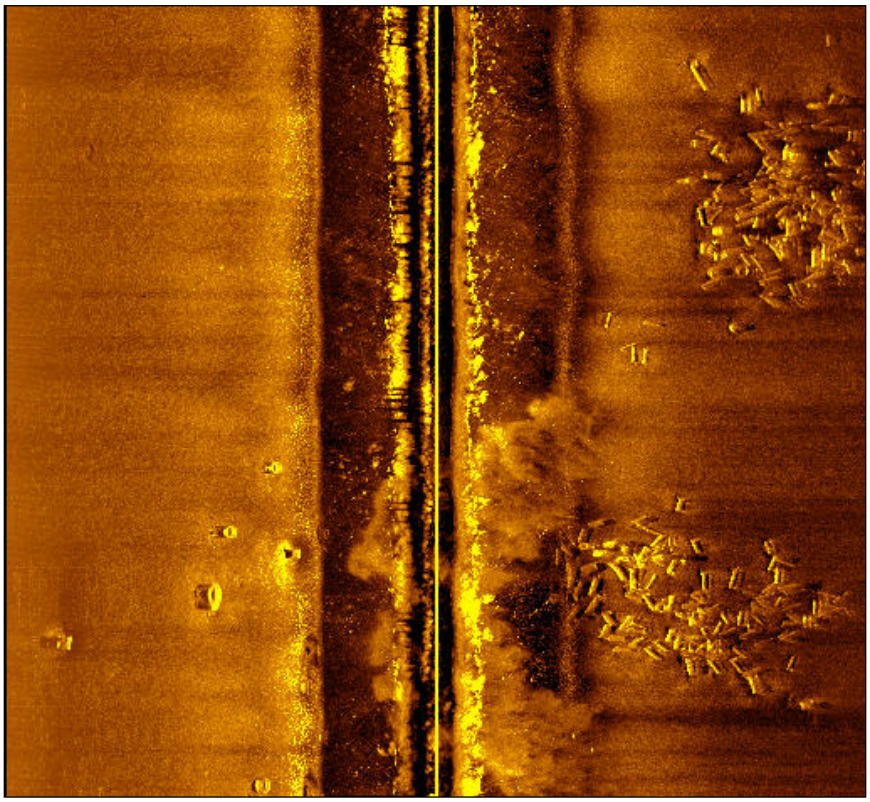

Figure 68. Artificial Reef Material located just south of Borrow Area Y.

CONCLUSIONS AND RECOMMENDATIONS

In Borrow Areas Q1 and U no remote sensing anomalies were identified that could be associated with a submerged cultural resource. All remote sensing anomalies were related to modern debris associated with either the North Carolina Artificial Reef – AR-315 or in the case of Borrow Area U a long linear ferrous object such as a cable or pipeline.

A total of 33 magnetic and or acoustic anomalies were selected as targets or target clusters in Borrow Area Q2. Of the 33 selected targets, ten (10) did not demonstrate characteristics that have the potential to be associated with a significant submerged cultural resource such as a historic shipwreck. No addition investigations or mitigation has been recommended for these targets (see Appendix B – Table of Unidentified Remote Sensing Targets).

The remaining twenty three (23) targets or target clusters in Borrow Area Q2 do have characteristic that could be associated with a significant submerge cultural resource. These targets are recommended for either additional underwater investigations to identify and access the target's cultural resource potential, or avoidance of potential impact by the creation of a no-impact buffer zone that surrounds the anomaly or cluster of anomalies.

One (1) target was identified within Borrow Area Y. This target was also recommended for additional investigations or avoidance by the creation of a no-impact buffer zone.

Hard Bottom Mapping

No natural hard bottom was identified within Borrow Areas Q1 or Q2. However, Borrow Area Q1 does have large areas that are part of the North Carolina Artificial Reef Program including an area of widely scatter tires.

Relatively small areas of hard bottom were identified and mapped within Borrow Areas U and Y.

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APPENDIX A - SHIPWRECKS IN THE VICINITY OF BOGUE BANKS

Name of Vessel	Type	Tons	Cause	Date Lost D-M-Y	Place	Comments	Reference
							6
Queen Anne's Revenge	ship	?	grounded	06-??-1718	Topsail Inlet/Beaufort Inlet		6
Adventure	sloop	?	grounded	06-??-1718	Topsail Inlet?Beaufort Inlet		6
El Salvador	snow	?	grounded	08-30-1750	Cape Lookout - South		3,4,6
Susannah	schooner	?	grounded	04-02-1753	At entrance to Old Topsail Inlet		4,6
unknown	brig	?	grounded	10-19-1769	At Old Topsail Inlet		6
unknown	brig	?	ran ashore	??-09-1769	Below Topsail Inlet		6
Betsy	sloop	?	grounded	01-01-1771	At Old Topsail Inlet		5,6
Hero	schnooner	?	grounded	02-09-1790	Beaufort Bar		5,6
Polly	sloop	?	unknown	07-16-1793	Ashore near Beaufort		5,6
unknown	brig	?	grounded	09-17-1814	Beaufort Bar		6
Antelope	schooner	?	grounded	03-10-1815	Near Beaufort		6
Eagle	brig	?	unknown	03-10-1815	Near Beaufort		6
Orleans	brig	?	unknown	03-10-1815	Near Beaufort		*6*
Harriot	ship	?	unknown	06-25-1817	Bogue Banks near Beaufort		*6*
Santa Maria	ship	?	grounded	03-22-1819	Beaufort Bar		6
Tionel	schooner	?	grounded	04-12-1842	West of Beaufort Bar		2
Delaware	schooner	?	unknown	28-12-1844	4 mi. SW Beaufort Bat		1
Colonel Hanson	schooner		ran ashore	04-09-1846	Bogue Banks	run ashore at Swansboro	1
Walter J. Doyle	schooner		unknown	03-??-1852	Beaufort Bar		2,3,4
Sun	schooner		unknown	01-13-1854	Beaufort Inlet		2,3,4
Charles M. Creese	schooner		unknown	09-??-1857	Beaufort Inlet		3
unknown	schooner		grounded	11-??-1863	Bogue Inlet		1
Pevensey	steamer	543	ran ashore	06-09-1864	Bogue Banks	iron hull blockade runner	2,3,
Quinnebaugh	steamer	186	stranded	07-20-1865	Shackleford Banks		4
Fearless	steamer	128	stranded	11-15-1866	Beaufort		4
Jonas Sparks	schooner	?	unknown	04-14-1867	Beaufort Bar		2,3,4
Katy Wentworth	schooner	294	unknown	18-11-1886	Bogue Banks	1 live lost	2,3,4
Bronx	sloop	24	unknown	06-21-1892	3 miles SW Beaufort		2,34
Carrie L. Davis	schooner	?	ran ashore	??-??- 1902	Bogue Inlet	total loss of cargo and vessel	1
Thomas L. James	schooner	?	ran ashore	??- ??- 1902	Bogue Inlet	total lost of cargo	1
Governor Safford	steamer	307	ran ashore	24-07-1908	near Bogue Inlet		1
Clifton	steamer	256	stranded	18-05-1909	Beaufort	built 1864	4
M.B. Davis	schooner	18	foundered	8-12-1917	near Bogue Inlet		1
Maside	steamer	39	unknown	12-14-1920	2 mi. S of Fort Macon		2
Louise Howard	schooner	173	unknown	14-04-1921	3 mi. S of Fort Macon station		1
Alela	power yacht	70	burnt	20-05-1923	2 mi. NE of Fort Macon station	built 1913	2,4
Juno	tug	62	foundered	22-07-1923	Beaufort	built 1876	4
Morris and Cliff	schooner	132	foundered	16-01-1926	near Bogue Inlet		1,2
W.E. Hutton	tanker	4359	sunk	18-03-1942	off Bogue Inlet	sunk by German Submarine	1,2
Senateur Duhamel	trawler	133	unknown	19-12-1942	34 41' 09"N, 76° 43' 18"W	built 1923	2
Libertad	cargo	93	foundered	08-12-1952	Beaufort Inlet		2
Doswell S. Edwards	cargo	93	foundered	12-08-1952	Beaufort Inlet	built 1926	2

Reference Sources to Shipwreck List

1. Angley, Wilson. *An Historical Overview of Bogue Inlet*, Research Branch, North Carolina Division of Archives and History.

2. Wreck lists and charts in North Carolina Department of Conservation and Development. Division of Mineral Resources. *An Oceanographic Atlas of the Carolina Continental Margin.* By J. G. Newton, O. N. Pilkey, and J. O. Blanton, 1971. Prepared at Duke University Marine Laboratory at Beaufort, North Carolina, from research supported by the North Carolina Board of Science and Technology, the United States Science Foundation, and the United States Geological Survey.

3. Stick, David. *Graveyard of the Atlantic: Shipwrecks of the North Carolina Coast*. Chapel Hill: The University of North Carolina Press, 1952.

4. Berman, Bruce D. *Encyclopedia of American Shipwrecks,* Boston, Mass.: The Mariners Press, 1972.

5. Marx, Robert F. *Shipwrecks of the Western Hemisphere,* 1492-1825. New York: David McKay and Co., 1975.

6. www.qaronline.org. *Eighteen Century Shipwrecks in the vicinity of Beaufort Inlet Area.* Archives and History, Division of Cultural Resource, State of the North Carolina web site

APPENDIX B- TABLE OF UNIDENTIFIED REMOTE SENSING TARGETS

DELETED

Archaeological Remote Sensing Survey of Bogue Bank Offshore Borrow Areas, Carteret County, North Carolina

Target

INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX F

Biological Assessment

US Army Corps
of Engineers
Wilmington District

BIOLOGICAL ASSESSMENT

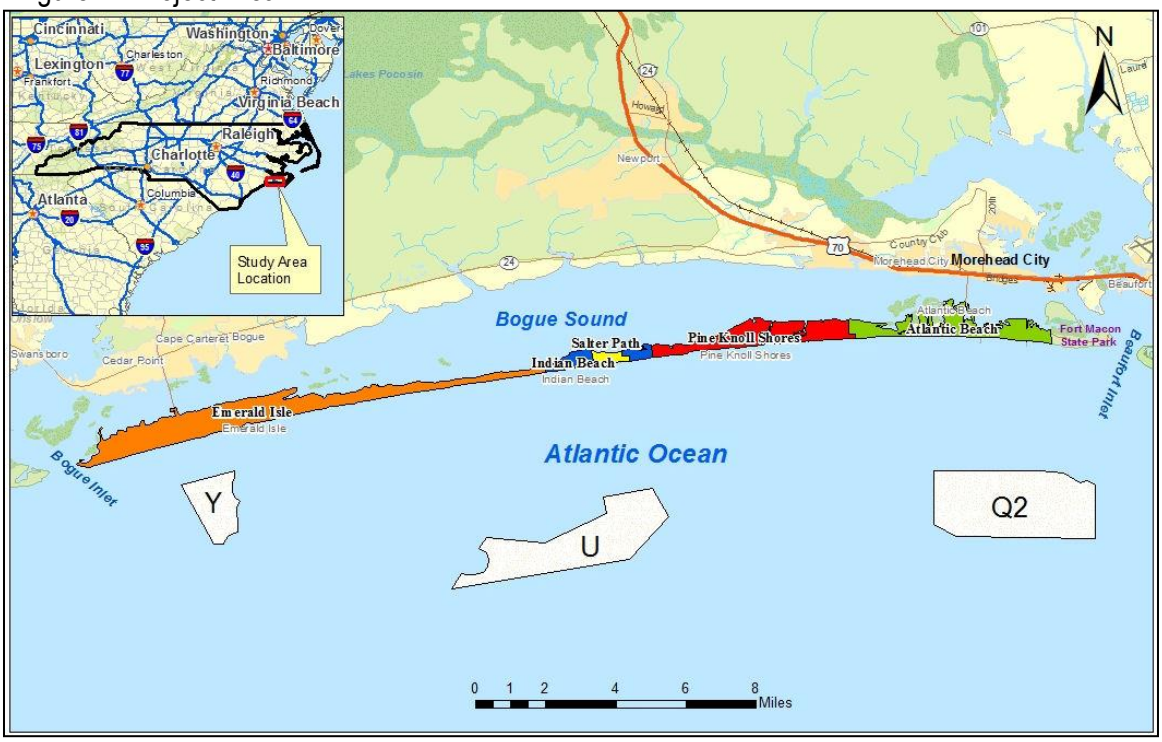
Bogue Banks
Carteret County, North Carolina
Coastal Storm Damage Reduction Project

1.00 PROPOSED PROJECT

The project consists of an 119,670 ft (22.7 miles) long main beachfill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project) at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County. The main beachfill is bordered on either side by a 1,000 ft tapered transition zone berm. Sand for the beachfill would be delivered from three offshore borrow areas by dredge. For further discussion of the proposed project, please see the Integrated Feasibility Report and Draft Environmental Impact Statement, Coastal Storm Damage Reduction, Bogue Banks, Carteret County, North Carolina, August 2013.

The proposed sediment borrow sites for both initial construction and nourishment intervals is located South of Bogue banks between 1 and 5 miles offshore in a depth contour range of -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 at 3-year intervals. In total, about 19.55 million cubic yards of borrow material would be required for the 50-year project (Figure 1).

Figure 1. Project Area.



2.00 NATIONAL MARINE FISHERIES SERVICE (NMFS): SECTION 7 CONSULTATION HISTORY

Prior to 1991, in accordance with Section 7 requirements under the Endangered Species Act (ESA), each US Army Corps of Engineers (USACE) district within the Corps' South Atlantic Division (SAD) prepared individual project specific biological assessments for dredging activities in the South Atlantic and received subsequent individual biological opinions from the National Marine Fisheries Service (NMFS). Beginning in 1991, NMFS moved away from individual consultations for Corps dredging activities with the development of the 1991 South Atlantic Regional Biological Opinion (SARBO) for dredging of channels in the Southeastern United States from North Carolina through Cape Canaveral, Florida. In order to assess the regional implications of USACE dredging actions, the NMFS extended the use of a Regional Biological Opinion (RBO) in subsequent 1995 and 1997 SARBO consultations. To date, SAD has been implementing its dredging program under the 1997 SARBO. However, since the 1997 consultation, several re-initiation triggers have been met, such as: (1) modification of the proposed activity, (2) listing of a new species and/or critical habitat, (3) the inclusion of Puerto Rico and the U.S. Virgin Islands which had been excluded from previous opinions and (4) the current status of Section 10(a)(1)(A) scientific research permits.

On April 30, 2007 SAD sent a letter to NMFS formally requesting re-initiation of consultation for dredging activities and other associated actions in the South Atlantic under Section 7 of the ESA. On 12 September 2008, SAD provided NMFS with the Corps' South Atlantic Regional Biological Assessment (SARBA) for 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 (ODMDS)), and sand mining areas in the South Atlantic Ocean (including OCS sand resources

under Minerals Management Service (MMS) jurisdiction) from the North Carolina/Virginia Border through and including Key West, Florida and the Islands of Puerto Rico and the US Virgin Islands (USVI). Dredging methods and other associated actions considered under this assessment include hydraulic dredges (i.e. pipeline and hopper), mechanical dredges, bed leveling, transportation methodology (i.e. hopper, tugs/scows, and barges), and relocation trawling. Federally threatened, endangered, or candidate species considered under this assessment include: six species of marine turtles (leatherback, loggerhead, Kemp's ridley, hawksbill, green, and olive ridley sea turtles), Acroporid corals (staghorn and elkhorn), three large whale species (North Atlantic right whale (NARW), humpback whale, and sperm whale), Johnson's seagrass, and three anadromous or marine fish species (shortnose sturgeon, Atlantic sturgeon, and smalltooth sawfish). On 1 July 2010, NMFS submitted a request to the Corps for additional information in order to initiate ESA Section 7 consultation. In a letter dated 9 August 2010, the Corps provided NMFS with the requested information in order to complete preparation of the SARBO.

Of the species covered under the 12 September 2008 SARBA, the following are found within the Bogue Banks proposed project area: five species of sea turtles (loggerhead, green, Kemp's ridley, hawksbill, and leatherback), three large whale species (NARW, humpback whale, and sperm whale), shortnose sturgeon, and Atlantic sturgeon.

In May 2007, during a SARBA scoping meeting at the NMFS Southeast Regional Office in St. Pete, Fl, Corps 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. For the purposes of this assessment, all dredging actions will work under the Reasonable and Prudent Measures (RPM's), Terms and Conditions (T&C's), and Incidental Take Statement (ITS) of the 1997 SARBO until a superseding SARBO is completed. The NMFS concurred no new ESA consultation was needed in a January 17, 2014 email. Upon completion of the new SARBO by NMFS, all new RPM's, T&C's, and ITS will be adhered to as a component of this project. For those species present within the proposed project vicinity that have already been addressed in the Corps' 12 September 2008 SARBA, an additional species life history analysis and project impact evaluation will not be provided in the ensuing text, but rather reference to the existing NMFS consultation will be made.

In summary, based on a detailed evaluation provided in the 12 September 2008 SARBA of the effects of the proposed action on sea turtle, large whale, and sturgeon species found within the Bogue Banks project area, Table 1 provides the effect determinations for hopper dredging and associated activities.

Table 1. Effect determination for hopper dredging and associated activities for sea turtle, large whale, and sturgeon species found within the proposed Bogue Banks project area (No Effect (NE – green); May Affect Not Likely to Adversely Affect (MANLA – orange); May Affect Likely to Adversely Affect (MALAA – red); and Not Likely to Adversely Modify (NLAM – yellow/orange)). (Reference: *USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE, Wilmington District. Submitted to NMFS on 12 September 2008.)*
*(*Refers to "closed net" sea turtle relocation mitigation trawling)*

Proposed Activity	**Effect Determination**									
	Sea Turtle					**Large Whales**			**Shortnose Sturgeon**	**Atlantic Sturgeon**
	Leatherback	***Loggerhead***	***Green***	***Kemp's Ridley***	***Hawksbill***	***NARW***	***Humpback***	***Sperm***		
Hydraulic Hopper	MANLAA	MALAA	MALAA	MALAA	MALAA	NE	NE	NE	NE	MALAA
Bed Leveling	NE	MANLAA	MANLAA	MANLAA	MANLAA	NE	NE	NE	NE	NE
Transport - Hopper, Tug/Scow, Barge	NE	NE	NE	NE	NE	MANLAA	MANLAA	NE	NE	NE
*Trawling	MANLAA	MANLAA	MANLAA	MANLAA	MANLAA				MALAA	MALAA
Tissue Sampling	MANLAA	MANLAA	MANLAA	MANLAA	MANLAA					
Tagging	MANLAA	MANLAA	MANLAA	MANLAA	MANLAA					
Dredge Lighting	MANLAA	MANLAA	MANLAA	MANLAA	MANLAA					
Critical Habitat	NLAM	NLAM		NLAM	NLAM					

3.00 SPECIES CONSIDERED UNDER THIS ASSESSMENT

Updated lists of endangered and threatened (T&E) species for the project area (Carteret County, NC) were obtained from the NMFS (Southeast Regional Office, St. Petersburg, FL) (http://sero.nmfs.noaa.gov/pr/endangered%20species/specieslist/PDF2010/South%20Atlantic.pdf) and the USFWS (Field Office, Raleigh, NC) (http://www.fws.gov/raleigh/es_tes.html) websites. These lists were combined to develop the following composite list of T&E species that could be present in the project area based upon their geographic range. However, the actual occurrence of a species in the area would depend upon the availability of suitable habitat, the season of the year relative to a species' temperature tolerance and migratory habits, and other factors.

Table 2. Threatened and Endangered Species Potentially Present in Carteret County, NC.

Species Common Names	**Scientific Name**	**Federal Status**
Mammals		
West Indian Manatee	*Trichechus manatus*	Endangered
North Atlantic Right whale	*Eubaleana glacialis*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Finback whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered
Birds		
Roseate Tern	*Sterna dougallii dougallii*	Endangered
Wood Stork	*Mycteria Americana*	Endangered
Piping Plover	*Charadrius melodus*	Threatened
Red-cockaded woodpecker	*Picoides borealis*	Endangered
Red Knot	*Calidris canutus*	FSC
Reptiles		
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
Fish		
Atlantic Sturgeon	*Acipenser oxyrhynchus oxyrhynchus*	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Smalltooth sawfish	*Pristis pectinata*	Endangered
Vascular Plant		
Cooley's meadowrue	*Thalictrum cooleyi*	Endangered
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened
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."	
Federal Species of Concern (FSC)	A species under consideration for listing, for which there is insufficient information to support listing at this time.	

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

4.00 ASSESSMENT OF IMPACTS TO LISTED THREATENED AND ENDANGERED SPECIES

4.01 General Impacts

Dredging and placement of beach quality sand have the potential to affect animals and plants in a variety of ways. The potential for adverse impacts may result from actions of the dredging equipment (i.e. suction, sediment removal, hydraulic pumping of water and sediment); physical contact with dredging equipment and vessels; physical barriers imposed by the presence of dredging equipment (i.e. pipelines); and placement of dredged material on the beach within the proposed construction template (i.e. covering, suffocation). Although beach placement of material, and associated construction operations (i.e. operation of heavy equipment, pipeline route, etc.), may adversely affect some species and their habitat, the resultant constructed beach profile also promotes restoration of important habitat that has been lost or degraded as a result of erosion. Potential impacts vary according to the type of equipment used, the nature and location of sediment discharged, the time period in relation to life cycles of organisms that could be affected, and the nature of the interaction of a particular species with the dredging activities.

Any potential impacts on federally listed threatened and endangered species would be limited to those species that occur in habitats provided by the project area. Therefore, the proposed work will not affect any listed species which could be found within adjoining habitats surrounding the study area but do not have interrelated linkage to the habitats directly within the study area. These species include the wood stork, red-cockaded woodpecker, Cooley's meadowrue, and rough-leafed loosestrife. Dredging methods and placement of beach quality sand associated with the proposed action are similar to current maintenance dredging methods and existing beach nourishment projects. These methods have been addressed in a number of previous environmental documents, including biological assessments and biological opinions rendered regarding endangered and threatened species. The accounts, which follow, will summarize this information as it applies to the proposed action.

4.02 Species Accounts

4.02.1 Blue Whale, Finback Whale, Humpback Whale, North Atlantic Right Whale (NARW), Sei Whale, and Sperm Whale

a. Status. Endangered

b. Occurrence in Immediate Project Vicinity. These whale species all occur infrequently in the ocean off the coast of North Carolina. Of these, only the NARW and the humpback whale routinely come close enough inshore to encounter the project area. Humpback whales were listed as "endangered" throughout their range on June 2, 1970 under the Endangered Species Act and are considered "depleted" under the Marine Mammal Protection Act. Humpbacks are often found in protected waters over shallow banks and shelf waters for breeding and feeding. They migrate toward the poles in summer and toward the tropics in winter and are in the vicinity of the North Carolina coast during seasonal migrations, especially between December and April. Since 1991, humpback whales have been seen in nearshore waters of North Carolina with peak abundance in January through March (NMFS, 2003). In the Western North Atlantic, humpback feeding grounds encompass the eastern coast of the United States, the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland. Major prey species include small schooling fishes (herring, sand lance, capelin, mackerel, small Pollock, and haddock) and large zooplankton, mainly krill (up to 1.5 tons per day) (http://www.nmfs.noaa.gov). Based on an increased number of sightings and stranding data, the Chesapeake and Delaware Bays and the U.S. mid-Atlantic and southeastern states, particularly along Virginia and North Carolina coasts, have become increasingly important habitat for juvenile humpback whales (Wiley *et al*., 1995).

The NARW continues to be one of the most critically endangered populations of large whales in the world as revealed by the most recent review of the photo-ID recapture database in 2009 indicating that, at a minimum, 361 individually recognized whales in the catalog were known to be alive during 2005 (NMFS, 2010a). There are 6 major habitats or congregation areas for the western NARW; these are the coastal waters of the southeastern United States, the Great South Channel, Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bays, the Bay of Fundy, and the Scotian Shelf. However, the frequency with which NARWs occur in offshore waters in the southeastern U.S. remains unclear (NMFS, 2003). While it usually winters in the waters between Georgia and Florida, the NARW can, on occasion, be found in the waters off North Carolina. Additionally, systematic surveys conducted off the coast of North Carolina during the winters of 2001 and 2002 sighted 8 calves, suggesting the calving grounds may extend as far north as Cape Fear (McLellan *et al.* 2004). NARWs swim very close to the shoreline and are often noted only a few hundred meters offshore (Schmidly, 1981). NARWs have been documented along the North Carolina coast, as close as 250 meters from the beach, between December and April with sightings being most common from mid to late March (Dr. Frank J. Schwartz, personal communication, 1996). Sighting data provided by the NARW Program of the New England Aquarium indicates that 93 percent of all North Carolina sightings between 1976 and 1992 occurred between mid-October and mid-April (Slay, 1993). The occurrence of NARWs in the State's waters is usually associated with spring or fall migrations. Due to their occurrence in the nearshore waters, the transport of hopper dredges to and from the offshore borrow areas could result in an encounter with humpback and NARW species.

c. Project Impacts.

(1) Habitat. No critical habitat has been designated for NARWs and humpback whales within the proposed project area.

(2) Food Supply. North Atlantic right whales feed primarily on copepods (*Calanus* sp.) and euphausids (krill) (NMFS, 1991) and humpback whales feed on small fish and krill. The proposed dredging will not diminish productivity of the nearshore ocean; therefore, the food supply of these species should be unaffected.

(3) Relationship to Critical Periods in Life Cycle.

North Atlantic Right Whale (NARW).

Detailed life history information for NARWs and potential effects from dredging activities area provided within the following Section 7 consultation documents:

National Marine Fisheries Service. 1997. Regional Biological Opinion for the Continued Hopper Dredging of Channels and Borrow Areas in the Southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, Maryland

USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE, Wilmington District. Submitted to NMFS on 12 September 2008.

The referenced September 2008 Section 7 consultation document discusses in detail the 26 June, 2006 proposed regulations by NMFS to implement mandatory vessel speed restrictions of 10 knots or less on vessels 65 ft. or greater in overall length in certain locations and at certain times of the year along the east coast of the U.S. Atlantic seaboard. Following the release of the referenced USACE consultation document, NMFS announced the release of the Final Rule and subsequent OMB approval of the collection-of-information requirements. Specifically, on October 10, 2008 NMFS published a final rule implementing speed restrictions to reduce the incidence and severity of ship collisions with North Atlantic right whales (73 FR 60173) with an effective date of December 9, 2008 through December 9, 2013. That final rule contained a collection-of-information requirement subject to the Paperwork reduction Act (PRA) that had not yet been approved by OMB. Specifically, 50 CFR 224.105(c) requires a logbook entry to document that a deviation from the 10-knot speed limit was necessary for safe maneuverability under certain conditions. On October 30, 2008, OMB approved the collection-of-information requirements contained in the October 10, 2008, final rule. On 5 December 2008, NMFS announced that the collection-of-information requirements were approved under Control Number 0648–0580, with an expiration date of April 30, 2009 (15 CFR Part 902).

Humpback Whales.

The overall North Atlantic population of humpback whales is increasing with an estimated average trend of 3.1% for the period 1979-1993 (Stevick *et al.,* 2003). Estimates of population size vary depending on how they are derived (i.e. genetic tagging, photographic marc-recapture analysis, and genotype based analysis) but range between about 7,700 to 11,570 animals (NMFS, 2010b). However, the best estimate of abundance for the Gulf of Maine stock is 847 animals with a minimum population estimate 549 animals. Current data suggest that the Gulf of Maine humpback whale stock is steadily increasing in size (NMFS, 2010b). For the period 1993-1997, the total estimated human-caused mortality and serious injury from fishery interactions and vessel collisions was estimated at 4.4 per year (NMFS, 2003) and recent data from 2004-2010 estimate a slight increase to 4.6 per year (NMFS, 2010b). According to Jensen and Silber's (2003) large whale ship strike database, of the 292 records of confirmed or possible ship strikes to large whales, 44 records (15%) were of humpback whales, the second most often reported species next to finback whales (75 records) (26%). Of the 5 documented ship strikes resulting in serious injury or mortality for North Atlantic humpback whales from January 1997-December 2001, 3 where located in North Carolina and South Carolina waters. Though the total level of human-caused mortality and serious injury is unknown, current data indicate that it is significant; furthermore, mortality off the U.S. Mid-Atlantic States continues to increase (NMFS, 2003).

(4) Effect Determination. 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 is not likely to adversely affect 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, the proposed project may affect, not likely to adversely affect the NARW and humpback whale species.

4.02.2 West Indian Manatee

a. Status. Endangered.

b. Occurrence in Immediate Project Vicinity. Manatees are a sub-tropical species with little tolerance for cold. Though they are generally restricted to warm inland and coastal waters of Florida, in warmer months they may be found throughout the United States (USFWS, 2009). North Carolina is one location along the Southeast coast where the manatee is an occasional summer resident; however, populations numbers are presumably low (Clark, 1987). The species can be found in shallow (5 ft to usually <20 ft), slow-moving rivers, estuaries, saltwater bays, canals, and coastal areas (USFWS, 1991). The West Indian manatee is herbivorous and eats aquatic plants such as hydrilla, eelgrass, and water lettuce (USFWS, 1999a). Manatees are thermally stressed at water temperatures below 18ºC (64.4ºF) (Garrott *et al*., 1995); therefore, during winter months, when ambient water temperatures approach 20ºC (68ºF), the U.S. manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. During the summer months, sightings drop off rapidly north of Georgia (Lefebvre *et al., 2001*) and are rare north of Cape Hatteras (Rathbun *et al., 1982*; Schwartz, 1995). However, they are sighted infrequently in

southeastern North Carolina with most records occurring in July, August, and September, as they migrate up and down the coast (Clark, 1993). The Species is considered a seasonal inhabitant of North Carolina with most occurrences reported from June through October (USFWS, 2001). According to Schwartz (1995), manatees have been reported in the state during nine months, with most sightings in the August-September period. Manatee population trends are poorly understood, but deaths have increased steadily. A large percent of mortality is due to collisions with watercrafts, especially of calves. Another closely related factor in their decline has been the loss of suitable habitat through incompatible coastal development, particularly destruction of sea grass beds by boating facilities (USFWS, 2001).

Manatees are rare visitors to the Carteret County, NC project area. According to Schwartz (1995), a total of 68 manatee sightings have been recorded in 11 coastal counties of North Carolina during the years 1919-1994; thus, confirming their summer migration through North Carolina waters, including the project study area. Manatees are known to infrequently occur within nearly all North Carolina ocean and inland waters (Schwartz, 1995) with four North Carolina records having been from inlet-ocean sites and six from the open ocean (Rathbun, 1982). According to the existing literature, specific numbers of manatees using the region are not known but are presumed to be very low. More research is needed to determine the status of the species in North Carolina and identify areas (containing food and freshwater supplies), which support summer populations.

c. Current Threats to Continued Use of the Area. The minimum population estimate, based on the best available count of Florida manatees located in warm water refuges, in January 2009 was 3,802 animals (FWC FWRI Manatee Synoptic Aerial Surveys 2009). Recent demographic analyses indicate that, with the exception of the Southwest management unit, manatee populations are increasing or stable throughout much of Florida (USFWS, 2009). Sources of anthropogenic manatee mortality and injury throughout their distribution range include watercraft, water control structures, recreational and commercial fishing gear, and others. Specific threats to manatees in North Carolina and within the study area cannot be clearly assessed due to the lack of knowledge regarding population size, seasonality, distribution, and habitat requirements. However, considering that watercraft strikes are a leading cause of human induced mortality throughout their range, vulnerability to strikes likely occurs in North Carolina. Considering that manatees become thermally stressed at water temperatures below 18ºC (64ºF) (Garrot *et al*., 1995), the nature threat of cold winter temperatures is a likely a significant contributing stress to the species and keeps them from over wintering in the project area.

d. Project Impacts.

(1) Habitat. Typical coastal habitats utilized by manatees which are found within North Carolina include coastal tidal rivers, salt marshes, and vegetated bottoms where they feed on the aquatic vegetation and, in some cases, smooth cordgrass (*Spartina alterniflora*) (USFWS, 2007). Project related impacts to estuarine and nearshore ocean habitat of the area associated with the placement of sediment on the beach should be minor and direct impacts to specific habitat requirements will be avoided.

(2) Food Supply. Specific food sources utilized by the manatee in North Carolina are unknown; however, the manatee diet in Florida consists primarily of vascular plants and is likely the same in North Carolina, including aquatic vegetation and salt marsh grasses. The

proposed action will involve minimal change to the physical habitat of the estuary with no known impacts to vascular plants and overall estuarine and nearshore productivity should remain high throughout the project area. Therefore, potential food sources for the manatee should be unaffected.

(3) Relationship to Critical Periods in Life Cycle. Since the manatee is considered to be an infrequent summer resident of the North Carolina coast, the proposed action should have little effect on the manatee since its habitat and food supply will not be significantly impacted. In regards to vessel collisions, the proposed borrow sites are located offshore and the hopper dredge pumpout stations will be located within a mile offshore; thus, hopper dredging activities will not occur in the estuarine or inlet habitat area and direct impacts from collision will not occur. Nonetheless, the Corps will implement precautionary measures for avoiding impacts to manatees from associated transiting vessels during construction activities, as detailed in the "Guidelines for Avoiding Impacts to the West Indian Manatee" established by the USFWS.

(4) Effect Determination. 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 not likely to adversely affect the manatee.

4.02.3 Sea Turtles.

a. Status.

Loggerhead	*Caretta caretta*	Threatened
Hawksbill	*Eretmochelys imbricata*	Endangered
Kemp's Ridley	*Lepidochelys kempii*	Endangered
Green	*Chelonia mydas*	Threatened[1]
Leatherback	*Dermochelys coriacea*	Endangered

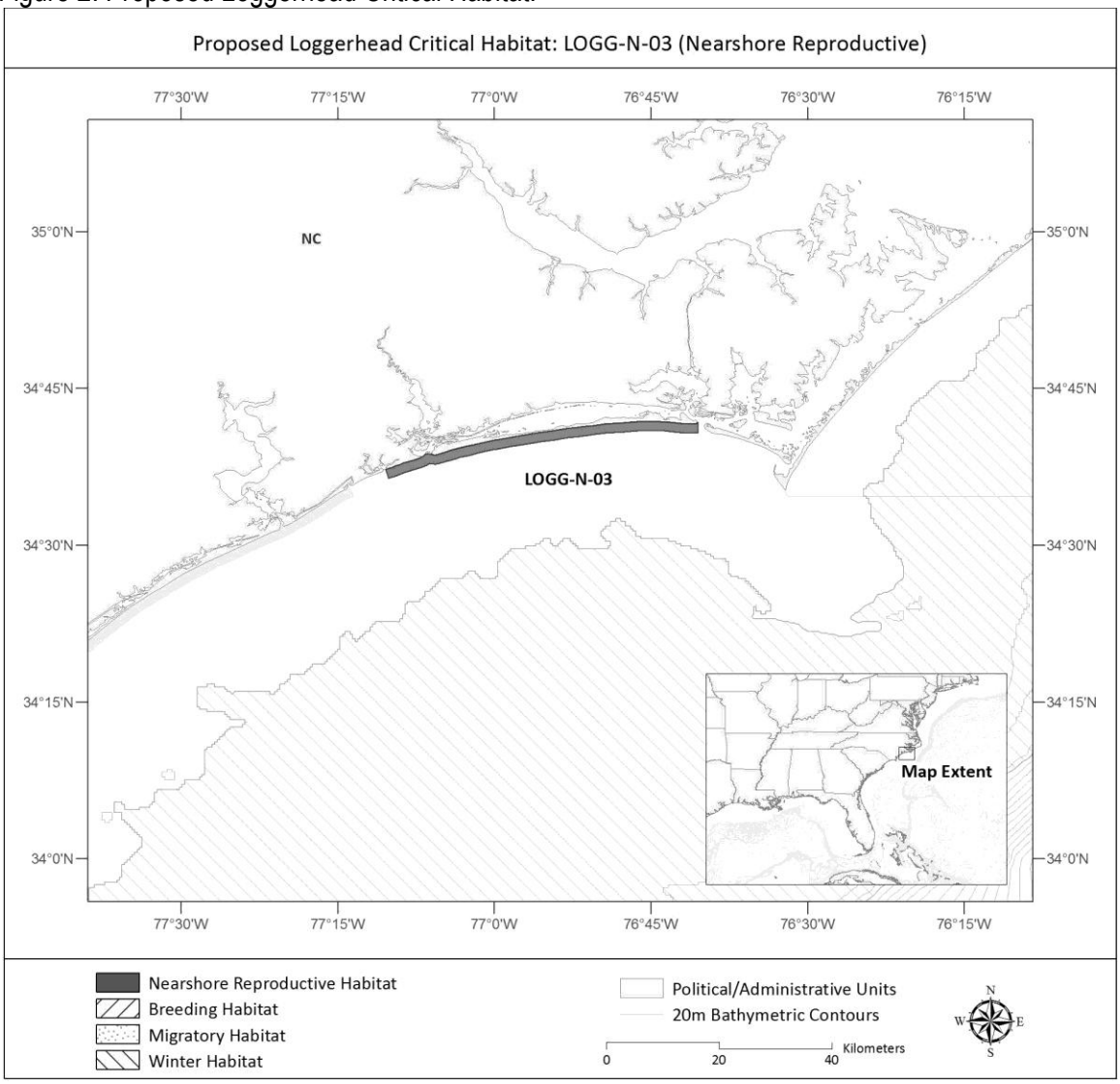
[1]Green turtles are listed as threatened, except for breeding populations in Florida and on the Pacific Coast of Mexico, which are listed as endangered.

b. 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).

Recovery Unit LOGG-N-3 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).

Figure 2. Proposed Loggerhead Critical Habitat.



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.

c. Background. Detailed life history information associated with the in-water life cycle requirements for sea turtles and a subsequent analysis of impacts from the proposed dredging activities is provided within the following NMFS Section 7 consultation documents:

National Marine Fisheries Service. 1997. Regional Biological Opinion for the Continued Hopper Dredging of Channels and Borrow Areas in the Southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, Maryland

USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE, Wilmington District. Submitted to NMFS on 12 September 2008

A summary of project specific information associated with beach and in-water habitat use is provided in the ensuing text.

1.) Occurrence in Immediate Project Vicinity. All five species of sea turtles identified above are known to occur in both the estuarine and oceanic waters of North Carolina. According to Epperly *et al.* (1994), inshore waters, such as Pamlico and Core Sounds, are important developmental and foraging habitats for loggerheads, greens, and Kemp's ridleys. Nearly all sea turtles found within these sounds are immature individuals immigrating into the sounds in the spring and emigrating from the sounds in the late fall and early winter (Epperly et. al, 1995). Loggerhead, green, and Kemp's ridley sea turtles are known to frequently use coastal waters offshore of North Carolina as migratory travel corridors (Wynne, 1999) and commonly occur at the edge of the continental shelf when they forage around coral reefs, artificial reefs, and boat wrecks.

Results from satellite tracking survey of male loggerhead sea turtles aggregated for mating in the Port Canaveral, FL, shipping entrance channel suggest that residents and transients co-occurred in near shore waters during April and mid-May, after which time residents moved offshore to deeper waters (>26m) and transients dispersed to multiple locations along the U.S. East Coast, including Cape Hatteras, NC. These results are consistent with other studies tracking male loggerhead sea turtles suggesting that that Cape Hatteras, NC may represent a seasonally important landmark for adult male loggerheads. Male turtles appear to migrate to Cape Hatteras in the fall before over-wintering near the edge of the continental shelf to the east/southeast of Cape Fear, NC (SCDNR, 2009).

Hawksbill and leatherback sea turtles infrequently enter inshore waters (Epperly *et al.*, 1995) and are normally associated solely with oceanic waters (Schwartz, 1977). However, Lee and Palmer (1981) document that leatherbacks normally frequent the shallow shelf waters rather than those of the open sea, with the exception of long-range migrants.

Of the five species of sea turtles considered for this project, only the loggerhead sea turtle (*Caretta caretta*), the green sea turtle (*Chelonia mydas*), and the leatherback sea turtle (*Dermochelys coriacea*) nest regularly on North Carolina beaches and have the potential to nest within the project area. There are no documented nesting attempts of hawksbill sea turtles on the project beaches; however, Kemp's ridley nests have been documented twice in North Carolina, once on Oak Island in 1992 and once on Cape Lookout in 2003 ((Matthew Godfrey, pers. comm.). With a few exceptions, the entire Kemp's ridley population nests on the approximately 15 miles of beach in Mexico between the months of April and June (USFWS, 1991). The hawksbill sea turtle nests primarily in tropical waters in south Florida and the Caribbean. Considering the infrequency of

Kemp's ridley nesting occurrence throughout North Carolina and the lack of historical nesting of hawksbill sea turtles, these species are not anticipated to nest within the project area. The loggerhead is considered to be a regular nester in the state, while green sea turtle nesting is infrequent and primarily limited to Florida's east coast (300 to 1,000 nests reported annually). According to Rabon *et al*. (2003), an increased number of leatherback nests have been documented in North Carolina since 1998 constituting the northernmost nesting records for leatherbacks along the East Coast of the United States. Through 2003, almost all confirmed nesting activity in North Carolina was between Cape Lookout and Cape Hatteras. Since 1982, a total of 2 leatherback nests were laid on Bogue Banks.

The beaches of Bogue Banks consist of approximately 25 linear miles of available nesting habitat. Table 3, shows the total number of recorded nesting activity on these beaches from 1982 to 2011. A total of 841 nests were laid within the project areas since 1982, consisting of predominantly of loggerhead sea turtle nests with six green and two leatherback sea turtle nests. The 2013 FEMA project off of Bogue Banks conducted relocation trawling from January to March and did not catch any sea turtles.

Table 3. Bogue Banks sea turtle nest data (1982-2011). Includes Fort Macon, Atlantic Beach, Pine Knoll Shores, Indian Beach, Salter Path and Emerald Isle.
NOTE: Standardized monitoring for the whole island was not instituted until 2002 (Atlantic Beach did not have regular monitoring before that). The rest of the island had standardized monitoring by 1997 (Matthew Godfrey, pers. comm.)

Year	Loggerheads	Green	Leatherback	Total Nests
1982	3	0	0	3
1983	?	?	?	?
1984	23	0	0	23
1985	5	0	0	5
1986	3	0	0	3
1987	33	0	0	33
1988	25	0	0	25
1989	32	0	0	32
1990	47	0	0	47
1991	51	0	0	51
1992	46	0	0	46
1993	21	0	0	21
1994	33	0	0	33
1995	29	0	0	29
1996	19	0	0	19
1997	38	0	0	38
1998	25	0	0	25
1999	38	0	0	38
2000	15	2	0	15
2001	23	0	0	23
2002	19	0	0	19
2003	41	0	0	41
2004	21	0	0	21
2005	38	1	2	41
2006	33	0	0	33
2007	27	0	0	27
2008	33	0	0	33
2009	34	1	0	35
2010	52	2	0	54
2011	28	0	0	28

2.) Current Threats to Continued Use of the Area. In addition to affecting the coastal human population, coastal sediment loss also poses a threat to nesting sea turtles. A large percentage of sea turtles in the United States nest on nourished beaches (Nelson and Dickerson, 1988a), therefore, nourishment has become an important technique for nesting beach restoration (Crain *et al.*, 1995). The beaches of Bogue Banks are important nesting beaches for the declining Northern loggerhead population; thus restoration of nesting habitat on these eroding beaches is critical. Most of the project area has experienced severe erosion because of frequent hurricanes passing over or near the area since 1996. In response to short and long term erosion processes,

beach communities continue to implement short term efforts to mitigate the lost beach. Past mitigative efforts included beach scraping, dune building, beach nourishment, placement of navigation dredged material, etc. Though the creation of habitat through these mitigation and restoration efforts facilitates successful nesting in the short term, the beaches are still susceptible to erosion and subsequent loss of nesting over the long term.

The primary threats facing these species worldwide are the same ones facing them in the project area. Of these threats, the most serious seem to be loss of breeding females through accidental drowning by shrimpers (Crouse, *et al.*, 1987) and human encroachment on traditional nesting beaches. Research has shown that the turtle populations have greatly declined in the last 20 years due to a loss of nesting habitat along the beachfront and by incidental drowning in shrimp trawl nets. It appears that the combination of poorly placed nests coupled with unrestrained human use of the beach by auto and foot traffic has impacted this species greatly. Other threats to these sea turtles include excessive natural predation in some areas and potential interactions with hopper dredges during the excavation of dredged material. With the exception of hopper dredges, none of the dredge plants (i.e., pipeline dredges) proposed for use in the construction of this project are known to take sea turtles.

d. Project Impacts.

In order to avoid periods of peak sea turtle abundance during warm water months and minimize impacts to sea turtles in the offshore environment, the proposed hopper dredging window for this project is 1 December through 31 March. By adhering to this dredging window to the maximum extent practicable, all subsequent beach placement of sediment will occur outside of the North Carolina sea turtle nesting season of 1 May through 15 November. The limits of the nesting season window are based on the known nesting sea turtle species within the state and the earliest and latest documented nesting events for those species.

In the unanticipated event that construction activities extend into the nesting season (i.e. weather, equipment breakdown, etc.), all available data associated with the nesting activities within the project area will be utilized to consider risks of working within the nesting season. Variables to consider will include the number of days construction will extend into the nesting season, existing conditions of the pre-project nesting habitat such as: erosion rates, existing protective measures (i.e. sandbags, beach bulldozing, etc.), development, recreational use, the historic nesting density within the project area, etc. In coordination with the USFWS and NCWRC, an evaluation of these variables will be used to potentially incorporate project modifications (i.e. modified pipeline routes, staging areas, etc.) during the nesting season that may avoid or minimize potential impacts.

Upon evaluation of site-specific conditions, if nourishment beach activities extend into a portion of the nesting season, monitoring for sea turtle nesting activity will be considered throughout the construction area including the disposal area and beachfront pipeline routes, in accordance with guidelines provided by the NCWRC and USFWS, so that nests laid in a potential construction zone can be bypassed and/or relocated outside of the construction zone prior to project commencement. However, relocation measures should be considered as a last alternative. The location and operation of heavy equipment on the beach within the project area will be limited to daylight hours to the maximum extent practicable in order to minimize impacts to nesting sea turtles.

Considering that the proposed 1 December to 31 March construction window for initial construction and each nourishment interval will avoid the nesting season, direct impacts associated with construction activities during the nesting season are not anticipated and will be avoided to the maximum extent practicable. However, if construction extends into the nesting season do to unforeseen circumstances, the following direct impacts may occur:

(1) Both stockpiled pipe on the beach and the pipeline route running parallel to the shoreline may impede nesting sea turtles from accessing more suitable nesting sites.
(2) The operation of heavy equipment on the beach may impact incubating nests.
(3) During nighttime operations, the nourishment construction process, including heavy equipment use and associated lighting, may deter nesting females from coming ashore and disorient emerging hatchlings down the beach.
(4) Burial of existing nests may occur if missed by monitoring efforts.
(5) Escarpment formations and resulting impediment to nesting females.
(6) Reduced nest success as a result of relocation efforts.

Indirect impacts associated with changes to the nesting and incubating environment, from the placement of sediment from alternate sources on the beach, are expected. The following section discusses both potential direct and indirect impacts to nesting sea turtles associated with the proposed project:

(1) <u>Beach Placement of Sediment Impacts</u>.

Post-nourishment monitoring efforts have documented potential impacts on nesting loggerhead sea turtles for many years (Fletemeyer, 1984; Raymond, 1984; Nelson and Dickerson, 1989; Ryder, 1993; Bagley *et al*., 1994; Crain *et al*., 1995; Milton *et al*., 1997; Steinitz *et al.*, 1998; Trindell *et al*., 1998; Davis *et al*., 1999; Ecological Associates, Inc., 1999; Herren, 1999; Rumbold *et al*., 2001; Brock, 2005; and Brock *et. al*., 2009). Results from these studies indicate that, in most cases, nesting success decreases during the year following nourishment as a result of escarpments obstructing beach accessibility, altered beach profiles, and increased compaction. A comprehensive post-nourishment study conducted by Ernest and Martin (1999) documented an increase in abandoned nest attempts on nourished beaches compared to control or pre-nourished beaches as well as a change in nest placement with subsequent increase in wash-out of nests during the beach equilibration process. Contrary to previous studies, this study suggests that a post-nourishment decline in nest success is more likely a result from changes in beach profile than an increase in beach compaction and escarpment formation. According to Brock (2005) and Brock et. al. (2009), the sediment used for the nourishment of Brevard County beaches in Florida offered little or no impediment to sea turtles attempting to excavate an egg chamber. Furthermore, the physical attributes of the nourished sediment did not facilitate excessive scarp formation and; therefore, turtles were not limited in their ability to nest across the full width of beach. However, a decrease in nest success was still documented in the year following nourishment with an increase in loggerhead nesting success rates during the second season post-nourishment. This was attributed to increased habitat availability following the equilibration process of the seaward crest of the berm (Brock, 2005). Additionally, since nest success rates returned to normal following initial construction, it is possible that the constructed profile in the first nesting season following construction caused a decrease in nest success until the beach equilibrated to a natural profile by

the second season (Brock *et. al*., 2009). Increasing the time between construction completion and the commencement of the nesting season would allow more time for equilibration to the natural profile to occur (Brock *et. al.,* 2009). The Brock (2005) study suggests that, if compatible sediment and innovative design methods are utilized to minimize post-nourishment impacts documented in previous studies, than the post-nourishment decrease in nest success without the presence of scarp formations, compaction, etc. may indicate an absence of abiotic and or biotic factors that cue the female to initiate nesting.

As suggested by the historical literature, there are inherent changes in beach characteristics as a result of mechanically placing sediment on a beach from alternate sources. The change in beach characteristics often results in short-term decreases in nest success and/or alterations in nesting processes. However, when done properly, beach construction projects may mitigate the loss of nesting beach when the alternative is severely degraded or non-existent habitat (Brock et. al., 2009). Based on the available literature, it appears that these impacts are, in many cases, site specific. Careful consideration must be placed on pre- and post-project site conditions and resultant beach characteristics after beach-fill episode at a given site in order to thoroughly understand identified post-project changes in nesting processes. By better understanding potential project specific impacts, modifications to project templates and design can be implemented to improve habitat suitability. The following sections review, more specifically, documented direct or indirect impacts to nesting females and hatchlings.

a. Pipe Placement**.**

In the event unanticipated circumstances arise and construction operations extend into the sea turtle nesting season pipeline routes and pipe staging areas may act as an impediment to nesting females approaching available nesting habitat or to hatchlings orienting to the water's edge. If the pipeline route or staging areas extend along the beach face, including the frontal dune, beach berm, mean high water line, etc., some portion of the available nesting habitat will be blocked. Nesting females may either encounter the pipe and false crawl, or nest in front of the pipeline in a potentially vulnerable area to heavy equipment operation, erosion, and washover. If nests are laid prior to placement of pipe and are landward of the pipeline, hatchlings may be blocked or mis-oriented during their approach to the water.

Though pipeline alignments and staging areas may pose impacts to nesting females and hatchlings during the nesting season, several measures can be implemented to minimize these impacts. If construction activities extend into the nesting season, monitoring should be done in advance to document all nests within the beach placement template. Construction operations and pipeline placement could be modified to bypass existing nests. If bypassing is not a practical alternative for a given project, the relocation of nests outside of construction areas could be implemented as a last resort. Throughout the period of sea turtle nesting and hatching, construction pipe that is placed on the beach parallel to the shoreline could be placed as far landward as possible so that a significant portion of available nesting habitat can be utilized and nest placement is not subject to inundation or wash out. Furthermore, temporary storage of pipes and equipment can be located off the beach to the maximum extent practicable. If placement on the beach is necessary, it will be done in a manner so as to impact the least amount of nesting habitat by placing pipes perpendicular to shore and as far landward as possible without compromising the integrity of the existing or constructed dune system.

b. Slope and Escarpments.

Beach nourishment projects are designed and constructed to equilibrate to a more natural profile over time relative to the wave climate of a given area. Changes in beach slope as well as the development of steep escarpments may develop along the mean high water line as the constructed beach adjusts from a construction profile to a natural beach profile (Nelson *et al.*, 1987). For the purposes of this assessment, escarpments are defined as a continuous line of cliffs or steep slopes facing in one general direction, which is caused by erosion or faulting. Depending on shoreline response to the wave climate and subsequent equilibration process for a given project, the slope both above and below mean high water may vary outside of the natural beach profile; thus resulting in potential escarpment formation. Though escarpment formation is a natural response to shoreline erosion, the escarpment formation as a result of the equilibration process during a short period following a nourishment event may have a steeper and higher vertical face than natural escarpment formation and may slough off more rapidly landward.

Adult female turtles survey a nesting beach from the water before emerging to nest (Carr and Ogren, 1960; Hendrickson, 1982). Parameters considered important to beach selection include the geomorphology and dimensions of the beach (Mortimer, 1982; Johannes and Rimmer, 1984) and bathymetric features of the offshore approach (Hughes, 1974; Mortimer, 1982). Beach profile changes and subsequent escarpment formations may act as an impediment to a nesting female resulting in a false crawl or nesting females may choose marginal or unsuitable nesting areas either within the escarpment face or in front of the escarpment. Often times these nests are vulnerable to tidal inundation or collapse of the receding escarpment. If a female is capable of nesting landward of the escarpment prior to its formation, as the material continues to slough off and the beach profile approaches a more natural profile, there is a potential for an incubating nest to collapse or fallout during the equilibration process. Loggerheads preferentially nest on the part of the beach where the equilibration process takes place (Brock, 2005; Brock et. al., 2009; Ecological Associates, Inc., 1999) and are more vulnerable to fallout during equilibration. However, according to Brock (2005), the majority of green turtle nests are placed on the foredune and; therefore, the equilibration process of the nourished substrate may not affect green turtles as severely.

A study conducted by Ernest and Martin (1999) documented increased abundance of nests located further from the toe of the dune on nourished vs. control beaches. Thus, post-nourishment nests may be laid in high-risk areas where vulnerability to sloughing and equilibration are greatest. Though nest relocation is not encouraged, considering that immediately following nourishment projects the likelihood of beach profile equilibration and subsequent sloughing of escarpments as profile adjustment occurs, nest relocation may be used as a last alternative to move nests that are laid in locations along the beach that are vulnerable to fallout (i.e. near the mean high water line). As a nourished beach is re-worked by natural processes and the construction profile approaches a more natural profile, the frequency of escarpment formation declines and the risk of nest loss due to sloughing of escarpments is reduced. According to Brock (2005) and Brock *et.al*. (2009), the return of loggerhead nesting success to equivalent rates similar to those on the adjacent non-nourished beach and historical rates two seasons post-nourishment were observed and are attributed to the equilibration process of the seaward crest of the berm.

Though the equilibration process and subsequent escarpment formation are features of most beach projects, management techniques can be implemented to reduce the impact of escarpment formations. For completed sections of beach during beach construction operations, and for subsequent months following as the construction profile approaches a more natural profile, visual surveys for escarpments and slope adjustments could be performed. Escarpments that are identified prior to or during the nesting season that interfere with sea turtle nesting (exceed 18 inches in height for a distance of 100 ft.) can be leveled to the natural beach for a given area. If it is determined that escarpment leveling is required during the nesting or hatching season, leveling actions will be directed by the NCWRC and USFWS. Additionally, allowing sufficient time for the equilibration process to adjust the constructed profile to the pre-project profile of the native beach prior to the nesting season could facilitate improved nesting success (Brock *et. al*., 2009)

The Corps' Jacksonville, FL District Headquarters has worked with the Florida DEP and other stakeholders to identify aspects of beach nourishment construction templates that negatively impact sea turtles in order to potentially develop alternative design criteria that may minimize these impacts. Project design modifications to develop a more "turtle friendly" beach profile could potentially increase post-nourishment nest density and success. However, according to Brock et. al. (2009), equilibrated profiles of constructed beaches should reflect the pre-project native beach. Since there are regional differences in natural beach profiles, care should be taken when considering implementation of a single profile on constructed beaches. A draft final report for phase one of this study, "Assessment of Alternative Construction Template for Beach Nourishment Projects," has been developed and reviewed and preliminary concepts have been implemented on select projects. However, no specific literature is currently available suggesting the feasibility of integrating the recommended construction criteria into large scale projects. Based on the final results and feasibility of recommendations, the Corps may incorporate, to the maximum extent practicable, 'turtle friendly' beach profile criteria in future project designs in order to enhance sea turtle nesting habitat requirements; however, at this point in time no formal recommendations have been identified.

c. <u>Incubation Environment</u>.

Physical changes in sediment properties that result from the placement of sediment, from alternate sources, on the beach pose concerns for nesting sea turtles and subsequent nest success. Constructed beaches have had positive effects (Broadwell, 1991; Ehrhart and Holloway-Adkins, 2000; Ehrhart and Roberts, 2001), negative effects (Ehrhart, 1995; Ecological Associates, Inc., 1998), or no apparent effect (Raymond, 1984.; Nelson *et al*., 1987; Broadwell, 1991; Ryder, 1993; Steinitz *et. al.*, 1998; Herren, 1999; Brock et. al., 2009) on the hatching success of marine turtle eggs. Differences in these findings are related to the differences in the physical attributes of each project, the extent of erosion on the pre-existing beach, and application technique (Brock, 2005).

If nesting occurs in new sediment following beach construction activities, embryonic development within the nest cavity can be affected by insufficient oxygen diffusion and variability in moisture content levels within the egg clutch (Ackerman, 1980; Mortimer, 1990; Ackerman *et al*., 1992); thus, potentially resulting in decreased hatchling success. Ambient nest temperature and incubation time are affected by changes in sediment color, sediment grain size, and sediment shape as a result of beach nourishment (Milton *et al.*, 1997) and; thus, affect incubation duration (Nelson and Dickerson, 1988a). Sexual differentiation in chelonians depends on the temperature

prevailing during the critical incubation period of the eggs (Pieau, 1971; Yntema, 1976; Yntema and Mrosovsky, 1979; Bull and Vogt, 1979), which occurs during the middle third of the incubation period (Yntema, 1979; Bull and Vogt, 1981; Pieau and Dorizzi, 1981; Yntema and Mrosovsky, 1982; Ferguson and Joanen, 1983; Bull, 1987; Webb *et al*. 1987; Deeming and Ferguson, 1989; Wibbels *et al*., 1991), and possibly during a relatively short period of time in the second half of the middle trimester (Webster and Gouviea, 1988). Eggs incubated at constant temperatures of 28°C or below develop into males. Those kept at 32°C or above develop into females. Therefore, the pivotal temperature, those giving approximately equal numbers of males and females, is approximately 30°C (Yntema and Mrosovsky, 1982). Estimated pivotal temperatures for loggerhead sea turtles nesting in North Carolina, Georgia, and southern Florida are close to 29.2°C (Mrosovsky and Provancha, 1989). Therefore, fluctuation in ambient nest temperature on constructed beaches could directly impact sex determination if nourished sediment differs significantly from that found on the natural beach. Since, the pivotal temperatures for the northern and southern geographic nesting ranges of loggerheads in the United States are similar, a higher percentage of males are produced on North Carolina beaches and a higher percentage of females on Florida beaches. Hatchling sex ratios are of conservational significance (Mrosovsky and Yntema, 1980; Morreale *et al*., 1982) since they may affect the population sex ratio and thus could alter reproductive success in a population (Hanson *et al*., 1998).

d. Nest Relocation.

Relocation of sea turtle nests to less vulnerable sites was once common practice throughout the southeastern U.S. to mitigate the effects of natural or human induced factors. However, the movement of eggs creates opportunities for adverse impacts. Therefore, more recent USFWS guidelines are to be far less manipulative with nests and hatchlings to the maximum extent practicable. Though not encouraged, nest relocation is still used as a management technique of last resort where issues that prompt nest relocation cannot be resolved. Specific criteria have been established by the NCWRC for when sea turtle nests can be relocated in North Carolina. However, turtle nests should be allowed to incubate at their original location if there is any reasonable likelihood of survival and relocation must be considered as a last resort in terms of nest management (NCWRC, 2006). Potential adverse impacts associated with nest relocation include: survey error (Shroeder, 1994), handling mortality (Limpus *et al.* 1979; Parmenter 1980), incubation environment impacts (Limpus *et al*., 1979; Ackerman, 1980; Parmenter, 1980; Spotila *et al*., 1983; McGehee, 1990), hatching and emergence success, and nest concentration.

Construction efforts associated with this project are scheduled, to the maximum extent practicable, to work outside of the sea turtle nesting season in order to avoid impacts to nesting females and the nest incubation environment. However, in some instances where an extension into the nesting season cannot be avoided, nest relocation may be used as a management tool to re-locate nests laid in the impact area to areas that are not susceptible to disturbance. For the identified project area, if the earliest documented nest attempt precludes the project completion date, nest relocation may be used as a last resort mitigation effort. If relocation is implemented, the proper protocol established by the NCWRC and USFWS will be adhered to in order to avoid the potential adverse impacts outlined above.

e. Beach Compaction and Hardness.

Sediment placed on the beach, as a component of coastal storm damage reduction projects, beach disposal, sand-bypassing, etc. is often obtained from three main sources: inlets, channels, or offshore borrow sites (Crain *et al*., 1995) with occasional use of upland sources. Significant alterations in beach substrate properties may occur with the input of sediment types from other sources. Sediment density (compaction), shear resistance (hardness), sediment moisture content, beach slope, sediment color, sediment grain size, sediment grain shape, and sediment grain mineral content can be changed by beach nourishment.

Current sea turtle literature has attributed post-nourishment beach hardness to sand compaction but it should be more appropriately attributed to sediment shear resistance. Increased shear resistance can be due to increased sand compaction (density), but it can also be due to other factors such as sand particle characteristics (size, shape) and interactions between the particles (Spanger and Handy, 1982; Nelson *et al.*, 1987; Nelson and Dickerson, 1989; Ackerman, 1996). Shear resistance describes the ability of the beach sand to resist sliding along internal surfaces. A measure of shear resistance can be described as a measure of beach hardening or strength. The sand particle surface characteristics contribute to the sliding friction ability of the sand particles. Various parameters (chemical composition, cohesion, moisture content, sediment layering and mixing) contribute to the interlocking ability of the sand particles. Sliding friction, interlocking, and compaction of the sand particles all contribute to a measure of shear resistance. Thus, a measurement of increased shear resistance does not necessarily mean that the beach is also compacted (Ackerman, 1996).

Factors which may contribute to increased shear resistance on nourished beaches include a high silt component, angular fine-grained sand, higher moisture content, equipment and vehicular traffic, and hydraulic slurry deposition of sediments (Nelson, 1985; Nelson *et al.*, 1987; Nelson and Dickerson, 1988a; 1989; Ackerman, 1996). Beach fill can vary in amount of carbonate sand, quartz sand, shell, coral, silt, and clay content (National Research Council 1995). Sediments used for beach fill with clay or silt contents higher than 5-10% may cause high beach hardness once the sediment dries (Nelson, 1985; Dean, 1988). Harder nourished beaches typically result from angular, finer grain sand dredged from stable offshore borrow sites; whereas, less hard or “softer” beaches result from smoother, coarse sand dredged from high energy locations (e.g. inlets) (Spangler and Handy 1982; Nelson *et al.,* 1987; Nelson and Dickerson 1988a; 1989). However, as a component of the Corps’ planning process for Coastal Storm Damage Reduction projects, detailed sediment compatibility analysis are conducted to assure that sediment used for beach nourishment is compatible with the native grain size characteristics, regardless of where the sediment is coming from. Nourished beaches may result in sediment moisture content more than 4% higher than adjacent, natural beaches (Ackerman 1996, Ackerman *et al.,* 1992). Placement of fill material with heavy equipment imparts a component of “compactness” that should not occur on natural beaches. The natural process of beach formation, over an extended period of time, results in extensive sorting of the sand both by layers and within layers. Layer orientation is determined by the wave wash which is not the same for nourished beaches (National Research Council, 1995).

Hard sediment can prevent a female from digging a nest or result in a poorly constructed nest cavity. Females may respond to harder physical properties of the beach by spending more time on the beach nesting, which may result in physiological stress and increased exposure to disturbances and predation; thus, in some cases leading to a false dig (Nelson and Dickerson,

1989). Although increased shear resistance does not occur with every nourishment project, higher shear resistance measurement values have been more frequently reported over the past 30 years from nourished beaches than on natural beaches of the same area (e.g. Mann 1977; Fletemeyer 1983; Raymond 1984; Nelson *et al.,* 1987; Moulding and Nelson 1988; Nelson and Dickerson 1988a; Ryder 1995; Bagley *et al*., 1994; Crain *et al.,* 1995; Ernest *et al.,* 1995; Foote and Truitt 1997; Milton *et al.,* 1997; Steinitz *et al.,* 1998; Trindell *et al*., 1998; Davis *et al.,* 1999; Herren 1999; Allman *et al*., 2001; Rumbold *et al.,* 2001; Piatkowski, 2002; Scianna *et al.,* 2001; Brock, 2005). Results have varied tremendously on the nesting success reported in these studies when comparing nourished and natural beaches of different shear resistance values. The natural variance in shear resistance values and the nesting success related to these values is still poorly understood. Due to the many variables involved from natural and non-natural causes, it is extremely difficult to identify impacts from nourishment projects by only evaluating nesting success data. According to Brock *et. al*. (2009), if shear resistance associated with beach construction on the Archie Carr National Wildlife Refuge, FL prevented construction of an egg chamber; a larger portion of abandoned egg chambers than were observed would be expected. Analyses of shear resistance values and nesting success have yet to determine a consistent relationship (Trindell *et al*., 1998). It is difficult to define absolute or optimal shear resistance values until these relationships are better understood throughout the sea turtle nesting range in the United States (Gulf and South Atlantic states). Crain *et al.* (1995) also recommended this as a research priority for beach nourishment impact studies.

Measuring shear resistance has become a common procedure of most beach nourishment projects and is usually done with a hand-held cone-penetrometer (Crain *et. al.* 1995). While holding the instrument in a vertical orientation, measurements are obtained by manually pushing it into the beach sediment. Based on data collected during the 1980's from nourished and non-nourished projects on the Atlantic coast of Florida, the U.S. Army Corps of Engineers provided initial guidelines on maximum cone-penetrometer values (600) below which might be more compatible with natural nesting beaches (Nelson *et al..,* 1987; Moulding and Nelson 1988; Nelson *et al.,* 1987; Nelson and Dickerson 1988a; 1989). The USFWS later adopted these guidelines into permitting regulations for all nourished projects along the U.S. Atlantic and Gulf of Mexico coasts with potential sea turtle nesting habitat. These requirements are still in effect to date and are outlined in state construction permit requirements and Biological Opinions issued by USFWS. According to the general USFWS compaction measurement guidelines for NC outlined below, compaction measurements of 500 PSI establishes the level of beach hardness when post-nourishment beach tilling should be done to reduce the shear resistance measurements.

General USFWS Compaction Guidelines

1. Compaction sampling stations will be located at 500-foot intervals along the project area. One station will be at the seaward edge of the dune line (when material is placed in this area); and one station must be midway between the dune line and the high water line (normal wrack line).

At each station, the cone penetrometer will be pushed to a depth of 6, 12, and 18 inches three times (three replicates). Material may be removed from the hole if necessary to ensure accurate readings of successive levels of sediment. Layers of highly compact material may lie over less compact layers. Replicates will be located as close to each

other as possible, without interacting with the previous hole and/or disturbed sediments. The three replicate compaction values for each depth will be averaged to produce final values for each depth at each station. Reports will include 18 values for each transect line, and the final 6 averaged compaction values.

2. If the average value for any depth exceeds 500 pounds per square inch (psi) for any two or more adjacent stations, then that area must be tilled prior to May 1. If values exceeding 500 psi are distributed throughout the project area, but in no case do those values exist at two adjacent stations at the same depth, then consultation with the Fish and Wildlife Service will be required to determine if tilling is required. If a few values exceeding 500 psi are randomly present within the project area, tilling will not be required. For all circumstances where tilling is implemented, the designated area shall be tilled to a depth of 36 inches. Tilling will be performed (i.e. overlapping rows, parallel and perpendicular rows, etc.) so that all portions of the beach are tilled and no furrows are left behind All tilling activities must be completed prior to May 1 in accordance with the following protocol..

Readings of cone index values can be roughly equated to pounds per square inch (psi). However, this is a relative value and caution should be used when attempting to compare cone index values in pounds per square inch to other sources of data (Moulding and Nelson 1988). Ferrel *et al.* (2002) and Piatkowski (2002) used a Lang penetrometer, as opposed to the cone-penetrometer, because readings are not influenced by the mass of the user. This is an issue when multiple people of varying mass and strength are conducting the measurements. Much of the variation in the compaction data could be due to variability inherent in the use of the cone-penetrometer itself. Ferrell *et al.* (2002) investigated the strengths and weaknesses of several different types of instruments that measure sediment compaction and shear resistance suggesting that other instruments may be more suitable for measuring beach compaction relative to sea turtle nesting behavior. Because of instrument error and given that turtles do not dig vertically in the same fashion as a penetrometer moves through the sediment layers, some have concluded that penetrometers are not appropriate for assessing turtle nesting limitations (Davis *et al.*, 1999). However, even with this limitation, the hand-held cone-penetrometer remains the accepted method for assessing post-nourishment beach hardness.

According to Davis *et al.* (1999), on the Gulf Coast of Florida (1) there was no relationship between turtle nesting and sediment compactness, (2) the compactness ranges and varies widely in both space and time with little rationale, (3) tilling has a temporary influence on compactness and no apparent influence on nesting frequency, (4) and current compactness thresholds of 500 psi are artificial. According to Brock (2005) and Brock et. al. (2009), the physical attributes of the fill sand for Brevard County beaches did not result in severe compaction and therefore did not physically impede turtles in their attempts to nest. Therefore, additional studies should be considered to evaluate the validity of this threshold (500 PSI) and its general application across all beaches as a means to assess beach-tilling requirements. If sediment characteristics are similar to the native beach and sediment grain sizes are homogenous, the resultant compaction levels will likely be similar to the native beach and tilling should not be encouraged. A study by Nelson and Dickerson (1988b) documented that a tilled nourished beach will remain un-compacted for up to one year; however, this was a site-specific study and for some beaches it may not be necessary to till beaches in the subsequent years following nourishment.

Beach hardness impacts can be minimized by using borrow area sediment that is compatible with the native beach. In some cases, though sediment placed on the beach is compatible with the native sediment characteristics and the resultant compaction is similar to the native beach, tilling is still encouraged regardless of compaction levels. It has been suggested that, in some cases, the process of tilling a beach, with compaction levels similar to native beach, may have an effect on sea turtle nesting behavior and nest incubation environment. Research on evaluating tilling impacts to nesting turtles is limited. Therefore, the idea of not tilling beaches (immediately following and/or during consecutive years after construction operations) where compatible sediments are used and compaction levels are similar to the native beach should be taken into consideration on a case-by-case basis in order to account for potential impacts of tilling activities on nest success.

Recognizing the recent literature on beach compaction measurements and associated tilling, as well as and the current concerns with the existing compaction evaluation and subsequent tilling process outlined in the USFWS general compaction guidelines, the Corps, in coordination with NCWRC and USFWS, has initiated a more qualitative approach for post construction compaction evaluations on North Carolina beaches where sediment is compatible with the native material. Results from this effort have recognized a reduction in the need for post construction tilling for many disposal and nourishment projects. Considering that only beach compatible sediment will be placed on the beach as a component of this project, the Corps will continue to work with NCWRC and USFWS in this qualitative post construction compaction and tilling evaluation in order to assure that impacts to nesting and incubating sea turtles are minimized.

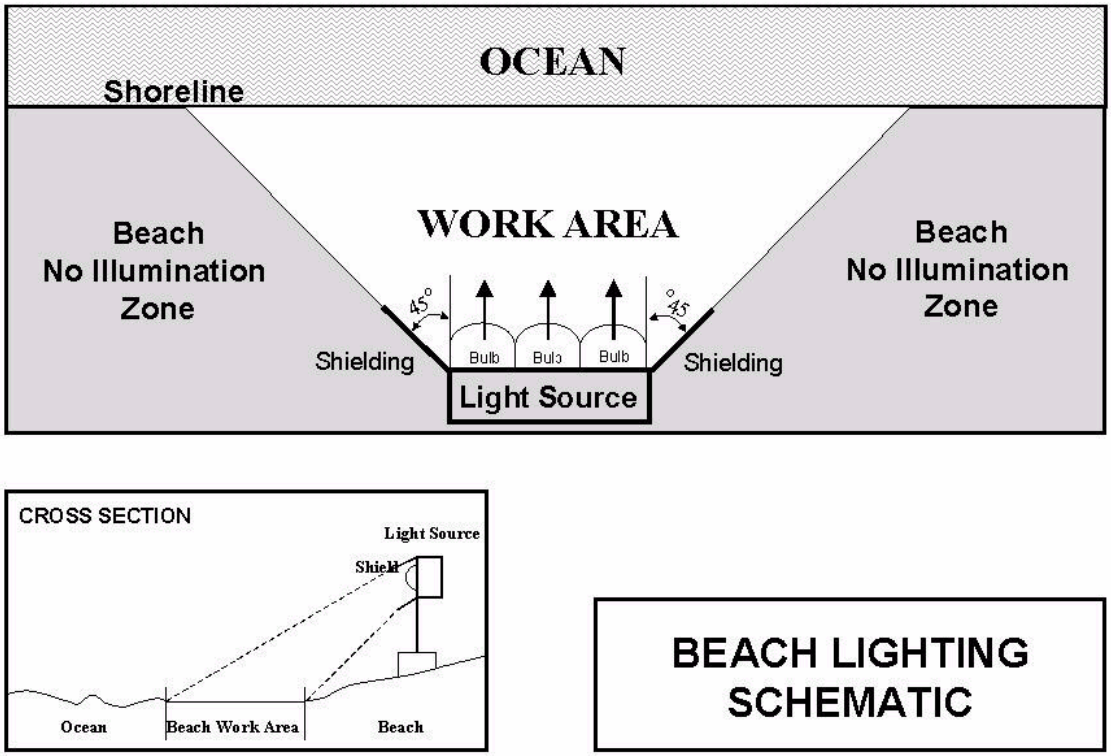
f. Lighting.

The presence of artificial lighting on or within the vicinity of nesting beaches is detrimental to critical behavioral aspects of the nesting process including nesting female emergence, nest site selection, and the nocturnal sea-finding behavior of both hatchlings and nesting females. Artificial lighting on beaches tends to deter sea turtles from emerging from the sea to nest; thus, evidence of lighting impacts on nesting females is not likely to be revealed by nest to false crawl ratios considering that no emergence may occur (Mattison *et al*., 1993; Witherington, 1992; Raymond, 1984). Though nesting females prefer darker beaches (Salmon *et al.*, 1995), considering the increased development and associated lighting on most beaches, many do nest on lighted shorelines. Although the effects of lighting may prevent female emergence, if emergence, nest site selection, and oviposition does occur, lighting does not affect nesting behavior (Witherington and Martin, 2003). However, sea turtles rely on vision to find the sea upon completion of the nesting process and use a balance of light intensity within their eyes to orient towards the brightest direction (Ehrenfeld, 1968); thus, misdirection by lighting may occur resulting in more time being spend to find the ocean. Furthermore, successful nesting episodes on lighted shorelines will directly effect the orientation and sea-finding process of hatchlings during the nest emergence and frenzy process to reach the ocean. Hatchlings rely almost exclusively on vision to orient to the ocean and brightness is a significant cue used during this immediate orientation process after hatch out (Mrosovsky and Kingsmill, 1985; Verheijen and Wilschut, 1973; Mrosovsky and Shettleworth, 1974; Mrosovsky *et al*., 1979). Hatchlings that are mis-oriented (oriented away from the most direct path to the ocean) or disoriented (lacking directed orientation or frequently changing direction or circling) from the sea by artificial lighting may die from exhaustion, dehydration, predation, and other

causes. Though hatchlings use directional brightness of a natural light field (celestial sources) to orient to the sea, light from artificial sources interferes with the natural light cues resulting in misdirection (Witherington and Martin, 2003).

The impact of light on nesting females and hatchlings can be minimized by reducing the number and wattage of light sources or by modifying the direction of light sources through shielding, redirection, elevation modifications, etc. (Figure 3). If shielding of light sources is not effective, it is important that any light reaching the beach has spectral properties that are minimally disruptive to sea turtles like long wavelength light. The spectral properties of low-pressure sodium vapor lighting are the least disruptive to sea turtles among other commercially available light sources.

Figure 3. Schematic for recommended shielding of lighting associated with beach construction activities.



During beach placement construction operations associated with the proposed project, lighting is required during nighttime activities at both the hopper dredge pumpout site and the location on the beach where sediment is being placed. In compliance with the US Army Corps of Engineers Safety and Health Requirements Manual (2003), a minimum luminance of 30 lm/ft^2 is required for dredge operations and a minimum of 3 lm/ft^2 is required for construction activities on the beach. For dredging vessels, appropriate lighting is necessary to provide a safe working environment during nighttime activities on deck (i.e. general maintenance work deck, endangered species observers, etc.). During beach construction operations, lighting is generally associated with the

active construction zone around outflow pipe and the use of heavy equipment in the construction zone (i.e. bulldozers) in order to maintain safe construction operations at night. Furthermore, on newly nourished beaches where the elevation of the beach berm is raised for coastal storm damage reduction purposes, it is possible that lighting impacts to nesting females and emerging hatchlings from adjacent lighting sources (streets, parking lots, hotels, etc) may become more problematic as shading from dunes, vegetation, etc. is not longer evident (Brock, 2005; Brock et. al., 2009; Ehrhart and Roberts, 2001). In a study on Brevard county beaches, Brock (2005) found that loggerhead hatchling disorientations increased significantly post-nourishment. This was attributed to the increase in light sources not previously visible to be seen by hatchlings as a result of the increase in profile elevation combined with an easterly expansion of the beach. However, a dune feature will be constructed as a component of this project and is, therefore, expected to reduce lighting impacts to nesting and hatchling sea turtles that are associated with raising the beach elevation.

If beach construction activities extend into the sea turtle nesting and hatching season, all lighting associated with project construction will be minimized to the maximum extent practicable while maintaining compliance with all Corps, U.S. Coast Guard, and OSHA safety requirements. Direct lighting of the beach and near shore waters will be limited the immediate construction area(s). Lighting aboard dredges and associated vessels, barges, etc. operating near the sea turtle nesting beach shall be limited to the minimal lighting necessary to comply with the Corps, U.S. Coast Guard, and OSHA requirements. Lighting on offshore or onshore equipment will be minimized through reduced wattage, shielding, lowering, and/or use of low pressure sodium lights, in order to reduce illumination of adjacent beach and nearshore waters will be used to the extent practicable.

The use of sea turtle friendly lighting has been shown to significantly improve beaches for sea turtle nesting. Therefore, in conjunction with the proposed beach project, local lighting ordinances will be encouraged to the maximum extent practicable in order to reduce lighting impacts to nesting females and hatchlings. The local sponsors will be encouraged to work with the USFWS, local monitoring groups, and other concerned organizations to develop the best plan for the towns of Emerald Isle, Pine Knoll Shores, Salter Path, Indian Beach, and Atlantic Beach.

(2) Dredging Impacts.

a. Food Supply.

After leaving the nesting beach, hatchling green and loggerhead turtles head towards the open ocean pelagic habitats (Carr, 1987) where their diet is mostly omnivorous with a strong carnivorous tendency in green turtles (Bjorndal, 1985). At about 20-25 cm carapace length Atlantic green turtles enter benthic foraging areas and shift to an herbivorous diet, feeding predominantly on sea grasses and algae but may also feed over coral reefs and rocky bottoms (Mortimer, 1982). At about 40 to 50 cm carapace length, loggerheads move into shallow water where they forage over benthic hard and soft bottom habitats (Carr, 1986). Loggerhead sea turtles feed on benthic invertebrates including mollusks, crustaceans, and sponges (Mortimer, 1982) but have also been found to eat fish, clams, oysters, sponges, jellyfish, shrimp, and crabs when near shore. Hawksbill and Kemp's ridley sea turtles are carnivorous (Mortimer, 1995) with a principal food source of crustaceans, mollusks, other invertebrates, and fish (Schwartz, 1977). Hawksbills feed on encrusting organisms such as sponges, tunicates, bryozoans, mollusks, and algae; whereas Kemp's ridleys feed

predominantly on portunid crabs (Bjomdal, 1985). Leatherback sea turtles are carnivorous (Mortimer, 1995) and feed primarily on cnidarians and tunicates (salps, pyrosomas) throughout the water column but are commonly observed feeding at the surface (Bjorndal, 1985).

Dredging will be performed within offshore borrow areas located offshore and will not affect these resources in the inshore environment. Impacts on benthic habitat at the offshore borrow sites will be minor as dredging will only affect a limited portion of the offshore benthic habitat. Hardbottom surveys and subsequent mapping were performed within proposed borrow sites. Low relief hardbottoms were identified in the U and Y borrow areas. A 500 meter buffer will be used around the hardbottoms. Impacts to sandy bottom foraging habitat are expected to be isolated and short term in duration. Therefore, the project should not significantly affect the food supply of benthic foraging sea turtles in the offshore borrow sites. Considering that leatherbacks feed primarily within the water column on non-benthic organisms, the project should not significantly affect the food supply of this species

b. Relationship to Critical Periods in Life Cycle.

Sea turtles migrate within North Carolina waters throughout the year, mostly between April and December. The dredging of sediment from designated borrow sites during initial construction and each nourishment interval will likely be performed using a hopper dredge. Hopper dredges potentially pose the greatest risk to benthic oriented sea turtles through physical injury or death by entrainment as the hopper dredge dragheads remove sediment from sea bottom.

In order to minimize potential impacts, hopper dredges will be used from 1 December to 31 March of any year, to the maximum extent practicable, when water temperatures are cooler and sea turtle abundance is low, generally <14°C (57.2°F). However, because some sea turtle species may be found year-round in the offshore area, hopper-dredging activities may occur during low levels of sea turtle migration. Therefore, the proposed hopper dredging activities may adversely effect 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. The Corps will abide by the incidental take authorization and associated provisions of the September 25, 1997 Regional Biological Opinion for The Continued Hopper Dredging Of Channels And Borrow Areas In The Southeastern United States or any superseding RBO provided by NMFS. To reduce impacts, the Corps anticipates taking certain precautions as prescribed by NMFS and USACE under standard hopper dredging protocol and will maintain observers on hopper dredges for the periods prescribed by NMFS to document any takes of turtle species and to ensure that turtle deflector dragheads are used properly.

(3) Summary Effect Determination.

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 can enhance nesting success of sea turtles by expanding the available nesting habitat beyond erosion and inundation prone areas.

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 1 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 project may affect, likely to adversely affect loggerhead, green, hawksbill, and Kemp's ridley sea turtles. Based on historic hopper dredging take data, the proposed project may affect, not likely to adversely affect leatherback sea turtles.

The USACE will comply with all previous agreements with the resource agencies. With these commitments in place, 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.

4.02.4 Shortnose Sturgeon

Detailed life history information associated with the life cycle requirements for shortnose sturgeon and a subsequent analysis of impacts from the proposed dredging activities are provided within the following Section 7 consultation documents:

National Marine Fisheries Service. 1997. Regional Biological Opinion for the Continued Hopper Dredging of Channels and Borrow Areas in the Southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, Maryland

USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE, Wilmington District. Submitted to NMFS on 12 September 2008

A summary of project specific information and associated impacts is provided in the ensuing text.

a. Status. Endangered

b. Occurrence in Immediate Project Vicinity. Populations of shortnose sturgeon range along the Atlantic seaboard from the Saint John River in New Brunswick, Canada to the Saint Johns River, Florida (USFWS, 1999b). It is apparent from historical accounts that this species may have once been fairly abundant throughout North Carolina's waters; however, many of these early records are unreliable due to confusion between this species and the Atlantic sturgeon (*Acipenser oxyrhynchus*). There are historical records of the shortnose sturgeon both in Albemarle Sound and the nearshore ocean (Dadswell, *et al*., 1984). However, in the recent past, this species was thought to be extirpated from North Carolina (Schwartz, 1977). During the winter

of 1986-87, the shortnose sturgeon was taken from the Brunswick River, a component of the Cape Fear River basin. With this discovery, the species is once again considered to be a part of the state's fauna and has been documented in the Cape Fear River, NC. As a component of a fishery-independent gill net survey and sonic tagging study conducted by Moser and Ross (1993), a total of only seven shortnose sturgeon were captured in the Cape Fear River over a wide distribution from the lower esturary at km 15.7 to Lock and Dam #1 at km 96.4 during January-July. Three of the seven fish were recaptures further indicating that shortnose sturgeon in the Cape Fear River are rare. Shortnose sturgeon are considered to be anadromous with most at sea captures being in the nearshore. Considering that the project area is within the marine environment, freshwater spawning areas would be avoided and any shortnose sturgeon present would most likely be non-spawning adults (NMFS, 1998).

c. Current Threats to Continued Use of the Area. Pollution, blockage of traditional spawning grounds, and over fishing are generally considered to be the principal causes of the decline of this species. The prohibition by North Carolina Division of Marine Fisheries (NCDMF) on taking any sturgeon in North Carolina should help to protect the species from commercial and recreational fishing pressure.

d. Project Impacts.

(1) Habitat.

The shortnose sturgeon is principally a riverine species and is known to use three distinct portions of river systems: (1) non-tidal freshwater areas for spawning and occasional over wintering; (2) tidal areas in the vicinity of the fresh/saltwater mixing zone, year-round as juveniles and during the summer months as adults; and (3) high salinity estuarine areas (15 parts per thousand (ppt.) salinity or greater) as adults during the winter. Habitat conditions suitable for juvenile and adult shortnose sturgeon could occur within the project area; however, spawning habitat should lie well outside of the project area and should not be affected by this project. The presence of juvenile shortnose sturgeon is not likely due to high salinity. Adults are found in shallow to deep water (6 to 30 feet) and, if present, would be expected to occupy the deeper channels during the day and the shallower areas adjacent to the channel during the night (Dadswell *et al*., 1984).

(2) Food Supply.

The shortnose sturgeon is a bottom feeder, consuming various invertebrates and stems and leaves of macrophytes. Adult foraging activities normally occur at night in shallow water areas adjacent to the deep-water areas occupied during the day. Juveniles are not known to leave deep-water areas and are expected to feed there.

Dredging for this project will occur at borrow sites located offshore; therefore, shallow water feeding areas will not be affected by the project.

(3) Effect Determination.

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. Because of the unlikelihood of shortnose sturgeon being present in the immediate project area and since dredging will occur in the offshore environment, it has been determined that the actions of the proposed project have no effect on the shortnose sturgeon.

4.02.5 Atlantic Sturgeon

Detailed life history information associated with the life cycle requirements for Atlantic Sturgeon and a subsequent analysis of impacts from the proposed dredging activities are provided within the following Section 7 consultation documents:

National Marine Fisheries Service. 1997. Regional Biological Opinion for the Continued Hopper Dredging of Channels and Borrow Areas in the Southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, Maryland

USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE, Wilmington District. Submitted to NMFS on 12 September 2008

A summary of project specific information and associated impacts is provided in the ensuing text.

a. Status. Endangered. Within the Federal Register dated February 6, 2012 (Volume 77, Number 24), NMFS issued a final determination to list the Carolina and South Atlantic distinct population segments (DPSs) of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) as endangered under the Endangered Species Act (ESA) of 1973, as amended. This final rule was made effective April 6, 2012. NMFS had not designated any "critical habitat" for this species at the time this document was prepared. Since the Atlantic sturgeon is found within the project area, the purpose of this section is to address project impacts on this potentially listed species.

b. Occurrence in Immediate Project Vicinity. Although specifics vary latitudinally, the general life history pattern of Atlantic sturgeon is that of a long lived, late maturing, estuarine dependent, anadromous species. The species' historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida (Murawski and Pacheco, 1977; Smith and Clungston, 1997).

Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in the spring/early summer; February-March in southern systems, April-May in mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clungston, 1997; Caron *et al*., 2002). In some southern rivers, a fall spawning migration may also occur (Rogers and Weber, 1995; Weber and Jennings, 1996; Moser *et al*., 1998). Comprehensive information on current or historic abundance of Atlantic sturgeon is lacking for most river systems; however, use of the Cape Fear River, NC for spawning and nursery habitat is well documented. Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers, where optimal flows are 46-76 cm/s and deep depths of 11-27 meters (Borodin, 1925; Leland, 1968; Crance, 1987; Moser *et al*.,

1998; Bain *et al*., 2000). Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobble) (Gilbert, 1989; Smith and Clungston, 1997).

Juveniles spend several years in the freshwater or tidal portions of rivers prior to migrating to sea (Gilbert, 1989). Upon reaching a size of approximately 76-92 cm, the subadults may move to coastal waters (Murawski and Pacheco, 1977; Smith, 1985), where populations may undertake long range migrations (Dovel and Berggren 1983, Bain 1997, Van den Avyle, 1984). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon may travel widely once they emigrate from rivers. Subadult Atlantic sturgeon wander among coastal and estuarine habitats, undergoing rapid growth (Dovel and Berggren, 1983; Stevenson, 1997). These migratory subadults, as well as adult sturgeon, are normally captured in shallow (10-50m) near shore areas dominated by gravel and sand substrate (Stein *et al*., 2004). Coastal features or shorelines where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy, Massachusetts Bay, Rhode Island, New Jersey, Delaware, Delaware Bay, Chesapeake Bay, and North Carolina, which presumably provide better foraging opportunities (Dovel and Berggren, 1983; Johnson *et al*., 1997; Rochard *et al*., 1997; Kynard *et al*., 2000; Eyler *et al*., 2004; Stein *et al*., 2004; Dadswell, 2006).

Little is known regarding the offshore distribution of Atlantic Sturgeon along the Atlantic Coast. Opportunistic Atlantic sturgeon catches associated with the Annual Cooperative Winter Tagging Cruises for migratory striped bass off the coast of Virginia and North Carolina have been used to better understand offshore distribution of Atlantic Sturgeon. These data indicate that shallow nearshore waters (i.e. 30-60 ft.) off North Carolina are an important winter habitat for juvenile Atlantic Sturgeon originating from nearly throughout their range and representing a “mixed” stock. Based on the catch patterns, there is some indication that Atlantic sturgeon select habitats in the same general vicinity or may even school to some extent (Laney *et. al*., 2007). Genetic analysis of tissue taken from Atlantic sturgeon captured from Cape Lookout north to Virginia waters indicated that some of those fish are from southern (GA) populations (Wilson Laney, Personal Communication, 10 November 2011).

c. Current Threats to Continued Use of the Area. According to the Atlantic sturgeon status review (Atlantic Sturgeon Status Review Team, 2007), projects that may adversely affect sturgeon include dredging, pollutant or thermal discharges, bridge construction/removal, dam construction, removal and relicensing, and power plant construction and operation. Potential direct and indirect impacts associated with dredging that may adversely impact sturgeon include entrainment and/or capture of adults, juveniles, larvae, and eggs by dredging and closed net sea turtle relocation trawling activities, short-term impacts to foraging and refuge habitat, water quality, and sediment quality, and disruption of migratory pathways.

d. Project Impacts.

(1) Habitat and Food Supply.

Data pertaining to the distribution and habitat use of nearshore Atlantic Sturgeon throughout the North Carolina coast is limited. However, habitat use and migratory behavior can be inferred from fish collected incidentally in the winter striped bass beach seine fishery as well as recent telemetry tagging information of migrating fish from the Roanoke River and Savannah River stocks. Based on these available tagging data, it appears that fish may be migrating into the inshore waters of

North Carolina in the late spring (April – May) and early fall (September) and that the nearshore Atlantic Ocean off the coast of North Carolina is an important migratory pathway for potential all five Distinct Population Segments (DPS's) of Atlantic Sturgeon (Personal Communication, Wilson Laney (USFWS) and Mike Loeffler (NCDENR), email dated September 22, 2011).

Detailed distribution data within the project area and adjacent nearshore environment is limited and no new distribution studies have been completed since Moser and Ross (1993) and Moser et. al. (1998). Though specific aggregation areas for feeding, resting, etc. have not been identified within the proposed project borrow areas, it is still possible that Atlantic Sturgeon may be at risk to direct impact from dredging activities associated with this project based on their documented migration pathways and behaviors in other portions of the state. Based on the current understanding of the variables required (ie. salinity regime, depth, substrate, etc.) for various stages of the sturgeon life cycle (ie. spawning, migrating, foraging, etc.), dredging activities presumably create some level of disruption based on their location relative to the life stage requirements. As identified in the 2007 Status Review of Atlantic Sturgeon, "Hatin *et al.* (*in press*) tested whether dredging operations affected Atlantic sturgeon behavior by comparing Catch Per Unit Effort (CPUE) before and after dredging events in 1999 and 2000. The authors documented a three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating that sturgeon avoid these areas during operations." Dredging activities performed in areas identified as known high aggregation areas for spawning, feeding, resting, etc., which require specific measures to minimize impacts, may require separate consultation.

Dredging activities can impact benthic assemblages either directly or indirectly and may vary in nature, intensity, and duration depending on the project, site location, and time interval between maintenance operations. Direct catastrophic impacts include physical removal or smothering by the settlement of suspended materials (Morton, 1977; Guillory, 1982). Suspended materials may also interfere in the feeding respiration or reproduction of filter feeding benthos and nekton (Sherk and Cronin, 1970). Though initial loss of benthic resources are likely, quick recovery between 6-months (McCauley *et al*., 1977; Van Dolah *et al*., 1979; Van Dolah *et al.,* 1984; and Clarke and Miller-Way, 1992) to two years (Bonsdorff, 1980; Ray, 1997) is expected; thus, the impacts to sturgeon foraging habitat are expected to be short-term. Recovery in dredged sites occurs by four basic mechanisms: remnant (undredged) materials in the sites, slumping of materials with their resident fauna into the site, adult immigration, and larval settlement. Remnant materials, sediments missed during the dredging operation, act as sources of "seed" populations to colonize recently defaunated sediments. Adult immigration can occur as organisms burrow laterally throughout the sediments, drift with currents and tides, or actively seek out recently defaunated sediments (Ray, 1997). Likewise materials slumping or falling into the site from channel slopes provide organisms for colonization (Kaplan *et al.,* 1974). During periods of extreme conditions (i.e. extreme temperature regimes, low dissolved oxygen, etc.), sturgeon may become relatively immobile and forage extensively in one area. Therefore, considering that limited mobility would not allow for sturgeon to move to more productive foraging grounds following dredging activities, it is possible that reduced benthic assemblages during site and time specific conditions could have a more significant impact to foraging behavior.

For benthic assemblages in estuarine and riverine systems, the distribution of individual species is consistent with their known sediment and salinity preferences (polyhaline, mesohaline, and oligohaline). The distribution of each of these assemblages varies depending on the intensity of

river flow, often correlated with season (Ray, 1997; Posey *et al*., 1996). Therefore, in addition to the anthropogenic dredging impacts to benthic assemblages, natural community shifts are correlated with river flow rates. Considering the ephemeral nature of this environment, the benthic assemblages consist of opportunistic species which are capable of adapting to natural fluctuations in the environment (Ray, 1997). Furthermore, assuming that natural benthic community shifts are an inherent component of sturgeon foraging behavior, it is possible that post dredging movements to more productive foraging grounds are not far outside of the normal foraging behavior response to natural benthic community shifts.

Extensive studies have been done on the behavioral responses of fish to increased turbidity. These studies measured reactions such as cough reflexes, swimming activity, gill flaring, and territoriality that may lead to physiological stress and mortality; however, specific studies on sturgeon responses are limited. The effects of suspended sediment on fish should be viewed as a function of concentration and exposure duration (Wilber and Clarke, 2001). The behavioral responses of adult salmonids for suspended sediment dosages under dredging-related conditions include altered swimming behavior, with fish either attracted to or avoiding plumes of turbid water (Newcombe and Jensen, 1996)

Water quality impacts to sturgeon as a result of proposed dredging activities are expected to be temporary, with suspended particles settling out within a short time frame. These sediment disturbance impacts are expected to be minimal in nature and are not expected to have a measurable effect on water quality beyond the frequent natural increases in sediment load.

(2) Relationship to Critical Periods in Life Cycle.

Analyses of the surficial and sub-bottom sediments have been conducted within the proposed borrow areas to assure compatibility with the native sediment. Several vibracore samples were taken to document the physical characteristics of the sediment relative to depth and sub-bottom geophysical surveys were conducted to correlate the physical samples with the underlying geology layers of the borrow area. These data are used to evaluate quality and quantity of sediment relative to depth so that post-dredging surface sediments are not different from pre-dredging conditions. Assuming similarity in post dredging composition of sediment, no long term impacts to sturgeon from alterations physical habitat (i.e. changes in benthic substrate) are expected.

(3) Effect Determination. Though no site specific data pertaining to Atlantic sturgeon distribution within the borrow areas is available, based on their documented migratory pathways using existing tagging data, it is likely that sturgeon may be migrating through or spending time on or near the borrow areas.

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 affect, likely to adversely affect the Atlantic sturgeon species.

Endangered species observers (ESOs) on board hopper dredges as well as trawlers 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. Furthermore, all ESOs on board trawlers will be capable of identifying Atlantic sturgeon as well as following safe handling protocol as outlined in Moser *et. al.* 2000.

4.02.6 Seabeach Amaranth

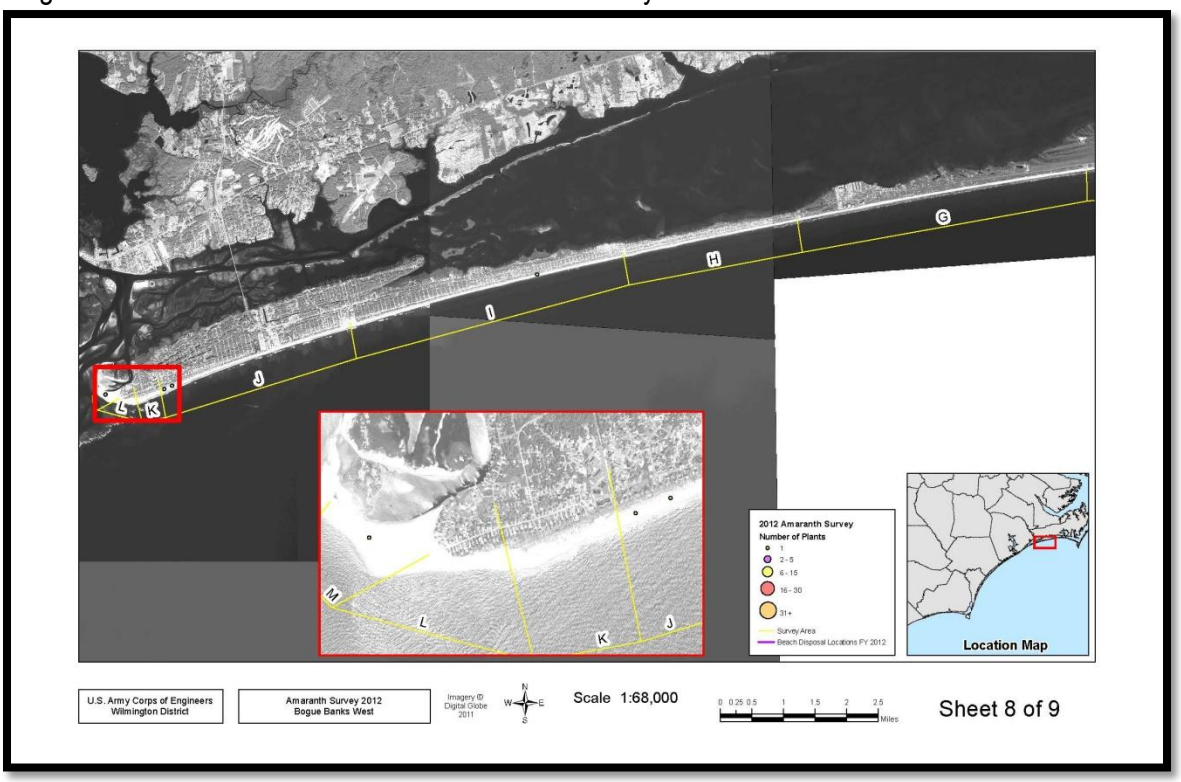
a. Status. Threatened

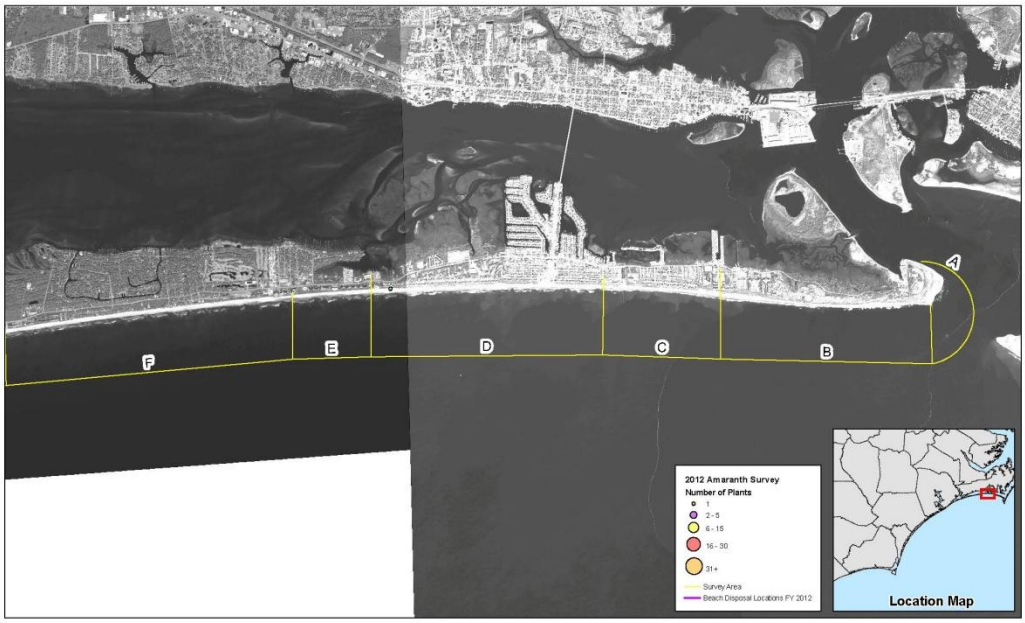
b. Occurrence in Immediate Project Vicinity. Seabeach amaranth is an annual or sometimes perennial plant that usually grows between the seaward toe of the dune and the limit of the wave uprush zone occupying elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher, 1992). Greatest concentrations of seabeach amaranth occur near inlet areas of barrier islands, but in favorable years many plants may occur away from inlet areas. It is considered a pioneer species of accreting shorelines, stable foredune areas, and overwash fans (Weakley and Bucher, 1992; Hancock and Hosier, 2003). Seed dispersal of seabeach amaranth is achieved in a number of ways, including water and wind dispersal (USFWS, 1995).

Historically, seabeach amaranth was found from Massachusetts to South Carolina, but according to recent surveys (USACE 1992-2004), its distribution is now restricted to North and South Carolina with several populations on Long Island, New York. The decline of this species is caused mainly by development of its habitat, such as inlet areas and barrier islands, and increased ORV and human traffic, which tramples individual plants (Fussell, 1996).

Seabeach amaranth surveys have been performed along all of Bogue banks, NC since 1991. Based on the available data, a total of 49,484 plants have been recorded along the beaches of Bogue Banks (Table 4). Shoreline erosion and accretion processes associated natural storm events and beach dynamics likely play an important role in explaining the random spatial and temporal abundance patterns since 1992. Figures 4 and 5 show the location of survey reaches along Bogue Banks in 2012.

Figure 4 and 5. Seabeach Amaranth Locations Surveyed in 2012





U.S. Army Corps of Engineers
Wilmington District

Amaranth Survey 2012
Bogue Banks East

Imagery © Digital Globe 2011

N W E S

Scale 1:40,000

0 0.25 0.5 1 1.5 Miles

Sheet 9 of 9

Table 4. Annual seabeach amaranth survey results (1991-2011) Carteret County, NC.

County	Beach Name	Sub-Part (Reach)	Length Feet	Calc Miles	Estimated Miles	TOTAL AMARANTHUS PLANT COUNT BY YEAR																					Total All Yrs
						1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Carteret	Core Banks	Drum Inlet			2.75		1																				1
Carteret	Bogue Banks (Fort Macon)	A	2,325	0.44	0.50	23	4	3	0	0		0	27	0	0	7	18	60	1	1	0	0	0	0	1	0	145
Carteret	" "	B	10,425	1.97	2.00	238	55	5	1	1,077		0	40	2	1	41	181	250	0	13	0	1	35	10	0	0	1,950
Carteret	Bogue Banks (Atlantic Beach)	C	5,680	1.08	1.10	11	0	1	5	5		0	29	0	0	4	46	82	0	68	2	14	48	18	0	0	333
Carteret	" "	D	11,460	2.17	2.20	218	238	117	100	7,300		74	429	2	17	81	39	87	1	60	10	1	16	13	1	0	8,804
Carteret	Bogue Banks	E	3,800	0.72	0.72		12	8	20	927						16	9	35	6	21	1	0	0	0	0	1	1,056
Carteret	" "	F	14,100	2.67	2.67		28	45	4	4						27	628	1,020	341	1,752	3	3	4	16	0	0	3,875
Carteret	" "	G	25,000	4.73	4.73	###	64	22	24	5						41	772	2,477	1,768	>12,468	40	42	118	93	0	1	5,467
Carteret	" "	H	15,000	2.84	2.84		15	31	8	2						2	44	384	733	6,560	19	3	4	17	0	0	7,822
Carteret	" "	I	23,500	4.45	4.45		37	64	85	7						10	75	586	^^^	1,405	128	27	37	3	0	1	2,465
Carteret	" "	J	16,700	3.16	3.20		72	254	186	1,122		5	799	5	1	29	157	54	85	812	47	35	4	13	7	0	3,687
Carteret	" "	K	2,150	0.41	0.40		1,109	1,114	295	3,170		0	2,384	197	1	89	32	295	0	20	0	4	0	93	25	5	8,833
Carteret	" "	L	1,950	0.37	0.40		896	2,033	201	692		2	256	12	0		0	0	0	0	1	0	47	3	16	10	4,169
Carteret	" "	M	1,071	0.20	0.90		26	65	252	465		0	9	0	0	0	0	0	0	0	0	0	0	2	20	38	877
NOTES:			133,161	25.22	28.86	490	2,557	3,762	1,181	14,776	0	81	3,973	218	20	347	2,001	5,330	2,935	10,712	251	130	313	281	70	56	49,484

= Not surveyed

= Not surveyed due to hurricane(s)

^ ^ ^ = Count combined in reach above

= Isolated plants were also found prior to 1991

= Year of hurricane impact

= Reach no Amaranthus ever found

= Count exceeding 1,000 Amaranthus

Since sea beach amaranth seeds are fairly resilient and germination is dependent on critical physical conditions, populations of seabeach amaranth are very dynamic with numbers of plants fluctuating dramatically from year to year. Germination begins in April as temperatures reach about 25ºC (77ºF) and continues at least through July with greatest germination occurring at 35ºC (95ºF) (USFWS, 1996b; Hancock and Hosier, 2003). Seed production begins in July or August, peaks in September, and continues until the plant dies (USFWS, 1996b). According to Hancock and Hosier (2003) sea beach amaranth is physically controlled (salt water inundation, temperature, emergence at depth, etc.) rather than biologically controlled (web worm). Furthermore, seedlings are unable to emerge from depths greater than 1cm; however, seabeach amaranth seeds are resilient, and century–old seeds of some species of amaranth are capable of successful germination and growth (USFWS, 1996b).

c. Current Threats to Continued Occurrence in the Project Area.

Seabeach amaranth has been eliminated from approximately two-thirds of its historic range. Habitat loss and degradation are the greatest threats to the continued existence of seabeach amaranth with localized herbivory by webworms also contributing to mortality in North Carolina. Though beach stabilization efforts are thought to be a leading contributor to the decrease in the population (USFWS, 1996b), significant spatial variability over time on natural beaches makes it difficult to discern project related impacts. Additionally, new populations have been observed to follow sand placement on beaches where sand has been disposed by the Corps of Engineers (ex. Wrightsville Beach and Bogue Banks) (USFWS, 1996b; CSE, 2004). Seabeach amaranth is dependent on terrestrial, upper beach habitat that is not flooded during the growing season from May in to the fall. Therefore, beach erosion is probably the primary threat to the continued presence in the study area. Furthermore, beach bulldozing is common practice on the study area beaches and in many cases may add to the existing erosion problem and loss of seabeach amaranth habitat.

d. Project Impacts.

(1) Habitat.

The project consists of an 119,670 ft (22.7 miles) long main beachfill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beachfill is bordered on either side by a 1,000 ft tapered transition zone berm. The proposed project limits avoid the inlet vicinity of both ends of Bogue Banks which have historically been areas of consistently higher abundance. The beachfront within the project limits is currently conducive to the growth of seabeach amaranth; 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 plants and seeds; however, much of the habitat requirements for seabeach amaranth lost to erosion will be restored.

(2) Relationship to Critical Periods in Life Cycle.

Beach nourishment will be conducted outside of the germination and growing period. Initial construction and each nourishment event will be performed from 1 December through 31 March. If dredging takes place in the winter when only seabeach amaranth seeds are present, the direct

impacts on individual plants will be avoided; however, burying seeds during any season could affect the population. While such construction is not an ideal management practice for the species, the restoration of the habitat is of prime importance. Beach nourishment rebuilds habitat for seabeach amaranth and can have long-term benefits (USFWS, 1996b).

(3) Effect Determination. Beach nourishment 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, not likely to adversely affect seabeach amaranth.

4.02.7 Piping Plover

a. Status. Threatened

b. Occurrence in Immediate Project Vicinity: The Atlantic Coast piping plover population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast (from North Carolina south), the Gulf Coast, and in the Caribbean where they spend a majority of their time foraging. Since being listed as threatened in 1986, only 800 pairs were known to exist in the three major populations combined and by 1995 the number of detected breeding pairs increased to 1,350. This population increase can most likely be attributed to increased survey efforts and implementation of recovery plans (Mitchell *et. al*., 2000).

The species typically nests in sand depressions on unvegetated portions of the beach above the high tide line on sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Piping plovers head to their breeding grounds in late March or early April (http://pipingplover.fws.gov/overview.html) and nesting usually begins in late April; however, nests have been found as late as July (Potter, *et al*., 1980; Golder, 1985). During a statewide survey conducted in 1988, 40 breeding pairs of piping plovers were located in North Carolina. LeGrand (1983) states that "all of the pipings in the state nest on natural beachfronts, both completely away from human habitation and [yet] in moderate proximity to man". The largest reported nesting concentration of the species in the State appears to be on Portsmouth Island where 19 nests were discovered in 1983 by John Fussell (LeGrand, 1983). The southernmost nesting record for the state was one nest located in Sunset Beach by Phillip Crutchfield in 1983 (LeGrand, 1983). Feeding areas include intertidal portions of ocean beaches, washover areas, mud flats, sand flats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes (USFWS, 1996a). Prey consist of worms, fly larvae, beetles, crustaceans, mollusks, and other invertebrates (Bent, 1928).

The piping plover is a fairly common winter resident along the beaches of North Carolina (Potter *et al*., 1980). On 10 July 2001, the USFWS designated 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas as critical habitat for the wintering population of the piping plover where they spend up to 10 months of each year on the wintering grounds. 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 USFWS has defined textual unit descriptions to designate areas within the critical habitat boundary. These units describe the geography of the area using reference points, include the areas from the landward boundaries to the MLLW, and may describe other areas within the unit that are utilized by the piping plover and contain the primary constituent elements.

NC-10 is the only designated unit within the vicinity of the project. NC-10 is located at the western most tip of Bogue Banks and also includes portions of Bear Island directly across from Bogue Inlet. It includes the contiguous shoreline from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur along the Atlantic Ocean and Bogue Inlet. Though the limits of critical habitat are constantly evolving based on the presence or absence of constituent elements, this approximation facilitated a more detailed and site specific impact analysis relative to the proposed action.

Piping plovers are known to nest in low numbers in widely scattered localities on North Carolina's beaches. Though most piping plovers in the study area have been observed as predominantly migratory and winter residents (n=118) utilizing intertidal flats exposed at low tide for feeding and roosting; a total of 2 breeding pairs have been identified based on opportunistic shorebird surveys conducted by the NCWRC between 1989-2008 (Sara Schweitzer (NCWRC), Personal Communication, 07/26/2012).

Table 5. Piping plovers identified within the vicinity of the project area based on shorebird surveys conducted between 1989-2008. (*Source: NCWRC (Sara Schweitzer) (07/26/2012))

Date	Season[a]	Number of birds
1/31/1989	Winter	3
5/19/1989	Breeding	0
1/15/1990	Winter	2
1/27/1990	Winter	2
1/19/1991	Winter	4
6/18/1991	Breeding	0
7/1/1994	Breeding	0
1/15/1996	Winter	1
1/18/1996	Winter	0
6/1/1996	Breeding	0
1/15/1997	Winter	2
1/18/1997	Winter	3
1/18/1997	Winter	3
2/15/1997	Winter	2
4/15/1997	Spring Migration	2
7/1/1997	Breeding	0
12/20/1997	Winter	5
6/1/1998	Breeding	0
7/1/1998	Breeding	0
7/26/1998	Fall Migration	2
2/25/1999	Winter	1

3/5/1999	Spring Migration	1
3/18/1999	Spring Migration	4
4/15/1999	Spring Migration	4
6/1/1999	Breeding	0
7/1/1999	Breeding	0
9/27/1999	Fall Migration	2
11/21/1999	Fall Migration	1
3/5/2000	Spring Migration	2
6/1/2000	Breeding	0
7/1/2000	Breeding	0
8/21/2000	Fall Migration	0
2/8/2001	Winter	0
4/5/2001	Spring Migration	3
5/25/2001	Breeding	0
7/1/2001	Breeding	0
8/3/2001	Fall Migration	0
8/6/2001	Fall Migration	0
11/27/2001	Fall Migration	0
7/1/2002	Breeding	0
9/17/2002	Fall Migration	0
11/22/2002	Fall Migration	2
4/2/2003	Spring Migration	1
4/2/2003	Spring Migration	2
4/14/2003	Spring Migration	4
4/17/2003	Spring Migration	2
4/22/2003	Spring Migration	3
5/1/2003	Breeding	0
5/16/2003	Breeding	0
5/30/2003	Breeding	0
5/30/2003	Breeding	0
6/16/2003	Breeding	0
6/30/2003	Breeding	0
7/15/2003	Fall Migration	0
7/25/2003	Fall Migration	0
8/4/2003	Fall Migration	0
8/4/2003	Fall Migration	0
8/14/2003	Fall Migration	0
8/25/2003	Fall Migration	0
9/3/2003	Fall Migration	0
9/12/2003	Fall Migration	0
9/23/2003	Fall Migration	0
10/3/2003	Fall Migration	0
10/13/2003	Fall Migration	0
10/23/2003	Fall Migration	2

11/3/2003	Fall Migration	0
11/12/2003	Fall Migration	1
11/21/2003	Fall Migration	0
12/16/2003	Winter	1
1/15/2004	Winter	2
2/19/2004	Winter	0
2/23/2004	Winter	1
3/1/2004	Spring Migration	0
3/11/2004	Spring Migration	2
3/22/2004	Spring Migration	1
3/31/2004	Spring Migration	4
4/22/2004	Spring Migration	3
6/1/2004	Breeding	0
7/30/2004	Fall Migration	0
8/18/2004	Fall Migration	0
8/26/2004	Fall Migration	0
10/28/2004	Fall Migration	0
11/15/2004	Fall Migration	0
12/3/2004	Winter	0
12/14/2004	Winter	0
12/22/2004	Winter	0
1/5/2005	Winter	0
1/12/2005	Winter	0
1/20/2005	Winter	0
1/28/2005	Winter	0
2/2/2005	Winter	0
2/13/2005	Winter	1
2/18/2005	Winter	2
2/22/2005	Winter	0
3/4/2005	Spring Migration	1
3/11/2005	Spring Migration	1
3/18/2005	Spring Migration	0
3/24/2005	Spring Migration	4
4/2/2005	Spring Migration	5
4/4/2005	Spring Migration	0
4/13/2005	Spring Migration	2
4/19/2005	Spring Migration	2
4/28/2005	Spring Migration	0
5/3/2005	Breeding	0
5/9/2005	Spring Migration	2
5/19/2005	Breeding	0
5/25/2005	Breeding	0
5/30/2005	Breeding	0
6/3/2005	Breeding	0

6/10/2005	Breeding	0
6/16/2005	Breeding	0
6/22/2005	Breeding	0
6/30/2005	Breeding	0
7/7/2005	Breeding	0
7/13/2005	Breeding	0
7/21/2005	Fall Migration	0
7/28/2005	Fall Migration	0
8/4/2005	Fall Migration	0
8/10/2005	Fall Migration	0
8/18/2005	Fall Migration	0
8/26/2005	Fall Migration	0
9/1/2005	Fall Migration	0
9/7/2005	Fall Migration	0
9/19/2005	Fall Migration	0
9/30/2005	Fall Migration	0
10/14/2005	Fall Migration	0
10/18/2005	Fall Migration	0
10/31/2005	Fall Migration	0
11/4/2005	Fall Migration	0
11/9/2005	Fall Migration	0
11/15/2005	Fall Migration	0
11/30/2005	Fall Migration	1
12/7/2005	Winter	0
12/20/2005	Winter	0
1/5/2006	Winter	0
1/27/2006	Winter	0
1/27/2006	Winter	0
2/8/2006	Winter	0
2/17/2006	Winter	0
3/10/2006	Spring Migration	2
3/17/2006	Spring Migration	0
3/27/2006	Spring Migration	1
4/6/2006	Spring Migration	0
4/13/2006	Spring Migration	1
4/21/2006	Spring Migration	0
5/2/2006	Breeding	0
5/12/2006	Breeding	0
5/18/2006	Breeding	0
5/24/2006	Breeding	0
6/1/2006	Breeding	0
6/1/2006	Breeding	0

6/9/2006	Breeding	0
6/15/2006	Breeding	0
6/22/2006	Breeding	0
6/28/2006	Breeding	0
7/1/2006	Breeding	0
7/4/2006	Breeding	0
7/13/2006	Breeding	0
7/20/2006	Fall Migration	0
7/26/2006	Fall Migration	0
8/2/2006	Fall Migration	0
8/10/2006	Fall Migration	0
8/21/2006	Fall Migration	2
8/25/2006	Fall Migration	0
9/7/2006	Fall Migration	0
9/7/2006	Fall Migration	0
9/13/2006	Fall Migration	0
9/18/2006	Fall Migration	1
9/28/2006	Fall Migration	0
10/3/2006	Fall Migration	0
10/11/2006	Fall Migration	0
10/19/2006	Fall Migration	0
10/31/2006	Fall Migration	0
11/9/2006	Fall Migration	0
11/15/2006	Fall Migration	0
11/20/2006	Fall Migration	0
11/29/2006	Fall Migration	0
12/4/2006	Winter	0
12/15/2006	Winter	0
1/9/2007	Winter	0
1/30/2007	Winter	1
2/12/2007	Winter	0
2/22/2007	Winter	0
3/8/2007	Spring Migration	0
3/13/2007	Spring Migration	0
3/26/2007	Spring Migration	0
4/3/2007	Spring Migration	1
4/18/2007	Spring Migration	4
4/26/2007	Spring Migration	2
4/30/2007	Spring Migration	0
5/12/2007	Breeding	1
5/19/2007	Breeding	0
5/26/2007	Breeding	0

6/2/2007	Breeding	0
6/2/2007	Breeding	0
6/9/2007	Breeding	0
6/14/2007	Breeding	0
6/21/2007	Breeding	0
6/29/2007	Breeding	0
7/6/2007	Breeding	0
7/12/2007	Breeding	0
7/18/2007	Fall Migration	0
7/25/2007	Fall Migration	0
8/1/2007	Fall Migration	0
8/8/2007	Fall Migration	0
8/14/2007	Fall Migration	0
8/23/2007	Fall Migration	0
8/30/2007	Fall Migration	1
9/6/2007	Fall Migration	0
9/13/2007	Fall Migration	0
9/24/2007	Fall Migration	0
10/4/2007	Fall Migration	0
10/9/2007	Fall Migration	0
10/17/2007	Fall Migration	0
10/25/2007	Fall Migration	0
10/31/2007	Fall Migration	0
11/8/2007	Fall Migration	0
11/19/2007	Fall Migration	0
11/24/2007	Fall Migration	0
12/10/2007	Winter	0
12/31/2007	Winter	0
1/18/2008	Winter	0
1/29/2008	Winter	0
2/19/2008	Winter	0
2/29/2008	Spring migration	0
3/6/2008	Spring Migration	0
3/12/2008	Spring Migration	0
3/21/2008	Spring Migration	0
3/28/2008	Spring Migration	0
4/9/2008	Spring Migration	0
4/18/2008	Spring Migration	0
4/24/2008	Spring Migration	1
5/2/2008	Breeding	0
5/8/2008	Breeding	0
5/21/2008	Breeding	1

5/21/2008	Breeding	0
5/29/2008	Breeding	0
6/6/2008	Breeding	0
6/13/2008	Breeding	0
6/20/2008	Breeding	0
6/25/2008	Breeding	0
7/1/2008	Breeding	0
7/3/2008	Breeding	0
7/11/2008	Breeding	0
7/21/2008	Fall Migration	0
7/30/2008	Fall Migration	0
8/8/2008	Fall Migration	0
8/15/2008	Fall Migration	0
8/20/2008	Fall Migration	0
8/29/2008	Fall Migration	0
9/3/2008	Fall Migration	0
9/9/2008	Fall Migration	0
9/18/2008	Fall Migration	0
9/22/2008	Fall Migration	0
9/30/2008	Fall Migration	0
10/10/2008	Fall Migration	0
10/17/2008	Fall Migration	0
10/23/2008	Fall Migration	0

North Carolina piping plover survey methodologies record a 0 for sites or transects if no piping plovers are detected in order to maintain a record for detection probabilities and subsequent translation into population parameters.

c. Current Threats to Continued Use of the Area. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the decline of piping plovers. Depending on timing and location, anthropogenic coastal stabilization activities may degrade plover habitat by altering natural processes of dune and beach erosion and accretion (Melvin et. al., 1991). The current commercial, residential, and recreational development has decreased the amount of coastal habitat available for piping plovers to nest, roost, and feed. Washover habitat created after large hurricane events is a significant feature of natural barrier islands and serves as important habitat for piping plovers. However, these features are usually developed and/or rebuilt with residential homes shortly after they are created resulting in a continued decrease in nesting habitat availability. Dune construction and subsequent vegetative stabilization is often utilized to protect property and can serve as an impediment to natural overwash features; thus, limiting available nesting habitat. Cross-island transport of sediment and subsequent washover fan formation is considered a primary constituent element used in defining piping plover critical habitat. These low lying sand flats contain sparse vegetation and offer optimum habitat for piping plovers. Beach construction projects can also reduce sparse vegetation and coarse substrate, which may affect Piping Plover nest site selection (Cohen *et. al.,* 2008). Long and short-term coastal erosion and the abundance of predators, including wild and domestic animals as well as feral cats, have further diminished the potential for successful nesting of this species. Since the project beaches are wintering area for the piping plover, the major threat to its occupation of the area during the winter months would be continued degradation of beach foraging habitat. Similar degradation of beaches elsewhere could be a contributing element to declines in the state's nesting population.

d. Project Impacts.

(1) Habitat. The existing study area shorelines of Bogue Banks are heavily developed and are experiencing significant shoreline erosion. Piping plover breeding territories on the Atlantic Coast typically include a feeding area along expansive sand or mudflats in close proximity to a sandy beach that is slightly elevated and sparsely vegetated for roosting and nesting (http://nc-es.fws.gov/birds/pipiplov.html). As erosion and development persist, piping plover breeding, nesting, roosting, and foraging habitat loss continues. Habitat loss from development and shoreline erosion and heavy public use has led to the degradation of piping plover habitat in the project area. The enhancement of beach habitat through the addition of beach fill may potentially restore lost roosting and nesting habitat; however, short-term impacts to foraging and roosting habitat may occur during project construction.

Initial construction and each periodic nourishment cycle will be performed using a hopper dredge and will adhere to a 1 December to 31 March dredging window. Since piping plovers head to their breeding grounds in late March and nesting occurs in late April, project initial construction and nourishment events will avoid impacts to breeding and nesting piping plovers to the maximum extent practicable. Additionally, the project construction limits and activities, including pipeline routes, heavy equipment, staging, etc., and associated direct impacts to habitat will avoid the designated piping plover critical wintering habitat at NC-10. However, wintering habitat for roosting and foraging may be impacted along the project beaches. All personnel involved in the construction process along the beach will be trained in recognizing the presence of piping plovers prior to the initiation of the work on the beach. A contractor representative authorized to stop or redirect work shall be responsible for conducting a shorebird survey prior to 9 am each day of sand placement

activities. The survey shall cover the work area and any location where equipment is expected to travel. The contractor shall note on their Quality Assurance form for each day any observance of red knots and/or piping plovers and provide the information to the Wilmington District Office.
Direct short-term foraging habitat losses will occur during construction of the project fill. Since only a small portion of the foraging habitat is directly affected at any point in time during pumpout and adjacent habitat is still available, overall direct loss of foraging habitat will be minimal and short-term.

The project consists of an 119,670 ft (22.7 miles) long main beachfill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beachfill is bordered on either side by a 1,000 ft tapered transition zone berm. Piping plover nesting habitat includes blowout areas behind primary dunes as well as washover areas cut into or between dunes. The size and shape of the constructed dune may minimize the frequency of sand washover areas and subsequent nesting habitat availability. However, the project area is heavily developed already and based on the post-storm development response evidenced by Hurricane Fran, the washover fans created by large storm events are quickly re-developed by land owners. Due to the current development practices within the project area, the formation of these washover features will not be sustained in a similar fashion to undeveloped barrier islands; rather, it is anticipated that, without the proposed project, these washover features would be located on private (private residences) or state (NC Department of Transportation) owned property and would be cleared or built upon in order to re-establish the community to the pre-storm condition.

(2) Food Supply. Piping plovers feed along beaches and intertidal mud and sand flats and wintering plovers in NC forage predominantly in bay and sound intertidal zones and roost on ocean beaches (Cohen *et. al*., 2008). Primary prey includes polychaete worms, crustaceans, insects, and bivalves. According to Section 8.2.6 of integrated document with EIS, the benthic invertebrate community will suffer short-term impacts from the placement of sediment on the beach; thus, a diminished prey base will subsequently impact piping plovers over the short term. However, only a portion of the beach is affected at any point in time (approximately 4-5,000 feet per month). Once construction passes that point, recruitment from adjacent beaches can begin. Therefore, un-impacted or recovering foraging habitat will be available within the project throughout the duration of construction.

Temporary impacts on intertidal macrofauna in the immediate vicinity of the project are expected as a result of discharges of material on the beach. Any reduction in the numbers and/or biomass of intertidal macrofauna present immediately after placement of sediment may have localized limiting effects on foraging piping plovers due to a reduced food supply or shift in species abundance and diversity. In such instances, these birds may be temporarily displaced to other locations.

(3) Relationship to Critical Periods in Life Cycle. Beach placement of sand derived from identified borrow sites is expected to occur from 1 December to 31 March during initial construction and each periodic nourishment interval. Therefore, the breeding and nesting season will be avoided. However, foraging, sheltering, and roosting habitat may be temporarily impacted.

(4) Effect Determination. 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, not likely to adversely affect the piping plover. Considering that the project construction limits and associated activities will avoid the designated piping plover critical wintering habitat and associated constituent elements at NC-10, the proposed project is not likely to adversely modify critical habitat.

4.02.8 Roseate Tern.

a. Status. Endangered – Northeast population

b. Occurrence in Immediate Project Vicinity.

Breeding populations for the North American subspecies of roseate terns are divided into two separate populations, one in the northeastern U.S. and Nova Scotia, and one in the southeastern U.S. and Caribbean. Wintering sites are concentrated along the north and northeastern coasts of South America. These migratory birds are rarely seen in North Carolina although they are usually seen offshore along the barrier islands from March-May and August-October. Additionally, this species is primarily observed south of Cape Hatteras, particularly at Cape Point within Cape Hatteras National Seashore, during the months of July and August. They are colonial nesters, often associating with other terns along open sandy beaches isolated from human activity and predators. However, only one breeding record has been confirmed for North Carolina and individuals are reported annually during the breeding season at tern colonies along the North Carolina coast.

c. Food supply.

The Roseate Tern is often observed plunge-diving in the nearshore surf foraging on small fish such as small flounder, herring, and mullet. When feeding chicks, they have been observed flying up to 20 km from the colony returning with a single fish (Nisbet, 1989).

d. Project Impacts.

Increased turbidity in the nearshore environment is often associated with the beach construction process, depending on the characteristics of the material, and may affect foraging activities of Roseate Terns. As the sediment slurry is released from the outflow pipe, courser sediments fall out while finer sediment remains in suspension and are carried into the nearshore water column. The resultant increase in turbidity of the nearshore environment is generally short-term, isolated, and is no more significant than increased turbidity episodes associated with large-scale storm events. Though increased turbidity may impact foraging capabilities of the Roseate Tern and subsequent feeding of chicks, long range foraging (20 km) (Nisbet, 1989) has been documented and it is likely that foraging outside of turbid areas would occur.

e. Effect Determination.

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 has no effect on this species.

4.02.9 Smalltooth Sawfish

Detailed life history information associated with the life cycle requirements for smalltooth sawfish and a subsequent analysis of impacts from the proposed dredging activities are provided within the following Section 7 consultation document:

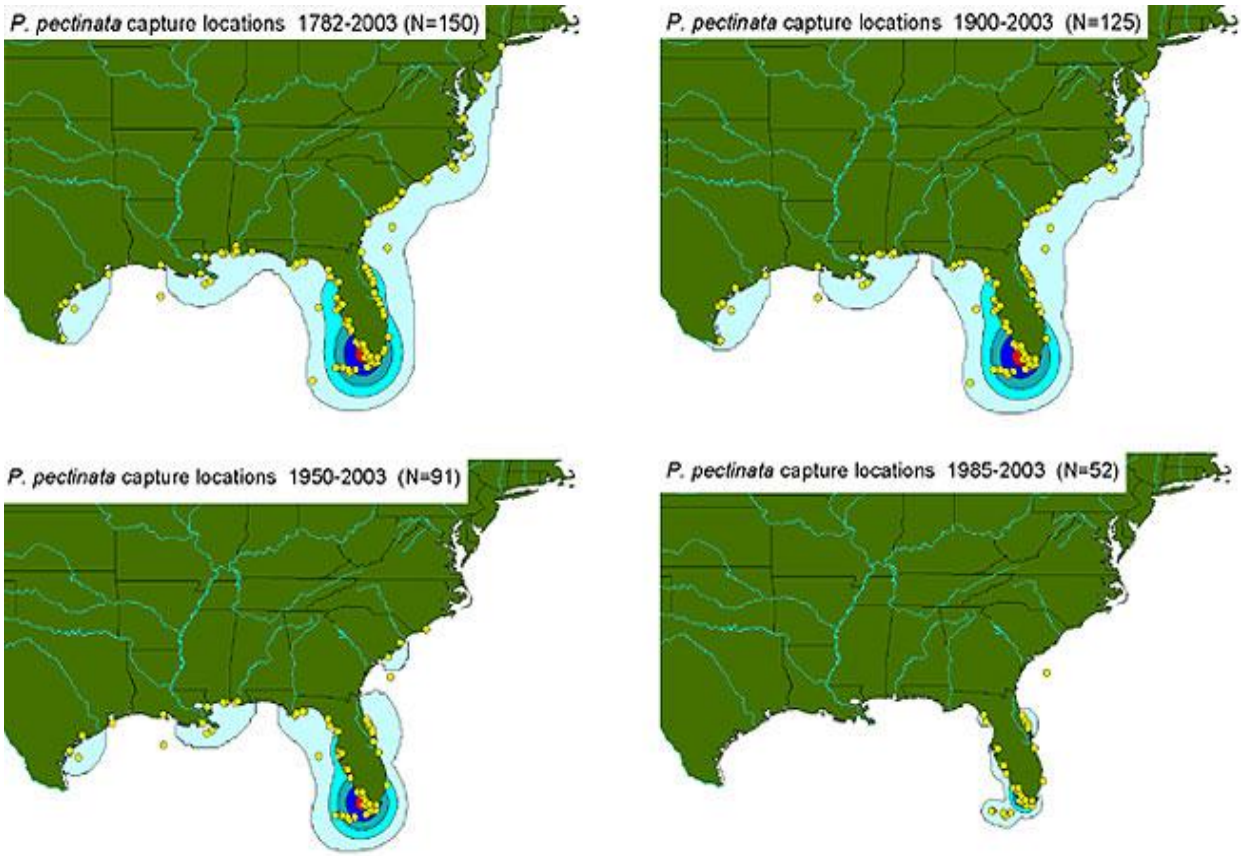
USACE. September 2008. Regional Biological Assessment for Dredging Activities in the Coastal Waters, Navigation Channels (including designated Ocean Dredged Material Disposal Sites (ODMDS)), and Sand Mining Areas in the South Atlantic Ocean. USACE,Wilmington District. Submitted to NMFS on 12 September 2008

A summary of project specific information and associated impacts is provided in the ensuing text.

a. Status. Endangered. The U.S. smalltooth sawfish distinct population segment (DPS) was listed as endangered under the ESA on April 1, 2003 (68 FR 15674) and is the first marine fish to be listed in the United States.

b. Occurrence in Immediate Project Vicinity. Historic records suggest that during the 19th century the smalltooth sawfish was a common resident of the Atlantic and Gulf coastal waters of the southeastern United States. Throughout the 20th century it was recorded with declining frequency and today it can be no longer considered a functional member of the nearshore coastal community of the northwest Atlantic. Historic records indicate that the smalltooth sawfish abundantly occurred in the mid-Atlantic region only during the summer months (Adams and Wilson, 1995). The smalltooth sawfish range has subsequently contracted to peninsular Florida and, within that area, can only be found with any regularity off the extreme southern portion of the state between the Caloosahatchee River and the Florida Keys (Figure 6). Smalltooth sawfish are most common within the boundaries of the National Everglades National Park and the Florida Keys, and become less common with increasing distance from this area (Simpfendorfer, 2002).

Figure 6. Historic and Current Distribution of Smalltooth Sawfish in the U.S. (Burgess *et al.,* 2003).



c. Current Threats to Continued Use of the Area. The principal habitats for smalltooth sawfish in the southeast U.S. are the shallow coastal areas and estuaries, with some specimens moving upriver in freshwater (Bigelow and Schroeder, 1953). The continued urbanization of the southeastern coastal states has resulted in substantial loss of coastal habitat through such activities as agricultural and urban development; commercial activities; dredge and fill operations; boating; erosion and diversions of freshwater run-off (SAFMC, 1998). Smalltooth sawfish may be especially vulnerable to coastal habitat degradation due to their affinity to shallow, estuarine systems. Smalltooth sawfish have historically been caught as by-catch in various fishing gears throughout their historic range, including gillnet, otter trawl, trammel net, seine, and to a lesser degree, hand line. Today, they are occasionally incidentally caught in commercial shrimp trawls, bottom longlines, and by recreational rod-and-reel gear. With the K-selected life history strategy of smalltooth sawfish, including slow growth, late maturation, and low fecundity, long-term commitments to habitat protection are necessary for the eventual recovery of the species.
A complete review of the factors contributing to the decline of the smalltooth sawfish can be found in the "Status Review of Smalltooth Sawfish (*Pristis pectinata*)", (NMFS, 2000). The Draft Recovery plan for smalltooth sawfish (NMFS, 2006) also presents a detailed threats assessment with four major categories of threats: 1) Pollution; 2) Habitat degradation or loss; 3) Direct injury and 4) Fisheries Interactions.

d. Project Impacts. As identified in the August 2006 Draft Smalltooth Sawfish Recovery Plan, "habitat effects of dredging include the loss of submerged habitats by disposal of excavated materials, turbidity and siltation effects, contaminant release, alteration of hydrodynamic regimes, and fragmentation of physical habitats (SAFMC, 1998). Cumulatively, these effects have degraded habitat areas for smalltooth sawfish." The current range of sawfish has contracted to peninsular Florida and can only be found with any regularity off the extreme southern portion of the state. Smalltooth sawfish occur in shallow estuarine environments and juvenile sawfish are particularly dependent on mangrove habitat.

In the GRBO issued by NMFS on November 19, 2003 (as amended in 2005 and 2007), in the section entitled "Species Not Likely to Be Affected," NMFS concludes the following: "Smalltooth sawfish (*Pristis pectinata*) are tropical marine and estuarine fish that have the northwestern terminus of their Atlantic range in the waters of the eastern U.S. Currently, their distribution has contracted to peninsular Florida and, within that area, they can only be found with any regularity off the extreme southern portion of the state. The current distribution is centered in the Everglades National Park, including Florida Bay. They have been historically caught as by-catch in commercial and recreational fisheries throughout their historic range; however, such by-catch is now rare due to population declines and population extirpations. Between 1990 and 1999, only four documented takes of smalltooth sawfish occurred in shrimp trawls in Florida (Simpfendorfer, 2000). After consultation with individuals with many years in the business of providing qualified observers to the hopper dredge industry to monitor incoming dredged material for endangered species remains (C. Slay, Coastwise Consulting, pers. comm. August 18, 2003) and a review of the available scientific literature, NOAA Fisheries determined that there has never been a reported take of a smalltooth sawfish by a hopper dredge, and such take is unlikely to occur because of smalltooth sawfishes affinity for shallow, estuarine systems."

(e) Effect Determination. Based on the current South Atlantic distribution of smalltooth sawfish and only one sighting in North Carolina since 1999, hopper 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, this project will have no effect on the smalltooth sawfish.

4.02.10 Red Knot

a.) Status Federal – Proposed Threatened

b.) Background The Red Knot (*Calidris canutus rufa)* is a medium-sized shorebird that undertakes an annual 30,000 km hemispheric migration, one of the longest among shorebirds. Their migration route extends from overwintering sites in the southernmost tip of South America at Tierra del Fuego, up the Eastern coast of the Americas through the Delaware Bay, and ultimately to breeding sites in the central Canadian Arctic. Red Knots break their migration into strategically timed and selected non-stop segments, of approximately 1,500 miles, throughout the entire Atlantic coast, including North Carolina. These staging areas consist of highly productive foraging locations which are repeatedly used year to year. As the Red Knot moves towards the northern extent of its

migration route, the timing of departures becomes increasingly synchronized. One critical foraging stop for Red Knots occurs in the Delaware Bay where they feed almost exclusively on horseshoe crab eggs, due to their high fat content and ease of digestion, in order to reach threshold departure masses (180-200 grams) prior to heading for the Arctic breeding grounds. The arrival of the Red Knot in the Delaware Bay coincides with the spawning of the horseshoe crabs, which peaks in May and June. Birds arrive emaciated and can nearly double their mass (~4.6 grams/day) prior to departure if foraging conditions are favorable (Baker *et. al*., 2001), eating an estimated 18,000 fatrich horseshoe crab eggs per day (Andres et al. 2003). This critical foraging stopover enables Red Knots to achieve the nutrient store levels necessary for migration, survival, and maximizing the reproductive potential of the population (Baker et. al. 2004). In order to increase their body mass at such a rapid rate during their refueling stopover in the Delaware Bay, Red Knots morph their guts during their migration route from South America to Delaware.

Ms. Sara Schweitzer, North Carolina Wildlife Resources Commission, provided the following information (email dated 1 August 2011): *The data we have for Red Knots is from opportunistic counts of them, as well as counts of them during other surveys. There have not been surveys or studies on Red Knots specifically. Therefore, there may be more birds in NC than are indicated by our data. From the extant data, it appears that Red Knots are present in NC in greatest numbers (>100 per flock) during spring migration (April through May) during which time they may be in flocks up to 1000 birds.*

Red Knots do feed extensively in the intertidal zone and on small coquina clams and horseshoe crab eggs. So they are either seen feeding voraciously or resting. Once they build up adequate fat reserves, they fly to their next stopover site. Some Red Knots have geo-locators on their leg bands and such data demonstrate that they can fly 100s of miles without stopping if they have adequate fat stores.

The best places for them to feed and rest are large intertidal areas for foraging, with foredunes in which to rest. No disturbance as these sites from pedestrians, dogs, or vehicles would be tolerated by the birds; thus, busy sites are not used. Our database indicates that sites with greatest numbers of Red Knots include:

Sunset Beach (northeast end and shoals in inlet) (private) Lea-Hutaff Island (Audubon) Masonboro Island (NERR) Topsail Beach, South end (private) Bald Head Island (foundation) Bear Island (State Park) Bogue Inlet shoals Bogue Sound-Bogue Inlet CLNS South Core Banks, North Core Banks, Shackleford Banks (NPS) New Drum Inlet shoals Clam Shoal CHNS Hatteras Island, South (NPS) CHNS, Ocracoke Island (NPS) Pea Island NWR -- N end Hatteras Island (USFWS & NPS).

Most areas where Red Knots occur in great numbers in spring migration are protected due to their ownership. However, there are areas with no protection from a conservation entity.

More recently, Niles *et. al.* (2009) reports continued shortage of horseshoe crab eggs at a critical stop in Delaware Bay for the Red Knot. Over the past 10 years, heavy commercial harvest of horseshoe crabs has caused a rapid decline in the crab's breeding population in Delaware Bay, reducing the number of eggs available to shorebirds. During this time the Red Knot population has declined from over 90,000 birds counted on Delaware Bay in 1989, to 32,000 in 2002. Similar declines have been shown in the South American wintering grounds suggesting that the viability of

the Red Knot is seriously threatened. Demographic modeling predicts imminent endangerment and an increased risk of extinction without urgent management (Baker et al. 2004).

Morrison *et al*. (2004) have identified four factors that cause this vulnerability: (1) a tendency to concentrate in a limited number of locations during migration and on the wintering grounds, so that deleterious changes can affect a large proportion of the population at once; (2) a limited reproductive output, subject to vagaries of weather and predator cycles in the Arctic, which in conjunction with long lifespan suggests slow recovery from population declines; (3) a migration schedule closely timed to seasonally abundant food resources, such as horseshoe crab (*Limulus polyphemus*) eggs during spring migration in Delaware Bay, suggesting that there may be limited flexibility inmigration routes or schedules; and (4) occupation and use of coastal wetland habitats that are affected by a wide variety of human activities and developments.

Considering the threat of extinction, petitions have been submitted to the United States Fish and Wildlife Service for emergency listing of the *rufa* subspecies of the Red Knot (*Calidris canutus rufa*) as endangered and to designate "critical habitat" under the Endangered Species Act ("ESA"). On September 12, 2006, the USFWS included the Red Knot as a candidate species that may warrant protection under the Endangered Species Act (ESA). On July 20, 2007, the Red Knot final status assessment report was made available in which the Service determined that the Red Knot warranted protection, but placing the bird on the endangered species list is precluded by higher priority listing actions for species at greater risk. Although the candidate species status does not provide any regulatory protection under ESA, the USFWS recommends that, given its candidate status, all Federal agencies funding, authorizing, or conducting actions that may affect the Red Knot or its habitat, including impacts to prey resources, give full consideration to the species in project planning.

On September 30, 2013, USFWS published in the Federal Register their proposal to list the red knot (*Calidris canutus rufa*) as Threatened species under the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531-1543).

c. <u>Project Impacts.</u> The disposal of sediment on the beach may have short-term impacts on benthic invertebrates. However, recovery occurs within 1-3 years depending on sediment compatibility and the frequency and size of disturbance. Given their mobile foraging patterns, local disruptions to foraging habitat is likely not that disruptive to Red Knots (Harrington, Personal Communication, September 2006). Therefore, disruption from construction activities associated with beach disposal of sediment will likely result in the movement of Red Knots to an alternative foraging location. However, multiple or large scale disruptions effecting all key foraging locations at one time could have a profound impact. Though Red Knots can relocate with localized disruption, large scale disturbances that impact the entire range of foraging locations may be significant. Within the limits of foraging distribution, beach disposal activities should be constructed in a manner as to allow for unimpacted foraging habitat locations and avoid large scale disruption to benthic invertebrates to the maximum extent practicable. All personnel involved in the construction process along the beach will be trained in recognizing the presence of red knots prior to the initiation of the work on the beach. A contractor representative authorized to stop or redirect work shall be responsible for conducting a shorebird survey prior to 9 am each day of sand placement activities. The survey shall cover the work area and any location where equipment is expected to travel. The contractor

shall note on their Quality Assurance form for each day any observance of red knots and/or piping plovers and provide the information to the Wilmington District Office.

Habitats used by red knots in migration and wintering areas are similar in character, generally coastal marine and estuarine (partially enclosed tidal area where fresh and salt water mixes) habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks. In many wintering and stopover areas, quality high-tide roosting habitat (i.e., close to feeding areas, protected from predators, with sufficient space during the highest tides, free from excessive human disturbance) is limited. The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated (78 FR 60023). Furthermore, large scale development and continued beach erosion along the wintering and stopover range along the Atlantic has limited the availability of habitat that contains the necessary features for a suitable roosting environment. Beach disposal actions that occur within these limited roosting locations should avoid roosting time frames or implement appropriate buffer requirements during construction to the maximum extent practicable in order to minimize impacts. Beach disposal of sediment may have a beneficial effect on the Red Knot's roosting habitat in areas where significant erosion is occurring.

d.) Effect Determination. Short-term impacts of the proposed action on the Red Knot would result from the disposal of sediment within the 22.7 mile long Bogue Banks approximately every 3-5 years. This activity would restore beach and intertidal area for this species. Moreover all work on the ocean beaches of Bogue Banks would not be instantaneous. Only a small portion of the beach would be impacted. The long-term effects of the project may restore lost sheltering, feeding, roosting and nesting habitat through the addition of beach disposal activities within the 22.7 mile long disposal area on Bogue Banks; however, short-term impacts (mentioned above) to foraging, feeding, sheltering, and roosting habitat may occur during project construction. Considering that construction activities will (1) avoid large scale disturbance within the entire range limits of Red Knot foraging distribution and allow for areas of un-impacted or recovered foraging habitat within a given year, (2) avoid roosting timeframes or provide appropriate buffers around existing roosting habitat identified during shorebird surveys and construction operations, and (3) beach placement on Bogue Banks will only take place from December 1 to March 31 approximately once every 3-5 years, the disposal of sediment on the Bogue Banks beaches may affect not likely adversely affect the Red Knot.

5.00 COMMITMENTS TO REDUCE IMPACTS TO LISTED SPECIES

The following is a summary of environmental commitments to protect listed species related to the construction and maintenance of the proposed project. These commitments address agreements with resource agencies, mitigation measures, and construction practices:

1. The Corps will strictly adhere to all conditions outlined in the most current National Marine Fisheries Service RBO for dredging of channels and borrow areas in the southeastern United States. Furthermore, as a component of this project, hopper dredging activities for both initial construction and each nourishment interval will adhere, to the maximum extent practicable, to a dredging window of 1 December to 31 March in order to avoid periods of

peak sea turtle abundance. The use of turtle deflecting dragheads, inflow and/or overflow screening, and NMFS certified turtle and whale observers will also be implemented.

2. In order to determine the potential taking of whales, turtles and other species by hopper dredges, NMFS certified observers will be on board during all hopper dredging activities. Recording and reporting procedures will be in accordance with the conditions of the current NMFS RBO.

3. Endangered species observers (ESOs) will be on board all hopper dredges and will record all large whale sightings and note any potential behavioral impacts. The Corps and the Contractor will keep the date, time, and approximate location of all marine mammal sightings. Care will be taken not to closely approach (within 300 feet) any whales, manatees, or other marine mammals during dredging operations or transportation of dredged material. An observer will serve as a lookout to alert the dredge operator and/or vessel pilot of the occurrence of these animals. If any marine mammals are observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions shall be avoided either through reduced vessel speed, course alteration, or both.

4. Established precautionary collision avoidance measures will be implemented during dredging and disposal operations that take place during the time NARW's are present in waters offshore and within the project area. These include:

    a. Before the initiation of each project, at the pre-construction/partnering meeting, the Corps briefs the contractor on the presence of the species, and reviews the requirements for right whale protection,

    b. Each contractor will be required to instruct all personnel associated with the dredging/construction project about the possible presence of endangered North Atlantic right whales in the area and the need to avoid collisions. Each contractor will also be required to brief his personnel concerning the civil and criminal penalties for harming, harassing or killing species that are protected under the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. Dredges and all other disposal and attendant vessels are required to stop, alter course, or otherwise maneuver to avoid approaching the known location of a North Atlantic right whale. The contractor will be required to submit an endangered species watch plan that is adequate to protect North Atlantic right whales from the impacts of the proposed work.

5. The Corps will avoid the sea turtle nesting season during initial construction and each nourishment interval. If, due to unforeseen circumstances, construction extends into the nesting season, the following measures will be implemented:

    a. The Corps will implement, in coordination with USFWS and NCRC, a sea turtle nest monitoring and avoidance/relocation plan in advance of construction activities in order to document all nests within the beach placement template.

b. Construction operations and pipeline placement will be modified to bypass existing nests. If bypassing is not a practical alternative for a given project, the relocation of nests outside of construction areas will be implemented as a last resort.

c. Throughout the period of sea turtle nesting and hatching, construction pipe that is placed on the beach parallel to the shoreline could be placed as far landward as possible so that a significant portion of available nesting habitat can be utilized and nest placement is not subject to inundation or wash out.

d. Temporary storage of pipes and equipment will be located off the beach to the maximum extent practicable. If placement on the beach is necessary, it will be done in a manner so as to impact the least amount of nesting habitat by placing pipes perpendicular to shore and as far landward as possible without compromising the integrity of the existing or constructed dune system.

e. All lighting associated with project construction will be minimized to the maximum extent practicable while maintaining compliance with all Corps, U.S. Coast Guard, and OSHA safety requirements. Direct lighting of the beach and near shore waters will be limited the immediate construction area(s). Lighting aboard dredges and associated vessels, barges, etc. operating near the sea turtle nesting beach shall be limited to the minimal lighting necessary to comply with the Corps, U.S. Coast Guard, and OSHA requirements. Lighting on offshore or onshore equipment will be minimized through reduced wattage, shielding, lowering, and/or use of low pressure sodium lights, in order to reduce illumination of adjacent beach and nearshore waters will be used to the extent practicable.

6. The beach will be monitored for escarpment formation by the Contractor prior to completion of beach construction activities associated with initial construction and each nourishment interval. Additionally, the beach will be monitored by the local sponsor for escarpment formation prior to each turtle nesting season every year between nourishment events. Escarpments which exceed 18 inches in height for a distance of 100 ft. will be leveled by the Contractor or local sponsor accordingly. If it is determined that escarpment leveling is required during the nesting or hatching season, leveling actions should be directed by the USFWS

7. Only beach compatible sediment will be placed on the beach as a component of this project. Detailed analyses of the borrow area and native beach sediments will be completed prior to placing sediment on the beach to assure compatibility. Post nourishment beach compaction (hardness) will be evaluated by the Corps, in coordination with the NCWRC and USFWS, using qualitative assessment techniques to assure that impacts to nesting and incubating sea turtles are minimized and, if necessary, identify appropriate mitigation responses.

8. Local lighting ordinances will be encouraged to the maximum extent practicable in order to reduce lighting impacts to nesting females and hatchlings. The local sponsors will be encouraged to work with the USFWS, local monitoring groups, and other concerned

organizations to develop the best plan for the Towns of Emerald Isle, Pine Knoll Shores, Salter Path, Indian Beach, and Atlantic Beach.

9. Throughout the duration of each nourishment event, both initial construction and periodic nourishment, the Contractor will be required to monitor for the presence of stranded sea turtles, live or dead. If a stranded sea turtle is identified, the Contractor will immediately notify the NCWRC of the stranding and implement the appropriate measures, as directed by the NCWRC. Construction activities will be modified appropriately as not to interfere with stranded animals, live or dead.

10. The Corps will implement precautionary measures for avoiding impacts to manatees during construction activities as detailed in the "Guidelines for Avoiding Impacts to the West Indian Manatee in North Carolina Waters" established by the USFWS.

11. ESO's on board hopper dredges and closed net sea turtle relocation trawlers 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 Atlantic sturgeon following the same ESO protocol for sea turtles. All ESOs on board trawlers will be capable of identifying Atlantic sturgeon as well as following safe handling protocol as outlined in Moser *et. al.* 2000.

12. The Corps will adhere to appropriate environmental windows for piping plovers and other shorebirds to the maximum extent practicable.

13. All staging areas, pipeline routes, and associated construction activities will avoid high value piping plover and shorebird habitat, located within the vicinity of New River Inlet, to the maximum extent practicable and all personnel involved in the construction process along the beach will be trained in recognizing the presence of piping plovers and red knots prior to the initiation of the work on the beach. A contractor representative authorized to stop or redirect work shall be responsible for conducting a shorebird survey prior to 9 am each day of sand placement activities. The survey shall cover the work area and any location where equipment is expected to travel. The contractor shall note on their Quality Assurance form for each day any observance of red knots and/or piping plovers and provide the information to the Wilmington District Office.

14. Only beach quality sand shall be used for this project. The Contractor will conduct daily visual survey of the material being placed. Should the dredging operations encounter sand deemed non-compatible with the native grain size or sorting characteristics of the native beach, the dredge operator shall immediately cease operation and contact the DCM. Dredge operations will resume only after the issue of sand compatibility is resolved.

6.00 SUMMARY EFFECT DETERMINATION

Threatened and endangered species summary effect determination for beach placement and dredging activities associated with the proposed project area (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) Critical Habitat.

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

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INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX G

ENVIRONMENTAL COMMITMENTS

US Army Corps of Engineers

Wilmington District

The tables below include a list of environmental commitments associated with construction and maintenance of the proposed project.

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Sediment Compatibility	(1) Only beach compatible sediment would be placed on the beach as a component of this project. (2) During the PED phase of this project, additional borings or geophysical surveys or both would be performed to better delineate the borrow area boundaries and material types. (3) If the dredging operations encounter sand deemed non-compatible with native grain size or sorting characteristics of the native beach, the Wilmington District would make the decision on a suitable contingency measure that may include moving the dredge to another site in the borrow area and would notify the NCDCM and other resource agencies of such a contingency measure.
Piping Plover and Other Shorebirds	(4) The Corps would adhere to appropriate environmental windows to the maximum extent practicable. (5) All staging areas, pipeline routes, and associated construction activities would avoid piping plover critical wintering habitat and high valued shorebird habitat located within Bogue Banks, to the maximum extent practicable and all personnel involved in the construction process along the beach will be trained in recognizing the presence of piping plovers and red knots prior to the initiation of the work on the beach. A contractor representative authorized to stop or redirect work shall be responsible for conducting a shorebird survey prior to 9 am each day of sand placement activities. The survey shall cover the work area and any location where equipment is expected to travel. The contractor shall note on their Quality Assurance form for each day any observance of red knots and/or piping plovers and provide the information to the Wilmington District Office. (6) Endangered Species Observers (ESO's) on board the hopper dredges will be required to document bird species present and associated behavioral activities in the project area. All bird data will be provided to the NCWRC.
Manatee	(7) The Corps would implement precautionary measures for avoiding impacts to manatees during construction activities as detailed in the *Guidelines for Avoiding Impacts to the West Indian Manatee in North Carolina Waters* established by the USFWS.

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Large Whales and other Marine Mammals	(8) ESO's would be on board all hopper dredges and would record all large whale sightings and note any potential behavioral effects. The Corps and the contractor would keep the date, time, and approximate location of all marine mammal sightings. They would take care not to closely approach (within 500 yards) any whales, manatees, or other marine mammals during dredging operations or transport of dredged material. An observer would serve as a lookout to alert the dredge operator or vessel pilot or both of the occurrences of such animals. If any marine mammals are observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions would be avoided either through reduced vessel speed, course alteration, or both.
Sea Turtles	(9) The Corps would strictly adhere to all conditions outlined in the most current NMFS Regional Biological Opinion (RBO) for dredging of channels and borrow areas in the southeastern United States. Furthermore, as a component of this project, hopper dredging activities for both initial construction and each nourishment interval would adhere, to the maximum extent practicable, to a dredging window of December 1 to March 31 to avoid periods of peak sea turtle abundance. Turtle-deflecting dragheads, inflow and overflow screening, and NMFS-certified turtle observers would also be implemented. (10) To determine the potential taking of whales, turtles, and other species by hopper dredges, NMFS-certified observers would be on board during all hopper dredging activities. Recording and reporting procedures would be followed in accordance with the conditions of the current NMFS RBO. (11) The Corps would attempt to avoid the sea turtle nesting season during initial construction and each nourishment interval. If, because of unforeseen circumstances, construction extends into the nesting season, the Corps would implement a sea turtle nest monitoring and avoidance/relocation plan through coordination with USFWS and NCWRC.

Species, habitat, other	Commitments to reduce environmental impacts and other impacts
Sea Turtles (continued)	(12) The beach would be monitored for escarpment formation by the contractor before completion of beach construction activities associated with initial construction and each nourishment interval. Additionally, the local sponsor would monitor the beach for escarpment formation before each turtle nesting season every year between nourishment events. Escarpments that exceed 18 inches in height for a distance of 100 ft. would be leveled by the contractor or the local sponsor accordingly. If it is determined that escarpment leveling is required during the nesting or hatching season, leveling actions should be directed by the USFWS. (13) Only beach-compatible sediment would be placed on the beach as a component of the project. The Corps would, in coordination with the NCWRC and USFWS, evaluate post-nourishment beach compaction (hardness)would using qualitative assessment techniques to assure that impacts to nesting and incubating sea turtles are minimized and, if necessary, identify appropriate mitigation responses, which may include tilling. (14) Local lighting ordinances would be encouraged to the maximum extent practicable to reduce lighting impacts to nesting females and hatchlings. The local sponsors would be encouraged to work with the USFWS, local monitoring groups, and other concerned organizations to develop the best plan for the project beaches.
Seabeach Amaranth	(15) The 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.

Species, habitat, other	Commitments to reduce environmental impacts and other impacts
Benthic Invertebrates	(16) The anticipated construction time frame for initial and periodic nourishment events would avoid peak recruitment and abundance time period for surf zone fishes and benthic invertebrates.

	(17) Initial construction would be completed over one year with renourishment every 3 years. With this approach, effects would be expected to be localized, short-term, and reversible. .
Shellfishing	(18) The Corps would contact the North Carolina Shellfish Sanitation and Recreational Water Quality Section before start of work, so the project area may be posted as required.
Erosion/Sediment Control	(19) Before initiating any land-disturbing activities, the Corps would obtain the approval of the North Carolina Division of Land Resources of an erosion and sedimentation control plan. The Corps would comply with the requirements of the approved erosion and sedimentation control plan. A copy of the plan approval will be forwarded to NCDCM.
Water Quality	(20) Before construction, the Corps would obtain a Section 401 Water Quality Certification from the NCDWQ for the proposed project. The Corps would comply with the requirements of the Section 401 Water Quality Certification. A copy of the certification would be forwarded to NCDCM. (21) Temporary dikes would be used to retain and direct flow of material parallel to the shoreline to minimize surf zone turbidities. The temporary dikes would be removed and the beach graded in accordance with approved profiles on completion of pumping activities in that section of beach.

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Terrestrial Habitat	(22) Land-based equipment necessary for beach nourishment work would be brought to the site through existing accesses. If the work results in any damage to existing accesses, the accesses would be restored to pre-project conditions immediately on project

	completion. (23) Dune disturbance would be kept to a minimum. Any alteration of existing dunes would be coordinated with NCDCM and the appropriate property owner(s). All disturbed areas would be restored to original contours and configuration with reference to the surveyed normal high water line and would be revegetated immediately after project completion in that area. (24) 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*). (25) To prevent leakage, dredge pipes would be routinely inspected. If leakage is found and repairs cannot be made immediately, pumping of material must stop until such leaks are fixed.
Hard Bottom Habitat	(26) Once pipeline corridor and pumpout details are defined during PED, the Corps intends to survey all area before construction to avoid potential hard bottom 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. (26a) Low relief hardbottoms are present in borrow area U and Y. A 500 meter buffer will be implemented to avoid impacts to the resources.

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Other	(27) Before construction the existing MHW line would be surveyed,

Commitments	and a copy provided to the NCDCM. If construction is not initiated within 60 days or there is a major shoreline change before beginning beach nourishment (or both), a new survey would be conducted. (28) Before initiating any beach nourishment activity, the Corps would coordinate with NCDCM to determine the static vegetation line to be used as the reference point for measuring future oceanfront setbacks. That static vegetation line would then be marked, and a survey depicting the static vegetation line would be submitted to NCDCM before any beach nourishment activities. (29) After the post-construction beach profile surveys are completed, the Corps would coordinate with the North Carolina Floodplain Mapping Program to support revisions to the Digital Flood Insurance Rate Maps (DFIRMs). As part of such coordination, the Corps would provide a Letter of Map Revision. (30) No sand would be placed on any sandbags that have been determined by NCDCM to be subject to removal under 15A NCAC 07H .0308(a)(2). To ensure compliance with that condition, NCDCM would be contacted before project initiation so that NCDCM staff may meet on-site with the Corps or the contractor or both. (31) To mitigate the possibility of encountering UXO, the beach would be inspected daily, and any potential UXO discovered would be handled in accordance with the Military Munitions Rule, 40 CFR 266, Subpart M. Explosive Ordnance Disposal (EOD) Teams stationed at nearby military installations are available (on call) to be summoned if potential UXO items are discovered 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 UXO 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 UXO found on the beach would be promptly removed.

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Other	(32) To assure the risk of potential impacts to cultural resources

Commitments (continued)	within inshore areas subject to pumpout activities are avoided, specific pumpout locations would identified, surveyed, and investigated for cultural resources in conjunction with hard-bottom surveys before beginning nourishment activities. (33) To further minimize the risk of cultural resource impacts before and during construction, the following commitments would be implemented: (1) Areas subject to pump-out activities are avoided, specific pump-out locations would identified, surveyed, and investigated for cultural resources in conjunction with hard bottom surveys before commencement of nourishment activities, (2) Should any previously unidentified or unanticipated historical, archaeological, and cultural resources be discovered or found within the inflow screening of the dredge or within the beach placement area, all activities that may damage or alter such resources would be temporarily suspended. The Corps' Contracting Officer would be immediately notified so that the appropriate authorities, including BOEM, can be notified in accordance with Corps policy and 30 CFR 250.194(c) and a determination made as to their significance and what, if any, special disposition of the finds should be made. All activities that could result in effects on or the destruction of those resources would cease. The area would be secured to prevent employees or other persons from trespassing on, removing, or otherwise disturbing such resources until the sites potential historic significance can be assessed and protected.

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BOGUE BANKS, CARTERET COUNTY

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APPENDIX H

Real Estate Plan

US Army Corps of Engineers
Wilmington District

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SECTION 1. THE REAL ESTATE REPORT

1.1. STATEMENT OF PURPOSE

This report is tentative in nature, focuses on the Tentatively Selected Plan (TSP), and is to be used for planning purposes only. There may by modifications to the plans that occur during Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative and land cost. This Real Estate Plan is intended to support the Integrated Feasibility Report for the coastal storm damage reduction project and is written to the same level of detail. This report pertains specifically to the towns of Emerald Isle, Indian Beach, Salter Path, Pine Knoll Shores and Atlantic Beach which are located on Bogue Banks. Carteret County is the Non-Federal Sponsor for the project. The author of this report has inspected the Project areas. Date of this report is May 2014.

1.2. STUDY AUTHORITY

Coastal Storm Damage Reduction (CSDR) for Bogue Banks was originally 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.*

1.3. PROJECT LOCATION

The island of Bogue Banks, shown in Figure 1.3-1, is located in Carteret County near the center of North Carolina's coast. The island faces the Atlantic Ocean on the south and extends approximately 25.4 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 of the island, from west to east are 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 ½ mile wide.

The study area is roughly the incorporated towns located on Bogue Banks in Carteret County, North Carolina. The study area extends from Bogue Inlet at the west end to Atlantic Beach on the east end, approximately 23 miles. For 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. From the ocean shoreline the study area extends landward approximately 500 feet. Seaward the study area extends from the shoreline

approximately 1 mile. The study area also includes three offshore borrow sites lying 1 to 8 miles from the shoreline (shown in Figure 1.3-1), including a portion of the Offshore Dredged Material Disposal Site (ODMDS) which is labeled as Q2.

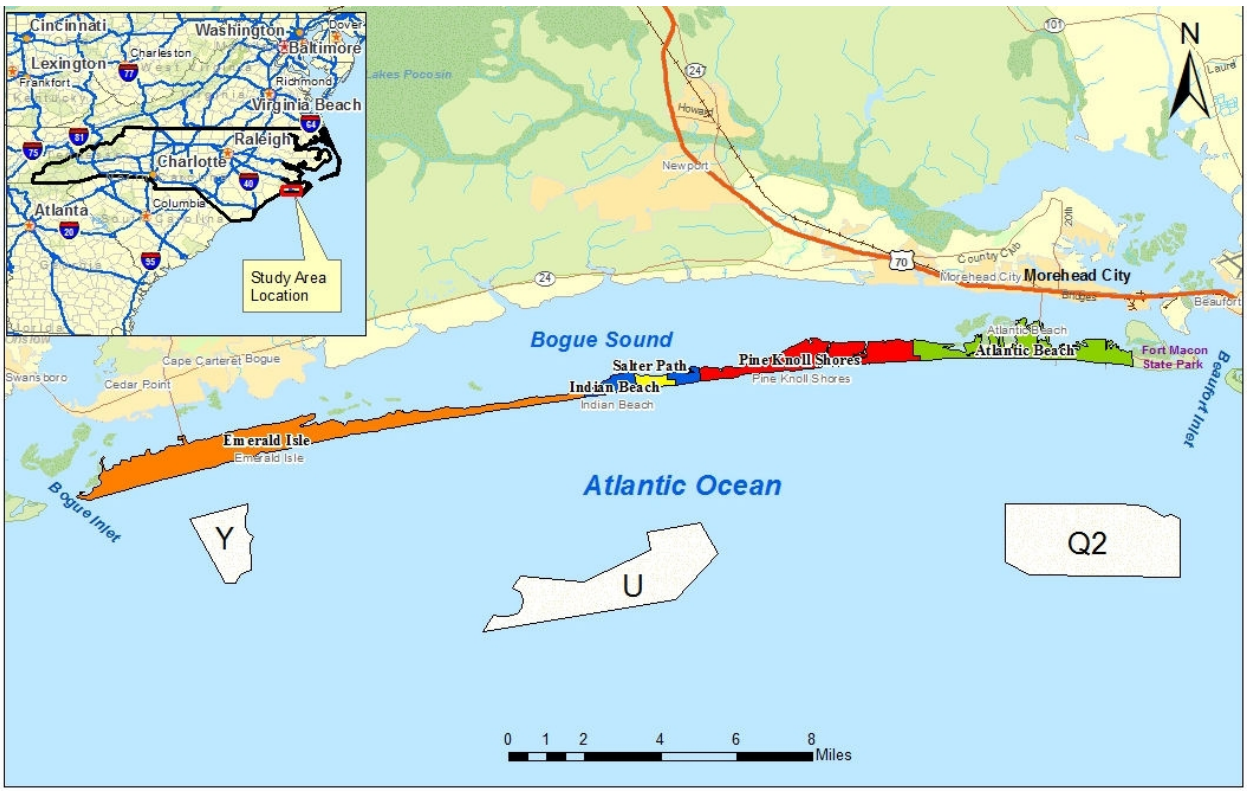

Figure 1.3-1 - Vicinity map, including potential offshore borrow locations (Y, U, O2)

1.4. PROJECT DESCRIPTION

The TSP, which is also the NED Plan, consists of a 119,670 ft (22.7 miles) long main beachfill, with a consistent berm profile across the entire area, and dune expansion in certain portions (approximately 5.9 miles of the project). The main beachfill is bordered on either side by a 1,000 ft tapered transition zone berm. Renourishment cycles are expected to occur every three years after initial construction. Typical cross sections for the berm profile and dune expansion are shown below in Figures 1.4-1 and 1.4-2. More detailed information is available in the Coastal Engineering Appendix A.

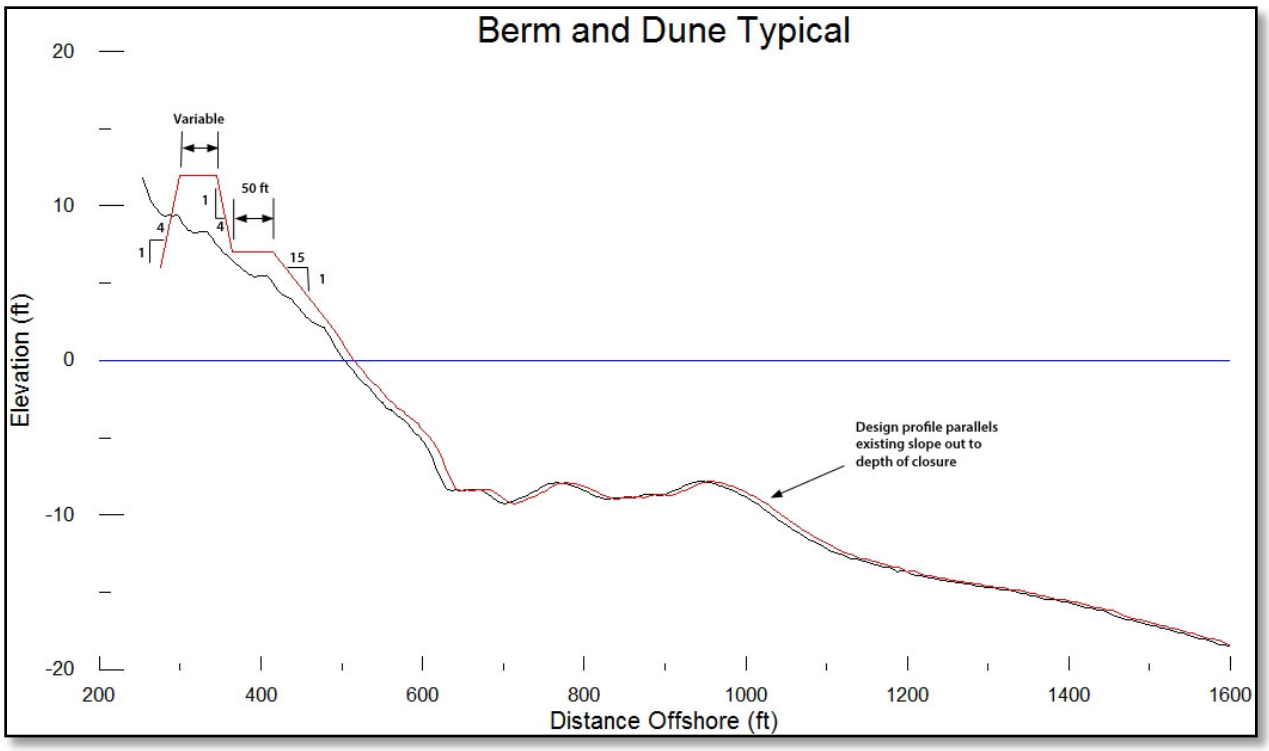

Figure 1.4-1 – Typical Dune and Berm Cross Section

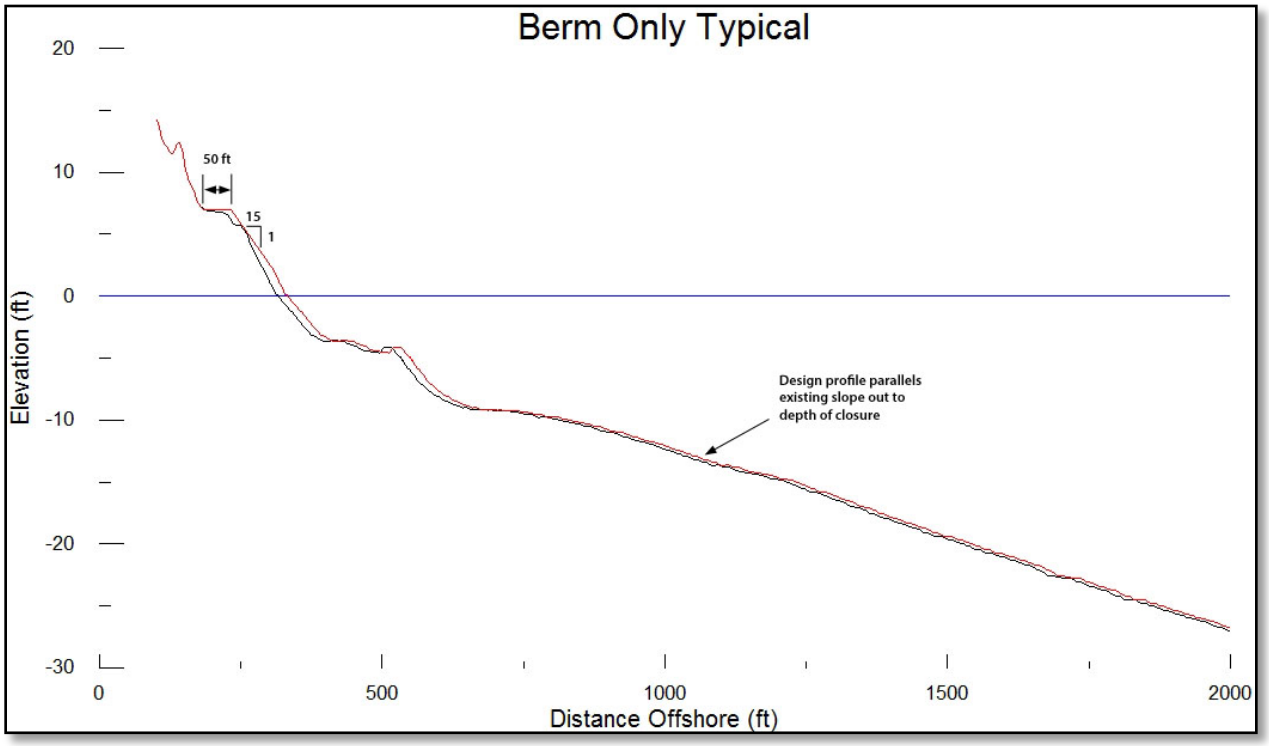

Figure 1.4-2 - Typical Berm Only Cross Section

The dimensions representing berm and dunes for the recommended plan are summarized in Table 1.4-1 below. While the recommended plan dune conditions vary the recommended berm for the plan is consistent at 50 feet throughout the project area. The berm elevations for the recommended plan mirror the existing conditions and are +5.5 feet NAVD for reaches 1, 11, and 12. The remaining project area berm elevation is set at +7 feet NAVD.

Table 1.4-1

TSP Main Beachfill Dimensions

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

Sand for the beachfill would be delivered from offshore borrow areas by dredge. Three offshore borrow locations were identified as sources for providing enough compatible material for a 50 year beachfill project. These three areas were depicted in Figure 1.3-1 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 the ODMDS (approximately 3-5 miles offshore the eastern end of Bogue Banks).

1.5 REAL ESTATE REQUIREMENTS

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. Figure 1.5-1 shows a typical reach of the project where structures are present. Improvements in the proposed easement area are walkways, beach access crossovers and one fishing pier. The Storm Damage Reduction Easement does allow owners to build and maintain walkover structures subject to sponsor approval. Damage to the existing structures within the acquired easement area is not compensable and not creditable as the easement allows for the removal of obstructions or obstacles within the limits of the easement. However, every effort is made during construction to avoid damage to structures. The landward construction line for the project is placed to minimize effects on existing structures, to parallel the existing shoreline, to allow the Perpetual Beach Storm Damage Reduction Easement to extend about 20 ft. landward of the dune toe, and to tie the fill into the existing elevations. 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.

Figure 1.5-1 – Typical Reach of Project

There are no easements for public water or power located within the proposed Project area. The Town of Emerald Isle owns 4 parcels within the project area, the Town of Indian Beach owns 1 parcel within the project area, the Town of Pine Knoll Shores owns 2 parcels within the project area, the Town of Atlantic Beach owns 5 parcels within the project area, and the State of North Carolina owns 2 parcels within the project area. According to the tax maps there are approximately 98 public access points to the beach within the project limits.

Access to the Project will be 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 onto the beach. Staging areas will be acquired under Temporary Work Area Easements. Areas identified for staging at Emerald Isle include the Western Regional Access (Figure 1.5-2) owned by the Town of Emerald Isle and the Eastern Regional Access (Figure 1.5-3) owned by the State of North Carolina. The Indian Beach Access (Figure 1.5-4) is a public access at Indian Beach/Salter Path. The Iron Steamer Regional Access (Figure 1.5-5) and Knollwood Access (Figure 1.5-6) are both owned by the Town of Pine Knoll Shores, and the Circle Regional Access (Figure 1.5-7) and Tom Doe Regional Access (Figure 1.5-8) are owned by the Town of Atlantic Beach. All staging and placement of pipe is expected to be within public areas or acquired easements.

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). The OCS is a zone that generally extends from 3 nautical miles seaward of the coastal State boundaries out to 200 nautical miles. Any required permitting to borrow from sources within the OCS will be addressed during the National Environmental Policy Act (NEPA) and Environmental Impact Statement (EIS) process.

There is one pier located within the study area, Bogue Inlet Pier, which is located at Emerald Isle and is privately owned and operated. Historically, in prior projects in North and South Carolina, fishing piers and their associated buildings have never been acquired, regardless of their location in relation to project lines. The primary reason is the significant economic impact that it would have on the community. Traditionally easements are acquired up to the face of the structures and beneath the pier. For purposes of this report, it is assumed that neither the pier nor appurtenances will be acquired. No values have been estimated for this structure. The pier is shown in Figure 1.5-9.

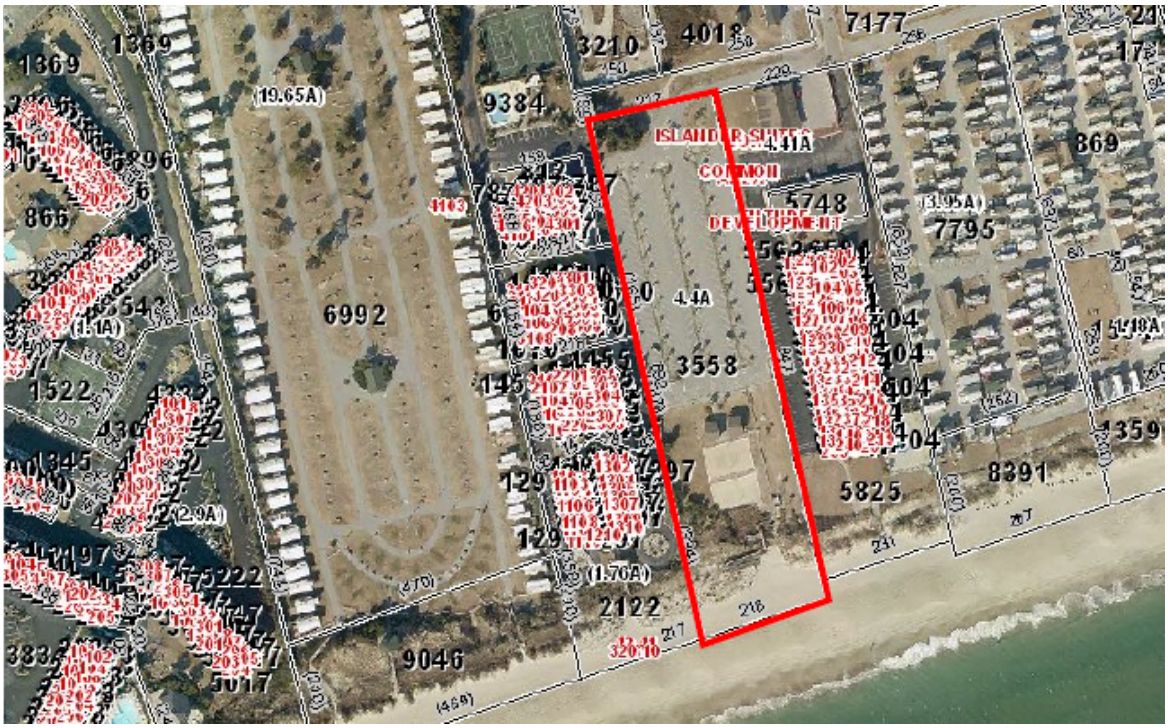

Figure 1.5-2 – Western Regional Access – Emerald Isle

Figure 1.5-3 – Eastern Regional Access – Emerald Isle

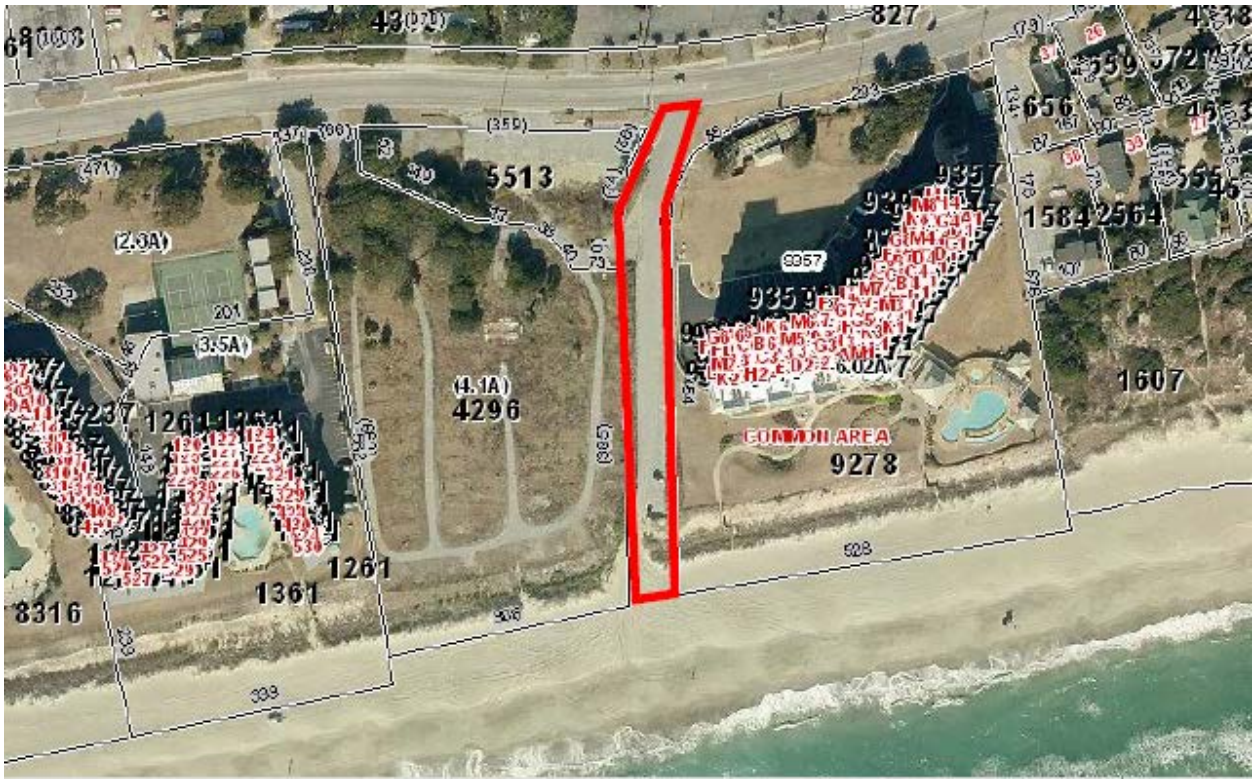

Figure 1.5-4 – Indian Beach Access at Indian Beach /Salter Path

Figure 1.5-5 – Iron Steamer Regional Access – Pine Knoll Shores

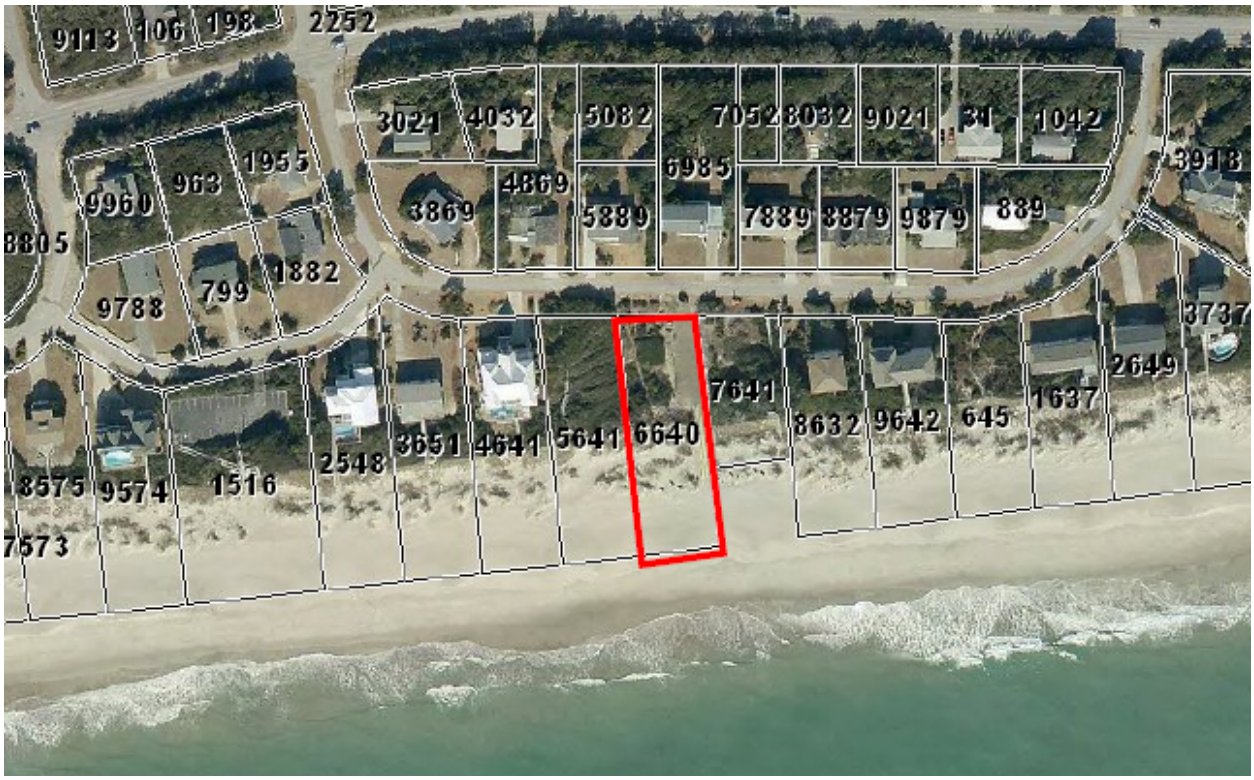

Figure 1.5-6 – Knollwood Access – Pine Knoll Shores

Figure 1.5-7 – Circle Regional Access – Atlantic Beach

Figure 1.5-8 – Tom Doe Regional Access – Atlantic Beach

Figure 1.5-9 – Bogue Inlet Pier – Emerald Isle

Acquisition of lands under the proposed Perpetual Beach Storm Damage Reduction Easement will be along the existing dune system. Based on a ground examination, it appears that there will be no adverse impact to the upland portion of ownership. Improvements in the proposed easement area are walkways, beach access crossovers and the fishing pier. 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. It is noted that any walkway that may be damaged during construction would most probably be at least partially located within the proposed easement area. Within the easement area we have the right to remove any structures if necessary that may impact construction of the project. While every effort will be made to avoid damage to an existing walkway, no guarantee can be made that no damage will occur. Should damage occur to a walkway, a landowner is not entitled to any compensation for such damage and repair to a walkway is not considered to be a creditable item. The Storm Damage Reduction Easement does allow owners to build and maintain walkover structures subject to sponsor approval. It is noted that walkovers constructed by landowners after project construction may be subject to impact by subsequent nourishment events.

Project maps and county tax parcel maps were used to identify the number of easements that may be required to construct the project area. After careful consideration a determination was made to count each parcel within the project limits as a potential easement required for the project. The project maps and tax maps show parcel lines based on original subdivision plats. The problem in estimating comes in that a large portion of the easement falls into the area between the property lines as shown on the maps and MHW. Defining ownership of those areas this early in the planning stages is difficult due to the numbers of landowners along the beach strand. In randomly pulling deeds on different tax parcels, it is noted that some deeds reference ownership based on reference to a lot and block number as shown on a recorded subdivision plat or an actual metes and bounds description and reference to a particular plat map. They do not specifically state ownership to Mean High Water (MHW) of the Atlantic Ocean. However, some parcels are indicated on the project maps or tax maps as having lot lines as shown by a subdivision line but the deed references ownership to MHW of the Atlantic Ocean. Per the project maps, the projected easement line may very well appear to lie seaward of the lot line. Consequently, at first look, it would appear that the parcel is not impacted; however the deed may define ownership going to MHW of the Atlantic, so in fact the parcel is impacted. Without searching title to each oceanfront parcel it cannot be determined who actually owns the property to MHW. In view of this, it seems prudent for planning purposes to assume that an easement may be needed from each property owner in the project.

The towns within the project limits have acquired a number of perpetual easements for beach renourishment over the past years for local projects at Bogue Banks. Emerald Isle has approximately 866 easements, Pine Knoll Shores has approximately 174 easements and Atlantic Beach has approximately 150 easements for a total of 1190 existing local easements. Each of these easements has not been reviewed but based on the deed samples provided by the Towns, the easement language used is the standard Perpetual Beach Storm Damage Reduction Easement. To reduce project cost and acquisition time, CESAS-RE requests approval to use those existing easements that are deemed sufficient for the project and also requests a delegation to the District to determine sufficiency of easements. During PED phase each deed will have to be reviewed for sufficiency. This will include confirmation that the deed is in fact perpetual, that it is not granted for a specific project and that it contains the “the right of public use and access” language. The easement will have to be assigned to the sponsor for the project and recorded in the Carteret County Register of Deeds. If an easement is deemed not sufficient for use then a new standard easement will have to be acquired by the sponsor. An assumption is made that approximately 75 percent or 893 of the 1190 existing easements may be usable for the project leaving approximately 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. A copy of a representative local easement is at Exhibit A.

The North Carolina Coastal Area Management Act (CAMA), enacted in 1974 and amended 1 April 1987, designated sensitive environmental areas within its 20-county coastal jurisdiction as Areas of Environmental Concern (AEC). Within an AEC, development must conform to specific regulations, which are designated to promote and protect environmental values as set out in CAMA and in the AEC development regulations. There are four categories of AECs: the estuarine system, the ocean hazard system, public water supplies, and natural and cultural resource areas. All of the properties within the project boundaries will probably fall within the ocean hazard system AEC. The most important requirement of this AEC is that no construction

is permitted within 60 feet of the first line of stable natural vegetation. The effect of the 60-foot CAMA (rear) setback coupled with the zoning setback for front yards is to effectively render some lots undevelopable since the remaining buildable land will be too small to permit construction of most structures.

Local sponsors must meet requirements for public access every ½ mile within the project limits to participate in cost sharing with the Federal Government for the project. These areas should be acquired either in fee or perpetual easement. Acquisition of public beach access points or parking areas that are necessary for compliance in cost sharing is strictly a sponsor responsibility and is not considered a project cost. Accordingly, any land cost or administrative cost incurred with the acquisition of public access points or parking areas is not considered a creditable expense towards project cost. Appendix I Parking and Access contains more detailed information.

1.6. UTILITY/FACILITY RELOCATION

The term "relocation" shall mean providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other public facility or town when such action is authorized in accordance with applicable legal principles of just compensation or as otherwise provided by Federal statute or any project report or House or Senate document referenced therein. Providing a functionally equivalent facility may take the form of adjusting, altering, lowering, raising, or replacement and attendant removal of the affected facility or part thereof. It is important to note that relocation assistance under Public Law 91-646 relates specifically to displaced persons, and should be distinguished from the separate concept of facility or utility relocations. There are no utility or facility relocations in this project.

1.7. EXISTING PROJECTS

See Section 1 subtitle “Existing Federal and Non-Federal Projects “in the main report for information on other projects in the area. Any credits to the non-federal sponsor for lands provided as an item of local cooperation for other Federal project cannot be duplicated as credit for the proposed hurricane and storm damage reduction project.

1.8. ENVIRONMENTAL IMPACTS

No adverse environmental impacts are expected as a result of the project.

1.9. PROJECT SPONSOR RESPONSIBILITIES AND CAPABILITIES

The County of Carteret will be the non-Federal Project Sponsor (NFS) for the project. The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. The sponsor will have operation and maintenance responsibility for the project after construction is completed.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “B” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2

January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "C" to the Real Estate Appendix.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. In addition, the specific requirements relating to valuation and crediting contained in the executed PPA for a project must be reviewed and applied. For shore damage reduction projects, lands subject to shore erosion, that are required for project purposes and that must be provided by the non-federal sponsor must be appraised for crediting purposes considering special benefits in accordance with relevant Federal statutes and Department of Justice guidance.

The NFS should not acquire lands required for the project prior to execution of the Project Partnership Agreement (PPA). Should the NFS proceed with acquisition of lands prior to execution of the PPA, it is at the risk of not receiving credit or reimbursement for any costs incurred in the connection with the acquisition process should the PPA not be signed. There is also risk in acquiring lands either not needed for the project or not acquired in compliance with requirements for crediting purposes in accordance with 49 CFR Part 24, dated March 2, 1989. Letters advising the NFS of the risks of early acquisition are at Exhibit "D".

1.10. GOVERNMENT OWNED PROPERTY

There is no land owned by the Federal Government within the proposed project.

1.11. HISTORICAL SIGNIFICANCE

The potential for encountering shipwreck 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. No known submerged cultural resources are located within the ODMDS. See Section 2.08 Cultural Resources in the main report for further discussion.

1.12. MINERAL RIGHTS

There are no known mineral activities within the scope of the proposed project.

1.13. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

A search of the USEPA Brownfields-Cleanups, Cleanups, and Resource Conservation and Recovery Act Information (RCRA Info) showed no documented hazardous material spills or environmental issues within the project area. See Section 2.13 Hazardous, Toxic and Radioactive Wastes (HTRW) in the main report for further discussion.

1.14 ZONING ORDINANCES

Zoning ordinances are not of issue with this project. Application or enactment of zoning ordinances is not to be used in lieu of acquisition.

1.15 NAVIGATION SERVITUDE

Exercise of Navigation Servitude is not applicable to the subject project as the focus of the project is for storm damage reduction rather than for commerce related purposes and there is no nexus to navigation.

1.16. PUBLIC LAW 91-646, RELOCATION ASSISTANCE BENEFITS

Public Law 91-646, Uniform Relocation Assistance provides entitlement for various payments associated with federal participation in acquisition of real property. Title II makes provision for relocation expenses for displaced persons, and Title III provides for reimbursement of certain expenses incidental to transfer of property. There will be no relocations in this project.

1.17. ATTITUDE OF PROPERTY OWNERS

There is no known opposition from landowners to the project.

1.18. ACQUISITION SCHEDULE

The project sponsor is responsible for acquiring real estate interests required for the project. However, It is projected that acquisitions will take approximately 24-36 months, and can begin when final plans and specs have been completed and the PPA has been executed. The Project Sponsor, Project Manager and Real Estate Technical Manager will formulate the milestone schedule upon project approval to meet dates for advertisement and award of a construction contract.

1.19. ESTATES FOR PROPOSED PROJECT

The standard Perpetual Beach Storm Damage Reduction Easement will be used for those parcels where easements are required to construct the project. The Temporary Work Area Easement will be used for the staging areas. A non–standard estate (NSE) for use in the project if necessary has been approved by the Chief of Real Estate, Savannah District. The NSE and approval memorandum is at Exhibit D.

PERPETUAL BEACH STORM DAMAGE REDUCTION EASEMENT.

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. __) for use by the (Sponsor), its representatives, agents, contractors, and assigns, to construct; preserve; patrol; operate; maintain; repair; rehabilitate; and replace; a public beach a dune system, and other erosion control and storm damage reduction measures together with appurtenances thereto, including the right to deposit sand; to accomplish any alterations of contours on said land; to construct berms and dunes; to nourish and renourish periodically; to move, store and remove equipment and supplies; to erect and remove temporary structures; and to perform any other work necessary and incident to the construction, periodic renourishment and maintenance of the **Bogue Banks Coastal Storm Damage Reduction Project**, together with the right of public use and access; to plant vegetation on said dunes and berms; to erect, maintain and remove silt screens and sand fences; to facilitate preservation of dunes and vegetation through the

limitation of access to dune areas; to trim, cut, fell, and remove from said land all trees, underbrush, debris, obstructions, and any other vegetation, structures and obstacles within the limits of the easement; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns, the right to construct dune overwalk structures in accordance with any applicable Federal, State or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape, dimension or function, and that prior approval of the plans and specifications for such structures is obtained from the (designated representative of the Project Sponsor) and provided further that such structures are subordinate to the construction, operation, maintenance, repair, rehabilitation and replacement of the project; and further reserving to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns all such rights and privileges as may be used and enjoyed without interfering with or abridging the rights and easements hereby acquired; subject however to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easement

A temporary easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. _____, _____, and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and /or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the **Bogue Banks Coastal Storm Damage Reduction Project**, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

1.20 INDUCED FLOODING

There will be no flooding induced by the construction or the operation and maintenance of the project.

1.21. REAL ESTATE ESTIMATE

Due to offsetting benefits, the Perpetual Beach Storm Damage Reduction Easements are determined to have a $0 value. As a matter of policy the Federal Rule of offsetting benefits is applied in determining credit for storm damage reduction projects. The North Carolina Court of Appeals in June 2000, held in NC Department of Transportation V. Rowe, (97-1470-2) that special project benefits may offset compensation due for a taking and that general project benefits may not offset compensation. This interpretation of North Carolina general statutes is consistent with the Federal Rule.

In the valuation of lands for the project, it is assumed that all lots are buildable in the before value. Since the before value and the after value of the lots will remain the same, or possibly increase due to an improved dune structure, the Before Value and the After Value are identical. In the after value, the lands will be subject to a perpetual beach renourishment easement. Though data at other beaches has shown an increase in value of lots once they were protected

by a renourishment project, no local data was available which suggests the "After Value" of the land will be higher as a result of this project. There is an indication that the lots would have superior damage reduction from storm damage and, therefore, would not have a lower value.

The Base Cost Estimate for Real Estate (BCERE) at Table 1.21-1 includes land and improvement values and federal and non-federal administrative costs. The land costs that are shown are the estimated costs for staging/laydown areas. The administrative costs are based on historical costs of prior projects constructed along the east coast in South Atlantic Division and include title and legal services, survey, appraisal, document preparation, negotiations and other real estate related items. As stated in Section 1.5, an assumption is made that approximately 893 of 1190 existing easements may be usable for the project. This equates to seventy five percent (75%) of the existing easements. In reviewing acquisition for the Morehead City 933 project (Bogue was used for least cost disposal), the number of easements acquired was 209. Approximately 75% of those were the same or very similar to the standard estate for beach storm damage reduction. Some were acquired specifically for the 933 project and others had been acquired for local projects. All may not have the right to public use and access language and some have other conditions that may not be acceptable so every deed will need to be reviewed for sufficiency. Based on the information at hand it seems reasonable and prudent to use a 75% factor in the current analysis. A reduced administrative cost is used for deed review, preparation of assignments and recordation of the assignments for the existing easements. A higher administrative cost is used for acquisition of approximately 577 new easements. Real estate risks were included in the risk register for the project, and evaluated in a detailed risk analysis performed by the Cost MCX using the crystal ball program. Through this analysis a contingency of 24% was developed and applied to the base real estate cost estimate. The real estate cost may either increase or decrease based on the number of existing easements determined to be sufficient for use for the project.

Table 1.21-1

Real Estate Cost Estimate for Bogue Banks

a. Lands		
7 Ownerships - TWA Easement (Staging Areas)		628,300
b. Improvements		0
(Residential)		0
(Commercial)		
c. Mineral Rights		0
d. Damages		0
e. P.L. 91-646 Relocation costs		0
f. Acquisition Cost - Admin (1470 ownerships)		2,888,450
Use @ 893 Existing Easements		
Federal	223,250	
Non-Federal	357,200	
Acquire @577 New Easements		
Federal	346,200	
Non-Federal	1,961,800	
Sub-Total		3,516,750
Contingencies (24%)		844,020
TOTAL		**4,360,770**
ROUNDED TO		**4,361,000**

1.22. CHART OF ACCOUNTS

The estimated real estate costs below include land and improvement values and federal and non-federal administrative costs. The land costs that are listed are due to the projected costs for staging areas. The administrative costs are based on historical costs of prior projects constructed along the east coast in South Atlantic Division and include title and legal services, survey, appraisal, document preparation and other real estate related actions.[1] The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES).

Table 1.22-1.

Chart of Accounts

		NON-FEDERAL	FEDERAL	TOTALS
01A	PROJECT PLANNING			
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (24%)			
	Subtotal			
01B	LANDS AND DAMAGES			
01B40	Acq/Review of PS	2,319,000		2,319,000
01B20	Acquisition by PS		569,450	569,450
01BX	Contingencies (24%)	556,560	136,668	693,228
	Subtotal	2,875,560	706,118	3,581,678
01H	AUDIT			
01H10	Real Estate Audit			
01HX	Contingencies (24%)			
	Subtotal			
01R	REAL ESTATE LAND PAYMENTS			
01R1B	Land Payments by PS	628,300		628,300
01R2B	PL91-646 Relocation Pymt by PS			
01R2D	Review of PS			
01RX	Contingencies (24%)	150,792		150,792
	Subtotal	779,092		779,092
	TOTALS	**3,654,652**	**706,118**	**4,360,770**
	ROUNDED TO			**4,361,000**

[1] Administrative cost for existing local easements is based on $400 per tract for non-federal and $250 for federal. Administrative cost for new easements is based on $3400 per tract for non-federal and $600 per tract for federal.

1.23. REAL ESTATE PLAN CERTIFICATION

This Real Estate Appendix has been prepared in accordance with policy and guidance set forth in ER 405-1-12, Chapter 12, Real Estate Planning and Acquisition Responsibilities for Civil Works Projects.

Prepared by:

Realty Specialist

Reviewed and approved by:

Ralph J. Werthmann
Chief, Real Estate Division

1.24. EXHIBITS

Exhibit A – Local Easement Proposed for Use in Federal Project

Exhibit B – Authorization for Entry for Construction

Exhibit C – Non-Federal Sponsor Assessment of Capability to Acquire Real Estate

Exhibit D – Risk Letters

Exhibit E – Non Standard Estate Approval

Melanie Arthur 3P
CARTERET COUNTY
PL Date 06/30/2003 Time 12:47:51
GR 1002251 Page 1 of 3

NORTH CAROLINA, CARTERET COUNTY
The foregoing certificate(s) of Notary Public(s) is/are certified to be correct. This instrument and this certificate are duly registered at the date and time and in the Book and Page shown on the first page hereof.

Melanie Arthur, Register of Deeds
By _____
Asst./Deputy, Register of Deeds

Return to: Kirkman & Whitford

ATLANTIC BEACH BEACH RENOURISHMENT EASEMENT

OWNER: Point Inlet

PROPERTY: **In the Town of Atlantic Beach, Carteret County, North Carolina and being more particularly described as:**

See Attached Exhibit A

(As used in this document the masculine, feminine, and neuter genders are interchangeable and the singular includes the plural. Further, the Property may be common area of a condominium project or planned development and the Owner may be an owners association with jurisdiction over said Property.)

This EASEMENT is granted for purposes of reference the 15th day of February, 2003 by the above named Owner to the Town of Atlantic Beach (hereinafter "Town"), a municipal corporation.

From time to time the Atlantic Ocean beaches and ocean front sand dune system within the city limits of the Town need to be renourished or restored by the placing or distribution of sand thereon by various means. Most beach and sand dune renourishment activity takes place on public trust beaches, but occasionally renourishment sand is placed on private ocean front property. The Owner's Property is located adjacent to the public trust Atlantic Ocean beach within the city limits of the Town. The Town, to facilitate future beach renourishment and sand dune restoration projects, has requested that Owner grant a perpetual easement for the placement of sand on that part of Owner's Property described below adjacent to the beach strand. Owner agrees according to the terms hereof.

NOW THEREFORE, in consideration of the potential beach strand and sand dune stability resulting from renourishment projects, and the potential preservation of Owner's Property and preservation of the value of said Property, Owner does give, grant, and convey to the Town, its successors and assigns a perpetual easement and right of way as follows:

1. EASEMENT AREA: The easement area for purposes of beach renourishment and stabilization and sand dune restoration is that part of Owner's Property which (i) visibly appears as a part of the Atlantic Ocean beach strand and which is covered with little or no vegetation, (ii) is seaward of the last line of stable vegetation, (iii) is within the frontal sand dune adjacent to said beach strand, or (iv) is seaward of the crest of the erosion escarpment.

2. EASEMENT RIGHTS; RESERVATION OF RIGHTS: The Town and its representatives, agents, employees, officials, engineers, consultants, surveyors, contractors, subcontractors, permittees, invitees and assignees, are authorized to enter the easement area to evaluate, survey, inspect, construct, preserve, patrol, operate, maintain, repair, rehabilitate, and replace a public beach, a dune system and other erosion control and storm damage reduction measures together with appurtenances thereto, including the right to deposit sand, to accomplish any alterations of contours on said land, to construct berms and dunes, to nourish and renourish periodically, to move, store and remove construction equipment and supplies, to erect and remove temporary structures, and to perform any other work necessary and incident thereto together with the right of public use and access over that part of the easement area where sand is deposited pursuant to this easement; to plant vegetation on said dunes and berms, to erect, maintain and remove silt screens and sand fences, to facilitate preservation of dunes and vegetation through the limitation of access to dune areas, to trim, cut, fell, and remove from said land all trees, underbrush, debris, obstructions, and any other vegetation, structures and obstacles within the limits of the easement; RESERVING HOWEVER TO OWNER, his successors and assigns, the right to construct dune walkover structures in accordance with any applicable Federal, State or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape, dimension or function, and that prior approval of the plans and specification for such structures is obtained from the Town and provided further that such structures are subordinate to the construction, operation, maintenance, repair, rehabilitation and replacement of the work authorized herein; and further reserving to Owner his successors and assignees all such rights and privileges as may be used and enjoyed without interfering with or abridging the rights and easements hereby acquired. Owner agrees to neither remove nor grade (except for finish grading with hand tools) sand placed in the easement area or in the adjacent public trust beach once deposited in a government funded renourishment project without the written permission of the Town or other governmental agency sponsoring such project.

3

BOOK 1002 PAGE 251

Exhibit A

3. NO DAMAGE TO "PERMANENT" IMPROVEMENTS. Nothing contained herein shall authorize the Town, or anyone operating under license or permission of the Town, to move or damage any permanent improvement within the easement area. If the Town needs for Owner's permanent improvements in the easement area to be removed or relocated in connection with a renourishment or stabilization project, the Owner will be so notified, and the parties will in good faith negotiate for such removal or relocation. In the event of inadvertent damage, the Town agrees to restore the same to its condition prior to the damage. Notwithstanding the foregoing, the Town shall have no responsibility to restore improvements that have been severely damaged by beach or sand dune erosion, or ocean over wash, or that are further damaged during an emergency beach renourishment or stabilization project following a natural disaster.

4. ASSIGNMENT OF RIGHTS. The Town shall have the right to temporarily or permanently assign its rights under this instrument to the federal, state, or county governments, or any agencies or departments thereof or any governmental authority formed to implement beach renourishment and stabilization on Bogue Banks.

5. RUNS WITH THE LAND. This easement shall be binding on the Owner, and his heirs, successors and assigns, and shall run with the title of the Property.

IN WITNESS WHEREOF this instrument is executed by the Owner under seal.

POINT INLET

_____(SEAL)
Owner/Manager

_____(SEAL)
Owner

STATE OF North Carolina
COUNTY OF Nash

I, a Notary Public of the County and State aforesaid, do hereby certify that _____
William H. Batchelor, personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

Witness my hand and official seal this 8th day of April, 2003.

ELIZABETH O. ROBBINS
NOTARY PUBLIC
NASH COUNTY, NC

(Notary's seal or stamp)

Elizabeth O. Robbins
Notary Public

My commission expires:

03-03-04

BOOK 1002 PAGE 257

EXHIBIT A

Beginning at a point in the centerline of Commerce Way 125 feet southerly of its intersection with the centerline of Asbury Avenue as shown on map of Club Colony recorded in Map Book 2, Page 48, Carteret County Registry; thence along the centerline of Commerce Way South 03 degrees 00 minutes West 470.95 feet to a stake at the high water mark of the Atlantic Ocean; thence along the high water mark of the Atlantic Ocean, North 80 degrees 19 minutes 42 seconds West 71.48 feet to a stake, cornering; thence North 03 degrees 00 minutes East 377.42 feet to a stake, cornering; thence North 87 degrees 00 minutes West 22.0 feet to a stake, cornering; thence North 03 degrees 00 minutes East 81.0 feet to a stake, cornering; thence South 87 degrees 00 minutes East 93.0 feet to a point in the centerline of Commerce Way, the point of beginning, and being the identical property conveyed by A. Don Stallings and wife, Billie J. Stallings to The Eagle's Nest Company by deed dated March 17, 1984, duly recorded in the Carteret County Registry, and further being the identical property as shown on Exhibit A attached to the Declaration of Co-Ownership Interests dated March 17, 1984, for Dwellings A and 1B and incorporated herein by reference.

BOOK 1002 PAGE 257

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I _____, _____ for the
(Name of accountable official) (Title)

(Sponsor Name), do hereby certify that the (Sponsor Name) has acquired the real property interest required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction for (Project Name, Specifically identified project features, etc.). Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon _____ to construct
(identify tracts)

(Project Name, Specifically identified project features, etc.) as set forth in the plans and specifications held in the U. S. Army Corps of Engineers' (district, city, state)

WITNESS my signature as _____ for the
(Title)

(Sponsor Name) this _____ day of _____, 20_____.

BY: _____
(Name)

_____
(Title)

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, _____ , _____ for the
(Name) (Title of legal officer)

(Sponsor Name), certify that _____ has
(Name of accountable official)

authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as _____ for the
(Title)

(Sponsor Name), this_____day of_____, 20___.

BY: _____
(Name)

_____
(Title)

Exhibit B

Assessment of Non-Federal Sponsor's
Real Estate Acquisition Capability
Carteret County – Bogue Banks

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? Yes

b. Does the sponsor have the power to eminent domain for this project? Yes

c. Does the sponsor have "quick-take" authority for this project? Yes

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? No

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? Yes – The State of North Carolina owns land in the project area; however condemnation will not be an issue as the State is cooperative in all coastal storm damage reduction projects

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? No – However, SAS-RE will meet with the sponsor prior to PED phase to fully explain the acquisition process for the project

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? NA)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? Yes

e. Can the sponsor obtain contractor support, if required in a timely fashion? Yes

f. Will the sponsor likely request USACE assistance in acquiring real estate? No – Possibly general guidance

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes

b. Has the sponsor approved the project/real estate schedule/milestones? No – Schedule will be developed prior to PED and will be a joint effort of RE, Sponsor and PM

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects?
Yes – Morehead City 933

b. With regard to the project, the sponsor is anticipated to be: Highly Capable/

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes

b. Does the sponsor concur with this assessment? Yes

Prepared by:

Belinda S. Estabrook
Realty Specialist

Reviewed and approved by:

Ralph J. Werthmann
Chief, Real Estate Division

DEPARTMENT OF THE ARMY
SAVANNAH DISTRICT, CORPS OF ENGINEERS
100 W. OGLETHORPE AVENUE
SAVANNAH, GEORGIA 31401-3640

REPLY TO
ATTENTION OF:

August 22, 2012

Real Estate Division

SUBJECT: Bogue Banks Integrated Feasibility Report and Environmental Impact Statement, Coastal Storm Damage Reduction, Carteret County, North Carolina

Mr. Gregory Rudolph
Carteret County Shore Protection Office
PO Box 4297
Emerald Isle, North Carolina 28594

Dear Mr. Rudolph:

The intent of this letter is to formally advise Carteret County, as the potential non-Federal sponsor for the proposed project, of the risks associated with land acquisition prior to the execution of the Project Partnership Agreement (PPA) or prior to the Government's formal notice to proceed with acquisition. If a non-Federal sponsor deems it necessary to commence acquisition prior to an executed PPA for whatever reason, the non-Federal sponsor assumes full and sole responsibility for any and all costs, responsibility, or liability arising out of the acquisition effort.

Generally, these risks include, but may not be limited to, the following:

a. Congress may not appropriate funds to construct the proposed project;

b. The proposed project may otherwise not be funded or approved for construction;

c. A PPA mutually agreeable to the non-Federal sponsor and the Government may not be executed and implemented;

d. The non-Federal sponsor may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, whether such liability should arise out of local, state, or Federal laws or regulations including liability arising out of CERCLA, as amended;

e. The non-Federal sponsor may acquire interests or estates that are later determined by the Government to be inappropriate, insufficient, or otherwise not required for the project;

f. The non-Federal sponsor may initially acquire insufficient or excessive real property acreage which may result in additional negotiations and/or benefit payments under P.L. 91-646 as well as the payment of additional fair market value to affected landowners which could have

been avoided by delaying acquisition until after PPA execution and the Government's notice to commence acquisition and performance of LERRD; and

g. The non-Federal sponsor may incur costs or expenses in connection with its decision to acquire or perform LERRD in advance of the executed PPA and the Government's notice to proceed which may not be creditable under the provisions of Public Law 99-662 or PPA.

We appreciate the City's participation in this project. Should you have questions or concerns pertaining to this letter please feel free to contact Ms. Belinda Estabrook at (912) 652-5667.

Sincerely,

Ralph J. Werthmann
Chief, Real Estate
Savannah District

CESAS-RE

Project: Bogue Banks Coastal Storm Damage Reduction Project

Non-Standard Perpetual Beach Storm Damage Reduction Easement Estate

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. __) for use by the (Sponsor), its representatives, agents, contractors, and assigns, to construct; preserve; patrol; operate; maintain; repair; rehabilitate; and replace; a public beach a dune system, and other erosion control and storm damage reduction measures together with appurtenances thereto, including the right to deposit sand; to accomplish any alterations of contours on said land; to construct berms and dunes; to nourish and renourish periodically; to move, store and remove equipment and supplies; to erect and remove temporary structures; and to perform any other work necessary and incident to the construction, periodic renourishment and maintenance of the **Bogue Banks Coastal Storm Damage Reduction Project**, together with the right of public use and access; to plant vegetation on said dunes and berms; to erect, maintain and remove silt screens and sand fences; to facilitate preservation of dunes and vegetation through the limitation of access to dune areas; to trim, cut, fell, and remove from said land all trees, underbrush, debris, obstructions, and any other vegetation, structures and obstacles within the limits of the easement **(except *);** reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns, the right to construct dune overwalk structures in accordance with any applicable Federal, State or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape, dimension or function, and that prior approval of the plans and specifications for such structures is obtained from the (designated representative of the Project Sponsor) and provided further that such structures are subordinate to the construction, operation, maintenance, repair, rehabilitation and replacement of the project; and further reserving to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns all such rights and privileges as may be used and enjoyed without interfering with or abridging the rights and easements hereby acquired; subject however to existing easements for public roads and highways, public utilities, railroads and pipelines.

*** the right to remove or demolish the existing fishing pier and appurtenances thereto;**

In accordance with the provisions of paragraph 12-10c. of ER 405-1-12, I approve the use of the above non-standard estate for the Bogue Banks Coastal Storm Damage Reduction project. The estate serves the intended project purpose, substantially conforms with and does not materially deviate from the corresponding standard estate contained in the Real Estate Handbook and does not increase the costs nor potential liability of the Government.

Date: 10/22/12

Ralph J. Werthmann
Savannah District
Chief, Real Estate

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX I

CUMULATIVE IMPACTS

US Army Corps of Engineers
Wilmington District

APPENDIX I
Cumulative Impact Assessment
Bogue Banks, NC
Coastal Storm Damage Reduction Project

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). This analysis follows the 11-step process outlined by the CEQ in their 1997 publication Considering Cumulative Effects Under the National Environmental Policy Act (Table I-1).

Table I-1. Steps in the Cumulative Effects Analysis (as adapted from CEQ 1997)

Environmental Impact Assessment Components	CEA Steps
I. Scoping	a. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals. b. Establish the geographic scope for the analysis. c. Establish the time frame for the analysis. d. Identify other actions affecting the resources, ecosystems, and human communities of concern.
II. Describing the Affected Environment	a. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses. b. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds. c. Define a baseline condition for the resources, ecosystems, and human communities.
III. Determining the Environmental Consequences	a. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities. b. Determine the magnitude and significance of the cumulative effects. c. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects. d. Monitor the cumulative effects of the selected alternative and adapt management.

1. Significant Cumulative Effects Issues

This assessment of cumulative impacts will focus on significant coastal shoreline resources and the impacts associated with offshore dredging activities and the placement of compatible sediment on the beach (whether for beach nourishment or disposal of dredge maintenance material). The following referenced reports prepared by the USACE Wilmington District include comprehensive assessments of state-wide cumulative impacts through the date in which they were prepared. This assessment will update these previous documents by incorporating all subsequent dredging and beach placement actions completed to date and evaluate the relative cumulative effect of the proposed action.

- U.S. Army Corps of Engineers Dare County Beaches (Bodie Island Portion) Final Feasibility Report and EIS on Hurricane Protection, dated September 2000
- U.S. Army Corps of Engineers Draft Evaluation Report and Environmental Assessment, Morehead City Harbor Section 933, dated May 2003.
- U.S. Army Corps of Engineers Final Integrated General Reevaluation Report and Environmental Impact Statement, Shore Protection, West Onslow Beach and New River Inlet (Topsail Beach), North Carolina, dated March 2009.
- U.S. Army Corps of Engineers Final Integrated Feasibility Report and Environmental Impact Statement, Coastal Storm Damage Reduction, Surf City and North Topsail Beach, North Carolina, dated December 2010.
- U.S. Army Corps of Engineers Draft Integrated General Reevaluation Report and Environmental Impact Statement, Coastal Storm Damage Reduction, Brunswick County, North Carolina.

In discussing the potential cumulative impacts of offshore borrow area dredging and beach nourishment, we consider time crowded perturbations, and space crowded perturbations, as defined below, to be pertinent to this action.

> ***Time crowded perturbations*** *– repeated occurrence of one type of impact in the same area.*
> ***Space crowded perturbations*** *– a concentration of a number of different impacts in the same area.*

2. Geographic Scope

This analysis will consider the impacts associated with dredging an offshore borrow area and beach placement of sediment along the Bogue Banks Beaches relative to the cumulative nature of these activities along the entire North Carolina coastline. It will focus on cumulative impacts within the project area since all of affected beaches under the current proposal have received beach placement of sediment in the past, the proposed action represents zero additional miles of North Carolina beaches affected by sand placement as described documents referenced above. Additionally, this analysis will study the cumulative impacts within the project area associated with increased offshore borrow area use. The proposed project utilizes borrow material from a three borrow

areas and represents new impacts to the offshore benthic resources in the study area and throughout North Carolina. Cumulative impacts of beach nourishment/disposal and offshore borrow area use on a statewide scale will also be assessed herein.

3. Time Frame

This analysis considers known past, present and the reasonably foreseeable future sand placement and offshore borrows on a statewide scale and project vicinity scale over a 50-year period of analysis from 1965 to 2015. This time period was selected to include the first U.S. Army Corps of Engineers Wilmington District, beach nourishment projects in 1965 and includes the first Wilmington District beach placement of dredged material within the project area in about 1991. Projections were extended to 2015, as that date represents a reasonably foreseeable future and the majority of remaining ocean beach that could reasonably be expected to have federal and non-federal projects implemented or studies initiated. Additional non-federal projects will likely be pursued beyond 2015, but for the purposes of this assessment, it is assumed that these actions will be re-occurring within areas that had already been previously permitted and constructed (non-federal) or authorized (federal). This cumulative analysis also considers the potential that future federal and non-federal CSDR/beach nourishment projects under study could be constructed.

4. Actions Affecting Resources of Concern

This analysis of cumulative effects of the proposed action will focus on the impacts of dredging from the proposed ocean borrow sites and placement of sand material on the beach. In making this assessment, we have reviewed an Environmental Report prepared for and published by the U.S. Department of Interior, Bureau of Ocean Energy and Management (BOEM) (previously Minerals Management Service (MMS)), entitled "Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia," dated November 1999 (DOI 1999) and the report titled "Collection of Environmental Data Within Sand Resource Areas Offshore North Carolina and the Environmental Implications of Sand Removal for Coastal and Beach Restoration," dated 2003 (Byrnes et al. 2003). Additionally, a detailed review of the current pier reviewed scientific literature on the effects of dredging and beach placement of sediment was conducted and cited in sections 2.0 and 7.0 of the main report.

4a. Actions Affecting Benthic Resources

Dredging: Table I-2 summarizes federal and non-federal documents with placement of sediment on the beach as well as the currently identified borrow sources. For North Carolina projects, borrow areas have been identified predominantly within inlets and associated channels as well as offshore borrow areas between approximately 1-5 miles offshore. Additionally, portions of ebb shoals and cuspate forelands have been dredged or identified to be dredged. Upland borrow sources as well as Confined

Disposal Facilities (CDF's) have also been utilized; however, this assessment will only focus on the marine benthic resources.

Exiting literature and monitoring reports have documented that dredging activities may result in impacts to benthic resources; however, the significance of impacts is dependent on a myriad of planning considerations relative to the borrow area design, location, dredge type, etc. However, careful consideration of mitigation conditions during borrow area use planning, re-colonization by opportunistic species is expected to begin soon after the dredging activity stops. Due to the opportunistic nature of the species that inhabit these soft bottom benthic habitats, recovery is expected to occur within 1-2 years. Rapid recovery is expected from re-colonization from the migration of benthic organisms from adjacent areas and by larval transport.

Monitoring studies of post dredging effects and recovery rates of borrow areas indicates 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; and Van Dolah *et al*. 1992). According to Posey and Alphin (2000), benthic fauna associated with sediment removal from borrow areas off of Carolina Beach 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 as well as 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 much as 3 years to reach pre-disturbance abundance. According to Turbeville and Marsh (1982), long term effects of a borrow site at Hillsboro Beach, FL, 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 due to the dredge's inability to completely remove all of 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 a result of the significant number of borrow areas identified throughout NC for beach nourishment sand, there is concern for potential cumulative impacts to benthic organisms due to statewide borrow area cumulative acreage, spatial relationship, and frequency of dredging which may impact recovery times.

Other factors affecting Benthic Resources: Many factors unrelated to dredging of sand from borrow areas may affect benthic resources including, beach resources and ocean fish stocks. The factors can be a result of natural events such as natural population cycles or as a result of favorable or negative weather conditions including La Niña, El Niño, climate change, and major storms or hurricanes to name a few. These global

events have far greater impacts on these resources at the population level than relatively local activities such as removal of sand from a given area of ocean bottom. Primary man-induced factors affecting fish stocks are over fishing and degradation of water quality due to pollution. When examining the cumulative effect of space crowded perturbations, these other factors may outweigh the potential incremental effects of borrow dredging of sand on benthic or fish populations.

4b. 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). Of particular concern are macroinvertebrate, fisheries, shorebird, and sea turtle species that utilize or occur on or adjacent to ocean beaches. These resources are also impacted by natural events and anthropogenic activities that are unrelated to disposal of sand on the beach as discussed below.

Local Maintenance Activity: Under the existing condition the project area is subjected to repeated and frequent maintenance disturbance by individual homeowners and local communities following major 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. Such frequent maintenance efforts could keep the natural resources of the barrier island ecosystems from re-establishing a natural equilibrium with the dynamic coastal forces of the area.

Non-Federal Beach Nourishment: Several large local beach nourishment efforts have been conducted or are in the permitting process throughout NC (Table I-2). The number of locally funded beach nourishment activities has increased significantly in the last 10 years as local communities continue to seek avenues for restoring severally 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 under permit, or have submitted a permit application to be nourished are provided in Table I-2. Individually, these projects total approximately 93 miles of beach or 29% of North Carolina beaches. These frequent maintenance efforts could keep the natural resources of the barrier island ecosystems from reestablishing a natural equilibrium with the dynamic coastal forces of the area.

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 1975 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 I-2) or are awaiting authorization and/or appropriation. Individually, these existing or proposed federal projects total approximately 122 miles of beach or 38% of North Carolina beaches. 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 have private or federal beach nourishment projects by 2015.

Table I-2. Summary of federal and non-federal beach nourishment projects in North Carolina that have recently occurred, are currently underway, or will occur in the reasonably foreseeable future. (This list is not entirely comprehensive and does not include all small scale beach fill activities (i.e. dune restoration, beach scraping, etc.). (* - federal or non-federal projects which may utilize the same borrow sources and/or overlap beach placement locations).

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	250
	Dare County Beaches, NC Hatteras to Ocracoke Portion	NA	Hatteras and Ocracoke Island (Hot Spots)	10	150
	Cape Lookout National Seashore -East Side of Cape Lookout Lighthouse	Channel	East Side of Cape Lookout Lighthouse	1	100
	*Beaufort Inlet Dredging - Section 933 Project (Outer Harbor)	Beaufort Inlet Outer Harbor	Indian Beach, Salter Path, and Portions of Pine Knoll Shores	7	100
	*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	100
	*Bogue Banks, NC (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Communities of Bogue Banks	24	100
	Surf City and North Topsail Beach - (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Surf City and North Topsail Beach	10	50
	*West Onslow Beach New River Inlet (Topsail Beach) (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Topsail Beach	6	50
	Wrightsville Beach (Coastal Storm Damage Reduction)	Masonboro Inlet and Banks Channel	Wrightsville Beach	3	30
	Carolina Beach and Vicinity, NC Carolina Beach Portion (Coastal Storm Damage Reduction)	Carolina Beach Inlet	Carolina Beach	2	20
	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	20
	*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	0
	*Wilmington Harbor Deepening (Section 933 Project) - Sand Management Plan	Wilmington Harbor Ocean Entrance Channels	Bald Head Island, Caswell Beach, Oak Island	4	0
	*Holden Beach (Section 933 Project)	Wilmington Harbor Ocean Entrance Channels	Holden Beach	2	0
	*Oak Island Section 1135 - Sea Turtle Habitat Restoration	Upland Borrow Area - Yellow Banks	Oak Island	2	0
	Ocean Isle Beach, NC (Coastal Storm Damage Reduction)	Shallotte Inlet	Ocean Isle Beach	2	20

Non-Federal	*Town of Kill Devil Hills - Beach Nourishment Project	Offshore Borrow Areas	Kill Devil Hills	4	250
	*Town of Nags Head - Beach Nourishment Project	Offshore Borrow Areas	Nags Head	10	250
	*Emerald Isle FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle	4	100
	*Emerald Isle "Hotspots" FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle	7	100
	*Bogue Banks FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle (2 segments), Indian Beach, Salter Path, Pine Knoll Shores	13	100
	*Bogue Banks Restoration Project – Phase I – Pine Knoll Shores and Indian Beach Joint Restoration	Offshore Borrow Areas	Pine Knoll Shores and Indian Beach	7	100
	*Bogue Banks Restoration Project – Phase II – Eastern Emerald Isle	Offshore Borrow Areas	Indian Beach and Emerald Isle	6	100
	*Bogue Banks Restoration Project – Phase III– Bogue Inlet Channel Realignment Project	Bogue Inlet Channel	Western Emerald Isle	5	100
	*North Topsail Dune Restoration (Town of North Topsail Beach)	Upland borrow source near Town of Wallace, NC	North Topsail Beach	NA	60
	*North Topsail Beach Shoreline Protection Project	New River Inlet Realignment and Offshore Borrow Area	North Topsail Beach	11	60
	*Topsail Beach - Beach Nourishment Project	Disposal Island	Topsail Beach	6	50
	*Topsail Beach - Beach Nourishment Project	New Topsail Inlet	Topsail Beach	6	50
	Figure Eight Island	Banks Channel and Nixon Channel	North & South Sections of Figure Eight Island	3	30
	Rich Inlet Management Project	Relocation of Rich Inlet	Figure Eight Island	NA	30
	Mason Inlet Relocation Project	Mason Inlet (new channel) and Mason Creek	North end of Wrightsville Beach and south end of Figure Eight Island	2	30
	New Hanover County Beaches - Beach Nourishment	TBD	Wrightsville Beach, Carolina Beach, Kure Beach	TBD	20
	Bald Head Island Creek Project	Bald Head Creek	South Beach	0.34	10
	Bald Head Island - Beach Nourishment	Offshore Borrow Area (Jay Bird Shoals)	West and South Beach of Bald Head Island	4	10
	Bald Head Island - Terminal Groin and Beach Nourishment	TBD	TBD	TBD	10
	*Holden Beach - Terminal Groin and Beach Nourishment	TBD	Holden Beach w/in vicinity of Lockwood Folly Inlet	TBD	0
	*Holden Beach Interim Beach Nourishment	Offshore Borrow Area	Holden Beach	4	0
	*Holden Beach East & West	Upland Borrow Source (Truck Haul)	Extension of 933 Project	3	0
	*Ocean Isle - Terminal Groin and Beach Nourishment	TBD	Ocean Isle Beach w/in vicinity of Shallotte Inlet	TBD	15

Federal (USACE) Navigation Beach Disposal: Maintenance material from dredging the AIWW, inlets, and connecting channels in the vicinity of study area has historically been disposed within authorized disposal limits along the beach (Table I-3). Throughout North Carolina, a total of approximately 41 miles of beach (~13% of North Carolina beaches) are authorized 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 authorized disposal limits overlap with existing federal or non-federal beach projects. Therefore, without double counting for overlapping beach projects, navigation dredged material is placed along approximately 19 miles, or 6% of North Carolina beaches. 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 to provide wide beaches for recreation and tourism, as well as to provide hurricane and wave protection for public and private property in these communities. When beach quality sand is dredged from navigation projects, it has become common practice of the Corps 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. The design of beach placement sites generally extends the elevation of the natural berm seaward.

TableI-3. 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. (***** - Navigation disposal sites which may overlap with existing Federal or Non-Federal beach nourishment projects).

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 mile (3,000 lf)	0.4 mile 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 NE (Ocracoke Island)	0.4 miles (2,000 lf)	0.4 miles or 2,000 linear feet	<50,000 every 2 yrs	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**	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 27,800 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 yrs	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.
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)	1mile (5,280 lf)	0.4 miles or 2,000 linear feet	<100,000 annually	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 yrs	
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 linear feet	<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 ft	<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 Carolina 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

Table I-3 (Continued)

Other factors affecting Beach Resources: Many factors unrelated to placement of sand on the beach may affect beach resources including: benthic invertebrate resources, shorebird populations, and ocean fish stocks. The factors can be a result of natural events such as natural population cycles or as a result of favorable or negative weather conditions including droughts, floods, La Niña, El Niño, and major storms or hurricanes to name a few. A primary anthropogenic factor affecting shorebird populations is beach development resulting in a loss or disturbance of nesting habitat and invasion of domestic predators. Primary man-induced factors affecting fish stocks are over fishing and degradation of water quality due to pollution.

5. Significant Resources

Based on scoping comments from resource agencies and stakeholders, the primary concerns with the proposed dredging and beach disposal are direct and indirect impacts to macro-invertebrates, fish, shorebirds, and threatened and endangered species. Federally listed threatened or endangered species which could be present along the North Carolina coast are the blue whale, finback whale, humpback whale, North Atlantic right whale, sei whale, sperm whale, West Indian manatee, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, shortnose sturgeon, Atlantic sturgeon, seabeach amaranth, and piping plover. Impacts to all listed species are summarized below and include, but are not limited to, mortality, reduction in prey species, habitat change, and disturbance during construction activities. Also discussed are the benefits of periodic renourishments, which are expected to enhance nesting habitat of sea turtles and to provide additional habitat for sea beach amaranth and piping plover. In relation to dredging of offshore sites for material, the primary concerns are the potential impacts to benthic organisms and fish species associated with the borrow areas. Detailed discussions of all significant resources and associated impacts considered in this assessment are included in Sections 2.0 and 7.0 of the main report.

Beach and Dune. Terrestrial habitat types within these areas include sandy or sparsely vegetated beaches and vegetated dune communities. Mammals occurring within this environment are opossums, cottontails, gray foxes, raccoons, feral house cats, shrews, moles, voles, and house mice. Common vegetation of the upper beach includes beach spurge, sea rocket and pennywort. The dunes are more heavily vegetated, and common species include American beach grass, panic grass, sea oats, broom straw, seashore elder, and salt meadow hay. Seabeach amaranth, a federally listed threatened species, is present throughout most of North Carolina. Ghost crabs are important invertebrates of the beach/dune community. The beach and dune also provide important nesting habitat for loggerhead and green sea turtles as well as habitat for a number of shorebirds and many other birds, including resident and migratory songbirds. Placement of material along the ocean beach enhances and improves important habitat for a variety of plants and animals, and restores lost habitat in the areas of most severe erosion. This is especially important for nesting loggerhead sea turtles, piping plovers, and seabeach amaranth. Historic nesting data from the study area beaches indicate that sea turtles continue to nest on disposal beaches with hatch rate successes similar to non-disposal

beaches. Furthermore, new populations of seabeach amaranth have been observed to follow sand placement on beaches where sand has been disposed by the Corps of Engineers (ex. Wrightsville Beach) (USFWS, 1996b; CSE, 2004). Individually and cumulatively, in addition to providing important habitat, beach nourishment projects protect public infrastructure, public and private property, and human lives.

Marine Waters. Along the coast of North Carolina, marine waters provide habitat for a variety of ocean fish and are important commercial and recreational fishing grounds. Kingfish, spot, bluefish, weakfish, spotted seatrout, flounder, red drum, king mackerel, and Spanish mackerel are actively fished from boats, the beach, and local piers. Offshore marine waters serve as habitat for the spawning of many estuarine dependent species. Oceanic large nekton located offshore of North Carolina are composed of a wide variety of bony fishes, sharks, and rays, as well as fewer numbers of marine mammals and reptiles. Marine mammals and sea turtles may be present in the offshore borrow sites. Dredging and placement of beach fill may create impacts in the marine water column in the immediate vicinity of the activity, potentially affecting the surf zone and nearshore ocean. These impacts may include minor and short-term suspended sediment plumes and related turbidity, as well as the release of soluble trace constituents from the sediment. Overall water quality impacts for any given project are expected to be short-term and minor. Cumulative effects of multiple simultaneous beach nourishment operations could potentially impact fishes of the surf zone. However, the high quality of the sediment selected for beach fill and the small amount of beach affected at any point in time would not suggest that this activity poses a significant threat.

Intertidal and Nearshore Zones. The intertidal zone within the proposed beach nourishment areas serves as habitat for invertebrates including mole crabs, coquina clams, amphipods, isopods, and polychaetes, which are adapted to the high energy, sandy beach environment. These species are not commercially important; however, they provide an important food source for surf-feeding fish and shore birds. 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 various fish and bird species. Therefore, feeding activities of these species may be interrupted in the immediate area of beach sand placement. These mobile species are expected to temporarily relocate to other areas as the project proceeds along the beach. Though a short-term reduction in prey availability may occur in the immediate disposal area, only a small area is impacted at any given time, and once complete, organisms can recruit into the nourished area. The anticipated construction timeframes for beach projects are typically from December 1 to March 31 and would avoid a majority of the peak recruitment and abundance time period of surf zone fishes and their benthic invertebrate prey source. To summarize, the impacts of beach renourishment projects on the intertidal and nearshore zones are considered temporary, minor and reversible. Cumulative effects of multiple simultaneous beach nourishment operations could be potentially harmful to benthic invertebrates in the surf zone; however, the high quality of the sediment selected for beach fill and the small amount of

beach affected at any point in time would suggest that this activity would not pose a significant threat.

Hardbottoms. Hardbottoms are also called "live-bottoms" because they support a rich diversity of invertebrates such as corals, anemones, and sponges, which are refuges and food sources 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. While hardbottoms are most abundant in southern portions of North Carolina, they are located along the entire coast (USFWS, 1990). Recognizing the detailed hard bottom resource inventory completed for this project and the avoidance measures identified impacts to hard bottom communities are not anticipated from this project. Though hard bottom communities are located throughout North Carolina, recognizing the current resource inventories in place to identify and avoid hard bottom communities for dredging and beach nourishment projects, the cumulative effects are not significant.

Nearshore Zone. Beach nourishment projects introduce fill into nearshore waters out to a specified depth of closure, usually from about –20 to –25 feet NGVD Benthic organisms, phytoplankton, and seaweeds are the major primary producers in this community with species of *Ulva* (sea lettuce), *Fucus*, and *Cladocera* (water fleas) being fairly common where suitable habitat occurs. Many species of fish-eating birds are typically found in this area including gulls, terns, cormorants, loons, and grebes (Sections 2.04 and 7.02). Marine mammals and sea turtles also are frequently seen in this area and are discussed in detail in Section 2.0, and Appendix F. Fishes and benthic resources of this area are discussed in Sections 2.04.

Borrow Areas U, Y and the ODMDS. The borrow areas U, Y and the ODMDS are located 1-5 off the shore. Due to the length of Bogue Banks, three borrow areas roughly divided evenly along the project area. Changes in geophysical conditions associated with dredging activities may affect the resources that inhabit these areas due to changes in sediment characteristics, bathymetry, habitat complexity, etc. (Diaz *et al*., 2004; Slacum *et. al*., 2010). Though short term bathymetric changes will occur following dredging, it is anticipated that the shoal will infill and re-establish its structure (Dibajnia and Nairn *et. al*., 2011) and post dredging surface sediments will be consistent with the adjacent and pre-dredging sediment; thus maximizing macro invertebrate recruitment and recovery. Similar to other offshore borrow sources, post dredging recovery of the benthic resources and the organisms that rely on them could take 1-4 years depending on the magnitude and duration of the perturbation and local rates of recruitment. Assuming that physical changes to the system are not significant following dredging, macro invertebrates are expected to recruit rapidly; however, reestablishment of pre-dredging species composition may take longer.

5a. Other Resources

Air Quality. The ambient air quality for all of coastal North Carolina has been determined to be in compliance with the National Ambient Air Quality Standards. All

coastal counties in North Carolina are designated as attainment areas and do not require conformity determinations.

Additionally, although ozone is not a significant problem in the coastal counties, 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. The ozone season is April through October. Dredging with beach disposal or renourishment typically takes place during the cooler months of the year, during times of low biological activity and outside of the ozone season. Section 7 provides detailed emissions analysis of the proposed project. Based on this analysis, this project is not anticipated to create any adverse effect on the air quality of this attainment area or cumulative effect on the ambient air quality for all of coastal North Carolina.

Social and Economic. Though in the short term, the economic recession has resulted in a down real estate market, it is assumed that in the long term coastal areas of NC will continue to grow and expand both with and without beach nourishment projects. Therefore, the economic benefit analysis for the proposed project claims no increase in benefits or hurricane and storm damage due to induced development. Development of vacant lots is limited to lots buildable under the regulations set forth by CAMA, flood plain regulations, State and local ordinances, and applicable requirements of the Federal Flood Insurance Program.

IWR Report 96-PS-1, FINAL REPORT: An Analysis of the U.S. Army Corps of Engineers Shore Protection Program, June 1996 states: "Corps projects have been found to have no measurable effect on development, and it appears that Corps activity has little effect on the relocation and/or construction decisions of developers, homeowners, or housing investors."

Wave Conditions. Localized deepening of the offshore borrow area is the only potential source of impacts on wave conditions, however, these changes are not expected to be significant.

Shoreline and Sand Transport. The drivers of the littoral transport of sand both along shore and cross shore include wind, waves, and currents. For the proposed project along Bogue Banks the project will not modify these drivers. The project does not include placement of sand within the inlet complexes and it is not anticipated the small relative quantities from the project would influence the large scale physical drivers of the inlet system.

6. Resource Capacity to Withstand Stress and Regulatory Thresholds

There are no known thresholds relating to the extent of ocean bottom that can be disturbed without significant population level impacts to fisheries and benthic species. Therefore, a comparison of cumulative impacts to established thresholds is not made. However, the potential impact area of the proposed project is small relative to the area of

available similar habitat on a local, vicinity, and statewide basis and the quick recovery rate of opportunistic species. It is expected that there is a low risk that the direct and cumulative impacts of the proposed action and other known similar activities would reach a threshold with potential for population level impacts on important commercial fish stocks. In regard to physical habitat alterations it is expected that alterations in depths and bottom sediment may occur and be persistent for some borrow areas. However, site modifications would be within the range of tolerance by these species and, although man-altered, consistent with natural variations in depth and sediment within the geographic range of EFH for local commercial fish species. The Final Report, Collection of Environmental Data Within Sand Resource Areas Offshore North Carolina and The Environmental Implications of Sand Removal for Coastal and Beach Restoration (Byrnes et al. 2003) provided the following assessment of potential impacts to benthic organisms from dredging:

Because the sedimentary regime of North Carolina sand source areas is vertically uniform, recolonization of surficial sediments by later successional stages likely will proceed even if dredged shoals are not completely reestablished. Furthermore, dredging of only a small portion of the area within each of the resource areas will ensure that a supply of non-transitional, motile taxa will be available for rapid migration into dredged sites. While community composition may differ for a period of time after the last dredging, the infaunal assemblage type that exists in mined areas will be similar to naturally occurring assemblages in the study area, particularly those assemblages inhabiting inter-ridge troughs. Based on previous observations of infaunal reestablishment in dredged sites, the infaunal community in dredged sites most likely will become reestablished within 2 years, and will exhibit levels of infaunal abundance, diversity, and composition comparable to nearby non-dredged sites.

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, (DOI 1999) provided the following assessment of potential impacts to beach fauna from beach disposal:

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; Levison and Van Dolah 1996). This is again attributed to the fact that intertidal organisms are living in high energy habitats where disturbances are 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 recolonized by the same species that existed before nourishment (Van Dolah et al. 1992; Nelson 1985; Levison and Van Dolah 1996; Hackney et al. 1996).

While the proposed beach disposal may adversely impact benthic macrofauna, these organisms are highly resilient and any effects will be localized, short-term, and reversible.

7. Baseline Conditions

The following main report section describes the status of significant resources that may be affected by this and other similar projects that are pertinent to this analysis.

Section 2.0, Affected Environment.

8. Cause and Effect Relationships

The following main report section describes impacts of the proposed action on significant resources. Cause and effect relationships described in the report are consistent with those that would be expected for other similar projects that are pertinent to this analysis.

Section 7.0, Environmental Effects.

9. Magnitude and Significance of Resource Impacts

9a. Offshore Borrow Areas

Site Specific Impacts: Borrow areas U, Y and the ODMDS are the identified borrow sources for this project and extends 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 economic optimization of the use of the borrow areas for the life of the project will be further evaluated when the final borrow area data has been collected and fully analyzed during the Plans and Specifications (P&S) phase. Both 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. Upon each dredging interval, recovery in adjacent areas will have already occurred; therefore, re-occurring impacts to any sub-component of a borrow area are not anticipated. Therefore, the total acreage of impact that could occur during any given dredging event is the one time impact of the surface area required to dredge the volume of sediment for initial construction or nourishment. This cyclic use of borrow areas would result in cumulative effects from space crowded perturbations on a local scale. Assuming that the borrow areas are not impacted by unusually high sedimentation rates or some other disturbance, a natural succession of species should occur, potentially restoring the area to its original levels of abundance and biomass within 1-5 years (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; Johnson and Nelson, 1985; Van Dolah *et al*., 1984; and Wilber and Stern, 1992). Considering that un-impacted or recovered portions of the borrow area will likely be available during any particular dredging event, more rapid recruitment from adjacent areas is expected to expedite recovery. The impacts of this activity on benthic invertebrates are discussed in more

detail in Section 7. Cumulative impacts from space crowded perturbations could occur at the local scale resulting from the use of the borrow areas.

Statewide Impacts:

Existing and Potential Sites: 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 (Table I-2). 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 navigation servitude. Of all the projects listed with offshore borrow areas in Table I-2, 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, and are currently in use. 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 not significant. However, recognizing the potential for all of the federal and non-federal projects identified in North Carolina to occur within the reasonably foreseeable future (Table I-2), there is a potential for cumulative impacts for time and space crowded perturbations associated with the cyclic use of the offshore borrow areas throughout the state.

9b. Beach Areas

The impacts of beach disposal on North Carolina beaches are evaluated in Section 7.0 of the main report. 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 disposal are beach nourishment projects.

As shown in Table I-5 below, the North Carolina ocean beaches (320 miles) can be divided up based on the potential that a beach nourishment project will be proposed for them. The Coastal Area Management Act (CAMA) applies to all 20 North Carolina Coastal Counties. Proper beach nourishment , navigation disposal, and/or local maintenance within these counties is generally regulated under CAMA or USACE permitting authorities alone, and for this analysis, are labeled CAMA regulated. Approximately 37 percent of North Carolina beaches are in this category. Other North Carolina ocean beach areas which are less likely to be considered for beach disposal include those identified under the Coastal Barrier Resources Act (CBRA) of 1982 (PL 9-348), the Coastal Barrier Improvement Act of 1990 (PL 101-591), and National and State

park lands. CBRA restricts federal expenditures in those areas comprising the Coastal Barrier Resources System (CBRS); thus, long term federal beach nourishment projects will not occur in defined CBRA zones. However, though long term federal beach nourishment projects are restricted from CBRA zones, non-federal permitted projects may still occur (i.e. North Topsail Beach) on a short term basis. National or state park lands are the least likely to have beach nourishment projects considering that their mission is often to manage lands in their natural state and protection of infrastructure is less common. National and state parks allow highly restricted disposal under special use permits and conduct disposal only as required to protect resources, such as at Pea Island. Only about 10 percent (on National/Federal and State Parks) of all existing or projected disposal/nourishment in North Carolina are on beaches within this category.

Table I-4. North Carolina beach classifications and associated potential for beach disposal/nourishment activities.

Beach Classification	Percentage of NC Beaches	Potential for Beach Disposal/Nourishment Activities
Coastal Barrier Resource System	19	Medium
Developed and/or CAMA Regulated	37	High
National Park Lands	40	Low
State Park Lands	4	Low

Statewide Impacts

The following quantitative analyses of statewide impacts were determined based on data provided in Tables J-2 and J-3. These data represent an estimate of the percent of North Carolina beach affected by sand disposal for maintenance of federal navigation channels, and existing, proposed, or potential federal and non-federal beach nourishment projects. Table I-5 represents the total project miles for all existing and proposed federal and non-federal beach nourishment projects and the full authorized limits for beach disposal of navigation dredged material. However, assuming all of these activities were constructed to the full extent (which is very unlikely considering funding constraints, dredging needs from navigation channels, etc.) these estimates would not represent the actual extent of North Carolina ocean beach impacted because of overlapping project areas.

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Table I-5. Summary of total project miles for existing and/or proposed federal and non-federal nourishment activities and federal navigation disposal.

Project Type	Total Project Miles	% NC Beach
Federal Beach Nourishment	122	38
Non-Federal Beach Nourishment	93	29
Federal Authorized Beach Disposal	41	13
TOTAL	**256**	**80**

Recognizing that many of the existing or proposed federal and non-federal beach nourishment project limits overlap and that some portions of the federal authorized beach disposal limits are within these project areas as well, Table I-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.

Table I-6. Summary of cumulative mileage of North Carolina Ocean beach that could be impacted by beach nourishment and/or navigation disposal activities.

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**

a. Existing Beach Nourishment:

- Of the total 197 potential federal and non-federal beach nourishment project miles proposed for NC ocean beaches (Table I-5), a total of 92 (29%) have actually been constructed. However, this estimate represents actual project miles nourished and does not reflect circumstances where the projects overlap. Therefore, the total number of actual miles of beach nourished is less.

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b. Proposed Beach Renourishment:

- 121 miles or 38 percent of the North Carolina ocean beaches are proposed for beach nourishment (federal and non-federal).

c. Cumulative Impacts:

- Considering all proposed and existing disposal and nourishment impacts throughout the ocean beaches of North Carolina, a significant portion of the shoreline will 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.

Project Level Impacts

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

a. Existing Local Beach Placement:

- **Non-Federal Projects:** The Bogue Banks Restoration (BBR) Project was implemented by Carteret County as an interim measure, to go along with placement resulting from 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 has placed approximately 4.3 million cy of material along the island since 2001.
-

b. Existing Federal Beach Placement:

- **Morehead City Section 933:** 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.

- **Morehead City Harbor Maintenance:** Since 1978, about 9 million cy of material dredged during harbor maintenance has been placed on the eastern end of the island as least cost disposal.

d. Proposed Beach Nourishment:

- The proposed project consists of an 119,670 ft (22.7 miles) long main beachfill.
- Carteret County is currently in the early planning stages of a 30 year non-federal beach nourishment project that would extend along the entire length of Bogue Banks. Although this project is being planned as contingency in case the Federal project is not implemented, the actual likelihood of the longer term local plan being implemented is uncertain.
- The Corps is preparing the Morehead City DMMP which will place material from the maintenance of the Morehead City Harbor onto Bogue Banks and Shackelford Banks.

e. Cumulative Impacts:

- The proposed project beach placement activities are approximately every three years and allow for recovery between events.

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 permitted beach nourishment projects has increased in recent years in efforts to initiate coastal storm damage reduction measures in the interim of federal projects being authorized and/or funded (i.e. Nags Head, 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 likely that the proposed beach nourishment projects within the reasonably foreseeable future will 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. However, 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.

10. Actions to Reduce Cumulative Impacts

Appendix G includes environmental commitments and monitoring proposed to minimize project impacts. These actions will also reduce any cumulative impacts related to beach nourishment and offshore borrow activities. Several of the incrementally larger beach projects considered in this assessment including Wilmington Harbor, Bogue Banks (local nourishment project), and Dare County Beaches have conducted significant monitoring components that address beach impacts on northern, central and southern North Carolina beaches.

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BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX J

404(b)(1) ANALYSIS

US Army Corps of Engineers
Wilmington District

BOGUE BANKS, NORTH CAROLINA
Final Evaluation of Section 404 (b) (1) Guidelines 40 CFR 230

This evaluation of the placement of any and all fill material into waters and wetlands of the United States required for construction and maintenance of the Bogue Banks, North Carolina, Coastal Storm Damage Reduction Project.

The tentatively selected 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 19.55 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.

Section 404 Public Notice No. CESAW-TS-PE

		Preliminary 1/	Final 2/
1.	Review of Compliance (230.10(a)-(d)) A review of the NEPA Document indicates that:		
a.	The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose	YES|X| NO|_|	YES|X| NO|_|
	Remarks: The Corps planning process has brought us to the conclusion the TSP was the LEDPA.		
b.	The activity does not: 1) violate applicable State water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of federally listed endangered or threatened species or their habitat; and 3) violate requirements of any federally designated marine sanctuary (See Section 7.0 and Appendix F of the Final Integrated Feasibility Report and EIS)	YES|X| NO|_|	YES|X| NO|_|
c.	The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (See Section 8.0 of the Final Report)	YES|X| NO|_|	YES|X| NO|_|
d.	Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (see Section 8.0 of the Final Report).	YES|X| NO |_|	YES|X| NO|_|

Proceed to Section 2

*, 1, 2/ See page 6.

2. Technical Evaluation Factors (Subparts C-F)	N/A	Not Significant	Significant*
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
(1) Substrate impacts.		X	
(2) Suspended particulates/turbidity impacts.		X	
(3) Water column impacts.		X	
(4) Alteration of current patterns and water circulation.		X	
(5) Alteration of normal water fluctuations/hydroperiod.		X	
(6) Alteration of salinity gradients.	NA		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
(1) Effect on threatened/endangered species and their habitat.		X	
(2) Effect on the aquatic food web.		X	
(3) Effect on other wildlife (mammals, birds, reptiles, and amphibians).		X	
c. Special Aquatic Sites (Subpart E)			
(1) Sanctuaries and refuges.	NA		
(2) Wetlands.		X	
(3) Mud flats.	NA		
(4) Vegetated shallows.	NA		
(5) Coral reefs.	NA		
(6) Riffle and pool complexes.	NA		
d. Human Use Characteristics (Subpart F)			
(1) Effects on municipal and private water supplies.	NA		
(2) Recreational and commercial fisheries impacts.		X	
(3) Effects on water-related recreation.		X	
(4) Aesthetic impacts.		X	
(5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves.		X	

Remarks: See Section 7.0 and Appendix F of the Final Integrated Feasibility Report and EIS, Bogue Banks, North Carolina for more information on the above topics.

Proceed to Section 3
*See page 6.

3. Evaluation of Dredged or Fill Material (Subpart G) 3/

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

(1) Physical characteristics. . . . . |X|
(2) Hydrography in relation to known or anticipated sources of contaminants . . . . . |X|
(3) Results from previous testing of the material or similar material in the vicinity of the project . . . . . |_|
(4) Known, significant sources of persistent pesticides from land runoff or percolation . . . . . |_|
(5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances . . . . . |_|
(6) Other public records of significant introduction of contaminants from industries, municipalities, or other sources. . . . . |X|
(7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities. . . . . |_|

(8) Other sources (specify). . . . . |_|

Reference: See Sections 2.0, 7.0.9, and the Geotechnical and Sand Compatibility Analyses Appendices Final Report for Bogue Banks, North Carolina.

Remark: Sediments to be dredged consist of beach quality sand. Contaminants do not bind to sand, therefore, contaminant testing of sediments was not required.

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to result in degradation of the disposal site. YES |X| NO |_|

Proceed to Section 4
*, 3/, see page 6.

4. Disposal Site Determinations (230.11(f)).

a. The following factors as appropriate, have been considered in evaluating the disposal site.

(1) Depth of water at disposal site. . . . . |X|

(2) Current velocity, direction, and variability at disposal site . . . . . |X|

(3) Degree of turbulence. . . . . |X|

(4) Water column stratification . . . . . |X|

(5) Discharge vessel speed and direction . . . . . |X|

(6) Rate of discharge . . . . . |X|

(7) Dredged material characteristics (constituents, amount and type of material, settling velocities). . . . . |X|

(8) Number of discharges per unit of time. . . . . |X|

(9) Other factors affecting rates and patterns of mixing (specify) . . . . |_|

Reference: See Final Integrated Feasibility Report and EIS, Bogue Banks, North Carolina.

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable. YES |X| NO |_|*

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77, to ensure minimal adverse effects of the proposed discharge. YES |X| NO |_|*

See Section 7.2 of Final Report for Marine Environment
See Section 7.9 of Final Report for Water Resources
See Appendix F of the Final Report for threatened and endangered species

Return to section 1 for final stage of compliance review.
See also note 3/, page 6.
*See page 6.

6. Factual Determinations (230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

a. Physical substrate at the disposal site (review sections 2a, 3, 4, and 5). YES |X| NO |_|*

b. Water circulation, fluctuation, and salinity (review sections 2a, 3, 4, and 5). YES |X| NO |_|*

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES |X| NO |_|*

d. Contaminant availability (review sections 2a, 3, and 4). YES |X| NO |_|*

e. Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5). YES |X| NO |_|*

f. Disposal site (review sections 2, 4, and 5). YES |X| NO |_|*

g. Cumulative impact on the aquatic ecosystem. YES |X| NO |_|*

h. Secondary impacts on the aquatic ecosystem. YES |X| NO |_|*

Remark: More detailed information on the topics above may be found in Sections 2.0, 7.0, and the Geotechnical, Sand Compatibility, and Cumulative Impacts analyses Appendices of the Final Report for Bogue Banks, North Carolina.

7. Findings.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines. . . . . |X|

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions:. . . . . |_|

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reasons(s):

(1) There is a less damaging practicable alternative . . . . . |_|

(2) The proposed discharge will result in significant degradation of the aquatic ecosystem . . . . . |_|

(3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem. . . . . |_|

*See page 6.

8. Signature.

COL. EN

Steven A. Baker
Colonel, U.S. Army
District Commander

Date: 16 APR 14

*A negative, significant, or unknown response indicates that the permit application may not be in compliance with the Section 404(b)(1) Guidelines.

1/ Negative responses to three or more of the compliance criteria at this stage indicate that the proposed projects may not be evaluated using this "short form procedure." Care should be used in assessing pertinent portions of the technical information of items 2 a-d, before completing the final review of compliance.

2/ Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate."

3/ If the dredged or fill material cannot be excluded from individual testing, the "short-form" evaluation process is inappropriate.

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BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX K
US FISH AND WILDLIFE SERVICE
FINAL
COORDINATION ACT REPORT

US Army Corps
of Engineers
Wilmington District

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

March 10, 2014

Mr. Eric Gasch
U. S. Army Corps of Engineers
Wilmington Regulatory Field Office
69 Darlington Avenue
Wilmington, North Carolina 28403

Subject: Final Fish and Wildlife Coordination Act Report
Bogue Banks Shore Protection Project

Dear Mr. Gasch:

This letter finalizes the U. S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (FWCA) Report for the U.S. Army Corps of Engineer's Bogue Banks Shore Protection Project. In November 2002, Howard Hall of our office submitted a draft FWCA report for this project. The draft included a description of the study area, a discussion of fish and wildlife concerns and planning objectives, a discussion of evaluation methods, discussions of existing fish and wildlife resources, a discussion of the alternatives, a comparison of impacts, conservation measures and recommendations, and the position of the Service. The general information concerning fish and wildlife resources in the draft FWCA report remains valid up to that date. Due to the very short timeframe in which this final FWCA report was requested, the Service has not updated all of the data for fish and wildlife and other resources discussed in the report. Attached to this letter is an updated Table 8, which lists the species of colonial waterbirds known to nest on islands within Bogue Sound, Bogue Inlet, and Beaufort Inlet. We are also including a new table (Table 14), which provides shorebird numbers in the project area for the years 2005 through 2013. Updated sea turtle nesting data is provided in Table 3 of the August 2013 draft Biological Assessment (BA).

In addition to the draft FWCA Report, the Service transmitted comments to the Corps by letter on January 8, 2004, and indicated that the Corps did not need to respond to all of the Conservation Measures and Recommendations in Section 10 of the Draft FWCA report. Instead, the 2004 letter recommended that the Corps focus on a subset of measures from that report.

Currently, the Service believes that all of the Conservation Measures and Recommendations in Section 10 (pages 106 through 113) of the draft FWCA report remain worthy of consideration.

However, we wish to highlight several which we believe are especially important. Many of these have been reiterated somewhat in our recent comments to the Draft EIS and the draft Biological Assessment. The background material for these recommendations can be found in the draft FWCA report.

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

6. The maintenance construction, or renourishment interval, should be greater than three years. We note that although the Corps 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.

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.

9. The potential mitigative measures listed on pages 111 through 113 should be considered by the Corps 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.

Final Summary and Position of the Service

As the Planning Objectives on pages 6 and 7 of the draft FWCA Report states, the Service's Mitigation Policy (January 23, 1981, FR 46:15 7644-7663) allows the Service to support a proposed project if the following criteria are met:

1. The project is ecologically sound;
2. The least environmentally damaging alternative is selected;
3. Every reasonable effort has been made to avoid or minimize damage or loss of fish and wildlife resources and uses;
4. All important recommended means and measures have been adopted with guaranteed implementation to satisfactorily compensate for unavoidable damage or loss consistent with the appropriate mitigation goal; and
5. For wetlands and shallow water habitats, the proposed activity is clearly water dependent and there is a demonstrated public need.

The Service uses these five criteria as planning objectives in the draft and final FWCA reports, and will support a project if it meets these five criteria. Currently, the Service is unsure whether the project as proposed meets the criteria listed above. Incorporation of the recommendations contained herein would greatly improve/clarify the environmental impacts and benefits of this project.

If you have questions regarding these comments, please contact Kathy Matthews at 919-856-4520, ext. 27 or by e-mail at <kathryn_matthews@fws.gov >.

Sincerely,

Pete Benjamin
Field Supervisor

Table 8. Species of colonial waterbirds known to nest on islands within Bogue Sound, Bogue Inlet, and Beaufort Inlet; the most recent year to record nesting, and the size range of the colonies. Data from 1975 to 2013. Data from the NC WRC.

Waterbird Species	Recent Nesting Years	Colony Size Range (number of nests in any colony)
Common tern *Sterna hirundo*	1977 - 2007	1 - 576
Least tern *Sterna antillarum*	1977 – 2011	1 - 296
Gull-billed tern *Sterna nilotica*	1977 – 1993	2 - 175
Forster's tern *Sterna forsteri*	1995 – 2007	5 - 17
Black Skimmer *Rynchops niger*	1997 - 2007	1 – 182
Black-crowned night heron *Nycticorax nycticorax*	1976 – 2011	1 – 72
Cattle egret *Bubulcus ibis*	1975 - 2011	8 - 689
Great egret *Casmerodius albus*	1975 – 2011	1 – 345
Green heron *Butorides striatus*	1975 - 1995	1 - 28
Little blue heron *Egretta caerulea*	1975 – 2011	8 - 362
Snowy egret *Egretta thula*	1975 – 2011	4 – 247
Tricolored heron *Egretta tricolor*	1975 – 2011	8 – 920
Great blue heron *Ardea herodias*	1977	1
Glossy ibis *Plegadis falcinellus*	1989 - 1995	4 – 5
White ibis *Eudocimus albus*	1989 - 2011	14 - 246

Table 14. Species of shorebirds recorded within Bogue Sound, Bogue Inlet, and Beaufort Inlet, by location. Data from 2005 to 2013. Data from the NC WRC.

Shorebird species	General Location	Number of birds sited at one time (Range)	Number of Breeding Pairs sited at one time (Range)
American Oystercatcher *Haematopus palliatus*	Bogue Banks Beaches	2	1
	Bogue Inlet	2 – 6	1 - 3
	Bogue Sound	2 – 10	1 – 5
	Beaufort Inlet	1 – 78	1
Piping plover *Charadrius melodus*	Bogue Banks Beaches	1 – 5	--
	Bogue Inlet	1 – 18	--
	Bogue Sound	--	--
	Beaufort Inlet	2 – 19	--
Red knot *Calidris canutus rufa*	Bogue Banks Beaches	1 - 230	--
	Bogue Inlet	4 - 27	--
	Bogue Sound	--	--
	Beaufort Inlet	40	--

Shorebird species	General Location	Number of birds sited at one time (Range)	Number of Breeding Pairs sited at one time (Range)
Willet *Tringa semipalmata*	Bogue Banks Beaches	--	--
	Bogue Inlet	4	2
	Bogue Sound	4	--
	Beaufort Inlet	--	--
Wilson's plover *Charadrius wilsonia*	Bogue Banks Beaches	1 – 4	0 – 2
	Bogue Inlet	6	3
	Bogue Sound	4	2
	Beaufort Inlet	1 – 13	0 - 10

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX L
PROJECT CORRESPONDENCE

US Army Corps of Engineers

Wilmington District

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United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
WASHINGTON, DC 20240-0001

MAR 12 2012

Mr. Elden J. Gatwood
Chief - Planning and Environmental Branch
USACE - Wilmington District
69 Darlington Avenue
Wilmington, North Carolina 28403

Dear Mr. Gatwood:

Thank you for your March 2, 2012, letter requesting that the Bureau of Ocean Energy Management (BOEM) become a cooperating agency during the preparation of an Environmental Impact Statement (EIS) for the island of Bogue Banks, North Carolina, Coastal Storm Damage Reduction (CSDR) Project. The proposed action, being evaluated by the U.S. Army Corps of Engineers (Corps) under a Congressional authorization, may involve beach nourishment of up to 24 miles of coastal shoreline from Beaufort to Bogue Inlets, North Carolina potentially using sand from borrow area located on the Outer Continental Shelf (OCS).

BOEM welcomes the opportunity to participate in this National Environmental Policy Act (NEPA) effort and agrees to serve as a cooperating agency since BOEM has jurisdiction over mineral leasing on the OCS. As a cooperating agency, BOEM expects to: participate and provide input in the NEPA process at the earliest possible time; assume, on the request of the Corps, responsibility for developing information and preparing environmental analyses for which BOEM has special expertise; make available staff support, at the lead agency's request, to enhance the interdisciplinary capability of the Corps; provide comment on draft versions of the EIS when requested; and use our own funds to accomplish these responsibilities.

BOEM also recognizes the importance of initiating and agrees to participate in the required Endangered Species Act (ESA) Section 7 consultation; the Magnuson-Stevens Fishery and Conservation Management Act Essential Fish Habitat (EFH) consultation (Section 305); the National Historic Preservation Act Section (NHPA) Section 106 process; and the Coastal Zone Management Act (CZMA) Section 307 consistency process. As the lead federal agency for ESA Section 7 and the EFH consultations, the Corps must notify the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) of its lead role and BOEM' cooperating role. BOEM would expect the Corps, as lead agency, to work with BOEM to ensure existing biological opinions from FWS and NMFS are applicable to BOEM's part of the Federal action and/or expect to jointly submit the ESA Section 7 and EFH assessments to FWS and NMFS. BOEM expects the Corps to be the lead federal agency for the NHPA Section 106 and CZMA Section 307 compliance with BOEM acting in a consulting role. BOEM requests that the Corps notify the State Historic Preservation Officer and North Carolina Division of Coastal Management of BOEM's involvement in the undertaking/proposed action.

BOEM looks forward to working with the Corps during this process. We would greatly appreciate be included on all correspondence to other federal and state agencies concerning this project. Likewise, we would appreciate the opportunity to join the Project Development Team if one is formed. If you would like to discuss any of these items further, please contact Jennifer Culbertson at (703) 787-1742 or by e-mail at Jennifer.Culbertson@boem.gov.

Sincerely,

James F. Bennett
Chief, Division of Environmental Assessment

cc: Mr. Eric Gasch
U.S. Army Corps of Engineers, Wilmington District

Mr. C. Broadwater
Bureau of Ocean Energy Management

BOEMRE COMMENTS (September 2013)

Draft Environmental Impact Statement: Coastal Storm Damage Reduction Project, Bogue Banks, Carteret County, NC			
	General Comments		
A	Consistent with the Council on Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, the Corps has combined the preparation of an Environmental Impact Statement (EIS) with a planning instrument. The draft Integrated Feasibility Report (IFR) and EIS integrate alternative development, engineering and economic analyses, and environmental review in a single document. In the draft document, the elements required in an EIS are presented in an atypical order, and the re-organization presents some fundamental challenges to the reader. For example, the reader must first read the Tentatively Selected Plan chapter (Chapter 6), the practical description of the proposed action, to fully comprehend the site-specific discussion of in the Affected Environment chapter (Chapter 2). Environmental commitments are enumerated before the presentation of the impact analyses in the Environmental Effects chapter (Chapter 7). Therefore, the reader must first read the effects analyses to fully appreciate the need and purpose of the proposed mitigation. BOEM recommends the Corps prepare prefatory guidance to better orient the reader to the organization of the document. Alternatively, the Corps could insert the Affected Environment chapter after the Tentatively Selected Plan chapter and before the Environmental Effects chapter. Mitigation should be linked in a logical manner to the effects analysis.		
B	Please include BOEM jurisdiction justification: Public Law 103-426 enacted 31 October 1994 gave BOEM the authority to convey, on a noncompetitive basis, the rights to 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 mi) fall under BOEM's jurisdiction, as found in the OCS Land Act.		
C	Please indicate earlier in the document: BOEM and the USACE are cooperating agencies having jurisdiction over different project facets and locations. OCS resources (beyond three mi) fall under BOEM's jurisdiction, as found in the OCS Land Act.		
D	Please note this earlier in the document: Since most of the borrow areas identified for the proposed project are located on the Outer Continental Shelf (OCS), BOEM may need to authorize their use for initial and/or maintenance construction. The BOEM, as a cooperating federal agency, may undertake a connected action (i.e., authorize use of the OCS borrow area) that is related, but unique from the Corps's proposed action (i.e., construction of the project). Consequently, the purpose and need of the BOEM's proposed action is different. Ideally, the EIS should provide a more accurate description of the BOEM's involvement under the Corps' proposed action. The BOEM's proposed action is the issuance of a negotiated agreement pursuant to its authority under the Outer Continental Shelf Lands Act. The purpose of that action is to authorize the use of OCS sand (or other sediment) resources in beach nourishment and coastal restoration projects undertaken by federal, state or local government agencies, and/or in other federally authorized construction projects. The BOEM's action will be needed because the localities and the Corps submitted authorization requests to the BOEM.		
E	The Environmental Effects chapter (Chapter 7) offers a robust discussion of the potential environmental impacts related to the Tentatively Selected Plan. In contrast, the document offers a limited discussion of potential impacts associated with other alternatives, including the no action alternative. BOEM suggests the Corps clearly indicate which alternatives were dismissed and on what basis. Otherwise, the direct and indirect impacts of alternatives should be discussed in more detail and in context of their relative significance in the Environmental Effects chapter.		
F	The biological assessment discusses protected species that are likely to occur in the proposed project area. However, the draft IFR/EIS does not address other marine mammals without protection status, such as dolphin species, that are likely to be present and may be affected by the proposed action. They are mentioned in App G but should be addressed within the document text.		
#	**Page**	**Section**	**Specific Comments**
1	2 App F	Fig. 1.1 Figure 1	Please add the OCS line to delineate Federal vs State waters
2	5 and 8	1.08 and Fig 1.2	No mention of the most recent 2013 Post Irene Renourishment Effort along BogueBanks
3	21	2.04.6	Please include a figure indicating hardbottom areas within and near offshore borrow areas. A more detailed description of offshore hardbottom would be helpful. A discussion of habitat association between benthic populations and habitat type (RSDs, hard bottom, sand and muddy substrate) should be provided. The benthic resources or hard bottom descriptions should include a detailed description of the occurrence and quality of benthic sargassum, corals, and sponges.
4	32	2.07	"In accordance with Section 7 (a)(2) of the ESA, the Corps has been in consultation with the USFWS and NMFS since beginning this study." Should indicate BOEM's involvement in the process to cover use of the OCS borrow site under ESA
5	33	Table 2.4	Update with new info on spp. Atl sturgeon are now endangered
6	38	2.08	There is no discussion of the potential for archaeological resources in the vicinity of pump-out locations and pipeline corridors, and the likely areas for those operations are not identified. Consideration of these areas may be important as they are subject to bottom disturbing activities such as anchoring, anchor drag, and pipeline emplacement
7		2.08	The Corps does not fully address the potential for prehistoric sites within the survey area. BOEM suggests that the following tasks relating to prehistoric site potential be addressed: 1. review current literature on late Pleistocene and Holocene geology, paleogeography, and sea level change in the area; marine and coastal prehistory; and previous archaeological resource reports in the area if available.

			2. discuss relict geomorphic features and their archaeological potential that includes the type, age, and association of the mapped features; the acoustic characteristics of channels and their fill material; evidence for preservation or erosion of channel margins; evidence for more than one generation of fluvial downcutting; and the sea level curves used in the assessment. 3. discuss, based on the capabilities of current technology in relation to the thickness and composition of sediments overlying the area of a potential site, the potential for identification and evaluation of buried prehistoric sites. The DEIS should incorporate information that summarizes the potential for prehistoric sites within the project area.
8	40	2.12.1	Ambient and anthropogenic noise in the marine environment is not described.
9	72	Table 5.8	Table 5.8 does not address potential impacts from the range of beach fill and non-structural alternatives proposed to physical processes and non-listed marine mammals.
10	79		Please indicate state vs federal borrow sites or give some explanation to the difference.
11	81		Note that the recent FEMA project off Bogue Banks went from January to March 25th on the ODMDS and did not catch any turtles during relocation trawling
12	103		The description of and potential impacts to protected marine mammals and sea turtles are incorporated by reference to the biological assessment. BOEM recommends a brief summary be provided in the EIS, or, the biological assessment should be included as a physical attachment to the Final IFR/EIS.
13	105	7.02.7	Suggest referencing some more recent literature which can be found the recent review on this subject Michel et al, 2013.
14	109	7.02.8.2	It should be stated that cross-shore sediment transport will likely occur beyond the depth of closure, but ultimately depends on the forcing conditions and the profile state at the time of the forcing event.
15	111	7.02.8.5	What about potential impacts to benthic *Sargassum*? It is noted to be in the area but then not further addressed.
16		7.02.8.6	Additional info from NASA Wallops Island EA (2013): "Dredging operations would cause sediment to be suspended in the water column. Studies of 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. (USACE 1983; Hitchcock et al. 1999; MMS 1999; Anchor Environmental 2003; Wilber et al. 2006)."
17		7.03.4	BOEM recommends a discussion of bird utilization of hard bottom areas and other offshore habitat.
18		7.03.5	It seems odd that T and E aren't addressed until the terrestrial section although it includes offshore species. Would be helpful to include a section in the marine environment on offshore T and E spp.
19		7.09.1	Additional info from the NASA/BOEM Wallops 2013 EA that may be useful: "During the initial Wallops Island beach fill in summer 2012, NASA partnered with BOEM and USACE (Reine et al, 2013) to record background in-water sound levels at the both offshore borrow area and the nearshore pumpout area. Data were collected at two listening depths at each site; approximately 10 ft and 30 ft depths at the offshore shoal and 10 ft and 20 ft at the nearshore sites. During the study, the majority of data collected when winds were at least 4-7 miles per hour and wave heights were at least 1-2 feet. Therefore, the data do not reflect "calm" sea conditions. Background sound pressure levels (SPLs) averaged 117 dB across all sampling days, sites, water depths and weather conditions. Minimum measured sound levels ranged from 91 dB to 107 dB depending on sampling location and water depth; maximum levels ranged from approximately 128 dB to just under 148 dB (Reine et al. in prep). Highest SPLs were found at frequencies of less than 200 hertz. The authors note that sea state and the associated sounds generated by waves interacting with the survey vessel likely contributed to the elevated readings. Based upon data collected by Reine et al. (2013), sediment removal and the transition from transit to pump-out would be expected to produce the highest sound levels at an estimated source level (SL) of 172 dB at 3 ft. The two quietest dredging activities would be expected to be seawater pump-out (flushing pipes) and transiting (unloaded) to the borrow site, with expected SLs of approximately 159 and 163 dB at 3 ft, respectively…. Based upon attenuation rates observed by Reine et al. (in prep.), it would be expected that at distances approximately 1.6-1.9 mi from the source, underwater sounds generated by the dredges would attenuate to background levels. However, similar to in-air sounds, wind (and corresponding sea state) would play a major role in dictating the distance to which project related underwater sounds would be above ambient levels and potentially audible to nearby receptors"
20	137	7.11.4	The Corps should also discuss the potential benefits/costs of a borrow area management plan that requires the rotational use of borrow areas over initial and maintenance construction cycles as a means to mitigate cumulative effects to benthic communities and habitat.
21	144-145		The Corps has "lead agency" status for Section 7 and EFH consultations/coordination, and as "lead agency", the Corps should notify NMFS HCD, NMFS PRD, and FWS of BOEM's involvement in the proposed action.
22	Appendix F		Please indicates BOEM's involvement with the Section 7 process within this Biological Assessment.
23	Appendix F	Table 1	Is trawling allowable under the SARBO? If trawling is to be completed it should also be noted and potential impacts addressed within the document text.
24	Appendix F		Will you be adding an analysis of potentials impacts to proposed loggerhead critical habitat?
25	Appendix	5.00	"The Corps will strictly adhere to all conditions outlined in the most current National Marine Fisheries Service RBO for dredging of channels and borrow areas in the southeastern United

	F		States." Please include BOEM on any environmental requirements throughout 5.00 that apply to areas within our jurisdiction.

Shore Protection Manager

Greg L. Rudolph
Tel: (252) 393.2663
Fax: (252) 393.6639
rudi@carteretcountygov.org

carteret county Shore protection office
protectthebeach.com

September 5, 2013

Eric Gasch
Environmental Resources Section (CESWA-TS-PE)
U.S. Army Corps of Engineers, Wilmington District
P.O. Box 1890
Wilmington, NC 28402

Re: Comments
Integrated Feasibility Report and Draft Environmental Impact Statement
Coastal Storm Damage Reduction
Bogue Banks, Carteret County, North Carolina

Dear Mr. Gasch,

Carteret County, through the auspices of its Shore Protection Office and Beach Commission and in cooperation with the municipalities of Bogue Banks would first like to compliment the Wilmington District for completing the Draft Bogue Banks Feasibility Report and compulsory Environmental Impact Statement (EIS). In the past we have been very critical of the duration and costs associated with this study, especially compared to the schedule provided in the Feasibility Agreement that was executed in 2001. We have spent considerable time over the past decade securing federal, State, and local funds for the study, which languished for reasons that were systemic Corps-wide and within the District. However there has been noticeable change the past couple of years, and again the District and upper Corps hierarchy should be commended for implementing Nation-wide directives to eliminate the backlog of studies and projects. Likewise, it takes the hard work of the personnel within local Districts to re-assess the goals and complete the Study, and this is duly noted along with the in-person District briefings provided to us over the past couple of years.

Pertaining to the Draft Report & EIS, we would like to go on record specifically at this time regarding the parking and access requirements, which is supported in the document by Appendix I. We have long questioned the interpretation and unilateral judgments the District and Division/Headquarters have applied to their own internal regulations (ER 1105-2-100 and ER 1165-2-130) that sometimes seemingly have no consideration for larger issues such as cost, practicality, and "quantity over quality (i.e., amenities)" of the access/parking facilities existing or planned. We have shared some of these concerns as well during and after the implementation of the Morehead Harbor Section 933 Project (2004 and 2007) and this correspondence should be considered as reiteration of these points in addition to the topics introduced below.

Draft Report is <u>Missing</u> Six Accesses and Parking Locations in Pine Knoll Shores – Attached is a map depicting the existing access and parking locations in Pine Knoll Shores. The accesses on this map from west to east are identified as; (1) Beacon's Reach West, (2) Beacon's Reach East, (3) The Qualls, (4) Dayton Place, (5) Dogwood, and (6) Knollwood; and are not reflected in the Draft Report. Moreover, these accesses have designated

parking areas also described in the attached that were designed to service the access points. Many of these access/parking areas were constructed in association with the aforementioned Morehead City Harbor Section 933 Project and were deemed to fulfill the Corps of Engineers requirements with full federal cost-sharing (65%) applied to the Project. We request the Draft Report to be modified to reflect these access/parking areas, and to also be considered to meet peak demand (see discussion below).

Waiver Requested in Indian Beach and Salter Path – The Draft Report identifies that, *"The distance between the Indian Beach Regional Access and the Salter Path Regional Access has been calculated to be 0.58 Miles."* and *"The distance between Salter Path Regional Access and the Sea Plantation West Access has been calculated to be 0.59 Miles."* (pages 2 and 3, Appendix I). The Draft Report further mentions to technically meet the access density requirements, an additional Public Access would be required between these points to meet the every 0.5 mile standard; yet because these distances are within 500 feet of the maximum allowable distance, the Corps may consider a waiver for these segments of the project. To this effect, we request a waiver be approved and formally incorporated into the Final Report, rather than undergoing a waiver decision-making process subsequent to its approval and Congressional authorization – especially considering the insignificant distances involved.

Peak Demand Calculations Needs to be Revisited – We disagree with the parking requirements in the draft report (copied below) and the peak demand methodology used to generate these numbers. Atlantic Beach represents roughly 5 of the 24 miles that encompasses Bogue Banks, or 20% of the geographic area. However the parking spaces required for Atlantic Beach is 2,303 of the total 3,271 spaces required for the entire island, or 70%. Considering the peak demand calculation is based upon the number of non-overnight visitors; this makes no sense. Obviously if there were more beach visitors on Atlantic Beach, then they ***were*** overnight visitors staying in larger hotels, ***not*** non-overnight visitors. This statement is also very consistent with the fact that almost all of the multiple-story hotels along the entire island reside in Atlantic Beach. This was also very much the case in 2003 when the peak demand analysis was conducted. The on-the beach and telephone surveys were apparently interpreted incorrectly and the current snapshot of peak demand is overstated in the Draft Report.

Town	Total Parking Spaces Needed	Current Parking Spaces
Emerald Isle	662	525
Salter Path/Indian Beach	96	141
Pine Knoll Shores	201	155
Atlantic Beach	2,303	1,011*
Total	3,271	1,832

*Includes parking spots available at Fort Macon State Park

We also contend the Corps' forecasts for increases in peak demand envisioned for the project, which were based on increases to beach width is a false premise, and again needs to be revisited. Future visitation and demand are based on many other factors besides beach width including National and regional economic conditions, regional shifts in population that impact the day user segment, and infrastructure capacity – the latter is especially pertinent to Bogue Banks. The island is essentially "built out" and there is not a municipal sewer system that serves any of the political jurisdictions located on the island. Accordingly there are only finite amount of visitors (overnight or day visitors) that the island can support. Bogue Banks is also known and marketed as a family beach because of the high density of home rentals that accommodate week-long visits – this has and will continue to represent the highest visitation demographic (overnight) and parking for these

individuals is already accounted for when they rent property for the week, coupled with the many accesses already located on Bogue Banks. Also to this effect, many of the additional parking spaces that were recently constructed in Indian Beach/Salter Path and Pine Knoll Shores under the auspices of the Morehead City Harbor Section 933 Project have been empty on the busiest days of the year and should be able to accommodate any future growth. Therefore we contend that no additional parking spaces are required for these municipalities.

We hope the Wilmington District will incorporate all of these recommendations into the Final Feasibility Report. If the President's Budget and/or Congressional funding is received to construct the project and we do not have the requisite parking/access locations in-place at that time; we will work towards those ends to ensure the maximum federal cost-share (65%) is applied to the project. As mentioned earlier in respect to the Morehead City Harbor Section 933 Project (2004 and 2007), we have an excellent track record of providing high-quality accesses and parking areas/facilities after projects have been constructed that meet the Corps' standards for full federal participation. The aforementioned Section 933 Project included ~7 miles of beach and a total of 9 access/parking areas were constructed for this effort – all were completed well after sand placement activities were concluded.

Again we would like to congratulate the District for completing the Draft Report and & EIS, and look forward to working towards its final approval and Congressional authorization.

Respectfully,

Greg Rudolph
Shore Protection Manager

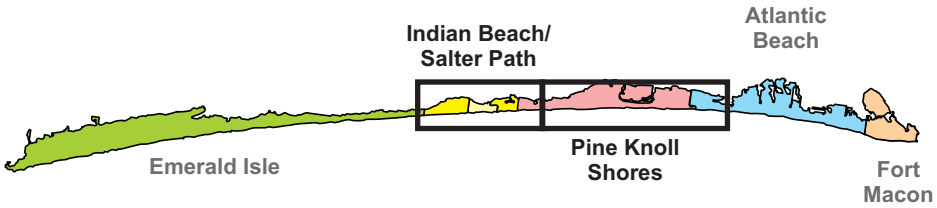
cc: Colonel Steven A. Baker, Wilmington District, USACE
Pamela Castens, Project Manager

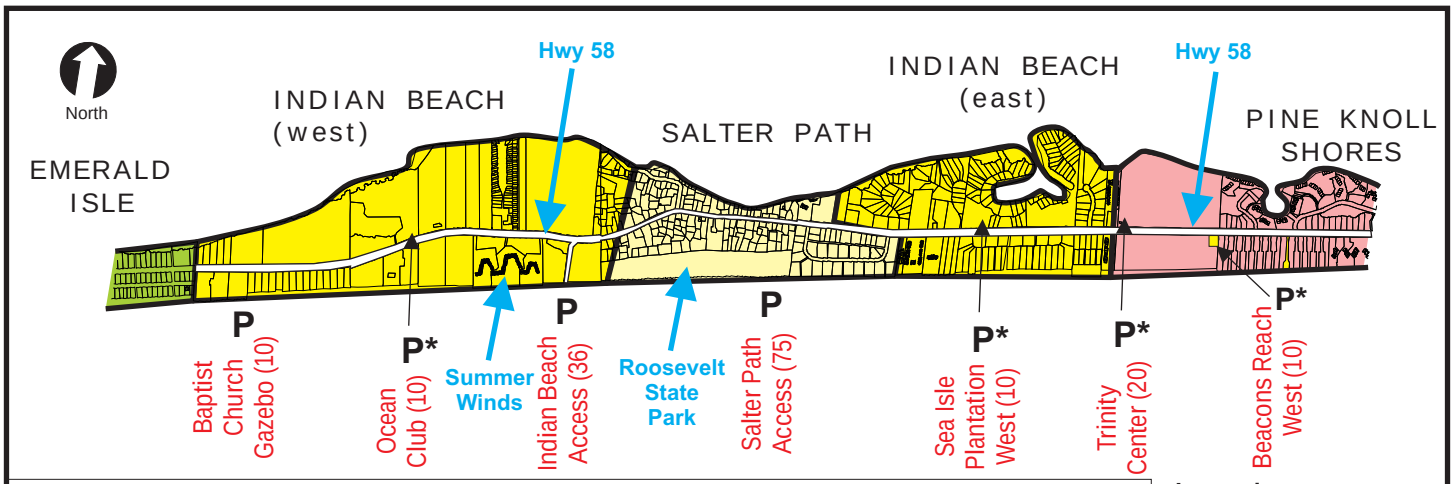
d:.../shore protect/2013/feas comments.docaug

BEACH PARKING & ACCESS LOCATION MAP

INDIAN BEACH, SALTER PATH, PINE KNOLL SHORES

Bogue Banks, Carteret County





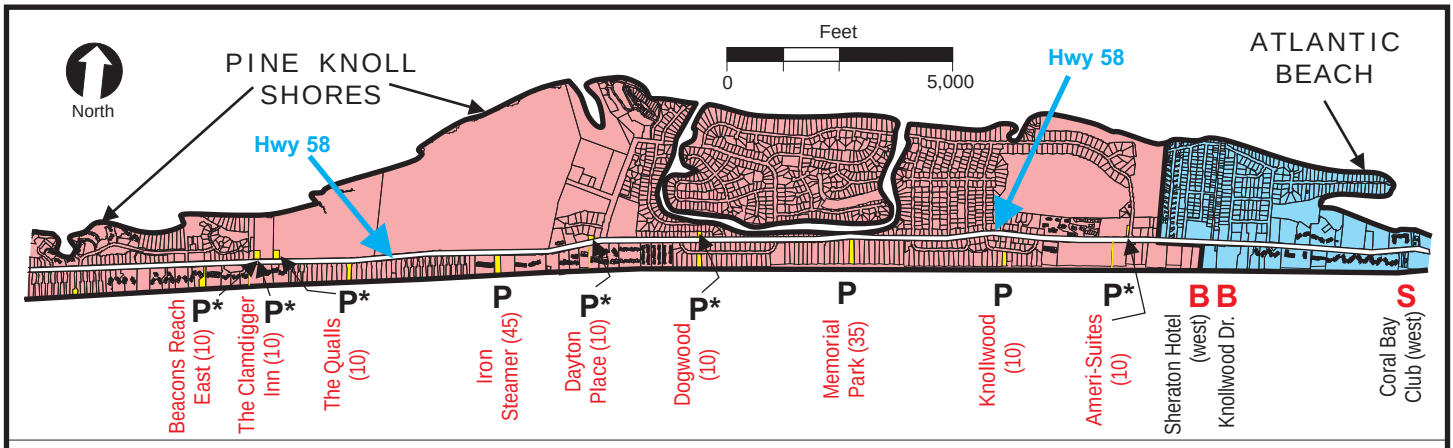
Parking Notes (east to west):

(1) **Beacons Reach West** ocean side parking (10 spaces) located across the street from Trinity Center entrance.
(2) **Trinity Center** parking (20 spaces) is located underneath the water tower at the Indian Beach/Pine Knoll Shores town boundary, milepost 9.5. The beach walkway is located across the street, south side of Hwy 58.
(3) **Sea Isle Plantation West** parking (10 spaces) located in wooded area just east of milepost 10.
(4) **Salter Path Regional Access** includes 75 parking spaces, outside showers, picnic tables, and bathrooms located within the Roosevelt State Park area.
(5) **Indian Beach Access** includes 36 parking spaces and a 4-wheel drive access ramp.
(6) **Ocean Club** parking (10 spaces) and access are located at the border of the Salter Path Campground and the Ocean Club Townhouses, milepost 11.5.
(7) **Baptist Church Gazebo** is an oceanfront facility with 10 parking spaces located at milepost 12.

Legend

P = Parking (* denotes oceanfront access with associated parking north of Hwy 58).
B = Boardwalk Access
S = Sand Path Access

Feet
0 2,500



Parking Notes (east to west):

(1) **Ameri-Suites** access is positioned along the western boundary of the Atlantis Lodge, south of Hwy 58 with associated parking located at the intersection of Oakleaf Drive & Hwy 58.
(2) **Knollwood** oceanfront parking (10 spaces) and access, emergency ramp.
(3) **Memorial Park** is an oceanfront facility located west of milepost 6 and includes 35 parking spaces, an overlook deck, and a picnic table.
(4) **Dogwood** includes an oceanfront wooden walkway with an associated wood fenced parking lot located across the street along Hwy 58.
(5) **Dayton Place** includes an oceanfront walkway with associated parking located across the street on Hwy 58 near the Fire/EMS building.
(6) **Iron Steamer** is a regional, oceanfront area (45 parking spaces) located just west of the former Iron Steamer fishing pier, near milepost 7.5 and includes a bathroom facility, showers, etc.
(7) **The Qualls** includes an oceanfront walkway within the Beacons Reach/Maritime West subdivision and associated parking located 0.25 miles west of the access, situated across Hwy 58, near the Clamdigger Inn.
(8) **The Clamdigger Inn** - Parking (20 spaces total) is within a gated public complex located north of Hwy 58 at the Clamdigger Inn. The walkway to the beach is located across the street, on the south side of Hwy 58, west of the Clamdigger.
(9) **Beacons Reach East** ocean side access with associated parking east of the access at the Clamdigger Inn.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

October 24, 2013

Mr. Eric Gasch
Planning and Environmental Branch
U.S. Army Corps of Engineers
Wilmington District
69 Darlington Avenue
Wilmington, North Carolina 28403

Subject: EPA NEPA Review Comments on Wilmington District's DEIS "Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS) Bogue Banks Coastal Storm Damage Reduction Project"; CEQ #20130238

Dear Mr. Gasch:

The U.S. Environmental Protection Agency (EPA) has reviewed the subject U.S. Army Corps of Engineers' (Corps) Draft Environmental Impact Statement (DEIS) in accordance with our responsibilities under Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. It is our understanding that the Corps initiated this study and subsequent DEIS to evaluate coastal storm damage reduction at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County.

The Corps indicates that this Feasibility study and DEIS identifies a National Economic Development (NED) plan, which is the plan that maximizes net benefits to the nation through reduction of future storm damages. The NED 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).[1]

The EPA was invited to and participated in multiple project delivery team (PDT) meetings associated with this project over the past several years. We appreciate the Corps efforts to coordinate with the Region on this project. We also appreciate the Corps granting additional time to provide comments and allow for discussion with the District on the proposed project.

Based on our analysis of the above referenced proposed action, EPA rates this DEIS as **"EC-2" i.e., EPA has "Environmental Concerns and Request Additional Information"** in the Final EIS (FEIS). The EPA's rating system criteria can be found online at: http://www.epa.gov/oecaerth/nepa/comments/ratings.html.

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[1] p. i of Executive Summary of DEIS

Our primary concerns associated with the proposed action are consideration of impacts on federally listed species, prediction of future beach renourishment needs, disclosure of current water quality conditions, potential impacts to hard bottom areas in the borrow areas, disclosure of causes of erosion along the island, timeline of the proposed action, and the need for an environmental justice analysis in the DEIS. Detailed comments are enclosed with this letter which more clearly identifies our concerns and comments. We request that a dedicated section of the FEIS include specific responses to our comments.

EPA appreciates the opportunity to review the DEIS. Should the Corps have questions regarding our comments, please feel free to contact Dan Holliman of my staff at 404/562-9531 or holliman.daniel@epa.gov.

Sincerely,

Ramona K McConney for

Heinz J. Mueller
Chief, NEPA Program Office
Office of Environmental Accountability

Attached: EPA Detailed Comments

cc: Kathy Matthews, USFWS, Raleigh Field Office

U.S. EPA DETAILED COMMENTS
ON THE INTEGRATED FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATEMENT COASTAL STORM DAMAGE REDUCTION BOGUE BANKS, CARTERET COUNTY NORTH CAROLINA
FOR THE U.S. ARMY CORPS OF ENGINEERS WILMINGTON DISTRICT

BACKGROUND:

The Draft Environmental Impact Statement (DEIS) and Feasibility Report was prepared by the U.S. Army Corps of Engineers (Corps) for a proposed coastal storm damage reduction project for Bogue Banks. Bogue Banks extends from Beaufort Inlet in the East to Bogue Inlet in the West. Bogue Banks includes the communities of Fort Macon, Atlantic Beach, Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle. EPA understands that the Corps initiated this study and subsequent DEIS to evaluate coastal storm damage reduction at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County. It is also our understanding that the Corps' ultimate goal of the project is to formulate the beach maintenance plan for Bogue Banks over the next 50 years that maximizes net economic benefits and is feasible from both an environmental and constructability standpoint.

ALTERNATIVES PROPOSED:

Multiple alternatives were considered in the DEIS, including structural measures like beach fill measures, groins, seawalls and revetments, breakwaters, vegetation, sand fencing. Nonstructural measures considered in the DEIS included regulatory measures and removal of threatened beachfront properties.

The Corps indicates in the DEIS that only the no action, regulatory measures, demolition non-structural measure and beach fill structural measures were forwarded in the plan formulation process and considered for more detailed evaluation. In addition, the Corps indicates in the DEIS that the structural (beach fill) and non-structural measures can be applied independently and in combinations with each other to develop alternative plans.

THE TENATIVELY SELECTED PLAN (TSP):

The Corps indicates that this Feasibility study and DEIS identifies a National Economic Development (NED) plan, which is the plan that maximizes net benefits to the nation through reduction of future storm damages. The NED plan consists of 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).[1]

This plan provides an estimated average annual $11,511,000 in coastal storm damage reduction benefits and $3,432,000 in recreation benefits, at an average annual cost of $6,583,500 a year, and has a Benefit Cost Ratio of 2.3 to 1. In addition, if implemented the project would also

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[1] p. i of Executive Summary of DEIS

enhance the beach area available for recreation use and provide and maintain habitat for a variety of plants and animals. [2]

The estimated first cost of the plan is $37,469,000, which would be cost-shared 65% Federal and 35% non-Federal. The project includes a 3-year nourishment cycle (16 total nourishments) with an estimated cost of $14,370,000 per nourishment. Total cost for nourishments over the 50 year life cycle of the project is $229,920,000. Nourishments would be cost shared at 50% Federal and 50% non-Federal. Beach fill monitoring is estimated at $187,500 per year and $9,375,000 over the 50 year life cycle of the project and would be cost shared at 50% Federal and 50% non-Federal. The total cost per year for the general repair, maintenance, and inspection of the project is estimated at $75,000 per year and $3,750,000 with 100% paid by non-Federal project sponsor[3]. The Corps states that the total project cost for the 50 year life cycle is $267,395,000 in current dollars.[4]

EPA COMMENTS:

Project Need and Causes of Erosion

Causes of erosion and project need should be more clearly identified and discussed in the FEIS. EPA recommends adding additional information in the FEIS related to property damage and beach erosion issues due to actual past storms events. Providing such information would better support the project need statement. EPA is unclear from the DEIS if storms are the sole cause of erosion on the island or if other causes of erosion exist. EPA recommends that the causes of erosion on Bogue Banks be fully discussed in the FEIS.

Economics

Appendix B provides tables describing the average annual remaining damages, cost and benefits by reach for all alternatives including the TSP, Alternative 9. Based on this table the total average annual net benefit from the TSP will be $7,916,625. This estimate includes potential positive benefits from protection of structures, prevention of loss of property, minimizing loss of recreation, etc.

The Corps states in Appendix B that "The average annual present value of coastal storm damages over the 50-year period of analysis without a damage reduction project totals $17,304,000 ($14,556,000 in structure and content damage and $2,748,000 in land loss) in October 2011 price levels."[5]

EPA Recommendation: EPA recommends providing additional details from actual storm events in the economic report for the FEIS that support these average annual damage estimates.

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[2] p. i of Executive Summary of DEIS
[3] Project cost estimates derived from Table 8.3 of DEIS
[4] p. 173 of DEIS – see comments below regarding total project cost discrepancies
[5] p. Appendix B-14

Examples of information that would help the reader better understand historical impacts from storms could be; 1) property and infrastructure damage estimates 2) days of recreation lost, and 3) areas of the island that were inundated by previous storm events.

Project Cost and Benefits

The Corps estimates total project cost for the 50 year life cycle is $267,395,000 in current dollars.[6] EPA notes that the average annual cost estimate for the TSP (Alternative 9) is significantly less than the cost estimate for Alternative 9 in Table 6.3. We note that these cost estimates appear to be based on different price level years, but the difference is significant. EPA also notes that if the average annual cost of the project presented in Table 6.3 is multiplied over the life of the project the total cost is significantly different from the total cost estimate provided on p. 173 of the DEIS. EPA notes that this may be due to interest and amortization, but this is unclear in the document.

EPA Recommendation: The DEIS appears to provide for multiple average annual project costs and total project cost for the TSP (Alternative 9). EPA recommends the Corps clarify the total project cost and average annual project cost in the FEIS. We also recommend that the Corps clearly state which total project cost and/or average annual cost the benefit cost ratio is based on in the FEIS.

Water Quality

EPA notes that the proposed project has the potential to impact water quality, however, the Corps suggest that the Bogue Banks project would have minimal impact on water quality. EPA concurs that the potential for significant water quality impacts for the proposed action are low, however we are concerned about the level of baseline data and information that is conveyed in the DEIS regarding water quality. Section 2.02 – Water Resources – appears to summarize surface water classifications in North Carolina and the CWA 303(d) programs. Minimal information is provided regarding the current water quality condition of Bogue Sound, Bogue Inlet, White Oak River, Newport River, and Beaufort Inlet. In addition, no information is provided in the DEIS relating to currently permitted NPDES discharges and there is no discussion regarding wastewater effluent, treatment facilities (septic/municipal, types, locations, etc.) from homes and businesses. EPA believes this information is very important and should be provided in this document.

EPA Recommendation: EPA recommends the Corps provide significantly more information in the FEIS regarding existing water quality for Bogue Sound, Bogue Inlet, White Oak River, Newport River, and Beaufort Inlet. This additional information should include but not be limited to recent water quality assessments of these areas, maps of sampling locations, and existing water quality classifications of potently impacted waters. Furthermore, we recommend that additional information be provided in the FEIS regarding existing permitted NPDES discharges and wastewater treatment facilities and infrastructure in the project area. Significant storms have

[6] Total project cost estimates from p. 173 of DEIS

the potential of damaging this infrastructure which can cause runoff to marine and sound waters of bacteria and other pollutants that can cause public health issues following storm events. If the proposed project provides protection for this infrastructure then it should be disclosed in the FEIS.

Selection of Least Environmentally Damaging Practicable Alternative (LEDPA)
EPA understands that the proposed project must comply with the requirements of our regulations pursuant to the Clean Water Act (CWA) Section 404(b)(1) Guidelines ("Guidelines"; 40 C.F.R. 230). The Corps provides a 404(b) Analysis in Appendix K of the DEIS. Based on our assessment of Appendix K and the main document of the DEIS it is unclear on how the Corps came to the conclusion that the proposed project is the LEDPA. The LEDPA is not identified in the main document of the DEIS in the context of the multiple alternatives presented.

EPA Recommendation: EPA recommends the Corps provide significantly more information in the FEIS on how the TSP meets the CWA Section 404(b)(1) Guidelines ("Guidelines"; 40 C.F.R. 230). The rationale of how the LEDPA was determined in the context of the other alternatives presented in the DEIS should be provided in the FEIS. Actions to avoid and minimize adverse impacts to the environment should be included in this additional information in the FEIS. In addition, it is also unclear from the DEIS if the Corps considers the TSP, Alternative 9, as the "environmentally preferable alternative"[7], therefore EPA also encourages the Corps to identify the environmentally preferable alternative in the FEIS.

Length of Project
EPA is concerned with the length of the project (50-year project period) because so much could change environmentally and economically over such a long period of time. After a number of years of borrow site use, monitoring of the sediments and trends in offshore borrow site topography could indicate substantial changes occurring to the island and the near-shore environment. If unexpected erosion loss of borrow site sediment is detected, it could necessitate major revisions to the long term shoreline maintenance plan. From a biological perspective, increased knowledge and trends of fish migrations, turtle nesting, and shore bird nesting behavior could also require modification of the proposed maintenance plan. The plan, therefore, should have required periodic adaptive management. The only reference in the DEIS to adaptive management can be found on p. 58, "Adaptive management plans formulated to address project uncertainties also have to be considered."

EPA Recommendation: EPA recommends the Corps provide a clear adaptive management strategy in the FEIS that includes performance and/or success criteria that will adequately capture the dynamic nature of the proposed project and help direct any future changes to the project that may be needed to avoid and minimize impacts to the environment.

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[7] NEPA Section 101

Estimated Material for Project

Figure 1.2 provides a clear visual of historical placement of material on Bogue Banks shoreline between (1978-2010). Based on our calculations the following amount of material has been deposited along the shoreline during the following time periods:

1978-1984	1985-1991	1992-1998	1999-2005	2006-2010 (5 yrs.)
1,194,600 cy	**4,254,600 cy**	**4,824,400 cy**	**8,380,533 cy**	**2,238,560 cy**

The total amount of material deposited over the 33 year period depicted in Figure 1.2 is 20,892,693 cy.

The TSP consists of 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).[8] The Corps states that the TSP will require 2.45 million cubic yards of material during initial construction and approximately 1.07 million cubic yards of material for each renourishment cycle (16 total renourishments planned). The total amount of material needed for this project is estimated at 19.55 million cubic yards for the initial construction all subsequent renourishments.[9] EPA notes that the amount of material proposed for this project over the 50 year life is less than the amount of material that has historically been placed on the Bogue Banks shoreline over a 33 year period. However, after additional discussion with the Corps we understand that there is a significant difference between material disposal activities presented in Figure 1.2. Historically, material used in beach nourishment activities at Bogue Banks has originated from multiple sources (Bogue Inlet AIWW Crossing Disposal, MHC Inner Harbor Maintenance Dredge Disposal, etc.), and these disposal activities may or may not function as storm damage reduction similar to the currently proposed project.

EPA Recommendation: We recommend the Corps provide additional discussion in the FEIS about the difference in historical material placement presented in Figure 1.2. Specifically, we recommend the Corps make clear distinctions between storm damage reduction activities and disposal of navigational dredge material that may not provide storm damage reduction benefits. In addition, if historical nourishment activities associate with Bogue Inlet AIWW Crossing Disposal, MHC Inner Harbor Maintenance Dredge Disposal, etc. are to continue through the life of the currently proposed project, we recommend providing additional discussion in the FEIS on how these activities are interrelated with the currently proposed project.

Federally Listed Species

EPA notes that Table 2.4 provides a list of Federal Threatened and Endangered Species potentially present in Carteret County, North Carolina. This table appears to be significantly different from information provided on USFWS's website for the current list of Endangered

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[8] p. i of Executive Summary of DEIS

[9] Fill estimates based on p. 77 of DEIS

Species, Threatened Species, Federal Species of Concern, and Candidate Species, Carteret County, North Carolina. USFWS Website:

http://www.fws.gov/raleigh/species/cntylist/carteret.html

EPA notes that the Atlantic Sturgeon, *Acipenser oxyrhynchus oxyrhynchus*, is listed as a Federal Species of Concern. However, EPA notes that the USFWS's website provided above list the Atlantic Sturgeon as Endangered. EPA also notes several species listed on the USFWS website are not listed in Table 2.4.

EPA also notes that the discussion about Piping Plover Critical Habitat is not described fully in text. Figure 2.3 identifies general locations including NC Units 7, 8, 9 and 10. The extent of these areas is not fully described (e.g. linear feet of beach; acreage, etc.). Lastly, discussion concerning a rare butterfly, *Atrytonopsis* sp. *1*, was not fully evaluated in the context of the current survey being conducted for the USFWS.

EPA Recommendation: EPA recommends continued coordination with the USFWS. EPA recommends the Corps revise and update Table 2.4 in the FEIS to reflect the current status of federally listed species. EPA also recommends that the linear feet of beach and acreages be provided in the FEIS with respect to piping plover critical habitat. EPA also recommends that the Corps provide additional details about the on-going study of *Atrytonopsis* sp. *1*. Including details in the FEIS about the study such as when the study started, projected completion date, and any interim results would be helpful for reviewers.

Hard Bottom Areas

EPA continues to be concerned with potential impacts to hard bottom areas from off-shore dredging and beach nourishment activities. We continue to recommend rigorous delineation of all hard bottom resources within the proposed borrow areas and fill placement areas to avoid impacts to hard bottom resources. EPA notes that the Corps determined in the DEIS that there are no hardbottom resources in the nearshore zone for the project. However, the Corps indicates that there are hardbottom resources located within Borrow Areas U and Y.[10] The Corps proposes to protect these resources by providing for a 500 meter buffer, but does not provide a citation for scientific study that supports the 500 meter buffer as protective for the hardbottom areas.

EPA Recommendation: EPA recommends the Corps revise the FEIS by adding additional data and citations to support the proposed 500 meter buffer for hardbottom areas. Any loss of the existing hard bottom features offshore should be investigated promptly to determine causal factors and appropriate action.

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[10] p. 20 of DEIS

Sand Compatibility

According to a study cited in the DEIS,[11] management strategies recommended to protect surf zone fishes and invertebrates include: (1) project timing, (2) sediment compatibility, (3) nourishment duration, and (4) innovative ways to minimize effects (i.e., staging nourishment events). EPA considers using borrow material that is comparable to the natural beach material is paramount in protecting surf zone fishes and invertebrates and federally listed species. Based on our review of the DEIS, it appears that the Corps has not committed to using the North Carolina Sediment Criteria Rule (15A NCAC 07H.0312: Technical Standards for Beach Fill Projects). EPA continues to support the use of the North Carolina Sediment Criteria Rule. Ensuring the grain size of the dredged material is compatible with existing beach sands will not inhibit turtle and seabird nesting activities and will minimize future beach erosion. Based on discussions with the Corps we understand that the Corps believes the sediment criteria proposed in the DEIS will be protective federally listed species.

EPA Recommendation: EPA recommends the Corps provide addition clarification in the FEIS regarding historical beach renourishment activities in North Carolina as they relate to the sand compatibility criteria proposed in this DEIS and impacts on federally listed species. Specifically, if the Corps has conducted species surveys and /or other studies of historical beach nourishment activities using the proposed sand criteria for this project and impacts to species, we recommend the Corps include these in the FEIS.

Nourishment Schedule

Due to the potential impacts of beach nourishment activities on federally listed species, EPA supports a longer period of time between renourishment intervals (currently 3 years is the proposed interval). The Corps provides an analysis in the DEIS that provides a comparison of benefits and cost for the different renourishment intervals.[12] Based on Table 5.10, the difference or delta for the average annual benefits for the 3 year interval vs. the 5 year interval is only $79,000.

EPA Recommendation: EPA recommends the Corps provide additional support in the FEIS for selection of the 3 year interval versus a longer renourishment interval which EPA believes would be more protective of federally-listed species.

Consideration of Environmental Justice Impacts

Pursuant to the Executive Order 12898 entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" and the accompanying Presidential Memorandum, EPA is unable to locate an EJ analysis in the DEIS with the exception of a no effect determination provided in table 5.9.

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[11] Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. *A Review and Synthesis of Data on Surf Zone Fishes and Invertebrates in the South Atlantic Bight and the Potential Impacts from Beach Nourishment.* Prepared for the U.S. Army Corps of Engineers, Wilmington, NC.

[12] Section 5.08.2 of DEIS – p. 75

EPA Recommendation: EPA recommends that the FEIS include an EJ analysis that includes descriptions of the local demographics and identifies low-income and minority populations that have the potential to be impacted by the proposed action. Should the demographic analysis identify minority and low-income populations, the FEIS should describe efforts made to meaningfully engage these populations in the decision-making process. In addition, EPA recommends the FEIS identify communities with EJ concerns that may engage in subsistence activities within the project area (i.e., subsistence fishing). A summary of EJ comments or concerns identified during the public involvement process along with agency responses to those concerns and efforts to avoid, minimize or mitigate potential impacts should also be included in the FEIS.

Environmental Commitments and Record of Decision (ROD)

EPA recommends that general repair, maintenance, inspection, monitoring requirements, and environmental commitments being made by the project sponsor and the Corps be documented in the ROD. The ROD should also clearly outline adaptive management plan commitments for the 50 year life of the project.

Editorial Comments

- List of acronyms and abbreviations should be provided for main document and all appendices.
- Several tables and graphs in the appendices have no table or figure numbers and are not clearly relatable back to text. (example p. 60-77 of Appendix B)
- Page 12: Lobate sand. Not defined.
- Page 13: ppt not defined.
- Page 13: EPA recommends addition clarification in the FEIS as to which areas or parts of Bogue Sound are SB, SC & SA HQW
- Page 14: EPA recommends additional details regarding drinking water source for residents on Bogue Banks be added to this section.
- Page 15. Last check on attainment status was 11/26/2010.
- Several Reports cited in DEIS are dated:
    - Page 15: Marine environment draft report from 2002 (USFWS)
    - Page 16: benthic sampling in 2000
    - Page 22: EFH reports from 2001
    - Pages 28 and 29: Discussions regarding Maritime forest, Beach and Dune areas, and other vegetation discussions referenced to 2002 USFWS report
    - Pages 30 and 31: Discussions regarding birds are from 1985 and 2002
    - EPA is concerned that these
- Page 40: Table 2.6 Pine Knoll Shores lost population between 2000 and 2010 (i.e., 1,524 to 1,337). EPA recommends providing explanation for this decrease is provided (all other populations trends showed a substantial increase during the same period).
- Page 49: Key general assumptions: "near full development" for the purposes of economic modeling. No additional shorefront development will be occurring. EPA recommends

providing the actual land use data (required in 5-year CAMA plans) supporting this assumption.

- Page 50: Historic trends of FEMA emergency beach renourishment actions are not provided in DEIS. The assumption that this trend would/would not continue into the future or be part of the alternatives and decision-making process is an important missing element in this discussion of 'key general assumptions'. EPA recommends providing this information in the FEIS.
- Page 51: '*Monte Carlo simulation*' not explained. EPA recommends providing a description of *Monte Carlo simulation* in the FEIS.
- Pages 52 and 53: Within economic reach 21-41, the Corps does not provide information as to why this area is not showing significant erosion or accretion rates. EPA recommends clarifying this in the FEIS.
- Page 53: '*300 Life-cycles*' not defined or explained. EPA recommends clarifying this in the FEIS.
- Page 56: Section 4.07: Pine Knoll Shores lost population between 2000 and 2010 (i.e., 1,524 to 1,337). No explanation for this decrease is provided in the context of the Carteret County population increase projection. EPA recommends clarifying this in the FEIS.

From: Lauren Shaffer
To: Gasch, Eric K SAW
Subject: [EXTERNAL] Bogue Banks Coastal Storm Damage Reduction Draft EIS Comment
Date: Saturday, September 21, 2013 8:31:44 AM

Mr. Gasch,

In studying the Integrated Feasibility Report and Draft Environmental Impact Statement for the Coastal Storm Damage Reduction Project for Bogue Banks, Carteret County North Carolina, I felt that the described economic and constraints of the alternatives of the proposed shoreline stabilization project were well developed. The draft report succinctly outlines the current state of shoreline erosion and vulnerability to storms on Bogue Banks, providing a valid argument for the necessity of decisive action to enhance the shoreline. The EIS outlines the potential detrimental effects of several project alternatives, including the alternative of no action.

My one concern is the restoration of benthic resources along the beach and surf zones. This document describes the short term and localized impact to the surf zone benthic macroinvertebrate community from direct burial and the turbidity associated with the placement of dredged materials and sediment. As this community is utilized by shorebirds and other fauna, the detrimental effects apply not only to the benthic macroinvertebrate community, but to the larger fauna as well. Since the topmost layer of sediment, which provides the habitat for this community, will be buried under the dredged sediment that will be used to reconstruct the beach, I was interested to see if there could be any action taken to prevent this adverse effect from the proposed project. Similar to the retention of topsoil in terrestrial projects, I was curious about the feasibility of removing the topmost layer of sand prior to the addition of dredged material to the beach. Could the topmost layer be retained and held in a state that could protect the viability of the existing benthic community as well as other organisms, with the intention of returning this layer to the top of the dredged material after a section of the shoreline stabilization project has been finished? This alternative may have the potential to reduce the lag time between the finalization of the project and the restoration of the community that originally existed in this segment of the beach and shoreline. This could also provide a benefit to shorebirds as well as other organisms that are dependent on the shoreline habitat.

In all likelihood, this action may not be feasible and may be cost prohibitive, but as the EIS has outlined the proposed detrimental and beneficial effects of the addition of dredged materials to the beach and shoreline, I was curious if a proposal had been made to mitigate this impact.

Sincerely,

Lauren

Lauren Shaffer

Graduate Student

Virginia Tech

Department of Natural Resources

laurls7@vt.edu

North Carolina
Department of Administration

Pat McCrory, Governor

Bill Daughtridge, Jr., Secretary

September 12, 2013

Mr. Eric Gasch
Department of the Army
Wilmington District
Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402

Re: SCH File # 14-E-0000-0060; DEIS to evaluate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks.

Dear Mr. Gasch:

The above referenced environmental impact information has been submitted to the State Clearinghouse under the provisions of the National Environmental Policy Act. According to G.S. 113A-10, when a state agency is required to prepare an environmental document under the provisions of federal law, the environmental document meets the provisions of the State Environmental Policy Act. Attached to this letter for your consideration are the comments made by agencies in the course of this review.

If any further environmental review documents are prepared for this project, they should be forwarded to this office for intergovernmental review.

Should you have any questions, please do not hesitate to call.

Sincerely,

Crystal Best

Crystal Best
State Environmental Review Clearinghouse

Attachments

cc: Region P

Mailing Address:
1301 Mail Service Center
Raleigh, NC 27699-1301

Telephone: (919)807-2425
Fax (919)733-9571
State Courier #51-01-00
e-mail state.clearinghouse@doa.nc.gov

Location Address:
116 West Jones Street
Raleigh, North Carolina

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North Carolina Department of Environment and Natural Resources

Pat McCrory
Governor

John E. Skvarla, III
Secretary

MEMORANDUM

TO: Crystal Best
State Clearinghouse

FROM: Lyn Hardison
Division of Environmental Assistance and Customer Service
Permit Assistance & Project Review Coordinator

RE: 14-0060
Draft Environmental Impact Statement
DEIS to evaluate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks
Carteret

Date: September 11, 2013

The Department of Environment and Natural Resources has reviewed the proposal for the referenced project. The comments are attached for the applicant's consideration.

The Department encourages the applicant to continue communicating with the agencies as they move forward with the project.

Thank you for the opportunity to respond.

Attachment

1601 Mail Service Center, Raleigh, North Carolina 27699-1601
Phone: 919-707-8600 \ Internet: www.ncdenr.gov

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Department of Environment and Natural Resources
Project Review Form

Project Number: 14-0060 **County: Carteret** **Date Received: 08/09/2013**

Due Date: 9/4/2013

Project Description: Draft Environmental Impact Statement - DEIS to evaulate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks.

This Project is being reviewed as indicated below:

Comments sent to Jackie & Paddy

Regional Office	Regional Office Area	In-House Review	
___ Asheville	___ Air	___ Air Quality	✓ Coastal Management (DCM)
___ Fayetteville	✓ DWR-Surface Water JHS 08-30-13	✓ DCM- Marine Fisheries J.Baker	___ Military Affairs
___ Mooresville	___ DWR-Aquifer	✓ Parks & Recreation	✓ DWR-Water Quality Program
___ Raleigh	✓ DEMLR SW 8/20/13	___ Waste Mgmt	___ DWR-Water Quality - DOT
___ Washington	___ UST 8/4/13 RS no comment	___ Water Resources Mgmt (DWR)	✓ Wildlife Maria Dunn
✓ Wilmington		___ DWR-Water Supply Section	___ Wildlife - DOT
___ Winston-Salem			

Manager Sign-Off/Region:	Date:	In-House Reviewer/Agency:

Response (check all applicable)

___ No objection to project as proposed. ___ No Comment

___ Insufficient information to complete review ✗ Other (specify or attach comments) JHS 8/30/13

If you have any questions, please contact:

Lyn Hardison at lyn.hardison@ncdenr.gov or (252) 948-3842
943 Washington Square Mall Washington NC 27889
Courier 16-04-01

North Carolina Department of Environment and Natural Resources
Division of Water Resources
Water Quality Programs
Thomas A. Reeder
Director

Pat McCrory
Governor

John E. Skvarla, III
Secretary

September 3, 2013

MEMORANDUM

TO: Lyn Hardison, Environmental Assistance Coordinator
Department of Environment and Natural Resources

THROUGH: Evan Kane 9/3

FROM: Hannah Headrick

SUBJECT: DEIS – Coastal Storm Damage Reduction, Bogue Banks
DWQ#14493; DENR#14-0060

The Division of Water Resources Water Quality Program section has the following comments on the subject project:

1) The use of berms to reduce the turbidity needs to be described in better detail as to the exact location of the berm for each section of beach and if it is located within the surf zone. Please specify the location of the discharge pipe in relation to the berm and the water. Also, an alternative plan of how the turbidity may be reduced could be necessary if the turbidity exceeds the turbidity limits outside the 1000' mixing zone.
2) The project will require a 401 permit application.
3) A plan for measuring the turbidity at the 1000' and 1500' limits of the project during daily operation needs to be included with the 401 application.

If you have any questions about these comments, please contact me at (919) 807-6434 or hannah.headrick@ncdenr.gov. Thank you.

Ecc: Jim Gregson – WiRO
Jackie Roddy – WPS

1617 Mail Service Center, Raleigh, North Carolina 27699-1617
Location: 512 N. Salisbury St. Raleigh, North Carolina 27604
Phone: 919-807-6300 \ Fax: 919-807-6492
Internet: www.ncwaterquality.org

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State of North Carolina
Department of Environment and Natural Resources

Reviewing Office: Wilmington Regional Office

INTERGOVERNMENTAL REVIEW - PROJECT COMMENTS

Project Number: 14-0060 Due Date: 9/4/13

After review of this project it has been determined that the ENR permit(s) and/or approvals indicated may need to be obtained in order for this project to comply with North Carolina Law. Questions regarding these permits should be addressed to the Regional Office indicated on the reverse of the form. All applications, information and guidelines relative to these plans and permits are available from the same Regional Office.

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
☐	Permit to construct & operate wastewater treatment facilities, sewer system extensions & sewer systems not discharging into state surface waters.	Application 90 days before begin construction or award of construction contracts. On-site inspection. Post-application technical conference usual.	30 days (90 days)
☐	NPDES - permit to discharge into surface water and/or permit to operate and construct wastewater facilities discharging into state surface waters.	Application 180 days before begin activity. On-site inspection. Pre-application conference usual. Additionally, obtain permit to construct wastewater treatment facility-granted after NPDES. Reply time, 30 days after receipt of plans or issue of NPDES permit-whichever is later.	90-120 days (N/A)
☐	Water Use Permit	Pre-application technical conference usually necessary	30 days (N/A)
☐	Well Construction Permit	Complete application must be received and permit issued prior to the installation of a well.	7 days (15 days)
☐	Dredge and Fill Permit	Application copy must be served on each adjacent riparian property owner. On-site inspection. Pre-application conference usual. Filling may require Easement to Fill from N.C. Department of Administration and Federal Dredge and Fill Permit.	55 days (90 days)
☐	Permit to construct & operate Air Pollution Abatement facilities and/or Emission Sources as per 15 A NCAC (2Q.0100 thru 2Q.0300)	Application must be submitted and permit received prior to construction and operation of the source. If a permit is required in an area without local zoning, then there are additional requirements and timelines (2Q.0113).	90 days
☐	Permit to construct & operate Transportation Facility as per 15 A NCAC (2D.0800, 2Q.0601)	Application must be submitted at least 90 days prior to construction or modification of the source.	90 days
☐	Any open burning associated with subject proposal must be in compliance with 15 A NCAC 2D.1900	N/A	60 days (90 days)
☐	Demolition or renovations of structures containing asbestos material must be in compliance with 15 A NCAC 20.1110 (a) (1) which requires notification and removal prior to demolition. Contact Asbestos Control Group 919-707-5950.		
☐	Complex Source Permit required under 15 A NCAC 2D.0800		
☐	The Sedimentation Pollution Control Act of 1973 must be properly addressed for any land disturbing activity. An erosion & sedimentation control plan will be required if one or more acres to be disturbed. Plan filed with proper Regional Office (Land Quality Section) At least 30 days before beginning activity. A fee of $65 for the first acre or any part of an acre. An express review option is available with additional fees.		20 days (30 days)
☐	Sedimentation and erosion control must be addressed in accordance with NCDOT's approved program. Particular attention should be given to design and installation of appropriate perimeter sediment trapping devices as well as stable stormwater conveyances and outlets.		(30 days)
☐	Mining Permit	On-site inspection usual. Surety bond filed with ENR Bond amount varies with type mine and number of acres of affected land. Any are mined greater than one acre must be permitted. The appropriate bond must be received before the permit can be issued.	30 days (60 days)
☐	North Carolina Burning permit	On-site inspection by N.C. Division Forest Resources if permit exceeds 4 days	1 day (N/A)
☐	Special Ground Clearance Burning Permit - 22 counties in coastal N.C. with organic soils	On-site inspection by N.C. Division Forest Resources required "if more than five acres of ground clearing activities are involved. Inspections should be requested at least ten days before actual burn is planned."	1 day (N/A)
☐	Oil Refining Facilities	N/A	90-120 days (N/A)
☐	Dam Safety Permit	If permit required, application 60 days before begin construction. Applicant must hire N.C. qualified engineer to: prepare plans, inspect construction. certify construction is according to ENR approved plans. May also require permit under mosquito control program. And a 404 permit from Corps of Engineers. An inspection of site is necessary to verify Hazard Classification. A minimum fee of $200.00 must accompany the application. An additional processing fee based on a percentage or the total project cost will be required upon completion.	30 days (60 days)

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
☐	Permit to drill exploratory oil or gas well	File surety bond of $5,000 with ENR running to State of NC conditional that any well opened by drill operator shall, upon abandonment, be plugged according to ENR rules and regulations.	10 days N/A
☐	Geophysical Exploration Permit	Application filed with ENR at least 10 days prior to issue of permit. Application by letter. No standard application form.	10 days N/A
☐	State Lakes Construction Permit	Application fees based on structure size is charged. Must include descriptions & drawings of structure & proof of ownership of riparian property.	15-20 days N/A
☒	401 Water Quality Certification	N/A	60 days (130 days)
☐	CAMA Permit for MAJOR development	$250.00 fee must accompany application	55 days (150 days)
☐	CAMA Permit for MINOR development	$50.00 fee must accompany application	22 days (25 days)
☐	Several geodetic monuments are located in or near the project area. If any monument needs to be moved or destroyed, please notify: N.C. Geodetic Survey, Box 27687 Raleigh, NC 27611		
☐	Abandonment of any wells, if required must be in accordance with Title 15A. Subchapter 2C.0100.		
☐	Notification of the proper regional office is requested if "orphan" underground storage tanks (USTS) are discovered during any excavation operation.		
☐	Compliance with 15A NCAC 2H 1000 (Coastal Stormwater Rules) is required.		45 days (N/A)
☐	Tar Pamlico or Neuse Riparian Buffer Rules required.		
*	Other comments (attach additional pages as necessary, being certain to cite comment authority)		

REGIONAL OFFICES

Questions regarding these permits should be addressed to the Regional Office marked below.

☐ **Asheville Regional Office**
2090 US Highway 70
Swannanoa, NC 28778
(828) 296-4500

☐ **Fayetteville Regional Office**
225 North Green Street, Suite 714
Fayetteville, NC 28301-5043
(910) 433-3300

☐ **Mooresville Regional Office**
610 East Center Avenue, Suite 301
Mooresville, NC 28115
(704) 663-1699

☐ **Raleigh Regional Office**
3800 Barrett Drive, Suite 101
Raleigh, NC 27609
(919) 791-4200

☐ **Washington Regional Office**
943 Washington Square Mall
Washington, NC 27889
(252) 946-6481

☐ **Wilmington Regional Office**
127 Cardinal Drive Extension
Wilmington, NC 28405
(910) 796-7215

☐ **Winston-Salem Regional Office**
585 Waughtown Street
Winston-Salem, NC 27107
(336) 771-5000

20130060

Department of Environment and Natural Resources
Project Review Form

Project Number: 14-0060 **County: Carteret** **Date Received: 08/09/2013**

AUG 09 2013

Due Date: 9/4/2013

AUG 16 2013

Project Description: Draft Environmental Impact Statement - DEIS to evaulate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks.

This Project is being reviewed as indicated below:

Regional Office	Regional Office Area	In-House Review	
___ Asheville	___ Air	___ Air Quality	✓ Coastal Management (DCM)
___ Fayetteville	✓ DWR-Surface Water	✓ DCM- Marine Fisheries J.Baker	___ Military Affairs
___ Mooresville	___ DWR-Aquifer	✓ Parks & Recreation	✓ DWR-Water Quality Program
___ Raleigh	✓ DEMLR	___ Waste Mgmt	___ DWR-Water Quality - DOT
___ Washington	___ UST	___ Water Resources Mgmt (DWR)	✓ Wildlife Maria Dunn
✓ Wilmington		___ DWR-Water Supply Section	___ Wildlife - DOT
___ Winston-Salem			

Manager Sign-Off/Region:	Date:	In-House Reviewer/Agency:
[illegible]	8/16/2013	Coastal Management

Response (check all applicable)

___ No objection to project as proposed.

✓ No Comment

___ Insufficient information to complete review

___ Other (specify or attach comments)

Project was submitted for Consistency Review and will be evaluated under that review

If you have any questions, please contact:

Lyn Hardison at lyn.hardison@ncdenr.gov or (252) 948-3842
943 Washington Square Mall Washington NC 27889
Courier 16-04-01

Return to Lyn

Saeed Mohamed

NORTH CAROLINA STATE CLEARINGHOUSE
DEPARTMENT OF ADMINISTRATION
INTERGOVERNMENTAL REVIEW

COUNTY: CARTERET

H05: IRRIGATION/DRAINAGE/FLOOD CONTROL

STATE NUMBER: 14-E-0000-0060
DATE RECEIVED: 08/09/2013
AGENCY RESPONSE: 09/04/2013
REVIEW CLOSED: 09/09/2013

MS CARRIE ATKINSON
CLEARINGHOUSE COORDINATOR
DEPT OF TRANSPORTATION
STATEWIDE PLANNING - MSC #1554
RALEIGH NC

REVIEW DISTRIBUTION

CC&PS - DIV OF EMERGENCY MANAGEMENT
DENR - COASTAL MGT
DENR LEGISLATIVE AFFAIRS
DEPT OF AGRICULTURE
DEPT OF CULTURAL RESOURCES
DEPT OF TRANSPORTATION
EASTERN CAROLINA COUNCIL

AUG 2013 RECEIVED

PROJECT INFORMATION

APPLICANT: Department of the Army
TYPE: National Environmental Policy Act
Draft Environmental Impact Statement

DESC: DEIS to evaulate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks.

The attached project has been submitted to the N. C. State Clearinghouse for intergovernmental review. Please review and submit your response by the above indicated date to 1301 Mail Service Center, Raleigh NC 27699-1301.

If additional review time is needed, please contact this office at (919)807-2425.

AS A RESULT OF THIS REVIEW THE FOLLOWING IS SUBMITTED: ☒ NO COMMENT ☐ COMMENTS ATTACHED

SIGNED BY: Saeed Mohamed DATE: 8/23/2013

AUG 2013 RECEIVED Secretary's Office DOA

NORTH CAROLINA STATE CLEARINGHOUSE
DEPARTMENT OF ADMINISTRATION
INTERGOVERNMENTAL REVIEW

COUNTY: CARTERET

H05: IRRIGATION/DRAINAGE/FLOOD CONTROL

STATE NUMBER: 14-E-0000-0060
DATE RECEIVED: 08/09/2013
AGENCY RESPONSE: 09/04/2013
REVIEW CLOSED: 09/09/2013

MS ELIZABETH HEATH
CLEARINGHOUSE COORDINATOR
DEPT OF AGRICULTURE
1001 MSC - AGRICULTURE BLDG
RALEIGH NC

REVIEW DISTRIBUTION

CC&PS - DIV OF EMERGENCY MANAGEMENT
DENR - COASTAL MGT
DENR LEGISLATIVE AFFAIRS
DEPT OF AGRICULTURE
DEPT OF CULTURAL RESOURCES
DEPT OF TRANSPORTATION
EASTERN CAROLINA COUNCIL

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If additional review time is needed, please contact this office at (919)807-2425.

AS A RESULT OF THIS REVIEW THE FOLLOWING IS SUBMITTED: ☒ NO COMMENT ☐ COMMENTS ATTACHED

SIGNED BY: Elizabeth H. Heath DATE: 8/27/13

AUG 2013
RECEIVED
Secretary's Office
DOA

NORTH CAROLINA STATE CLEARINGHOUSE
DEPARTMENT OF ADMINISTRATION
INTERGOVERNMENTAL REVIEW

COUNTY: CARTERET

H05: IRRIGATION/DRAINAGE/FLOOD CONTROL

STATE NUMBER: 14-E-0000-0060
DATE RECEIVED: 08/09/2013
AGENCY RESPONSE: 09/04/2013
REVIEW CLOSED: 09/09/2013

MS CAROLYN PENNY
CLEARINGHOUSE COORDINATOR
CC&PS - DIV OF EMERGENCY MANAGEMENT
FLOODPLAIN MANAGEMENT PROGRAM
MSC # 4719
RALEIGH NC

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REVIEW DISTRIBUTION

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DENR LEGISLATIVE AFFAIRS
DEPT OF AGRICULTURE
DEPT OF CULTURAL RESOURCES
DEPT OF TRANSPORTATION
EASTERN CAROLINA COUNCIL

PROJECT INFORMATION

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If additional review time is needed, please contact this office at (919)807-2425.

AS A RESULT OF THIS REVIEW THE FOLLOWING IS SUBMITTED: [X] NO COMMENT [ ] COMMENTS ATTACHED

SIGNED BY: John D Burdock DATE: 21 AUG 2013

11988 Addressed.

AUG 2013
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Secretary's Office
DCA

North Carolina Department of Cultural Resources

State Historic Preservation Office

Peter B. Sandbeck, Administrator

Michael F. Easley, Governor
Lisbeth C. Evans, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

November 26, 2007

Richard H. Kimmel, Archaeologist
Wilmington District Corps of Engineers
P.O. Box 1890
Wilmington, NC 28402-1890

Re: Remote Sensing Survey of Bogue Banks Offshore Borrow Areas, Carteret County, ER 03-3634

Dear Mr. Kimmel:

Thank you for your letter of September 14, 2007, transmitting the archaeological survey report by Mid-Atlantic Technology and Environmental Research, Inc. (MATER) for the above project. During the course of the project, MATER surveyed four areas designated as Borrow Area U, Borrow Area Y, Borrow Area Q1, and Borrow Area Q2. We have reviewed the results of the remote sensing survey of these areas and MATER's analysis and recommendations and provide the following comments, regarding the need for additional archaeological investigation and/or avoidance of those areas.

Borrow Area U: No unidentified remote sensing targets were located in this borrow area, and MATER recommends no further archeological investigation. We concur.

Borrow Area Y: One potentially significant target was located in this borrow area. MATER recommended additional investigation of that target or avoidance by the creation of a no-impact buffer zone. We concur.

Borrow Area Q1: No unidentified remote sensing targets were located in this borrow area, and MATER recommends no further archeological investigation. We concur.

Borrow Area Q2: MATER identified thirty-three magnetic and/or acoustic targets or target clusters in this area. In reviewing the distribution of those targets, there appears to be two concentrations of anomalies. One concentration encompasses the northeastern quadrant of the borrow area and includes targets Q2-1 to Q2-17 and Q2-19 and Q2-22. MATER recommended additional investigation or avoidance of fourteen of those targets.

Our recommendation is that this entire area be excluded from sand borrowing activities. We base our recommendation on two factors.

1. This area incorporates a portion of Beaufort Inlet's historic shoal, an area likely to contain shipwreck remains. In fact, two of MATER's targets have previously been located and identified. Q2-3 is an 18th century anchor associated with the *Queen Anne's Revenge* shipwreck site and Q2-9 coincides with a shipwreck investigated by Intersal, Inc. in 1997. It is likely that most of the other targets identified by MATER in this area also represent shipwreck remains.

Location: 109 East Jones Street, Raleigh NC 27601 **Mailing Address**: 4617 Mail Service Center, Raleigh NC 27699-4617 **Telephone/Fax**: (919) 807-6570/807-6599

2. Even if all of these sites could be avoided, sand mining from this portion of the inlet's ebb tide delta would have an adverse effect on nearby shipwrecks, including the *Queen Anne's Revenge* — a property listed in the National Register of Historic Places. Our May 6, 2005, letter to Col. Charles Alexander provides a detailed discussion of our concerns regarding dredging, related sand loss of the ebb tide delta, and its impact on the *Queen Anne's Revenge* site. Our Underwater Archaeology Branch staff is available to work with you in developing a reasonable boundary to incorporate the targets located in the northeastern quadrant of Borrow Area Q2.

The second concentration of targets in Borrow Area Q2 is located adjacent to and north of the Offshore Dredge Material Disposal Site (ODMDS) and includes targets Q2-18, Q2-20, Q2-21, and Q2-23 to Q2-33. MATER has recommended that nine of those targets be investigated or avoided. We concur.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, contact Renee Gledhill-Earley, environmental review coordinator, at 919-807-6579. In all future communication concerning this project, please cite the above referenced tracking number.

Sincerely,

Renee Gledhill-Earley

Peter Sandbeck

cc: Wes Hall, MATER

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Coastal Management

Pat McCrory
Governor

Braxton C. Davis
Director

John E. Skvarla, III
Secretary

September 10, 2013

Philip M. Payonk, Chief
Environmental Resources Section
Wilmington District, US Army Corps of Engineers
69 Darlington Avenue
Wilmington, NC 28403-1343

SUBJECT: **CD13-060** – Consistency Concurrence Concerning the Construction of a Berm to Reduce Storm Damage, Bogue Banks, Carteret County, North Carolina (DCM#20130086)

Dear Mr. Payonk:

We received your consistency submission on August 7, 2013 concerning the establishment of a berm as a means of reducing storm damage on Bogue Banks, Carteret County, North Carolina. The planned berm is expected to span a distance of 22.7 miles. The berm would be eligible for maintenance re-nourishment on a three year cycle. Material for the project would be dredged from three offshore borrow locations. Initial project construction is scheduled to occur between December 2019 and March 2020.

North Carolina's coastal zone management program consists of, but is not limited to, the Coastal Area Management Act, the State's Dredge and Fill Law, Chapter 7 of Title 15A of North Carolina's Administrative Code, and the land use plan of the County and/or local municipality in which the proposed project is located. It is the objective of the Division of Coastal Management (DCM) to manage the State's coastal resources to ensure that proposed Federal activities would be compatible with safeguarding and perpetuating the biological, social, economic, and aesthetic values of the State's coastal waters.

To solicit public comments, DCM circulated a description of the proposed project to State agencies that would have a regulatory interest. No comments asserting that the proposed activity would be inconsistent with the State's coastal management program were received. However, DCM staff submitted two comments regarding the proposed project. In the first comment, it was recommended that the final project plans be submitted to DCM prior to implementation. In the

400 Commerce Ave., Morehead City, NC 28557-3421
Phone: 252-808-2808 \ FAX: 252-247-3330 Internet: www.nccoastalmanagement.net

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second comment, it was noted that the US Army Corps of Engineers (Corps) would be using the Wilmington District Corps sediment criteria rather than DCM's sediment criteria. At this time, DCM's sediment criteria has not yet been certified by the NOAA Office of Ocean and Coastal Resource Management (OCRM) as being a certified enforceable policy of North Carolina's costal management program (NCCMP). Furthermore, in this case, DCM accepts the Corps sediment criteria as adequately complying with the NCCMP in protecting coastal resources.

DCM has reviewed the submitted information pursuant to the management objectives and enforceable policies of Subchapters 7H and 7M of Chapter 7 in Title 15A of the North Carolina Administrative Code and concurs, as conditioned below, that the proposed Federal activity by the Corps (Applicant) is consistent, to the maximum extent practicable, with North Carolina's certified coastal management program.

- The Applicant, prior to initiating berm construction activities shall submit to DCM final project plans to ensure that the proposed project remains consistent with North Carolina's coastal management program.

This letter of concurrence is contingent on the Federal agency agreeing with the condition stated above. In the event that the Federal agency does not agree with the condition of concurrence, this letter effectively becomes a letter of State "*Objection*". Should the Federal agency not agree with the condition stated above, a letter of non-agreement should be sent to DCM. The procedures of 15 CFR 930.43 would then need to be followed.

Should the proposed action be modified, a revised consistency determination could be necessary. This might take the form of either a supplemental consistency determination pursuant to 15 CFR 930.46, or a new consistency determination pursuant to 15 CFR 930.36. Likewise, if further project assessments reveal environmental effects not previously considered by the proposed development, a supplemental consistency certification may be required. If you have any questions, please contact Stephen Rynas at 252-808-2808 x209. Thank you for your consideration of the North Carolina Coastal Management Program.

Sincerely,

Doug Huggett

Doug Huggett
Manager, Major Permits and Consistency Unit

Cc: Roy Brownlow, Division of Coastal Management
Eric Gasch, US Army Corps of Engineers

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Coastal Management

Pat McCrory
Governor

Braxton C. Davis
Director

John E. Skvarla, III
Secretary

September 25, 2013

Philip M. Payonk, Chief
Environmental Resources Section
Wilmington District, US Army Corps of Engineers
69 Darlington Avenue
Wilmington, NC 28403-1343

SUBJECT: NC Division of Water Resources Comments Concerning the Proposed Berm to Reduce Storm Damage, Bogue Banks, Carteret County, North Carolina (DCM#20130086)

Dear Mr. Payonk:

Since the issuance of the consistency concurrence we received the attached comments from the North Carolina Division of Water Resources (NCDWR), Water Quality Program. The North Carolina Division of Coastal Management, to the extent practical, encourages the US Army Corps of Engineers to incorporate the suggestions provided by the NCDWR into the proposed project. Please feel free to contact me at 252-808-2808 x209 should you have any questions. Thank you for your consideration of the North Carolina Coastal Management Program.

Sincerely,

Stephen Rynas, AICP
Federal Consistency Coordinator

Cc: Doug Huggett, Division of Coastal Management
Roy Brownlow, Division of Coastal Management
Joanne Steenhouse, Division of Water Resources
Eric Gasch, US Army Corps of Engineers

400 Commerce Ave., Morehead City, NC 28557-3421
Phone: 252-808-2808 \ FAX: 252-247-3330 Internet: www.nccoastalmanagement.net

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North Carolina Department of Environment and Natural Resources
Division of Water Resources
Water Quality Programs

Pat McCrory
Governor

Thomas A. Reeder
Director

John E. Skvarla, III
Secretary

TO: **Stephen Rynas, Division of Coastal Management Federal Consistency Coordinator**

FROM: **Joanne Steenhuis, Senior Environmental Specialist** JHS

THROUGH: **James H. Gregson, Surface Water Protection Regional Supervisor** JHG

DATE: **September 3, 2013**

SUBJECT: **Bogue Banks Coastal Storm Damage Reduction**

Project: **Beach fill affecting 22.7 miles of coastline to provide storm protect through the creation of a berm**

DCM Project No. **20130086**

COUNTY: **Carteret County**

The Wilmington Regional Office has reviewed the document for the coastal storm damage reduction for Bogue Banks proposing the beach fill for the area as a means to reduce potential storm damage. The Division of Water Resources (DWR) Water Quality Program section has the following comments:

1) The project will require a 401 permit application
2) The use of berms to reduce the turbidity needs to be described in better detail as to the exact location of the berm for each section of beach and if it is located within the surf zone. The location of the discharge pipe in relation to the berm and the water. An alternative plan of how the turbidity may be reduced, if the turbidity exceeds the turbidity limits outside the 1000' mixing zone.
3) A plan for measuring the turbidity at the 1000' and 1500' limits of the project during daily operation needs to be included with the 401 application.

Thank you for the opportunity to comment.

WiRO

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SEP 23 2013

DCM-MHD CITY

Wilmington Regional Office
127 Cardinal Drive Extension, Wilmington, North Carolina 28405
Phone: 910-796-7215 \ FAX: 910-350-2004 \ DENR Assistance: 1-877-623-6748
Internet: www.ncwaterquality.org

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
http://sero.nmfs.noaa.gov

October 28, 2013 F/SER47:FR/pw

(Sent via Electronic Mail)

Colonel Steven A. Baker, Commander
US Army Corps of Engineers Wilmington District
69 Darlington Avenue
Wilmington, North Carolina 28403-1398

Attention: Eric Gasch

Dear Colonel Baker:

NOAA's National Marine Fisheries Service (NMFS) reviewed the *Integrated Feasibility Report and Draft Environmental Impact Statement, Coastal Storm Damage Reduction, Bogue Banks, Carteret County, North Carolina, Draft Report* (DEDIS), dated August 2013, prepared by the U.S. Army Corps of Engineers Wilmington District. The DEIS evaluates alternatives for reducing coastal storm damages from beach erosion on Bogue Banks, a 25.4-mile-long barrier island on North Carolina's central coast. The recommended plan (which is Alternative 9 and the National Economic Development plan) calls for a 22.7-mile-long main beach fill and dune expansion in approximately 5.9 miles of the project. The main beach fill would be bordered on either side by a 1,000-foot tapered transition zone. Sand for the beach fill would be delivered by dredge from three offshore borrow areas. After the initial construction, the projected nourishment interval is three years. Impact minimization measures, such as environmental windows and judicious borrow site selection, are integrated into the project design. The DEIS includes an Essential Fish Habitat (EFH) Assessment. The Wilmington District concludes the proposed action is not expected to cause significant adverse impacts to EFH or Habitat Areas of Particular Concern (HAPC) for species managed by the South Atlantic Fishery Management Council, Mid-Atlantic Fishery Management Council, or NMFS. As the nation's federal trustee for the conservation and management of marine, estuarine, and diadromous fishery resources, the following comments and recommendations are provided pursuant to the authorities of the Fish and Wildlife Coordination Act and the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act).

Sections 2.04 and 7.02 of the DEIS list EFH by fishery management plan in the Bogue Banks project area and describe measures to minimize impacts to these habitats. These measures include:

- Not allowing dredging within 500 meters of low-relief hardbottom habitat within or near borrow areas "U" and "Y" and a state-managed artificial reef near borrow area "Y."
- Limiting dredging and beach placement to the maximum extent practicable to the period between December 1 and March 31. While the sea turtles and shorebirds are the primary impetus behind this environmental window, an additional benefit of the window is work would occur when fishery species are less common in the project area.

Unavoidable impacts from the project include temporary elevations in turbidity and suspended solids in both borrow and beach areas that could smother benthic communities or abrade the gills and skin of fishes. By limiting the dredging to winter months and by selecting borrow areas with less than 10 percent fine material, this impact should be reduced. The project would likely bury ripple scour depressions (RSDs) the features within the nearshore area. While RSDs are not well studied, fish and shrimp likely concentrate in RSDs due to the relief and sharp contrasts in sediment texture. Based on a literature

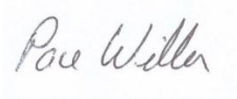
review and discussions with geomorphologists, the District believes RSDs along Bogue Banks are persistent features resulting from the local current and wave regime, which would not be altered by the project and indicates buried RSDs will likely reform within a reasonable time period.

In summary, the EFH assessment adequately describes EFH and federally managed fishery species in the area of Bogue Banks and the EFH conservation recommendations typically issued for a project of this nature are already included in the project design. While no EFH conservation recommendations are provided at this time, NMFS has two general requests:

- To facilitate rapid recovery of the benthic community, NMFS recommends that shallow dredge furrows (up to 5 feet deep) and oriented in a longitudinal pattern be employed. The undisturbed space between the dredge cuts would allow the relatively intact benthic communities between the furrows to be a source of colonists to adjacent disturbed areas, thereby hastening recovery of the infaunal community.
- The Wilmington District meet with NMFS during development of the pipeline corridor to ensure no additional impacts to EFH are proposed.

Thank you for the opportunity to provide these comments. NMFS especially appreciates the extensive interagency discussions the District fostered throughout the planning of the Bogue Banks project. These discussions and timely inclusion of data to inform the discussions were instrumental in the EFH consultation. Related questions or comments should be directed to the attention of Mr. Fritz Rohde at our Beaufort Field Office, 101 Pivers Island Road, Beaufort, North Carolina 28516-9722, or at (252) 838-0828.

Sincerely,



/ for

Virginia M. Fay
Assistant Regional Administrator
Habitat Conservation Division

cc:

COE, Eric.K.Gasch@usace.army.mil
USFWS, Pete_Benjamin@fws.gov
NCDCM, Doug.Huggett@ncdenr.gov
EPA, Bowers.Todd@epa.gov
SAFMC, Roger.Pugliese@safmc.net
NOAA PPI, PPI.Nepa@noaa.gov
F/SER4, David.Dale@noaa.gov
F/SER47, Fritz.Rohde@noaa.gov

The Town of Pine Knoll Shores

September 16, 2013

Eric Gasch
Environmental Resources Section (CEWSA-TS-PE)
U.S. Army Corps of Engineers, Wilmington District
69 Darlington Avenue
Wilmington, NC 28403

Re: Comments
Integrated Feasibility Report and Draft Environmental Impact Statement
Coastal Storm Damage Reduction
Bogue Banks, Carteret County, North Carolina

Dear Mr. Gasch,

Thank you for the opportunity to provide feedback to the Integrated Feasibility Report and Draft Environmental Impact Statement for Bogue Banks. As a member of the Carteret County Beach Commission, Pine Knoll Shores is a partner with Carteret County, Atlantic Beach, Indian Beach, and Emerald Isle in ensuring that we all have healthy and well-maintained beaches. Your report is a positive step in helping ensure that this is a reality for many decades.

This correspondence is intended to complement the letter from the Carteret County Shore Protection Office dated 5 September 2013. In this letter Greg Rudolph updated you on the status of public beach access (PBA) locations here in Pine Knoll Shores. As Mr Rudolph pointed out, Pine Knoll Shores has opened six new PBA's in the past 36 months. These accesses are depicted by Mr. Rudolph in the attachment to his letter. We now have a total of eleven PBA's along our approximately 4.5 miles of beachfront. There are two points related to these PBA's that I would like to discuss.

First, the location of these accesses, and more specifically their compliance with ER 1105-2-100 and ER 1165-2-130, was finalized and approved by the ACE's Wilmington Office in November of 2010. At that time we installed the eleventh and final access in order to meet the

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requirements mandated in the Morehead Harbor Section 933 Project agreement. As I am sure the Wilmington office's records will show, the access locations were approved by the ACE's Project Officer, a final reimbursement was made to Carteret County and Pine Knoll Shores, and the project was closed out.

Next, the number of assigned parking spaces was ruled acceptable to the Corps in 2010. Additionally, we have records of the usage of the parking spaces we have installed, and they are in fact underutilized.

PBA Locations- Pine Knoll Shores installed five PBA's along its beachfront 12 years ago. These were the first PBA's in our town, and were required by the North Carolina Division of Coastal Management (NCDCM) as a prerequisite to receiving a CAMA permit for a locally funded beach renourishment project. These five "original" PBA's were not tied directly to ER 1105-2-100 and ER 1165-2-130. The Town selected these locations, and sought and achieved NCDCM approval for them, based on the best available locations allowing for the most public access.

In 2004 Pine Knoll Shores agreed to participate in the Morehead Harbor Section 933 Project. This project required the Town to comply with ER 1105-2-100 and ER 1165-2-130. Specifically, we were required to add six additional PBA's to the original five, for a total of eleven. Due to a number of reasons unrelated to public access, the 933 Renourishment Project did not take place until 2007, and PKS did not initiate action to comply with the two regulations until 2008. As per the regulations, we sought to locate an access each half-mile along the Town's beachfront. The number of parking spaces mandated by the ACE for these new "933 PBA's" was ten per access.

When searching for access locations that complied with the two regulations the Town was required to synchronize the locations of the six new PBA's with the locations of the five original NCDCM-mandated locations. This proved difficult. Pine Knoll Shores is somewhat unique amongst beach towns, as we have no public roads that run perpendicular to the shoreline. Said another way, we have no north-south public roads that terminate at the dunes. Our four oceanfront public roads account for less than .8 miles of our 4.5 miles of beachfront. It took two years of expensive and serious negotiation with private entity's to get accesses through their property. This was finally achieved in November 2010, and as previously stated, was approved by the ACE's Morehead Harbor Section 933 Project Officer.

The point here is that the accesses are very close to meeting the specific requirements of ER 1105-2-100 and ER 1165-2-130. In fact, the half-mile spacing requirement, as depicted in Mr Rudolph's letter, is fully met. The quarter mile distance from each access to its associated parking lot is nearly compliant. There is one access which is marginally outside your tolerance of +/- 500 feet. In 2010 we demonstrated to the ACE that we took all reasonable measures to

meet the requirement, and eventually received approval for the location of the access and the associated parking.

Total Parking Spaces needed- Appendix I to the report requires Pine Knoll Shores to have 210 parking spaces within the town. Both the report and the County's letter of 5 September reflect that we currently have 155 spaces available. That number is in error. The number of spaces currently available, after our eleventh and final 933 PBA was installed is 180.

While the Tobit regression model used to measure peak demand for parking spaces on our beaches is interesting from an academic standpoint, it does not reflect reality. It does not account for the fact that, as previously mentioned, 3.7 miles our 4.5 beach front is privately owned property that holds a finite amount of people, and has no public roadway network approaching the beach. Relative to other beach towns, we have no commercial areas that attract tourists. Instead, we have condominium and hotel units that have a finite amount of *overnight* visitors. Widening the beach in the future via renourishment projects will not bring additional people to our beaches.

Starting in 2011 we began collecting data on the usage of our 180 spaces. We collected this data in 2011 and 2012. While our data collection methods were simple, they accurately reflect the usage of our 180 parking spots at key heavy usage periods. The data below reflects usage of our parking spaces at noon and 4pm on Saturdays during the 2011 and 20012 summer seasons.

Parking usage for Pine Knoll Shores 180 parking spots- Noon on Saturdays, 2011 & 2012

2012 Counts			2011 Counts		
Date	Gross	% of Total	Date	Gross	% of Total
24-May	101	56%	--		
2-Jun	60	33%	--		
9-Jun	N/A	N/A	--		
16-Jun	70	39%	--		
23-Jun	62	34%	25-Jun	51	28%
30-Jun	N/A	N/A	2-Jul	67	37%
7-Jul	71	39%	9-Jul	35	19%
14-Jul	54	30%	16-Jul	68	38%
21-Jul	25	14%	23-Jul	71	39%
28-Jul	82	45%	30-Jul	65	36%
4-Aug	60	33%	6-Aug	73	40%
11-Aug	2	1%	13-Aug	63	35%
18-Aug	54	30%	--		
25-Aug	25	14%	--		
1-Sep	60	33%	--		

Parking usage for Pine Knoll Shores 180 parking spots- 4PM on Saturdays, 2011 & 2012

2012 Counts			**2011 Counts**		
Date	Gross	Percent	**Date**	**Gross**	**% of Total**
24-May	75	41%	--		
2-Jun	112	62%	--		
9-Jun	N/A	N/A	--		
16-Jun	77	43%	--		
23-Jun	69	38%	--		
30-Jun	N/A	N/A	--		
7-Jul	109	60%	9-Jul	33	18%
14-Jul	96	53%	16-Jul	109	60%
21-Jul	23	13%	23-Jul	78	43%
28-Jul	71	39%	30-Jul	33	18%
4-Aug	96	53%	6-Aug	25	14%
11-Aug	23	13%	13-Aug	58	32%
18-Aug	71	39%	--		
25-Aug	44	24%	--		
1-Sep	84	46%	--		

Without question our peak parking requirement is on the weekends, and noon and 4pm are good times to gauge the use of the spaces. As the numbers above demonstrate, we do not come close to using all of our180 spaces, even at the busiest time of our summer. I am also attaching our raw data from 2011 and 2012. I must apologize in advance that formats were not the same during these two summers, nor was our counting scheme the same. If I may would direct you to the highlighted section of each page. I believe this demonstrates what the actual usage of our spaces really is.

Pine Knoll Shores requests that the Integrated Feasibility Report and Draft Environmental Impact Statement for Bogue Banks be adjusted in Appendix I to require PKS to have 180 public parking spaces in support of our 11 PBA's. We have been managing these accesses and maintaining the associated parking spaces. They are not close to being fully utilized, and we do not feel there is any rationale for requiring additional spaces.

Thank you for the opportunity to submit comments to your study.

Brian Kramer

Town Manager, Pine Knoll Shores

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1890
WILMINGTON, NORTH CAROLINA 28402-1890

December 9, 2003

IN REPLY REFER TO

Environmental Resources Section

Dear Sir or Madam:

The U.S. Army Corps of Engineers, Wilmington District, has initiated the Bogue Banks Shore Protection Feasibility Study in Carteret County, North Carolina (see enclosed figure). The feasibility study is being carried out under the Corps of Engineers General Investigation Program and was authorized by a resolution (Docket 2578) of the Committee on Transportation and Infrastructure of the U. S. House of Representatives, dated July 23, 1998.

The purpose of the feasibility study is to develop and evaluate alternatives for implementing solutions to shore protection and related problems for Bogue Banks, in Carteret County, North Carolina. Opportunities for shore protection for Bogue Banks include the no-action alternative, the restoration of berms and/or dunes, as well as other non-structural and structural alternatives. The final outcome of the study will be a feasibility report, and an environmental impact statement (EIS), which will likely recommend a project for construction authorization. We are now requesting comments from agencies, interest groups, and the public to identify and discuss significant resources and issues related to selection of a preferred alternative.

Bogue Banks, located in Carteret County, North Carolina is a barrier island located between Beaufort Inlet to the east and Bogue Inlet to the west. The barrier island is approximately 24 miles in length, with the Atlantic Ocean to the south and Bogue Sound to the north. From east to west, the communities of Atlantic Beach, Pine Knoll Shores, Salter Path, Indian Beach, and Emerald Isle are located on Bogue Banks. Fort Macon State Park is located at the east end adjacent to Beaufort Inlet, and the Theodore Roosevelt Natural Area is located adjacent to Pine Knoll Shores. The communities are rapidly growing and visitation to Bogue Banks is high due to the unique character of the island and the presence of one of the last remaining maritime forests on a barrier island in North Carolina. The study area is located in the eastern portion of North Carolina in the 3rd Congressional District.

Increased storm activity in the last years, including Hurricanes Bertha (1996), Fran (1996), Bonnie (1998), Dennis (1999), Floyd (1999), and Irene (1999) have eroded the berm and dunes, and have damaged structures and their contents at Bogue Banks. Erosion of the protective berm and dune has left the upland areas extremely vulnerable to future hurricane storm damage. Potential advantages of a proposed shore protection plan include the potential alteration of wave and current effects on shoreline erosion at nearby beaches.

All private interests and federal, state, and local agencies that have an interest in the project are invited to comment at this time and to identify any concerns and issues that should be addressed or considered by the U.S. Army Corps of Engineers during project planning and engineering. An EIS will be prepared in accordance with the requirements of the National Environmental Policy Act of 1969, as amended, and will address the project's relationship to all applicable federal and state laws and Executive Orders. The EIS would describe the environmental effects of the proposed action on socioeconomic resources; hazardous, toxic, and radiological wastes; natural resources; endangered and threatened species; wetlands; floodplains; air quality resources; marine, estuarine, and beach habitat; cultural resources, including important historic shipwrecks; recreational and commercial fisheries; water quality, and cumulative impacts. The EIS is currently scheduled for distribution to the public in the winter of 2004.

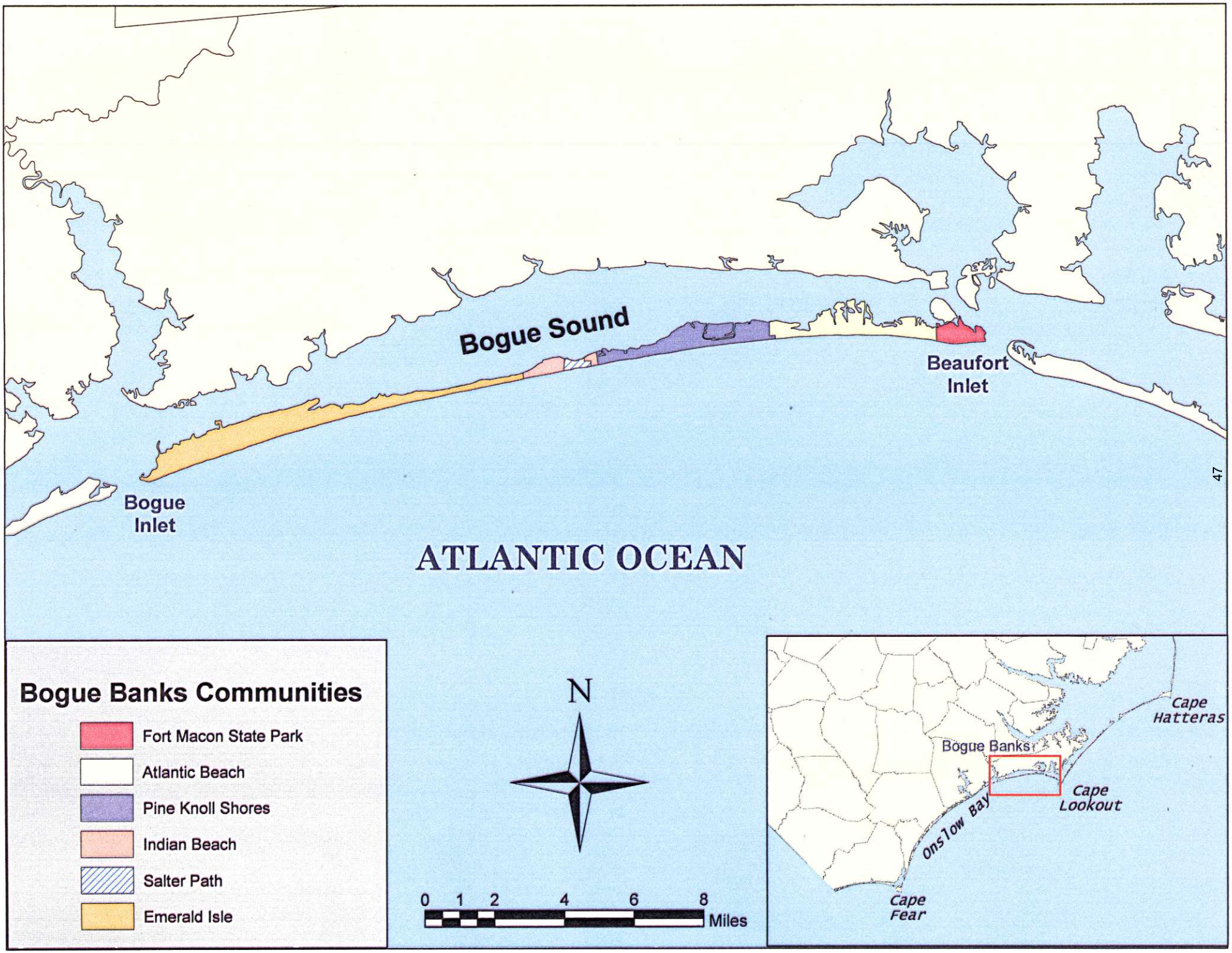
No formal scoping meetings are planned at this time. However, based on the responses to this scoping letter, meetings may be held with specific agencies as required.

Written comments are requested on any of these matters. Responses to this letter will be considered during our selection of a preferred alternative and our assessment of potential impacts on the environment. Significant issues will be addressed, as appropriate, in an EIS. Please send your written comments to arrive within 30 days from the date of this letter in order that they may be considered during our evaluations and decision process. Questions about the feasibility study or the EIS should be addressed to Mr. Hugh Heine, Environmental Resources Section, e-mail address hugh.heine@usace.army.mil or telephone (910) 251-4070.

Sincerely,

W. Coleman Long
Chief, Planning and Environmental Branch

Enclosure


Bogue Sound
Beaufort Inlet
Bogue Inlet
ATLANTIC OCEAN
Bogue Banks Communities
Fort Macon State Park
Atlantic Beach
Pine Knoll Shores
Indian Beach
Salter Path
Emerald Isle
N
0 1 2 4 6 8
Miles
Cape Hatteras
Bogue Banks
Cape Lookout
Onslow Bay
Cape Fear

US Army Corps of Engineers®
Wilmington District

CESAW-TS-PE **August 2, 2013**

PUBLIC NOTICE
AND
NOTICE OF AVAILABILITY

Integrated Feasibility Report and Draft Environmental Impact Statement
Coastal Storm Damage Reduction
Bogue Banks, Carteret County, North Carolina

The U.S. Army Corps of Engineers (USACE), Wilmington District (Corps) has prepared a Draft Environmental Impact Statement (DEIS) to evaluate the impacts of the proposed alternative to reduce coastal storm damages from beach erosion on Bogue Banks North Carolina. The Bogue Banks study area is located on the coast of North Carolina, about 80 miles north of Wilmington, North Carolina. The project area is up to 24 miles in length, from Beaufort to Bogue Inlets. Benefits from the proposed project, include the protection of structures and their related infrastructure (i.e., roads, utility lines, etc.), improved aesthetic and recreation opportunities, and improved habitat conditions for endangered species.

The DEIS has been prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended, and addresses the relationship of the proposed action to other applicable Federal and State Laws and Executive Orders. The DEIS addresses the proposed project's impacts on environmental resources including: federally listed threatened and endangered species, archaeological and historical resources, wetlands, fish and wildlife habitat, soils, and water and air quality. We are requesting written comments related to the proposed project from agencies, interest groups, and the public. Comments received will be considered in preparation of the Final EIS. The DEIS is available on the internet at: http://www.saw.usace.army.mil/Missions/CoastalStormDamageReduction/BogueBanks.aspx

Written comments should be addressed to the U.S. Army Corps of Engineers, Wilmington District, Attention: Mr. Eric Gasch, (CESAW-TS-PE) Environmental Resources Section, Post Office Box, 1890, Wilmington, North Carolina, 28402. Please send your comments within 45 days from the date of this letter so they may be considered during our evaluation and decision process. If you have any questions or need further information, please contact Mr. Gasch at telephone (910) 251-4553.

Elden Gatwood
Chief, Planning and
Environmental Branch

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
69 DARLINGTON AVENUE
WILMINGTON, NORTH CAROLINA 28403-1343

REPLY TO
ATTENTION OF:

February 14, 2014

Planning and Environmental Branch

Mr. Pete Benjamin, Field Supervisor
U.S. Fish and Wildlife Service
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

Dear Mr. Benjamin:

A Draft Environmental Impact Statement (DEIS) with Biological Assessment (BA) for the Bogue Banks Coastal Storm Damage Reduction (CSDR) project was prepared and transmitted for a 45-day public review period on August 2, 2013. On August 20, 2013, the Corps sent a letter requesting concurrence under continuing informal consultation that began over 10 years ago.

On September 12, 2013, the U.S. Fish and Wildlife Service (Service) provided comments in accordance with Section 7 of the Endangered Species Act of 1973, as amended. The Service concluded they did not concur with the Corps' determination of May Affect, Not Likely to Adversely Affect (MA-NLTAA) for the piping plover, and loggerhead, leatherback, and green sea turtles because more information was needed on the compatibility of the sediment to be dredged and placed on the beach. The Service also had seven other recommendations to be addressed.

Within the framework of continued informal consultation, a meeting was conducted between the Service and the Corps on October 30, 2013, to discuss the Service's recommendations and concerns regarding the Corps' use of the "Wilmington District Compatibility Practice" versus the "NC Sediment Criteria" as documented in the DEIS. The purpose of this letter is to transmit the enclosed Corps' responses to the Service's non-concurrence to the Corps' affects determination and to request the Service's concurrence that Section 7 consultation has been satisfied for this project.

If you have any questions regarding this matter, please contact Mr. Eric Gasch of the Environmental Resources Section either at (910) 251-4553, Eric.K.Gasch@usace.army.mil; or at the mailing address at the top of this letter.

Sincerely,

Elden Gatwood

Elden Gatwood
Chief, Planning and Environmental Branch

Enclosure

ENCLOSURE

Corps Responses to USFWS Comments
(Letter Dated September 12, 2013)

1. <u>USFWS COMMENT</u>: At this time, the Service cannot concur with the Corps' determination of May Affect, Not Likely to Adversely Affect (MA-NLTAA) for the piping plover, and loggerhead, leatherback, and green sea turtles. More information is needed on the compatibility of the sediment to be dredged and placed on the beach, including sand grain size (percent fines and percent granular and gravel), density, shear resistance, and color. In addition, no monitoring is proposed to be conducted during construction or maintenance events for piping plover, and the length of monitoring for sea turtle nests is not clear in the draft BA.

<u>USACE RESPONSE</u>: Sufficient data regarding compatibility of sediment to be dredged and placed on the beach are provided in Section 5.06.1 in the DEIS and in the Geotech Appendix C. For clarity, that information was not repeated in the BA. Also, further information regarding sediment compatibility is addressed in USFWS Comment #3. Color of the sediment was not investigated and historically has not in previous projects.

Monitoring, specifically daily visual surveys for piping plover, is not proposed because placement is timed to minimize impacts. A visual survey will be performed before placing or removing pipe along the beach to avoid piping plover impacts. Piping plover impact minimization measures are also addressed in USFWS Comment #7.

Beach renourishment is proposed during the time period when sea turtle nesting is not occurring. The Corps will not and historically has not monitored for sea turtle nests when placement is within the environmental window. However, the local communities, through the NC Sea Turtle Project, monitor sea turtle activity along the entire coast of North Carolina and the data is collected by Dr. Matthew Godfrey of NCWRC. Further information regarding sea turtle monitoring is addressed in USFWS Comment #4 below. Section 5.00 of the BA was updated to remove commitment of post nourishment nest activity for clarification.

2. <u>USFWS COMMENT</u>: The Service recommends that the proposed Critical Habitat for the loggerhead sea turtle and the candidate species red knot be added to the list of considerations under Section 7 of the Endangered Species Act. Consideration of proposed critical habitat and candidate species in project planning is prudent and should not delay or impede decision-making.

<u>USACE ACTION</u>: The Corps agrees with USFWS Comment #2.

Section 4.02.3 and 6.0 of the BA was updated with proposed loggerhead Critical Habitat information and the Corps determined the proposed project will not result in an adverse modification of critical habitat for the threatened loggerhead sea turtle.

Section 4.02.10 and 6.0 of the BA was updated with a Red Knot evaluation and includes the Corps determination that the disposal of sediment on the Bogue Banks beaches may affect not likely adversely affect the Red Knot because construction activities will (1) avoid large scale disturbance within the limits of Red Knot foraging distribution and allow for areas of un-impacted or recovered foraging habitat within a given year, (2) avoid roosting timeframes or provide appropriate buffers around existing roosting habitat during construction operations, and (3) beach placement on Bogue Banks will only take place from in appropriate environmental windows approximately once every 3-5 years.

Consideration and analysis was added to the DEIS in section 2.07.3 and 2.07.4 for loggerhead critical habitat and red knots. Table 2.4(Threatened and Endangered Species Potentially Present in Carteret County, North Carolina) was updated and Figure 2.4 (Proposed Loggerhead Critical Habitat) was also added to the DEIS.

3. <u>USFWS COMMENT</u>: The Service recommends that the Corps commit to using only sediment that complies with the NC Sediment Criteria Rule, and also has a wet Munsell color of 5 or greater.

Specifically, the Service recommends that the Corps commit to meet the following criteria:

1. The average % by weight of fine grained sediment (less than 0.0625 mm) in each borrow site shall not exceed the average % by weight of fine grained sediment of the recipient beach characterization plus 5%.

2. The average % by weight of granular sediment (Greater than or = to 2 mm and less than 4.76mm) in a borrow site shall not exceed the average % by weight of coarse sand sediment of the recipient beach plus 5%.

3. The average % by weight of gravel (greater than or = to 4.76 mm) in a borrow site shall not exceed the average % by weight of gravel sized sediment for the recipient beach characterization plus 5%.

4. The average % by weight of calcium carbonate in a borrow site shall not exceed the average % by weight of calcium carbonate on the recipient beach characterization plus 15%.

Use of material that meets the above criteria and is similar in color to the native beach would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize

potential impacts to piping plover, red knot, and sea turtles, as well as beach invertebrates, surf fishes, and other shorebirds.

The service recommends that Section 5.00 of the BA include a commitment to monitoring sediment each day as it is being placed on the beach to ensure that it is similar to the existing sediment on the beach.

<u>USACE RESPONSE</u>: The Corps disagrees with USFWS Comment #3.

The Corps believes the sand compatibility methods used are adequate to evaluate the placement of sand on Bogue Banks. The Wilmington District has met the intent of the State sediment compatibility standards through detailed sediment compatibility analyses, which evaluate the grain size characteristics of the material within the potential borrow area. In order to assure that beach placement material consists predominately of sand, the Wilmington District compatibility practice requires that the borrow area contains sediment with an average weighted fine-grained material content of less than (<) 10% passing the #200 sieve. These guidelines have historically been utilized by the Wilmington District to assure compatibility for CSDR projects (i.e. Wrightsville, Carolina, Kure, and Ocean Isle beaches) with much success and additionally continue to be used for beach placement of dredged material from navigation channels. As discussed above, previously constructed CSDR projects which utilized the Wilmington District compatibility practice did not result in resource impacts that were outside of what the literature base documents for recovery.

The State Criteria were intended to serve as a guideline to support material placed on the beach that is "compatible" with the native beach. They were not developed to define thresholds of environmental recovery realizing that the current science does not discern small incremental differences when evaluating recovery time. The incremental difference in the sediment characteristics proposed to be being placed on the Bogue Banks and the "State Criteria" is not discernible with respect potential benthic impacts and recovery and the interrelated impact to foraging plovers as well as the impacts to sea turtle nesting habitat does not discern between increments of silt. Therefore, the existing science does not support use of the State Criteria as a required minimization method.

The results of the geotechnical investigation for the Feasibility Report for the Bogue Banks Coastal Storm Damage Reduction Project are presented in Appendix C of that report. A number of sites were investigated for the determination of quality and an adequate quantity of material appropriate for borrow and placement of sand for storm damage reduction. The sites investigated in this study include the Beaufort Inlet Ebb Tide Delta, Bogue Inlet, and various sites offshore of Bogue Banks.

Geophysical data was collected in the area between 1.0 nautical miles (30 foot isobath) to 6.0 nautical miles offshore of Bogue Banks. The geophysical surveys were used to recommend boring locations for detailed analyses. These locations were concentrated in areas that showed

promise for use as borrow sources for sand. A total of 200 borings were performed in Bogue Inlet, offshore of Bogue Banks, Beaufort Inlet and the Bogue Sound area. The borings offshore of Bogue Banks were located between 1 and 6 miles from the beach and in water depths greater than 30 feet. The recovered vibracore tubes were visually classified by Wilmington District personnel in accordance with the Unified Soils Classification System (USCS). Representative samples were taken at a minimum of every two feet or at each change of material. A total of 1400 samples were collected in the Bogue Banks area, of which 1369 samples were tested for this project. The grain size tests were performed in accordance with ASTM D-422 using a fifteen-sieve test and visual classifications were performed in accordance with ASTM D-2488. The sieves used in these tests were the 3/4, 3/8, #4, #7, #10, #14, #18, #25, #35, #45, #60, #80, #120, #170, and #200.

Once the lab grain size testing of the vibracore samples was completed, the borrow areas were reassessed to determine the quality of the material in the proposed borrow areas. The borrow sites for this project were selected through an iterative process to find the most economic and best quality material for use as borrow. Some areas contained too high a shell content and were eliminated. Other areas with higher silt content were also eliminated from consideration. Also, some other areas which no longer had a large enough quantity of suitable material to use for a full renourishment cycle were eliminated. An assessment of environmental and archeological features of the remaining areas was performed. One area greatly reduced due to the presence of features such as artificial reefs, the ebb tide delta, and archeological areas such as the Queen Anne's Revenge.

In addition, the beach material on Bogue Banks was characterized. Beach material sampling consisted of a total of 25 transects, with 2 transects in Fort Macon, 5 transects in Atlantic Beach, 6 transects in Pine Knoll Shores, 2 transects in Indian Beach, 7 transects in Emerald Isle, and 3 transects in the Bogue Inlet area west of Emerald Isle. The sample locations are the toe of the dune, crest of the berm, mean high water (MHW) at an approximate elevation of +2.5 feet above mean sea level, mean low water (MLW) at an approximate elevation of -2.5 feet below MSL, and at 2-foot elevation increments from -2.0 feet below MSL to -24.0 feet below MSL.

Based on the analysis of the overfill ratio and the grain size analysis borrow areas Q2 (ODMDS), U, and Y were selected as the source of borrow material. The geotechnical data are summarized in the following tables from the Geotechnical Appendix C.

Table C-1. Bogue Banks Grain Size Comparison (Taken from Geotech Appendix C).

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

* % Passing #200 is comparable to % silt

The suitability of the borrow material for placement on the beach was also assessed using the overfill ratio. The overfill ratio is computed by numerically comparing the size distribution characteristics of the native beach sand with that in the borrow area and includes an adjustment for the percent of fines in the borrow area. The overfill ratio is primarily based on the assumption that the borrow material will undergo sorting and winnowing once exposed to waves and currents in the littoral zone, with the resulting sorted distribution approaching that of the native sand. Since borrow material will rarely match the native material exactly, the amount of borrow material needed to result in a net cubic yard of beach fill material will generally be greater than one cubic yard. The excess material needed to yield one net cubic yard of material in place on the beach profile is the overfill ratio. The overfill ratio is defined as the ratio of the volume of borrow material needed to yield one net cubic yard of fill material. For example, if 1.5 cubic yards of fill material is needed to yield one net yard in place, the overfill factor would equal 1.5.

The overfill criteria developed by James (1975) is the method used in the Automated Coastal Engineering System (ACES). The procedure is also described in the U.S. Army Coastal Engineering Manual EM-1110-2-1100 Part V (July 2003). The overfill ratio for the Bogue Banks Beach was compared to the borrow area material was calculated by the Aces Method. Based on the Aces Method, the overfill ratio for is varied between 1.05 and 1.41. Any overfill ratio value of less that 1.5 with a fine content of less than 10% is considered acceptable for use as beach renourishment. See Table C-3.

Table C-3. Bogue Banks Overfill Ratios. (Taken from Geotech Appendix C).

LOCATION	OVERFILL RATIO
Bogue Inlet - Ocean	1.10
Emerald Isle - West	1.05
Emerald Isle - Central	1.05
Emerald Isle - East	1.05
Indian Beach/Salter Path	1.05
Pine Knoll Shores - West	1.05
Pine Knoll Shores - East	1.11
Atlantic Beach	1.07
Fort Macon	1.41

NOTE: The overfill ratio is calculated using the James Method.

With regard to monitoring of sediment as it is discharged, the project plans and specifications will require that the contractor be present and monitor the dredge discharge location and work zone continuously while the discharge is occurring. Additionally, frequent inspections of the beach placement by a government inspector and Wilmington District technical staff including environmental and geotechnical staff will occur. These inspections will be visually based. Visual classifications of these materials rely primarily on sight and feel of the material. The color and in some circumstances smell can be factors considered. Should the material being placed on the beach contain amounts of silt and clay or other materials not considered suitable for placement on the beach (as defined previously), the contractor will be required to promptly notify the Contracting Officer.

In addition to monitoring the beach location, the plans and specifications require monitoring of dredge position and dredge status (i.e., depth of cut) at the borrow area.

Section 5.0 of the BA was updated to include this monitoring information.

4. <u>USFWS COMMENT</u>: The Service recommends that Section 5.00, Item 6 of the Draft BA be modified to reflect that sea turtle nesting activities will be monitored annually for the life of the project.

<u>USACE RESPONSE</u>: As discussed below, monitoring of sea turtle nesting activities is expected to continue as it has historically. However, this monitoring will not be a federal project action. The local communities, through the NC Sea Turtle Project, monitor sea turtle activity along the entire coast of North Carolina and the data is collected by Dr. Matthew Godfrey of the North Carolina Wildlife Resources Commission (NCWRC). The data is in turn provided to the USFWS.

Also, placement of material is timed through environmental windows to minimize impacts. Throughout the duration of each nourishment contract, during initial construction and each periodic nourishment event, the Contractor will be responsible for the protection of threatened and endangered species. The Contractor is responsible will take such measures as may be required to assure that any activities conducted do not kill, injure, capture, pursue, or otherwise harm any species. The Contractor will be aware of the protected species that frequently occur in the project area and work will be planned accordingly.

Section 5.00 of the BA was updated to remove commitment of post nourishment nest activity for clarification.

5. <u>USFWS COMMENT</u>: The Service recommends that Section 5.00 of the BA include a commitment to conduct visual surveys each morning in the area of work for that day, to determine if piping plovers are present and allow those individuals to move out of the area.

<u>USACE RESPONSE</u>: The Corps disagrees with USFWS Comment #5.

The Corps will coordinate with the Service and NCWRC prior to mobilization and demobilization of the pipeline to avoid piping plover impacts. Placement of material is timed to minimize impacts to piping plovers and therefore daily visual surveys are not necessary.

Piping plover impact minimization measures are also addressed in USFWS Comment #7.

6. <u>USFWS COMMENT</u>: The Service recommends that Section 5.00 of the BA include a commitment to conduct surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant, for the life of the project.

<u>USACE RESPONSE</u>: The Corps agrees with USFWS Comment #6.

The 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 30 in the study area.

The 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.

Though beach nourishment will offer additional habitat for seabeach amaranth, because of seed burial there is risk of slow germination and population recovery in the short term following burial. Previous literature has suggested that following disposal efforts, seabeach amaranth populations have rebounded suggesting that beach nourishment is beneficial for seabeach amaranth populations. However, seabeach amaranth recovery associated with nourishment is often tied to nearshore borrow sources associated with inlet complexes. It has been suggested that the sediment from these inlet complexes contains a seabeach amaranth seed source which germinates when disposed on the beach. However, the sediment utilized for this project is from deep offshore borrow areas that does not contain a seed source. Therefore, during nourishment operations the placement of sediment on the beach may bury existing seed sources and prevent germination over the short term.

7. USFWS COMMENT: Each construction or maintenance event should start at the southern project limit and move northward in order to avoid potential impacts to nesting piping plovers. All construction for shaping the beach within the southern mile of the project area should be completed by March 1 and all construction equipment removed from this area. Equipment access points should be within the day's work area or as close as possible, to minimize impacts from movement of heavy equipment along other stretches of beach. Also, the Corps should coordinate with the Service and North Carolina Wildlife Resources Commission prior to mobilization and demobilization of the pipeline on the beach, to determine the best location for the pipeline route.

USACE RESPONSE: The Corps disagrees with the USFWS Comment #7 recommendation that all construction for shaping the beach be completed by March 1 and each construction or maintenance event should start at the southern project limit and move northward.

First, it is assumed that the Service meant to say the construction and maintenance (renourishment) events should start at the westernmost project limits and move east instead of the southernmost project limits and move north due to Bogue Banks running in a west to east direction (Bogue Inlet to Beaufort Inlet).

Placement as well as mob and de-mob of equipment will be timed (December 15-March 31) to avoid piping plover impacts. Piping plover Critical Habitat Unit NC-10 is located west, but not in, the project area. Therefore a west to east construction plan is not practical or necessary to protect piping plovers.

The Corps agrees with the USFWS Comment #7 recommendation that the Corps should coordinate with the Service and North Carolina Wildlife Resources Commission prior to

mobilization and demobilization of the pipeline on the beach, to determine the best practical location for the pipeline route which minimizes potential risk to plovers.

8. <u>USFWS COMMENT</u>: The Service recommends that the Corps investigate the necessary minimum maintenance interval for storm damage reduction, which may be greater than 3 years. A longer interval between maintenance events would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize potential impacts to piping plover, red knot, and sea turtles, as well as beach macro invertebrates, surf fishes, and other shorebirds. A longer maintenance interval would also require a smaller amount of compatible borrow material for the life of the project. We recommend that the final EIS consider the non-economic benefits of longer maintenance intervals.

<u>USACE RESPONSE</u>: The Corps disagrees with USFWS Comment #8.

Non-economic benefits were considered in the planning process. Longer renourishment intervals may increase the environmental risks between renourishment events by allowing accumulated erosion to create escarpments, narrow the non-dune portion of the beachfill, erode the toe of the dune, and damage dune vegetation. Longer renourishment intervals may result in an eroded beach that is not suitable to sea turtles as compared to a beach renourished on a shorter interval. As the renourishment interval increases, the large volumes needed would require additional hopper dredges and/or expansion of the dredging window. This presents a greater risk for impacts to benthic invertebrates and surf zone fishes by extending construction into more biologically productive periods. The present analysis allows for evolution of the design template between renourishment events. It should be noted that as the design template erodes, the character of the beach can change unacceptably if the nourishment interval is too long. Also renourishment would not occur in areas of the Bogue Banks project that remain at or above the design template or were only minimally eroded. It is highly likely that the full project length will actually require renourishment every three years. Therefore, the estimated beach replacement cycle of between 3-5 years was selected as the recommended plan.

United States Department of the Interior

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ER 13/0548
9043.1

September 26, 2013

Mr. Eric Gasch
U.S. Army Corps of Engineers
Wilmington District
Environmental Resources Section
69 Darlington Avenue
Wilmington, NC 28403

Re: Comments and Recommendations on the Review of the Draft Environmental Impact Statement (DEIS) for the Bogue Banks Coastal Storm Damage Reduction Project located in Carteret County, North Carolina

Dear Mr. Gasch:

The Department of the Interior (Department) has reviewed the DEIS for the Bogue Banks Coastal Storm Damage Reduction Project and our comments are as follows. This is in response to the request for review of the U.S. Army Corps of Engineers' (Corps) Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS) for Bogue Banks Coastal Storm Damage Reduction Project (CSDR) (August 2013), and the draft Biological Assessment (BA) (Appendix F of the DEIS). The Corps provided the DEIS for the Bogue Banks project by letter dated August 2, 2013. The letter also requested initiation of formal consultation on the project. In a letter dated August 20, 2013, the Corps rescinded their August 2 letter, and instead requested concurrence under continuing informal consultation that began over ten years ago.

We have worked with the Corps on the review of this Civil Works project since approximately 2000. The Department provided scoping comments to this project on February 14, 2000 and drafted a Fish and Wildlife Coordination Act (FWCA) Report in November 2002. A final FWCA report has not yet been produced. However, many of the recommendations of the 2002 draft FWCA report remain valid. The Corps has indicated that a Final FWCA report will be contracted with a final delivery date in January, 2014. We will provide additional comments directly to the Corps in regards to the DEIS and Section 7 consultation.

Project Area, Proposed Activities, and Anticipated Impacts

The project area is Bogue Banks Beach and the adjacent Atlantic Ocean. Waters of the Atlantic Ocean, Beaufort Inlet and parts of Bogue Inlet and Bogue Sound are classified as SB, a water quality classification designated by the state. According to the DEIS, the purpose of this study is to evaluate coastal storm damage reduction at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County. The preferred alternative consists of an 119,670-foot (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). Material for the project is proposed to be dredged from three offshore borrows locations (Y, U, and Q2). The project is proposed to be renourished as often as every three years following initial construction, in order to build the project back up to the authorized dimensions.

Federally Protected Species

The Corps has made a determination of May Affect, Not Likely to Adversely Affect the piping plover, seabeach amaranth, and loggerhead, leatherback, and green sea turtle. The Corps also determined that the proposed project is Not Likely to Adversely Modify critical habitat for the piping plover. For the West Indian manatee and the roseate tern, the Corps has made a No Effect determination in the BA. At this time, the Department cannot concur with the Corps determinations for piping plover and the sea turtle species, for the following reasons:

(1) A lack of information on the compatibility of the sand to be used for nourishment, particularly regarding the percentage of material of a large grain size (greater than2.00mm) and Munsell color.

(2) The Corps' decision to forego compliance with the North Carolina Sediment Criteria Rule (15A NCAC 07H .0312: Technical Standards for Beach Fill Projects). Instead, the Corps proposes to "continue to use its best engineering judgment, accompanied by appropriate sampling and monitoring, to determine sediment compatibility." We recommend that the Corps commit to meet the NC Sediment Criteria Rule, and also to commit to using material which is compatible in color (a wet Munsell color of 5 or greater). Since the DEIS currently estimates that the overall 50-year project would utilize only about 47% of the total volume available at the three borrow sites, we are asking the Corps to determine if there would be enough sand for the overall project if the NC Sediment Criteria Rule is met. This commitment would be a minimization measure under Section 404(b)(1) of the Clean Water Act. Finally, the Department is concerned with a lack of consistency in the applicability of the NC Sediment Criteria Rule. It is unclear how the Corps may hold itself to one standard of sediment compatibility, and expect private permittees to meet a higher standard. We are concerned that allowing the Corps to utilize a different level of compliance will make it more difficult to uphold the NC Sediment Criteria Rule for private permittees.

(3) A failure to minimize impacts to listed species by basing the proposed maintenance intervals on the estimated erosion rate and need for renourishment. Section 5.08.02 on page 75 of the DEIS states that a 3-year maintenance interval was chosen because of the net costs and benefits of the nourishment activities. However, a longer maintenance interval of 4 or 5 years would allow the benthic infauna longer time to recover both on the beach and in the borrow areas. A longer interval between maintenance events would be a minimization measure under Section 404(b)(1) of the Clean Water Act. A longer maintenance interval would also require a smaller amount of compatible borrow material for the life of the project. We recommend that the final EIS consider the non-economic benefits of longer maintenance intervals.

4. A lack of monitoring plans for piping plovers during construction and maintenance activities. Proposed monitoring includes post-nourishment monitoring of the project area for turtle nests, and to monitor sediment compaction and escarpment formation. In addition, we recommend the following minimum monitoring requirements:

- Monitoring of sediment color and compatibility prior to placement on the beach during any construction and maintenance activities

- Monitoring of bird presence and abundance by species during construction and maintenance operations and for the first year after sediment placement

In addition, the Department recommends that the proposed Critical Habitat for the Loggerhead Sea Turtle and the candidate species red knot (Calidris canutus rufa) be added to the list of considerations under Section 7 of the Endangered Species Act. Consideration of proposed critical habitat and candidate species in project planning is prudent and should not delay or impede decision-making.

Table 2.4 on page 33 of the DEIS lists red knot (Calidris canutus rufa) as endangered. A determination to list the red knot has not yet been made by the Department, although it is a candidate species. The Department recommends that potential impacts to the red knot be included in the final BA. Similarly, the Atlantic sturgeon (Acipenser oxyrhynchus oxyrhynchus) is listed in the DEIS as a Federal Species of Concern (FSC), when in fact, the Carolina Distinct Population Segment has been listed by the National Marine Fisheries Service (NMFS) as endangered. These corrections should be made in the Final EIS. The Corps should consult with NMFS regarding potential impacts to the Atlantic Sturgeon.

If you have questions or concerns, please contact Kathy Matthews at (856) 4520, ext. 27 or via email at kathryn_matthews@fws.gov. I can be reached on (404) 331-4524 or via email at joyce_stanley@ios.doi.gov.

Sincerely,

Joyce Stanley, MPA
Regional Environmental Protection Specialist

cc: Jerry Ziewitz – FWS
Gary Lecain - USGS
Anita Barnett – NPS
Tommy Broussard – BOEM
Harry J. Payne – OSMRE
OEPC – WASH

Wicker

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

January 8, 2004

Colonel Charles R. Alexander
District Engineer, Wilmington District
U. S. Army Corps of Engineers
P. O. Box 1890
Wilmington, NC 28402-1890

Attention: Mr. Hugh Heine, Environmental Resources Section

Dear Colonel Alexander:

In response to your letter dated December 9, 2003 regarding initiation of the Bogue Banks Shore Protection Study Feasibility Study in Carteret County, the U. S. Fish and Wildlife Service (Service) is pleased to provide these comments. Bogue Banks is located in Carteret County between Beaufort Inlet and Bogue Inlet and contains the communities of Atlantic Beach, Pine Knoll Shores, Salter Path, Indian Beach, and Emerald Isle.

As you are aware, the Corps has already received the **draft** report for this project of the Department of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661-667d). The draft report, dated November 2002, contains an exhaustive description of habitat types and this information should be used in the preparation of the feasability report and the environmental impact statement. Feel free to use content directly from this report for that purpose. It is a federal report prepared for your agency and the narrative can be used verbatim in instances that you find it helpful to do so.

Since November 2002, the Service has been working with your agency to address concerns relating to this project, and the Service would like to focus on the existing key elements for your response in the upcoming study. Many of our concerns are being addressed at the regularly scheduled meetings of the Project Delivery Team. Because of the new information that has been made available to the Service since the draft report was issued, it is no longer necessary for you to respond to all the Conservation Measures and Recommendations in Section 10 of the draft report. Instead, the Service requests you focus on the following measures that are taken from that same report. The Service believes that each of the following are very important and is hopeful that substantial attention can be given to them in your study and in the preparation of the environmental impact statement. The background material for these recommendations can be found in the draft report and will not be repeated in this letter.

- The construction, or renourishment interval, should be greater than three years. A six year interval would allow for a three year recovery period for benthic invertebrates and three years of relatively normal production before another event.

- The ODMDS and near shore disposal sites should be targeted for dredging before undisturbed marine areas, provided that the material is compatible and free of toxicants.

- Opportunities to improve bird habitat on dredge spoil islands should be investigated. We request that you schedule an informal meeting with yourself, Walker Golder with the Audubon Society, David Allen with the North Carolina Wildlife Resources Commission, and Mike Wicker of this office to discuss potential actions that could be taken to benefit the area's bird populations.

- Can benthic intertidal invertebrates be successfully collected ahead of the dredge pipeline and placed on new fill material behind the dredge pipeline? If so, does this result in quicker recovery of the invertebrate population density to pre-project levels?

- At what water depth and burial depth do coquina clams and mole crabs overwinter in offshore areas and what is the timing of the migration?

Construction activities may adversely affect sea turtles by placing obstacles on the beach that interfere with nesting and by altering natural beach physical characteristics (through compaction and potential escarpment formation) conducive to normal nesting and incubation. The project area provides important habitat for a diversity of fish and wildlife resources. The intertidal and near shore environments support a variety of fishery resources. Area beaches provide feeding, roosting, and nesting sites for shorebirds as well as important feeding and resting areas for other migrating birds.

Below are five negative environmental impacts resulting from beach nourishment and possible solutions. Solutions will likely gradually be reached by maintaining an open dialog and having our agencies work in collaboration toward mutually agreed goals. It is possible to partner with other projects on solutions. Solutions should be applied where they make the most sense. If one project does not have a solution opportunity in one area, it may work cooperatively with another project. It is our hope that as this process continues, solutions can be developed for all the impacts, so that by the time a final report is needed all potential problems have been resolved. We consider this identification of impacts and suggested solutions as a first step toward reaching that goal.

Impact #1: <u>Reduction in density of benthic invertebrates such as mole crabs that reduce the forage base for surf zone fish and birds such as oystercatcher and piping plover on the nourished beach</u>
Solution: Avoid impact by using reef ball or other environmentally benign breakwaters far

enough from the beach to provide new habitat. In some instances a benign breakwater may allow for beach accretion without the need for nourishment. In other instances nourishment may be necessary, but the breakwater may reduce erosion to a very low rate so that nourishment would only become necessary after many years.

Impact #2: Potential to impact sea turtle nesting success
Solution: Avoid impact by using compatible sand, not creating escarpments or compaction problems and observing nesting moratorium from May 1 - Nov 15.

Impact #3: Potential to impact seabeach amaranth
Solution: Observe a moratorium during the growing season from June through October. Support studies of the plant especially in regards to seeds and soil requirements. In some instances seabeach amaranth responds positively to nourishment. It appears that by learning more about the plant it may be possible to avoid negative impact and even enhance this plant. For example funding may be provided to conduct applied research on this topic.

Impact #4: Reduction in density of benthic invertebrates that provide forage for fish at the borrow site
Solutions: Avoid impact by using reef ball or other environmentally benign breakwaters far enough from the beach to provide new habitat thereby avoiding the need for borrow sites. In some instances a benign breakwater may allow for beach accretion without the need for nourishment. In other instances nourishment may be necessary, but the breakwater may reduce erosion to a very low rate so that nourishment would only become necessary after many years.

Impact #5: Potential to impact shorebird and colonial waterbird nesting success
Solution: Observe nesting moratorium for piping plover from April 1 - July 30.
Create, enhance or protect nesting habitat elsewhere.

The Service appreciates the opportunity to provide these comments. Please advise us of any action taken by the Wilmington Corps District. If you have questions regarding this letter, please contact Mike Wicker at 919-856-4520, ext. 22 or by e-mail at mike_wicker@fws.gov.

Sincerely,

Tom Augspurger x21

For Garland B. Pardue, Ph.D.
Ecological Services Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

September 12, 2013

Mr. Eric Gasch
Planning and Environmental Branch
Wilmington District, U.S. Army Corps of Engineers
69 Darlington Avenue
Wilmington, North Carolina 28403

Subject: Request for Informal Consultation
Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS)
Bogue Banks Coastal Storm Damage Reduction Project

This is in response to your letter requesting informal consultation concerning the U.S. Army Corps of Engineers' (Corps) Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS) for Bogue Banks Coastal Storm Damage Reduction Project (CSDR) (August 2013), and the draft Biological Assessment (BA) (Appendix F of the DEIS). The Corps provided the DEIS for the Bogue Banks project by letter dated August 2, 2013. The letter also requested initiation of formal consultation on the project. In a letter dated August 20, 2013, the Corps rescinded their August 2 letter, and instead requested concurrence under continuing informal consultation that began over ten years ago. The U.S. Fish and Wildlife Service (Service) has reviewed the DEIS and draft BA, and has several comments for your consideration. These comments are submitted in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543). We look forward to working with you on a final Fish and Wildlife Coordination Act (FWCA) Report.

Project Area, Proposed Activities, and Anticipated Impacts

The project area is Bogue Banks Beach and the adjacent Atlantic Ocean. Waters of the Atlantic Ocean, Beaufort Inlet and parts of Bogue Inlet and Bogue Sound are classified as SB. According to the DEIS, the purpose of this study is to evaluate coastal storm damage reduction at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County. The study team integrated representatives of Federal, State, and local governments, in the effort to identify cost-effective, publicly acceptable, and environmentally and technically sound alternatives to reduce damages within the towns and to the adjacent shoreline. The DEIS does not identify a Least Environmentally Damaging Practicable Alternative (LEDPA), which is required by the Clean Water Act.

Instead, the DEIS identifies a National Economic Development (NED) plan, that maximizes net benefits to the nation through reduction of future storm damages. The NED plan (preferred alternative #9) consists of an 119,670-foot (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-foot tapered transition zone berm. Material for the project is proposed to be dredged from three offshore borrow locations (Y, U, and Q2). The project is proposed to be renourished as often as every three years following initial construction, in order to build the project back up to the authorized dimensions.

The Service provided scoping comments to this project on February 14, 2000, provided a Planning Aid Report (PAR) on February 14, 2002, and drafted a FWCA Report in November 2002. A final FWCA report has not yet been produced. However, many of the recommendations of the 2002 draft FWCA report remain valid. The Service transmitted comments to the Corps by letter on January 8, 2004, and indicated that the Corps did not need to respond to all of the Conservation Measures and Recommendations in Section 10 of the Draft FWCA report. Instead, the 2004 letter recommended that the Corps focus on a subset of measures from that report. Among others, this subset of measures included:

- A recommendation that the construction or renourishment interval be greater than three years. A six year interval was proposed in the January 8, 2004 letter, although we currently recognize that such a long interval may not be feasible.

- The investigation of the potential to collect intertidal invertebrates such as *Donax* and *Emerita* immediately prior to beach nourishment activities, holding them, and then restoring those collected individuals in the new fill material behind the dredge pipeline. The January 8, 2004 letter recommends that the Corps investigate whether this action would result in a quicker recovery of the invertebrate population densities.

- A recommendation that beach compatible sand be used to avoid impacts to sea turtle nesting success.

Federally Protected Species

The Service has reviewed available information on federally-threatened or endangered species known to occur in Carteret County. Our review indicates that several species may occur in the project area, including the West Indian manatee (*Trichechus manatus*), piping plover (*Charadrius melodus*), roseate tern (*Sterna dougalii dougalii*), seabeach amaranth (*Amaranthus pumilus*), and the loggerhead (*Caretta caretta*), leatherback

(*Dermochelys coriacea*), Kemp's Ridley (*Lepidochelys kempii*), Hawksbill (*Eretmochelys imbricata*), and green (*Chelonia mydas*) sea turtle. Of the five sea turtle species, the loggerhead, leatherback, and green sea turtle may nest in the project area. The ESA Section 7 evaluation can be limited to these three turtle species. The project area includes portions of Critical Habitat Unit NC-10 for wintering piping plovers, as described on page 35 of the DEIS, in Section 4.02.7 of the Draft BA, and in 50 CFR Part 17 (66 FR 36038).

The Corps has made a determination of May Affect, Not Likely to Adversely Affect the piping plover, seabeach amaranth, and loggerhead, leatherback, and green sea turtle. The Corps also determined that the proposed project is Not Likely to Adversely Modify critical habitat for the piping plover. For the West Indian manatee and the roseate tern, the Corps has made a No Effect determination in the draft BA. At this time, the Service cannot concur with the Corps' determination, particularly for sea turtles and the piping plover.

Table 2.4 on page 33 of the DEIS incorrectly lists red knot (*Calidris canutus rufa*) as endangered. A determination to list the red knot has not yet been made by the Service, although it is a candidate species. As discussed further below, the Service recommends that potential impacts to the red knot be included in the final BA. Similarly, the Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) is listed in the DEIS as a Federal Species of Concern (FSC), when in fact, the Carolina Distinct Population Segment has been listed by the National Marine Fisheries Service as endangered. These corrections should be made in the Final EIS.

West Indian Manatee

Manatees move along the Atlantic Coast during summer months and are seasonal transients in North Carolina, primarily from June through October. Manatees may be found in water over one meter (3.3 feet) deep. The species moves extensively when in North Carolina waters and past occurrence records cannot be used to precisely determine the likelihood that it will be present at a particular construction site. Manatees may migrate through the project area during the warmer months of the year, primarily from June through October.

The Corps has committed to implementing precautionary measures for avoiding impacts to manatees from vessels during construction activities, by following the Service's "Guidelines for Avoiding Impacts to the West Indian Manatee." The Service concurs with the Corps' No Effect determination in the draft BA for the West Indian manatee.

Roseate Tern

The roseate tern (*Sterna dougalii dougalii*) is a medium-sized, colonial-nesting, marine waterbird with a deeply-forked tail. The roseate tern is a specialized plunge-diver, feeding on small marine fish. It is adapted for fast flight and relatively deep diving and often submerges completely when diving for fish. This species is distributed worldwide in a variety of coastal habitats. The North American subspecies is divided into two separate breeding populations, one in the northeastern U.S. and Nova Scotia, and one in the southeastern U.S. and Caribbean. Wintering areas are concentrated along the north and northeastern coasts of South America. It is not known if these two populations winter in proximity to each other. The roseate tern was listed as endangered in northeastern North America and threatened in the Caribbean and Florida in 1987 in response to nesting habitat loss, competition from expanding gull populations, and increased predation. Although both populations experienced severe population declines, it is believed that the northeastern breeding population is under greater threat. Roseate terns breed in colonies almost exclusively on small offshore islands, rarely on large islands. The northeastern colonies are on rocky offshore islands, barrier beaches, or salt marsh islands. The Caribbean birds nest in relatively open areas, often with no cover nearby. There is little information on the habitat of the wintering range. Some birds have been found roosting on sandbars or beaches at river mouths, estuaries, or ocean front.

Because the species' presence in the project area is quite limited, the Service concurs with the Corps' No Effect determination in the draft BA for the roseate tern.

Seabeach Amaranth

Seabeach amaranth, an annual plant, exists adjacent to inlets, along beaches between dunes and the high tide line, and in areas of extreme overwash. The plant helps to trap sand and build dunes. The species is listed as threatened by both the federal government and the State of North Carolina. Suitable habitat for this plant occurs in the project area. Seabeach amaranth begins to flower as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant. The proposed work period would place sand on the beach when only seeds are present. Sediment placement may bury seeds on the beach and delay germination the following year, but the seeds are likely to remain viable and may germinate when the imported sand washes away. The main long-term threat to this plant on Bogue Banks would be an increased frequency of large-scale sediment placements. As sea level continues to rise, major portions of the beach may need additional sand on an annual basis. If buried seeds are not given an opportunity to germinate and produce seeds, the population of the threatened plant on Bogue Banks could be reduced in the future.

The Service recommends that the Corps commit to conducting surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant (initial construction and all maintenance events). If this commitment is added to Section 5.00 of the draft BA, then the Service will be able to concur with the Corps determination that the proposed project May Affect, but is Not Likely to Adversely Affect seabeach amaranth.

Piping Plover

Piping plovers, designated as federally threatened, are known to occur in the project area. Designated Critical Habitat Unit NC-10 for the piping plover (as described in 50 CFR Part 17) is located on the west end of Bogue Banks. North Carolina is the only state where the piping plover's breeding and wintering ranges overlap and the birds are present year-round. Plovers may nest in the project area during the summer months, and overwinter in the project area during the winter months. Piping plovers from the federally endangered Great Lakes population as well birds from the threatened populations of the Atlantic Coast and Northern Great Plains overwinter on North Carolina beaches. Overwintering plovers may arrive as early as July, although most individuals arrive in early to mid-fall. Studies of wintering piping plovers indicate that they spend most of their time foraging on worms, fly larvae, beetles, crustaceans, molluscs, and other invertebrates (Bent 1929, Nicholls and Baldassarre 1990). In late February, piping plovers begin leaving the wintering grounds to migrate back to breeding sites. Northward migration peaks in late March, and by late May most birds have left the wintering grounds. Typically, piping plovers arrive on their breeding grounds in late March or early April. They nest above the high tide line on coastal beaches; on sand flats at the ends of sand spits and barrier islands; on gently sloping foredunes; in blowout areas behind primary dunes (overwashes); in sparsely vegetated dunes; and in overwash areas cut into or between dunes. The species requires broad, open, sand flats for feeding, and undisturbed flats with low dunes and sparse dune grasses for nesting. Following establishment of nesting territories and courtship rituals, the pair forms a depression in the sand, where the female lays her eggs. By early September both adults and young depart for their wintering areas.

As proposed in the DEIS, the initial construction of the preferred alternative is proposed to take place during the winter months (November 15 to March 31), which may adversely affect overwintering piping plovers. The Service does not agree with the statements in Section 4.02.7 d.(1) and (2) (no page numbers) that since only a portion of the beach on Bogue Banks will be nourished at any given time during pump-out, adjacent habitat is still available, and that recovering foraging habitat is available in the project area for the duration of construction. Studies show that recently nourished areas will not provide adequate forage for months, if not years after the nourishment project. In addition, the proposal by the Corps is to nourish the entire beach in one work season, and once an area

has been nourished, it will likely not provide suitable foraging habitat for the remainder of the winter and spring.

The Service is also concerned about the effect of sediment compatibility on the foraging habitat of the piping plover and other shorebirds. Too much large or fine-grained material or too much carbonate may make the beach substrate inhospitable for their prey species. Beach invertebrates live in the spaces between sand grains. The swash zone is dominated by mole crab (*Emerita talpoida*) and coquina clam (*Donax sp.*) which serve as the primary prey base for piping plover and other shorebirds, surf zone fish, and crabs. The health of the *Emerita* and *Donax* populations is closely linked with the sediment characteristics of the beach, and the availability of natural seawaters surging up and down the beach-face. The use of sediment matching the native beach would facilitate the recovery of these organisms. The Service recommends that Corps ensure that all sediment placed on the beach is similar to the historic, native beach in sand grain size, density, calcium carbonate content, shear resistance, and color. The most effective way to ensure compatibility would be for the Corps to commit to meet the NC Sediment Criteria (in Section 5.00 of the draft BA).

Each construction or maintenance event should start at the southern project limit and move northward in order to avoid potential impacts to nesting piping plovers. All construction for shaping the beach within the southern mile of the project area should be completed by March 1 and all construction equipment removed from this area. Equipment access to the beach should be within the day's work area or as close as possible, in order to minimize impacts from movement of heavy equipment along other stretches of beach. The placement of dredge pipelines and beach construction may disrupt wintering shorebirds, including the piping plover. To address this concern, the Corps should coordinate with the Service and North Carolina Wildlife Resources Commission (NCWRC) prior to mobilization and demobilization of the pipeline to determine the best location for the pipeline route.

Finally, we recommend that the Corps' commitments include a visual survey to be conducted each morning in the area of work for each day, to determine if piping plovers are present. If plovers are present in the work area, careful movement of equipment in the cold, early morning hours should allow those individuals to move out of the area. With these measures, potential impacts to wintering piping plovers are likely to be avoided, to the maximum extent practicable.

With the conservation measures proposed in the draft BA and those requested by the Service in the above paragraph, the Service would concur that the proposed project may affect, but is not likely to adversely affect the piping plover. The proposed project may modify, but is not likely to adversely modify, designated wintering critical habitat of the piping plover in the project area.

Sea Turtles

Sea turtle nesting habitat is present within the proposed project area. While all five Atlantic sea turtles are protected by the ESA and may occur in the coastal waters of North Carolina, we believe that Section 7 consultation can be limited to a consideration of the leatherback, loggerhead, and green sea turtles. The leatherback sea turtle is listed as endangered, while the loggerhead and green sea turtle are listed as threatened. Sediment placement on the beach may have both direct and indirect impacts on sea turtle reproduction. The most important aspects of any beach construction effort are the construction schedule and the compatibility of the material imported for beach fill. Disposal operations and subsequent grading during the sea turtle nesting and incubation season (May 1 through November 15) may result in the burial or crushing of nests or hatchlings or loss of sea turtles through disruption of nesting activity.

The Corps should ensure that all sediment placed on the beach is similar to the historic, native beach in sand grain size, density, calcium carbonate content, shear resistance, and color. The most effective way to ensure compatibility would be for the Corps to commit (in Section 5.00 of the BA) to meet the NC Sediment Criteria Rule, and also commit to using material which is compatible in color. Since the DEIS (page 89) currently estimates that the overall project (initial construction and all maintenance events) would utilize only about 47% of the total volume available at the three borrow sites, we recommend that the Corps determine whether there would be enough sand for the overall project if the NC Sediment Criteria Rule is met.

In order to ensure quality sea turtle nesting habitat over the entire duration of the project, the sediment monitoring program should have objective criteria for rejecting fill material based on color. Wet sand with a value of less than 5 is darker than what the Service considers acceptable for normal sea turtle incubation, because the darker color may cause higher incubation temperatures and greatly skew the sex ratio towards female (Mrosovsky et al. 1984, Mrosovsky & Provancha 1992). The Service recommends that material with a Munsell color value of less than 5 (for wet sand) not be considered compatible. A remediation plan should be developed to correct any placement of incompatibly-colored sand on the beaches.

In Item 6, Section 5.00 of the draft BA, the Corps commits to monitoring of sea turtle nesting activities in beach nourishment areas. However, the length of monitoring has not been provided. The Service recommends that Item 6 be modified to reflect that sea turtle nesting activities will be monitored annually for the life of the project.

Finally, the BA should also consider potential impacts to critical habitat for the loggerhead turtle. The Service is proposing to designate portions North Carolina beaches

as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles. North Topsail Beach is located within Critical Habitat Unit LOGG-T-NC-03 (Topsail Island, Onslow and Pender Counties). From the Federal Register Notice (see http://www.regulations.gov/#!documentDetail;D=FWS-R4-ES-2012-0103-0001), this unit consists of 35.0 km (21.8 miles) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Chadwick Bay, Alligator Bay, Goose Bay, Rogers Bay, Everett Bay, Spicer Bay, Waters Bay, Stump Sound, Banks Channel, and salt marsh. The unit extends from New River Inlet to New Topsail Inlet. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures.

With the conservation measures proposed in the draft BA and those requested by the Service in the above paragraph, the Service would concur that the proposed project may affect, but is not likely to adversely affect the loggerhead, leatherback, and green sea turtle. The proposed project may modify, but is not likely to adversely modify, proposed critical habitat of the loggerhead in the project area.

Red Knot

The Service encourages consideration of the red knot (*Calidris canutus rufa*), a candidate species, in project planning. Candidate species are species that the Service has determined warrant listing under the Endangered Species Act and await formal listing. These species receive no substantive or procedural protection under the Endangered Species Act until formal listing. The red knot was designated as a candidate species in 2006. At nine to ten inches long, the red knot is a large, bulky sandpiper with a short, straight, black bill. During the breeding season, the legs are dark brown to black, and the breast and belly are a characteristic russet color that ranges from salmon-red to brick-red. Males are generally brighter shades of red, with a more distinct line through the eye. When not breeding, both sexes look alike—plain gray above and dirty white below with faint, dark streaking. As with most shorebirds, the long-winged, strong-flying knots fly in groups, sometimes with other species. Red knots feed on invertebrates, especially bivalves, small snails, crustaceans, and, on breeding grounds, terrestrial invertebrates.

Coastal Barrier Resources Act

Section 2.14 on pages 42 and 43 of the DEIS discuss the Coastal Barrier Resource System and Coastal Barrier Resource Areas (CBRA) protected under the Coastal Barrier Improvement Act of 1990. The Fort Macon Unit (NC-04P) and the Roosevelt Natural Area (NC-05P) are both designated "P" (otherwise protected area or OPA). OPAs are generally comprised of lands held by a qualified organization primarily for wildlife refuge, sanctuary, recreational, or natural resource conservation purposes. The boundaries of these units are generally intended to coincide with the boundaries of

conservation or recreation areas such as state parks and national wildlife refuges. The only Federal spending prohibition within OPAs is the prohibition on Federal flood insurance. Since both units are owned by the State of North Carolina, and both hold the designation of "P," the Service agrees that no further actions or information regarding CBRA is required for this project.

Other Service Concerns and Recommendations

Determination of LEDPA: The DEIS identifies a "Tentatively Selected Plan" (TSP) based upon the determination of the NED plan, which is the plan that "maximizes net benefits to the nation through reduction of future storm damages." There is no mention of the identification of a LEDPA for the project. Appendix L of the DEIS does check "yes" next to the box stating "The discharge represents the least environmentally damaging practicable alternative…," however, there is no information or data to support this supposition. As recommended in our February 14, 2000 scoping comments, the Service recommends that the Corps determine a LEDPA for the project and present that alternative for consideration in the FEIS and BA. The LEDPA may be the same alternative as the NED; however the information used to make this determination was not provided in the DEIS. Along with determining the LEDPA amongst the 10 proposed alternatives, compliance with Section 404(b) of the CWA requires avoidance and minimization of impacts. Increasing the proposed interval between maintenance events and using sediment that meets the NC Sediment Criteria are minimization measures that would also benefit fish and wildlife resources in the project area.

As stated on Page 6 of the November 2002 Draft FWCA, the Service's Mitigation Policy (January 23, 1981, Federal Register v. 46, n. 15, pp. 7644-7663) allows for the Service to support a proposed project if the following criteria are met:

1) The project is ecologically sound;
2) The **least environmentally damaging alternative** is selected;
3) Every reasonable effort has been made to avoid or minimize damage or loss of fish and wildlife resources and uses;
4) All important recommended means and measures have been adopted with guaranteed implementation to satisfactorily compensate for unavoidable damage or loss consistent with the appropriate mitigation goal; and
5) For wetlands and shallow water habitats, the proposed activity is clearly water dependent and there is a demonstrated public need.

In addition, we note that the Service recommended in the February 14, 2002 cover letter to the PAR that the Corps "give fish and wildlife resources equal consideration with other aspects of this project in the development and evaluation of possible alternatives." We

continue to recommend that factors other than economic be given equal weight in consideration of alternatives.

Sediment compatibility: The draft BA states in Section 4.02.3 (no page numbers) that only beach compatible sediment will be placed on the beach, but does not state how compatibility will be determined. Section 5.06.1.1 of the DEIS states that although the sediment in the borrow areas appears to comply for the most part with the North Carolina Sediment Criteria Rule (15A NCAC 07H .0312: Technical Standards for Beach Fill Projects), the Corps will "continue to use its best engineering judgment, accompanied by appropriate sampling and monitoring, to determine sediment compatibility."

Appendix C (the Geotechnical Engineering Section) of the DEIS provides sediment compatibility data and analysis for the three borrow areas (Y, U, and Q2). Although the number of sediment samples collected from the three borrow areas are rather small, and color data was not provided, the available data indicates that both borrow area U and Q2 appear to have sediment compatible with the native beaches, when applying the NC Sediment Criteria Rule. We note that it is difficult to determine the compatibility with respect to the amount of calcium carbonate, since a visual measurement of shell was used rather than a measurement of calcium carbonate. Carbonate material breaks down faster than quartz and other inorganic sediments, making it more susceptible to chemical dissolution (King et al. 2002). Carbonate material that is sand-sized or finer will be intermixed with the quartz sediments and not sort out with wave reworking of the fill. Over time, this material may break down and/or dissolve, forming a carbonate cement that hardens the beach. Cementation of the beach can significantly impair a sea turtle's ability to dig a nest, and the sea turtle hatchling's ability to emerge from the nest chamber. A higher than background coarse-grained or carbonate fraction also inhibits the burrowing of beach infauna and the foraging of shorebirds (Peterson et al. 2000).

Aside from carbonate and color, material in borrow area Y appears to be compatible with the exception of the percentage of gravel-sized material ($\geq$4.76 mm), which is close to 8%, and approximately 7.4 to 7.5% higher than the average native beach percentage. Because the Corps is not currently following the NC sediment criteria, the percent gravel is not being considered in determining compatibility. However, a high percentage of large material may cause significant impacts to the native beach fauna and sea turtle nesting, and may also be expensive to remediate. Since 2000, there have been significant incidents with the placement of large materials on North Carolina beaches. Examples include the placement of rocky, muddy and shell-strewn sand onto Bogue Banks, placement of rocky material on Oak Island's beach, and placement of sand strewn with rocks and road building material on Holden Beach. Those incidents and others prompted the state to develop the NC Sediment Criteria Rule.

Finally, the Service is concerned with a lack of consistency in the applicability of the NC Sediment Criteria Rule. It is unclear how the Corps may hold itself to one standard of sediment compatibility, and expect private permittees to meet a higher standard. The Service is aware of several privately-funded beach nourishment projects currently being conducted or proposed along the coast of North Carolina, some of them in the same project area. It is difficult to afford the Corps Civil Works program one level of compliance for sediment compatibility, when we expect a greater level of compliance from private applicants. The Service is concerned that allowing the Corps to utilize a different level of compliance will make it more difficult to uphold the NC Sediment Criteria for private permittees. For all of the reasons stated above and in the sections dealing with sea turtles and piping plover, the Service recommends that the Corps commit to meet the NC Sediment Criteria Rule, and also commit to using material which is compatible in color.

Non-Structural Alternative: On Pages 72 and 73 of the DEIS, Table 5.8 provides a comparison of alternatives, and the potential impacts to the marine and terrestrial environment and to threatened and endangered species. The table indicates that the no action alternative and a non-structural alternative (Alternative 10) would have similar environmental consequences for threatened and endangered species. The non-structural alternative entails the buyout and demolition of vulnerable properties, which would allow natural processes to occur along large portions of the beach. The no action alternative assumes that the Federal project would not be conducted, but other actions may be taken. The DEIS does not provide enough information to support the statement that the non-structural alternative would result in a "long-term decrease in sea turtle nesting habitat and nest success due to beach erosion, scarping, and scouring of the dune." The DEIS also does not provide any information to support the statement that the non-structural alternative would cause a "risk of increased beach lighting impacts to sea turtles as the dune erodes," or the supposition that both seabeach amaranth and piping plover habitat would suffer long-term losses due to beach erosion. The resumption of natural beach processes may allow the movement of dunes and beach shoreward, which, in the long-term, could provide ample habitat for sea turtle nests, piping plovers, and seabeach amaranth. We recognize that this alternative is not preferred because of the failure to provide storm damage protection for structures on the beach, and because it is currently not economically feasible. However, we recommend that the language of the table be revised to reflect the more likely long-term benefits of allowing natural processes to resume on Bogue Banks.

Maintenance Intervals: Section 5.08.02 on page 75 of the DEIS states that a 3-year maintenance interval was chosen because of the net costs and benefits of the nourishment activities. However, a longer maintenance interval of 4 or 5 years would be less-damaging, and allow the benthic infauna longer time to recover both on the beach and in the borrow areas. A longer interval between maintenance events would be a

minimization measure under Section 404(b)(1) of the Clean Water Act. A longer maintenance interval would also require a smaller amount of compatible borrow material for the life of the project. We recommend that the final EIS consider the non-economic benefits of longer maintenance intervals.

Lack of Monitoring: The Service is concerned with a lack of monitoring for this project, particularly for seabeach amaranth and piping plover. The Service recommends that the additional commitments be added to Section 5.00 of the BA:

1. Conducting surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant (initial construction and all maintenance events);

2. Conducting visual surveys each morning in the area of work for that day, to determine if piping plovers are present and allow those individuals to move out of the area.

3. Monitoring of sediment each day as it is being placed on the beach to ensure that it is similar to the existing sediments on the beach.

Sea Level Rise: The Service would be concerned with the acceleration of nourishment schedules based upon increased storm surge or sea level rise, or other factors. The Service recommends that beach nourishment for this project be conducted no more often than once every five years.

Summary

1. At this time, the Service cannot concur with the Corps' determination of May Affect, Not Likely to Adversely Affect (MA-NLTAA) for the piping plover, and loggerhead, leatherback, and green sea turtles. More information is needed on the compatibility of the sediment to be dredged and placed on the beach, including sand grain size (percent fines and percent granular and gravel), density, shear resistance, and color. In addition, no monitoring is proposed to be conducted during construction or maintenance events for piping plover, and the length of monitoring for sea turtle nests is not clear in the draft BA.

2. The Service recommends that the proposed Critical Habitat for the Loggerhead Sea Turtle and the candidate species red knot (*Calidris canutus rufa*) be added to the list of considerations under Section 7 of the Endangered Species Act. Consideration of proposed critical habitat and candidate species in project planning is prudent and should not delay or impede decision-making.

3. The Service recommends that the Corps commit to using only sediment that complies with the NC Sediment Criteria Rule, and also has a wet Munsell color of 5 or greater.

Specifically, the Service recommends that the Corps commit to meet the following criteria:

- 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 average percentage by weight of granular sediment (greater than or equal to 2 millimeters and less than 4.76 millimeters) in a borrow site shall not exceed the average percentage by weight of coarse-sand sediment of the recipient beach characterization plus five (5) percent.
- The average percentage by weight of gravel (greater than or equal to 4.76 millimeters) in a borrow site shall not exceed the average percentage by weight of gravel-sized sediment for the recipient beach characterization plus five (5) percent.
- The average percentage by weight of calcium carbonate in a borrow site shall not exceed the average percentage by weight of calcium carbonate of the recipient beach characterization plus 15 percent.

Use of material that meets the above criteria and is similar in color to the native beach would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize potential impacts to piping plover, red knot, and sea turtles, as well as beach invertebrates, surf fishes, and other shorebirds. The Service recommends that Section 5.00 of the BA include a commitment to monitoring sediment each day as it is being placed on the beach to ensure that it is similar to the existing sediment on the beach.

4. The Service recommends that Section 5.00, Item 6 of the draft BA be modified to reflect that sea turtle nesting activities will be monitored annually for the life of the project.

5. The Service recommends that Section 5.00 of the BA include a commitment to conduct visual surveys each morning in the area of work for that day, to determine if piping plovers are present and allow those individuals to move out of the area.

6. The Service recommends that Section 5.00 of the BA include a commitment to conduct surveys for seabeach amaranth both before and for three years after sediment

placement in order to avoid direct burial and to monitor recovery of the plant, for the life of the project.

7. Each construction or maintenance event should start at the southern project limit and move northward in order to avoid potential impacts to nesting piping plovers. All construction for shaping the beach within the southern mile of the project area should be completed by March 1 and all construction equipment removed from this area. Equipment access points should be within the day's work area or as close as possible, to minimize impacts from movement of heavy equipment along other stretches of beach. Also, the Corps should coordinate with the Service and North Carolina Wildlife Resources Commission (NCWRC) prior to mobilization and demobilization of the pipeline on the beach, to determine the best location for the pipeline route.

8. The Service recommends that the Corps investigate the necessary minimum maintenance interval for storm damage reduction, which may be greater than 3 years. A longer interval between maintenance events would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize potential impacts to piping plover, red knot, and sea turtles, as well as beach macroinvertebrates, surf fishes, and other shorebirds. A longer maintenance interval would also require a smaller amount of compatible borrow material for the life of the project. We recommend that the final EIS consider the non-economic benefits of longer maintenance intervals.

The Service appreciates this opportunity to comment. We look forward to working with you on a final FWCA report and final EIS and BA for this project. If you have questions regarding these comments, please contact Kathy Matthews at 919-856-4520, ext. 27 or by e-mail at <kathryn_matthews@fws.gov >.

Sincerely,

Pete Benjamin
Field Supervisor

cc:

Fritz Rohde, NOAA Fisheries, Beaufort, NC
Daniel Holliman, USEPA, Atlanta
Maria Dunn , NC Wildlife Resources Commission, Wilmington
Doug Huggett, NC Division of Coastal Management, Morehead City, NC

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March 10, 2014

Mr. Eric Gasch
Planning and Environmental Branch
Wilmington District, U.S. Army Corps of Engineers
69 Darlington Avenue
Wilmington, North Carolina 28403

Subject: Request for Concurrence
Bogue Banks Coastal Storm Damage Reduction Project

This is in response to your February 14, 2014 letter, concerning the U.S. Army Corps of Engineers' (Corps) Bogue Banks Coastal Storm Damage Reduction Project (CSDR), and the February 2014 revised draft Biological Assessment (BA) (Appendix F of the DEIS). The Corps requested concurrence under section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543) with its determination of May Affect, Not Likely to Adversely Affect the piping plover, seabeach amaranth, and loggerhead, leatherback, and green sea turtles, and is Not Likely to Adversely Modify critical habitat for the piping plover, and proposed critical habitat for loggerhead sea turtles. The letter also provided responses to the Service's September 12, 2013 comments on the Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS) for Bogue Banks CSDR, and the August 2013 draft BA.

For the West Indian manatee and the roseate tern, the Corps previously made a No Effect determination in the draft BA. The Service concurred with the effect determination for these two species in our September 12, 2013 letter.

Comments and Recommendations

1. In our September 12, 2013 letter, the Service recommended that the Corps use sediment that complies with the NC Sediment Criteria Rule, and has a wet Munsell color of 5 or greater. The Corps has disagreed with our recommendation, and believes that its criteria will result in compatible material. The Service continues to have concerns for applying one set of criteria to private beach nourishment projects and a different set of criteria to the Corps projects. However, we recognize that the Corps currently is not required to comply with the NC Sediment Criteria Rule.

The Corps has also stated that it will require the contractor be present and monitor the dredge discharge location and work zone continuously while the discharge is occurring, and that frequent visual inspections of the beach placement will be conducted by a government inspector and Wilmington District technical staff.

2. The Service recommended that the BA be modified to reflect that sea turtle nesting activities will be monitored annually for the life of the project. The Corps responded that it doesn't conduct sea turtle nest monitoring, but pointed out that the local communities monitor sea turtle nesting activities on annual basis in the project area. The Service recognizes the extensive local and regional monitoring efforts, and agrees that the Corps does not need to duplicate them.

3. The Service recommended that the BA include a commitment to conduct visual surveys each morning in the area of work for that day, to determine if piping plovers are present and allow those individuals to move out of the area. In response, the Corps has added language stating that personnel involved in the construction process along the beach will be trained in recognizing the presence of piping plovers and red knots prior to the initiation of the work on the beach. A contractor representative authorized to stop or redirect work shall be responsible for conducting a shorebird survey prior to 9 am each day of sand placement activities.

4. The Service recommended that the BA include a commitment to conduct surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant, for the life of the project. In response, the Corps has proposed to conduct seabeach amaranth surveys for five years following the initial placement of sediment. Subsequent monitoring will depend on the results of the initial monitoring. The Corps made this commitment in the letter to the Service; however, this commitment has not been incorporated into the EIS or BA. The Service recommends that this commitment be included in the environmental commitments for the project.

5. The proposed construction window for the project is December 1 to March 31, to avoid impacts to manatees, nesting sea turtles, and nesting piping plovers. However, the revised BA includes a discussion of potential direct impacts to sea turtles, and actions that will be taken by the Corps, if construction extends into the nesting season. We acknowledge the discussions in the BA, but please be aware that our concurrence on the determinations made by the Corps for this project do not include consideration of work within the sea turtle nesting or piping plover nesting seasons. Extension of the construction window into the nesting season is likely to require formal consultation.

Service Position

With the commitments made by the Corps in the BA, as stated above, and the addition of a commitment to the BA to monitor seabeach amaranth for at least 5 years after the initial placement of sediment, the Service can concur with the Corps determination of May Affect, Not Likely to Adversely Affect (MA-NLTAA) for the piping plover, seabeach amaranth, and loggerhead, leatherback, and green sea turtle. We also concur that the project May Affect, but is Not Likely To Adversely Affect the red knot, and that the project is Not Likely to Aversely Modify critical habitat for piping plovers and proposed nesting critical habitat for loggerhead sea turtles.

The Service appreciates the continued opportunity to provide input on this project. If you have questions regarding these comments, please contact Kathy Matthews at 919-856-4520, ext. 27 or by e-mail at <kathryn_matthews@fws.gov >.

Sincerely,

Pete Benjamin
Field Supervisor

cc:

Fritz Rohde, NMFS, Beaufort, NC
Pace Wilbur, NMFS, Charleston, SC
Maria Dunn, NC Wildlife Resources Commission, Washington
Doug Huggett, NC Division of Coastal Management, Morehead City, NC
Dan Holliman, USEPA, Atlanta, GA

FINAL
INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX M

PUBLIC AND AGENCY REVIEW COMMENTS AND RESPONSES

US Army Corps of Engineers
Wilmington District

	Appendix Reference	From	Comment	Corps Responses	Changes
1	L-47	NCDENR DWR from DCM	The project will require a 401 permit application	Concur. The document indicates in several areas that a Section 401 Water Quality Certification is required.	No additional text is required.
2	L-47	NCDENR DWR from DCM	The use of berms to reduce the turbidity needs to be described in better detail as to the exact location of the berm for each section of beach and if it is located within the surf zone. The location of the discharge pipe is relation to the berm and the water. An alternative plan of how the turbidity may be reduce, if the turbidity exceeds the turbidity limits outside the 1000' mixing zone	The Corps will construct berms so they are inshore as much as practicable. If turbidity exceeds limits, the Corps will coordinate with the State to address issues.	None
3	L-47	NCDENR DWR from DCM	A plan for measuring the turbidity at the 1000' and 1500' limits of the project during daily operation needs to be included with the 401 application.	The Corps will not violate Water Quality standards because 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.	None
4	L-48	Lauren Shaffer	Could the topmost layer be retained and held in a state that could protect the viability of the existing benthic community as well as other organisms, with the intention of returning this layer to the top of the dredged material after a section of the shoreline stabilization project has been finished?	Retaining benthic organisms would be cost prohibitive. Additionally the viability of these organisms being held is not known. The beach is a dynamic area and the re-colonization of the beach following placement of sand will occur.	None

5	L-14	BOEM	Consistent with the Council on Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, the Corps has combined the preparation of an Environmental Impact Statement (EIS) with a planning instrument. The draft Integrated Feasibility Report (IFR) and EIS integrate alternative development, engineering and economic analyses, and environmental review in a single document. In the draft document, the elements required in an EIS are presented in an atypical order, and the re-organization presents some fundamental challenges to the reader. For example, the reader must first read the Tentatively Selected Plan chapter (Chapter 6), the practical description of the proposed action, to fully comprehend the site-specific discussion of in the Affected Environment chapter (Chapter 2). Environmental commitments are enumerated before the presentation of the impact analyses in the Environmental Effects chapter (Chapter 7). Therefore, the reader must first read the effects analyses to fully appreciate the need and purpose of the proposed mitigation.	The purpose of this document is to combine NEPA with the Planning process. CE 230.13 allows for integration to reduce paper and the size of the document. CEQ guidelines also allows for flexibility in how the document is structured. This current format has been used in the past with success and is the Corps preferred template.	
6	L-14	BOEM	BOEM recommends the Corps prepare prepatory guidance to better orient the reader to the organization of the document. Alternatively, the Corps could insert the Affected Environment chapter after the Tentatively Selected Plan chapter and before the Environmental Effects chapter. Mitigation should be linked in a logical manner to the effects analysis.	Section 1.01 outlines the report organization and is consistent with historical templates used in the past on the Brunswick and Topsail Beaches projects.	None

7	L-14	BOEM	Please include BOEM jurisdiction justification: Public Law 103-426 enacted 31 October 1994 gave BOEM the authority to convey, on a noncompetitive basis, the rights to 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 mi) fall under BOEM's jurisdiction, as found in the OCS Land Act.	Concur	The following was added to section 10.02: Public Law 103-426 enacted 31 October 1994 gave BOEM the authority to convey, on a noncompetitive basis, the rights to 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.
8	L-14	BOEM	Please indicate earlier in the document: BOEM and the USACE are cooperating agencies having jurisdiction over different project facets and locations. OCS resources (beyond three mi) fall under BOEM's jurisdiction, as found in the OCS Land Act.	Concur	A new section 1.07 was added to the Feasibility Report titled Cooperating Agencies. The following was put in the section: 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 will 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. See Section 10.02 for more information about BOEM's involvement is this study.

9	L-14	BOEM	Please note this earlier in the document: Since most of the borrow areas identified for the proposed project are located on the Outer Continental Shelf (OCS), BOEM may need to authorize their use for initial and/or maintenance construction. The BOEM, as a cooperating federal agency, may undertake a connected action (i.e., authorize use of the OCS borrow area) that is related, but unique from the Corps's proposed action (i.e., construction of the project). Consequently, the purpose and need of the BOEM's proposed action is different. Ideally, the EIS should provide a more accurate description of the BOEM's involvement under the Corps' proposed action. The BOEM's proposed action is the issuance of a negotiated agreement pursuant to its authority under the Outer Continental Shelf Lands Act. The purpose of that action is to authorize the use of OCS sand (or other sediment) resources in beach nourishment and coastal restoration projects undertaken by federal, state or local government agencies, and/or in other federally authorized construction projects. The BOEM's action will be needed because the localities and the Corps submitted authorization requests to the BOEM.	Concur	Changes have been made to sections 1.03, 1.07 and 10.02 of the report.

10	L-14	BOEM	The Environmental Effects chapter (Chapter 7) offers a robust discussion of the potential environmental impacts related to the Tentatively Selected Plan. In contrast, the document offers a limited discussion of potential impacts associated with other alternatives, including the no action alternative. BOEM suggests the Corps clearly indicate which alternatives were dismissed and on what basis. Otherwise, the direct and indirect impacts of alternatives should be discussed in more detail and in context of their relative significance in the Environmental Effects chapter.	In accordance with Corps policy, the impacts were integrated in the plan formulation process. We used Table 5.7 to address alternatives. Chapter 7 is only the NED plan.	None
11	L-14	BOEM	The biological assessment discusses protected species that are likely to occur in the proposed project area. However, the draft IFR/EIS does not address other marine mammals without protection status, such as dolphin species, that are likely to be present and may be affected by the proposed action. They are mentioned in App G but should be addressed within the document text.	Concur	Updated section 7.2.5 with marine mammal affects. We have added references to effects of dredging activities on marine mammals and sea turtles which are addressed in the NMFS South Atlantic Regional Biological Opinion (SARBO). See section 7.03.5.2 of this document for more information on the NMFS SARBO. Effects on marine mammals are also discussed in section 7.09.1 as well as Appendix G.
12	L-14	BOEM	Please add the OCS line to delineate Federal vs. State waters	Concur	Line was added to Figure 1.1
13	L-14	BOEM	No mention of the most recent 2013 Post Irene Renourishment Effort along Bogue Banks	Concur	Figure 1.2 was updated with Post Irene information.

14	L-14	BOEM	Please include a figure indicating hardbottom areas within and near offshore borrow areas. A more detailed description of offshore hardbottom would be helpful. A discussion of habitat association between benthic populations and habitat type (RSDs, hard bottom, sand and muddy substrate) should be provided. The benthic resources or hard bottom descriptions should include a detailed description of the occurrence and quality of benthic Sargassum, corals, and sponges.	Concur. In 2007, 2008 and 2009 the Corps contracted out with Geodynamics, Mid-Atlantic Technology and Environmental Research, Inc. and ANAMAR to record and identify benthic resources. Results of which are located in Sections 2.04.6 and 7.02.8.2.	Figure 2.1 was added. Added citations to section 7.02.8.2
15	L-14	BOEM	"In accordance with Section 7 (a)(2) of the ESA, the Corps has been in consultation with the USFWS and NMFS since beginning this study." Should indicate BOEM's involvement in the process to cover use of the OCS borrow site under ESA.	Concur	BOEM was added to the first paragraph of Section 2.07, Threatened and Endangers Species.
16	L-14	BOEM	Update with new info on spp. Atl sturgeon are now endangered	Concur	Updated table 2.4
17	L-14	BOEM	There is no discussion of the potential for archaeological resources in the vicinity of pump-out locations and pipeline corridors, and the likely areas for those operations are not identified. Consideration of these areas may be important as they are subject to bottom disturbing activities such as anchoring, anchor drag, and pipeline emplacement.	Concur. Included discussion of archaeological resource potential in the vicinity of pump-out locations and pipeline corridors.	Section 2.08 was updated.

18	L-14	BOEM	The Corps does not fully address the potential for prehistoric sites within the survey area. BOEM suggests that the following tasks relating to prehistoric site potential be addressed: 1. review current literature on late Pleistocene and Holocene geology, paleogeography, and sea level change in the area; marine and coastal prehistory; and previous archaeological resource reports in the area if available. 2. discuss relict geomorphic features and their archaeological potential that includes the type, age, and association of the mapped features; the acoustic characteristics of channels and their fill material; evidence for preservation or erosion of channel margins; evidence for more than one generation of fluvial downcutting; and the sea level curves used in the assessment. 3. discuss, based on the capabilities of current technology in relation to the thickness and composition of sediments overlying the area of a potential site, the potential for identification and evaluation of buried prehistoric sites. The DEIS should incorporate information that summarizes the potential for prehistoric sites within the project area.	Concur. Addressed the potential for prehistoric sites within survey area and incorporate suggestions 1, 2, and 3 based on available data.	Section 2.08 was updated.
19	L-15	BOEM	Ambient and anthropogenic noise in the marine environment is not described.	A discussion on noise was added to Section 2.	Added discussion on ambient and anthropogenic noise to Section 2.04.8 Added to citations: Clarke, D., C. Dickerson, and K. Reine. 2002. Characterization of Underwater Sounds Produced by Dredges. In Proceedings of the Third Specialty Conference on Dredging and Dredged Material Disposal. May 5–8 2002, Orlando, FL.
20	L-15	BOEM	Table 5.7 does not address potential impacts from the range of beach fill and non-structural alternatives proposed to physical processes and non-listed marine mammals.	Table 5.7 was updated to add marine mammal and physical processes.	Marine Mammals and Physical Processes were added to Table 5.7.

21	L-15	BOEM	Please indicate state vs. federal borrow sites or give some explanation to the difference.	Concur	The following sentence was added to section 1.03. Also figure 1.1 was revised to include the three mile limit line: The borrow areas within the three mile limit line indicated on Figure 1.1 are within the jurisdiction of the State of NC and the ones offshore of 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.
22	L-15	BOEM	Note that the recent FEMA project off Bogue Banks went from January to March 25th on the ODMDS and did not catch any turtles during relocation trawling.	Concur	Information regarding FEMA turtle trawling was be added to Section 4.02.3 in the BA (Appendix F).
23	L-15	BOEM	The description of and potential impacts to protected marine mammals and sea turtles are incorporated by reference to the biological assessment. BOEM recommends a brief summary be provided in the EIS, or, the biological assessment should be included as a physical attachment to the Final IFR/EIS.	BA is attached that includes descriptions of potential impacts to protected marine mammals and sea turtles.	Attached BA to Appendix. Updated Table 5.7 with marine mammal information.
24	L-15	BOEM	Suggest referencing some more recent literature which can be found the recent review on this subject (Near Shore) Michel et al, 2013.	Concur	Updated information and references in section 7.02.7
25	L-15	BOEM	It should be stated that cross-shore sediment transport will likely occur beyond the depth of closure, but ultimately depends on the forcing conditions and the profile state at the time of the forcing event.	Concur	Paragraph from section 7.02.8.2 change to: "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 depending on the wave climate and state of cross shore profile. 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."

26	L-15	BOEM	What about potential impacts to benthic Sargassum? It is noted to be in the area but then not further addressed.	Section 7.02.8.5 will be updated to reflect that there will be no direct impacts to benthic Sargassum. All dive transects in which benthic Sargassum was identified were located on hard bottom communities, not within the sediments proposed for dredging. Considering that no direct impacts will occur from dredging and no indirect impacts are anticipated from sedimentation considering the incorporation of buffers, the Corps believes that the conclusion of no impacts to benthic Sargassum from the dredging activities is supported.	None
27	L-15	BOEM	Additional info from NASA Wallops Island EA (2013): "Dredging operations would cause sediment to be suspended in the water column. Studies of 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. (USACE 1983; Hitchcock et al. 1999; MMS 1999; Anchor Environmental 2003; Wilber et al. 2006)."	Thank you for the information.	Reference was incorporated into the document in Section 7.02.8.6.
28	L-15	BOEM	BOEM recommends a discussion of bird utilization of hard bottom areas and other offshore habitat.	Section 7.03.4 Birds describes utilization of offshore areas off Bogue Banks by birds. The Corps believes that all available scientific information pertaining to existing literature and survey data for bird resources within the project area was incorporated into the report. Recognizing all of the avoidance and minimization measures incorporated into the project planning and design, the Corps does not believe that mitigation for impacts to bird resources is warranted.	None

29	L-15	BOEM	It seems odd that T and E aren't addressed until the terrestrial section although it includes offshore species. Would be helpful to include a section in the marine environment on offshore T and E spp.	Concur	Moved T&E to section7.4 to avoid confusion.

30	L-15	BOEM	Additional info from the NASA/BOEM Wallops 2013 EA that may be useful: "During the initial Wallops Island beach fill in summer 2012, NASA partnered with BOEM and USACE (Reine et al, 2013) to record background in-water sound levels at the both offshore borrow area and the nearshore pump out area. Data were collected at two listening depths at each site; approximately 10 ft and 30 ft depths at the offshore shoal and 10 ft and 20 ft at the nearshore sites. During the study, the majority of data collected when winds were at least 4-7 miles per hour and wave heights were at least 1-2 feet. Therefore, the data do not reflect "calm" sea conditions. Background sound pressure levels (SPLs) averaged 117 dB across all sampling days, sites, water depths and weather conditions. Minimum measured sound levels ranged from 91 dB to 107 dB depending on sampling location and water depth; maximum levels ranged from approximately 128 dB to just under 148 dB (Reine et al. in prep). Highest SPLs were found at frequencies of less than 200 hertz. The authors note that sea state and the associated sounds generated by waves interacting with the survey vessel likely contributed to the elevated readings. Based upon data collected by Reine et al. (2013), sediment removal and the transition from transit to pump-out would be expected to produce the highest sound levels at an estimated source level (SL) of 172 dB at 3 ft. The two quietest dredging activities would be expected to be seawater pump-out (flushing pipes) and transiting (unloaded) to the borrow site, with expected SLs of approximately 159 and 163 dB at 3 ft, respectively…. Based upon attenuation rates observed by Reine et al. (in prep.), it would be expected that at distances approximately 1.6-1.9 mi from the source, underwater sounds generated by the dredges would attenuate to background levels. However, similar to in-air sounds, wind (and corresponding sea state) would play a major role in dictating the distance to which project related underwater sounds would be above ambient levels and potentially audible to nearby receptors"	Thank you for the information.	Reference was incorporated into the document in Section 7.10.3

31	L-15	BOEM	The Corps should also discuss the potential benefits/costs of a borrow area management plan that requires the rotational use of borrow areas over initial and maintenance construction cycles as a means to mitigate cumulative effects to benthic communities and habitat.	A site specific borrow area use plan has yet to be defined. The economic optimization of the use of the borrow areas for the life of the project will be further evaluated when the final borrow area data has been collected and fully analyzed during the Plans and Specifications (P&S) phase.	None
32	L-15	BOEM	The Corps has "lead agency" status for Section 7 and EFH consultations/coordination, and as "lead agency", the Corps should notify NMFS HCD, NMFS PRD, and FWS of BOEM's involvement in the proposed action.	Concur. In the informal consultation process, the Corps has informed these agencies on BOEM's involvement in the proposed action.	None
33	L-16	BOEM	Please indicates BOEM's involvement with the Section 7 process within this Biological Assessment.	Concur	BOEM's involvement is addressed in comment #4/#8 above.
34	L-26	Town of Pine Knoll Shores	Pine Knoll Shores requests that the Integrated Feasibility Report and Draft Environmental Impact Statement for Bogue Banks be adjusted in Appendix I to require PKS to have 180 public parking spaces in support of our 11 PBA's.	The access mapping, and associated requirements are updated in the final report.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.
35	L-27	Carteret County	Pertaining to the Draft Report & EIS, we would like to go on record specifically at this time regarding the parking and access requirements, which is supported in the document by Appendix I. We have long questioned the interpretation and unilateral judgments the District and Division/Headquarters have applied to their own internal regulations (ER 1105- 2-100 and ER 1165-2-130) that sometimes seemingly have no consideration for larger issues such as cost, practicality, and "quantity over quality (i.e., amenities)" of the access/parking facilities existing or planned.	Noted. The concerns with the policies in question have been elevated through the USACE 'vertical chain' and are being addressed as such. This said, there is yet to be a resolution to this issue. The sponsor will be kept fully abreast of developments as they occur.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.

36	L-27	Carteret County	Draft Report is Missing Six Accesses and Parking Locations in Pine Knoll Shores. We request the Draft Report to be modified to reflect these access/parking areas, and to also be considered to meet peak demand.	The access mapping, and associated requirements is updated in the final report.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.
37	L-28	Carteret County	Waiver Requested in Indian Beach and Salter Path- we request a waiver be approved and formally incorporated into the Final Report, rather than undergoing a waiver decision-making process subsequent to its approval and Congressional authorization – especially considering the insignificant distances involved.	The 'insignificant distance' has been noted and deviation from policy, given the distance, will most likely be granted. Issues that involve USACE policy are elevated through our vertical command chain, and the ultimate decision will lie with USACE policy interpreters.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.
38	L-28	Carteret County	Peak Demand Calculations Needs to be Revisited: We disagree with the parking requirements in the draft report and the peak demand methodology used to generate these numbers.	Noted. The concerns with the policies in question have been elevated through the USACE 'vertical chain' and are being addressed as such. This said, there is yet to be a resolution to this issue. The sponsor will be kept fully abreast of developments as they occur.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.
39	L-28	Carteret County	We also contend the Corps' forecasts for increases in peak demand envisioned for the project, which were based on increases to beach width is a false premise, and again needs to be revisited.	Noted. The concerns with the policies in question have been elevated through the USACE 'vertical chain' and are being addressed as such. This said, there is yet to be a resolution to this issue. The sponsor will be kept fully abreast of developments as they occur.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.
40	L-3	NCDENR DCM - CC	To solicit public comments, DCM circulated a description of the proposed project to State agencies that would have regulatory interest. No comments asserting that the proposed activity would be inconsistent with the State's coastal management program were received.	Noted	None

41	L-4	NCDENR DCM	the Applicant, prior to initiating berm construction activities shall submit to DCM final project plans to ensure that the proposed project remains consistent with North Carolina's coastal management program.	Concur	None
42	L-4	NCDENR DCM	At this time, DCM's sediment criteria has not been certified by the NOAA Office of Ocean and Coastal Resource Management (OCRM) as being certified enforceable policy of North Carolina's coastal management program (NCCMP). Furthermore, in this case, DCM accepts the Corps sediment criteria as adequately complying with the NCCMP in protecting coastal resources.	Noted	None
43	L-42	USFWS	At this time, the Service cannot concur with the Corps' determination of May Affect, Not Likely to Adversely Affect (MA-NLTAA) for the piping plover, and loggerhead, leatherback, and green sea turtles. More information is needed on the compatibility of the sediment to be dredged and placed on the beach, including sand grain size (percent fines and percent granular and gravel), density, shear resistance, and color. In addition, no monitoring is proposed to be conducted during construction or maintenance events for piping plover, and the length of monitoring for sea turtle nests is not clear in the draft BA.	Sufficient data regarding compatibility of sediment to be dredged and placed on the beach are provided in Section 5.05.1 in the EIS and in the Geotech Appendix C. For clarity, that information was not repeated in the BA. Color of the sediment was not investigated and historically has not in previous projects. The Corps does not do daily visual surveys for piping plover during construction or maintenance events because placement of material is timed to minimize impacts to piping plovers and therefore surveys are not necessary. A visual survey is performed before placing pipe along the beach to avoid piping plover impacts. The locals, through the NC Sea Turtle Project, monitor sea turtle activity along the entire coast of North Carolina and the data is collected by Dr. Matthew Godfrey of NCWRC. The Corps will not and historically has not monitored for sea turtle nests when placement is within the environmental window.	Environmental Commitments Appendix was updated. An email was sent to USFWS addressing changes and an updated BA will be included in the Appendix.

44	L-42	USFWS	The Service recommends that the proposed Critical Habitat for the loggerhead sea turtle and the candidate species red knot be added to the list of considerations under Section 7 of the Endangered Species Act. Consideration of proposed critical habitat and candidate species in project planning is prudent and should not delay or impede decision-making.	Concur	Section 4.02.3 and 6.0 of the BA was updated with proposed loggerhead Critical Habitat information and the Corps determined the proposed project will not result in an adverse modification of critical habitat for the threatened loggerhead sea turtle. Section 4.02.10 and 6.0 of the BA was updated with a Red Knot evaluation and includes the Corps determination that the disposal of sediment on the Bogue Banks beaches may affect not likely adversely affect the Red Knot. Consideration and analysis was added to the EIS in section 2.07.3 and 2.07.4 for loggerhead critical habitat and red knots. Table 2.4(Threatened and Endangered Species Potentially Present in Carteret County, North Carolina) was updated and Figure 2.4 (Proposed Loggerhead Critical Habitat) was also added to the EIS.

45	L-43	USFWS	The Service recommends that the Corps commit to using only sediment that complies with the NC Sediment Criteria Rule, and also has a wet Munsell color of 5 or greater. Specifically, the Service recommends that the Corps commit to meet the following criteria: The average % by weight of fine grained sediment (less than 0.0625 mm) in each borrow site shall not exceed the average % by weight of fine grained sediment of the recipient beach characterization plus 5%. The average % by weight of granular sediment (Greater than or = to 2 mm and less than 4.76mm) in a borrow site shall not exceed the average % by weight of coarse sand sediment of the recipient beach plus 5%. The average % by weight of gravel (greater than or = to 4.76 mm) in a borrow site shall not exceed the average % by weight of gravel sized sediment for the recipient beach characterization plus 5%. The average % by weight of calcium carbonate in a borrow site shall not exceed the average % by weight of calcium carbonate on the recipient beach characterization plus 15%. Use of material that meets the above criteria and is similar in color to the native beach would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize potential impacts to piping plover, red knot, and sea turtles, as well as beach invertebrates, surf fishes, and other shorebirds. The service recommends that Section 5.00 of the BA include a commitment to monitoring sediment each day as it is being placed on the beach to ensure that it is similar to the existing sediment on the beach.	The Wilmington District guideline with regard to the percentage of fine-grained sediments is that borrow areas containing more than 10 percent fines passing the #200 sieve, or more than 10 percent by weight finer than 0.074 mm in mean grain size diameter, are generally considered to be incompatible for placement on the beach due to potential problems with turbidity and siltation during placement. Though the State of North Carolina has recently enacted sediment compatibility criteria, it is not a part of their Coastal Zone Management Program. Additionally, previous experience with Wilmington District beach nourishment projects (i.e., Wrightsville, Carolina, Kure, and Ocean Isle Beaches) have shown that high quality beaches can be constructed using sand with up to 10 percent fines passing the #200 sieve with no adverse environmental impacts. Therefore, the Wilmington District will continue to follow the no more than 10 percent fines criteria for sediment compatibility. Extensive Native Beach sampling was also performed and is located in Geotech Appendix C. Should the dredging operations encounter sand deemed non-compatible with the native grain size or sorting characteristics of the native beach, the dredge operator shall immediately cease operation and contact the DCM. Dredge operations will resume only after the issue of sand compatibility is resolved. The Corps agrees with visually monitoring sediment each day as it is being placed on the beach to ensure that it is similar to the existing sediment on the beach. The contractor will perform the daily survey.	Section 5.0 of the BA was updated to include daily visual surveys.

46	L-43	USFWS	The Service recommends that Section 5.00 of the BA include a commitment to conduct visual surveys each morning in the area of work for that day, to determine if piping plovers are present and allow those individuals to move out of the area.	The Corps does not do daily visual surveys for piping plover during construction or maintenance events. Placement of material is timed to minimize impacts to piping plovers and therefore surveys are not necessary. However, the Corps will coordinate with NCWRC prior to mobilization and demobilization of the pipeline to avoid piping plover impacts.	None
47	L-43	USFWS	The Service recommends that Section 5.00 of the BA include a commitment to conduct surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant, for the life of the project.	The Corps is not required to monitor for seabeach amaranth, but surveys have been performed along all of Bogue banks, NC since 1991. For this project, the Corps has decided to monitor for seabeach amaranth to assess whether availability of habitat would facilitate growth of more plants or whether burial of seeds hinders growth. Though 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.	Updated Appendix G and BA.

48	L-44	USFWS	Each construction or maintenance event should start at the southern project limit and move northward in order to avoid potential impacts to nesting piping plovers. All construction for shaping the beach within the southern mile of the project area should be completed by March 1 and all construction equipment removed from this area. Equipment access points should be within the day's work area or as close as possible, to minimize impacts from movement of heavy equipment along other stretches of beach. Also, the Corps should coordinate with the Service and North Carolina Wildlife Resources Commission prior to mobilization and demobilization of the pipeline on the beach, to determine the best location for the pipeline route.	First, it is assumed by the Corps that the Service meant to say the construction and maintenance events should start at the westernmost project limits and move east instead of the southernmost project limits and move north due to Bogue Banks running in a west to east direction (Bogue Inlet to Beaufort Inlet). Placement is dependent on where the sand is needed and its distance from the borrow areas. Also, placement is timed (December 15-March 31) to avoid piping plover impacts. Piping plover Critical Habitat Unit NC-10 is located west, but not in, the project area. Therefore a west to east construction plan is not practical or necessary to protect piping plovers. It will be up to the contractor to insure placement of material and removal of all construction equipment is performed within the December 15-March 31 window and equipment access point are as close as possible to minimize impacts.	None

49	L-44	USFWS	The Service recommends that the Corps investigate the necessary minimum maintenance interval for storm damage reduction, which may be greater than 3 years. A longer interval between maintenance events would be a minimization measure under Section 404(b)(1) of the Clean Water Act, and would minimize potential impacts to piping plover, red knot, and sea turtles, as well as beach microinvertebrates, surf fishes, and other shorebirds. A longer maintenance interval would also require a smaller amount of compatible borrow material for the life of the project. We recommend that the final EIS consider the non-economic benefits of longer maintenance intervals.	Non-economic benefits were considered in the planning process. Longer renourishment intervals increase the risks between renourishment events by allowing accumulated erosion to create escarpments, narrow the non-dune portion of the beachfill, erode the toe of the dune, and damage dune vegetation. As the renourishment interval increases, the large volumes needed would require additional hopper dredges and/or expansion of the dredging window. This presents a greater risk for impacts to benthic invertebrates and surf zone fishes by extending construction into more biologically productive periods. Therefore the estimated beach replacement cycle of between 3-5 years was selected as the recommended plan. Survey will be conducted prior to each construction event to assure need.	None
50	L-33	USFWS	DEIS incorrectly lists red knots as endangered. A determination to list the red knot has not been made by the Service, although it is a candidate species.	Noted. Changes will be made to the document as necessary.	Updated Table 2.4
51	L-33	USFWS	Atlantic sturgeon is listed in the DEIS as a Federal Species of Concern, when in fact, the Carolina Distinct Population Segment has been listed by the NMFS as endangered.	Concur. Changes will be made to the document as necessary.	Updated Table 2.4

52	L-39	USFWS	The DEIS does not identify a Least Environmentally Damaging Practicable Alternative (LEDPA), which is required by the Clean Water Act. Appendix L does check "yes" next to the box stating "The discharge represents the least environmentally damaging practicable alternative...", however, there is no information or data to support this supposition. The LEDPA may be the same alternative as the NED; however the information used to make this determination was not provided in the DEIS.	There are no other practicable alternatives that would have less adverse impacts to the aquatic ecosystem. Water quality impacts are addressed in section 7.09.2.	Updated section 7.09.2 to reflect that the TSP is the LEDPA.
53	L-32	USFWS	The Corps should investigate the potential to collect intertidal invertebrates such as *Donax* and *Emerita* immediately prior to beach nourishment activities, holding them, and then restoring those collected individuals in the new fill material behind the dredge pipeline.	Retaining benthic organisms would be cost prohibitive. Additionally the viability of these organisms being held is not known. The beach is a dynamic area and the re-colonization of the beach following placement of sand will occur.	None
54	L-35	USFWS	As proposed in the DEIS, the initial construction of the preferred alternative is proposed to take place during the winter months (Nov 15 to March 31), which may adversely affect overwintering piping plovers. The Service does not agree with the statements in Section 4.02.7 d.(1) and (2) (no page numbers) that since only a portion of the beach on Bogue Banks will be nourished at any given time during pump-out, adjacent habitat is still available, and that recovering foraging habitat is available in the project area for the duration of construction. Studies show that recently nourished areas will not provide adequate forage for months, if not years after the nourishment project. In addition, the proposal by the Corps is to nourish the entire beach in one work season, and once an area has been nourished, it will likely not provide suitable foraging for the remainder of the winter and spring.	Beach placement of sand for this project during initial construction and each periodic nourishment interval is scheduled to avoid the breeding and nesting season as well as peak recruitment periods for benthic invertebrate forage base; however, short term impacts to foraging may occur. Also, the entire length of Bogue Banks will not be filled in any given year. The initial construction, with the largest estimated footprint will have multiple areas not filled due to adequate sand already in place.	None

55	L-37	USFWS	In Item 6, Section 5.00 of the draft BA, the Corps commits to monitoring of sea turtle nesting activities in beach nourishment areas. However, the length of monitoring has not been provided. The Service recommends that Item 6 be modified to reflect that sea turtle nesting activities will be monitored annually for the life of the project.	The locals, through the NC Sea Turtle Project, monitor sea turtle activity along the entire coast of North Carolina and the data is collected by Dr. Matthew Godfrey of the North Carolina Wildlife Resources Commission (NCWRC). The data is in turn provided to the USFWS. Also, placement of material is timed through environmental windows to minimize impacts. Throughout the duration of each nourishment contract, during initial construction and each periodic nourishment event, the Contractor will be responsible for the protection of threatened and endangered species. The Contractor is responsible will take such measures as may be required to assure that any activities conducted do not kill, injure, capture, pursue, or otherwise harm any species. The Contractor will be aware of the protected species that frequently occur in the project area and work will be planned accordingly.	Section 5.00 of the BA was updated to remove commitment of post nourishment nest activity for clarification.

56	L-41	USFWS	The DEIS does not provide enough information to support the statement that the non-structural alternative would result in a "long-term decrease in sea turtle nesting habitat and nest success due to beach erosion, scarping, and scouring of the dunes." The DEIS also does not provide any information to support the statement that the non-structural alternative would cause a "risk of increased beach lighting impacts to sea turtles as dune erodes", or the supposition that both seabeach amaranth and piping plover habitat would suffer long-term losses due to beach erosion. The resumption of natural beach processes may allow the movement of dunes and beach shoreward, which, in the long-term, could provide ample habitat for sea turtle nests, piping plovers, and seabeach amaranth. We recognize that this alternative is not preferred because of the failure to provide storm damage protection for structures on the beach, and because it is currently not economically feasible. However, we recommend that the language of the table be revised to reflect the more likely long-term benefits of allowing natural processes to resume on Bogue Banks.	The Corps disagrees. Table is accurate with regard to effects to non-structural alternatives. Bogue Banks is populated and the houses are likely to remain.	None
57	L-53	EPA	Causes of erosion and project need should be more clearly identified and discussed in the FEIS. EPA recommends adding additional information in the FEIS related to property damage and beach erosion issues due to actual past storms events. Providing such information would better support the project need statement. EPA is unclear from the DEIS if storms are the sole cause of erosion on the island or if other causes of erosion exist. EPA recommends that the causes of erosion on Bogue Banks be fully discussed in the FEIS.	Concur	There are no detailed records of previous damages caused by erosion, but major erosion can be caused by northeasters that normally occur in the colder months and tropical cyclones occurring in the warmer months. Erosion related to individual storms are not listed separately be are included in the average erosion rates. This information has been added to sections 1.04, 4.06.2 and 9.10.

58	L-53	EPA	EPA recommends providing additional details from actual storm events in the economic report for the FEIS that support these average annual damage estimates.	The Corps does not formulate for specific storm events.	None
59	L-54	EPA	The DEIS appears to provide for multiple average annual project costs and total project cost for the TSP (Alternative 9). EPA recommends the Corps clarify the total project cost and average annual project cost in the FEIS. We also recommend that the Corps clearly state which total project cost and/or average annual cost the benefit cost ratio is based on in the FEIS.	Costs used in the report reflect the time which that action was performed. For instance, initial alternative screening was performed in FY 2012 and the Selected plan was analyzed in FY 2013. Both of these time periods carry different discount rates, but are never compared against one another at these different rates. Producing different iterations of costs would be time consuming and expensive from a manpower perspective, so in many cases the approach presented in the report is the most pragmatic way to define the economics of screening and plan selection. However, additional language will be included into the document to clarify any confusing areas to the reader, in the pertinent sections.	SAW is developing an updated parking and access map using the most recent CAMA information. This updated information will be included in both the Parking and Access appendix and any pertinent sections in the body of the Main Report.

60	L-54	EPA	EPA recommends the Corps provide significantly more information in the FEIS regarding existing water quality for Bogue Sound, Bogue Inlet, White Oak River, Newport River, and Beaufort Inlet. This additional information should include but not be limited to recent water quality assessments of these areas, maps of sampling locations, and existing water quality classifications of potently impacted waters. Furthermore, we recommend that additional information be provided in the FEIS regarding existing permitted NPDES discharges and wastewater treatment facilities and infrastructure in the project area. Significant storms have the potential of damaging this infrastructure which can cause runoff to marine and sound waters of bacteria and other pollutants that can cause public health issues following storm events. If the proposed project provides protection for this infrastructure then it should be disclosed in the FEIS.	Concur.	Section 2.02.1 was updated with Bogue Sound information. Section 7.09.2 was updated with infrastructure runoff information and identified all NPDES sites in Carteret County.
61	L-55	EPA	EPA recommends the Corps provide significantly more information in the FEIS on how the TSP meets the CW A Section 404(b)(1) Guidelines ("Guidelines"; 40 C.F.R.230). The rationale of how the LEDPA was determined in the context of the other alternatives presented in the DEIS should be provided in the FEIS. Actions to avoid and minimize adverse impacts to the environment should be included in this additional information in the FEIS. In addition, it is also unclear from the DEIS if the Corps considers the TSP, Alternative 9, as the environmentally preferable alternative, therefore EPA also encourages the Corps to identify the environmentally preferable alternative in the FEIS.	As stated in section 7.09.2, the Corps planning process has brought us to the conclusion the TSP was the LEDPA. There are no other practicable alternatives that would have less adverse impacts to the aquatic ecosystem. Water quality impacts are addressed in section 7.08.2.	None

62	L-55	EPA	EPA recommends the Corps provide a clear adaptive management strategy in the FEIS that includes performance and/or success criteria that will adequately capture the dynamic nature of the proposed project and help direct any future changes to the project that may be needed to avoid and minimize impacts to the environment.	Beach FX was used to formulate beach renourishment intervals. Furthermore, the Corps plan formulation process includes pre and post construction surveys to help manage coastal storm damage reduction.	None
63	L-56	EPA	We recommend the Corps provide additional discussion in the FEIS about the difference in historical material placement presented in Figure 1.2. Specifically, we recommend the Corps make clear distinctions between storm damage reduction activities and disposal of navigational dredge material that may not provide storm damage reduction benefits. In addition, if historical nourishment activities associate with Bogue Inlet AIWW Crossing Disposal, MHC Inner Harbor Maintenance Dredge Disposal, etc. are to continue through the life of the currently proposed project, we recommend providing additional discussion in the FEIS on how these activities are interrelated with the currently proposed project.	This project is not related to previous navigation projects. Previous projects were designed for the least cost disposal and not designed for coastal storm damage reduction. The document will be changed to identify navigation and coastal storm damage reduction.	Section 1.09 was updated to reflect the changes.
64	L-57	EPA	EPA recommends continued coordination with the USFWS. EPA recommends the Corps revise and update Table 2.4 in the FEIS to reflect the current status of federally listed species. EPA also recommends that the linear feet of beach and acreages be provided in the FEIS with respect to piping plover critical habitat. EPA also recommends that the Corps provide additional details about the on-going study of Atrytonopsis sp. l. Including details in the FEIS about the study such as when the study started, projected completion date, and any interim results would be helpful for reviewers.	Concur. Piping plover critical habitat is located west and out of the project area.	Federally listed species are updated in Table 2.4.

65	L-57	EPA	EPA recommends the Corps revise the FEIS by adding additional data and citations to support the proposed 500 meter buffer for hardbottom areas. Any loss of the existing hard bottom features offshore should be investigated promptly to determine causal factors and appropriate action.	The State of North Carolina's hard bottom buffer rule language requires that dredging should not be conducted "on or within 500 meters of significant biological communities, such as high relief hard bottom areas." North Carolina Coastal Resources Commission [CRC Rule 15A NCAC 07H .0208(b)(12)(A)(iv)].	Add North Carolina Coastal Resources Commission [CRC Rule 15A NCAC 07H .0208(b)(12)(A)(iv)] to section 7.02.7
66	L-58	EPA	EPA recommends the Corps provide addition clarification in the FEIS regarding historical beach renourishment activities in North Carolina as they relate to the sand compatibility criteria proposed in this DEIS and impacts on federally listed species. Specifically, if the Corps has conducted species surveys and /or other studies of historical beach nourishment activities using the proposed sand criteria for this project and impacts to species, we recommend the Corps include these in the FEIS.	Previous projects the used the Corps sand compatibility in North Carolina are the Wrightsville Beach, Carolina Beach, Cure Beach and Ocean Isle. No long term consequences have been documented to protected species that use the area for these projects.	The specific compatibility criteria used for this project is included in USFWS BA (Appendix F) which assesses impacts to protected species. The Corps has not conducted studies on varying sand compatibility impacts to protected species; therefore no change has been made to the document.

67	L-58	EPA	EPA recommends the Corps provide additional support in the FEIS for selection of the 3 year interval versus a longer renourishment interval which EPA believes would be more protective of federally-listed species.	The TSP is a balance between longer and shorter dredging intervals. Reducing the renourishment interval could be justified by concerns regarding dredging window constraints and impacts on turtle nesting, recreation, and storm protection due to loss of the berm and scarping of the dune during long cycles. Longer renourishment intervals increase the risks between renourishment events of allowing accumulated erosion to create escarpments, narrow the non-dune portion of the beachfill, erode the toe of the dune, and damage dune vegetation. The potential reduction in the project's ability to sustain recreational uses and to provide a suitable habitat for sea turtles and other species on the beach outweigh the slight gain in net storm damage reduction benefits. Therefore the recommended renourishment interval is 3-5 years which captures most of the economic benefits and better sustains other benefits.	None

68	L-59	EPA	EPA recommends that the FEIS include an EJ analysis that includes descriptions of the local demographics and identifies low-income and minority populations that have the potential to be impacted by the proposed action; Should the demographic analysis identify minority and low-income populations, the FEIS should describe efforts made to meaningfully engage these populations in the decision-making process. In addition, EPA recommends the FEIS identify communities with EJ concerns that may engage in subsistence activities within the project area (i.e., subsistence fishing). A summary of EJ comments or concerns identified during the public involvement process along with agency responses to those concerns and efforts to avoid, minimize or mitigate potential impacts should also be included in the FEIS.	No subsistence fishing is known in the project area. It is not likely that low-income and minority populations are going to be impacted by the proposed action. EJ section of the document was updated to clarify the above determinations.	Section 9.15 was added along with Figure 9.1 and 9.2 Text discussing demographics was added to Section 2.11. Added fishing information to section 7.06.1
69	L-59	EPA	EPA recommends that general repair, maintenance, inspection, monitoring requirements, and environmental commitments being made by the project sponsor and the Corps be documented in the ROD. The ROD should also clearly outline adaptive management plan commitments for the 50 year life of the project.	Concur	This information will be added to the ROD when written.

FINAL
INTEGRATED FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

BOGUE BANKS, CARTERET COUNTY

NORTH CAROLINA

APPENDIX N

VALUE ENGINEERING

US Army Corps of Engineers
Wilmington District

U.S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT

113670 - INTEGRATED FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATEMENT BOGUE BANKS, CARTERET COUNTY NORTH CAROLINA

VALUE ENGINEERING REPORT

September 2013

DOD SERVICE: USACE **VALUE ENGINEERING OFFICER:** C. Lee Danley, PE, LEED AP
CONTROL NO: CESAW 13-8

REPORT INFORMATION

VALUE ENGINEERING FIRM: U. S. Army Corps of Engineers
Jacksonville District
701 San Marco Blvd
Jacksonville, FL 32232-0019
(904) 232-1903

VALUE ENGINEERING WORKSHOP CONDUCTED: 16-17 September 2013

VALUE ENGINEERING STUDY TEAM LEADER: Jimmy Matthews, PE, CVS

VALUE ENGINEERING STUDY TEAM MEMBERS: Team member names and contact information are in Appendix B.

POINTS OF CONTACT: C. Lee Danley, PE, LEED AP
Value Engineering Officer
69 Darlington Avenue
Wilmington, NC 28403-1343
(910) 251-4562 Office

STUDY RESULTS:

Evidence of Unfettered Creativity: 47 ideas generated, several ideas were combined into single proposals and comments

Number of Proposals: n/a
Number of Accepted Proposals: n/a

Number of Recommendations: 11
Number of Recommendations Accepted: 7

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INTRODUCTION

This Value Engineering (VE) Report documents the completion of the Integrated Feasibility Report and Draft Environmental Impact Statement (DEIS), Coastal Storm Damage Reduction, Bogue Banks, Carteret County, North Carolina, Draft Report, August 2013 edition value analysis. The report and DEIS are near the Alternative Formulation Briefing stage of completion. Value improvements proposed herein will be addressed during further report and DEIS refinements and/or the Preconstruction, Engineering and Design Phase of project development.

PROJECT DESCRIPTION (on date of VE Study, 16-18Sep13)

The purpose of the subject feasibility study is to evaluate coastal storm damage reduction at Bogue Banks, a 25.4-mile long barrier island located on North Carolina's central coast in Carteret County. The study team integrated representatives of Federal, State, and local governments, in the effort to identify cost-effective, publicly acceptable, and environmentally and technically sound alternatives to reduce damages within the towns and to the adjacent shoreline. The study effort identifies a National Economic Development (NED) plan, which is the plan that maximizes net benefits to the nation through reduction of future storm damages.

The tentatively selected plan is the NED plan (Alternative 9), which has the following dimensions (an 'x' indicates that the project template does not contain a Federally maintained dune feature):

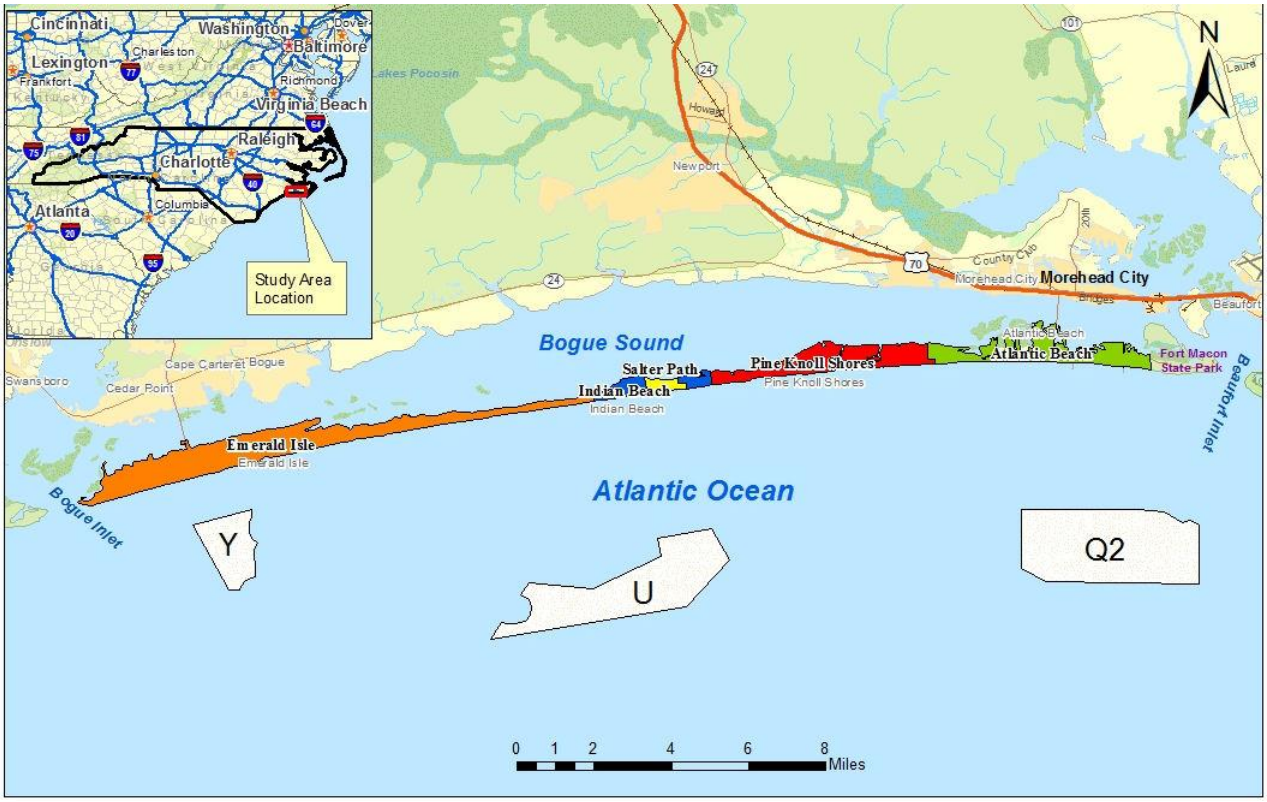
Reaches	Length (ft)	Landward Dune Slope (X:1)	Max Dune Elevation (ft)	Dune Width (ft)	Seaward Dune Slope (X:1)	Berm Height (ft)	Berm Width (ft)	Berm Seaward Slope (X:1)
4-10	4,876	4	16	95	-4	5.5	50	-15
11-15	5,633	4	15	45	-4	7	50	-15
16-21	6,891	4	20	10	-4	7	50	-15
22-92	82,053	4	x	x	-4	7	50	-15
93-110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

The NED 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. Sand for the beach fill would be delivered from 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. Material for the project would be dredged from three offshore borrow locations.

The plan is incrementally justified. The plan provides an estimated average annual $11,511,000 in coastal storm damage reduction benefits and $3,432,000 in recreation benefits, at an average annual cost of $6,583,500 a year, and has a Benefit Cost Ratio of 2.3 to 1. In addition, if implemented the project would enhance the beach strand available for recreation use and provide and maintain habitat for a variety of plants and animals.

The estimated First Cost of the plan is $37,469,000, which would be cost-shared 65% Federal and 35% non-Federal. 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 $14,370,000 per renourishment. Renourishments would be cost shared at 50% Federal and 50% non-Federal.

A vicinity map is on the following page.



Vicinity map, including potential offshore borrow locations (Y, U, and Q2).

VALUE METHODOLOGY

This report documents the VE workshop conducted 16-18 September 2013. The workshop was conducted using the six-phase Value Engineering Job Plan as sanctioned by USACE and the Society of American Value Engineers International (SAVE). This process, as explained below, was executed as part of daily activities as described in the Workshop Agenda exhibited in Appendix A. The VE Team was comprised of USACE Team Members from the Jacksonville and Wilmington Districts. The roster is located in Appendix B.

The VE Workshop culminated in the development phase where ideas were captured and refined into recommendations. Recommendations are topics that warrant consideration but theirs savings were not computable (quantitative) with current information. Appendix E contains the related documentation.

Information Phase

At the beginning of the study, the project team presents current planning and design status of the project. This includes a general overview and various project requirements. Project details are presented as appropriate. Discussion with the VE Team enhances the Team's knowledge and understanding of the project.

Function Analysis Phase

Key to the VE process is the Function Analysis. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions is a primary element in a value study, and is used to create ideas and develop proposals. This procedure is beneficial to the team, as it forces the participants to think in terms of functions. For this study, team members developed a function list and then considered the list in regards to the report's recommended plan features. This facilitated a deeper understanding of the project. The function analysis is presented in Appendix C.

Creativity Phase

The Creativity Phase involves identifying and listing creative ideas. During this phase, the team participates in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas is not permitted in order to generate a broad range of ideas. The creative phase continues through the other phases as ideas can, and often times do, create other ideas.

Evaluation Phase

The purpose of the Evaluation Phase was to systematically assess the potential impacts of ideas generated during the Creativity Phase relative to their potential for value improvement. Each idea is evaluated in terms of its potential impact to cost and overall project performance. Once each idea is fully evaluated, it is given a rating to identify whether it would be carried forward and/or developed as an alternative, combined with other ideas, presented as a design suggestion, dismissed from further consideration or that it is already being done by Project Delivery Team. Appendix D lists those ideas

with their evaluation disposition. The appendix tables also display the evolution of ideas from creation through their embodiment into recommendations.

Development Phase

During the Development Phase, ideas passing evaluation are expanded and developed into recommendations. The development process considers such things as the impact to performance, cost, constructability, and schedule of the alternative concepts relative to the baseline concept. This analysis is prepared as appropriate for each alternative, and the information may include an initial cost and/or life cycle cost comparisons. Each alternative or idea describes the baseline concept and proposed changes and includes a technical discussion.

Presentation Phase

The VE Workshop concluded with a preliminary presentation of the value team's assessment of the project and value alternatives and ideas. The presentation provides an opportunity for the owner, project team, and stakeholders to preview the alternatives and develop an understanding of the rationale behind them. The presentation is also used to refine proposal justification to include the corporate perspective.

STUDY RESULTS AND RECOMMENDATIONS

The VE team developed several recommendations that warrant more detailed investigation. Appendix E contains the related documentation. Related cost avoidance will be developed for awarded contract)s) and reported in the Value Engineering Reporting System (VERS). Should ideas/comments result in additional quantifiable cost avoidance, those ideas/comments will be documented as proposals and appended to this report. In general, VE team recommendations centered on:

- Developing contract alternatives to complete the project in one dredging season;
- Reducing costs with additional borrow sources and placement strategies; and
- Improving constructability.

RECOMMENDATIONS

The following recommendations have been evaluated by the PDT and the action noted as adopted or not adopted. Also noted is whether the recommendation will be addressed in the report, the Preconstruction, Engineering and Design Phase (PED) or both.

NO. 1 – *Evaluate additional navigation channel borrow source concepts – Adopted. To be further evaluated during the PED Phase.*

NO. 2 - *Multiple Dredging Plant Options to Complete the Project – Adopted.* The District has decided to accept this recommendation and evaluate further during PED. However, adoption of the use of the inlets will not be pursued.

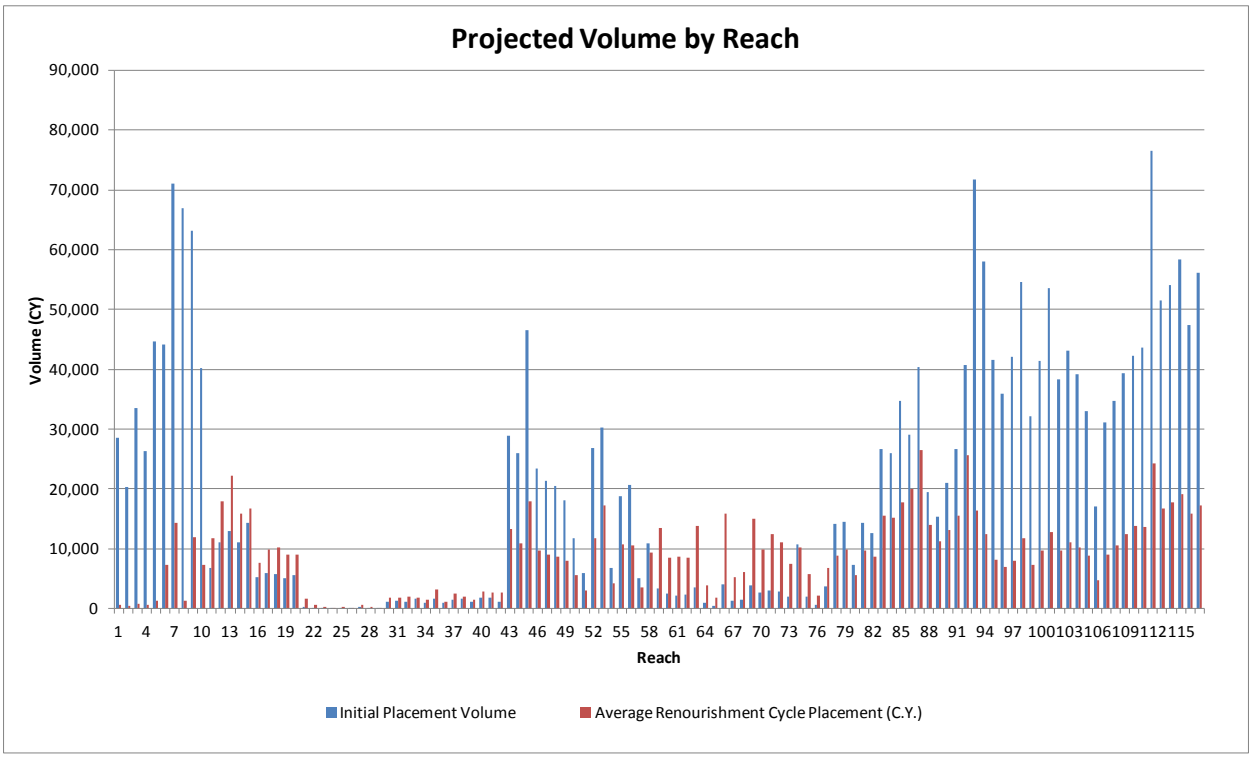
NO. 3 - *Nearshore Placement Strategies – Not Adopted.* The District has decided not to adopt this recommendation. Environmental concerns with double handling, grain size compatibility, potentially significant negative effects on storm damage risk reduction outputs associated with delay in benefit realization. Design concerns associated with segmentation of berm and dune protective features along the project shoreline.

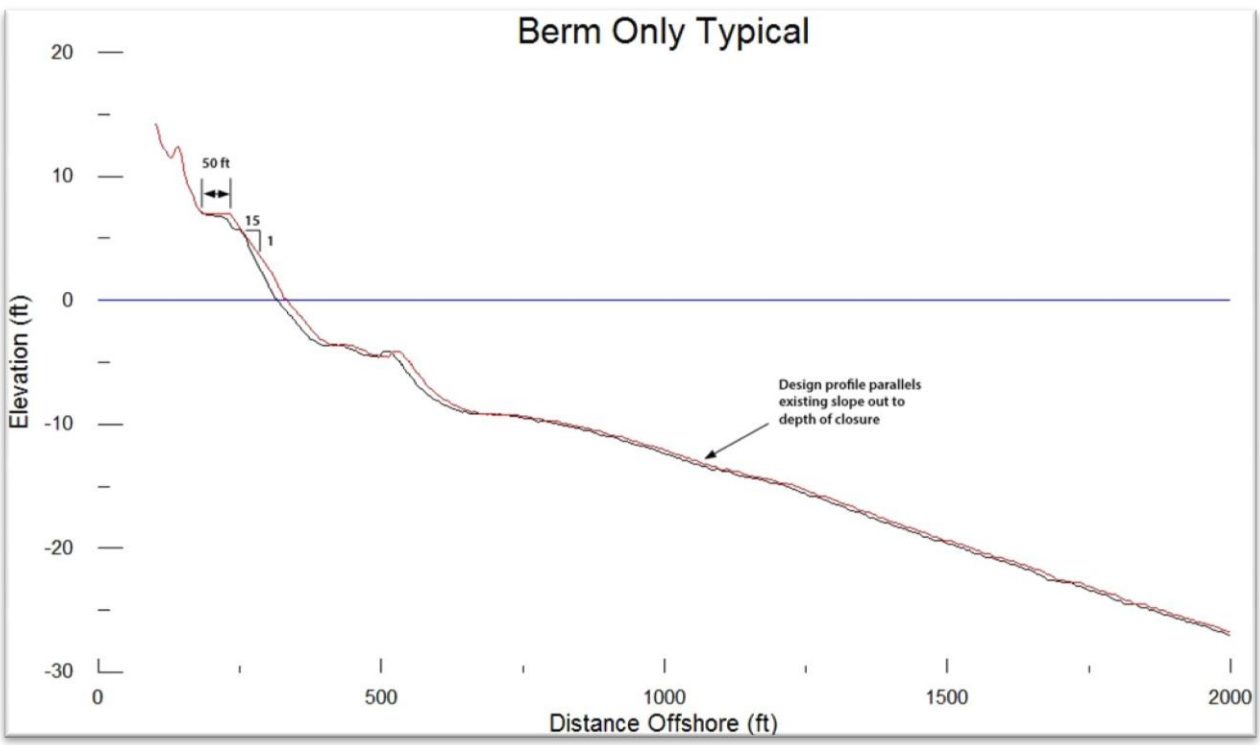
NO. 4 - *Further Investigate The Geotechnical Data To Optimize Material Within The Borrow Areas and To Locate Borrow Areas Closer To The Project – Adopted. To be further evaluated during the PED Phase.*

NO. 5 - *Dune Stabilization Utilizing Sand Fencing, Vegetation Planting, and Woody Debris – Adopted. To be further evaluated during the PED Phase – Adopted. To be further evaluated during the PED Phase.*

NO. 6 - *Evaluate Removing Shoreline Segment R23 – R36 From the Project – Not Adopted.* The District has decided not to adopt this recommendation. The graphics above illustrate the beach and nearshore conditions within the 2.5 mile beach segment in question. The bottom graphic indicates that the existing berm width along this area currently approximates the design template for the project, which is the reason that initial placement volumes are not required and subsequent renourishment volumes are comparatively low relative to the remainder of the project area. However, as future storms erode the existing shoreline in this area, 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 without consideration of recreational outputs. Only two 800-foot long subreaches are not justified based on

CSDR outputs alone, and as these are non-contiguous it is not feasible from a construction standpoint to remove these from the overall project plan.





No. 7 - R*evisit the advance nourishment option for life cycle cost – Adopted. To be further evaluated during the PED Phase.*

NO. 8 - *Extension of Environmental/Dredging Window Outside of Dec 15 through March 31 – Adopted.* This recommendation has already been incorporated into the document. Should the situation arise in which the contractor needs to extend into the environmental windows, clearance to do so would be sought from the environmental agencies.

NO. 9 - *Investigate and Evaluate Brandt Island as a Borrow Area for The Project – Not Adopted.* Based on the disadvantages described in the recommendation the District does not wish to adopt this recommendation. Several evaluations have been completed previously concerning beneficial use of this material with no positive outcome due to cost and environmental constraints due to compatibility issues.

NO. 10 - *Solicitation Options to Expedite Schedule and Reduce Construction Costs – Adopted.* This District will adopt this recommendation and pursue during the contracting phase of the project.

NO. 11 - *Feeder Points (Sand Engine) – Not Adopted.* The District has decided not to adopt this recommendation. Although this is a novel idea, there are many limitations in modeling of sand migration and project benefits. Individual "sand engines" would have to be models for particular wave actions at each location. Currently no along shore models are available to complete this.

DECISION DOCUMENT VALUE ENGINEERING CERTIFICATION

This VE report satisfies the requirements of ER 11-1-321, Army Programs Value Engineering for decision document VE Certification.

APPENDIX A: VALUE ENGINEERING WORKSHOP AGENDA

VALUE ENGINEERING WORKSHOP AGENDA
INTEGRATED FEASIBILITY REPORT AND DRAFT EIS AND OPERATIONS PHASES
BOGUE BANKS, CARTERET COUNTY, NORTH CAROLINA
16-17 SEP 2013

Meeting Location:
Virtual and Jacksonville District Office, Design Team Room 388, 3E
Call-in number:
USA Toll-Free: 877-336-1274
Access Code: 7299267
Security Code: 0916
Web Meeting Address:
https://www.webmeeting.att.com
Meeting Number: 8773361274
Access Code: 7299267
* The first time you use the Web Meeting Service, you will need to download the client software. Web Meeting HELP & Software Downloads can be found at: https://www.webmeeting.att.com*

16Sep13:

0855-0900	**Attendees Call In and Establish Web Meeting Connections**
0900-0915	Introductions and Web Meeting Rules
0915-0930	Workshop Purpose and VE Scope and Activities – Jimmy Matthews
0930-1020	Report and Project Overview – PDT
1020-1030	Break
1030-1100	Function Analysis – Jimmy Matthews
1100-1200	Creativity Phase – VE Team
1200-1245	Lunch
1245-1400	Evaluation Phase and Day 1 Wrap-up – VE Team

17Sep13:

0900-1000	Complete Evaluation Phase- J Matthews
1000-1030	Recommendation and Comment Development Assignments: - J Matthews
1030-1330	Complete the Development Phase – VE Team
1330-1400	Workshop Wrap Up and Completion Schedule - J Matthews

18-19Sep13

0900-1600	Complete Development Phase

20Sep13:

1000-1100	Provide draft VE Report and Conduct Decision Makers Briefing
24Sep13:	**Complete Final VE Report**

APPENDIX B: WORKSHOP PARTICIPANT ROSTER

Value Engineering Workshop - Bogue Banks CSDR Feasibility Report
16-20 Sep 2013
Virtual

				Attendance				
Name	**Office**	**Phone**	**E-mail (@usace.army.mil)**	**16-Sep-13**	**17-Sep-13**	**18-Sep-13**	**19-Sep-13**	**20-Sep-13**
Jimmy Matthews	CESAJ-EN-Q	(904)232-2087	Jimmy.D.Matthews@usace.army.mil	x	x	x	x	
Matthew Schrader	CESAJ-PD-PN	(904) 232-2043	Matthew.H.Schrader@usace.army.mil	x	x	x		
Pam Castens	CESAW-PM-C	(910) 251-4671	Pamela.G.Castens@usace.army.mil	x			x	
Chris Moore	CESAW-PM-C	(910) 251-4483	Daniel.C.Moore@usace.army.mil	x	x	x		
Kevin Conner	CESAW-TS-EW	(910) 251-4867	Kevin.B.Conner@usace.army.mil	x	x	x		
Doug Piatkowski	CESAW-TS-PE	(910) 251-4908	Douglas.Piatkowski@usace.army.mil	x		x		
Lee Danley	CESAW-TS-ED	(910) 251-4562	Charles.L.Danley@usace.army.mil	x	x	x	x	
Paul Sadowski	CESAW-TS-C	(910) 251-4464	Paul.A.Sadowski@usace.army.mil	x	x	x		
Erin Williams	CESAW-TS-EG	(202) 761-4692	Erin.M.Williams@usace.army.mil	x	x	x		
Justin Bashaw	CESAW-TS-PE	(910) 251-4581	Justin.P.Bashaw@usace.army.mil	x	x			

APPENDIX C: FUNCTION ANALYSIS

BOGUE BANKS, NC- FUNCTION LIST

Reduce Storm/Hurricane Damage	Identify/Distribute Sand Sources	Target Affordability
Maintain Sand in coastal system	Vegetate dunes	Control Cost Growth
Protect Property/Infrastructure	Distribute Sand (Pipe/Truck)	Reduce Processes
Minimize Erosion Impacts	Protect Environmental Habitat	Reduce Bureaucracy
Minimize wave attack & inudation	Increase public access and parking	
Enhance Beach/Shoreline	Minimize Environmental Impacts	Incentivize innovation
Add Beachfill	Monitor Impacts	Incentivize productivity
Develop Sand Delivery/Placement Options	Satisfy User	Promote Competition
Continue as a disposal option	Attract User	

APPENDIX D: CREATIVITY AND EVALUATION

BOGUE BANKS VE - Created Ideas

Idea	Idea Group	Action	Created Ideas
1			Coordinate with navigation disposal (dual source of funding)
2			Use pipeline on edges and hopper in the middle portion of the project
3			Use combination of pipeline and hopper (contractor selection)
4			Use channel as a borrow source (can dredge deeper under shore protection authority)
5			Evaluate the near shore placement further
6			near shore as borrow
7			near shore as a feeder beach
8			evaluate Bogue Inlet as a deep excavation for borrow
9			evaluate geotech information
10			included sand fencing
11			consider different species for vegetating the dunes
12			drop a section of nourishment from R21 to R27
13			show how R21 to R27 is justified incrementally
14			compare R21 to R27 to lack of access and parking (cost of parking and x-overs)
15			evaluate separable non-structural measures for the peak damage areas shown on slide 8
16			add a combination of structural non-structural measures to the plan mix
17			revisit the advance nourishment option for life cycle cost
18			evaluate use of debris (old x-mass trees) for stability of dune
19			evaluate extension of environmental windows
20			evaluate extension with risk parameters
21			include into the recommended plan the equivalent 933 provision to move material from the channels to the high eroding areas
22			inclusion of structures to stabilize fill and increase nourishment interval
23			evaluate Brandt Island as borrow
24			evaluate Brandt Island as source for near shore
25			include an enhancement area for threatened/protected species into the project
26			increase dune dimensions in order to increase nourishment interval
27			utilize Corps dredges for near shore options
28			evaluate dunes for optimization of benefits
29			evaluate dunes for raising dune height in the high damage areas
30			evaluate inclusion of dual dunes in more locations
31			evaluate 3 hopper dredges for the project
32			look for closer borrow locations
33			add an incentive clause in the contract to complete the project within the window
34			use of multiple hoppers, one for the borrow and one for the pump out
35			idea 34 with double handling
36			idea 34 with use of spider barge
37			build feeder points (some points with larger berms and let coastal process spread the sand naturally)
38			match up contract with navigation contracts for same plant (navigation portion may not be beach compatible but could save from mobilization cost)
39			use non uniform beach widths, wider at the higher damage areas
40			utilize nodal point for construction sequence

BOGUE BANKS VE - Created Ideas			
Idea	Idea Group	Action	Created Ideas
41			optimize placement direction vs net transport direction
42			consider recreation for project layout
43			option of 2 different pricing to allow extension of windows, one price for within window, one price for requirements included for extension of one month in either direction of window
44			take material from the navigation channel with finer material take offshore and wash material to meet specification for fines for beach placment
45			look at slope for beach
46			optimize the borrow sites for the highest allowable "coarse material" i.e.optimize the dredge plan
47			dredge the nearshore

BOGUES BANK VE - Evaluated and Grouped Ideas

16-Sep-13

Idea	Idea Group	Action	Already Being Done or Eliminate, Idea Group = 0.00; Keep Idea, Idea Group = Number; Combine into another idea, Idea Group = N.ii	POC
22	0.00	BD	inclusion of structures to stabilize fill and increase nourishment interval	
25	0.00		include an enhancement area for threatened/protected species into the project	
26	0.00	BD	increase dune dimensions in order to increase nourishment interval	
28	0.00	BD	evaluate dunes for optimization of benefits	
29	0.00	BD	evaluate dunes for raising dune height in the high damage areas	
30	0.00	BD	evaluate inclusion of dual dunes in more locations	
39	0.00	BD	use non uniform beach widths, wider at the higher damage areas	
42	0.00		consider recreation for project layout	
15	0.00	BD	evaluate separable non-structural measures for the peak damage areas shown on slide 8	
16	0.00	BD	add a combination of structural non-structural measures to the plan mix	
1	**1.00**		**Coordinate with navigation disposal (dual source of funding)**	**Lee/Matt/ Paul**
4	1.04		Use channel as a borrow source (can dredge deeper under shore protection authority)	
8	1.08		evaluate Bogue Inlet as a deep excavation for borrow	
21	1.21		include into the recommended plan the equivalent 933 provision to move material from the channels to the high eroding areas	
38	1.38		match up contract with navigation contracts for same plant (navigation portion may not be beach compatible but could save from mobilization cost)	
44	1.44		take material from the navigation channel with finer material take offshore and wash material to meet specification for fines for beach placment	
2	**2.00**		**Use pipeline on edges and hopper in the middle portion of the project**	**Paul/Lee**
3	2.03		Use combination of pipeline and hopper (contractor selection)	
27	2.27		utilize Corps dredges for near shore options	
31	0.00	BD	evaluate 3 hopper dredges for the project	
34	2.34		use of multiple hoppers, one for the borrow and one for the pump out	
35	2.35		idea 34 with double handling	
36	2.36		idea 34 with use of spider barge	
5	**5.00**		**Evaluate the near shore placement further**	**Matt**
6	5.06		near shore as borrow	
7	5.07		near shore as a feeder beach	
47	5.47		dredge the nearshore	
9	**9.00**		**evaluate geotech information**	**Erin/Lee**
32	9.32		look for closer borrow locations	
45	9.45		look at slope for beach	
46	9.46		optimize the borrow sites for the highest allowable "coarse material" i.e.optimize the dredge plan (overfill ratio)	
10	**10.00**		**included sand fencing**	**Justin**
11	10.11		consider different species for vegetating the dunes	
18	10.18		evaluate use of debris (old x-mass trees) for stability of dune	
12	**12.00**		**drop a section of nourishment from R21 to R27**	**Matt/Erin /Kevin**
13	12.13		show how R21 to R27 is justified incrementally	
14	12.14		compare R21 to R27 to lack of access and parking (cost of parking and x-overs)	
17	0.00	BD	revisit the advance nourishment option for life cycle cost	

Idea	Idea Group	Action	Already Being Done or Eliminate, Idea Group = 0.00; Keep Idea, Idea Group = Number; Combine into another idea, Idea Group = N.ii	POC
19	**19.00**		**evaluate extension of environmental windows**	**Justin**
20	19.20		evaluate extension of dredging window with specific parameters	
23	**23.00**		**evaluate Brandt Island as borrow**	**Erin**
24	23.24		evaluate Brandt Island as source for near shore	
33	**33.00**		**add an incentive clause in the contract to complete the project within the window**	**Paul**
43	33.43		option of 2 different pricing to allow extension of windows, one price for within window, one price for requirements included for extension of one month in either direction of window	
37	**37.00**		**build feeder points (some points with larger berms and let coastal process spread the sand naturally)**	**Matt**
40	37.40		utilize nodal point for construction sequence	
41	37.41		optimize placement direction vs net transport direction	

BOGUES BANK VE - Recommendations				16-Sep-13
Idea	Idea Group	Recom. No.	Created Ideas	POC
1	**1.00**	**1**	**Coordinate with navigation disposal (dual source of funding)**	**Lee/Matt/Paul**
4	1.04		Use channel as a borrow source (can dredge deeper under shore protection authority)	
8	1.08		evaluate Bogue Inlet as a deep excavation for borrow	
21	1.21		include into the recommended plan the equivalent 933 provision to move material from the channels to the high eroding areas	
38	1.38		match up contract with navigation contracts for same plant (navigation portion may not be beach compatible but could save from mobilization cost)	
44	1.44		take material from the navigation channel with finer material take offshore and wash material to meet specification for fines for beach placment	
2	**2.00**	**2**	**Use pipeline on edges and hopper in the middle portion of the project**	**Paul/Lee**
3	2.03		Use combination of pipeline and hopper (contractor selection)	
27	2.27		utilize Corps dredges for near shore options	
31	2.31		evaluate 3 hopper dredges for the project	
34	2.34		use of multiple hoppers, one for the borrow and one for the pump out	
35	2.35		idea 34 with double handling	
36	2.36		idea 34 with use of spider barge	
5	**5.00**	**3**	**Evaluate the near shore placement further**	**Matt**
6	5.06		near shore as borrow	
7	5.07		near shore as a feeder beach	
47	5.47		dredge the nearshore	
9	**9.00**	**4**	**evaluate geotech information**	**Erin/Lee**
32	9.32		look for closer borrow locations	
45	9.45		look at slope for beach	
46	9.46		optimize the borrow sites for the highest allowable "coarse material" i.e.optimize the dredge plan (overfill ratio)	
10	**10.00**	**5**	**included sand fencing**	**Justin**
11	10.11		consider different species for vegetating the dunes	
18	10.18		evaluate use of debris (old x-mass trees) for stability of dune	
12	**12.00**	**6**	**drop a section of nourishment from R21 to R27**	**Matt/Erin/Kevin**
13	12.13		show how R21 to R27 is justified incrementally	
14	12.14		compare R21 to R27 to lack of access and parking (cost of parking and x-overs)	
17	**17.00**	**7**	**revisit the advance nourishment option for life cycle cost**	**Lee**
19	**19.00**	**8**	**evaluate extension of environmental windows**	**Justin**
20	19.20		evaluate extension of dredging window with specific parameters	
23	**23.00**	**9**	**evaluate Brandt Island as borrow**	**Erin**
24	23.24		evaluate Brandt Island as source for near shore	
33	**33.00**	**10**	**add an incentive clause in the contract to complete the project within the window**	**Paul**
43	33.43		option of 2 different pricing to allow extension of windows, one price for within window, one price for requirements included for extension of one month in either direction of window	
37	**37.00**	**11**	**build feeder points (some points with larger berms and let coastal process spread the sand naturally)**	**Matt**
40	37.40		utilize nodal point for construction sequence	
41	37.41		optimize placement direction vs net transport direction	

APPENDIX E: PROPOSAL AND RECOMMENDATION DOCUMENTATION

RECOMMEDNATION NO. 1 (1.00, 1.04, 1.08, 1.21, 1.38, 1.44): ***Evaluate Additional Navigation Channel Borrow Source Concepts***

PROPOSED RECOMMENDATION:
There are several possible navigation channel reaches that could supply sand for beach fill. The recommendations proposes that all possible navigation materials be considered and evaluated for beach fill.

ADVANTAGES: (IF APPLICABLE)
Two programs could benefit, navigation and shore protection.

DISADVANTAGES: (IF APPLICABLE)
Consent from agencies would be required to allow off road dump trucks to haul material on the beach.

JUSTIFICATION: (IF APPLICABLE)
The benefits and related cost need additional evaluations. However, the benefits to pursue these concepts warrant further investigation.

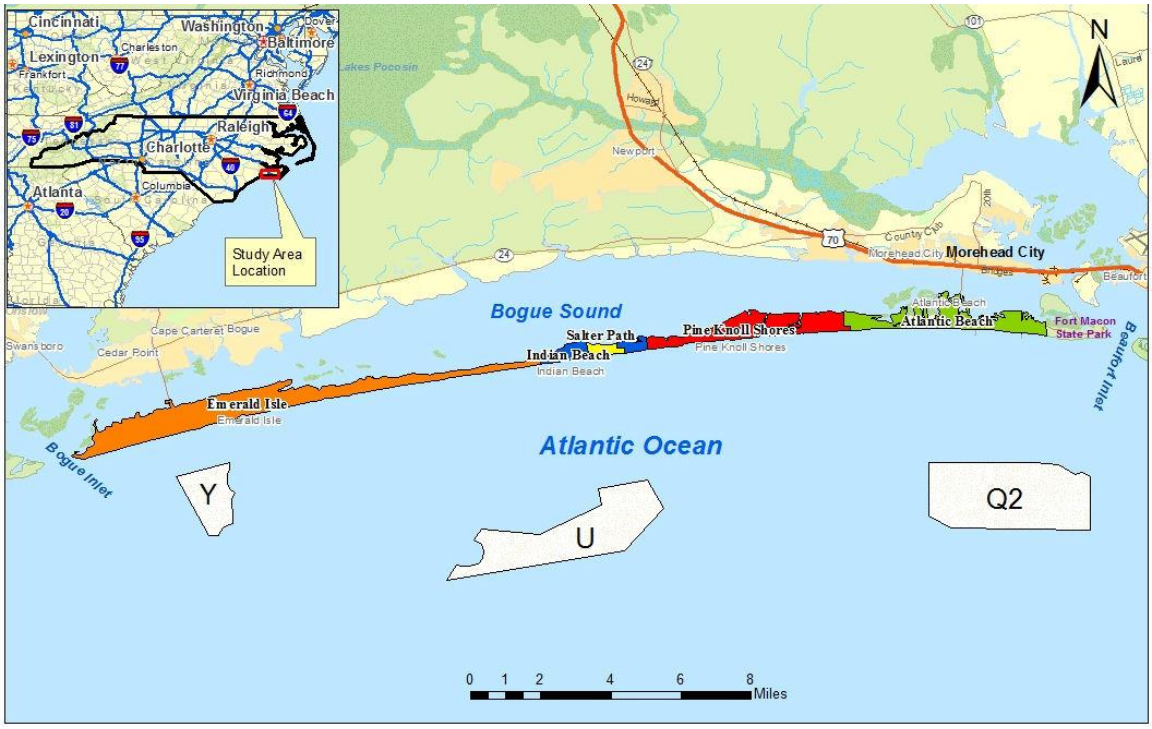
DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 2 (2.00, 2.03, 2.27, 2.31, 2.34, 2.35, 2.36): ***Multiple Dredging Plant Options to Complete the Project***

PROPOSED RECOMMENDATION:

The purpose of this recommendation is to investigate the multiple ways in which floating plant can be utilized in project completion to maximize potential bidders while minimizing construction costs.

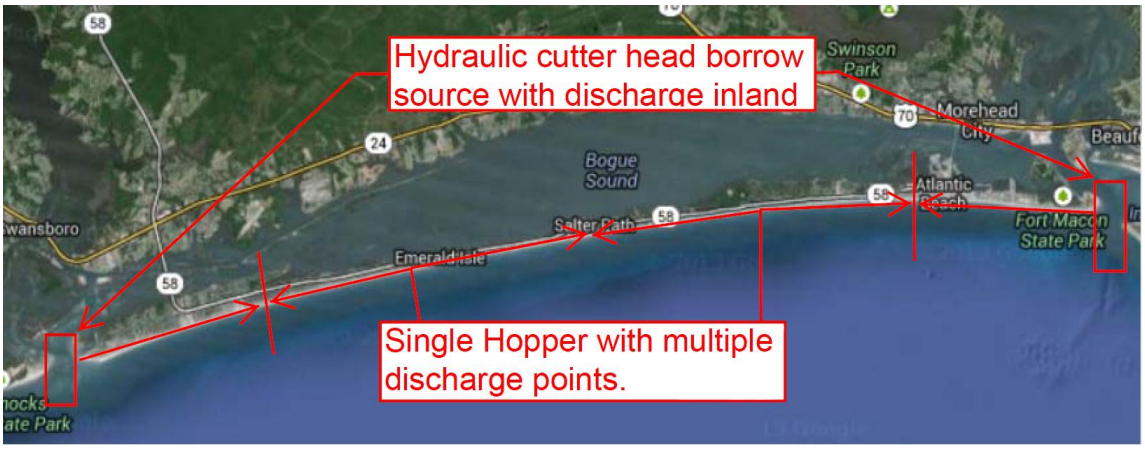
The current construction plan is to utilize 2 or 3 hopper dredges to obtain material from the offshore borrow sources below. These hoppers will utilize the borrow sources as they choose and bring the material to undefined pump out locations to build the beach profile.



CURRENT PROPOSED BORROW SOURCES (Y, U, Q2)

This current plan requires a large investment of a contractor's hopper fleet and also eliminates contractors with only hydraulic cutter head or bucket and barge plant from the bidding pool.

Ensuring the plans and specifications are written as to not restrict the contractor's means and methods would be the most effective approach to alleviating the concerns of this recommendation. The first approach would be to utilize inlet borrow sources with hydraulic cutter heads pumping inland a single hopper dredge obtaining material from the aforementioned borrow sources Y, U, or Q2 to a single discharge point in the center of the island. The diagram below illustrates this option.



An alternative means that would not require a hopper dredge would require the use of a spider barge. In this scenario the hydraulic cutter head would remain at the borrow source and pump material into a scow via the spider barge.

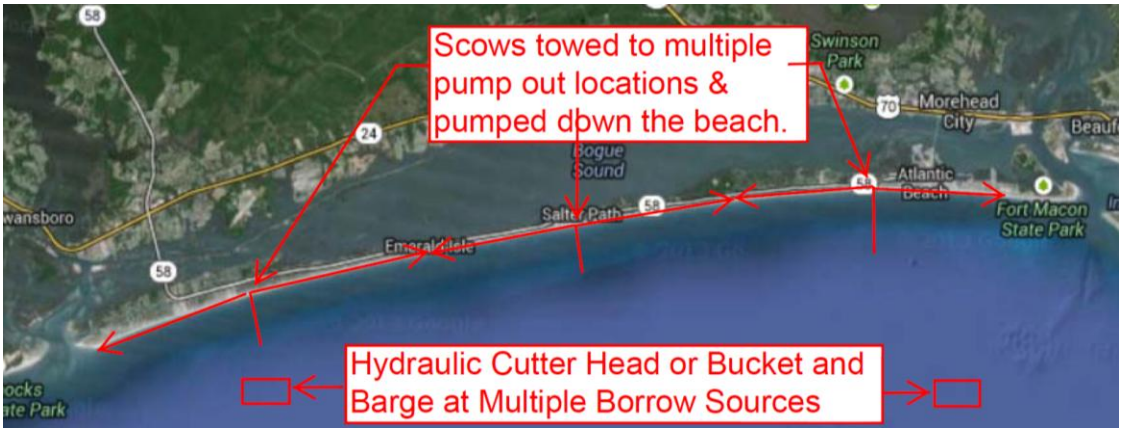
Hydraulic Cutter Head Dredge Loading a Scow Via Spider Barge

This same principal could be executed with a bucket and barge stationed at the borrow source and loading a scow which is then towed to the pump out location.

Loading a scow with via bucket operation.

The scow would then be towed to the pump out location and material removed from the scow and piped to the beach via a hydraulic pump out shown below.

Pumping out a loaded scow



Another option which could be utilized by a company only owning hydraulic cutter head equipment would be to discharge material as far down the beach as practical from the inlet borrow sources and have off road dump trucks transport the material to the final template location. This option is not feasible for the initial construction due to the limited quantity of material in the inlet borrow sources, but is viable for the renourishment projects. This option would also require agreement from environmental agencies and the cost of hauling down the beach may make it impractical.

There is current litigation between the Corps and local municipalities regarding the near shore disposal area. Utilizing the near shore as a multiple handing staging area or for Government Plant was not seen as one of the more economic solutions to the project.

ADVANTAGES: (IF APPLICABLE)
Ensuring the plans and specifications are written as to not restrict the contractor's means and methods would be the most effective approach to maximize potential bidders while minimizing construction costs.

DISADVANTAGES: (IF APPLICABLE)
Consent from agencies would be required to allow off road dump trucks to haul material on the beach.

JUSTIFICATION: (IF APPLICABLE)
Having plans and specifications are written as to not restrict the contractor's means and methods should increase the number of competitive bids. This historically has provided the Government with the most competitive prices in construction. However it is difficult to quantify a cost savings without knowing the availability of plant at bid time.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 3 (5.06, 5.07, 5.47): ***Nearshore Placement Strategies***

PROPOSED RECOMMENDATION:
Use of a nearshore placement area may present some cost effective options for getting beach quality sand to the project area rather than relying solely on dredging offshore borrow ares with hopper dredges as outlined in the feasibility study (Figure 1).

One option is to use the nearshore placement area for placement of material from navigation or upland disposal area sources with a maximum of 20% fines. May need modeling or ERDC assistance to predict transport of "beach quality" sand to the beach to provide benefits. Another option is to permit a new nearshore placement area closer to the beach in order to increase shore protection functions of nearshore fill.

A third option is to evaluate the potential of nearshore area as "storage" for fill: using a hopper dredge at offshore borrow areas and bottom dumping in the nearshore, then delivering to the beach by other methods.

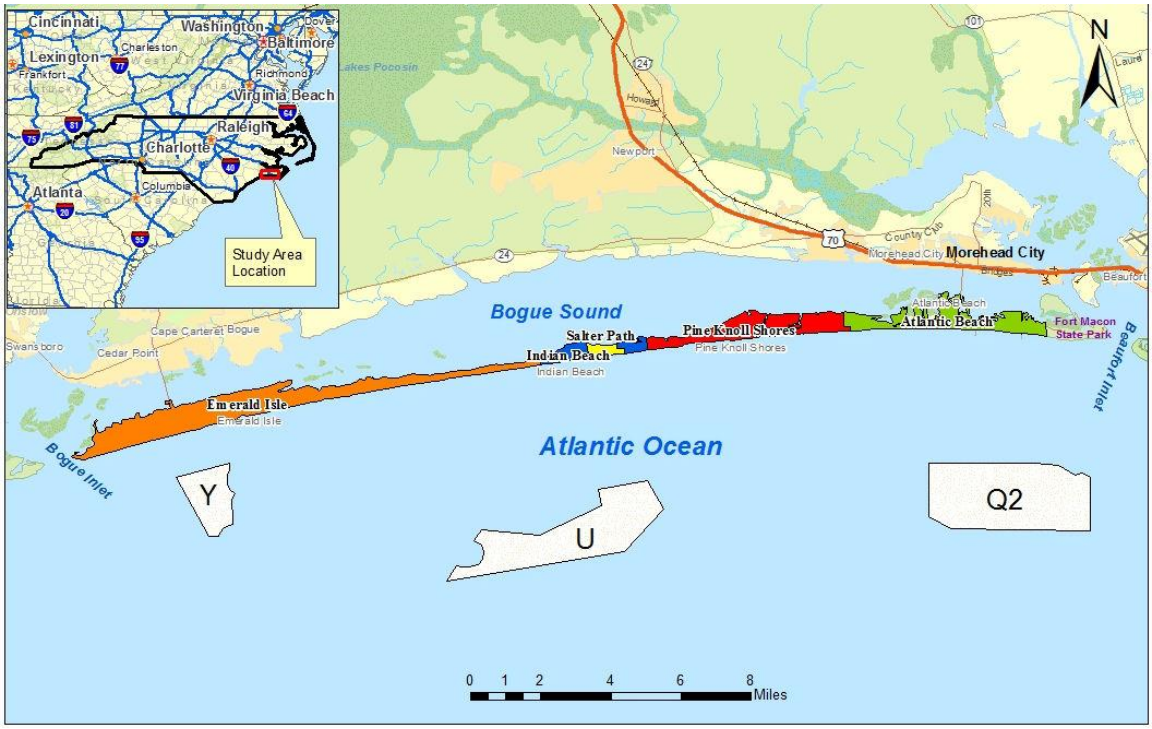


Figure 1: Offshore borrow areas outlined in the Feasibility Study and currently permitted nearshore placement area.

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)
Sand placed in the nearshore undergoes natural sorting processes where fines are winnowed out and beach quality sand is transported toward shore. This process is highly dependent on location/depth of placement, wave climate, and other processes.

The current nearshore placement area is located in approximately 20 ft water depth. SAW noted that material placed here slowly moves toward shore. There are potential sand sources (upland disposal areas, Bogue Inlet, and Beaufort Inlet) that may not have "beach quality" sand but do have sand that can be placed in the nearshore at lower costs and provide some shore protection benefit. If a nearshore placement area can be permitted closer to the beach (there would be depth limitations on plant), greater shore protection benefits could be possible.

The nearshore can also serve as a "storage" area for sand. Material dredged offshore by hopper dredges can be bottom dumped in the nearshore, then transferred to the beach by other plant.

ADVANTAGES: (IF APPLICABLE)
Beneficial use of navigation material. Increasing capacity in upland disposal area. Cost savings resulting from use of less plant and allowing natural processes to sort/distribute dredged material.

DISADVANTAGES: (IF APPLICABLE)
Nearshore placement does not give project an "immediate" beach, potentially not providing forecasted shore protection benefits and/or recreational benefits. Nearshore placement may have permitting issues and environmental effects related to turbidity.

ACTIVITIES TO IMPLEMENT: (IF APPLICABLE)
Evaluate sediment transport in the nearshore to identify location/timing of placement for maximum sorting and transport to the beach. ERDC is currently doing a lot of research on this (Julie Rosati and Tanya Beck). Investigate potential for a nearshore placement area closer to the beach. Evaluate sediment quality in DMMA and inlets to determine volume of nearshore compatible material available per year. Estimate cost savings resulting from nearshore placement (cost savings to navigation, storm damage reduction, and increasing capacity in upland disposal areas).

JUSTIFICATION: (IF APPLICABLE)
Nearshore placement could reduce costs. Demonstrates integration of storm damage reduction and navigation projects throughout the entire coastal system. Beneficial use of dredged material should result in cost savings to both HSDR and Navigation business lines.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 4 (9.32, 9.45, 9.46): ***Further investigate the geotechnical data to optimize material within the borrow areas and to locate borrow areas closer to the project.***

PROPOSED RECOMMENDATION:

The Bogue Banks CSDR project borrow areas (Q2, U, and Y) extend between 1-5 miles offshore at depths between -40' and -57'. Currently, the proposed plan will utilize hopper dredges to obtain the borrow material. The distance of some of the material within the borrow areas will increase the time and cost of dredging the material. To reduce the time and costs it is recommended that borrow areas located closer to the project are found and that the material is within the borrow areas are optimized to for construction, i.e. the overfill ratio and the slope of the project.

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)

The NED 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). This 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 19.55 million cubic yards of material are needed for initial construction and subsequent nourishments during the 50 year project.

To obtain the quantity of material needed three borrow areas (Q2, U, and Y) have been selected for the project. Small subset areas in borrow areas N, P, R, T, and Z appear to have compatible material but not the needed quantity. The subset borrow areas along with areas within the project nearshore could be further investigated during PED to determine if there is enough compatible material to propose as an option to the dredge contractor along to borrows Q2, U, and Y.

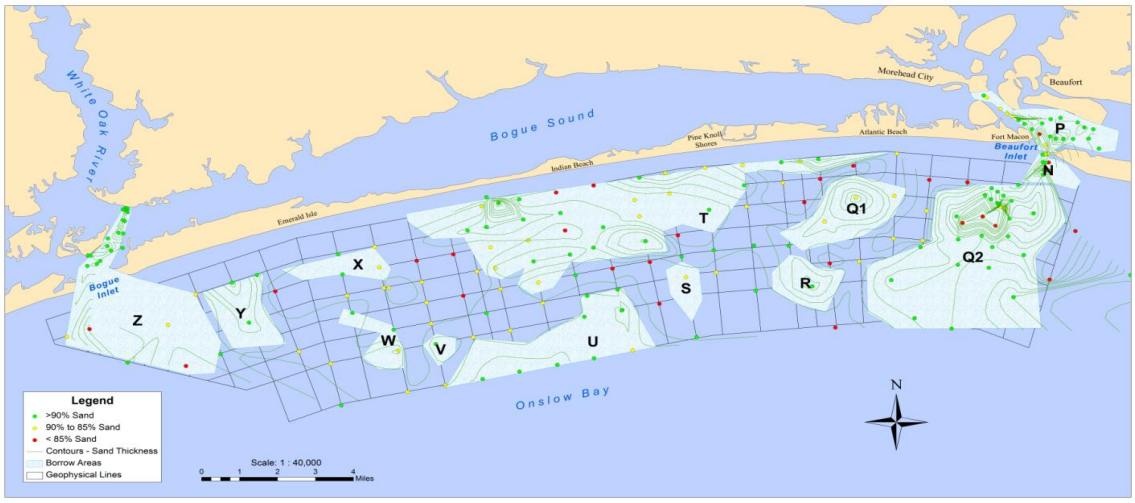


Figure 1. Vibracore borings and borrow areas within the Bogue Banks CSDR project.

ADVANTAGES: (IF APPLICABLE)

The investigation of additional borrow areas may locate compatible material that is closer to the project location. These areas could be included as an option to the dredging contractor to use at his/her discretion.

In addition, optimization of the placement of the material within the project may assist in reducing the costs. It is recommended that the borrow areas containing the coarser sediment are utilized for constructing the project slopes as coarse sand beaches have steeper gradients than fine sand beaches because they have less surface backwash and therefore less seaward movement of the grains.

DISADVANTAGES: (IF APPLICABLE)

Additional time and there will be an increase in the cost during PED for investigating the additional subsets within the borrow areas N, P, R, T, and Z and along the project nearshore.

ACTIVITIES TO IMPLEMENT: (IF APPLICABLE)

JUSTIFICATION: (IF APPLICABLE)

Utilizing borrow areas closer to the project may reduce the dredging costs for the project. Also, optimizing the placement of material (i.e. coarse sand on the slopes) may assist in maintaining the project between nourishments.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 5 (10.00, 10.11, 10.18): ***Dune Stabilization Utilizing Sand Fencing, Vegetation Planting, and Woody Debris***

PROPOSED RECOMMENDATION:
In order to minimize scouring, erosion, property damage, and intertidal habitat loss, the team recommends that measures be implemented to stabilize existing and created/modified dunes. Proposed methods of dune stabilization include sand fencing, vegetating dunes with native, dune-building plant species, and possible utilization of debris (such as discarded X-mas trees) to add strength to the dune mound structure. These methods may be combined to increase effectiveness.

Sand fences combine wood strips and metal wire to create a flexible fence designed to allow windblown sand to accumulate on either side (Figure 1). Although already in place at Fort Macon State Park and at Shackleford Point (as described in section 1.08 of the Draft Report), it may be advantageous to employ sand fences in other project areas.

At Bogue Banks, specifically, dunes are most commonly 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*). One or more of these species would likely be utilized in vegetating created/modified dunes (Figure 2). Dune vegetation is further discussed in section 6.02.2 of the Draft Report. 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).

Fort Macon State Park, in Atlantic Beach, collects discarded X-mas trees for use in dune restoration and stabilization. The trees function as both shelter for native plants to grow under, and as a means of windblown sand collection. This method of dune stabilization is used in conjunction with sand fencing (Figure 3). Through coordination with the Park, this woody debris may offer benefit to the project.

Figure 1. Sand Fence

Figure 2. Dune Vegetation

Figure 3. X-mas Trees

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)
Based on the calculated average erosion rate per year, it is anticipated that a good portion of the beach would continue to erode from the existing condition back into the dune. Once the beach has eroded back into the dune, escarpments would likely 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.

Sand fences are currently utilized at Fort Macon State Park and at Shackleford Point, and the Draft Report provides for 75 acres of native vegetation planting in section 6.02.2.

There is no existing discussion concerning utilizing discarded woody vegetation (X-mas trees) for dune stabilization.

ADVANTAGES: (IF APPLICABLE)

- Decreased future costs associated with dune construction/maintenance.
- Potential extension of beach renourishment/material placement cycles.
- Increased storm damage protection for property, utilities, and infrastructure behind dune faces.
- Decreased erosion, scouring, and loss of intertidal beach habitat.
    - Stabilization of intertidal beach habitat.
    - Potential increase in recreation and tourism.

DISADVANTAGES: (IF APPLICABLE)

n/a

ACTIVITIES TO IMPLEMENT: (IF APPLICABLE)

- Coordination with Fort Macon State Park regarding to X-mas tree utilization.
- Purchase of sand fencing and 75 acres-worth of native vegetation for planting.

JUSTIFICATION: (IF APPLICABLE)

Assuming that all dune stabilization methods are feasible, the relatively small initial cost of these measures stands to offer increased dune and beach permanence which will curb erosion, scouring, and loss of intertidal beach habitat, as compared to the current project plan. With decreased loss of beach sand, the renourishment cycle for Bogue Banks may be extended. This may lower internal costs associated with contracting and environmental coordination, as well as contracted dredging costs.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 6 (12.13, 12.14): ***Evaluate removing shoreline segment R23 – R36 from the project***

PROPOSED RECOMMENDATION:

Evaluate the justification for including nourishment between Reach 23 – Reach 36 for the TSP. If TSP is not justified in this roughly 2.5 mile segment, and no constructability issues result from dropping it from the TSP, total project costs could be reduced and Federal cost share could increase based on current parking availability (noted that sponsor intends to eventually provide parking in this segment).

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)

Total damages from approximately Reach 23 to Reach 36 (R23 – R36) are significantly lower than the rest of the study area (Figure 1). Table 5.6 in the study indicates that the majority of benefits (>50%) used to justify this segment are recreational. At approximately 1,000 linear feet per reach, this segment of low damages represents 13,000 feet of shoreline, or nearly 2.5 miles. This is a significant length of shoreline and could likely be removed from the TSP without impacting constructability.

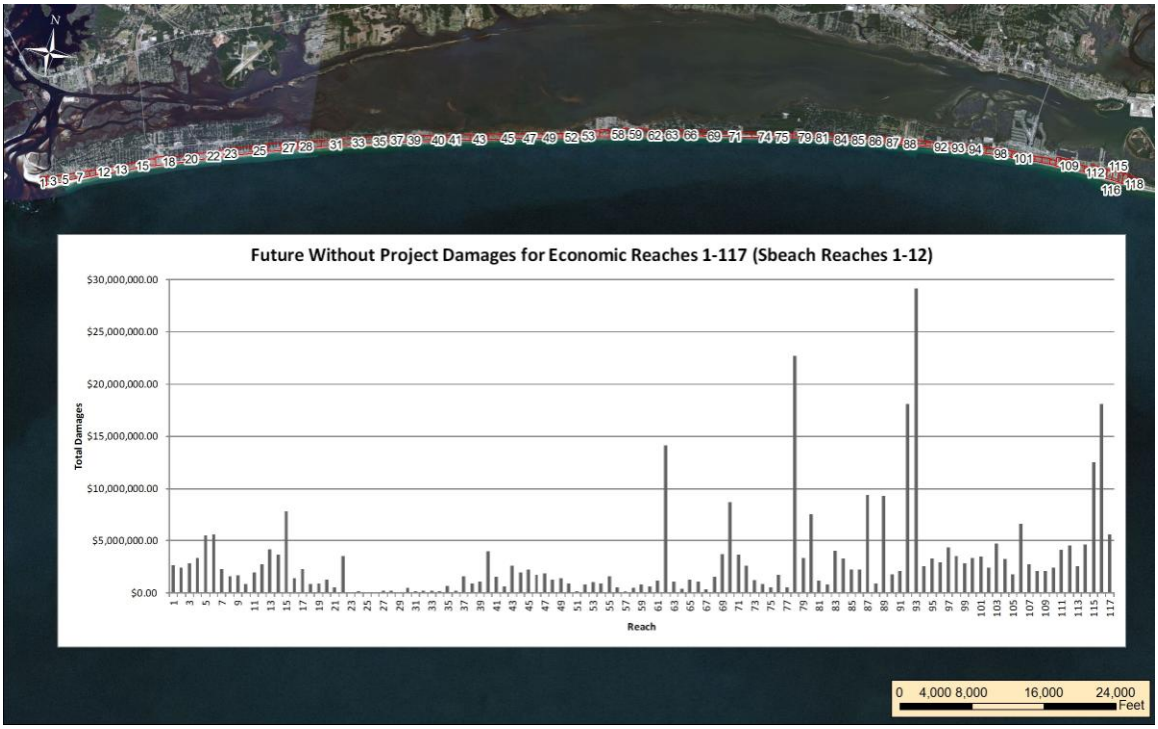


Figure 1: Note low damages from Reach 23 to Reach 36.

A ROM cost for alternative implementation should be compared to Future Without Project (FWOP) damages to demonstrate that the segment is likely justified. For R23-R36, recreational benefits may have to be included in the comparison in order to justify the segment.

SAJ employed the following method on a similar project: A project's Benefit-to-Cost Ratio (B/C Ratio) must be greater than 1.0 in order for an alternative to be justified and implementable (i.e.

the benefits must be greater than the costs). Benefits equal damages prevented. In Figure 2, damages are used as a proxy for benefits. Using the value of without project damages as a substitute for the benefits will overestimate the benefit provided by any alternative since this assumes that 100 percent of damages have been averted. Therefore if the ROM cost of implementing an alternative is equal to, or less than, the without project damages, the B/C ratio can be assumed to approximate 1 and the alternative may be justified. **Error! Reference source not found.** displays the costs per linear foot of alternatives in addition to damages along the shoreline for each of the three SLC scenarios. Wherever damages are far below an alternatives ROM cost, it is assumed that the alternative would not be justified along that shoreline length. Wherever damages are near or above ROM costs along a stretch of shoreline of sufficient length for an alternative to be realistically implemented, it is assumed that the alternative may be justified and it is carried forward. .

The cost of a measure's implementation may vary depending on the Sea Level Change scenario used for design. Because of this it is important to note that there is uncertainty around the future costs, and alternatives with costs just above projected damages should not be screened out prematurely.

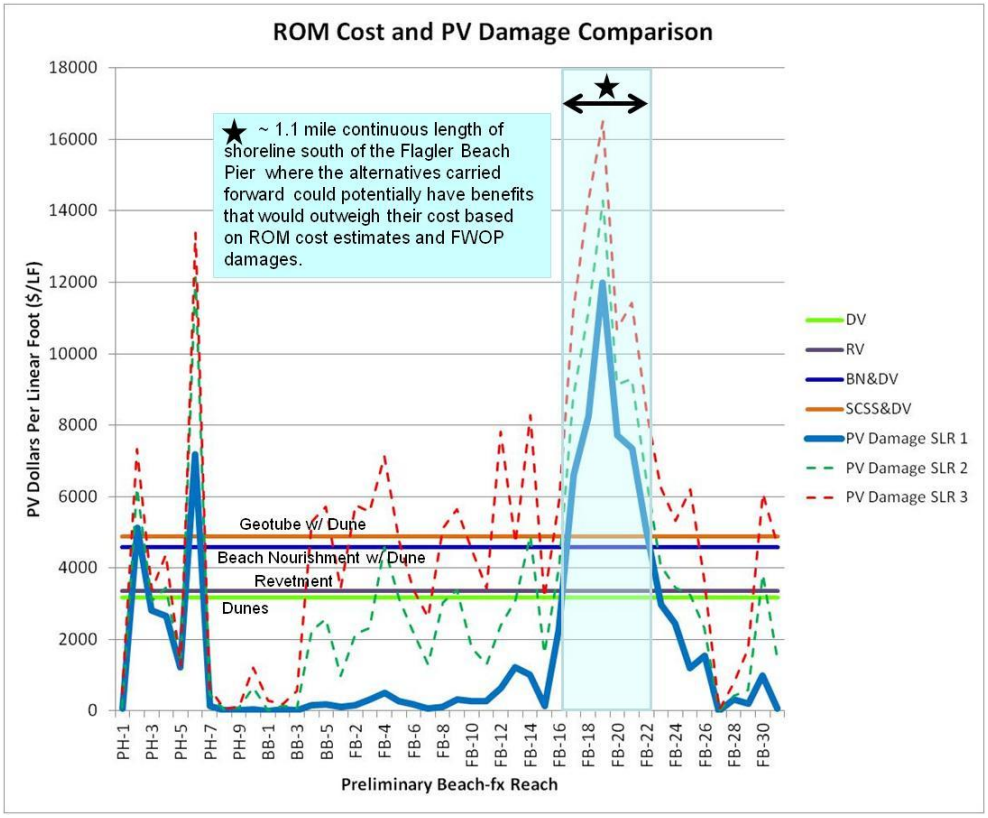


Figure 2: Present Value Damages vs ROM Costs for alternatives

<u>ADVANTAGES</u>: (IF APPLICABLE)

This comparison not only helps in screening, but it also serves to scale an alternative, showing what shoreline lengths may have enough FWOP damages to justify implementation. The mthod

also demonstrates use of Sea Level Change guidance during plan formulation which could improve acceptance.

A significant portion of this segment does not have adequate parking per Appendix I of the feasibility study. The study states that the sponsor intends to provide parking in areas currently without. However, if parking cannot be provided in this segment, dropping it from the TSP would improve the Federal percentage of the cost share.

DISADVANTAGES: (IF APPLICABLE)
Some additional time will be required for this analysis. Sponsor may be unhappy with dropping a segment. If this segment is dropped from the TSP and nourishment takes place to the east and west, end losses from the east and west would reduce constructed beach widths on adjacent beaches as sand is transported into the segment "gap".

ACTIVITIES TO IMPLEMENT: (IF APPLICABLE)
Complete a ROM cost analysis to justify including this section of the project. Verify that segment is justified, even with majority of benefits coming from recreation.

JUSTIFICATION: (IF APPLICABLE)

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 7 (17.00): R*evisit the advance nourishment option for life cycle cost*

PROPOSED RECOMMENDATION:
This recommendation calls for revisiting project advance nourishment to better life cycle costing.

JUSTIFICATION: (IF APPLICABLE)
The benefits and related cost need additional evaluations. However, the benefits to pursue these concepts warrant further investigation.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 8 (19.00, 19.20): ***Extension of Environmental/Dredging Window Outside of Dec 15 through March 31***

PROPOSED RECOMMENDATION:
Should additional time be required by the Contractor to complete dredging work associated with this project, the planned Dec 15 through March 31 dredging and environmental window would be extended. Any proposed extension would be closely coordinated with applicable stakeholder agencies to ensure any threatened and/or endangered species potentially present in the project area would be adversely affected.

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)
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.

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.

ADVANTAGES: (IF APPLICABLE)
- Assurance of completion of dredging, despite delays which may place completion outside the planned Dec 15 through March 31 window.
  - Assurance of recreation benefits associated with increased beach availability and tourism.
- Should an environmental window extension be necessary, acceptance of a window extension will allow for completion of the mission as well as saved costs in future mobilization/demobilization.
- A longer construction window may increase bid-availability of the project and result in less expensive bids.

DISADVANTAGES: (IF APPLICABLE)

- Environmental window extension request beyond planned dates may not be received well by USFWS as multiple environmental window extensions have recently requested, associated with other USACE projects.

ACTIVITIES TO IMPLEMENT: (IF APPLICABLE)

- Coordination of potential environmental dredging window extension with USFWS.

JUSTIFICATION: (IF APPLICABLE)

Assuming that an environmental dredging window extension is feasible and necessary, the potential project savings in avoiding additional Contractor mobilization/demobilization costs are sizeable. Additionally, allowing for project completion prior to the recreation season may allow for economic benefits to the project area in terms of increased tourism.

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 9 (23.00, 23.24): ***Investigate and evaluate Brandt Island as a borrow area for the project.***

PROPOSED RECOMMENDATION:

Brandt Island should be evaluated as a potential borrow area for the Bogue Banks CSDR project as sediment from within the channel and turning basin are stored in this location.

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)

Maintenance of the inner harbor has been conducted on a bi-annual basis utilizing a pipeline dredge that carries sediment from these areas to the confined disposal site of Brandt Island (Figure 1). In the past, inner harbor material has also been piped directly to Bogue Banks beaches concurrently with Brandt Island pump-outs during major construction improvements.

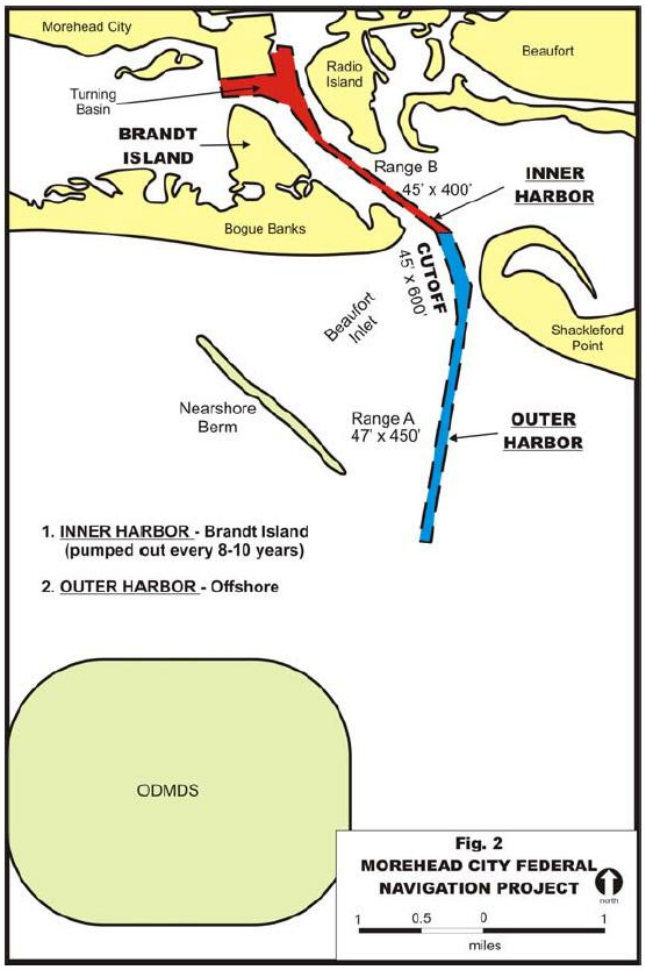


Figure 1. Location of the channel and Brant Island.

As part of the Morehead City DMMP, the material on Brant Island was evaluated. The evaluation determined that the material was not beach quality. Additionally, methods of sorting the

material to produce quality beach material were evaluated and it was determined to not be cost effective.

<u>ADVANTAGES</u>: (IF APPLICABLE)

Utilizing material from Brandt Island would assist in providing space for more material to be pumped-out of the channel and it would benefit the CSDR project by its' close location to a portion of the project (i.e., the north end).

<u>DISADVANTAGES</u>: (IF APPLICABLE)

The Morehead City DMMP determined that the quality of the material on Brant Island does not meet the beach quality standards set by USACE. To satisfy USACE standards the material would need to be sorted and that has previously been determine to not be cost effective. In addition, the map in Figure 2 appears to show limited available material at Brant Island. Material for this project would likely have to come directly from the channel and turning basin instead of from Brant Island.

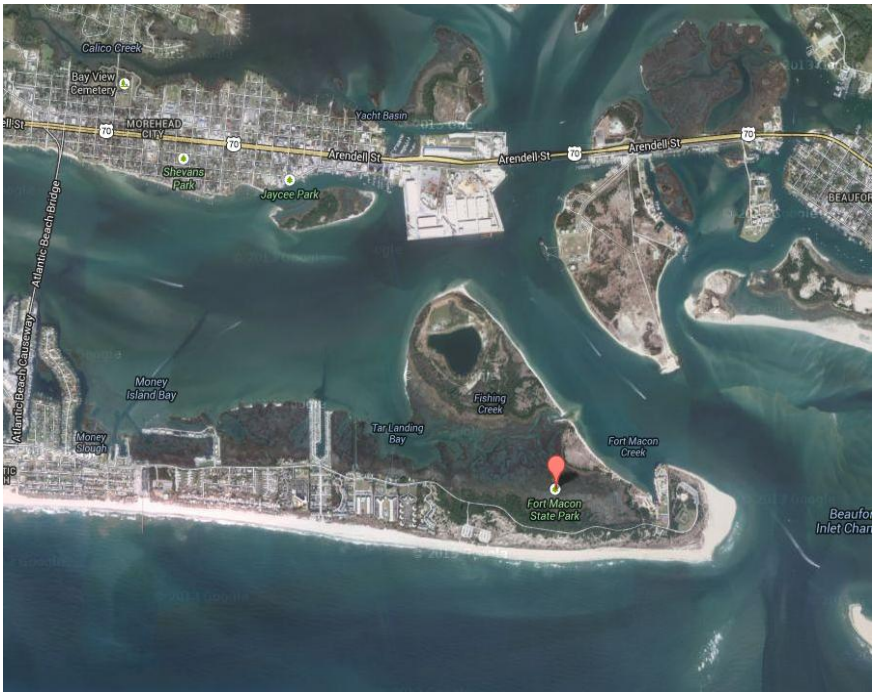


Figure 2. View of Brant Island provided from Google maps (taken sometime in 2013).

<u>ACTIVITIES TO IMPLEMENT</u>: (IF APPLICABLE)

None, the material has already been evaluated.

<u>JUSTIFICATION</u>: (IF APPLICABLE)

<u>DETERMINATION:</u> (PDT Responses)

RECOMMEDNATION NO. 10 (33.00 & 33.43): ***Solicitation options to expedite schedule and reduce construction costs.***

PROPOSED RECOMMENDATION:

The purpose of this recommendation is to investigate the multiple ways in which the solicitation can be structured to expedite schedule and reduce construction costs. The examples discussed below are assuming a 15 December through 31 March dredging window due to turtle activity.

The first option would be to add an incentive clause to the solicitation if the contractor would complete all initial construction prior to 31 March of the award year. From the perspective of being good stewards of the American tax dollar, the use of additional Federal funds to expedite the work which benefits a small community would not be practical. The Non-Federal Stakeholders would have a vested interest to have all work completed by 31 March to have the beach open for tourist season and berm/dune construction ready for hurricane season.

The use of an incentive clause must also be approached from a safety perspective. This large project that requires multiple dredges, miles of pipeline, and numerous pieces of earthmoving equipment that would put the prime contractor's daily overhead rate near $150,000 per day. Since the Contractor is already heavily invested to ensure early completion, it could be reasonably assumed that if an incentive was placed on the contract, the company would pass those benefits down to the employees in the field to increase production. Only the Captain has the authority to decide if weather is too severe to conduct dredging operation. A large financial incentive by the Government may cloud the Captain's judgment and result in an accident.

The second option would be to adjust the solicitation CLIN structure. One option would provide a price to complete all work within the 15 December through 31 March dredging window. The second option would be to complete all work between 1 November and 31 May and would require the contractor to provide additional turtle monitoring during November, April, and May. The mindset of this option is that by allowing more flexibility in the contract duration, more contractors would be available to bid on the work, resulting in more competitive pricing. There are numerous downsides to this approach. This may result in ongoing construction during the Memorial Day weekend, which would have financial impact on the local communities. There is also potential, even with turtle monitoring, of having negative impact on a nest or having a turtle take. To be allowed to work outside the established environmental window, the Government would need to request approval from outside agencies prior to solicitation. Requesting this approval prior to work starting would give the impression to the outside agencies that the Corps of Engineers has little respect for the principals behind the Environmental Windows and is only concerned with the financial savings on the dredging contract. In addition to potential negative publicity, this would result in a hampered partnership with the outside agencies.

ADVANTAGES: (IF APPLICABLE)
Early completion and/or reduced construction costs.

DISADVANTAGES: (IF APPLICABLE)
Safety concerns for both crew and environment and hindering partnering relationships with outside agencies.

JUSTIFICATION: (IF APPLICABLE)

DETERMINATION: (PDT Responses)

RECOMMEDNATION NO. 11 (37.40, 37.41): ***Feeder Points (Sand Engine)***

PROPOSED RECOMMENDATION:
Explore the potential of constructing feeder points along the TSP shoreline. Nodal points could be ideal locations for a feeder point, dubbed a "sand engine" by the Dutch (http://www.vanoord.com/activities/sand-motor) (Figure 1). Construction of one point, or multiple smaller points, could be possible.

Figure 1: Feeder point (Sand Engine) construction in the Netherlands.

EXISTING SITUATION, PROCESS, ACTIVITITY OR DESIGN: (IF APPLICABLE)
The idea is that rather than continuously moving pipeline and plant down the beach to construct a uniform berm width, pipeline is kept in one location to form a sand point and natural shoreline processes transport the sand along the shoreline (Figure 2). Since sand is transported both east and west from nodal points along the project shoreline, these could be ideal locations for a feeder point.

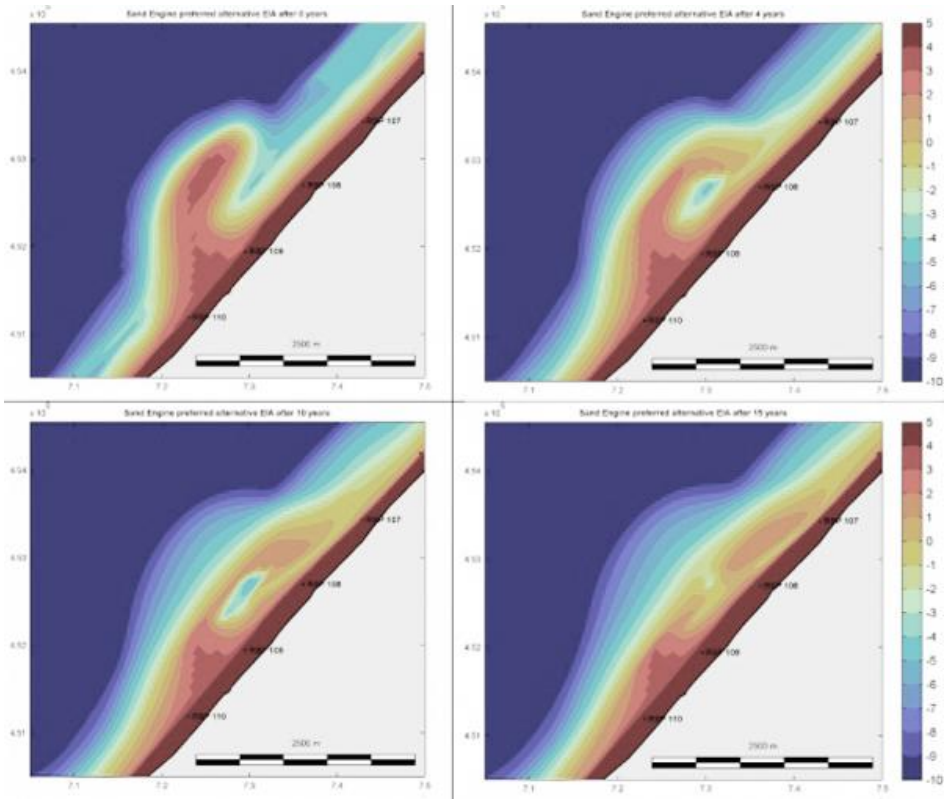


Figure 2: migration of sand point constructed in the Netherlands (http://www.seacityresearchnet.com/archives/tag/sand-engine)

ERDC's Engineering With Nature (EWN) program (http://el.erdc.usace.army.mil/ewn) has researched feeder beaches, and NAD has some experience with actual construction. SAJ has also constructed a large feeder beach in the 1970's (Figure 3).

Figure 3: SAJ feeder beach construction near nodal point south of the St. Johns River entrance channel in 1972

<u>ADVANTAGES</u>: (IF APPLICABLE)
Cost savings due to less plant required and less plant activity. Potential to create temporary surfing resources and recreational benefits. Some resource agencies may prefer this method.

<u>DISADVANTAGES</u>: (IF APPLICABLE)
Permitting issues related to filling farther seaward at feeder points. Potential resource impacts. Migration of fill is dependent on natural sediment transport, therefore the entire project shoreline would not have immediate benefit of full project construction. Creation of smaller, multiple points could mitigate some of these disadvantages.

<u>ACTIVITIES TO IMPLEMENT</u>: (IF APPLICABLE)
Coordinate with resource agencies and evaluate permitting requirements to place a feeder point. Evaluate potential placement areas (nodal points could be ideal) and model fill migration. Estimate resulting cost savings.

JUSTIFICATION: (IF APPLICABLE)
Resulting costs savings could be significant. Some resource agencies may prefer natural fill migration as opposed to mechanical berm construction.

DETERMINATION: (PDT Responses)