Chapter 1 *INTRODUCTION*

1. What is the purpose of this Environmental Impact Statement?

The purpose of this final environmental impact statement (EIS) is to assist in decision making – "to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment (43 CFR Section 1500.1, CEQ Regulations). The EIS will insure that the policies and goals defined in the National Environmental Policy Act (NEPA) are adequately addressed in the U.S. Army Corps of Engineers (USACE) permit evaluation process. It will provide full and fair discussion of significant environmental impacts and shall inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment.

NEPA is a United States environmental law created in 1969 that established a U.S. national policy promoting the enhancement of the environment and also established the President's Council on Environmental Quality (CEQ). NEPA ensures that relevant environmental information is available to public officials and citizens before decisions are made and actions are taken. The Act requires federal agencies to conduct an EIS for major actions that could have significant impacts on the quality of the human environment. Under NEPA, "environment" includes the natural and physical environment (such as air, water, geography, geology) as well as people's relationship with the environment (such as health, safety, jobs, schools, housing, and aesthetics). An EIS looks at both short-term and long-term effects and considers possible mitigation measures, if needed.

This EIS document has also been developed in accordance with the requirements of the State Clearinghouse review process under the North Carolina Environmental Policy Act (NCEPA, G.S. 113A-1). Upon the development and submittal of the Final EIS, additional filing under the NC EPA will not be required.

Each alternative presented in this document will be evaluated for its ability to satisfy the stated project goals and objectives, as well as the environmental, economic, and social consequences associated with each alternative. This evaluation process will help lead to the selection of the "least environmentally damaging practicable alternative" (LEDPA) that meets the project needs and objectives while resulting in minimal negative environmental impacts.

2. What is the NEPA EIS process and how does it relate to Figure "8" Beach Homeowners Association's proposed project?

This EIS will be prepared in a series of steps: gathering government and public comments to define the issues that should be analyzed in the EIS (a process known as "scoping"); gathering available data, preparing the draft EIS document and releasing it to the public requesting feedback; receiving and responding to public comments on the draft EIS; and preparing the subsequent final EIS. Decisions are not made in an EIS document; rather, the EIS primarily serves as an assessment of various project alternatives and their respective effects on the environment. Furthermore, the document is utilized to help evaluate and determine which of the project options is the LEDPA and meets the applicant's purpose and needs. This final evaluation will be made in the Record of Decision (ROD). The following describes the general concepts in the NEPA EIS process, which was used in evaluating Figure "8" Beach Homeowners Association proposed project:

Scoping

Scoping is the process of identifying the key issues as they pertain to the proposed action. The USACE began the scoping process for this EIS by publishing a Notice of Intent (NOI) in the *Federal Register* to let the public know that it is considering an action and will prepare an EIS. During the scoping period, the public can provide comments on the proposed action, alternatives, issues, and environmental impacts to be analyzed in the EIS. Scoping may involve public meetings and other means to obtain public comments on the EIS.

Appendix A, Subpart 1: Scoping Meeting and PDT Meeting Minutes

This appendix includes the minutes from the initial scoping meeting and subsequent PDT meetings. A list of meeting attendees is included.

Draft EIS

During scoping, information is collected and used for the preparation of a draft EIS. The draft EIS presents, analyzes, and compares the potential environmental impacts for the proposed action and alternatives and their implementation, and provides additional information on the methodologies and assumptions used for the analyses. A Notice of Availability (NOA) is published in the *Federal Register* announcing the release of the draft EIS for public review and comment. The NOA begins a 45-day comment period. Public comments on the draft EIS are considered in the preparation of the final EIS.

Supplemental EIS

After the release of the draft EIS, it was determined that a Supplemental EIS be prepared to allow the prospect for additional scoping and to provide the public further opportunity to review the components of the document. This document included two additional terminal groin alternatives that were considered minor deviations from the DEIS terminal groin alternative.

Final EIS

After the draft EIS commenting period is completed and through continuing scoping, a final EIS is prepared, published in the *Federal Register*, and released for any additional comments. All comments received during the commenting period will be addressed where applicable to prepare the final EIS.

Record of Decision

After the final EIS is published, a minimum 30-day waiting period is required before a ROD can be issued. The ROD notifies the public of the decision made on the proposed action and presents the reasons for that decision. The decision-making process may include consideration of the public interest factors, compliance with the Section 404(b)1 Guidelines and related Federal laws, and other considerations such as cost, logistics, existing technologies, technical feasibility, agency statutory missions, and national objectives, as well as the potential environmental impacts of an action(s).

3. How has the public been involved?

In accordance with NEPA and State Environmental Policy Act (SEPA) requirements, an early and open public forum process, identified as “scoping”, was initiated to identify significant issues related to the proposed action and establish an appropriate scope of work for addressing those issues in the EIS document.

In order to engage the general public, including residents of Figure Eight Island and all stakeholders, a NOI was issued and published in the *Federal Register* (Volume 72, Number 31) on February 26, 2007. This Notice of Intent served to inform the public of the “intent to prepare a Draft Environmental Impact Statement (EIS) for the development of an inlet management plan that includes the repositioning and realignment of the main ebb channel of Rich Inlet and to use the material to nourish Figure Eight Island, north of Wilmington, New Hanover County, NC”. The NOI provided the project description and described the proposed action, potential impacts, project alternatives, and the scoping process. Along with this issuance, a Public Notice (PN) containing similar information was released by the USACE on February 22, 2007. As announced in the NOI and PN, the initial scoping meeting was held at Eaton Elementary School, located at 6701 Gordon Road, Wilmington, NC, on March 1, 2007. For the DEIS, the Notice of Availability (NOA) was filed with U.S. Environmental Protection Agency (EPA) via e-NEPA on May 16, 2012. The NOA was subsequently published in the *Federal Register* (Volume 77, Number 97) on May 18, 2012. A local Public Notice was issued on May 18, 2012 announcing the release of the Draft EIS and a scheduled Public Hearing, as well as requesting public comments. An amended local Public Notice was issued on May 30, 2012 that extended the public commenting period until July 6, 2012, totaling the commenting period at 49 days. On June 7, 2012, a Public Hearing was held at Ogden Elementary School in Wilmington, North Carolina. For the SEIS, the NOA was filed with US EPA via e-NEPA on July 1, 2015, and the NOA was published in the *Federal Register* (Volume 80, Number 132) on July 10, 2015. The local Public Notice for the release of the NOA was issued on July 9, 2015 with a commenting deadline set for August 24, 2015. An amended Public Notice was issued on July 31, 2015 announcing a Public Hearing and the extension of the commenting deadline to September 14, 2015, totaling the commenting period at 67 days. The Public Hearing was held at Ogden Elementary School in Wilmington, North Carolina on September 2, 2015.

In a continual effort to include the public, State and Federal agencies, and all interested stakeholders in the process, a Project Delivery Team (PDT) was assembled. The PDT members were individually asked to: 1) provide input for the development of the EIS, 2) keep the public informed of project development, 3) discuss project-related concerns, and 4) to identify natural resources in the Permit Area. The PDT is comprised of a broad-based team of individuals who represent the following interests: local, state and federal government officials; business and property owners; non-governmental organizations; as well as the project design team (Table 1.1). PDT meetings were held on May 7, 2007, September 18, 2007, June 10, 2008, March 19, 2008, May 20, 2009, and August 11, 2010. See Appendix A, Subpart 1 for meeting minutes.

Table 1.1. Figure Eight Island Inlet and Shoreline Management Project PDT Members at the Time the DEIS was being Prepared

NAME	AFFILIATION	E-MAIL ADDRESS
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Brad Rosov	CPE	brad.rosov@shawgrp.com
Ken Willson	CPE	kenneth.willson@shawgrp.com
Bill Cleary	UNCW	wcleary@charter.net
David Webster	UNCW	webste@uncw.edu
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Greg Williams	USACE	greg.williams@usace.army.mil
David Ward	Hutaff Island	dlw@wardandsmith.com
David Rabon	USFWS	david_rabon@fws.gov
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Jim Iannucci	New Hanover County	jiannucci@nchgov.com
Paula and Jim Bushhardt	NE New Hanover Conservancy	bushhardt@bellsouth.net

4. How have government agencies been involved?

Participation in the EIS process by Federal, State, and local government agencies and other interested organizations and persons has been encouraged. The USACE has requested initiation of consultation with the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act and the Fish and Wildlife Coordination Act; with the National Marine Fisheries Service (NMFS) under the Magnuson-Stevens Act and Endangered Species Act; and with the North Carolina State Historic Preservation Office (NCSHPO) under the National Historic Preservation Act. Specifically, the USACE has requested formal consultation with the USFWS and NMFS Protected Resources Division regarding species listed under the Endangered Species Act (ESA) via the development of a Biological Assessment (BA). Essential Fish Habitat consultation, pursuant to the Magnuson-Stevens Act, with NMFS Habitat Conservation Division has been initiated and completed (see letter in Appendix A, Sub-Part 2). Additionally, because this EIS assesses the potential water quality impacts pursuant to Section 401 of the Clean Water Act, coordination efforts are being made with the North Carolina Division of Water Resources (DWR), and a DWR Section 410 water quality certification is required. Furthermore, the USACE has worked closely with the North Carolina Division of Coastal Management (DCM) through the development of this EIS to ensure the process complies with all State Environmental Policy Act (SEPA) requirements and to determine consistency with the Coastal Zone Management Act (CZMA).

As stated above, representatives of the relevant Federal agencies have been involved in the scoping meeting and the subsequent PDT meetings. Their input has been integrated into this EIS document.

5. What is the Figure Eight Island Shoreline Management Project and where is it located?

The Figure "8" Beach Homeowners Association (Figure "8" Beach HOA) is seeking Federal and State permits to allow development of a management plan for Rich Inlet that would mitigate chronic erosion on the northern portion of Figure Eight Island to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along the northernmost three miles of its oceanfront shoreline.

Figure Eight Island is located in northeastern New Hanover County. It is an unincorporated privately developed residential barrier island with 563 platted lots including 489 developed lots and 74 undeveloped lots. Eight (8) of these undeveloped lots do not currently meet the building setbacks rules (O'Mahoney, pers. comm.). The island is bordered to the south by Mason Inlet and Wrightsville Beach and to the north by Rich Inlet and Hutaff Island, an undeveloped, privately-owned island (Figure 1.1). Hutaff Island is one of the few remaining undeveloped and vehicle-free barrier islands on the North Carolina coast. It is among the largest near-pristine barrier island and salt marsh systems in the region.

Figure Eight Island covers approximately 1,300 acres, is approximately 5.0 mi long and approximately 0.4 mi wide. The proposed project is located along the oceanfront shoreline on the northeast end of the island, and within Nixon Channel and Rich Inlet.

Chronic erosion problems along the northern sections of Figure Eight Island have been directly linked to changes in the orientation and position of the main ebb channel through Rich Inlet (Cleary & Hosier, 1990; Cleary, 2001; Cleary & Knierim, 2006; Cleary & Jackson, 2004). When the main ebb channel of the inlet is oriented toward the southeast or in the direction of Figure Eight Island, and positioned close to the north end of the island, the shoreline immediately south of the inlet tends to accrete. The accretion is associated with the wave sheltering ("breakwater effect") provided by the south side of the ebb tide delta, which also moves with the channel. During periods when the main bar channel migrates to the north toward Hutaff Island and is oriented in a northeasterly direction, the north end of Figure Eight Island erodes. The northward movement of the main ebb channel is accompanied by the northward shift of the south side of the ebb tide delta away from the north end of Figure Eight Island, thus removing the protection afforded by the south side of the ebb tide delta.

In addition to erosion issues along the ocean shoreline south of Rich Inlet, erosion is also prevalent along 426 m (1,400 ft) of the Nixon Channel shoreline extending from Rich Inlet northwest to the entrance to Nixon Creek. Between 1993 and 2005, the average rate of shoreline change along this segment of the Nixon Channel shoreline was -8.3 ft per year. The erosion of the Nixon Channel shoreline is associated with the proximity of the main flow channel to the shoreline.

What is a Terminal Groin?

A shoreline protection structure that reduces beach erosion by temporarily trapping sand before it reaches the inlet. Once the sand forms an "accretion fillet" to protect the shoreline, sand continues its normal flow by moving over, thru or around the structure.

To alleviate these problems attributed to erosion, several alternatives have been evaluated. Initially, relocation of the main channel within Rich Inlet was determined to be the Applicant's Preferred Alternative, as noted in the NOI and PN. This was prior to the passage of SB110 on June 28, 2011, which allowed for the construction of four terminal groins in North Carolina. Since that time, the Applicant's Preferred Alternative, which has been modified since the release of the Draft EIS, includes the construction of a terminal groin 154 m (505 ft) in length with a 303 m (995 ft) shore anchorage section to protect against possible flanking of the landward end of the structure. This structure is intended to control tidal current-induced shoreline changes immediately south of Rich Inlet. In addition to the construction of the terminal groin, several areas of the shoreline would be nourished with material excavated from the previously permitted area within Nixon Channel and from upland dredge disposal sites located in proximity to the AIWW behind Figure Eight Island (pending approval of all landowners and receipt of a USACE consent for placement). Beach fill would be placed along 426 m (1,400 ft) of the Nixon Channel shoreline just south of Rich Inlet. In addition, material will be used to nourish 1,372 m (4,500 ft) of ocean shoreline extending from Rich Inlet south to

322 Beach Road North (Figure 1.1). The existing navigation feature in Nixon Channel would be maintained to its permitted depth of -2.7 m (-9 ft) MLW [or -3.5 m (-11.4 ft) NAVD] and permitted widths. Periodic nourishment of the beach fill would be accomplished in conjunction with continued maintenance of the previously permitted area in Nixon Channel.

As noted above, the Applicant's Preferred Alternative was modified from the initial project involving the relocation of Rich Inlet combined with beach nourishment to the alternative incorporating a terminal groin with associated beach nourishment. The passage of SB110 precipitated the exploration of a project involving a terminal groin. While the Figure "8" Beach HOA states that the inlet relocation project meets its purpose and needs, they have determined that the terminal groin alternative would result in an improved project in terms of economic benefits and reduced environmental impacts.

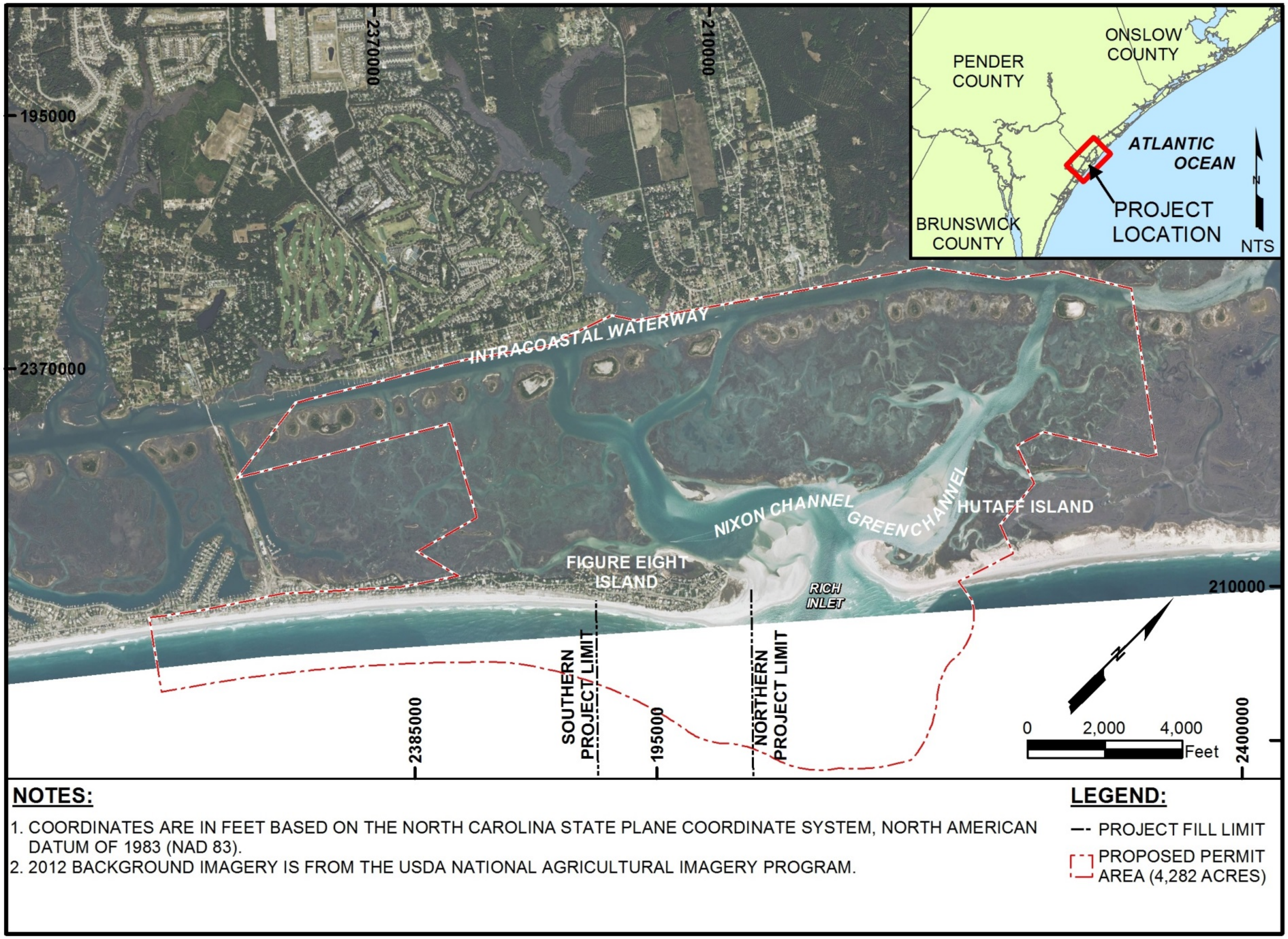


Figure 1.1. Figure Eight Island Inlet and Shoreline Management Project Location Map

6. What issues were identified as part of scoping?

Appendix A, Subpart 2: Pertinent Correspondences

This appendix includes various emails and letters submitted by agencies, stakeholders, and the general public regarding relevant information pertaining to the project.

During scoping (through public meetings and written comments), several issues were identified in association with the proposed project, including: funding concerns, impacts to environmental resources within the inlet complex, sand quality and compatibility, concerns with the use of a terminal groin, impacts to the bird resources within the inlet, and the obtaining of an easement for the construction of a terminal groin. Summaries of the public scoping meetings and PDT meetings held to date are listed below. Minutes to the PDT meetings can be found in Appendix A, Subpart 1. Additional written correspondence has been provided in Appendix A- Subpart 2 (Pertinent Correspondences). The transcripts of the two Public Hearings (June 7, 2012 and September 12, 2015) may be accessed by visiting: http://www.saw.usace.army.mil/Missions/RegulatoryPermitProgram/MajorProjects

- The March 1, 2007 Public Scoping Meeting convened on March 1, 2007 at Eaton Elementary School in Wilmington, NC. The scoping meeting was designed to solicit comments from the public, Federal, State and local agencies and officials, and other interested parties to identify issues to be addressed in the EIS document. Attendees included local residents, resource agencies, and representatives of the Figure "8" Beach HOA, and Coastal Planning & Engineering, Inc. (CPE). Concerns expressed from the attendees are documented in Appendix A – Subpart 1.

- The May 7, 2007 PDT Meeting included the following: a presentation by CPE-NC coastal engineer Tom Jarrett regarding an overview of past nourishment projects on Figure Eight Island, a presentation by UNCW’s Dr. William Cleary regarding the effects of Rich Inlet on adjacent shorelines, an update by CPE-NC geologist Ken Willson on geotechnical investigations, and a presentation by CPE-NC coastal biologist Dawn York regarding baseline biological resource investigations. The meeting format allowed for open discussions during and after the presentation.

- The September 18, 2007 PDT Meeting included a presentation by CPE coastal engineer Chris Day regarding Delft3D modeling results on the project alternatives. Discussions included the newly developed State Sediment Criteria and the need for hardbottom investigations. The meeting format allowed for open discussions during and after the presentation.

- The March 19, 2008 PDT Meeting included a presentation by UNCW’s Dr. Bill Cleary on updated findings on shoreline change for Figure Eight and Hutaff Islands, and estuarine shoreline change for Nixon and Green Channels between 1938 and 2007. CPE-NC coastal biologist Dawn York presented the baseline environmental data collected to date including salt marsh, submerged aquatic vegetation (SAV), shellfish and bird and turtle nesting areas. The meeting format allowed for open discussions during and after the presentation.

- The June 10, 2008 PDT Meeting included in depth discussions regarding the details of each project alternative. This was followed by a presentation by CPE coastal engineer Chris Day focusing on the engineering analysis performed for the Applicant's Preferred Alternative. Mickey Sugg of the USACE provided an overview of the NEPA process and the format of an EIS. The meeting format allowed for open discussions during and after the presentation.

- The May 20, 2009 PDT Meeting included a presentation by CPE-NC marine scientist Brad Rosov regarding the updated biological resource investigations which provide baseline conditions for the EIS. This presentation included information provided by UNCW's Dr. David Webster. CPE-NC coastal engineer Tom Jarrett presented modeling results for project alternatives including the terminal groin options. The meeting format allowed for open discussions during and after the presentation.

- The August 11, 2010 PDT Meeting included a presentation by CPE-NC coastal engineer Tom Jarrett regarding the updated Delft3D modeling results regarding project alternatives. Information regarding anticipated beach fill performance and shoreline change analysis was included in the presentation. The meeting format allowed for open discussions during and after the presentation.

- The June 7, 2012 Public Hearing, held at Ogden Elementary School in Wilmington, NC, included a presentation by the USACE Colonel Steven Baker regarding the role of the USACE in the public hearing process. USACE Project Manager Mickey Sugg provided an overview of the NEPA process and how it applies to the project. CPE-NC coastal engineer Tom Jarrett presented a summary of the contents of the Draft EIS which included the details of the project alternatives. Following the presentations, the floor was opened up to the general public to make comments on the proposed project.

- The September 2, 2015 Public Hearing, held at Ogden Elementary School in Wilmington, NC included a presentation by the USACE Colonel Kevin Landers regarding the regulatory process and discussed the public commenting procedures. USACE Regulatory Chief Scott McLendon and USACE Program Manager then provided a presentation regarding the status of this project within the NEPA process. CPE-NC coastal engineer then presented a summary of the contents of the SEIS. Following the presentations, a public commenting session commenced.

7. What laws are involved?

The following section includes a description of applicable Federal and State laws associated with the Figure Eight Island Inlet and Shoreline Management Project. This EIS document has been prepared to satisfy both the National Environmental Policy Act (NEPA) and the North Carolina State Environmental Policy Act (SEPA) requirements in accordance with State and Federal law.

National Environmental Policy Act of 1969.

The National Environmental Policy Act (42 U.S.C. 4321; 40 C.F.R. 1500.1) includes six fundamental objectives that have been developed since its enactment in 1970. These objectives include: supplemental legal authority; procedural reform; disclosure of environmental information; resolution of environmental problems; foster intergovernmental coordination and cooperation; enhance public participation in governmental planning and decision making (Bass *et al*., 2001). A NEPA document is required when a project includes Federal action including the need for Federal permits, the use of Federal funding, or if the action is to take place on Federal lands.

Section 10 of the Rivers and Harbors Act of 1899.

Pursuant to Section 10 of the Rivers and Harbors Act of 1899, certain structures or work in or affecting navigable waters of the US will be regulated under the purview of U.S. Army Corps of Engineers (33CFR 322.1). The Act states that "it shall not be lawful to excavate or fill…..alter or modify the course, location, condition, or capacity of, any port roadstead, haven, harbor, canal, lake, harbor of refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War…." (USACE, 2006). The geographic jurisdiction of the Rivers and Harbors Act includes all navigable waters of the United States which are defined (33 CFR Part 329) as, "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce." This jurisdiction extends seaward to include all ocean waters within a zone three nautical miles from the coastline (the "territorial seas").

Clean Water Act of 1972.

Section 404 of the Clean Water Act established a permit program under the purview of the U.S. Army Corps of Engineers, to regulate the discharge of dredged and fill material into waters of the U.S., including wetlands. These waters consisting of, but not limited to, "all waters which are currently used or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide" (33CFR 328.3(a)(1)). This program is jointly administered by the Environmental Protection Agency and the U.S. Army Corps of Engineers (USEPA, 2006).

Section 401 of the Clean Water Act includes the delegation of Federal authority to the State of North Carolina to issue a 401 Water Quality Certification. The 401 Water Quality Certification is applicable to all projects that require a Federal permit (i.e., Section 404 Permit) for discharge of dredge material into waters and wetlands of the U.S. The 401 Water Quality Certification Program is administered by the North Carolina Division of Water Quality to prevent the degradation of waters in the State and to prevent any violations of the State water quality standards.

Endangered Species Act of 1973.

The Endangered Species Act of 1973 (ESA) was signed on December 28, 1973, and provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The ESA replaced the Endangered Species Conservation Act of 1969; it has been amended several times.

The lead Federal agencies for implementing ESA are the U.S. Fish and Wildlife Service (USFWS) and the U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. The USFWS maintains a worldwide list of endangered species. Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Coordination with the USFWS and NOAA National Marine Fisheries Service (NMFS) includes consultation under Section 7 of the Endangered Species Act of 1973, as amended.

Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act affords protection to species that are morphologically adapted, or primarily inhabit the marine environment, such as species in the taxonomic orders of Sirenia, Pinnipedia, and Cetacea. Permits for incidental take are overseen by the Secretaries of the USFWS and NOAA. The Act establishes the importance of these species to the environment and defines their nexus to interstate commerce. Under the Act marine mammal populations should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part. Furthermore, they should not be permitted to diminish below their optimum sustainable population. The Act, requires effort be made to protect essential habitats, including the rookeries, mating grounds, and areas of similar significance for each species of marine mammal from the adverse effect of man' s actions.

National Historic Preservation Act of 1966.

The National Historic Preservation Act is legislation intended to preserve historical and archaeological sites in the United States of America. The act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices.

Senate Bill 3035, the National Historic Preservation Act, was signed into law on October 15, 1966. Several amendments have been made since. Among other things, the act requires Federal agencies to evaluate the impact of all Federally funded or permitted projects on historic properties (buildings, archaeological sites, etc.) through a process known as *Section 106 Review*.

Archival research, field work and coordination with the North Carolina State Historic Preservation Officer (SHPO), have been conducted in accordance with the National Historic Preservation Act of 1966 (Public Law 89-665), the National Environmental Policy Act of 1969 (Public Law 11-190), Executive Order 11593, the Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800) and the updated guidelines described in 36 CFR 64 and 36 CFR 66.

The North Carolina Office of State Archaeology (OSA) protects endangered archaeological sites on private or public lands through enforcement of the North Carolina Archaeological Resources Protection Act (G.S. 70, article 2), the North Carolina Archaeological Records Program (G.S. 70, article 4), and the “Abandoned Shipwreck Law” (G.S. 121, article 3).

Magnuson-Stevens Fishery Conservation and Management Act of 1996.

The Magnuson Fishery Conservation and Management Act of 1976, amended Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in October 1996 and also referred to as the Sustainable Fisheries Act, was enacted by the U.S. Congress to protect marine fish stocks and their habitat, prevent and stop overfishing and minimize bycatch. Congress defined Essential Fish Habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires that EFH be identified for all fish species Federally managed by the Fishery Management Councils and the National Marine Fisheries Service (NMFS).

Fish and Wildlife Coordination Act of 1958.

The Fish and Wildlife Coordination Act of 1958, as amended, mandates that Federal and State agencies cooperate "to protect, rear, stock, and increase the supply of game and fur-bearing animals….[and] study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife." The Act also requires consultation with the Bureau of Fisheries, Fish and Wildlife Service and State fish and wildlife agencies where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted…or otherwise controlled or modified" by any agency under a Federal permit or license. Additional amendments to the Act have "permitted lands valuable to the Migratory Bird Management Program to be made available to the State agency exercising control over wildlife resources (USFWS, 2006a).

Coastal Zone Management Act of 1972.

Enacted by Congress in 1972, the Coastal Zone Management Act does not require, but encourages that each State preserve, protect, restore or enhance natural coastal resources including; wetlands, floodplains, estuaries, beaches, dunes, barrier islands and coral reefs, as well as the fish and wildlife that utilize these resources. Since this Act is voluntary, any State that implements a coastal management program as defined in this Act will receive Federal financial aid.

The North Carolina Division of Coastal Management has developed and enforces a coastal management plan with the rules and policies that supports the ideals and concepts of the CZMA. The North Carolina Division of Coastal Management enforces this Act using the rules and policies of the Coastal Area Management Act of 1974 (enabled and delegated in 1972; adopted and implemented in 1974).

North Carolina Environmental Policy Act (As Amended).

The North Carolina (or State) Environmental Policy Act of 1971 (SEPA) requires State agencies to review and report the environmental effects of all activities that involve an action by a State agency, an expenditure of public monies or private use of public land, and that may have a potential negative environmental effect on natural resources, public health and safety, natural beauty, or historical or cultural elements of the State. This Environmental Impact Statement has been developed in accordance with the requirements of the State Clearinghouse review process under the North Carolina Environmental Policy Act, based upon the agreement between the

North Carolina Division of Coastal Management and the U.S. Army Corps of Engineers. Upon the development and submittal of the Final EIS, additional filing under the NC EPA will not be required.

North Carolina Coastal Area Management Act of 1974.

The North Carolina Coastal Area Management Act (CAMA) (§ 113A-100) was implemented to preserve the physical, aesthetic, cultural and recreational values, including the management of land and water resources in North Carolina's 20 coastal counties. Under CAMA, permits are necessary for development type projects proposing work in any Areas of Environmental Concern (AEC) established by the Coastal Resources Commission. An AEC includes areas of natural importance such as 1) estuarine and ocean systems, 2) ocean hazard system, 3) public water supplies, and 4) natural and cultural resource areas. Under CAMA, the proposed work cannot cause significant damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems identified in the AECs listed. In addition, significant cumulative effects cannot result from a development project (NCDCM, 2003).

North Carolina Dredge and Fill Law.

Under CAMA (§ 113-229), the North Carolina Division of Coastal Management regulates projects that involve excavation or filling in any estuarine waters, tidelands, marshlands, or State-owned lakes. An applicant proposing work in such lands must obtain a permit from both the North Carolina Department of Environment and Natural Resources and the USACE (NCDCM, 2006a).

North Carolina Surface Water Quality Standards.

The North Carolina Division of Water Quality Surface Waters and Wetlands Standards (North Carolina Administrative Code 15A NCAC 02B .0100 & .0200) was implemented for assigning and regulating water quality standards for waters in the State of North Carolina. The water column in the Figure Eight Island project area is classified as both SA waters and Outstanding Resource Waters. Class SA waters are surface waters suitable for shellfishing for market purposes. Waters designated as Class SA have specific water quality standards that must be met, as well as the water quality standards assigned to both Class SB and SC waters. Outstanding Resource Waters (ORW) includes waters of exceptional water quality. Waters designated as ORW and/or Class SA waters are also classified as High Quality Waters (HQW) (NCDWQ, 2003).

Based on the above classifications, water quality standards applicable to the project area include: 1) “turbidity in the receiving water shall not exceed 25 Nephelometric Turbidity Units (NTU)” 2) “changes in salinity due to hydrological modifications shall not result in the removal of the functions of a Primary Nursery Area (PNA)” 3) temperature “shall not be increased above the natural water temperature by more than 0.8°C (1.44°F) during the months of June, July or August nor more than 2.2°C (3.96°F) during other months, and in no cases to exceed 32°C due to the discharge of heated liquids” 4) dissolved oxygen cannot decrease below 5.0 mg/l, except in “poorly flushed tidally influenced streams or embayments, or estuarine bottom waters” which may have decreased values from natural causes and 5) pH levels “shall be normal for the waters in the area, which generally range between 6.8 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions” (NCDWQ, 2006).

Limitations on Erosion Control Structures, North Carolina General Statute § 113A-115.1.

This law establishes limitations of erosion control structures along the ocean shoreline. The “ocean shoreline” is defined as “the Atlantic Ocean, the oceanfront beaches, and frontal dunes”. Furthermore, the term "ocean shoreline" includes “an ocean inlet and lands adjacent to an ocean inlet but does not include that portion of any inlet and lands adjacent to the inlet that exhibits characteristics of estuarine shorelines”. This statute defines such a structure as “breakwater, bulkhead, groin, jetty, revetment, seawall, or any similar structure”. Terminal groins, or specifically a groin that is constructed at the end of a littoral cell or on the updrift side of an inlet to prevent sediment passage into the channel beyond, are included under this statute, as of the passing of Senate Bill 110. Prior to the passage of Senate Bill 110, such structures were prohibited in North Carolina. Senate Bill 110 now allows a total of four (4) terminal groins within the State as long as the applicant meets a suite of requirements. These requirements include the preparation of an Environmental Impact Statement, proof of financial assurance to cover post-construction monitoring and mitigation (if warranted), and notification to adjacent property owners amongst other requirements.

Chapter 2 *PURPOSE AND NEEDS*

1. What are the purpose and needs of this project?

The main concern of residents and property owners at Figure Eight Island are economic losses resulting from damages to structures and their contents due to hurricane and storm activity and the loss of beachfront land due to the shoreline erosion along portions of the ocean and estuarine shoreline. Current shoreline management strategies have not been successful in providing the long-term shoreline protection that the Figure "8" Beach HOA seeks. With a total tax value of property within the limits of Figure Eight Island of approximately $907,352,900 (based on the most recent available data reappraisal from 2012), the Figure "8" Beach HOA sees the need for an improved shoreline protection plan. This valuation includes the assessment of 563 platted lots including 489 developed lots and 74 undeveloped lots.

The purpose and needs of the Figure Eight Island Inlet and Shoreline Management Project are as follows:

- Reduce or mitigate erosion along 3.77 km (2.34 mi) of Figure Eight Island oceanfront shoreline south of Rich Inlet and 427 m (1,400 feet) of backbarrier shoreline on Figure Eight Island along Nixon Channel;
- Provide reasonable short-term protection to residential structures in response to any unpredicted shoreline change within the next five years;
- Provide long-term protection to Figure Eight Island homes and infrastructure over the next 30 years;
- Acquire compatible beach material in compliance with the North Carolina State Sediment Criteria for shore protection project;
- Maintain navigation conditions within Rich Inlet and Nixon Channel;
- Balance the needs of the human environment with the protection of existing natural resources;
- Maintain existing recreational resources; and
- Maintain the tax value of the homes and infrastructure on Figure Eight Island.

2. How is the Figure Eight Island shoreline managed today?

During the past several decades, the Figure "8" Beach HOA has had to address erosion problems associated with Rich and Mason Inlets and the Nixon Channel erosion hot-spot located on the estuarine side of the island. This erosion on the island was exacerbated by the hurricane activity in the 1990s.

Category 3 and 4 Hurricanes Affecting the North Carolina Coast

Name	Year	Landfall Location
Unnamed	1933	Ocracoke
Great Atlantic Hurricane	1944	Cape Hatteras
Hazel	1954	NC/SC Border
Connie	1955	Portsmouth
Ione	1955	Morehead City
Helene	1958	Offshore Outer Banks
Donna	1960	Emerald Isle
Diana	1984	Cape Fear
Gloria	1985	Offshore Hatteras Island
Emily	1993	Hatteras Island
Fran	1996	Cape Fear

(Hurricane Research Division, 2008).

Since the mid-1980s, shoreline changes along a 3,000 ft segment of shoreline at the southern portion of Figure Eight Island were in response to the migration of Mason Inlet to the south (Cleary and Jackson, 2004). In the fall and winter of 2001-2002, Mason Inlet was relocated approximately 2,500 ft to the north helping to alleviate severe erosion on the north end of Wrightsville Beach.

The estuarine shoreline along the northern portion of the island has also undergone significant changes since the mid-1980s when the Rich Inlet gorge began to migrate to the northeast from its southwest most position. The associated migration and deflection of Rich Inlet's ebb channel caused the thalweg to migrate toward the developed estuarine shoreline causing erosion problems. The migration of the channel within Rich Inlet, as described above, has resulted in both erosion and accretion on the oceanfront shoreline along the northern portion of the island. A detailed summary of the history of Rich Inlet followed by a summary of shoreline protection activities on Figure Eight Island is discussed below.

RICH INLET HISTORY

Dr. William J. Cleary of the University of North Carolina at Wilmington (UNCW) conducted a detailed geomorphic analysis of Rich Inlet. The geomorphic analysis of the Inlet was conducted through interpretation of ortho-rectified aerial photographs collected between 1938 and 2007, as well as corresponding shoreline changes along Figure Eight and Hutaff Islands.

This study indicated that unlike many inlets in the region, Rich Inlet has migrated within a relatively narrow corridor of approximately 500 m (1,600 ft) from 1938 to present. This relative stability can likely be attributed to the Inlet's large tidal prism of 18 x 10^6 m^3 (636 x 10^6 ft^3) (with positive correlation between an inlet's tidal prism and inlet stability), as well as the topography of the underlying Oligocene siltstone with Rich Inlet likely occupying an ancestral location of Futch Creek during a lower stand of sea-level (Cleary, pers. comm.).

Although the relative position of the inlet has been stable over the past century, fluctuations in orientation of the main ebb-channel have forced subsequent periods of erosion and accretion on the adjacent shorelines of Figure Eight and Hutaff Islands (Cleary, pers. comm.). Between 1938 and 1993, the main ebb-channel was oriented in a southeasterly direction between azimuths of approximately 112° to 181° (Figure 2.1). During this period, the Rich Inlet ebb-tide delta was aligned with the main ebb-channel in a more southerly orientation providing a wave sheltering effect for the north end of Figure Eight Island. This corresponded to the creation of a one-mile zone of accretion along the oceanfront shoreline immediately south of Rich Inlet.

From 1993 to 2000, the ebb-channel shifted to a more northeasterly alignment with a maximum azimuth of 83° in October 2000 (Figure 2.2). With this shift came a northward migration of the ebb-tide delta, exposing the north end of Figure Eight Island to wave attack. During this period, extensive erosion occurred along the northern 1,400 m (4,500 ft) of the island with a maximum of 150 m (500 ft) of shoreline retreat. Subsequently, during this time period the northward migration of the ebb-tide delta provided wave sheltering to the south end of Hutaff Island leading to accretion of the shoreline with a maximum progradation of 120 m (390 ft).

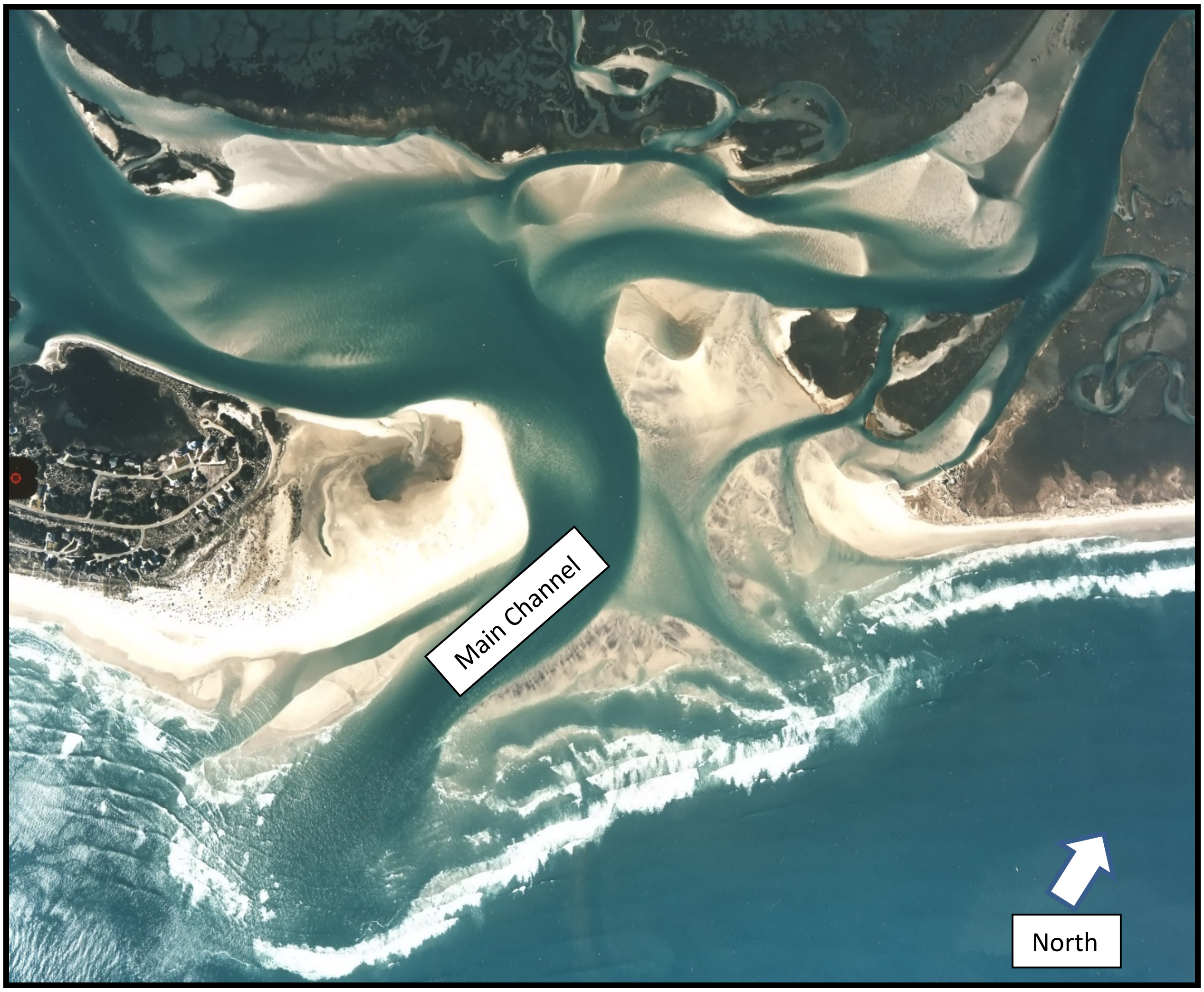


Figure 2.1. November 1993 photo of Rich Inlet.

Figure 2.2. March 1999 photo of Rich Inlet

An ebb-tide delta breach in late 2000 resulted in a deflection of the main ebb-channel to a shore-normal position, with further southward deflection to an azimuth of 190° in 2003. Since March 2003, the throat segment of the ebb channel reversed its migration direction and shifted to the southwest toward Figure Eight Island (Cleary, pers. comm.). Since 2004, the general configuration of the ebb delta has changed slightly while the inlet has widened to its most expansive dimension since 1956. During the period between 2002 and 2007, erosion was the norm along the oceanfront shoreline of Figure Eight Island within the inlet hazard area despite shoreline armoring (sandbags) and the placement of 250,000 cubic yards of beach fill along the northernmost 6,100 ft of the island in March 2001. Since approximately 2010, the northern end of Figure Eight Island has experienced accretion leading to a relatively larger oceanfront beach in comparisons to what was present during the previous erosive periods.

Between October 2010 and January 2015, the ocean bar channel of Rich Inlet began to migrate to the north and by January 2015 the channel had assumed an alignment essentially perpendicular to the adjacent shorelines of Figure Eight and Hutaff Islands (Figures 2.3, 2.4 and 2.5). If the channel orientation continues to move to the north, this change is expected to be followed by a period of renewed erosion on the north end of Figure Eight Island. Based on past inlet and shoreline history, as documented by Dr. Cleary, it is anticipated that there will be a lag period between the time the channel attains an alignment toward Hutaff Island and the initiation of renewed erosion on Figure Eight Island.

Figure 2.3. October 2010 photo of Rich Inlet (Google Earth).

Figure 2.4. January 2013 photo of Rich Inlet (Google Earth).

Figure 2.5. January 2015 photo of Rich Inlet (USACE database).

Dr. William Cleary's analysis of inlet and shoreline geomorphology has shown that fluctuation of Rich Inlet's main ebb-channel can be well correlated to patterns of erosion and accretion along the adjacent shorelines. When the ebb-channel is deflected to the south, the ebb-tide delta migrates southward resulting in accretion along the northern portion of Figure Eight Island and erosion along the southern portion of Hutaff Island. However, severe northward deflection of the ebb-channel leads to erosion along the northern portion of Figure Eight Island and accretion along the southern portion of Hutaff Island.

SHORELINE PROTECTION HISTORY

At least 34 shoreline protection projects have occurred along Figure Eight Island since 1977 (Table 2.1). These projects have included beach nourishment events, beach scraping (bulldozing to form protective berms and dunes), bulkheading, and the installation of sandbags. The material utilized for the majority of the beach nourishment projects was acquired from the maintenance of Mason Inlet, Nixon Channel, the Atlantic Intracoastal Waterway (AIWW), and Banks Channel.

Nourishment activities increased during mid to late 1990's due to changes to the Mason and Rich Inlet systems and the frequency of storm activity. However, the change in the orientation of Rich Inlet along with the increased rate of storm activity in the late 1990's exasperated the erosion occurring along the northern extremity of the developed oceanfront downdrift of Rich Inletand the 1,000 ft long developed estuarine shoreline fronting Nixon Channel (Cleary and Jackson, 2004).

Shoreline change rates along Figure Eight Island north of Bridge Road for the period 1999 to 2007 range from +4.9 feet/year just north of Bridge Road to -99.6 feet/year near the south shoulder of Rich Inlet. In response to the accelerated erosion rates, the Figure "8" Beach HOA nourished the area north of Bridge Road six (6) times between 1993 and 2011, with the cumulative volume of all six (6) fills totaling approximately 1.8 million cubic yards. The timeframe of these recent events corresponds with the increased erosion rate associated with the shifting of the ebb tide channel to a more northerly direction. Due to the extremely high erosion rates just south of Rich Inlet, the beach fills placed in this area did not provide long-lasting protection and eventually forced the oceanfront property owners on Surf Court, Inlet Hook Road, and Comber Road to install temporary sandbag revetments. Based on the permit conditions, all of the temporary sandbag revetments were to be removed by April 2008; however, statewide legal challenges to the rule have delayed their removal. Since approximately 2010, when the Rich Inlet channel began to reorient towards the Figure Eight Island side of the inlet, accretion on the northern end of the island became the norm. Accordingly, shoreline management efforts including the placement of additional sandbags and beach nourishment projects have not been needed in this area.

The ineffectiveness of the beach nourishment attempts along the extreme north end of Figure Eight Island during the cyclical periods of erosion emphasizes the need to address the inlet related process that impacts the area (Figures 2.6 and 2.7). Without some change in the inlet's impact, it is anticipated that future nourishment operations during the cyclical periods of erosion on the extreme north end of Figure Eight Island will suffer the same fate as the past efforts. Shoreline management issues south of Bridge Road on Figure Eight Island are being addressed through actions associated with the maintenance of the Mason Inlet Relocation Project and the periodic disposal of material removed to maintain the navigation channel in Banks Channel.

In total, the aforementioned shoreline protection projects along Figure Eight Island have placed well over 4 million cubic yards of material along the oceanfront shoreline along Figure Eight Island.

Table 2.1. Shoreline Protection Project History on Figure Eight Island

Project Date	Type of Project	Volume (c.y.)	Source	Region
June 1977	Dredge/Fill and Bulkhead	13,000	Banks Channel	Mason Inlet
June 1983	Dredge and Nourishment	90,000	Nixon Channel and Rich Inlet	North End*
March 1985	Dredge and Nourishment	46,300	Mason Inlet Connecting Channel	South End
January 1986	Dredge and Nourishment	250,000	Mason Inlet and Banks Channel	South End
January 1987	Beach Scraping	N/A	N/A	South End
March 1987	Beach Scraping	N/A	N/A	South End
April 1987	Beach Scraping	N/A	N/A	South End
January 1990	Beach Scraping	N/A	N/A	Island-Wide**
November 1992	Dredge and Nourishment	343,000	Banks Channel near Mason Inlet	South End
February 1993	Beach Nourishment	274,000	Nixon Channel	North End*
December 1994	Beach Scraping	N/A	N/A	Island-Wide**
November 1996	Beach Scraping	N/A	N/A	Island-Wide**

January 1997	Storm Recovery	250,000	Nixon Channel	North End*
March 1998	Channel Dredging	450,000	Banks Channel and Middle Sound	Island-Wide**
September 1998	Beach Scraping	N/A	N/A	Middle of Island
March 1999 and early 2000	Beach Nourishment	785,000	Cameron Disposal Island and Banks Channel	South End
January 2000	Sandbag Placement	N/A	N/A	North End*
March 2000	Beach Scraping	N/A	N/A	North End*
September 2000	Beach Scraping	N/A	N/A	North End*
October 2000	Beach Scraping	N/A	N/A	North End*
November 2000	Beach Scraping	N/A	N/A	North End*
November 2001	Beach Scraping and Sandbags	N/A	N/A	North and South End
March 2001	Beach Nourishment	350,000	Nixon Channel	North End*
Jan.-Feb. 2002	Mason Inlet Relocation	390,000	Mason Inlet	South End
March 2003	Channel Dredging	50,000	Masons Inlet & AIWW	South End
March 2003	Beach Nourishment	30,000	Banks Channel & AIWW	South End
February 2005	Dredge Nourishment	183,000	Mason Inlet	South End
November 2005	Beach Nourishment	261,235	Nixon Channel	North End*
February 2006	Beach Nourishment	179,175	Banks Channel	South End
April 2006	Beach Nourishment	148,969	Mason Creek & AIWW	South End
February 2009	Beach Nourishment	295,000	Nixon Channel	North End*
Spring 2009	Channel Dredging	176,000	Mason Inlet	South End
Jan-Mar 2011	Channel Dredging	275,000	Nixon Channel	North End*
2012-2013	Mason Inlet Maintenance	237,000	Mason Inlet	South End
2015	Beach Scraping	N/A	N/A	Island-Wide**
2016	Mason Inlet Maintenance	TBD	Mason Inlet	South End

***North end is defined as the area between the inlet gorge shoulder to Bridge Road**
****Island wide includes the majority of the oceanfront shoreline at Figure Eight Island**

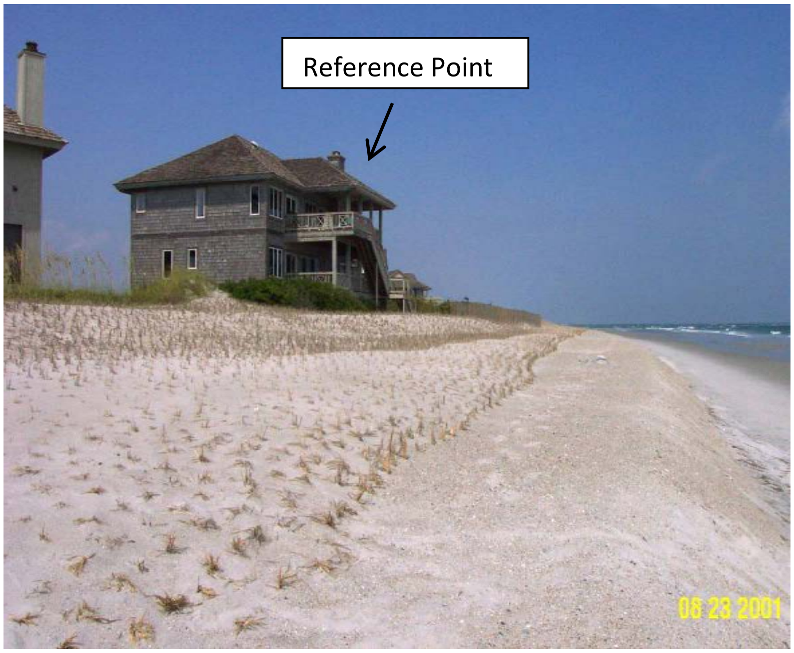


Figure 2.6. North end of Figure Eight Island after nourishment event in 2001

Figure 2.7. Evidence of rapid erosion approximately one month following 2001 nourishment

According to the Figure "8" Beach HOA, sandbag revetments were installed around 20 homes on the north end of Figure Eight Island between 2003 and 2010, however, one of the homes, located at 13 Comber Road, was relocated in 2010 leaving 19 homes along the north end of the island with sandbag revetments. Until the channel within Rich Inlet subsequently reconfigured to a southerly orientation, which resulted in a period of accretion on the north end of Figure Eight, these structures had been considered imminently threatened as defined by State Standard Rule 15A NCAC 7H .0308 (NC DCM, 2007a) (Figure 2.8). The basic premise of this rule is that a structure in the Ocean Hazard Area is considered imminently threatened when its foundation is less than 6.1 m (20 ft) from the toe of the erosion scarp (see Figure 1.2 as depicted in the North Carolina CAMA Handbook [2003]). Figure 2.9 depicts the location of each residential structure on Figure Eight Island protected by sandbags. As of 2012, the potential loss of these threatened structures could reduce the total tax base by $12.4 million (Table 2.2). However, the actual loss would likely be less than $12.4 million as the land on which the threatened homes lost due to erosion would retain some unknown value. At this time, these homes are no longer imminently threatened. Currently, the existing sandbags along the northern end of Figure Eight Island are either covered with sand and vegetated or partially covered with sand (Kellam, pers. comm.) However, should the inlet, consistent with the historical trends, eventually reconfigure to a more northeasterly location, erosion rates would be expected to increase along the northern portion of Figure Eight Island's oceanfront shoreline, and potentially put these homes at risk again at some time in the future.. If, at any time, any of the structures are destroyed or condemned and the home owner chooses to rebuild on the same lot, the structure would be required, pursuant to NC DCM regulations, to conform to the state's oceanfront setback rules. The oceanfront construction setback is measured landward from the first line of stable natural vegetation, or a static vegetation line when applicable. Setback distance is determined by two variables; (1) size of structure; (2) a setback factor based on shoreline position change rates. At this time, it is unknown which of these structures could be rebuilt due to the location of the the first line of vegetation in relation to the existing structures.

Sandbags protecting a home along the northern portion of Figure Eight Island, March 18, 2008

(Jarrett, 2008)

The area north of Bridge Road contains 116 oceanfront parcels and 134 non-oceanfront parcels. As of 2014, there are only ten (10) undeveloped oceanfront parcels and thirty-one (31) undeveloped non-oceanfront parcels north of Bridge Road. Using the most recent available data from the 2012 reappraisal, the total tax value of all the oceanfront parcels north of Bridge Road (structure and land) was approximately $183 million. The twenty-seven (27) oceanfront parcels located on Surf Court, Comber Road, and Inlet Hook Road- the area directly impacted by the changes in Rich Inlet- have a total tax value of $26.2 million. At the current tax rate for New Hanover County, the oceanfront parcels would generate over $1 million/year in ad valorem taxes.

In general, Beach Road North is not in any immediate danger of being lost to erosion. However, the road could eventually be subjected to storm overwash and occasional washouts during severe storm events should the inlet relocate and expose the northern part of Figure Eight Island to high rates of erosion again. Surf Court, Comber Road, and Inlet Hook Road, all located within 915 m (3,000 ft) south of Rich Inlet as of 2015, could also eventually be damaged or lost to long-term erosion, particularly once the oceanfront property owners are required to remove the existing sandbag revetments (see Figure 2.9). Surf Court lies approximately 108 m (350 ft) from the shoreline while Comber Road and Inlet Hook Road are 84 m (275 ft) and 101 m (330 ft) from the shoreline, respectively. Given the shoreline recession rates observed between 1999 and 2007, these roads could become imminently threatened and eventually undermined if the channel within the inlet reconfigures once more to the northeast.

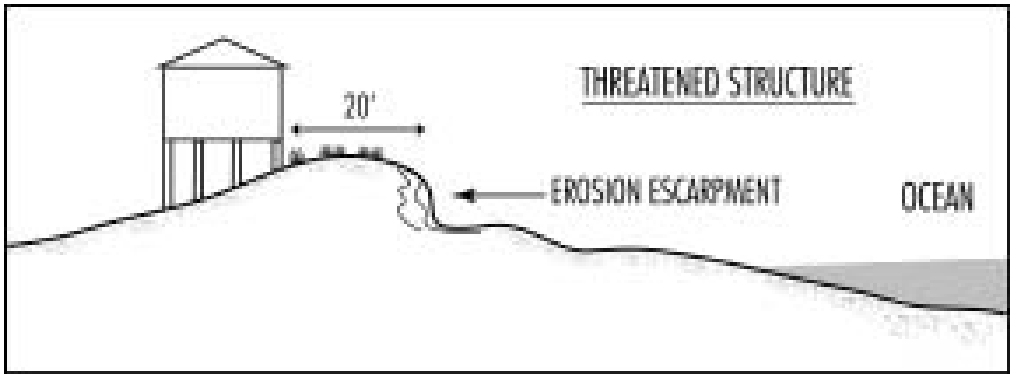


Figure 2.8. Diagram depicting imminently threatened structures (NCDCM, 2003a)

Table 2.2. Analysis of current and/or previously threatened structures with sandbags on Figure Eight Island

Address	**Property Value [a]**	**Structure Value [a]**	**Total Appraised Value**
5 Comber	$328,100	$379,400	$707,500
6 Comber	$322,900	$490,400	$813,300
7 Comber	$44,500	N/A[b]	$44,500
8 Comber	$287,000	$302,000	$589,000
9 Comber	$317,300	$269,800	$587,100
10 Comber	$334,500	$348,200	$682,700
11 Comber	$336,200	$402,100	$738,300
12 Comber	$346,400	$330,100	$676,500
14 Comber	$340,100	$315,400	$655,500
15 Comber	$336,100	$227,400	$563,500
16 Comber	$296,000	$349,500	$645,500
17 Comber	$323,000	$197,300	$520,300
3 Inlet Hook	$341,900	$240,100	$582,000
4 Inlet Hook	$340,200	$349,900	$690,100
5 Inlet Hook	$347,100	$353,800	$700,900
6 Inlet Hook	$362,100	$346,900	$709,000
7 Inlet Hook	$429,800	$289,000	$718,800
8 Inlet Hook	$488,400	$245,000	$733,400
544 Beach Road North	$701,600	$343,200	$1,044,800
Total	**$6,623,200**	**$5,779,500**	**$12,402,700**

[a] 2012 Property and Structure value information was provided by the New Hanover County GIS database (http://etax.nhcgov.com/Main/Home.aspx).
[b] N/A denotes those structures in which a value was not provided in the Town's tax database or through the New Hanover County GIS database.

Figure 2.9. Location of current and/or previously threatened residential structures on Figure Eight Island

Chapter 3 PROJECT ALTERNATIVES

1. What alternatives are evaluated in this EIS?

This section describes in detail the various alternatives evaluated for responding to the erosion threat along the northern 3.8 km (2.4 mi) of Figure Eight Island. These alternatives include:

- Alternative 1 – No Action
- Alternative 2 – Abandon/Retreat
- Alternative 3 – Rich Inlet Management with Beach Fill
- Alternative 4 – Beach Nourishment without Inlet Management
- Alternative 5A – Terminal Groin with Beach Fill from Nixon Channel and a New Connector Channel
- Alternative 5B – Terminal Groin with Beach Fill from Nixon Channel and Other Sources
- Alternative 5C – Terminal Groin at a More Northerly Location with Beach Fill from Nixon Channel and a New Connector Channel
- Alternative 5D (Applicant's Preferred Alternative) – Terminal Groin at a More Northerly Location with Beach Fill from Nixon Channel and Other Sources

The primary tools used to evaluate the effectiveness of the various alternatives in meeting the needs and objectives included:

- Delft3D
- GENESIS
- Geomorphic analysis of Rich Inlet and the influence the inlet has on the shorelines of Figure Eight Island and Hutaff Island

These tools were used to help assess and determine the differences between the alternatives and were not intended to represent predictions of what changes to expect in the future. Accurate future predictions for large-scale and long-term coastal changes are too difficult to make due to the absence of the necessary capabilities for those predictions (Barter, Burgess, and Hosking, 2003). With the dynamic nature and complexity of coastal inlets, there remain some processes that are not fully understood and can be difficult for quantitative predictions in estimating short- and long-term migration trends, collective morphologic evolution, and cycles of inlets and the interactions among inlets, adjacent beaches, bays, and estuaries (Demirbilek and Rosati, 2011). There continue to be limitations on modeling for predicting future long-term coastal changes, but numerical models are valid for qualitative comparisons (Beck, pers. comm. 2014).

Delft3D. Delft3D was the primary modeling package used for evaluating this project. The model simulates flows, sediment transport, and bathymetric changes by using advanced sediment transport formulations that respond to forcing functions that include waves, tides, winds, and density gradients. The model takes into account the movement of sediment along the bottom (bedload transport) as well as sediment transported in the water column (suspended transport). Delft3D was used to simulate changes in hydrodynamics, sediment transport, and the morphology of the inlet and nearshore environments in response to changes imposed by project alternatives over a 5 year period. Details of the application of the Delft3D model are provided in Appendix B.

The evaluation of the more northerly location of the terminal groin associated with Alternatives 5C and 5D necessitated a new round of model tests since these two options were not included in the initial model runs shown in the 2012 Draft EIS. The new round of model testing was also included to ensure that the alternatives were evaluated under more recent conditions, as several years had passed since the original modeling conditions during which significant accretion had occurred along the oceanfront of Figure Eight Island, particularly on the stretch of homes with sandbags. The additional modeling was conducted to determine whether such changes in conditions would cause significantly different results than under the original modeling conditions. The model setup for the new round of tests included some modification in the model grids used in the early model runs as well as some minor corrections in depths over portions of the model domain. In order to maintain the same relative comparison of potential impacts from one alternative to another, all the alternatives were re-run using a revised model setup, based upon the 2006 conditions of the inlet and adjacent shorelines, and the same input parameters (tides, waves, wind, etc.). This modeling was intended to reflect how the alternatives responded to erosive conditions which were present in 2006. The model was also run for Alternatives 2, 3, 4, and 5D using 2012 inlet and shoreline conditions, which was a period of accretion. Alternatives 5A and 5B were not modeled using the 2012 conditions (Table 3.1) since this position of the terminal groin was not supported by property owners and would not likely be approved by the Figure "8" Beach HOA. Alternative 5C was also excluded from the 2012 model setup due to the Figure "8" Beach HOA designating Alternative 5D as its preferred alternative prior to the initiation of the 2012 model simulations. Although not modeled using 2012 conditions, quantities and cost estimates to construct alternatives 5A, 5B, and 5C, given the 2012 conditions, were computed using actual 2012 survey data.

Table 3.1. Model conditions utilized for each Alternative

Alternative	2006 Conditions	2012 Conditions
2	Yes	Yes
3	Yes	Yes
4	Yes	Yes
5A	Yes	No
5B	Yes	No
5C	Yes	No
5D	Yes	Yes

The Delft3D model responds to prescribed or predetermined input conditions including waves, tides, winds, etc. The model results are by no means intended to represent predictions of what changes to expect in the future as this would require an ability to predict future weather and oceanic conditions. Rather, the Delft3D model results for Alternative 2, the abandon/retreat alternative where absolutely no shoreline stabilization measures are implemented, were used as a basis for comparing relative changes in Rich Inlet and the adjacent shorelines that could be attributable to physical changes in the system associated with each alternative.

<u>GENESIS</u>. GENESIS is a shoreline response model developed by the USACE. It is classified as an “on-line” model since model output is limited to changes in a specified contour (for example mean high water). The model can incorporate the effects of groins, revetments, seawalls,

breakwaters, and offshore bathymetry. GENESIS was used to develop a “second opinion” with regard to shoreline changes that could result from the channel modifications and a terminal groin. GENESIS results are reported in Appendix B.

Rich Inlet Geomorphic Analysis. Dr. William J. Cleary, formerly with the University of North Carolina Wilmington, was contracted by the Figure "8" Beach HOA to evaluate the impact of the changes that Rich Inlet had on the shorelines of Figure Eight Island as well as Hutaff Island. The results of Dr. Cleary’s analysis are provided in Sub-Appendix A of Appendix B.

Dr. Cleary’s assessment indicated that the condition of the shoreline along the north end of Figure Eight Island is linked to the orientation of the channel crossing through the ebb tide delta of Rich Inlet (ocean bar channel). Dr. Cleary’s report, which provides a history of the ocean bar channel orientation and its relationship to the shoreline response on both the north end of Figure Eight Island and the south end of Hutaff Island since 1938, is provided in Sub Appendix A of Appendix B. Based on this history, when the ocean bar channel of Rich Inlet is orientated toward Figure Eight Island, the north end of the island tends to accrete. When the channel orientation shifts toward Hutaff Island, the south end of Hutaff Island generally accretes while the north end of Figure Eight Island erodes.

Based on Dr. Cleary’s assessment, since 1938, the ocean bar channel of Rich Inlet has been oriented toward Figure Eight Island at least five (5) times over periods ranging from 2 years to about 9.5 years (see Figure 8 in Sub Appendix A). Similarly, the ocean bar channel was also oriented toward Hutaff Island during five (5) time periods with the durations ranging from 3.5 years to approximately 14 years.

During the early part of 1994, the ocean bar channel of Rich Inlet breached the ebb tide delta resulting in an almost instantaneous reorientation of the channel toward Hutaff Island. Following this breach, shoreline on the north end of Figure Eight Island, which had experienced a relatively long period of accretion, began to erode at accelerated rates. The erosion became so severe that the 20 homes were eventually deemed imminently threatened which allowed the owners to install temporary sandbags. In this regard, the definition of imminently threatened, as used by the State of North Carolina, refers to a condition in which the erosion scarp encroaches within 20 feet of its foundation. When this condition occurs, the property owners can employ temporary erosion response measures, such as the installation of sandbag revetments, to protect their property until such time the threat no longer exists or the structure is moved and/or abandoned.

One of the threatened homes was moved off the ocean shoreline in 2010 leaving 19 homes imminently threatened. The condition of the shoreline that existed following this channel breach prompted the Figure "8" Beach HOA to initiate the evaluation of shoreline protection measures that would provide long-term protection to the threatened homes. This effort was initiated in 2006.

Beginning around October 2010, the Rich Inlet ocean bar channel again assumed an orientation toward Figure Eight Island. As the result of the latest shift in the channel orientation, the north end of Figure Eight Island has experienced a period of accretion which has temporarily removed the imminently threatened status of the previously threatened 19 homes. However, as has been shown by the past behavior of Rich Inlet, the present configuration of the inlet bar channel and associated ebb tide delta is expected to again undergo changes at some point in the future that will result in a renewed period of erosion on the north end of Figure Eight Island.

A description of each alternative is provided below which includes detailed discussions of what each alternative entails and how it was formulated. An assessment of the economic impact of each alternative on the existing island development and infrastructure, developed by Dr. Peter W. Schuhmann, Professor of Economic, University of North Carolina Wilmington, is provided in Appendix G.

Alternative 1: No Action

Sandbag revetments along the northern portion of Figure Eight Island

Description. Under Alternative 1, the Figure "8" Beach HOA and individual property owners would continue to respond to erosion threats in the same manner as in the past. These measures, which involve obtaining Federal and/or State authorizations to allow beach scraping (bulldozing) to create and/or repair damaged dunes, intermittent beach nourishment, and the deployment of sandbags. A hydraulic cutter-suction pipeline dredge (pipeline dredge) would be used for alternative 1. These erosion response measures become necessary when the ocean bar channel of Rich Inlet shifts to a more northeasterly alignment, as was the case beginning in 1993 and extending to 2010 (Cleary, 2009). When the bar channel shifts to a more northeasterly alignment, the south side of the inlet's ebb tide delta also migrates to the north exposing the north end of Figure Eight Island to wave attack. As an example, when the bar channel was oriented toward Hutaff Island between 1993 and 2010, extensive erosion occurred along the northern 1,400 m (4,500 ft) of the Island, with a maximum of 150 m (500 ft) of shoreline retreat. During that time, sandbag revetments were installed around 20 homes on the north end of Figure Eight Island. Even so, one of the homes, located at 13 Comber Road, was relocated landward in 2010 leaving 19 homes along the north end of the island with sandbag revetments. Despite the accretion on the ocean beach, one home along Nixon Channel is still imminently threatened and is protected by a sandbag revetment. The activities described within Alternative 1 are anticipated to only provide temporary short-term protection from erosion and storm induced damage to Figure Eight Island's infrastructure. For Alternative 1, the distance between a structure or infrastructure element (roadway, utility, etc.) was measured relative to the 2007 shoreline positon and once the shoreline encroached within 20 feet of the foundation of a structure or within 20 feet of a road right-of-way, or 20 feet from a utility, under Alternative 1, action would be taken to protect the threatened structure or infrastructure element using sandbags. Eventually, without beach nourishment, the erosion would continue past the sandbags resulting in the need to either move the structure to a new location or demolish it.

With the shift of the ocean bar channel to an orientation toward Figure Eight Island in 2010, the shoreline on the north end of Figure Eight Island north of the intersection Comber Road and Dunes Point Road (approximately baseline station 80+00) has accreted considerably. For example, the shoreline at station 90+00accreted approximately 165 feet seaward between July 2006 and January 2013 while the shoreline at station 95+00 moved 350 feet seaward during this same time interval. Under the present conditions, none of the oceanfront structures located between Surf Court and Rich Inlet, including the 19 structures presently protected by temporary sandbag revetments, are in imminently threatened status as defined by the State Coastal Resources Commission (CRC). However, the recent accretion along the north end of Figure Eight Island has not changed the condition along Nixon Channel as the one structure protected by a sandbag revetment remains imminently threatened.

During periods when the bar channel of Rich Inlet is oriented toward Hutaff Island, the Figure "8" Beach HOA has utilized beach nourishment to counter the erosion threat. In general, the beach nourishment operations were carried out about every three to four years. A summary of past beach nourishment activities is provided in Table 1.1.

Past nourishment activities along the north end of the island consisted of depositing dredged material from maintenance of a previously permitted navigation channel and boat basin located in Nixon Channel. This previously permitted area is shown on Figure 3.1. Dredging in Nixon Channel was initiated in 1983 with the first maintenance event occurring in 1988. The permitted depth for these first two events was -1.8 m (-6 ft MLW) [-2.6 m (-8.4 ft) NAVD]. The area permitted in Nixon Channel was modified in 1993, covering the area shown on Figure 3.1. The modification increased the authorized depth to -2.7 m (-9 ft) MLW (or -3.5 m (-11.4 ft) NAVD). The modified area was initially dredged in 1993-94 with subsequent maintenance dredging in 1997, 2001, 2005, 2009 and 2011 (see Table 2.1 in Chapter 2). The volume of material deposited along the north end from the Nixon Channel permit area since 1993 has ranged from 90,000 cy to 350,000 cy, per event, with densities ranging from 26 cy/linear foot to 133 cy/linear foot. Since 1993, the total volume of material removed from Nixon Channel and deposited along the north end of Figure Eight Island north of Bridge Road totals approximately 1.75 million cy or an average of approximately 291,000 cy for each event (Appendix B).

With the Rich Inlet bar channel presently oriented more perpendicular to the adjacent shorelines of Figure Eight and Hutaff Islands, Figure Eight Island has not reached a point that beach nourishment is needed to protect the development on the extreme north end of the island. However, a continuation of the northerly shift of the channel alignment toward Hutaff Island, as shown when comparing the 2010 and 2015 images in Chapter 2, will likely result in a need to resume beach nourishment along the north end of the island. Assuming this shift in channel alignment continues, erosion rates along the north end of Figure Eight Island are expected to accelerate and may attain rates comparable to those measured between 1999 and 2007. Given the variable and unpredictable nature of the behavior of Rich Inlet, the need to periodically maintain the previously permitted area in Nixon Channel with disposal of the dredged material along the north end of Figure Eight Island will probably continue indefinitely.

With the expected shift of the channel back toward Hutaff Island, the cost to implement Alternative 1 was determined using conditions that existed in 2006 (considered to be a highly erosive period) and 2012 (considered to be a highly accretionary period). For the 2006 condition, the economic assessment assumed the shoreline would erode into the existing development at rates comparable to those measured between 1999 and 2007. The implementation costs for Alternative 1 include the value of homes that would be lost to erosion, the value of land that would be lost, the cost for installation of temporary erosion response measures, and the cost for continued beach nourishment over the 30-year evaluation period.

A similar cost evaluation was made for the 2012 condition, however, as noted above, the shoreline north of baseline station 80+00 was positioned somewhat seaward of the 2006 shoreline position, therefore, the damages and implementation cost along this northernmost portion of Figure Eight Island, given the accreted shoreline condition, would occur later in the 30-year evaluation period.

Over time, the continuation of the long term erosion south of baseline station 80+00 would also affect homes located along Surf Court and portions of Beach Road North just south of Surf Court. This will result in additional homes becoming imminently threatened which could result in the placement of additional temporary sandbag revetments.

<u>Implementation Cost-2006 Eroded Condition.</u> Alternative 1 includes the demolition and/or relocation of some of the threatened homes. With regard to whether the threatened homes would be demolished or relocated to a new lot, there is no definitive way to make this determination as such a decision depends primarily on the desires of the individual property owners as well as the availability of suitable building lots on the island. Therefore, the implementation costs for Alternative 1 was based on the assumption that ten (10) of the threatened homes would be relocated and thirty (30) homes demolished.

The ten (10) structures that were assumed to be relocated to another lot on Figure Eight Island have an appraised value of $6.5 million with their value assumed to remain the same even though they would no longer be on an oceanfront lot. However, the land on which they were situated would eventually be lost. The lost value of these ten (10) lots is included in the total land loss value. See Appendix B and Appendix G for more information regarding cost.

Over the thirty year analysis period, the total implementation cost associated with Alternative 1, given the 2006 eroded shoreline condition would be about $92.5 million. This includes $16.9 million for the value of 30 structures that would be demolished, $1.4 million to demolish the structures, $2.4 million to relocate 10 structures, $38.3 million for the loss of land, $1.2 million for temporary sandbag revetments, $3.3 million for damages to roads and infrastructure on the north end of Figure Eight, and $29.0 million for eleven (11) beach nourishment events that would take place approximately every three years beginning in year 0 of the 30-year evaluation period.

The equivalent annual cost for implementation of Alternative 1 given the 2006 eroded shoreline condition, computed using an interest rate of 6% and a 30-year amortization period is $3,191,000/year.

Implementation Cost-2012/13 Accreted Condition. Over the thirty year analysis period, the total implementation cost associated with Alternative 1, given the 2012/2013 accreted shoreline condition, would be about $84.6 million. This includes $16.9 million for the value of 30 structures that would be demolished, $1.4 million to demolish the structures, $2.4 million to relocate 10 structures, $38.3 million for the loss of land, $1.2 million for temporary sandbag revetments, $3.3 million for damages to roads and infrastructure on the north end of Figure Eight, and $21.1 for eight (8) beach nourishment events that would take place approximately every three years beginning in year 9 of the 30-year evaluation period.

The equivalent annual cost for implementation of Alternative 1 given the 2006 eroded shoreline condition, computed using an interest rate of 6% and a 30-year amortization period is $3,122,000/year.

Figure 3.1. Previously permitted dredge area in Nixon Channel.

Alternative 2: Abandon/Retreat

Description. For Alternative 2, the Figure "8" Beach HOA and the individual property owners would not take any action to slow erosion. Furthermore, no Federal and/or State authorization would be sought to conduct stabilization measures such as the installation of new sandbags, beach scraping/bulldozing, or other stabilization measures described above in Alternative 1. Also, the Figure "8" Beach HOA would not make any effort to pursue a long-term beach nourishment project or inlet channel relocation project. Once the existing temporary sandbag revetments fail or have to be removed upon reaching the end of their permit period, the affected structures would either be abandoned (demolished) or moved to another lot on the island.

Until recently, the shoreline along the north end of Figure Eight Island had been responding positively to the orientation of the ocean bar channel of Rich Inlet. While in this favorable orientation, immediate efforts to abandon and/or relocate structures from the ocean shoreline had not been necessary. In this regard, the position of the shoreline north of the intersection of Comber Road and Dunes Point Road (approximately baseline station 80+00) are now between 160 and 350 feet seaward of the 2006 shoreline position. As stated previously in Chapter 2, the inlet channel has demonstrated a history of migrating its orientation which directly impacts the rate of erosion or accretion along the northern end of Figure Eight Island. Based on the past history of the inlet channel, it is expected that this latest shift back in orientation toward Hutaff Island could result in another round of erosion on the north end of Figure Eight.

As demonstrated above by the comparison of the October 2010 and January 2015 aerial photographs of Rich Inlet, the bar channel of Rich Inlet appears to have begun to swing to an alignment toward Hutaff Island. If this shift continues as historical trends would indicate, shoreline erosion rates along the north end of Figure Eight Island are expected to accelerate with erosion rates possibly approaching rates observed between 1999 and 2007. As shoreline conditions deteriorate as the result of a change in the orientation of the ocean bar channel toward Hutaff Island, some oceanfront structures may have to be either abandoned (i.e., demolished) or moved to another lot somewhere on Figure Eight Island.

With regard to the relocation option, twenty-three (23) oceanfront homes located on Surf Court, Comber Road, and Inlet Hook Road fall into this category and could have to eventually be demolished or moved within the next five (5) years. If erosion rates revert back to the rates experienced during the time when the orientation of the bar channel was positioned towards Hutaff Island, Delft3D modeling results suggest that nine (9) homes on Beach Road North located immediately south of Surf Court are would become threatened within the next ten (10) years with an additional eight (8) homes on Beach Road North threatened within the next 25 years. Thus, over the 30-year analysis period used for the evaluation of the project alternatives, forty (40) oceanfront homes on the extreme north end of Figure Eight Island would either be demolished or moved. After the loss of these homes, it is presumed that no future homes will be built upon these lots. There are currently, eighty (80) undeveloped residential lots on the island. The vast majority of these lots are located on the waterfront; either on the ocean or sound side. Of these undeveloped lots, thirty-one (31) are located directly on the oceanfront. A total of forty-five (45) undeveloped lots are located on the sound side shoreline. Even though there appears to be a sufficient number of vacant lots to accommodate the relocation of oceanfront structures that may again become imminently threatened, the number of homes that would actually be relocated cannot be predicted with any degree of certainty as this decision would be made by each affected property owner. Also, owners of the existing vacant lots would have to be willing to sell the lots.

The determination of which threatened structures would be moved or demolished is difficult due to the inability to fully discern which individual property owner would choose to move a threatened structure or have it demolished. Also, even though there are available vacant lots, the owner of the vacant lot would have to be willing to sell the lot. For the Ocean Isle Beach Project at the east end of the island, the ratio used to determine how many threatened structures would be moved versus demolished was based on actual numbers that occurred on that island. For example, six structures on the east end of Ocean Isle Beach had become threatened within the past few years and 2 were moved and 4 demolished. Since moving a threatened structure to a new lot is more expensive than simply demolishing the structure, demolition was assumed to occur for 75% of the threatened structures and the remaining 25% moved to a new lot. This cannot be determined with any degree of certainty for Figure Eight Island since there are no actual numbers for comparison purposes. It is difficult to compare a higher valued property on a private island with property on a public beach. In the past years, only one Figure Eight property owner has previously elected to move his structure to a lot that was immediately landward of the structure.

Given the wide range of possible shoreline conditions along the north end of Figure Eight Island as dictated by conditions of the ocean bar channel of Rich Inlet, implementation costs for Alternative 2 were evaluated for the 2006 eroded shoreline condition and the 2012/2013 accreted condition.

<u>Implementation Cost-2006 Eroded Condition</u>. Over the 30-year analysis period, the total implementation cost associated with Alternative 2, given the 2006 eroded shoreline condition would be about $63.7 million. This total cost includes $16.9 million for the value of thirty (30) structures that would be demolished, $1.4 million to demolish the structures, $2.4 million to relocate ten (10) structures, $4.7 million for damages to roads and infrastructure on the north end of Figure Eight, and $38.3 million for the loss of land. The value of the land for the ten (10) homes that would be relocated to another lot on Figure Eight Island is included in the total land loss amount. However, the value of the ten (10) structures was assumed to remain the same even though they would no longer be situated on an oceanfront lot.

The equivalent annual cost for implementation of Alternative 2 given the 2006 eroded shoreline condition, computed using an interest rate of 6% and a 30-year amortization period is $2,610,000/year.

<u>Implementation Cost-2012/13 Accreted Condition</u>. Over the 30-year analysis period, the total implementation cost associated with Alternative 2, given the 2012/13 eroded shoreline condition would be about $63.7 million which is the same as under the 2006 eroded condition. However, on an equivalent average annual cost basis, the annual cost under the 2012/13 shoreline condition would be less than the 2006 shoreline condition due to actions such as abandoned and/or moving homes would occur later in the analysis period.

The equivalent annual cost for implementation of Alternative 2 given the 2012/13 accreted shoreline condition, computed using an interest rate of 6% and a 30-year amortization period is $2,503,000/year.

Alternative 3: Rich Inlet Management with Beach Fill

Description. The main bar channel of Rich Inlet, also referred to as the entrance channel, would be maintained in a positon closer to the north end of Figure Eight Island and along an alignment essentially perpendicular to the adjacent shorelines. The establishment of a preferred location of the ocean bar channel would be accompanied by new channels connecting the bar channel with Nixon Channel and Green Channel (Figure 3.2). Material removed to maintain the preferred location of the bar channel and construct the new connecting channels would be used to construct a closure dike across the existing ebb channel located next to Hutaff Island, provide beach fill along 426.8 m (1,400 ft) of the Nixon Channel shoreline just south of Rich Inlet, and nourish 3,810 m (12,500 ft) of ocean shoreline extending from Rich Inlet south to Bridge Road. The purpose of the closure dike would be to concentrate most of the tidal flow through the preferred channel. A hydraulic cutter-suction pipeline dredge (pipeline dredge) would be used for this alternatives.

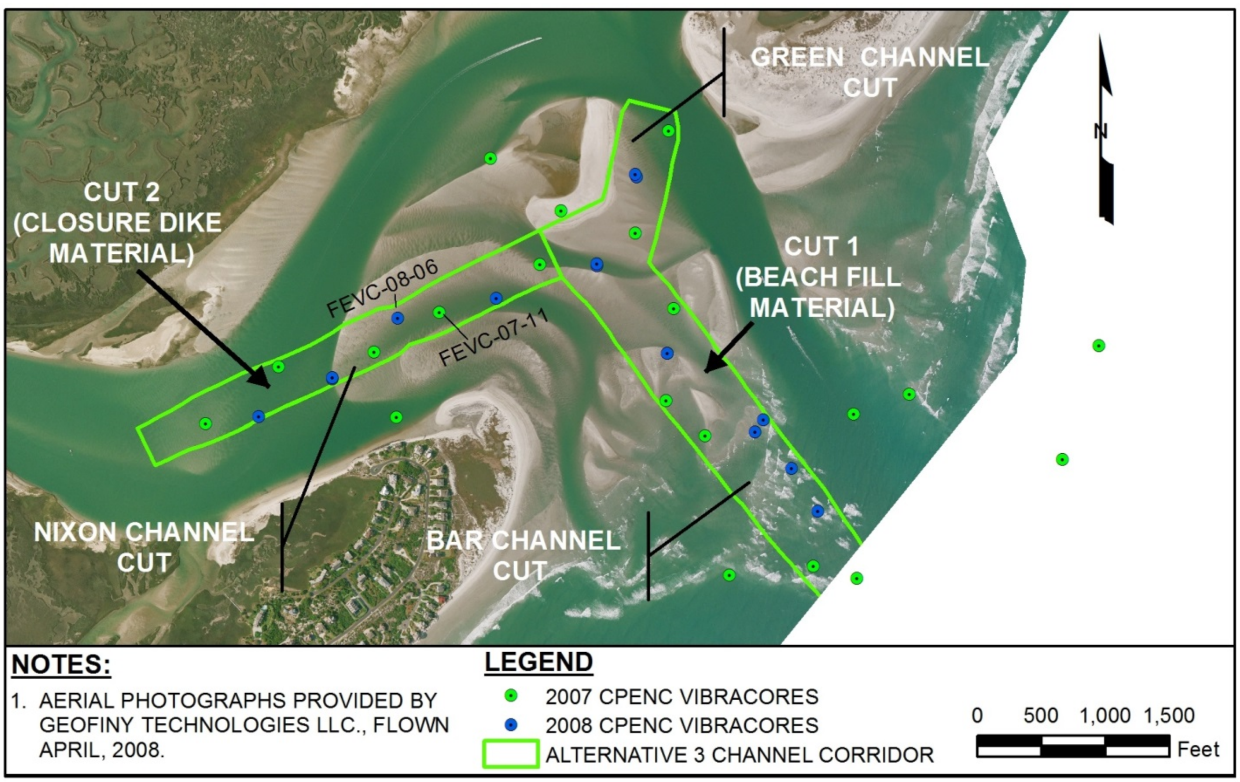


Figure 3.2. Map depicting the two different cuts designed for the Alternative 3 channel corridor. Note the locations of two vibracores (FEVC-07-11 and FEVC-08-06) in which clay material was found.

The performance of Alternative 3, as well as the other alternatives, was based on the results of a numerical model known as Delft3D. Delft3D simulates changes in hydrodynamics, sediment transport, and the morphology of the inlet and nearshore environments in response to changes imposed by project alternatives over a 5 year period. Details of the Delft3D model simulations are provided in Appendix B and Chapter 5 with summary discussions provided below.

The preferred bar channel position would be periodically maintained with maintenance episodes dictated by shoaling of the channel and/or natural shifts in the channel position outside the preferred channel corridor. Based on the results of the Delft3D model simulations, maintenance of the new channels connecting to both Nixon Channel and Green Channel will probably not have to be maintained on a regular basis. All the material removed to maintain the channel(s) would be distributed along the Figure Eight shoreline between Rich Inlet and Bridge Road and along the 426.8 m (1,400 ft) shoreline segment in Nixon Channel. Dredging associated with the construction and maintenance of the new channels would be performed by a cutter-suction pipeline dredge (pipeline dredge).

<u>Plan Formulation</u>. The major factor affecting shoreline stability along the extreme north end of Figure Eight Island is associated with the uncontrolled movement in the position and orientation of the main bar channel passing through Rich Inlet. At the time the Figure "8" Beach HOA initiated efforts to develop a shoreline and inlet management plan for the north end of the island the ocean bar channel of Rich Inlet was oriented toward Hutaff Island and the north end of Figure Eight Island was experiencing extremely high rates of erosion. The high rate of erosion was impacting several homes on the extreme north end of the island.

As previously mentioned, the ocean bar channel of Rich Inlet assumed an alignment toward Figure Eight Island around 2010 and the north end of Figure Eight Island has been accreting. As long as the ocean bar channel continues to occupy a position and alignment favorable to the north end of Figure Eight Island, implementation of a project involving the establishment and maintenance of a channel along in a preferred position would not be needed. However, as has been the case in the past, the present condition of the ocean bar channel is not expected to last in perpetuity. Based on historic trend of periodic changes in the ocean bar, the present bar channel condition may only last another 3 to 5 years. When the channel does eventually swing back toward Hutaff Island, the channel project developed under Alternative 3 could be considered as an option to respond to the renewed erosion threat.

Under Alternative 3, the main ocean bar channel would be maintained in a position and along an alignment that would produce favorable shoreline changes on the extreme north end of Figure Eight Island. The preferred bar channel would be accompanied by new channel connections to Nixon Channel and toward the mouth of Green Channel and the construction of a closure dike across the existing entrance channel. The purpose of the closure dike would be to force most of the tidal flow through the inlet into the preferred bar channel.

The development of the preferred channel modifications/inlet management plan for Rich Inlet involved a screening process utilizing Delft3D model runs in which various options for Nixon Channel, Green Channel, and the main entrance channel were evaluated. Simulations were also performed excluding the closure dike. The results of all screening runs are provided in Appendix B.

All the screening runs included a bar channel with a 152.4 m (500 ft) bottom width at a depth of 5.2 m (-17 ft) NAVD and 1V:5H (1 Vertical to 5 Horizontal) side slopes and various options with regard to the length of the interior channel cuts connecting the inlet throat with Nixon and Green Channels. The screening runs were conducted with a closure dike extending off the south end of Hutaff Island to close the entrance channel and interior channel depths of 5.2 m (-17 ft) NAVD, or the same depth as the inlet bar channel. The screening runs were conducted for the 2006-07 conditions which represent a highly erosive period with regard to the impacts of the bar channel on the behavior of the north end of Figure Eight Island. Selection of a preferred position and alignment for the bar channel, in terms of its impacts on Figure Eight Island, was based on historic morphological changes in the inlet and the accompanying impact of the inlet changes on the adjacent shorelines of Figure Eight Island and Hutaff Island. The morphologic history of Rich Inlet was developed by Dr. William Cleary formerly with the University of North Carolina at Wilmington. Dr. Cleary's complete report is included as Sub-Appendix A in Appendix B.

One other consideration for the location of the channel is the presence of the civil war era shipwreck, the *Wild Dayrell*. Geotechnical and geophysical investigations were conducted within Rich Inlet to determine its location. These targeted submerged cultural resource investigations were conducted to accurately map its location and allow for proper design and planning of a channel that would avoid adverse impacts to the wreck (Appendix C and Appendix D).

<u>Optimal Channel Modifications</u>. The recommended channel modifications for the preferred channel include a 1,158.2 m (3,800 ft) long cut within Nixon Channel and a 426.7 m (1,400 ft) long cut extending into Green Channel.

While all of the screening runs were performed with a channel depth of -5.2 m (-17 ft) NAVD, a review of cutter-suction pipeline dredge capabilities available from three dredging companies (Great Lakes Dredge & Dock, Weeks Marine, and Norfolk Dredging) found dredge plant capable of working in an ocean/inlet environment have minimum digging depths ranging from 4.3 m (14.0 ft) to -5.3 m (17.5 ft). If a dredge is to work continually throughout a complete tidal cycle, the minimum digging depths would be measured at mean low water. With mean low water in the project area being approximately -0.8 m (2.5 ft) below NAVD, the minimum digging depths for the available dredge plant would range from -5.0 m (-16.5 ft) NAVD to -5.9 m (-19.5 feet) NAVD. In order to assure competitive bidding and providing some margin of safety to allow for the turbulent nature of the inlet environment, the recommended design depth for the Alternative 3 channels was increased to -5.8 m (-19.0 feet) NAVD.

A similar channel relocation project was recently completed for New River Inlet and had a design depth of -5.5 m (-18.0 ft) NAVD. A comparison of wave hindcast data was generated by the USACE Wave Information Study (WIS) for two stations, one located seaward of Rich Inlet and the other seaward of New River Inlet (see Appendix B). Data results found that the average wave heights in the vicinity of Rich Inlet were slightly greater than the waves off New River Inlet. The WIS station 63297 located seaward of Rich Inlet has a 20-year (1980 to 1999) average wave height of 1.12 m (3.68 ft) compared to an average wave height for WIS station 63290 off New River Inlet of 1.04 m (3.40 ft). While the average wave height difference is relatively small, it would be magnified in the inlet environment when incoming waves interact with ebbing tidal currents; hence a larger margin of safety was adopted for Rich Inlet.

The increase of the channel depth to -5.8 m (-19 ft) NAVD was accompanied by a 50-foot reduction in the width of the main entrance channel to maintain the same flow carrying capacity as the -5.2 m (-17 ft) NAVD channel. Other channel modifications from those considered during the initial screening included a reduction in the width of the Nixon Channel cut from 83.8 m (275 ft) to 73.2 m (240 ft) and an increase in the width of the Green Channel cut from 68.6 m (225 ft) to 91.4 m (300 ft) (see Appendix B). The reduced width of the Nixon Channel cut was based on maintaining the same flow carrying capacity as the -17-foot NAVD channel while the increased width of the Green Channel cut was to accommodate possible increased shoaling associated with erosion of the closure dike across the exiting channel next to the south end of Hutaff Island.

Summary of Channel Modifications. The modifications to Rich Inlet for oceanfront shoreline stability and protection under Alternative 3 would move the channel approximately 304.8 m (1,000 ft) to the southwest of its present location and would consist of the following:

All new channel depths = -5.8 m (-19 ft) NAVD + 1-foot overdepth

Channel widths and lengths:

- Entrance (Bar) Channel = 137.2 m (450 ft) wide from inlet throat to -5.8 m (-19 ft) NAVD depth contour in the ocean
- Nixon Channel = 73.2 m (240 ft) x 1,154.8 m (3,800 ft)
- Green Channel = 91.4 m (300 ft) x 426.7 m (1,400 ft)

Channel Dredge Volumes:

April 2006 Survey:
1,773,300 cy + 150,400 cy overdepth = 1,923,700 cy

March 2012 Survey:
1,786,500 cy + 156,400 cy overdepth = total 1,942,900 cy

Closure Dike:

- Crest Elevation = +1.8 m (+6 ft) NAVD
- Crest Width = 137.2 m (450 ft)
- Side Slopes = 1 vertical on 20 horizontal (assumed)
- Volumes:
  April 2006 Survey: 513,700 cy
  March 2012 Survey: 393,000 cy

Beach Fill Design.

The beach fill along the ocean shoreline would cover the area from a point opposite the intersection of Bridge Road and Beachbay Lane (station F90+00) to Rich Inlet (station 105+00), a total distance of 3,810 m (12,500 ft) as shown in Figures 3.4a and 3.4b. The fill would include a 1,000-foot transition or taper section on the south end between stations F90+00 and F100+00 and a 500-foot taper on the north end between stations 100+00 and 105+00. The southern limit of the ocean beach fill area (F90+00) corresponds to the northern limit of the beach disposal area associated with the Mason Inlet Relocation Project.

The design for Alternative 3 focused on optimizing the distribution of the material removed to reposition the ocean bar channel and construct the new channel connectors into Nixon and Green Channels along the ocean shoreline between Rich Inlet and Bridge Road. To that end, the design widths of the beach fill along various sections of Figure Eight Island north of Bridge Road were based on maximum shoreline recession rates observed during the period from 1999 to 2007 and an assumed 5-year design life (Table 6.1 in Appendix B). In this regard, the design recession rate used for the area between stations 50+00 and 105+00 was -8.7 m (-24.8 ft)/year with a recession rate of -2.8 m (-9.2 ft)/year used for the area from Bridge Road (station F90+00) to station 40+00. The beach fill would be constructed to an elevation of 1.8 m (6.0 ft) NAVD and would have the placement rates and design berm widths shown in Table 3.2.

Table 3.2. Alternative 3 beach fill placement volumes and design berm widths.

Shoreline Segment (Baseline Stations)*	Placement Volume (cy/lf)	Design Berm Width (ft)
F90+00 to F100+00 (transition)	0 to 53.5	0 to 46.2
F100+00 to 40+00	53.5	46.2
40+00 to 50+00 (transition)	53.5 to 143.6	46.2 to 123.8
50+00 to 100+00	143.6	123.8
100+00 to 105+00 (transition)	143.6 to 0	123.8 to 0

*Refer to Figures 3.4a and 3.4b for station locations

A dune with a crest elevation of 4.6 m (15.0 ft.) NAVD would be provided in the area from baseline stations 77+50 to 95+00 or in the area presently devoid of a dune and where homes are protected by sandbag revetments. Based on the April 2006 survey, the total volume of beach fill along the ocean shoreline, including 29,900 cy used to construct the dune, would be 1,152,300 cy. For the March 2012 survey, the total volume of beach fill along the ocean shoreline, including 43,800 cy used to construct the dune, would be 1,190,700 cy. If required by permit conditions, once the beach fill is in place, the sandbags could be removed by manually tearing the fabric and utilizing heavy machinery to extract the bag leaving the sand in place. If removed, the site will be shaped, planted with dune vegetation, and sand fences installed for further stabilization.

The width of the Nixon Channel beach fill was based on shoreline recession rates observed between 1999 and 2005 and an assumed 5 year design life. The fill would consist of a 122.0 m (400 ft) long main section constructed to a width of approximately 50 feet and at an elevation of 1.8 m (6.0 ft) NAVD and two 152.4 m (500 ft) transitions on each end of the main fill. The estimated volume of material needed for the Nixon Channel beach fill is 57,000 cy.

The length of the beach fill along the Nixon Channel shoreline was reduced by 122.0 m (400 ft) from that presented in the DEIS to avoid impacts on the mouth of a small tidal finger that drains the marsh area on the extreme north end of Figure Eight Island. The reduced length of the Nixon Channel fill lowers the fill volume from 65,000 cy presented in the DEIS to 57,000 cy presented above.

Beach Fill Material Compatibility. In April 2008, the North Carolina Coastal Resources Commission (CRC) adopted State Sediment Criteria Rule (15A NCAC 07H .0312) which sets

State standards for borrow material aimed at preventing the disposal of incompatible material on the beach. The new rule limits the amount of material by weight in the borrow area with a diameter equal to or greater than 4.76 mm and less than 76 mm (gravel), between 4.76 mm and 2.0 mm (granular), and less than 0.0625 mm (fines) to no more than 5% above that which exists on the native beach. Several beach nourishment operations have taken place along the north end of Figure Eight Island since 1983 and as a result, the NC DCM requested native beach samples be collected on both Figure Eight Island and Hutaff Island to establish a “native” value. The locations of the native beach sampling transects on both Figure Eight Island and Hutaff Island are shown on Figure 3.3.

The results of the characterization of both Figure Eight and Hutaff Island are provided below in Table 3.2. The native beach material on Hutaff Island is slightly coarser (mean grain size of 0.21 mm) than the material found on Figure Eight Island (mean grain size of 0.18 mm) and is comprised of more carbonate (shell) and granular material. The material on both beaches has essentially the same silt content. Given the absence of artificial beach nourishment on Hutaff Island, the characteristics of the beach material on Hutaff Island were adopted as a proxy to represent the native beach material on Figure Eight Island.

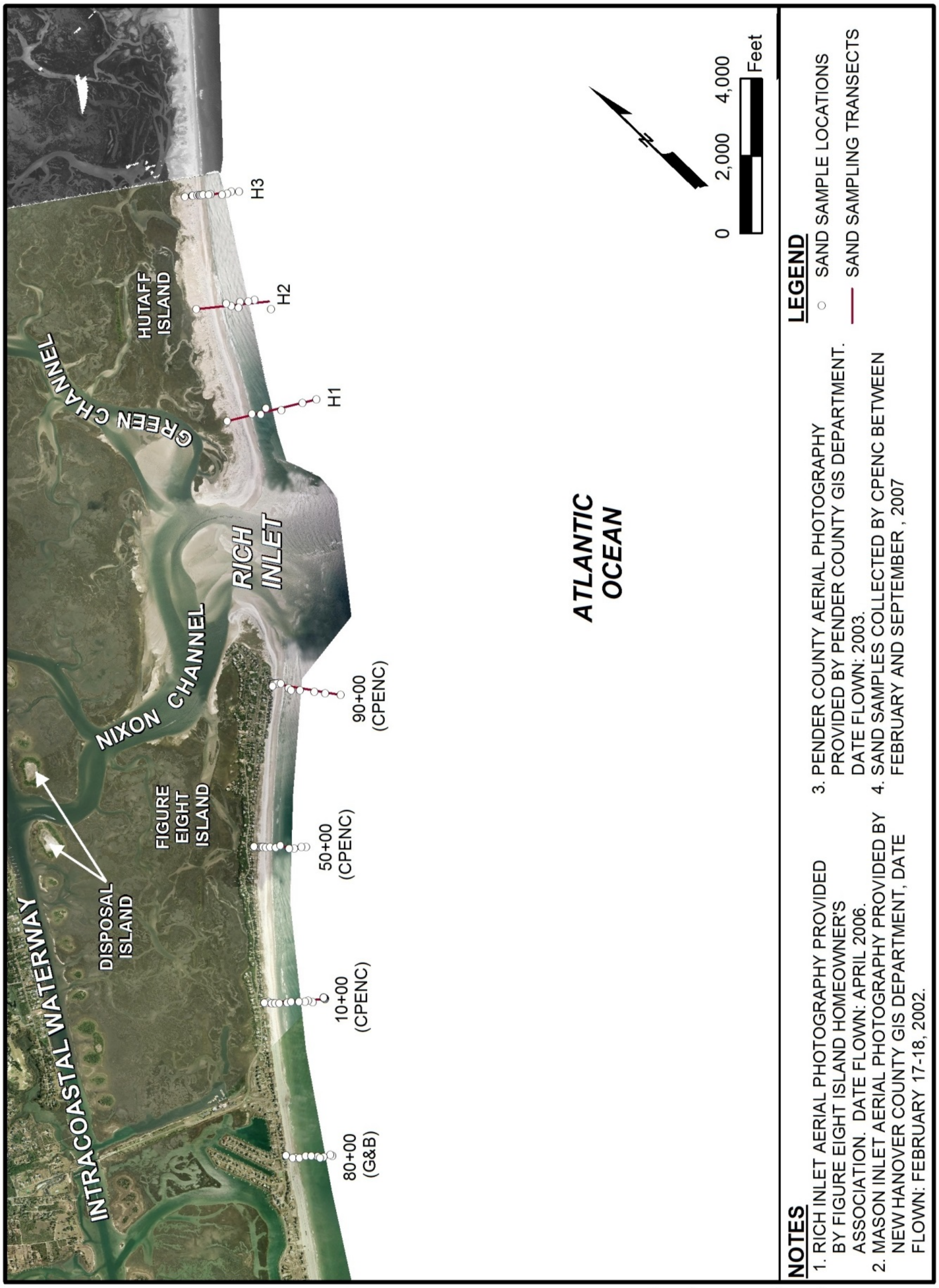


Figure 3.3. Map depicting the locations of sand samples collected on Figure Eight and Hutaff Island.

The performance of a beach fill along Figure Eight Island will depend on how closely the material removed to relocate the inlet bar channel and construct the two channel connectors matches the native beach material, or in this case, the native material on Hutaff Island. In general, borrow area material (channel material in this case) that is finer than the native material will generally form flatter slopes and require more fill to achieve a certain design template. Finer material also tends to erode faster which would require more periodic nourishment to maintain the desired beach profile configuration.

The geotechnical investigations conducted to characterize the material within the proposed new channels included two vibracores (FEVC-07-11 and FEVC-08-06) located in Nixon Channel that contained a layer of clay material at a depth of about -16 ft NAVD which is not compatible with the native beach. As a result, two separate cuts (Cut 1 and Cut 2) were designed (Figure 3.2) with material from Cut 1 to be placed along the ocean shoreline of Figure Eight Island and along the Nixon Channel shoreline while material from Cut 2 will be used to construct the closure dike. An estimated 29,700 cy of clay material that would be removed from Cut 2 would be deposited in an upland disposal area located on the south side of Nixon Channel at the intersection of Nixon Channel with the AIWW (Figure 3.3). With the exception of the 29,700 cy of material to be disposed of in an upland site, the material to be removed to construct the new channels meets all of the requirements for compatibility as stipulated in the State of North Carolina sand compatibility standards. From an engineering or performance standpoint, comparison of the channel material to the native beach material on Hutaff Island resulted in an overfill factor of 1.04, meaning only 4% of the material placed along the ocean shoreline could be lost from the active beach profile, which extends seaward to a depth of -24 feet NAVD, as a result of natural sorting and winnowing of the fill in response to wave and tidal action.

The composite characteristics of the material that would be removed from Cut 1 and Cut 2 (exclusive of the clay) are provided in Table 3.3 and include the silt, granular, gravel, and carbonate percentages for material in each cut. Material from Cuts 1 and 2 have mean grain sizes of 0.25 mm and 0.22 mm, respectively (Table 3.3) both of which are coarser than the native beach material. The characteristics of the material in both cuts (again exclusive of the clay in Cut 2) are well within the silt, carbonate, granular, and gravel contents allowed by the State Sediment Criteria.

Table 3.3. Characteristics of the native beach and Rich Inlet channel material.

	% Silt	% Carbonate	% Granular	% Gravel	Mean Grain Size (mm)
State Standard Allowance[(1)]	5	15	5	5	
Figure Eight Native Beach	1.04	6.0	0.26	0.05	0.18
State Standard Cutoff	6.04	21.0	5.26	5.05	
Hutaff Island Native Beach[(2)]	1.00	9.9	1.15	0.33	0.21
State Standard Limit	**6.00**	**24.9**	**6.15**	**5.33**	
Rich Inlet Borrow Area Cut 1	1.13	11.28	1.39	0.80	0.25
Rich Inlet Borrow Area Cut 2	1.25	8.12	0.77	0.52	0.22

(1) Refer to Figures 3.4a-d for station locations; allowances above native beach material.
(2) Characteristics of the native beach material on Hutaff Island adopted as representative of the native beach material on Figure Eight Island.

The channel modifications, closure dike, and general layout of the beach fills for Alternative 3 are shown in Figures 3.4a-d. The following depicts the approximate amount of dredged material that would be placed at each location based on both the April 2006 and March 2012 surveys:

April 2006 Survey

Ocean Shoreline Beach Fill	1,152,300 cy
Nixon Channel Beach Fill	57,000 cy
Closure Dike	513,700 cy
Upland Disposal (clay material)	42,300 cy
TOTAL	1,765,300 cy

March 2012 Survey

Ocean Shoreline Beach Fill	1,190,700 cy
Nixon Channel Beach Fill	57,000 cy
Closure Dike	393,000 cy
Upland Disposal (clay material)	29,700 cy
TOTAL	1,670,400 cy

The total volume of material that would be removed to construct the new bar channel and the connector channels in Nixon and Green Channels based on the April 2006 survey exceeds the disposal volumes to construct the dike and beach fills by 8,000 cy whereas the dredged volume based on the 2012 survey exceeds the disposal volume by 272,500 cy or roughly 14%. Since removal of 100% of the available volume from each of the channel areas is unlikely, the small difference in dredge and placement volumes for both surveys will account for some of the inefficiencies associated with the dredging operation.

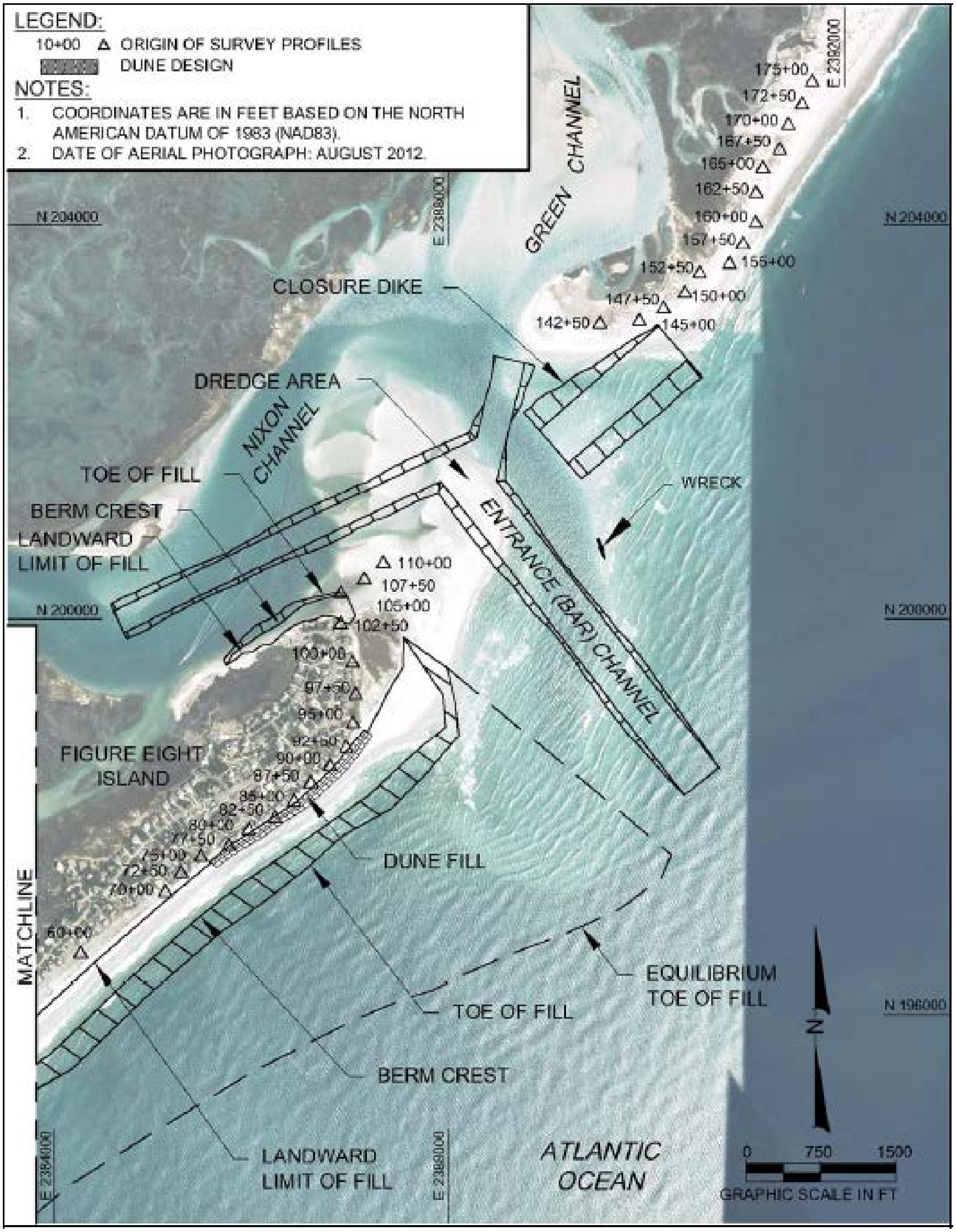


Figure 3.4a. Alternative 3: Optimal channel design, closure dike, and northern portion of beach fill; 2012 shoreline conditions.

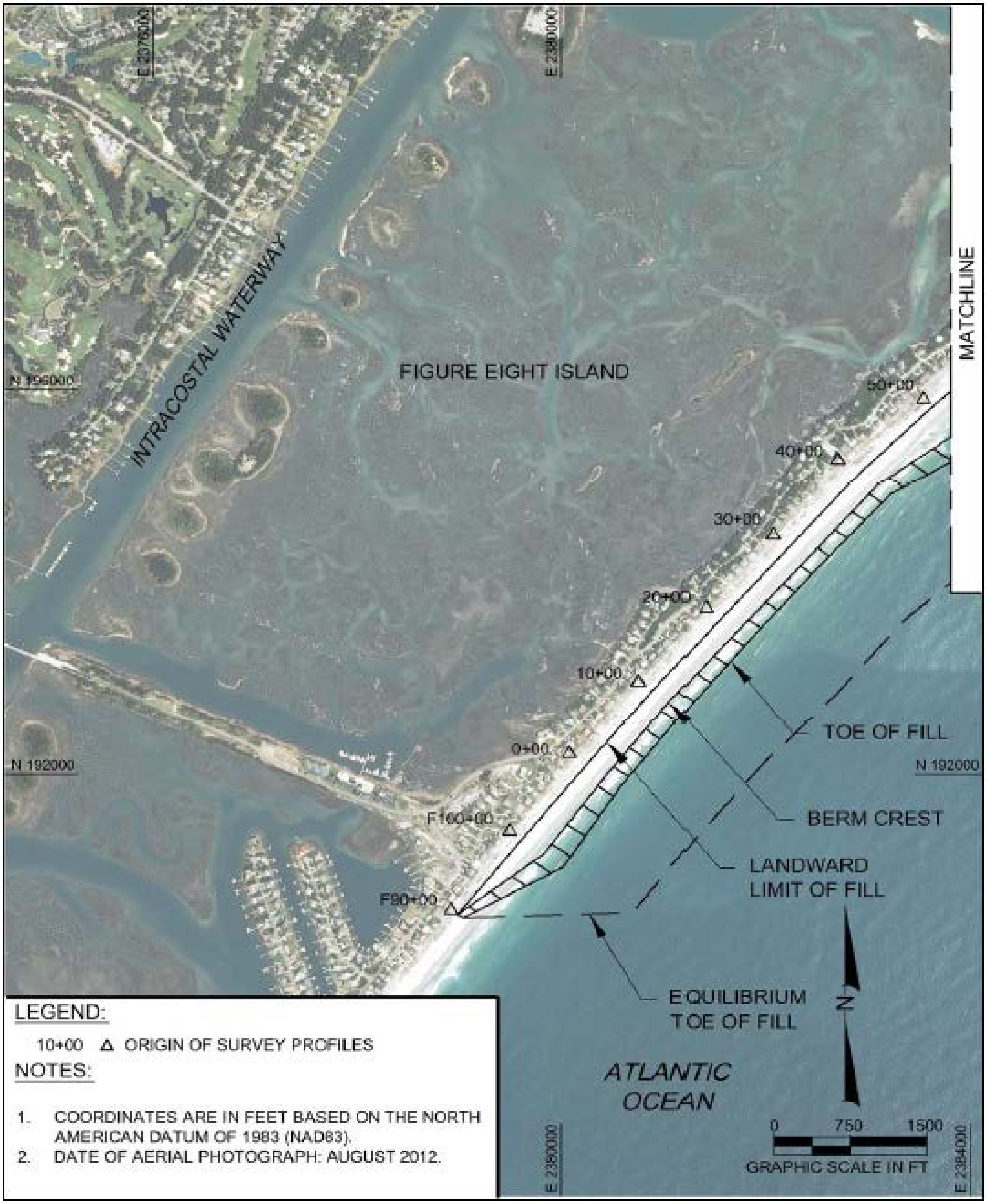


Figure 3.4b. Alternative 3: Southern portion of beach fill; 2012 shoreline conditions.

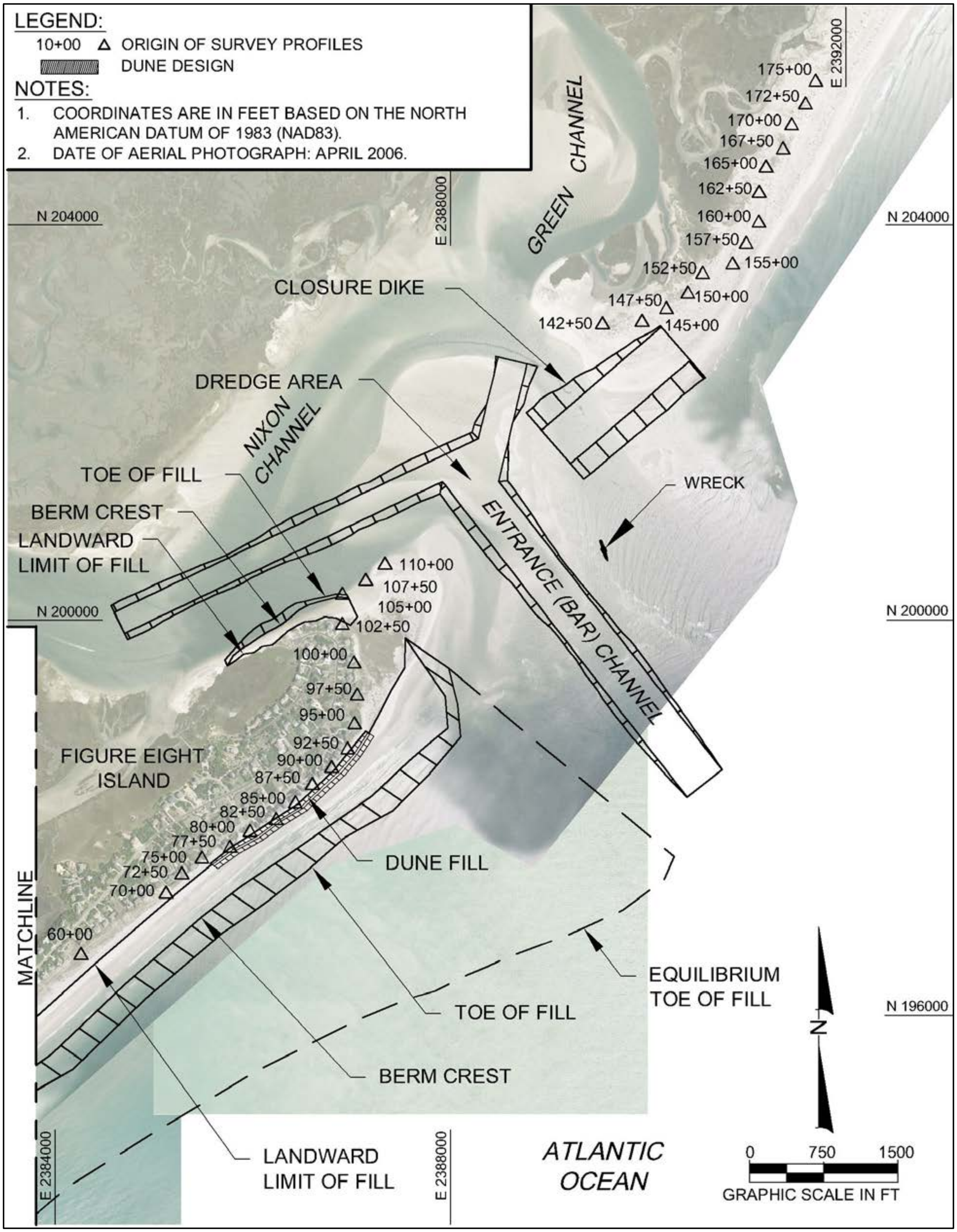


Figure 3.4c. Alternative 3: Optimal channel design, closure dike, and northern portion of beach fill; 2006 shoreline conditions.

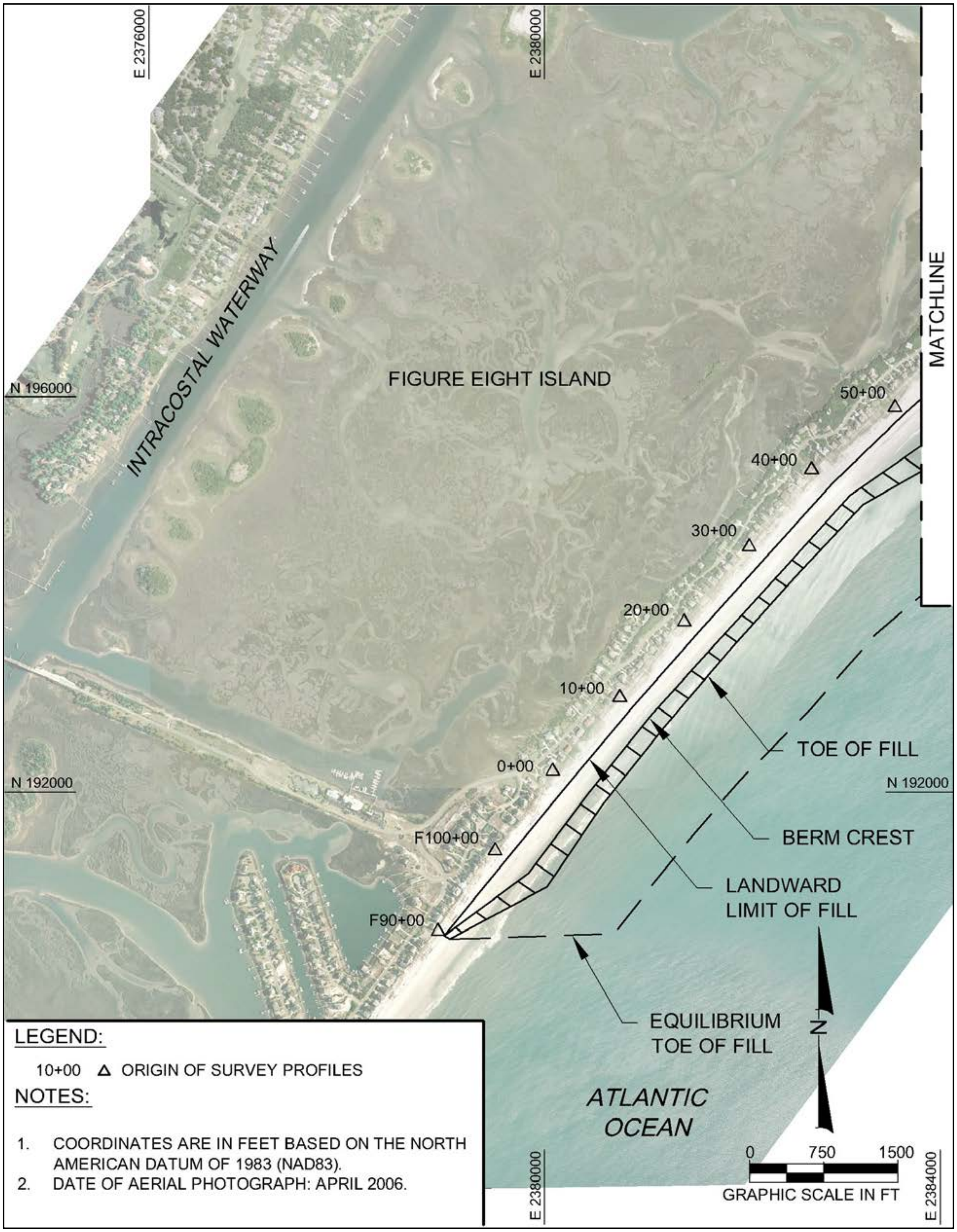


Figure 3.4d. Alternative 3: Southern portion of beach fill; 2006 shoreline conditions.

Channel Maintenance Requirements

Alternative 3 will likely require periodic maintenance of the new inlet bar channel to maintain its preferred position and alignment. While some maintenance may be needed for the Nixon and Green Channel connectors, as discussed below, future maintenance of these two channels would be deferred until conditions indicate maintenance would be desirable. The need to maintain the new bar channel would be evaluated when one of the following two thresholds is exceeded:

> Shoaling Threshold. Channel maintenance could be performed once the shoal volume in the new bar channel totals 60% of the initial construction volume.
>
> Bar Channel Position/Alignment Threshold. Channel maintenance could be performed if the thalweg of the new bar channel migrates toward Hutaff Island and 50% of the channel thalweg is located outside the 450-foot channel corridor established during initial construction. Shifts in the channel orientation toward Figure Eight Island would have a beneficial impact on the north end of Figure Eight Island and would not necessarily trigger the realignment threshold unless the landward portion of the channel moved to a position that threatened the integrity of homes located on the north end of the island.

As previously mentioned, maintenance of the new channels would be performed by the same type of equipment, i.e., cutter-suction pipeline dredge, used for initial construction.

Shoaling rates in the three new channel segments over the 5-year simulation period derived from the results of the Delft3D simulations are presented in Table 3.4a for the 2006 conditions and in Table 3.4b for the 2012 conditions. A plot of the cumulative shoal volume in each channel, expressed as a percent of the initial construction volume, is shown on Figure 3.5 for both the 2006 (dashed lines) and 2012 (solid lines) conditions. The initial construction volumes for the three channels (excluding overdepth allowances) are estimated to be 909,000 cy for the bar channel, 599,400 cy for Nixon Channel, and 264,900 cy for Green Channel (April 2006 survey data). For the 2012 survey, the initial construction volumes (excluding overdepth allowances) for the three channels are estimated to be 931,800 cy for the bar channel, 654,700 cy for Nixon Channel, and 200,000 cy for Green Channel (2012 survey data).

Table 3.4a. Estimated cumulative shoal volumes in each channel over the 5-year simulation for Alternative 3 (2006 Conditions).

Year	Channel Shoal Volume (cy)			
	Bar	Nixon	Green	Total
0	0	0	0	0
1	190,000	18,000	12,000	220,000
2	298,000	27,000	143,000	468,000
3	437,000	28,000	145,000	610,000
4	611,000	51,000	169,000	831,000
5	629,000	88,000	178,000	895,000

Table 3.4b. Estimated cumulative shoal volumes in each channel over the 5-year simulation for Alternative 3 (2012 Conditions).

Year	Channel Shoal Volume (cy)			
	Bar	Nixon	Green	Total
0	0	0	0	0
1	202,000	10,000	72,000	284,000
2	430,000	20,000	173,000	623,000
3	571,000	70,000	142,000	783,000
4	641,000	103,000	132,000	876,000
5	666,000	121,000	140,000	927,000

The initial size of all three channels was based on stability requirements and the need to initially capture flow in and out of the inlet. Once this flow pattern is established, restoration of the two connector channels to the original design dimensions may not be necessary as long as the flow through Nixon Channel does not induce erosion along the back side of Figure Eight Island and the flow distribution into Green Channel is comparable to existing conditions. However, since maintenance of the position and alignment of the bar channel is critical to the success of Alternative 3, the shoaling and migration of the bar channel derived from the results of the Delft3D model was used to formulate future maintenance requirements for Alternative 3.

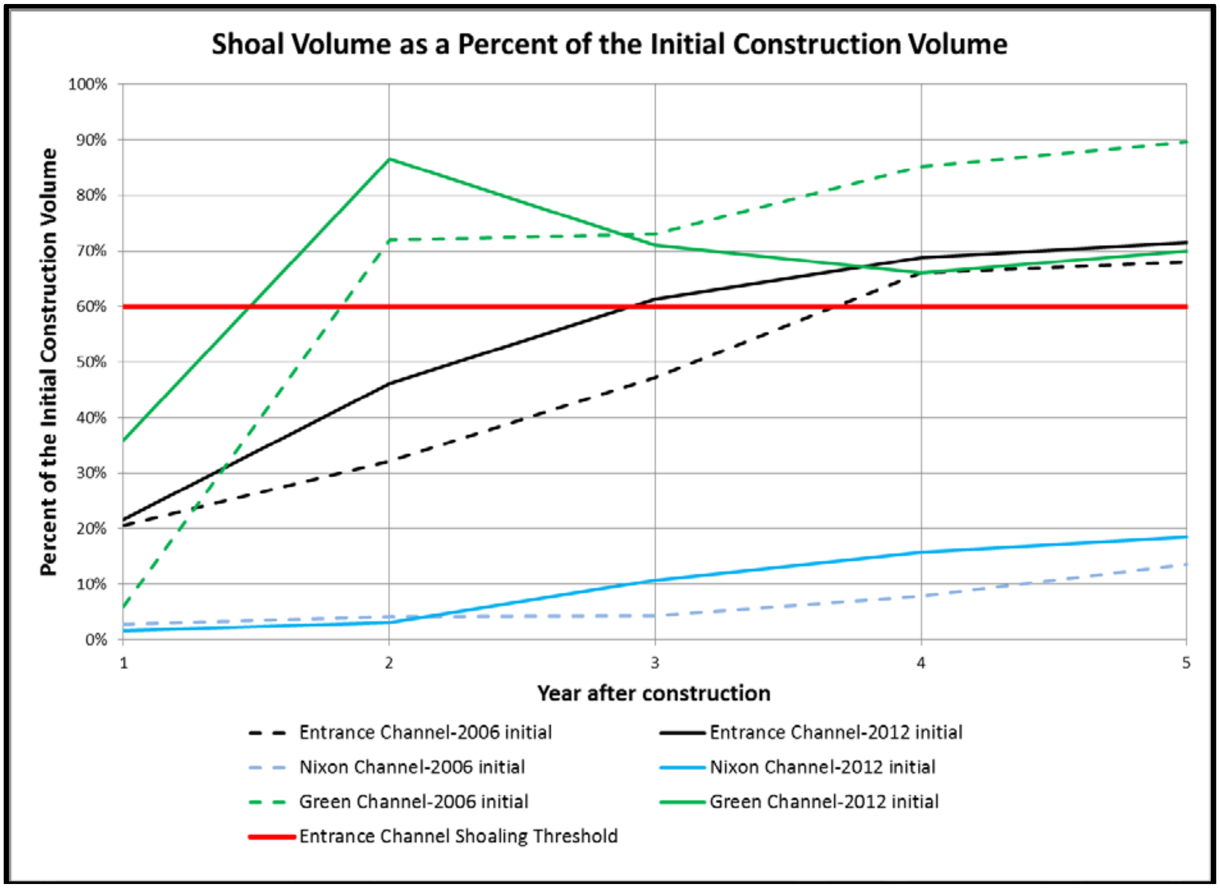


Figure 3.5. Alternative 3 - Cumulative channel shoal volumes over the 5-year model simulation expressed as a percent of the initial construction volume.

Figure 3.5 indicates that based on the 2012 conditions, shoaling of the Entrance Channel would approach the 60% shoaling threshold three years after initial construction. However, the rate of shoaling, expressed as a percentage of the initial volume, moderated after year 3. For the 2006 conditions, the Entrance Channel did not reach the 60% shoaling threshold until almost 4 years. The model also indicated the new bar channel could migrate out of the 450-foot corridor and orient toward Hutaff Island sometime between year 4 and year 5 of the simulation (Appendix B). Therefore, based on the estimated shoaling volumes and modeled behavior of the bar channel, maintenance of the bar channel would be required about every 5 years.

Shoaling of the Green Channel connector occurred rapidly during the first two years of the simulation for both conditions, as shown in Tables 3.3a and 3.3b and on Figure 3.5. This rapid rate of shoaling was associated with erosion of the closure dike as the dike morphed into a recurved sand spit off the south end of Hutaff Island. Once erosion of the sand dike moderated, shoaling of the Green Channel connector stabilized with some slight scour occurring in the channel during years 3 and 4 of the simulation with the 2012 conditions and only moderate shoaling with the 2006 condition. The Nixon Channel connector shoaled at a relatively slow rate throughout the 5-year simulation period with the total shoal volume at the end of year 5 equal to less than 20% of the initial dredge volume for both the 2006 and 2012 conditions. As a result of the slow rate of shoaling, flow through Nixon Channel was concentrated toward the middle of Nixon Channel and away from the back side of Figure Eight Island for both conditions. The slow rate of shoaling in the Nixon Channel connector and the moderation of shoaling in the Green Channel connector after the first couple of years indicated the two channels had achieved some equilibrium and would probably not need to be maintained.

Periodic Nourishment – Alternative 3.

Future maintenance of the channels would be limited to just the bar channel. For the 2006 conditions, the model indicated a 5 year shoal volume of 629,000 cy while the 2012 conditions resulted in a shoal volume of 666,000 cy. Maintenance of the Nixon and Green Channel connectors would be deferred until such time monitoring surveys find maintenance is required to restore flow volumes or in the case of Nixon Channel, divert the flow away from the shoreline in the critically eroding area.

The Delft3D model results for Alternative 3 were used to estimate volumetric changes along the ocean shoreline of Figure Eight Island north of Bridge Road and along the southern 3,000 ft of Hutaff Island. Details of the model results are provided in Appendix B and summarized in Chapter 5. In general, the model indicated favorable performance of the beach fill between baseline stations F90+00 and 60+00 for both the 2006 and 2012 conditions. Over the five year simulation period, the model indicated volume losses between stations F90+00 and 60+00 would only average 2,000 cy/year for the 2006 condition and 10,700 cy/year for the 2012 condition. Based on this performance, periodic nourishment of the fill between stations F90+00 and 60+00 would only be required on an infrequent basis. As a result, the estimated periodic nourishment requirement for the beach fill associated with Alternative 3 was based on nourishing the fill area between baseline stations 60+00 and 105+00 on a regular basis. The future need to nourish the area between stations F90+00 and 60+00, which should not be needed for at least 10 years or more, would be determined from the results of beach profile monitoring surveys.

The annual rate of erosion of the beach fill between stations 60+00 and 105+00 averaged 99,000 cy/year over the 5 year simulation period given the 2006 conditions and 81,000 cy/year for the 2012 condition. Based on the need to reposition the bar channel of Rich Inlet every five years, the five year nourishment requirement for this area would be 495,000 cy under 2006 conditions and 405,000 cy for the 2012 condition. Nourishment of the Nixon Channel area would require about 30,000 cy which brings the total 5-year nourishment requirement to 525,000 cy for the 2006 condition and 435,000 cy for the 2012 condition.

Regardless of the periodic nourishment requirement for the beach fills, the long-term recovery of the beach along the north end of Figure Eight Island is dependent on maintaining the bar channel of Rich Inlet within the preferred inlet corridor. As noted above, the Delft3D model simulation of Alternative 3 indicated the new entrance channel could migrate out of the 450-foot corridor and orient toward Hutaff Island sometime between years 4 and 5 after initial construction. Consequently, the new channels would probably have to be maintained approximately every five years regardless of the nourishment needs along Figure Eight Island. The estimated volume of material that would have to be removed every five years to maintain the entrance channel is 666,000 cy (Table 3.3b). Since the total nourishment requirement for the beach fill between stations 60+00 and 105+00 on the ocean shoreline and beach fill along Nixon Channel is estimated to be between 435,000 cy and 525,000 cy, the apparent excess of channel maintenance material could be used to provide some advanced fill between stations 60+00 and 105+00 or possibly distributed to beach areas south of station 60+00. Regardless, all of the material removed to maintain the entrance channel would be deposited on Figure Eight Island.

<u>Implementation Cost.</u> Over the thirty year planning period, the total implementation cost for Alternative 3, based on the April 2006 survey condition, would be about $61.8 million in current dollars. This total cost includes $17.1 million for initial construction of the new channels, sand dike, and beach fills and $44.7 million for maintaining the channel every 5 years with disposal of the dredged material along both the ocean shoreline of Figure Eight Island north of Bridge Road and along the Nixon Channel shoreline. The initial construction is expected to take approximately 2.5 months.

Over the thirty year planning period, the total implementation cost for Alternative 3, based on the 2012 survey condition, would be about $63.5 million in current dollars. This total cost includes $17.3 million for initial construction of the new channels, sand dike, and beach fills and $46.2 million for maintaining the channel every 5 years with disposal of the dredged material along both the ocean shoreline of Figure Eight Island north of Bridge Road and along the Nixon Channel shoreline. The initial construction is expected to take approximately 2.5 months. See Appendix B and Appendix G for more information regarding cost.

Alternative 4: Beach Nourishment without Inlet Management

This alternative involves the placement of fill material along the oceanfront and Nixon Channel shorelines using several potential borrow sources, however it does not implement any inlet management measures. A hydraulic cutter-suction pipeline dredge (pipeline dredge) would be used for this alternatives. However, a hopper dredge with direct pumpout capabilities would likely be used to transport material to the beach from offshore borrow sites. The model evaluation of the performance of the beach fill under Alternative 3 for both the 2006 and 2012 conditions indicated the volume of material in the initial fill for Alternative 3 exceeded the volume needed to protect upland development. Again, the beach fill volume for Alternative 3 was dictated by the volume of material that would be removed to construct the new bar channel and the connectors into Nixon and Green Channels. Accordingly, the fill density for Alternative 4 was reduced relative to Alternative 3 with the fill densities and design berm widths for Alternative 4 provided in Table 3.5. The layout of the beach fill for Alternative 4 is provided in Figures 3.6a-d.

Table 3.5. Alternative 4 beach fill placement volumes and design berm widths.

Shoreline Segment (Baseline Stations)	Placement Volume (cy/lf)	Design Berm Width (ft)
F90+00 to F100+00 (transition)	0 to 20	0 to 17
F100+00 to 20+00	20	17
20+00 to 30+00 (transition)	20 to 50	17 to 43
30+00 to 60+00	50	43
60+00 to 70+00 (transition)	50 to 100	43 to 86
70+00 to 80+00	100	86
80+00 to 82+50 (transition)	100 to 200	86 to 172
82+50 to 100+00	200	172
100+00 to 105+00 (transition)	200 to 0	172 to 0

The reduction in the fill density, particularly north of baseline station 60+00, was aimed at reducing losses from the fill area due to diffusion, i.e., the horizontal spreading or transport of material out of the placement area due to longshore sand transport.

For the April 2006 survey conditions, the total initial beach fill volume along the ocean shoreline from Rich Inlet to just south of Bridge Road (station F90+00) for Alternative 4 would be 864,300 cy which includes 43,800 cy that would be used to construct a dune between stations 77+50 and 95+00 (sandbag area). For the March 2012 survey conditions, the total initial beach fill volume along the ocean shoreline from Rich Inlet to just south of Bridge Road (station F90+00) for Alternative 4 would be 911,300 cy which includes 43,800 cy that would be used to construct a dune between stations 77+50 and 95+00 (sandbag area). If required by permit conditions, once the beach fill is in place, the sandbags could be removed by manually tearing the fabric and utilizing heavy machinery to extract the bag leaving the sand in place.

The beach fill along Nixon Channel would be the same as Alternative 3 or 57,000 cy resulting in a total beach fill volume for Alternative 4 of 921,300 cy based on the 2006 survey conditions and 968,300 cy based on the 2012 survey conditions.

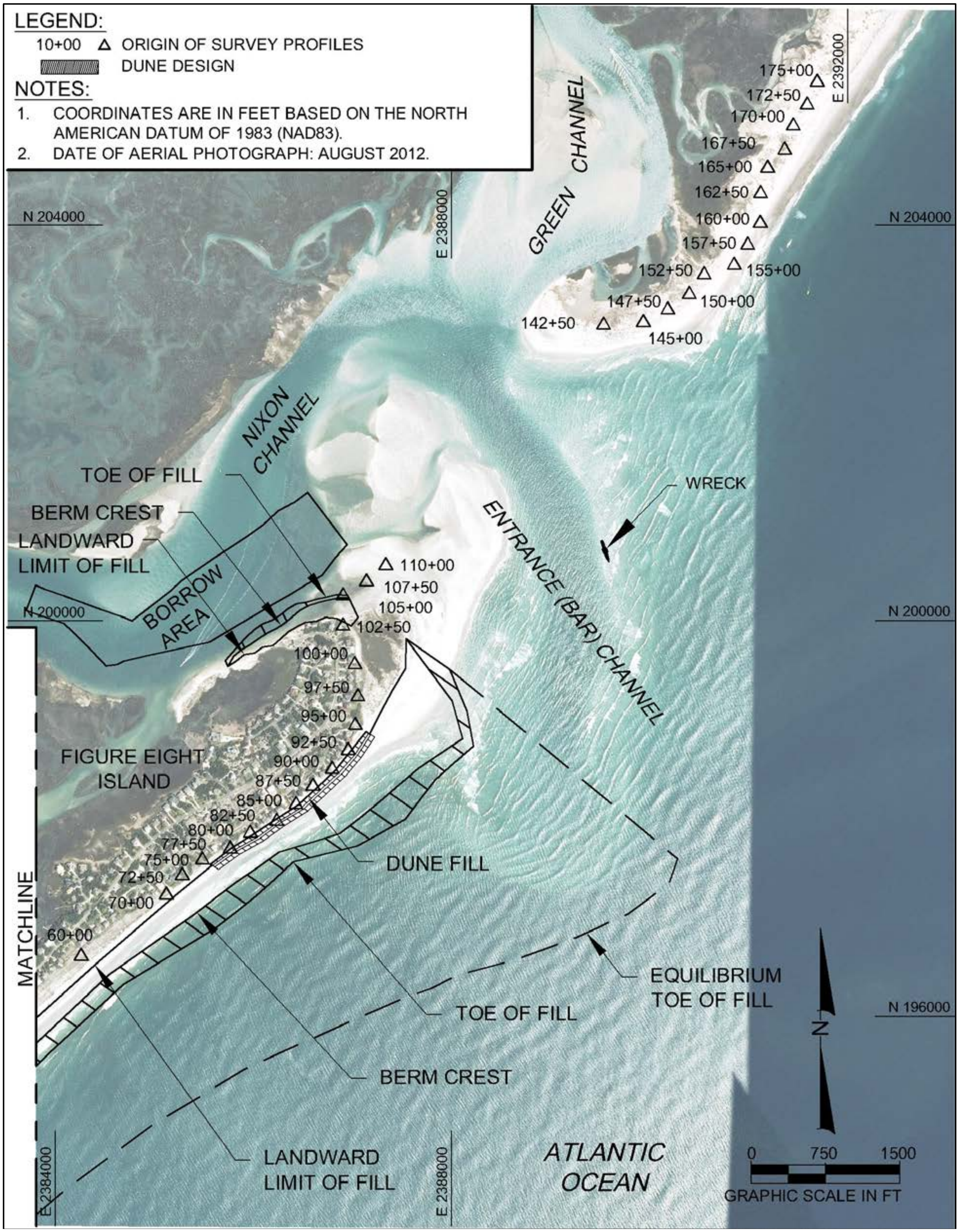


Figure 3.6a Alternative 4: Northern portion of beach fill; 2012 shoreline conditions.

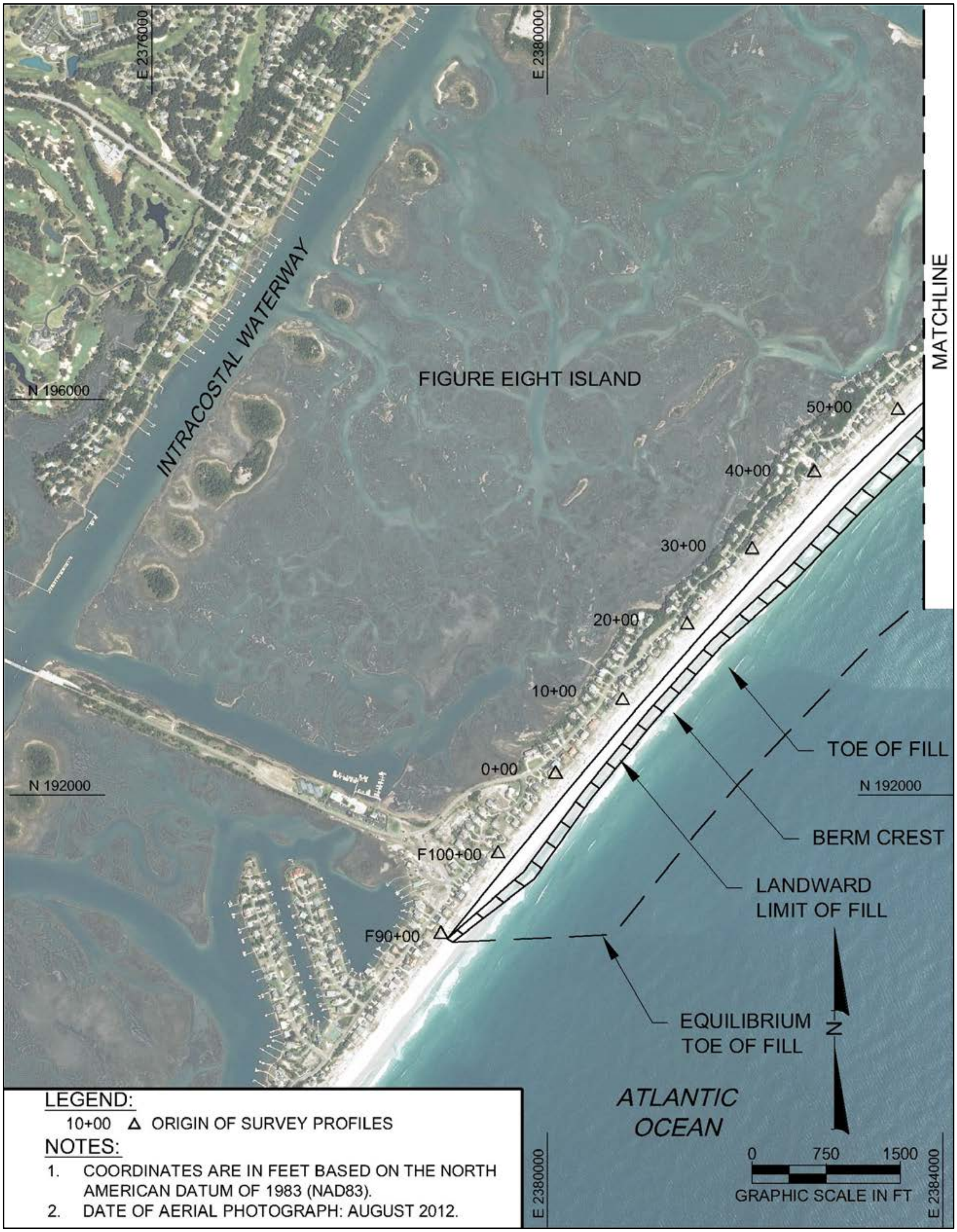


Figure 3.6b. Alternative 4: Southern portion of beach fill; 2012 shoreline conditions.

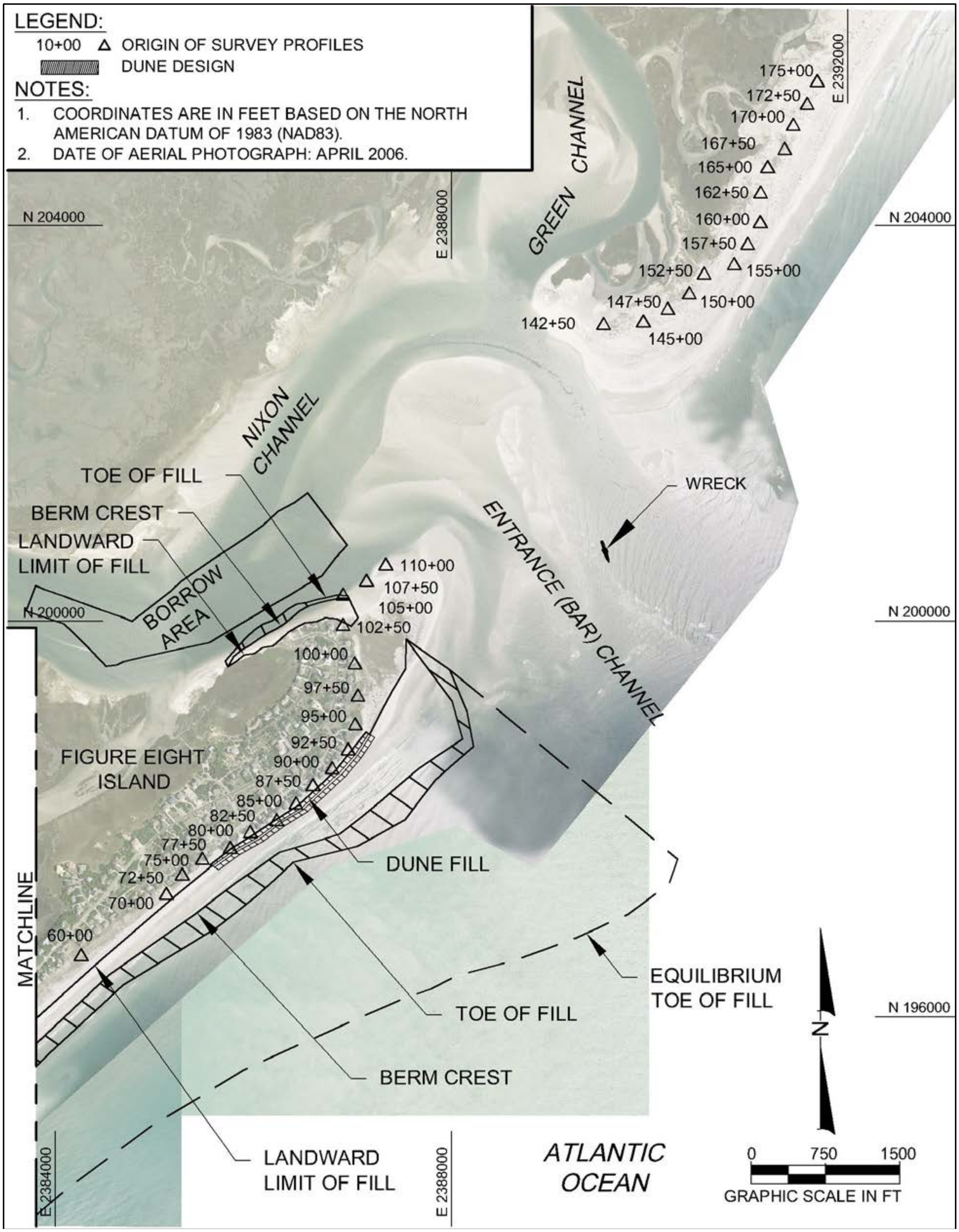


Figure 3.6c. Alternative 4: Northern portion of beach fill; 2006 shoreline conditions.

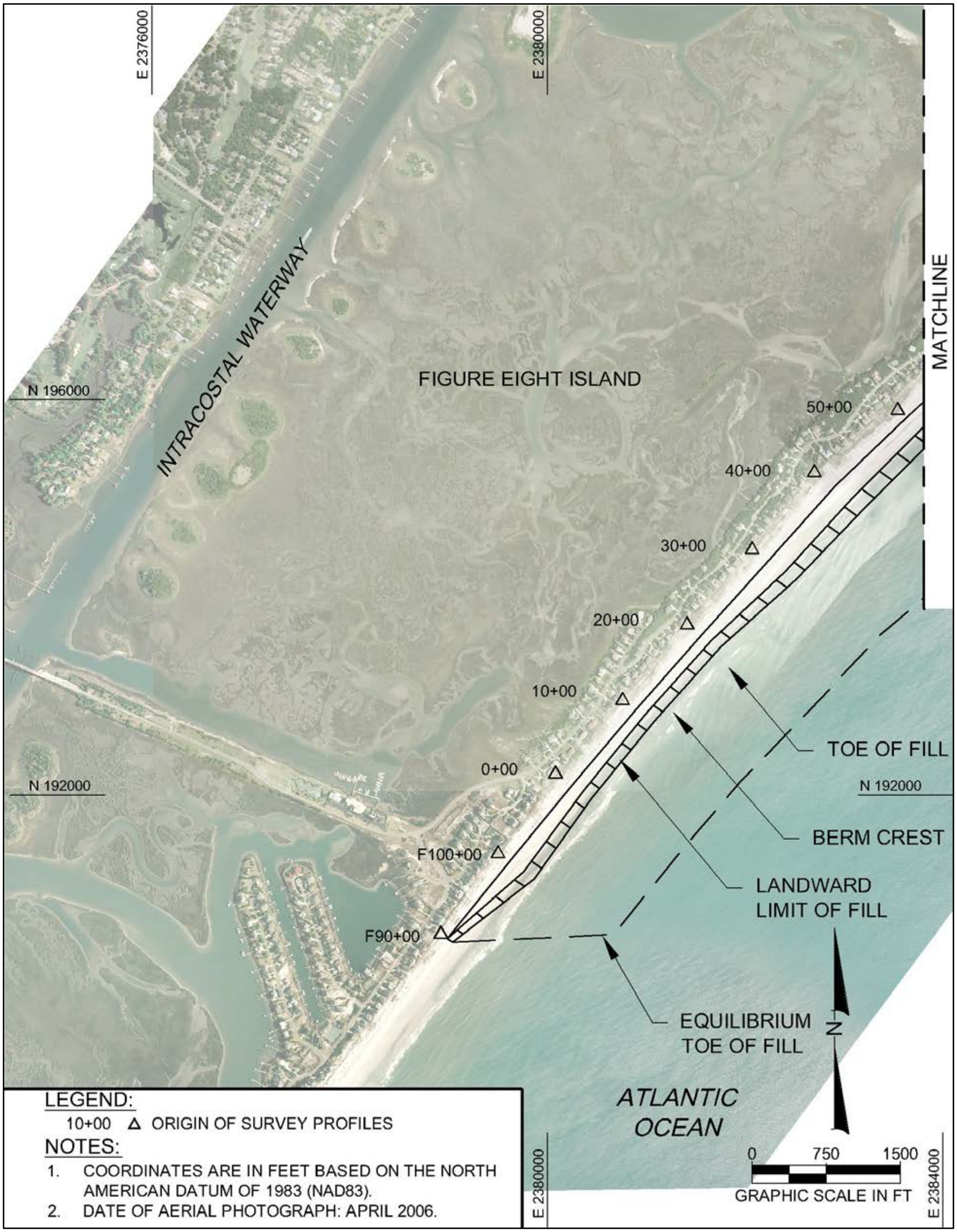


Figure 3.6d. Alternative 4: Southern portion of beach fill; 2006 shoreline conditions.

As discussed in Appendix B, the model simulation of Alternative 4 under both the 2006 and 2012 conditions indicated the beach fill would perform very well between baseline stations F90+00 and 60+00 and would not require periodic nourishment for the foreseeable future. However, losses from the fill area between stations 60+00 and 105+00 of the beach under Alternative 4 were relatively high and resulted in complete removal of the fill, including that placed above the -6-foot NAVD contour, by the end of year 4 given the 2006 condition and by the end of year 5 for the 2012 condition. Theoretically, more material could be placed between stations 60+00 and 105+00 in an attempt to prolong the life of the fill, however, there is a point of diminishing returns due to diffusion losses in which volume losses from the fill area increase exponentially with increased fill volume and fill width. Therefore, in order to limit periodic nourishment volumes needed for Alternative 4, a 4-year periodic nourishment interval was selected. Based on the model volume changes, the 4-year periodic nourishment requirement for Alternative 4 between stations 60+00 and 105+00 would be 764,000 cy given the 2006 conditions and 508,000 cy under 2012 conditions. Given the likelihood that the Rich Inlet bar channel will assume an alignment toward Hutaff Island in the near future and initiate another round of high erosion rates on the north end of Figure Eight Island, future maintenance of a beach fill under Alternative 4 was based on providing 764,000 cy every 4 years.

The identified borrow sources for Alternative 4 include the previously permitted area within Nixon Channel as described in Alternative 1, three (3) potential borrow sources located between 3 and 4 miles directly offshore of Figure Eight Island and three (3) upland dredged material disposal areas located next to the AIWW.

Nixon Channel. The six (6) dredging events carried out in Nixon Channel since 1993 removed a total of 1,748,000 cy. The volume of material for each event was generally limited to less than 300,000 by the Figure "8" Beach HOA in order to avoid the establishment of a static vegetation line. If dredging of the existing Nixon Channel permit area was not constrained by the static vegetation line rule, the volume of material that could have been removed could have ranged between 400,000 and 500,000 cy every 4 or 5 years. Since the last maintenance dredging in Nixon Channel occurred in 2011, at least 400,000 cy should be available for use during initial construction of Alternative 4. The balance of the material needed for initial construction and periodic nourishment would be obtained from other borrow sources.

What is a Static Vegetation Line?

Under current Coastal Resources Commission (CRC) rules, the seaward most line of stable vegetation existing immediately prior to the implementation of a large-scale beach nourishment project is designated as a “static vegetation line” following fill placement. The “static vegetation line” becomes the reference for establishing oceanfront setbacks in perpetuity even if the vegetation line moves seaward.

Offshore Borrow Areas. The potential offshore sand sources were investigated by Dr. Cleary (Cleary, 2000 and Cleary, 2003) with the 2000 investigation focusing on potential sources inside the State 3-mile territorial limit and the 2003 investigation extending the search to 5 miles offshore. No appreciable sand resources were located landward of the 3-mile limit, however, the three potential sites beyond the 3-mile limit shown on Figure 3.7 each contain an estimated 4.6 million cy of material. No further geotechnical or geosurvey work has been conducted within the sites, so the extent of compatibility at each borrow area has not been verified at this time.

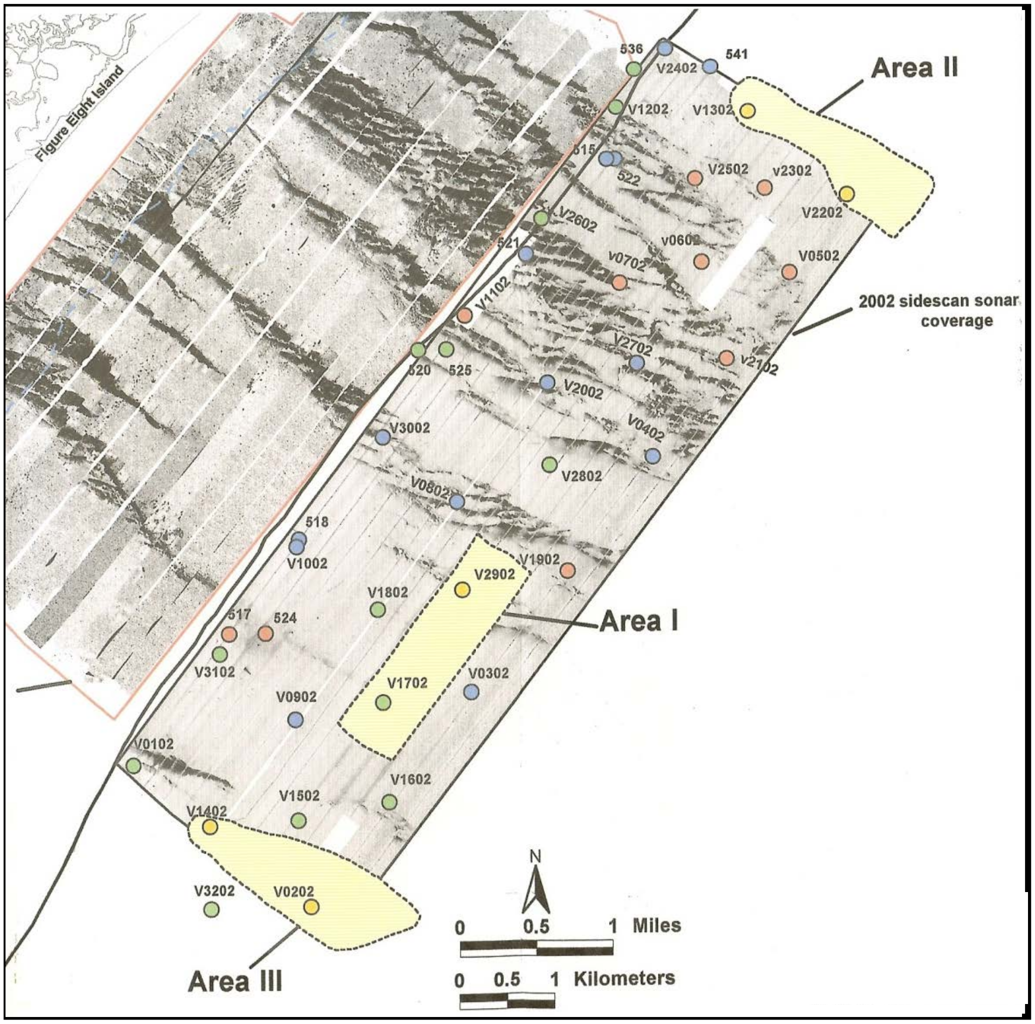


Figure 3.7. Potential offshore borrow areas identified by Dr. William Cleary.

AIWW dredged material disposal sites

Three (3) dredged material disposal sites are located adjacent to the AIWW behind Figure Eight Island near the confluence of Nixon Channel with the AIWW. These three (3) northern disposal sites shown on Figure 3.8 had been used in the past by the USACE for disposal of shoal material removed from the confluence of Nixon Creek with the AIWW. The islands are relatively small and have reached their maximum storage capacity with elevations ranging from 20 to 25 feet NAVD.

Figure 3.8. Location of AIWW dredged material disposal sites 1, 2, and 3.

The Figure "8" Beach HOA contracted with Criser, Troutman, Tanner Consulting Engineers (CTT) to determine the quantity and quality of material stored in each of the disposal areas. The investigation, conducted in 2010, included detailed topographic surveys, 9 to 12 core borings in each disposal site, core logs, soil classification, and grain size analyses. An estimate of the volume of material down to an elevation of -19 feet NAVD (-18 feet NGVD), the median grain size, silt content, and calcium carbonate content for each disposal site is provided in Table 3.6.

Table 3.6. Characteristics of the AIWW dredged material disposal areas near Nixon Creek.

Disposal Area	Estimated Volume (cy)	Median Grain Size (mm)	Silt Content(1) (%)	Calcium Carbonate (%)
1	202,000	0.19	5.7	2.2
2	225,000	0.15	4.8	2.0
3	132,000	0.17	6.9	3.5

(1) Based on #200 sieve.

The total volume of material contained in the three disposal sites is 559,000 cy. Adjusting this total volume for silt content, approximately 527,000 cy of sandy material is stored in the three (3) disposal sites. Due to the fact that dredge disposal material has been placed on one or more of these sites since the 2010 geotechnical investigations performed by CTT, additional studies to ensure compatibility may be required prior to using these sand sources on the oceanfront or Nixon channel shoreline.

Borrow Area Selection for Alternative 4

Additional borrow sources were assessed for beach placement, but were eliminated from further consideration. The elimination of these other source options for Alternative 4 is discussed in Chapter 5. Of all the potential borrow sources outside Rich Inlet discussed above, the maintenance dredging of the previously permitted area within Nixon Channel, the potential offshore borrow areas identified by Dr. Cleary, and the three (3) northern AIWW disposal sites would be suitable for nourishing the Figure Eight Island shoreline north of Bridge Road. Due to the relative small volume available from the three (3) AIWW disposal sites, these sites would be held in reserve and only used for periodic nourishment if the volume of material shoaling the previously permitted area within Nixon Channel is insufficient to meet nourishment requirements or other concerns over the removal of the material from Nixon Channel prevent its use. Also, the relatively high rate of periodic nourishment for Alternative 4 indicated by the model results, which exceeds the estimated shoaling rate of the previously permitted area in Nixon Channel, would require the continued use of the offshore borrow sites in order to satisfy the nourishment requirements.

The removal of material from borrow sources, with the exception of the upland sources and disposal on both the Nixon Channel and ocean shoreline would be accomplished by an 18-inch or smaller cutter-suction pipeline dredge. Material from the offshore borrow area would be transported to the beach via a trailer-suction hopper dredge equipped with direct pumpout capability. The dredge would attach to a mooring buoy positioned at two locations off Figure Eight Island and pump the material to the beach through a submerged pipeline.

Periodic Nourishment – Alternative 4.

Based on the Delft3D model results for Alternative 4 under both the 2006 and 2012 conditions, the beach fill between stations F90+00 and 60+00 would not require periodic nourishment on a regular basis. North of baseline station 60+00, modeled losses from the fill over four years totaled 704,000 cy under the 2006 condition and 520,000 cy for the 2012 condition. Periodic nourishment of the beach fill in Nixon Channel would require approximately 24,000 cy every 4 years. Therefore, the total 4-year nourishment requirement for Alternative 4 would be 728,000 cy given the 2006 conditions and 544,000 for the 2012 conditions.

Material for periodic nourishment under Alternative 4 would be derived from maintenance of the previously permitted area in Nixon Channel and the offshore borrow areas. Based upon documented shoaling rates in the Nixon Channel area, the previously permitted site should supply around 400,000 cy every 4 years. The balance of the periodic nourishment requirements would be obtained from the offshore sites to satisfy the 4-year nourishment needs.

Implementation Cost. Over the thirty year planning period, the total implementation cost for Alternative 4, based on the April 2006 survey conditions, would be about $84.9 million in current dollars. This total cost includes $12.7 million for initial construction of the beach fills along the ocean and Nixon Channel shorelines, $1.0 million for geotechnical investigations and permitting offshore borrow area, and $71.2 million to nourish the beach fills every four (4) years. Over the thirty year planning period, the total implementation cost for Alternative 4, based on the March 2012 survey conditions, would be about $69.0 million in current dollars. This total cost includes $13.3 million for initial construction of the beach fills along the ocean and Nixon Channel shorelines, $1.0 million for geotechnical investigations and permitting offshore borrow area, and $54.7 million to nourish the beach fills every four (4) years. Initial construction is expected to take approximately 4 months. The unit dredging cost per cubic yard for Alternative 4 would be more costly compared to Alternative 3 due to the use of offshore borrow areas for both initial construction and periodic beach nourishment. See Appendix B and Appendix G for more information regarding cost.

Alternative 5: Beach Fill with Terminal Groin

Introduction. This option has (4) variations: Alternatives 5A, 5B, 5C, and 5D. Each one is being considered as a separate alternative and was evaluated as such. For each alternative, a terminal groin would be constructed on the north end of Figure Eight Island near the south shoulder of Rich Inlet and the area immediately south of the terminal groin would be artificially filled to create an accretion fillet. Periodic nourishment would be used to maintain the shoreline south of the terminal groin to Bridge Road. A hydraulic cutter-suction pipeline dredge (pipeline dredge) would be used for all options considered under this alternative (i.e., 5A, 5B, 5C and 5D). As stated previously, all (4) options were modeled using the revised model set-up for the 2006/2007 inlet and shoreline conditions and only Alternative 5D was simulated using the 2012 inlet and shoreline conditions. Although not modeled using the 2012 conditions, quantities and cost estimates to construct Alternatives 5A, 5B, and 5C, given the 2012 conditions, were computed using actual 2012 survey data. A summary of the four (4) alternatives are provided below with details given in Appendix B, Sub-Appendix B, Sub-Appendix B-1, and Sub-Appendix B-2.

Terminal Groin Legislation. Prior to 2011, terminal groins and other so-called hard erosion response structures were prohibited along the ocean shoreline of North Carolina by NC Division of Coastal Management. During the 2011 legislation session, the North Carolina Legislature passed Session Law 2011-387, Senate Bill 110, which allows consideration of terminal groins adjacent to tidal inlets. The legislation limited the number of terminal groins to four (4) statewide and included a number of provisions and conditions that must be met in order for the groins to be approved and permitted.

A terminal groin, as defined by the above referenced legislation, is:

> **“***a structure that is constructed on the side of an inlet at the terminus of an island generally perpendicular to the shoreline to limit or control sediment passage into the inlet channel***”**

In 2013, the State Legislature passed the Coastal Policy Reform Act of 2013 (SL2013-384) that modified some of the requirements included in the 2011 legislation. The major changes include:

(a) Elimination of the requirement to show an imminent erosion threat to structures and infrastructure. Now the applicant only needs to demonstrate structures and infrastructure are threatened.
(b) Eliminated the need to demonstrate that nonstructural measures, including relocation of threatened structures, are impractical.
(c) The required inlet management plan "must be reasonable and not impose requirements whose costs outweigh the benefits."
(d) Eliminated the requirement of the applicant to fund restoration of public, private, or public trust property if the groin has an adverse impact on the environment or property.
(e) Provided more flexibility in providing financial assurances for maintenance and/or removal of the terminal groin.

In 2015, Session Law 2015-241, HB 97 was passed and increased the number of terminal groin structures in North Carolina that could be permitted from four to six. This legislation specified that the two additional terminal groin permits may only be issued for structures located on the sides of New River Inlet in Onslow County and Bogue Inlet in Carteret and Onslow County.

Terminal groins differ from jetties both in size and in intended function. Jetties are used to stabilize navigation channels through tidal inlets by concentrating tidal flow in the navigation channel and controlling the influx of sediment to the channel. Jetties are relatively long structures that normally extend from the shoreline seaward to a depth comparable to the depth of the navigation channel or at least to the outer lobe of the ebb tide delta of the inlet. Terminal groins, by virtue of their relatively short length compared to a jetty, will only retain sediment within a limited area immediately adjacent to the structure. This area is generally referred to as an accretion fillet. Once the accretion fillet is fully formed, wave driven sediment transport will move either through, over, or around the seaward end of the structure. The terminal groin legislation allowing consideration of terminal groins in North Carolina requires the structure to be accompanied by beach fill which would artificially create the accretion fillet.

In the May 2013 Draft EIS for the Figure Eight Island Shoreline and Inlet Management Project, only Alternatives 5A and 5B were presented and both alternatives included the same terminal groin design with a position and alignment shown schematically in Figure 3.9. These two options remain unchanged from the Draft EIS. The difference in the two terminal groin alternatives was primarily associated with the source of material that would be used to construct beach fills along the ocean shoreline and the Nixon Channel shoreline and the size of the fill along the ocean shoreline.

Alternative 5A included the construction of a channel that would extend from the previously permitted area in Nixon Channel across the flood tide delta of Rich Inlet and connect to the gorge of Rich Inlet. The purpose of the new channel was to divert flow in Nixon Channel away from the back side of Figure Eight Island to reduce current induced erosion pressures in that area. The material removed to construct the channel would be used to construct a beach fill from the terminal groin south to station F90+00, which is just south of Bridge Road. Some of the material would also be used to construct a beach fill along the Nixon Channel shoreline on the back side of Figure Eight Island.

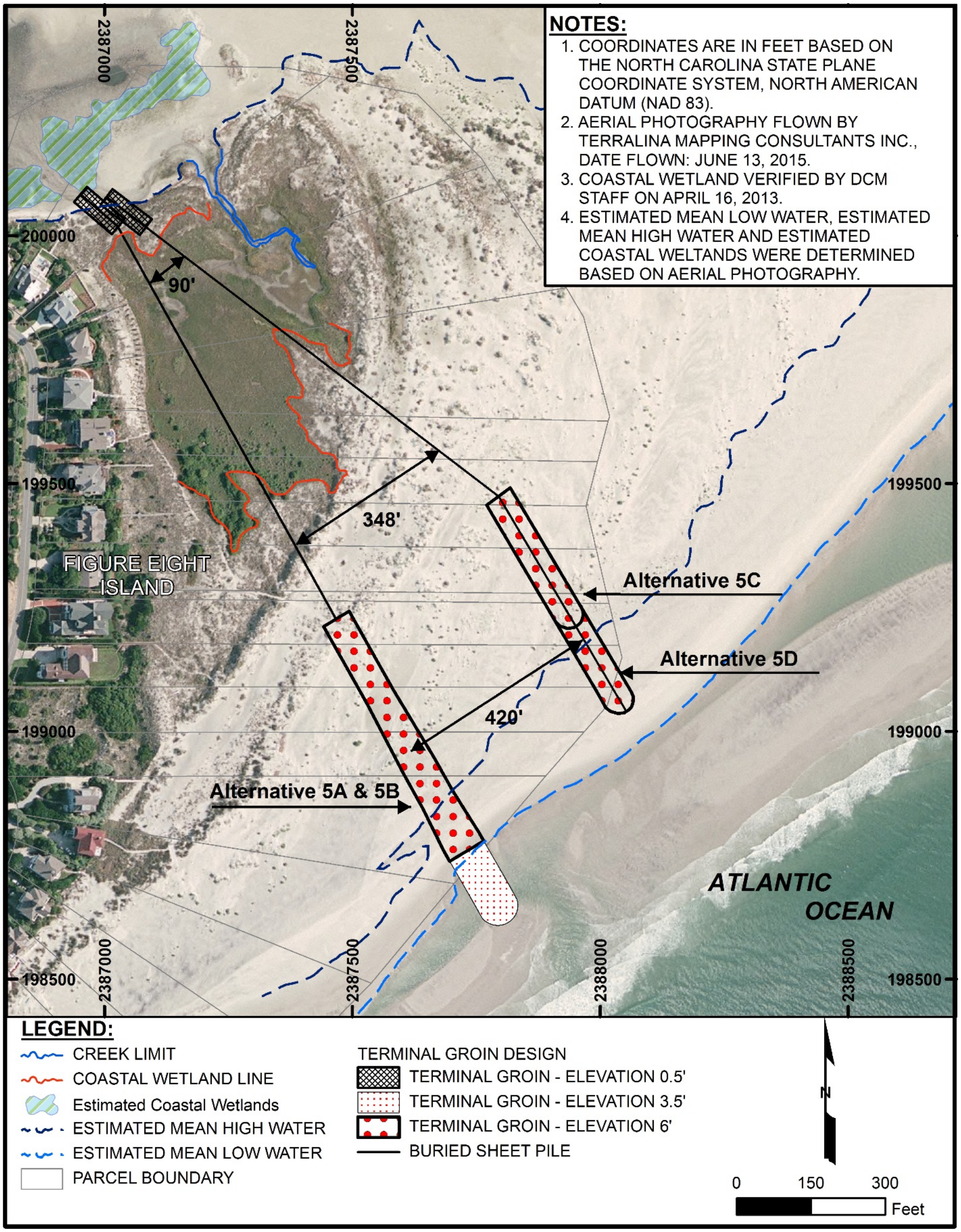


Figure 3.9. Terminal groin layout for all four (4) terminal groin alternatives on the north end of the island.

Alternative 5B has a much smaller beach fill on the ocean side that would extend from the terminal groin south to station 60+00 (located near 322 Beach Road North). A beach fill of the same design as Alternative 5A would also be provided along the Nixon Channel shoreline. Material to construct both beach fills would be obtained from maintenance of the previously permitted area in Nixon Channel (Figure 3.1).

In addition to Alternatives 5A and 5B presented in the DEIS, the initial screening process evaluated two (2) terminal groin lengths (1,600 feet and 2,100 feet), multiple channel sizes associated with Alternative 5A, and the effectiveness of orienting the terminal groin along an alignment rotated 10, 20, and 30 degrees toward Figure Eight Island. A discussion of these preliminary terminal groin screening options is provided in Appendix B with model results shown in Sub-Appendix B.

After the release of the Draft EIS, the Figure "8" Beach HOA determined the need to consider a more northerly terminal groin location (approximately 420 feet north of 5A and 5B) and opted to evaluate two (2) additional terminal groin options designated as Alternatives 5C and 5D as shown in Figure 3.9. Their decision was based upon the potential complications in obtaining all the necessary easements for constructing 5A and 5B, as some of the property owners on the extreme north end of the island were concerned about the position and alignment of Alternatives 5A and 5B. This prompted the Figure "8" Beach HOA to agree to reconsider a new northerly location for the structure, which initiated new Delft3D simulations for the terminal groin structures.

For Alternatives 5C and 5D, the total length of the terminal groin is 1,300 feet and 1,500 feet, respectively. Alternative 5C had a similar beach fill design as Alternative 5A (described below) with the beach fill being constructed using material derived from excavation of the previously permitted area in Nixon Channel and a new channel connecting Nixon Channel to the gorge of Rich Inlet. The excavation in Nixon Channel and the new channel connector would be the same as Alternative 5A. The beach fill along the ocean shoreline for Alternative 5D was similar to Alternative 5B with material for the fill to be obtained from maintenance of the previously permitted area in Nixon Channel.

A description of features of each of the terminal groin options (5A, 5B, 5C, and 5D) and a discussion of the model results for each follows.

Structural Design of Terminal Groins.

The following description of the structural design of the terminal groins is applicable to all terminal groin alternatives and is based on preliminary design considerations and the latest survey information. These considerations are subject to change during the preparation of detailed plans and specifications. The primary differences in the terminal groin designs between the various alternatives are the lengths of the shore anchorage and rubblemound sections as well as the position and alignment of the structures not with the type of material that would be used for their construction or the construction methodology.

The shore anchorage portion of the terminal groins would be constructed with sheet pile, either steel or concrete, and would have a top elevation of just below the elevation of the existing ground. The shore anchorage section would begin near the Nixon Channel shoreline and extend seaward to approximately the location of the 2007 mean high water shoreline (Figure 3.10). In general, the top elevation of the sheet pile will vary from +0.5 feet NAVD for the first 200 feet on the landward end to +1.5 ft NAVD over the remaining portion of the shore anchorage section. The top of the sheet pile over most of the shore anchorage section will be more than 0.5 ft below the existing ground level. This will facilitate continuing hydrologic exchange during all phases of the tidal cycle. Based on the April 2014 survey shown in Figure 3.10, the only portion of the shore anchorage section that would have a top elevation near the existing ground would be an 80-foot section located between 220 and 300 feet from the baseline measured along the centerline of the terminal groin.

The sheet pile section will begin near the Nixon Channel shoreline and end near the position of the 2007 mean high water line. To account for possible scour around the landward end of the shore anchorage section, a 10-foot wide rubble scour protection apron would be installed along both sides of the landward most 100 feet of the anchorage section. The toe apron would be installed at a depth of approximately -2 ft NAVD and would require the excavation of approximately 300 cy. Material excavated for the toe apron would be used to bury the toe protection stone following placement.

The total square feet of sheet pile will vary depending on the length of the shore anchorage section. The present preliminary design for the sheet pile would penetrate to a depth of -21 feet NAVD. Detailed design considerations would include soil borings along the alignment of the proposed structure to obtain soil characteristics as well as assumptions with regard to possible future positions of the south shoulder of Rich Inlet relative to the sheet piles. The assumed position of the south shoulder of the inlet would dictate soil and water loadings on the piles and hence dictate how deep the piles would need to be driven for stability.

The portion of the terminal groins extending seaward of the 2007 mean high water shoreline would be constructed with loose armor stone placed on top of a foundation mat or mattress. The top elevation of the rubblemound structure would not exceed +6.0 feet NAVD which is an elevation roughly equivalent to the elevation of the natural beach berm near Rich Inlet. Again, the final design of the rubblemound portion of the structure is subject to change given conditions near the time of actual construction.

The loose nature of the armor stone would be designed to facilitate the movement of littoral material through the structure. A typical profile of the terminal groin is shown on Figure 3.10. Figure 3.10 also shows the ground elevation along the centerline of the structure surveyed in April 2014 and the April 2007 profile taken at station 105+00 which was used as the basis of the terminal groin design. A typical cross-section of the rubblemound portion is shown in Figure 3.11.

As shown on Figure 3.11, the rubblemound section of the structure would include a 25-foot wide scour protection apron along the inlet side to protect the structure against undermining should the channel through Rich Inlet migrate next to the structure. Construction of the seaward portion of the terminal groin would require excavation of a trench approximately 75 to 80 feet wide at a depth of -5.5 ft NAVD. The excavated material would be returned to the trench, partially burying the structure, once construction is complete.

The concept design for the terminal groin presented here is intended to allow littoral sand transport to move over, around, and through the structure once the accretion fillet south of the terminal groin is artificially filled. This would be accomplished by setting the maximum crest elevation of the terminal groin to +6 feet NAVD, which is an elevation equal to approximately the natural berm elevation, and constructing the structure with large voids between adjacent stones. The relatively short length of the terminal groins seaward of the 2007 mean high water shoreline would also facilitate movement of sediment around the seaward end of the structures. The seaward 200 feet to 250 feet of the structure should be visible at all stages of the tide from both sides of the structure, however, the remaining portions of the structure would be buried below ground and would not be visible from the south side. While the north side of the rubblemound section may project a foot or two above ground, during normal weather conditions, wind-blown sand is expected to accumulate along the north side of the structure partially burying the exposed section.

Navigation aids to mark the location of the terminal groin, particularly its seaward end, will conform to the requirements of the US Coast Guard.

The shore anchorage section would be completely below ground and would not be visible. The only time the shore anchorage section could be visible would be in the unlikely event the entire north end of the island is eroded back to the position of the sheet piles.

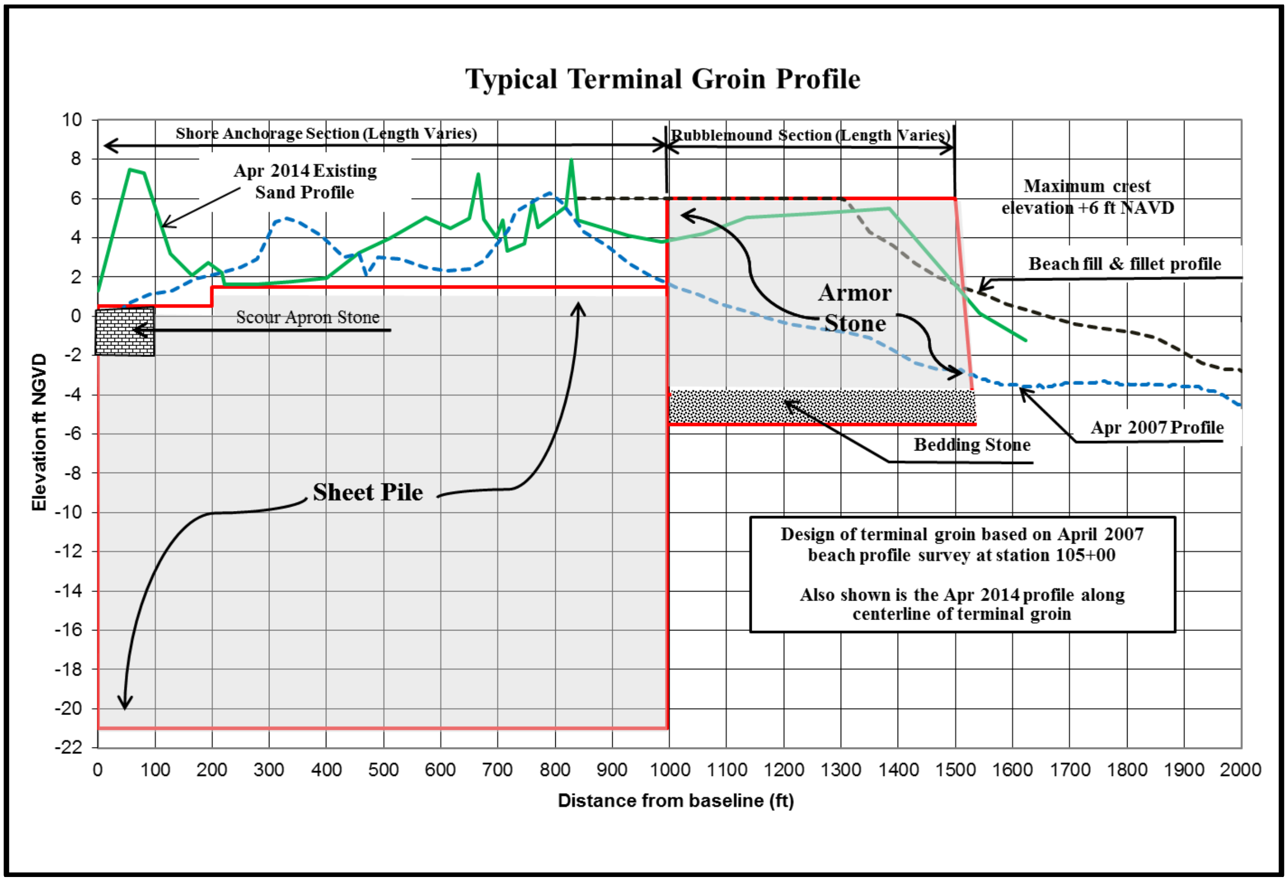


Figure 3.10. Typical Profile of terminal groins.

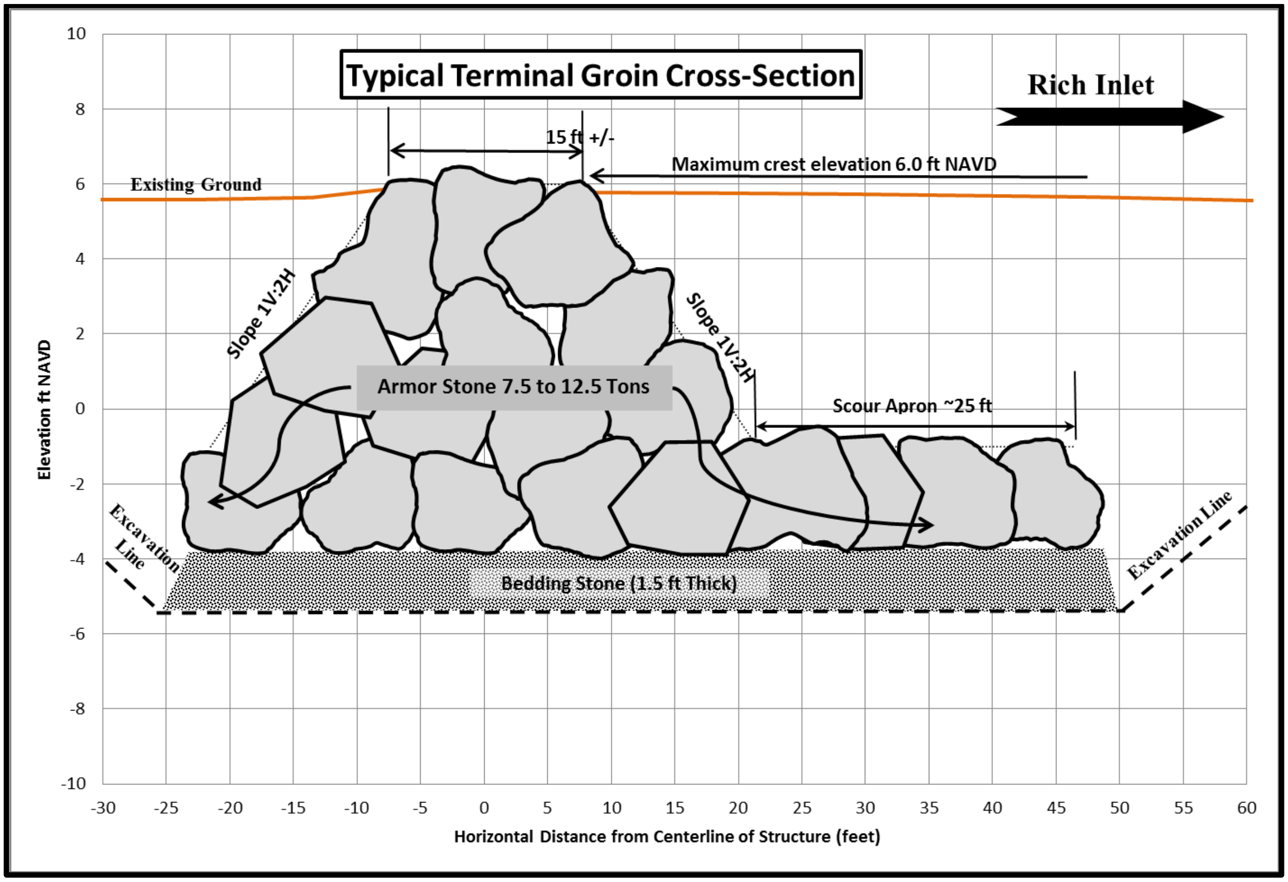


Figure 3.11. Typical terminal groin cross-section.

Terminal Groin Construction Methodology. The exact method used to construct the terminal groin would be left to the discretion of the construction contractor; however, the contractor would have to abide by defined construction corridors, shown in Figure 3.12, approved access locations, staging areas, permitted construction timeframes, and other restrictions that would limit adverse environmental impacts directly associated with the construction activity as defined below.

The stone required to construct the terminal groin would be transported via rail from commercial quarries to Wilmington Harbor where it would be offloaded onto barges and transported to the north end of Figure Eight Island via the Cape Fear River, Snows Cut, the AIWW, and Nixon Channel. A temporary offloading pier, a possible location of which is shown in Figure 3.12, could be constructed from the shoreline near the landward end of the terminal groin and extend northwestward into deep water in Nixon Channel. Note that during the time of actual construction, the contractor may be able to maneuver the stone barges close enough to shore to offload the stone directly to the shore without having to construct the temporary pier. The stone would be offloaded directly from the barges onto trucks which would transport the stone to the terminal groin site. Should the use of Beach Road North be permissible to transport stone to the terminal groin site, this option may be utilized by the contractor as well.

The sheet pile for the landward portion of the terminal groin would be transported directly to the site by truck from where it would be offloaded and driven into place with typical pile driving equipment.

A construction corridor of 100 ft on both sides of the terminal groin centerline would be established in all areas except portions of the shore anchorage section where the width of the corridor would be reduced to 50 ft and would only encompass the southeastern side of the centerline of the structure (Figure 3.12). This narrower construction corridor would apply to about 300 feet of the shore anchorage section that passes through jurisdictional wetlands on the north end of Figure Eight Island. A 75 to 80-ft wide trench would be excavated down to a depth of -5.5 ft NAVD along the seaward portion of the construction corridor to accommodate the rubblemound section of the terminal groin. Backhoes or large cranes would be used to excavate the trench. Excavation of the trench would involve the temporary removal of 8,000 cy. The excavated material would be temporarily stockpiled next to the trench within the construction corridor. The excavated material will be replaced around and on top of the terminal groin during the final construction stages.

A 1.5-foot thick foundation blanket consisting of stones ranging in size from 4 inches to 12 inches would be spread over the bottom of the trench. The foundation blanket could be replaced by a stoned-filled articulated mattress once the construction moves into open waters. This would be followed by the placement of armor stone directly on top of the foundation blanket in the form of a trapezoidal mound with side slopes of 1V:2H. The size of the armor stone used for the rubblemound portion of the structure would range from 7.5 tons to 12.5 tons.

For the section of the groin that would be constructed on dry land, trucks would carry the stone to the crane over land while staying within the construction corridor. Once the groin projects into the water, the stones would be delivered to the crane by the trucks traveling down the top of the groin or, if conditions allowed, delivery of the stones via barge may be possible. As another option, the construction contractor could elect to construct a temporary pier adjacent to the terminal groin and place the stone directly from the trucks.

The construction corridor would be restored to pre-construction conditions as much as possible by grading any disturbed land and replanting with native vegetation.

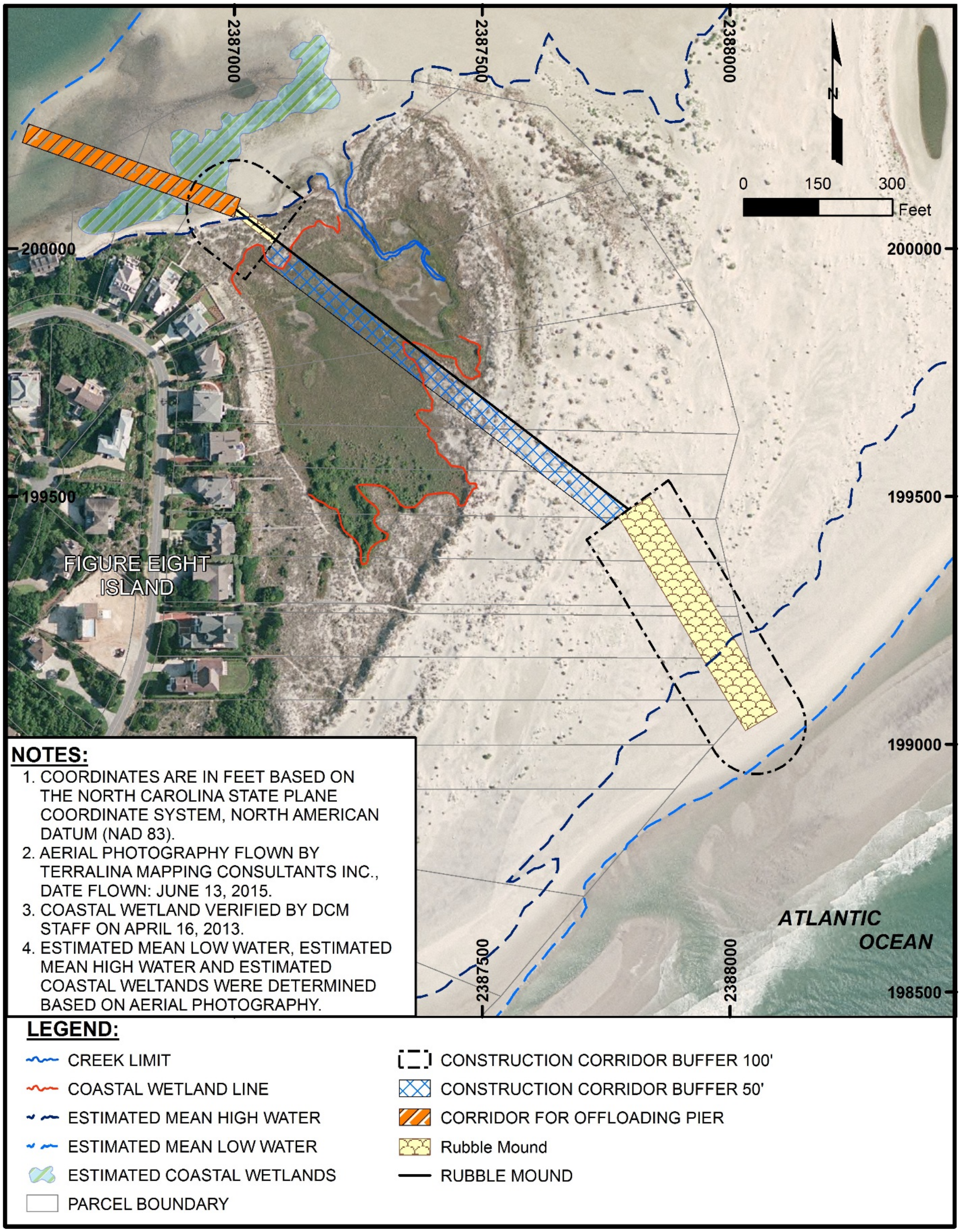


Figure 3.12. Footprint of the terminal groin, construction corridor, and offloading pier for Alternative 5D.

Alternative 5A: Terminal Groin with Beach Fill from Nixon Channel and a New Connector Channel

A 1,600-foot long terminal groin would be constructed at the extreme north end of Figure Eight Island to control both wave and tidal current induced shoreline changes immediately south of Rich Inlet (Figure 3.13a). The terminal groin would include a 900-foot shore anchorage section constructed with either steel or concrete sheet pile. The landward 100 feet of the shore anchorage section would include a 10-foot wide stone scour protection mat on both sides of the sheet pile. The purpose of the shore anchorage section is to protect against possible flanking of the landward end of the structure. In this regard, flanking is defined as erosion around the landward end of a structure which ultimately exposes the normally "dry" side of the structure to the water. The seaward portion of the structure would extend 700 feet seaward of the 2007 mean high water shoreline and would be constructed with loosely placed stone to facilitate the movement of sand through the structure.

Alternative 5A includes the construction of a new channel that would connect the previously permitted area within Nixon Channel with the inlet gorge (Figure 3.13a). The purpose of the new channel connector is to concentrate ebb flows away from the eroding portion of the Nixon Channel shoreline. Preliminary Delft3D model runs and engineering analysis were conducted to determine the optimal dredge options within Nixon Channel and the connector channel. All of the preliminary model runs were based on 2006 conditions; however, initial dredge quantities were computed using both the 2006 and 2012 survey data. These dredging options included:

- Option 1 – 660-740 foot wide connecting cut.
- Option 2 – 600 foot wide connecting cut.
- Option 3 – 395-416 foot wide connecting cut.

Engineering analysis determined that dredging Option 2 would provide the desired level of flow control by keeping concentrated flows away from the Nixon Channel shoreline. In addition, the model results found Option 2 would be conducive to navigation by maintaining a depth of at least -10 feet NAVD at the seaward end of Nixon Channel over the 5-year simulation period. Construction of the new channel connector and reestablishing the permitted dimensions in Nixon Channel would involve the total excavation of 994,400 cy based on the April 2006 survey condition and 1,077,100 cy based on the 2012 survey. Based on the 2006 survey, 319,600 cy would come from the existing Nixon Channel permit area and the remaining 675,300 cy excavated to construct the new channel connector. For the 2012 survey condition, 375,200 cy would come from the existing Nixon Channel permit area and the remaining 701,900 cy excavated to construct the new channel connector.

An estimated 29,700 cy of the channel material is clay and would be deposited in an upland disposal site. This would leave 964,700 cy of sandy or beach quality material based on the 2006 survey conditions and 1,047,400 cy or beach quality material based on the 2012 survey. For both the 2006 and 2012 conditions, the beach fill along the Nixon Channel shoreline would require 57,000 cy leaving 907,700 cy for the ocean shoreline based on the 2006 conditions and 990,400 cy based on the 2012 conditions.

The material removed to construct the new channel connector into Nixon Channel and reestablish the dimensions of the previously permitted area within Nixon Channel would be used to construct a beach fill in the same two areas as Alternatives 3 and 4, i.e., one fronting Nixon Channel and a second covering the ocean shoreline from Beachbay Lane (F90+00) to the terminal groin located at station 100+00. Dune fill would also be included in the area from stations 77+50 to 95+00. Excavation of the material from the Nixon Channel and construction of the new connector into Nixon Channel could be accomplished by a 20-inch or smaller cutter-suction pipeline dredge.

The beach fill design along the ocean shoreline for Alternative 5A was based on the optimal distribution of the 964,700 cy and 1,047,400 cy of beach quality material that would be removed based on the 2006 and 2012 surveys, respectively, to construct the new channel connector and maintain the previously permitted area within Nixon Channel. The volume of fill material placed along the 1,400-foot shoreline along Nixon Channel would be 57,000 cy which is the same as Alternatives 3 and 4 and will be tapered to terminate prior to the tidal creek which drains the marsh area on the north end of the island. The volume of fill needed for Nixon Channel was the same for both the 2006 and 2012 conditions. The distribution of balance of the material along the ocean shoreline would concentrate more of the fill in the area immediately south of the terminal groin in the area generally referred to as an accretion fillet. Also, no fill would be placed north of the terminal groin. The design berm widths and beach fill placement densities along the ocean shoreline for the 2006 and 2012 conditions are provided in Tables 3.7a and 3.7b, respectively.

An artificial dune similar to Alternatives 3 and 4 would be provided in the existing sandbag area between stations 77+50 and 95+00. If required by permit conditions, the sandbags could be removed upon completion of the beach fill by manually tearing the fabric and utilizing heavy machinery to extract the bag leaving the sand in place.

The plan layout for Alternative 5A, which is applicable for both the 2006 and 2012 conditions, is shown in Figures 3.13a-d.

Table 3.7a. Alternative 5A beach fill design (based on 2006 condition).

Shoreline Segment (Baseline Stations)	Design Berm Width (ft)	Fill Volumes (cy/lf)		
		Berm	Dune	Total
Terminal groin (100+00) to 95+00	91	106	0	106
95+00 to 75+00	91	106	21 to 23	127 to 129
75+00 to 50+00	74	106	0	106
50+00 to 40+00 (transition)	74 to 28	106 to 40	0	106 to 40
40+00 to F100+00	28	40	0	40
F100+00 to F90+00 (transition)	28 to 0	40 to 0	0	40 to 0

Table 3.7b. Alternative 5A beach fill design (based on 2012 condition).

Shoreline Segment (Baseline Stations)	Design Berm Width (ft)	Fill Volumes (cy/lf)		
		Berm	Dune	Total
Terminal groin (100+00) to 95+00	99	115	0	115
95+00 to 75+00	99	115	21 to 23	136 to 138
75+00 to 50+00	99	115	0	115
50+00 to 40+00 (transition)	99 to 37	115 to 43	0	115 to 43
40+00 to F100+00	37	43	0	43
F100+00 to F90+00 (transition)	37 to 0	43 to 0	0	43 to 0

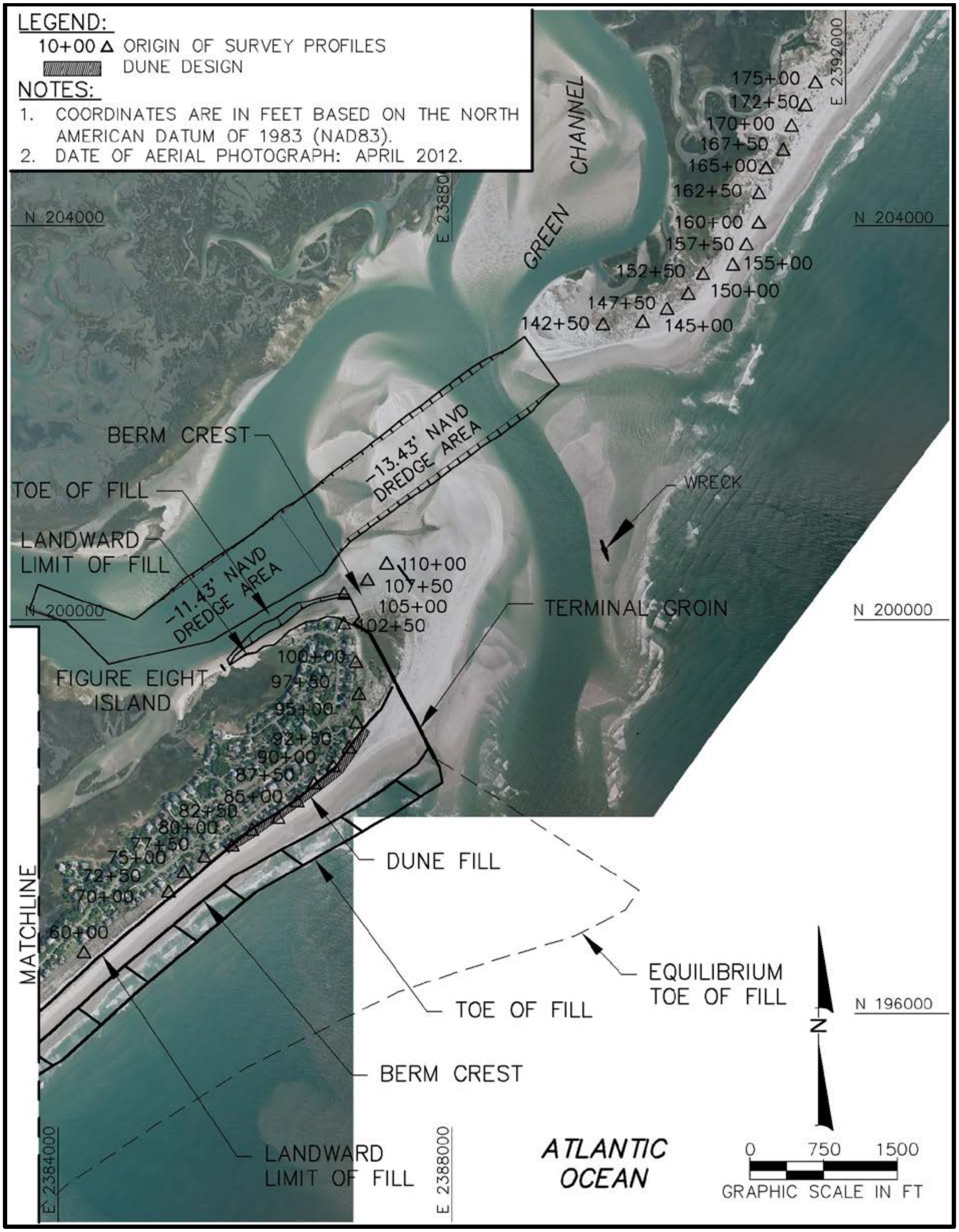


Figure 3.13a. Plan view of northern portion of Alternative 5A; 2012 shoreline conditions.

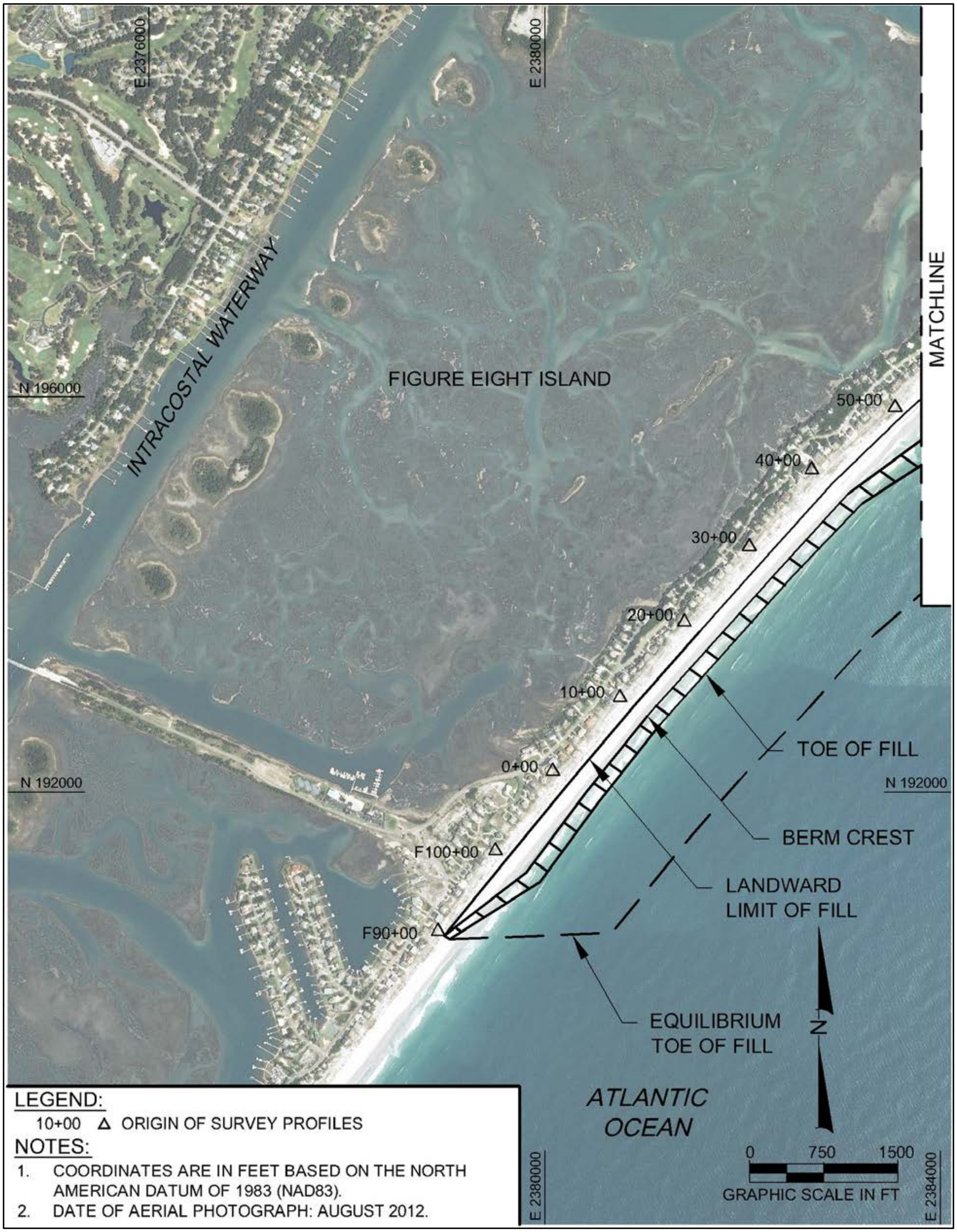


Figure 3.13b. Plan view of southern portion of Alternative 5A; 2012 shoreline conditions.

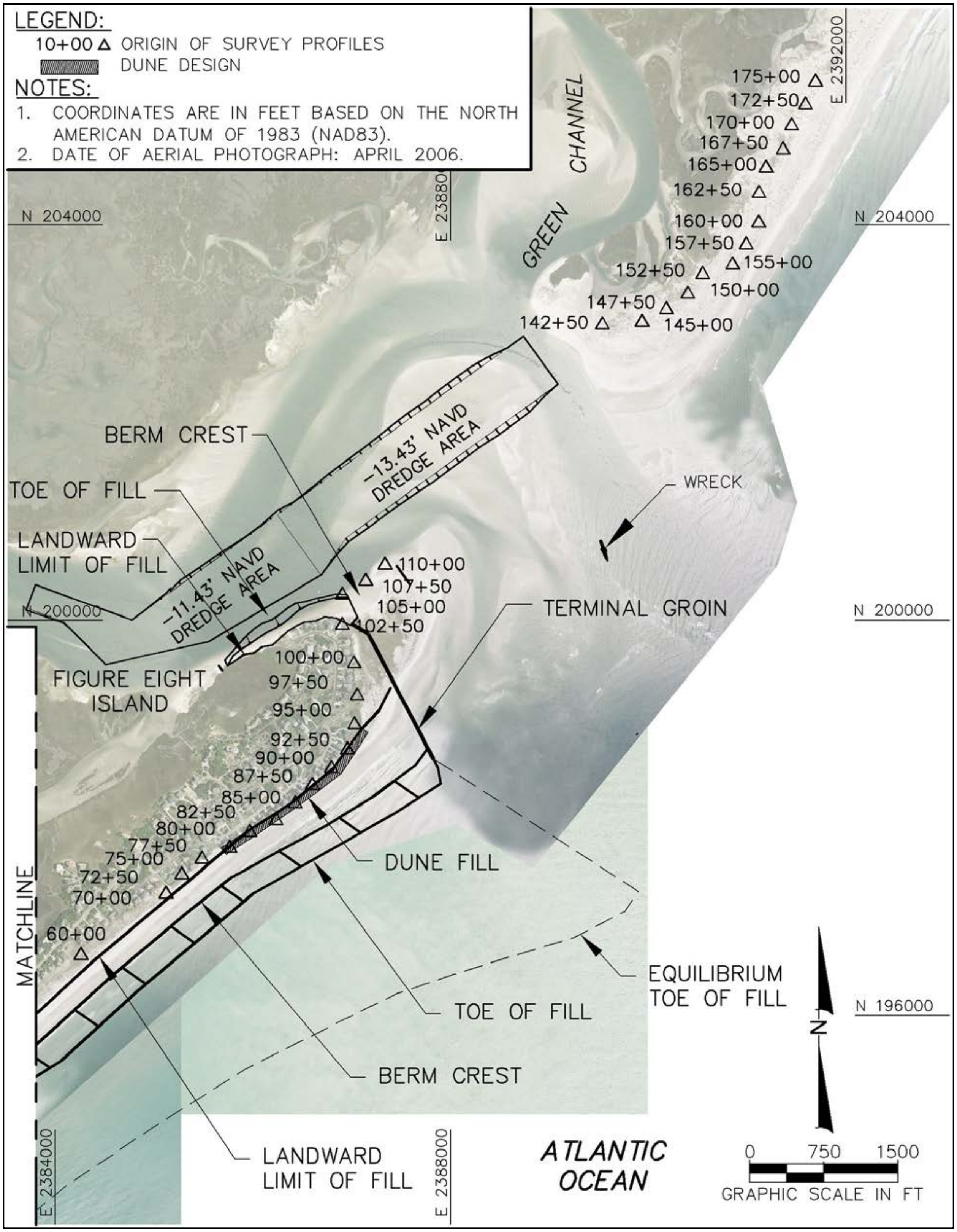


Figure 3.13c. Plan view of northern portion of Alternative 5A; 2006 shoreline conditions.

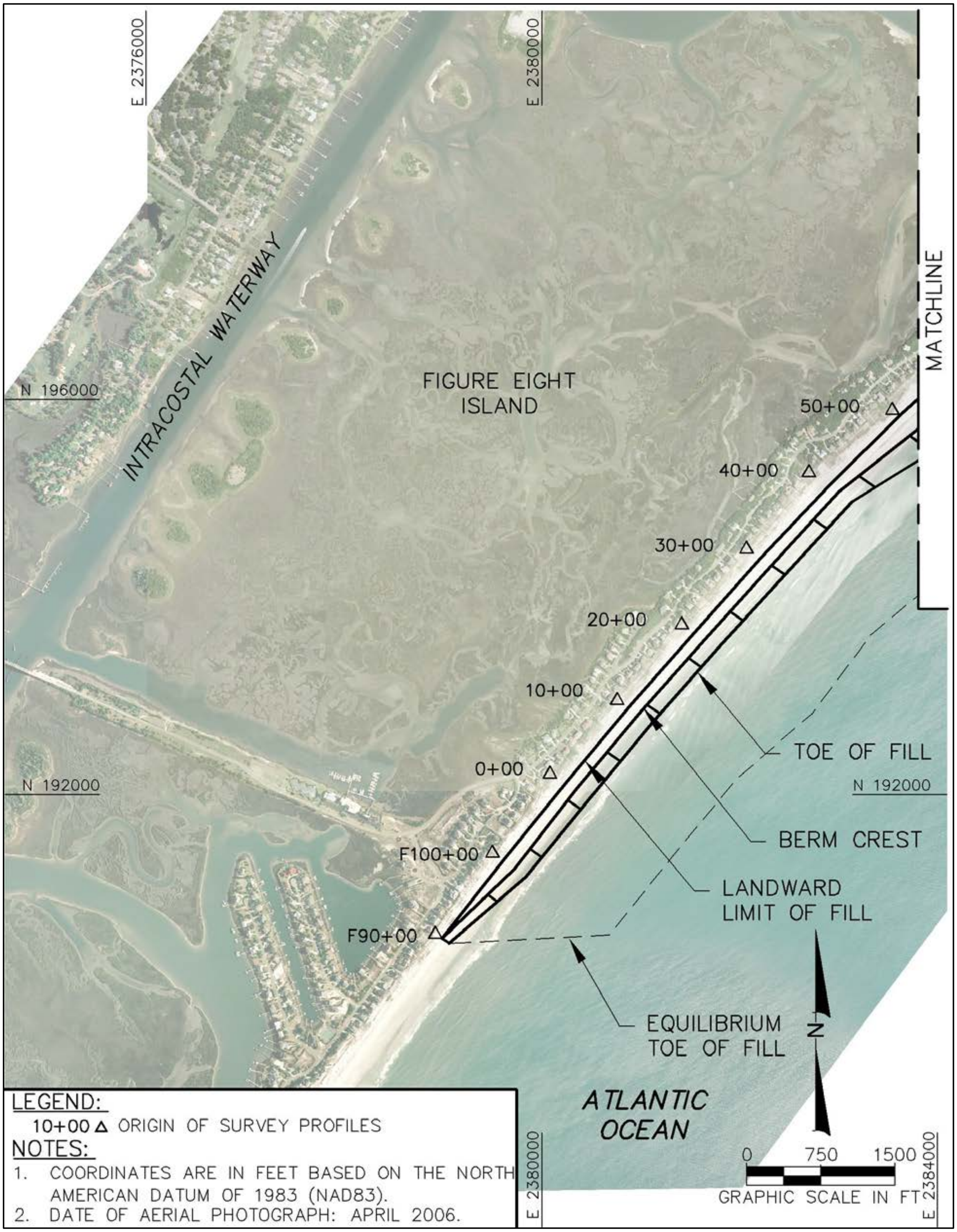


Figure 3.13d. Plan view of southern portion of Alternative 5A; 2006 shoreline conditions.

Channel Maintenance Requirements.

Based on the results of the Delft3D model simulation for Alternative 5A, the rate of shoaling of the previously permitted area was fairly steady during the five-year simulation while the proposed channel connector experienced rapid shoaling over the first two years. Shoaling of the proposed connector moderated between years 3 and 4 of the simulation with the model predicting some possible scour during the last year of the simulation. Based on the model results using the 2006 conditions, the 5-year channel maintenance requirement would be 487,000 cy. While Alternative 5A was not simulated using the 2012 conditions, maintenance of the channel in Nixon Channel would be comparable to that indicated by the model for the 2006 conditions.

Periodic Nourishment – Alternative 5A.

The beach area between stations F90+00 and 30+00 accreted during the 5-year simulation and would not require periodic nourishment. Using the 2006 conditions only, the computed volume losses from the fill between stations 30+00 and 100+00 averaged 85,000 cy/year over the 5-year simulation period. Assuming periodic maintenance of the previously permitted area in Nixon Channel and the proposed connecting channel is accomplished every five years, the nourishment requirement for the ocean shoreline would be 425,000 cy. Nourishment of the Nixon Channel fill area would also require 30,000 cy as with the other alternatives bringing the total five year nourishment requirement to 455,000 cy.

Material for periodic nourishment of Alternative 5A would be derived from maintenance of the previously permitted area in Nixon Channel and the new channel connecting Nixon Channel to the inlet gorge. The maintenance dredging would be performed by an 18-inch or smaller cutter-suction pipeline dredge.

The channel maintenance requirement of 487,000 cy every 5 years or 97,400 cy/year is approximately equal to the average annual amount of material removed to maintain the previously permitted area since 1993. As mentioned above, maintenance of the previously permitted area removed about 1.75 million cy between 1993 and 2011 which is equivalent to an annual rate of about 97,000 cy/year. Therefore, based on both actual experience and model predictions, maintenance of the previously permitted area in Nixon Channel and the new connector channel should be sufficient to satisfy periodic beach nourishment requirements for Alternative 5A.

Implementation Cost. The costs for implementing Alternative 5A are summarized below. Detailed cost estimates for Alternative 5A, as well as cost estimates for the other alternatives discussed in this Chapter, are provided in Appendix B and Appendix G.

Construction costs for Alternative 5A would include the cost of constructing the new channel from the inlet gorge into Nixon Channel with the disposal of that material along 1,400 feet of the Nixon Channel shoreline and along the ocean shoreline north of Bridge Road plus the cost of constructing the terminal groin. Construction of the new channel would involve the removal of 1,077,100 cy given the 2012 conditions and 994,400 for the 2006 conditions. As presented above, the terminal groin would be constructed with both sheet pile and rubblemound.

The initial construction cost of the terminal groin is estimated to be $4,836,000 which includes engineering and design and construction oversight. Maintenance of the terminal groin would depend on the number of times the design conditions for the structure would be exceeded over the 30-year planning period. Since this cannot be predicted with any degree of certainty, maintenance of the structure was based on an assumption that an average of 1% of the armor stone would have to be replaced every year. Given this assumption, maintenance of the Alternative 5A terminal groin would average $25,000 per year. Note this does not mean maintenance of the structure would be needed every year. Over the course of the 30-year evaluation period, maintenance of the structure may only be needed two or three times with the average annual equivalent cost of these future repairs equal to $25,000 per year.

Construction of the beach fills along Nixon Channel and the ocean shoreline and the dredging of Nixon Channel and the new channel to the inlet gorge would cost $8,984,000 based on the 2006 conditions and $9,617,000 based on the 2012 conditions. The total initial construction cost of Alternative 5A would be $13,820,000 for the 2006 conditions and $14,453,000 for the 2012 conditions.

Excavation of the material from Nixon Channel and the new channel connector would take about 4 months. Ideally, construction of the terminal groin would take place following completion of the beach fill; however, this is not a requirement as the rubblemound section could be installed either before or after initial beach fill placement. However, construction of the terminal groin following beach fill placement could be advantageous in terms of construction cost as most of the terminal groin could be constructed using land-based equipment. Overall, the total construction time for Alternative 5A is expected to take between 6 and 6.5 months.

Periodic nourishment of the beach fills in Nixon Channel and the ocean shoreline using material obtained from maintenance of the existing Nixon Channel permit area would cost $4,856,000 every five years.

The average annual equivalent cost for constructing and maintaining Alternative 5A, which was computed using a 6% discount rate over the 30-year planning period, would be $1,890,000 for the 2006 conditions and 1,936,000 for the 2012 conditions. Over the 30-year planning period, the total implementation cost for Alternative 5A in current dollars would range from $43.68 million for the 2006 condition to $44.31 million for the 2012 condition. See Appendix B and Appendix G for more information regarding cost.

Alternative 5B: Terminal Groin with Beach Fill from Nixon Channel and Other Sources

For Alternative 5B, the terminal groin would have the same design as that described for Alternative 5A as would the beach fill along Nixon Channel. With regard to the beach fill along the ocean shoreline, analysis of the Delft3D model results for Alternative 5A indicated the initial beach fill was excessive, particularly along the segment of the beach south of station 80+00. Also, the segment of the shoreline between stations F90+00 and 30+00 accreted while the area between stations 30+00 and 60+00 experienced very minor losses. Again, the beach fill design associated with Alternative 5A was based on the optimal utilization of the material removed to construct the new channel connector from the inlet gorge into Nixon Channel not on the beach fill volume needed to offset shoreline erosion tendencies. Therefore, the beach fill for Alternative 5B was designed to address erosion protection needs along the northern portion of Figure Eight Island.

The beach fill for Alternative 5B was limited to the area between station 60+00 (approximately 322 Beach Road North) and the terminal groin (station 100+00) since the Delft3D simulation for Alternative 5A indicated the shoreline south of station 60+00 would either be stable or only experience minor volume losses that would not require periodic nourishment on a regular basis. Details of the Delft3D model results for Alternative 5B are provided in Appendix B. The placement rates and design berm widths for the Alternative 5B beach fill are given in Table 3.8 with the plan layout provided in Figures 3.14a and 3.14b. The beach fill design for Alternative 5B would be the same for both the 2006 and 2012 survey conditions. The beach fill for Alternative 5B would not include an artificial dune in the areas presently fronted by sandbags. The total volume of beach fill along the ocean shoreline would be 197,500 cy. The Nixon Channel beach fill would require 57,000 cy bringing the total beach fill volume to 254,500 cy.

The material to construct the beach fill for Alternative 5B would be derived from maintenance of the previously permitted area in Nixon Channel. Based on past maintenance operations in the previously permitted area of Nixon Channel and anticipated shoaling rates indicated by the Delft3D simulations, the volume of material available from the previously permitted area would satisfy the volumetric requirements for Alternative 5B. The beach compatible material contained in the three (3) northern upland disposal areas (discussed under Alternative 4) would serve as contingency sediment sources. These sources would be used in the event shoaling of the previously permitted area in Nixon Channel is not sufficient to satisfy periodic beach nourishment needs and/or if Figure Eight Island needs additional material to respond to storm damage.

Construction of the beach fill could be accomplished with a 16-inch to 18-inch cutter-suction pipeline dredge which are similar to the ones that perform routine maintenance in the AIWW.

Table 3.8. Alternative 5B beach fill placement volumes and design berm widths under both 2006 and 2012 conditions.

Shoreline Segment (Baseline Stations)	Placement Volume (cy/lf)	Design Berm Width (ft)
Terminal groin (100+00) to 80+00	80	69
80+00 to 72+50 (transition)	80 to 20	69 to 17
72+50 to 70+00	20	17
70+00 to 60+00 (transition)	20 to 0	17 to 0

<u>Periodic Nourishment – Alternative 5B</u>.

Simulation of Alternative 5B in the Delft3D model indicated the beach fill area (station 60+00 to the terminal groin) would lose an average of 51,000 cy/year over the 5-year simulation period using both 2006 and 2012 survey conditions. As was the case for Alternative 5A, the segment south of stations 60+00 to F90+00 was stable to accretionary with the area actually gaining material at a rate of 50,000 cy/year.

Beginning in year 4 of the simulation and continuing into year 5, erosion began to affect the pre-nourishment profile primarily north of station 80+00. Given these model results under both 2006 and 2012 conditions, periodic nourishment of the beach fill under Alternative 5B would be needed about every 5 years. Based on the model indicated loss rate of 51,000 cy/year, the 5-year periodic nourishment requirement would be 255,000 cy. The beach fill along the Nixon Channel shoreline would again require 30,000 cy every five years resulting in a total 5-year periodic nourishment requirement for both fills of 285,000 cy.

The maintenance dredging would be performed by a 16-inch to 20-inch cutter-suction pipeline dredge, which is the same size dredge that would be used for initial construction of the Alternative 5B beach fill.

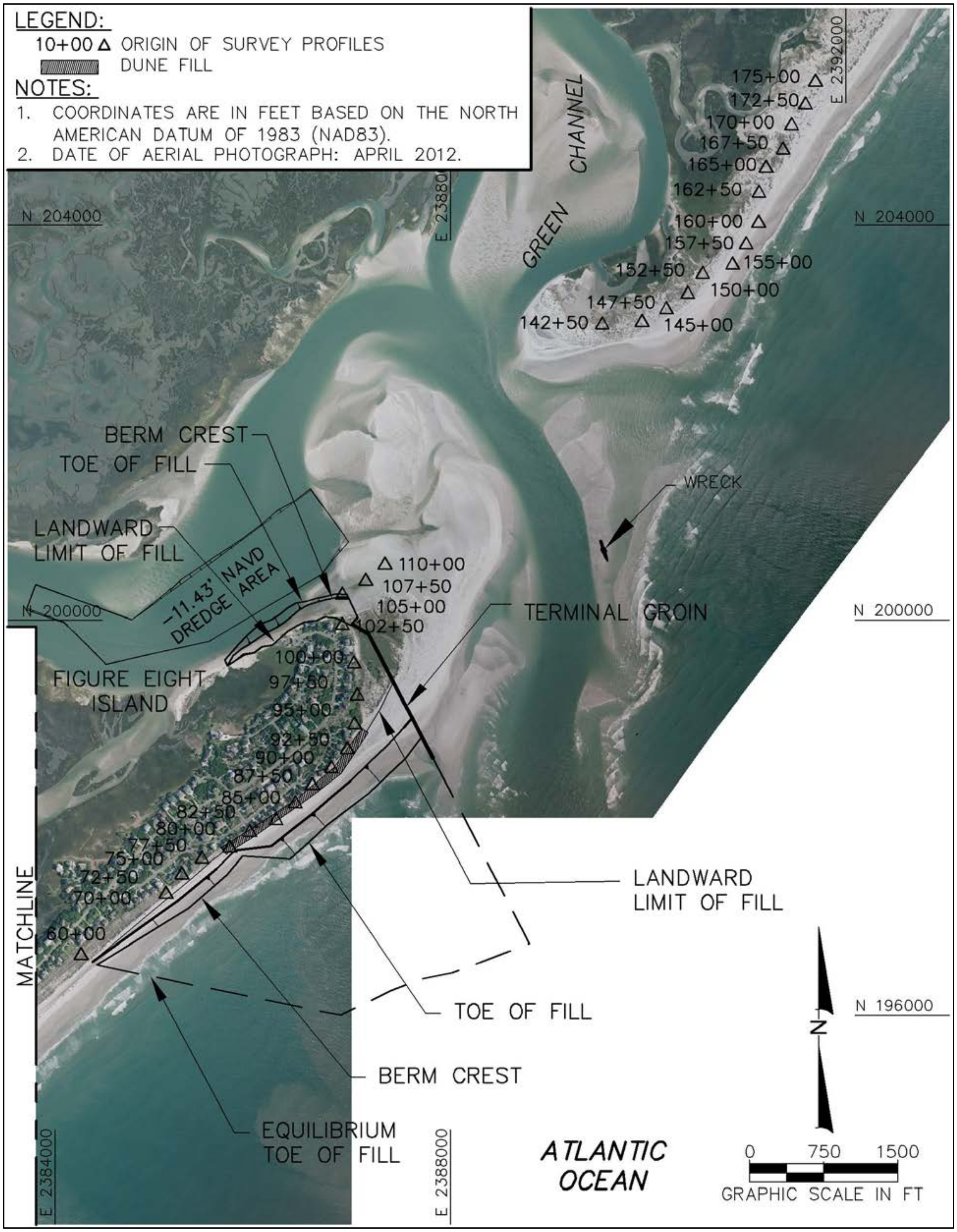


Figure 3.14a. Plan View of Alternative 5B; 2012 shoreline conditions.

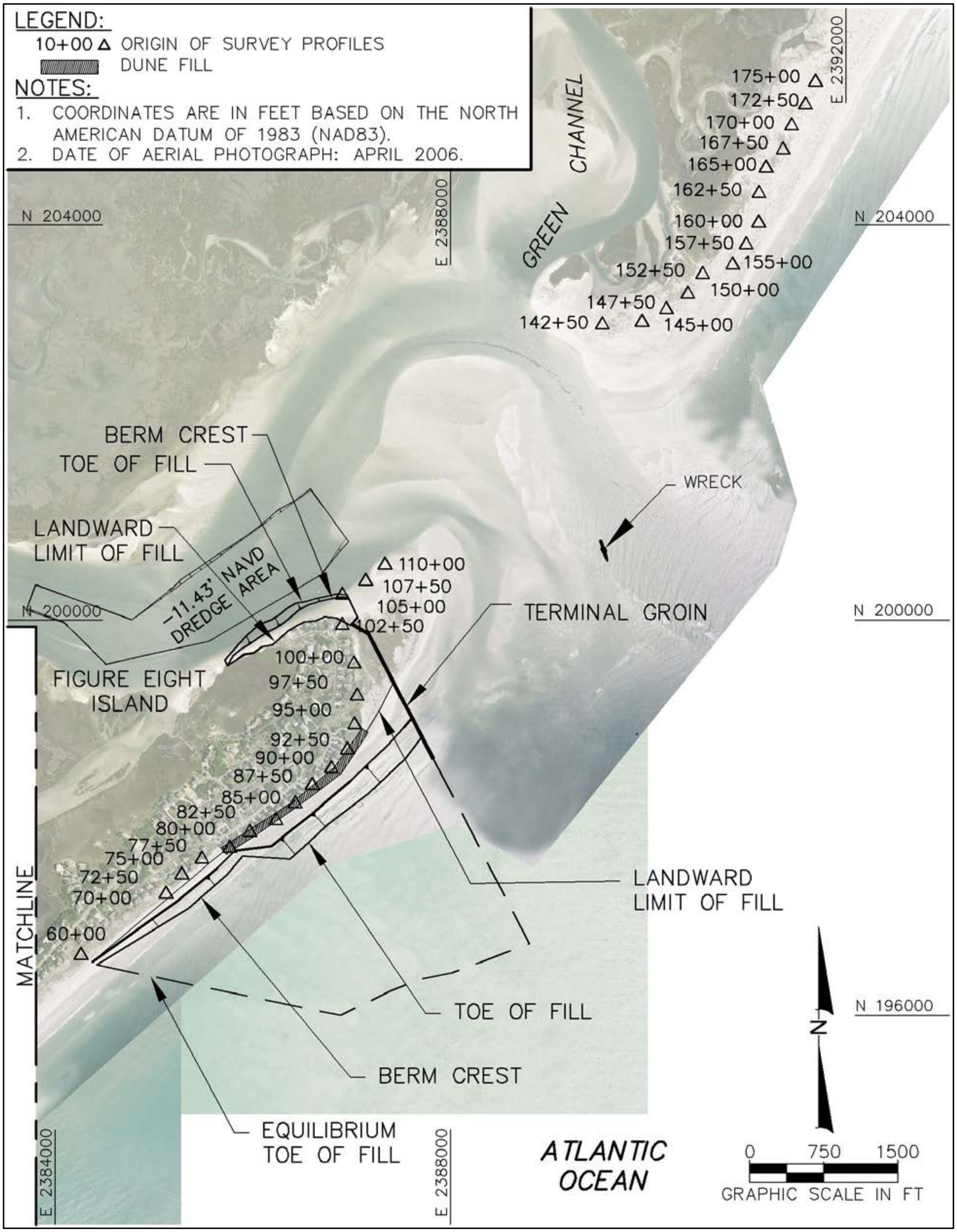


Figure 3.14b. Plan View of Alternative 5B; 2006 shoreline conditions.

Implementation Cost. Initial construction costs for the terminal groin would be $4,836,000 which is the same as Alternative 5A. The initial costs of the beach fills along the Nixon Channel and ocean shoreline using material from the Nixon Channel permit area would be $2,607,000 resulting in a total cost for initial construction (beach fills and terminal groin) of $7,443,000. The costs for Alternative 5B would be the same for both the 2006 and 2012 survey conditions. The construction time of the terminal groin would be the same as Alternative 5A, however, construction of the beach fill would only require about 1.5 months. The total construction time for Alternative 5B could range from 4 to 5 months.

Maintenance of the terminal groin would average $25,000 per year which is the same as Alternative 5A. Maintenance of the previously permitted area in Nixon Channel with disposal of the material along Nixon Channel shoreline and the ocean shoreline would cost $2,764,000 every 5 years. Over the 30-year planning period, the total cost for Alternative 5B in current dollars would be about $24.76 million.

The equivalent average annual cost for Alternative 5B, computed with a discount rate of 6% over an amortization period of 30 years is $1,056,000. See Appendix B and Appendix G for more information regarding cost.

Alternative 5C: Terminal Groin at a More Northerly Location with Beach Fill from Nixon Channel and a New Connector Channel

Alternative 5C includes a 1,300-foot terminal groin located near baseline station 105+00 or in the more northerly position relative to Alternatives 5A and 5B as shown in Figure 3.9. The terminal groin would include a 995-foot shore anchorage section extending landward of the 2007 mean high water shoreline and a 305-foot section extending seaward of the 2007 mean high water shoreline. The shore anchorage section would be constructed with sheet pile (steel or concrete) while the seaward section would be of rubblemound construction. The landward 100 feet of the shore anchorage section would include a 10-foot wide scour protection mat on both sides of the sheet pile. The beach fill for Alternative 5C would have a similar design as the fill described for Alternative 5A with material to construct the beach fill also being derived from the same source as described under Alternative 5A, i.e., the previously permitted area in Nixon Channel and a new channel connecting Nixon Channel with the gorge of Rich Inlet.

Excavation of the previously permitted area in Nixon Channel and the new channel connecting Nixon Channel with the gorge of Rich Inlet would involve the removal of 994,400 cy based on the 2006 conditions and 1,077,100 cy based on the 2012 condition. An estimated 29,700 cy of the channel material is clay and would be deposited in an upland disposal site. This would leave 964,700 cy of sandy or beach quality material based on the 2006 survey conditions and 1,047,400 cy or beach quality material based on the 2012 survey. For both the 2006 and 2012 conditions, the beach fill along the Nixon Channel shoreline would require 57,000 cy leaving 907,700 cy for the ocean shoreline based on the 2006 conditions and 990,400 cy based on the 2012 conditions.

Given the two possible dredge volumes from Nixon Channel and the new channel connector based on the 2006 and 2012 conditions, two possible beach fill plans were developed with the berms widths and fill distributions for each provided in Table 3.9a for the 2006 condition and

Table 3.9b for the 2012 condition. The plan layout for Alternative 5C is shown in Figures 3.15a-d.

Table 3.9a. Alternative 5C beach fill placement volumes and design berm widths based on 2006 conditions.

Shoreline Segment (Baseline Stations)	Design Berm Width (ft)	Fill Volumes (cy/lf)		
		Berm	Dune	Total
Terminal groin (105 +00) to 95+00	91	106	0	106
95+00 to 75+00	91	106	21 to 23	127 to 129
75+00 to 50+00	91	106	0	106
50+00 to 40+00 (transition)	91 to 34	106 to 40	0	106 to 40
40+00 to F100+00	34	40	0	40
F100+00 to F90+00 (transition)	34 to 0	40 to 0	0	40 to 0

Table 3.9b. Alternative 5C beach fill placement volumes and design berm widths based on 2012 conditions.

Shoreline Segment (Baseline Stations)	Design Berm Width (ft)	Fill Volumes (cy/lf)		
		Berm	Dune	Total
Terminal groin (105 +00) to 95+00	99	115	0	114.9
95+00 to 75+00	99	115	21 to 23	136 to 138
75+00 to 50+00	99	115	0	115
50+00 to 40+00 (transition)	99 to 37	115 to 43	0	115 to 43
40+00 to F100+00	37	43	0	43
F100+00 to F90+00 (transition)	37 to 0	43	0	43 to 0

Periodic Nourishment – Alternative 5C.

The 5-year simulation of Alternative 5C in the Delft3D model, under both 2006 and 2012 conditions, indicated the beach area between stations F90+00 and 30+00 would accrete while the segment between stations 30+00 and 60+00 would only experience minor losses and would not require periodic nourishment. As a result, periodic nourishment for Alternative 5C would be required primarily between stations 60+00 and 105+00. Even though model results indicate the area south of station 60+00 may not need periodic nourishment that area would continue to be monitored and nourishment provided if future conditions warrant. The Delft3D model simulated losses from the section of the shoreline between station 60+00 and the terminal groin (station 105+00) averaged 93,000 cy/year over the 5-year simulation period. Assuming periodic maintenance of the previously permitted area in Nixon Channel and the proposed connecting channel is accomplished every five years, the nourishment requirement for the ocean shoreline would be 465,000 cy. Nourishment of the Nixon Channel fill area would also require 30,000 cy as with the other alternatives bringing the total five year nourishment requirement to 495,000 cy. Details of the Delft3D model results for Alternative 5C are provided in Appendix B.

Material for periodic nourishment of Alternative 5C would be derived from maintenance of the previously permitted area in Nixon Channel and the new channel connecting Nixon Channel to the inlet gorge. The maintenance dredging would be performed by an 18-inch or smaller cutter-suction pipeline dredge.

Based on the Delft3D simulations, shoaling of Nixon Channel and the new channel connector over the 5-year simulation period totaled 487,000 cy, or 97,400 cy/year, whereas the total periodic nourishment requirement for Alternative 5C is estimated to be 495,000 cy every 5 years, or 99,000 cy/year. As mentioned above, maintenance of the previously permitted area in Nixon Channel removed about 1.75 million cy between 1993 and 2011 which is equivalent to an annual rate of about 97,200 cy/year. Even though the shoaling in the Nixon Channel borrow area over 5 years indicated by the Delft3D model is 8,000 cubic yards less than the periodic nourishment needed for both the ocean shoreline and the Nixon Channel, past operations did not include the new connector channel. Therefore, a reasonable assumption is that maintenance dredging in Nixon Channel and the new channel connector would be sufficient to satisfy periodic beach nourishment requirements for Alternative 5C.

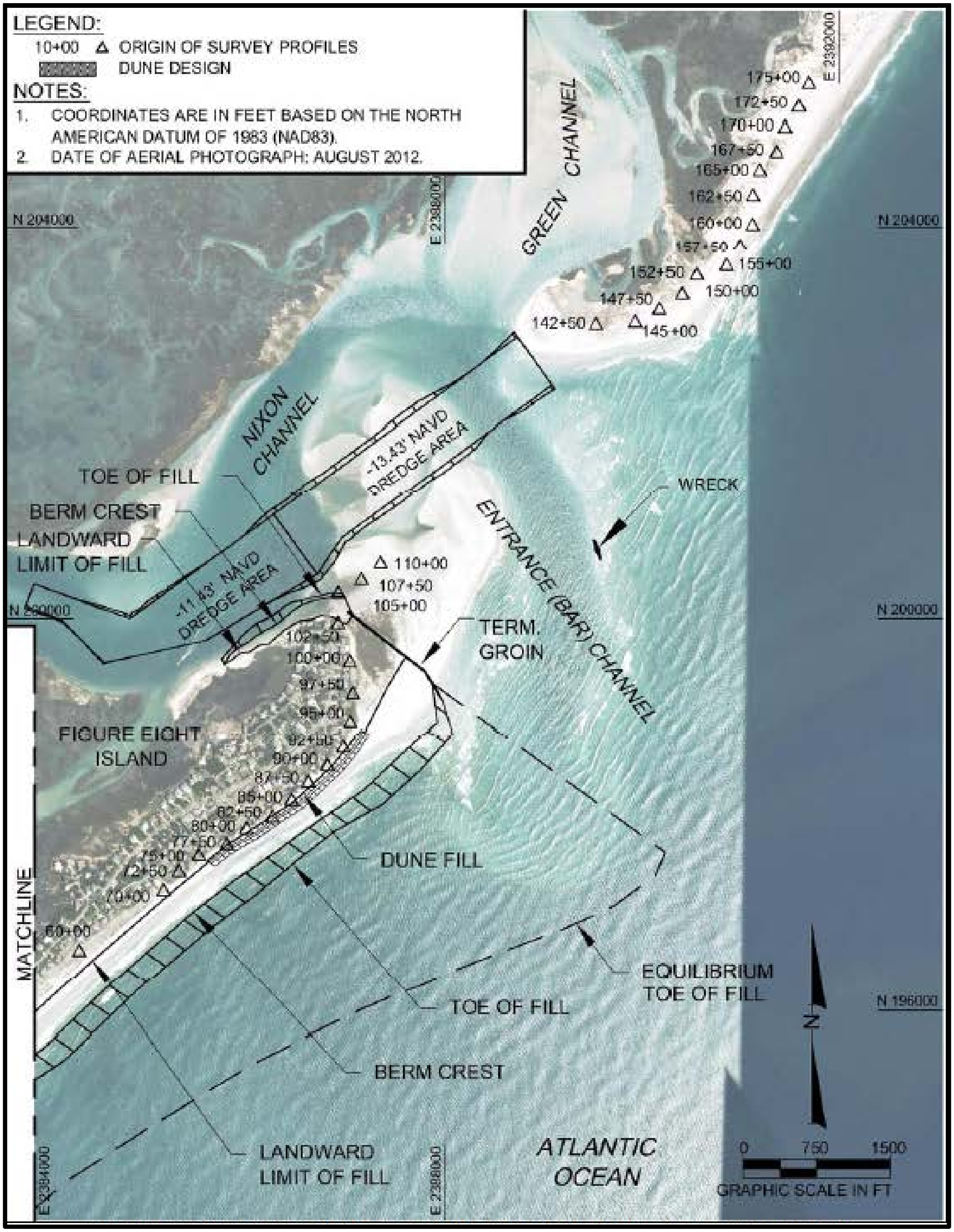


Figure 3.15a. Plan View of the northern portion of Alternative 5C; 2012 shoreline conditions.

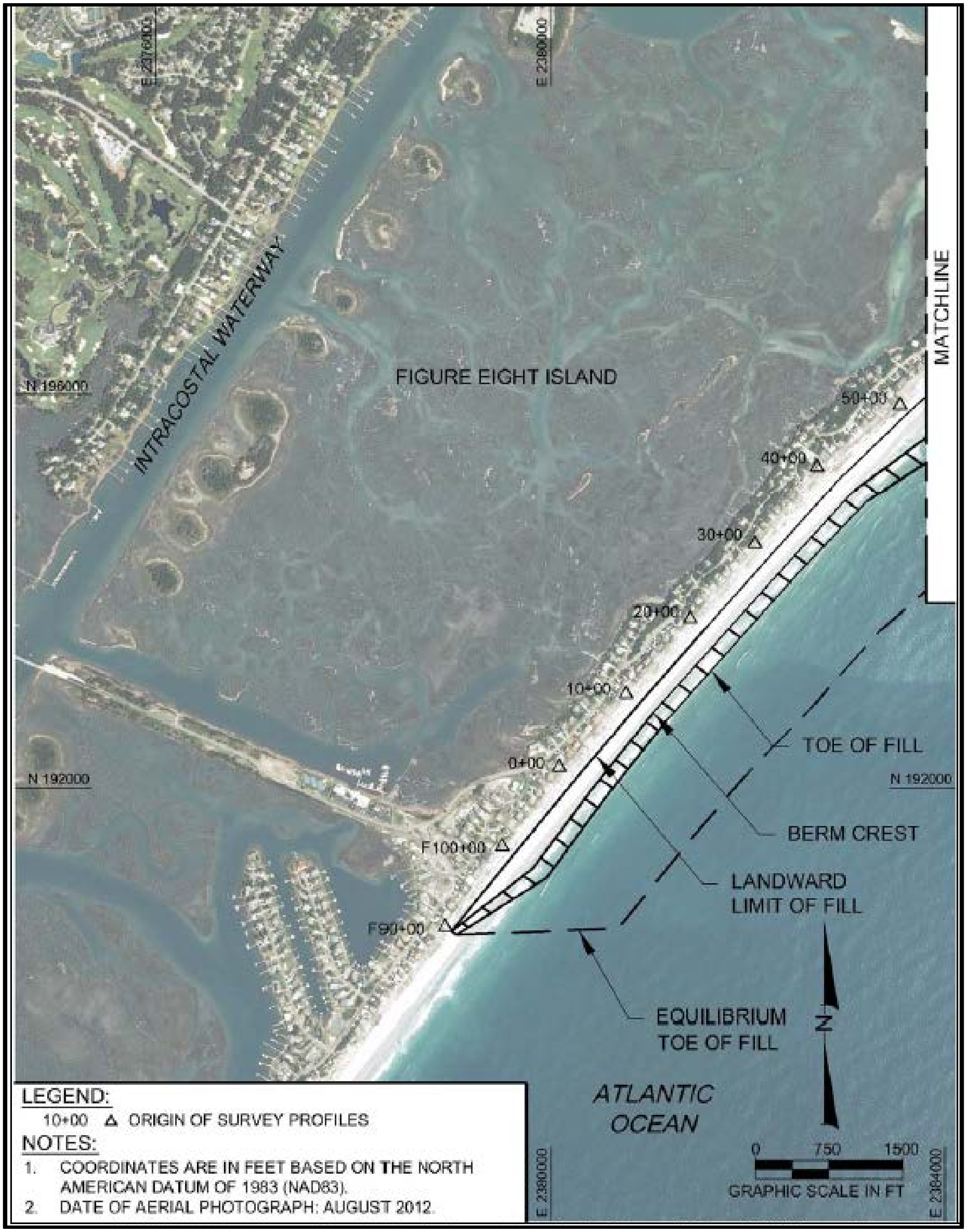


Figure 3.15b. Plan View of the southern portion of Alternative 5C; 2012 shoreline conditions.

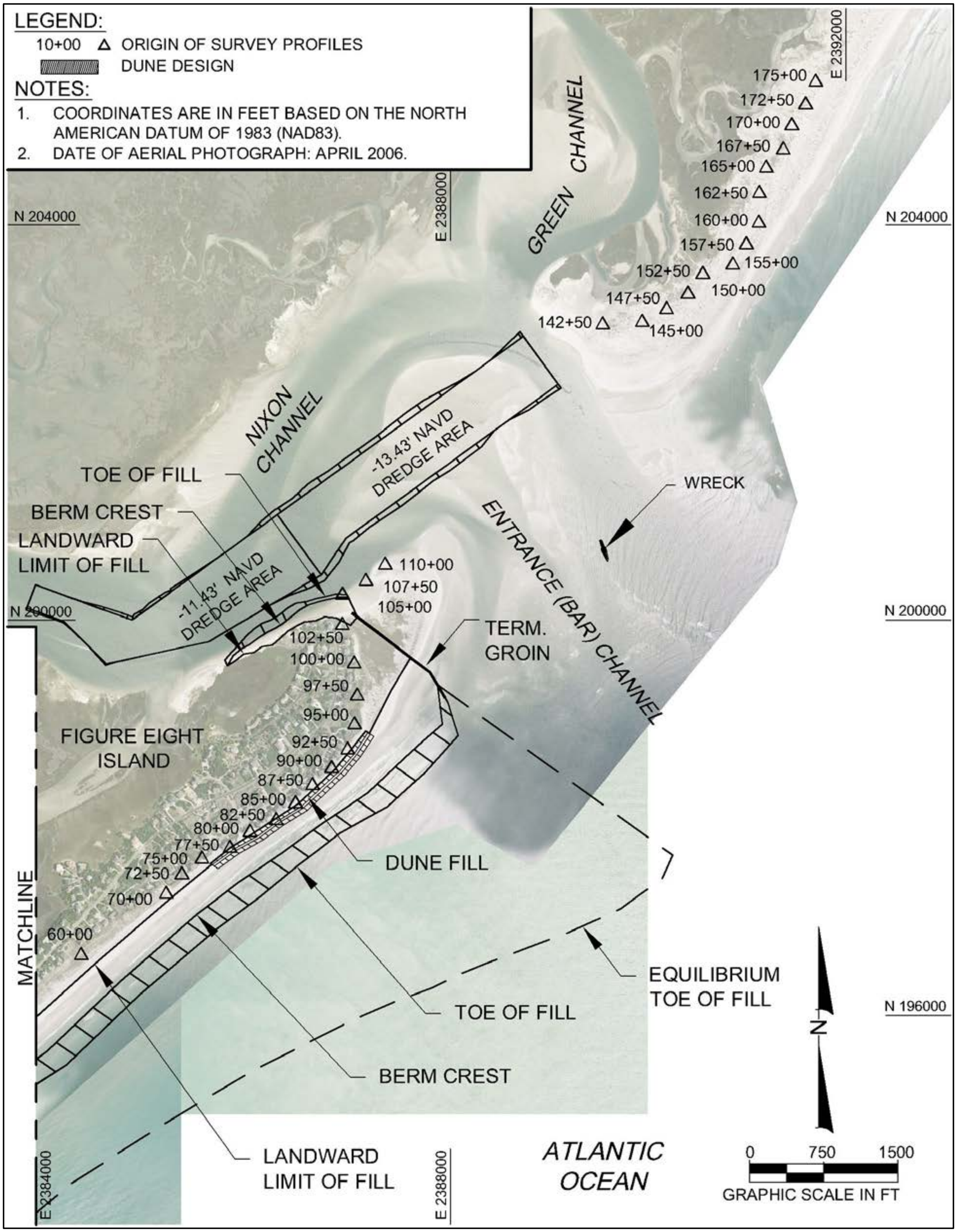


Figure 3.15c. Plan View of the northern portion of Alternative 5C; 2006 shoreline conditions.

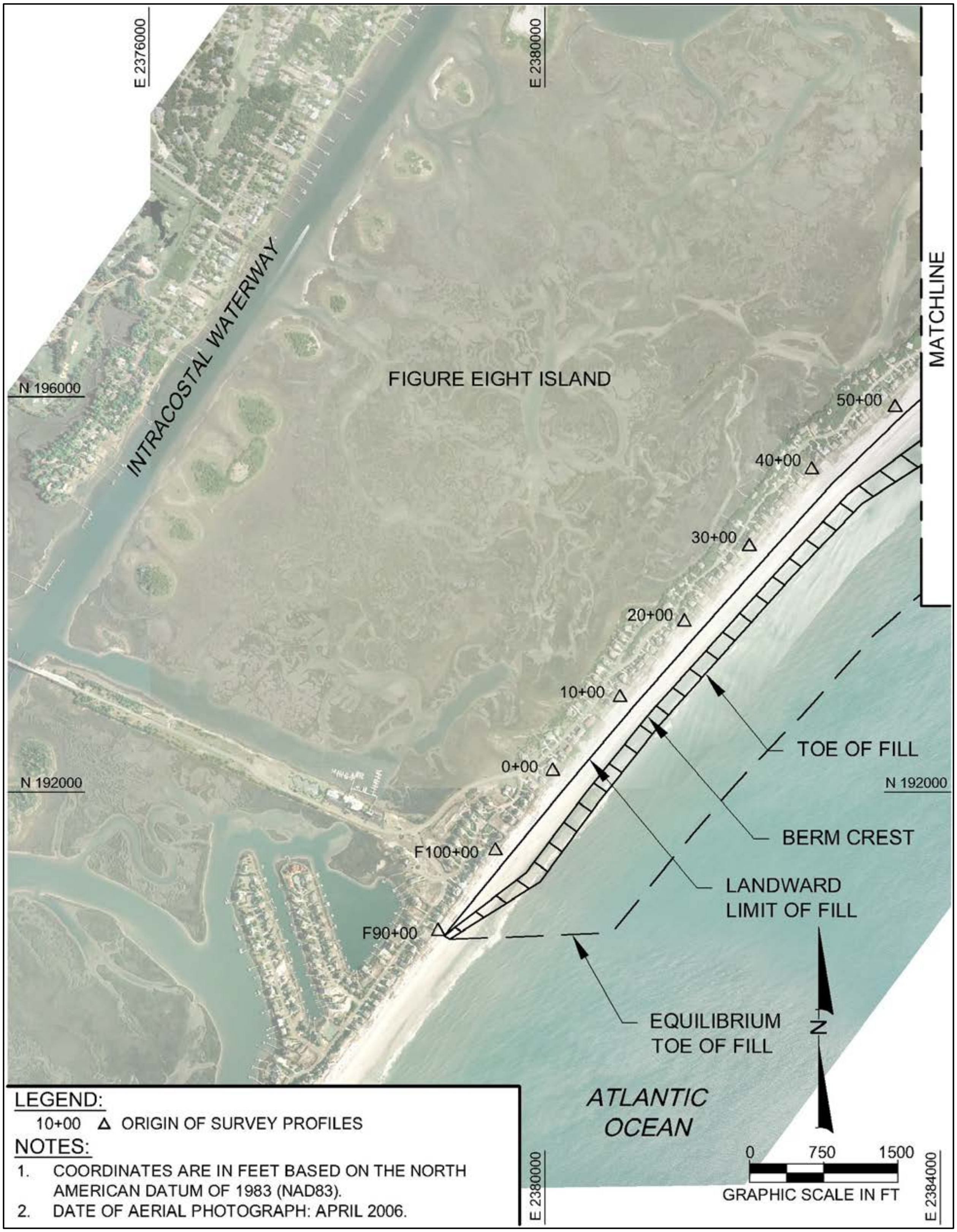


Figure 3.15d. Plan View of the southern portion of Alternative 5C; 2006 shoreline conditions.

Implementation Cost. Construction costs for Alternative 5C would include the cost of constructing the new channel from the inlet gorge into Nixon Channel with the disposal of that material along 1,400 feet of the Nixon Channel shoreline and along the ocean shoreline north of Bridge Road plus the cost of constructing the terminal groin. Removal of material from the previously permitted area in Nixon Channel and construction of the new channel connector would involve the removal of 994,400 cy based on the 2006 survey and 1,077,100 cy given the 2012 survey. Excavation of the material from Nixon Channel and the new channel connector and construction of the two beach fills would be $8,984,000 based on the 2006 conditions and $9,617,000 based on the 2012 conditions.

The initial construction cost of the 1,300-foot terminal groin for Alternative 5C is estimated to be $3,410,000 which includes engineering and design and construction oversight. The total initial construction cost of Alternative 5C given the 2006 survey condition would be $12,394,000. For the 2012 condition, the total initial construction cost would be $13,026,000. The initial construction of Alternative 5C is expected to take approximately 4.5 months.

Periodic nourishment of the beach fills in Nixon Channel and the ocean shoreline using material obtained from maintenance of the existing Nixon Channel permit area as well as the new channel connector would cost $5,162,000 every five years. Maintenance of the rubblemound portion of the terminal groin could average $15,000/year.

The average annual equivalent cost for constructing and maintaining Alternative 5C would be $1,831,000 based on the 2006 conditions and $1,877,000 for the 2012 conditions. Over the 30-year planning period, the total implementation cost for Alternative 5C in current dollars would be about $43.80 million for the 2006 condition and $44.43 million for the 2012 condition. See Appendix B and Appendix G for information regarding cost.

Alternative 5D (Applicant's Preferred Alternative): Terminal Groin at a More Northerly Location with Beach Fill from Nixon Channel and Other Sources

Alternative 5D, as shown in Figure 3.9, includes a terminal groin at the exact northerly location as Alternative 5C and the same beach fill along Nixon Channel as Alternatives 5A, 5B, and 5C. The beach fill along the ocean shoreline would be similar to Alternative 5B, however, with the terminal groin positioned farther north compared to Alternative 5B, the length of the fill would be about 500 feet longer, extending from baseline station 60+00 to the terminal groin which would be positioned near baseline station 105+00. The volume of material needed to construct the beach fill along the ocean shoreline would be 237,500 cy with 57,000 cy needed along the Nixon Channel shoreline resulting in a total beach fill volume of 294,500 cy for Alternative 5D. The volume of fill needed for both the ocean shoreline and the Nixon Channel shoreline would be the same for both the 2006 and 2012 conditions.

The cost for implementing Alternative 5D is not affected by the conditions in Nixon Channel or along the ocean and Nixon Channel shoreline as both the 2006 and 2012 conditions in Nixon Channel could supply the volume of material needed to construct the two fills. In this regard, the beach fill designs are based on providing a given volume of material per linear foot of shoreline regardless of the condition of the beach.

Two terminal groin lengths were evaluated for Alternative 5D, one having the same length as Alternative 5C (1,300 feet) and the other 200-feet longer (1,500 feet). Based on the Delft3D model results, which are presented in Appendix B, volume losses from the beach fill with the 1,300-foot terminal groin occurred rather rapidly with only 6% of the fill placed above the -6-foot NAVD depth contour remaining at the end of the 5-year simulation. Over the whole active profile, that is from the berm crest seaward to the depth of closure (-24 ft NAVD), the entire fill was removed by the end of year 3. For the 1,500-foot structure and the same beach fill design as used in the evaluation of the 1,300-foot structure, the Delft3D model indicated the longer terminal groin was able to retain 27.5% of the fill placed above the -6-foot NAVD depth contour through year 5 of the simulation given the 2006 conditions and 52.3% for the 2012 conditions. The improved performance of the fill with the 1,500-foot terminal groin, particularly above the -6 foot NAVD depth contour, resulted in the selection of the 1,500-foot terminal groin for Alternative 5D.

The primary difference between the performance of the 1,300-foot structure used for Alternative 5C and the 1,500-foot structure selected for Alternative 5D was associated with beach fill amounts included with Alternative 5C. That is, due to the overfilling of the beach profile, the beach fill was able to absorb high rates of losses and still prevent encroachment into the pre-nourished profile over the 5-year simulation period. Based on the model results, by adding 200 feet to the length of the terminal groin, the volume of material for the beach fill was reduced from 932,100 cy for Alternative 5C to 264,500 cy for Alternative 5D while still providing erosion protection to the upland area along the north end of Figure Eight Island.

The 1,500-foot terminal groin would include a 995-foot shore anchorage section and a seaward section that would project 505 feet seaward of the 2007 mean high water shoreline. The shore anchorage section would be constructed with either steel or concrete sheet pile while the seaward section would be of rubblemound construction. The landward 100 feet of the shore anchorage section would have a 10-foot wide stone scour protection apron on both sides.

As is the case with Alternative 5B, the material to construct the beach fills would be obtained from maintenance of the previously permitted area in Nixon Channel.

The plan layout for Alternative 5D is shown in Figures 3.16a and 3.16b with the distribution of the fill and design berm widths given in Table 3.10. The terminal groin for Alternative 5D includes the 200-foot extension labeled as optional extension in Figures 3.16a and 3.16b.

Table 3.10. Alternative 5D beach fill placement volumes and design berm widths.

Shoreline Segment (Baseline Stations)	Placement Volume (cy/lf)	Design Berm Width (ft)
60+00 to 70+00 (transition	0 to 20	0 to 17
70+00 to 77+50	20	17
77+50 to 80+00 (transition)	20 to 80	17 to 69
80+00 to 105+00	80	69

Periodic Nourishment – Alternative 5D.

Simulation of Alternative 5D in the Delft3D model indicated an average rate of volume loss from the beach fill placed between station 60+00 and the terminal groin (105+00) of 58,000 cy/years for the 2006 conditions and 45,000 cy/year for the 2012 conditions. South of station 60+00 the beach remained stable to slightly accretionary under both conditions. Assuming periodic nourishment would be accomplished every 5 years, the five year nourishment requirement for Alternative 5D would be 290,000 cy given the 2006 conditions and 225,000 cy for the 2012 condition. Periodic nourishment of the Nixon Channel beach fill would also require 30,000 cy every five years resulting in a total 5 year nourishment requirement of 320,000 cy for the 2006 condition and 255,000 cy for the 2012 condition. Like Alternative 5B, material for periodic nourishment of the beach fills would come from maintenance of the previously permitted area in Nixon Channel.

Implementation Cost. Initial construction costs for the 1,500-foot terminal groin would be $4,560,000. The initial cost of the beach fills along the Nixon Channel and ocean shoreline using material from the Nixon Channel permit area would be $2,879,000 for both the 2006 and 2012 conditions resulting in a total cost for initial construction (beach fills and terminal groin) of $7,439,000. As previously stated, the implementation costs for Alternative 5D are independent of the survey conditions. The initial construction of Alternative 5D is expected to take approximately 4 months.

Maintenance of the terminal groin would average $25,000 per year. Periodic nourishment of the beach fills along the ocean shoreline and Nixon Channel using maintenance material removed from the previously permitted area in Nixon Channel would cost $3,002,000 every 5 years under the 2006 conditions and $2,561,000 for the 2012 conditions. Over the 30-year planning period, the total cost for Alternative 5D in current dollars would be about $26.12 million given the 2006 conditions and $23.47 million for the 2012 conditions.

The equivalent average annual cost for Alternative 5D, computed with a discount rate of 6% over an amortization period of 30 years is $1,098,000 for the 2006 conditions and $1,020,000 for the 2012 conditions. See Appendix B and Appendix G for more information regarding cost.

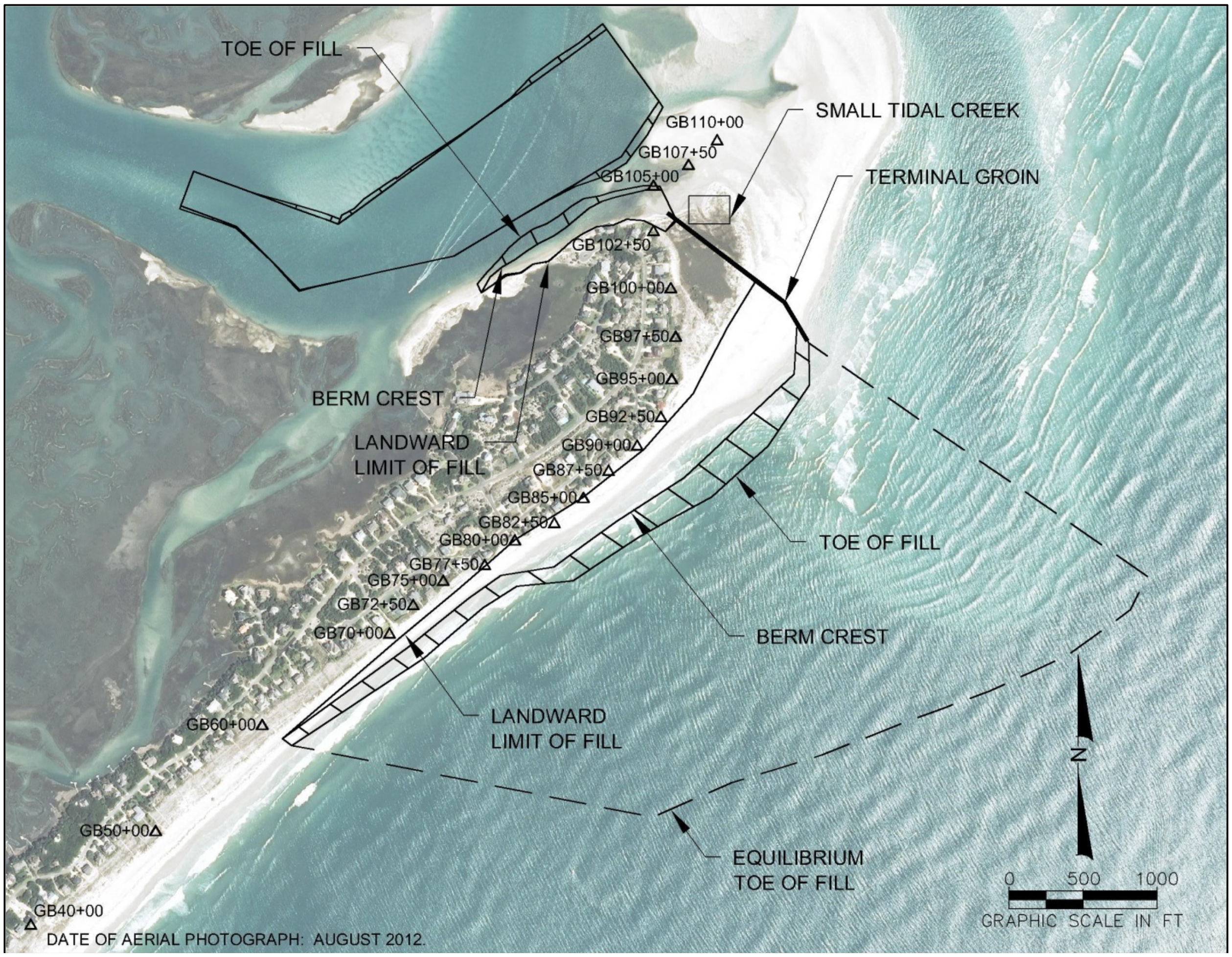


Figure 3.16a. Plan view of Alternative 5D; 2012 shoreline conditions.

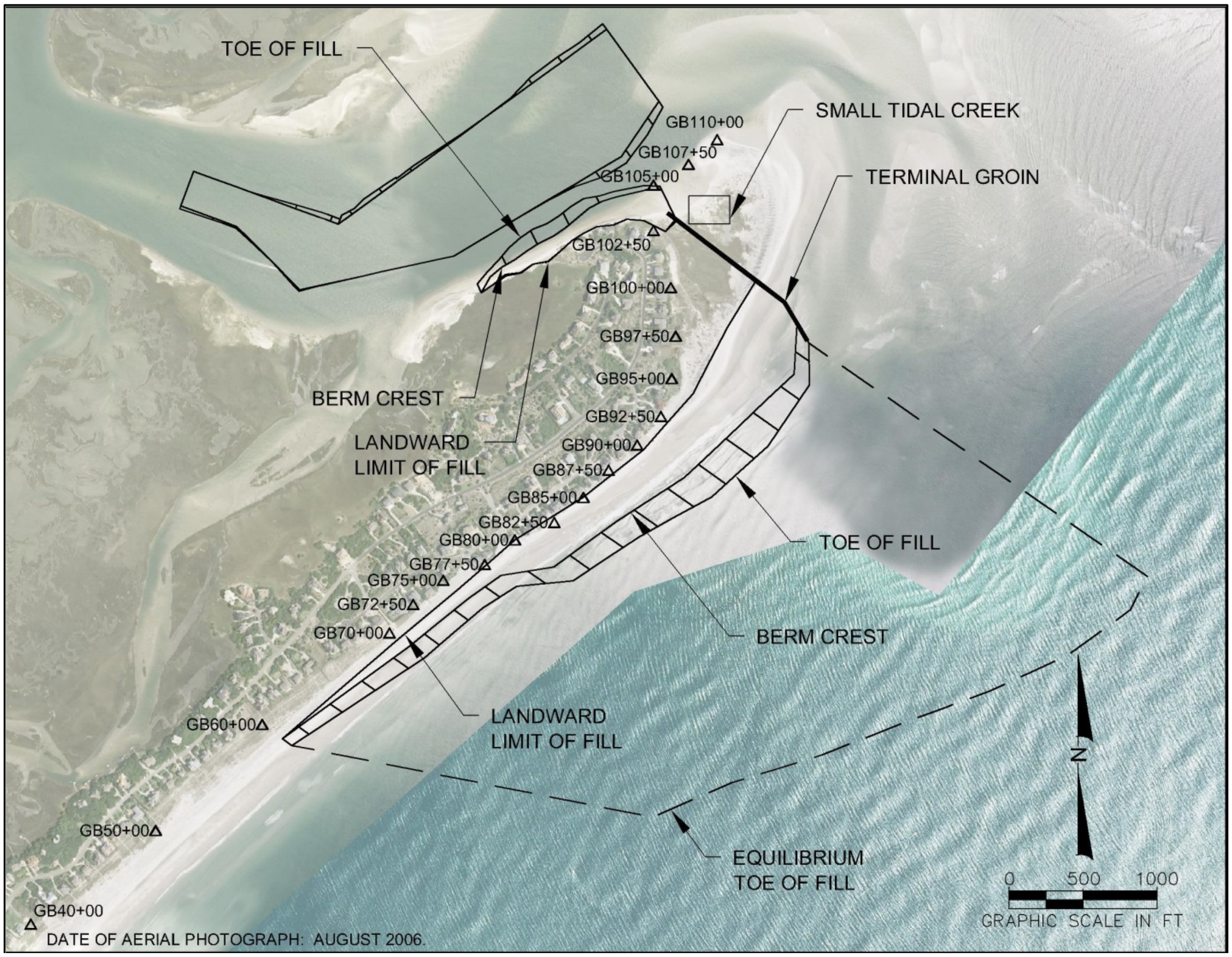


Figure 3.16b. Plan view of Alternative 5D; 2006 shoreline conditions.

<u>Terminal Groin Removal Cost – Alternative 5D</u>.

Removal of the terminal groin would include the cost of labor and equipment minus the salvage value of the sheet piles and stone. The cost for removing the terminal groin under Alternatives 5A and 5B would be $3.4 million whereas removal costs for Alternatives 5C and 5D would be $2.8 million and $3.2 million, respectively.

<u>Cost Summary</u>.

The equivalent average annual economic impact of each alternative is provided in Table 3.11a and Table 3.11b for the 2006 and 2012 conditions, respectively. The annual costs in this table were computed over a 30-year amortization period using a discount rate of 6%. Table 3.12a and Table 3.12b present summaries of the 30-year implementation costs for each alternative given the 2006 and 2012 conditions, respectively.

Table 3.11a. Summary of average annual economic impact of alternatives (2006 Conditions).

Alternative	Long-Term Erosion Damages	Loss of Tax Revenues	Response/Construction Cost	Total Economic Cost
1	$1,803,000	$184,000	$1,204,000	$3,191,000
2	$2,166,000	$275,000	$169,000	$2,610,000
3	0	0	$2,564,000	$2,564,000
4	0	0	$3,259,000	$3,259,000
5A	0	0	$1,890,000	$1,890,000
5B	0	0	$1,056,000	$1,056,000
5C	0	0	$1,831000	$1,831,000
5D	0	0	$1,098,000	$1,098,000

Table 3.11b. Summary of average annual economic impact of alternatives (2012 Conditions).

Alternative	Long-Term Erosion Damages	Loss of Tax Revenues	Response/Construction Cost	Total Economic Cost
1	$1,742,000	$179,000	$1,201,000	$3,122,000
2	$2,081,000	$257,000	$165,000	$2,503,000
3	0	0	$2,620,000	$2,620,000
4	0	0	$2,780,000	$2,780,000
5A	0	0	$1,936,000	$1,936,000
5B	0	0	$1,056,000	$1,056,000
5C	0	0	$1,877,000	$1,877,000
5D	0	0	$1,020,000	$1,020,000

Table 3.12a Summary of 30-year implementation costs of alternatives (2006 Conditions)

Alternative	30-Year Implementation Cost
1	$92.5 Million
2	$63.7 Million
3	$61,80 Million
4	$84.90 Million
5A	$43.68 Million
5B	$24.76 Million
5C	$43.80 Million
5D	$26.18 Million

Table 3.12b Summary of 30-year implementation costs of alternatives (2012 Conditions)

Alternative	30-Year Implementation Cost
1	$84.7 Million
2	$63.7 Million
3	$63.5 Million
4	$69.00 Million
5A[(1)]	$44.31 Million
5B[(1)]	$24.76 Million
5C[(1)]	$44.43 Million
5D	$23.53 Million

[(1)])Periodic nourishment costs based on 2006 conditions.

Chapter 4 AFFECTED ENVIRONMENT

1. What is the environmental setting of this project?

Figure Eight Island is located on the northwest end of New Hanover County, in southeastern North Carolina, approximately eight miles north of Wilmington. It is a private, gated residential barrier island with 489 developed lots and 74 undeveloped lots. The island is bordered to the south by Mason Inlet and Wrightsville Beach and to the north by Rich Inlet and Hutaff Island, an undeveloped, privately owned island. Figure Eight Island covers approximately 526.1 hectares (1300 acres) and is approximately 8.0 km (5.0 mi) long and approximately 0.6 km (0.4 mi) wide. The Permit Area encompasses 4,282 acres and includes a wide diversity of estuarine and nearshore habitat types supporting diverse ecosystems typically associated with a developed and undeveloped barrier island system in southeastern North Carolina. The proposed project is located on the northeast end of the island and within the channel and shoals in Nixon Channel and Rich Inlet.

Figures 4.1 and 4.2 depict the extent of the Permit Area which is defined as the boundary of where direct and indirect effects of the project will, or may likely occur. Figure 4.1 depicts the extent of the delineated biotic communities within the Permit Area based on the 2006 conditions. Figure 4.2 represents the extent of these communities based on 2015 conditions. The Permit Area was identified and delineated based on the modeling results depicting potential sedimentation distribution in the inlet as a result of the realigned inlet channel proposed for Alternative 3 and the point of intercept calculated along the oceanfront shoreline from proposed nourishment activities. Since developing the Permit Area, Alternative 5D has become the applicant's preferred alternative. Because the extent of the beach fill and the anticipated sedimentation distribution within the inlet are similar to Alternative 3, the scope of the Permit Area will remain unchanged. It should also be noted that all borrow sources for Alternative 5D are within the Permit Area.

The Permit Area also includes portions of Hutaff Island, which is located to the northeast of Rich Inlet. Hutaff Island is one of the few remaining undeveloped and vehicle-free barrier islands on the North Carolina coast. It is the 2nd largest near-pristine barrier island and salt marsh system in the region. Natural communities that are found in the area include: dune grass, upland forest, scrub-shrub, salt marsh, and beaches and foredunes. The natural area supports a gull-tern-skimmer colony, and the upper beach provides habitat for seabeach amaranth (*Amaranthus pumilus*). Threatened and endangered animals supported by the area include the loggerhead sea turtle (*Caretta caretta*), (*Charadrius melodus*), Carolina diamondback terrapin (*Malaclemys terrapin centrata*), black skimmer (*Rhychops niger*), least tern (*Sterna atillarum*), and eastern painted bunting (*Passerina ciris ciris*). The North Carolina Natural Heritage Program (NCNHP) has identified Hutaff Island as a Significant Natural Heritage Area (SNHA) of statewide significance (NCNHP, 2006). This site is partly owned

What is the North Carolina Natural Heritage Program?

As part of the Office of Natural Resource Planning and Conservation within the NC Department of Environment and Natural Resources, the program serves to inventory, catalogue, and support conservation of the rarest and the most outstanding elements of the natural diversity within North Carolina. These elements of natural diversity include those plants and animals which are so rare or the natural communities which are so significant that they merit special consideration as land-use decisions are made.

by the NC Division of Parks and Recreation; the remaining area is privately owned (NCNHP, 2006a). In addition, the NCNHP has designated a portion of the Figure Eight Island Marsh natural area as a Registered Natural Area (RNA) under agreement between the Northeast New Hanover Conservancy and NCDENR. In 2001, the United States Fish and Wildlife Service (USFWS) designated Hutaff Island as Piping Plover Critical Habitat, designated as Unit NC-11. This area provides foraging and nesting grounds for the endangered piping plover (*Charadrius melodus*). The Piping Plover Critical Habitat Area extends beyond Hutaff Island through Rich Inlet and onto approximately the northern 305 m (1,000 ft) of Figure Eight Island (Figure 4.1 and 4.2). In addition, the USFWS and NMFS has designated portions of North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles. A portion of the Permit Area is located within Critical Habitat Unit LOGG-T-NC-04 (Figure 4.1 and 4.2). As described in the Federal Register Notice, this unit includes Onslow Beach, Topsail Island, and Hutaff Island. The unit contains nearshore reproductive habitat only. Specifically, the unit consists of a nearshore area from Browns Inlet to Rich Inlet (crossing New River Inlet and New Topsail Inlet) from the MHW line seaward 1.6 km.

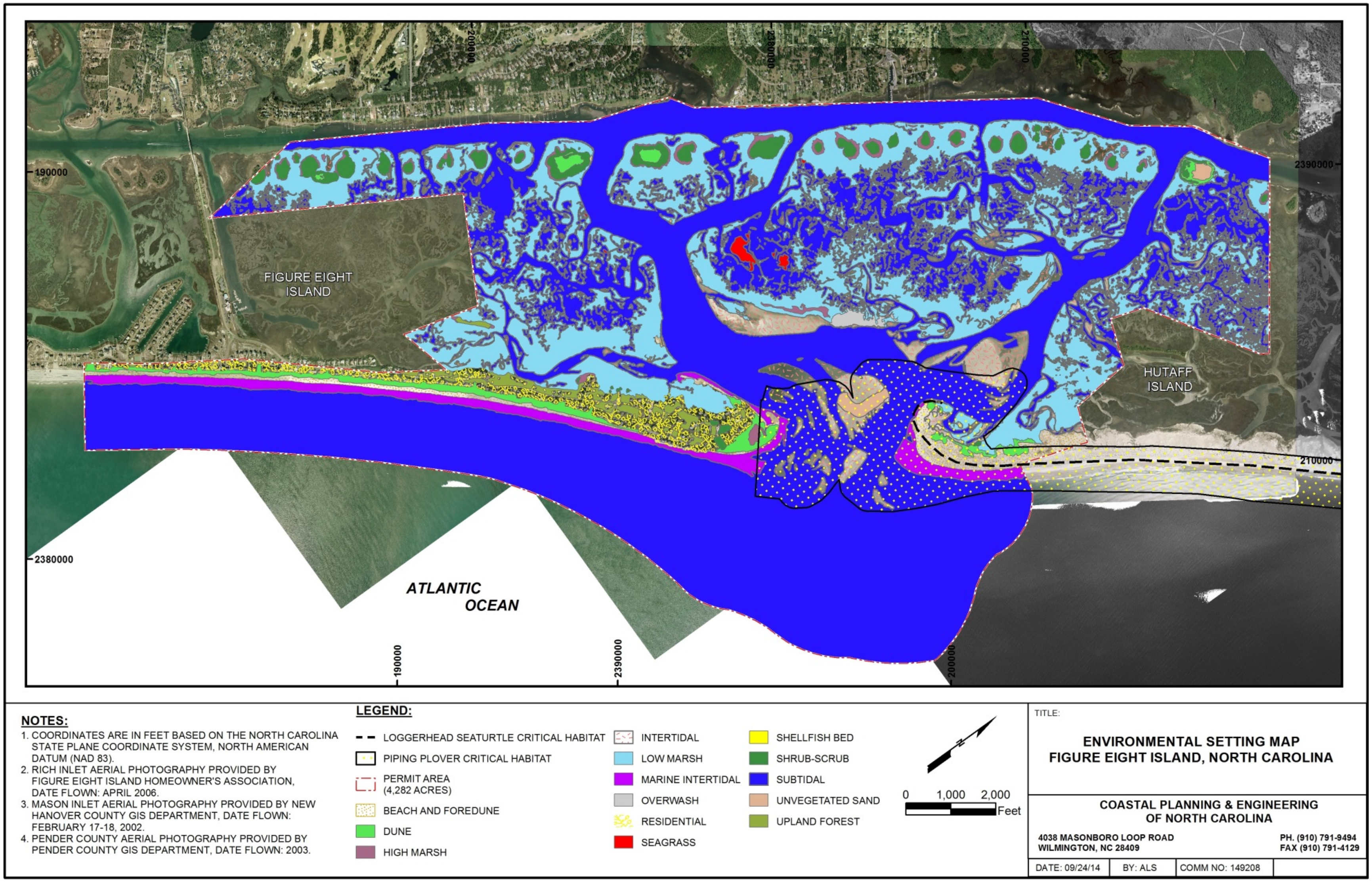


Figure 4.1. Figure Eight Island environmental setting map within the Permit Area based on 2006 conditions

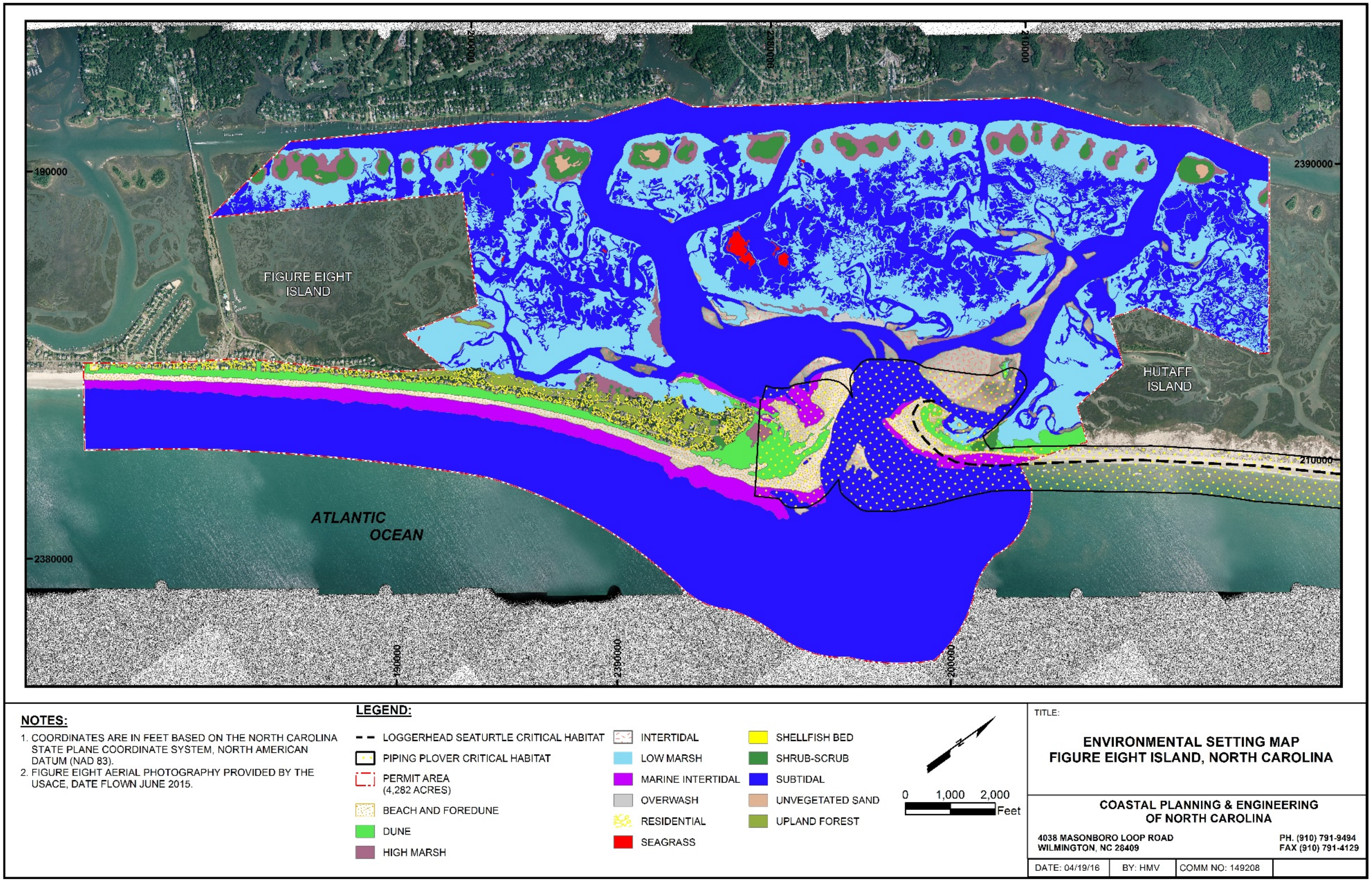


Figure 4.2. Figure Eight Island environmental setting map within the Permit Area based on 2015 conditions

The North Carolina Division of Marine Fisheries (NCCDMF) has designated about 595 km^2 (230 mi^2) of fishery nursery areas throughout North Carolina, dividing the habitats into three categories of nursery areas: Primary, Secondary and Special Secondary Nursery Areas (NCDMF, 2007). Primary Nursery Areas (PNAs) are usually shallow with soft muddy bottoms and surrounded by marshes and wetlands. PNAs are located within the Permit Area, specifically within the salt marsh habitat between the Atlantic Intracoastal Waterway (AIWW) and the back side of Figure Eight Island and Hutaff Island. To protect juveniles, many commercial fishing activities are prohibited in these waters including the use of trawl nets, seine nets, dredges or any mechanical methods used for taking clams or oysters.

The geomorphology of the Permit Area is characterized by beaches, dunes, and marshes typical of a barrier island complex. The Atlantic Coastal Plain and Onslow Bay are both underlain by relatively flat-lying sedimentary units which gently dip and thicken as they move to the southeast.

Barrier islands, such as Figure Eight Island, are composed of unconsolidated fine- to medium-sized quartz and shell material that is in a constant state of flux due to wind, waves, currents and storms. The oceanfront beach and the backing dunes are deposits of sand that are constantly changing their shape, and hence position, with time as they respond to coastal processes.

Areas of Environmental Concern

Lands adjacent to coastal inlets that are vulnerable to natural processes including erosion and flooding are known as inlet hazard areas. These inlet hazard areas, as designated by the North Carolina Coastal Area Management Act (CAMA), as important Areas of Environmental Concern (AEC). Generally, the Inlet Hazard Areas AEC are natural-hazard areas especially vulnerable to adverse effects of sand, wind, and water, because of their proximity to dynamic ocean inlets (NCAC T15A 7H.0304(3)). The Inlet Hazard Area AEC boundaries were originally approved by the Coastal Resources Commission (CRC) in 1979. Although the inlet hazard AEC boundaries are more than 30 years old, they are still in force at this time. It is not certain if or when new boundaries will be officially adopted.

Many AECs have also been designated as SNHA by the NCNHP. The NCNHP has identified more than 2,000 SNHAs in North Carolina, which are defined as an area of land or water important for conservation of biodiversity. SNHA's contain one or more natural heritage elements such as high-quality or rare natural communities, rare species, and/or special animal habitats.

What are Areas of Environmental Concern?

The Coastal Resources Commission designates areas as AECs to protect them from uncontrolled development, which may cause irreversible damage to property, public health or the environment, thereby diminishing their value to the entire state. The CRC has set up four categories of AECs:

A. The Estuarine and Ocean System
B. The Ocean Hazard System
C. Public Water Supplies
D. Natural and Cultural Resource Areas

2. What are the characteristics of the various habitats found within the project area?

Barrier islands within North Carolina are dominated by wave and tidal processes, often with large flood and ebb tidal deltas. Like other inlets in southeastern North Carolina, Rich Inlet serves as the primary pathway of sediment transportation into its sound via Green Channel and Nixon Channel. These inlets historically migrated along the Outer Banks and were typically created by storm breaching. Many are now maintained by the USACE for navigation purposes. Historically, Rich Inlet has shown little tendency to migrate, however, the cyclical reorientation of the ebb channel can produce very rapid erosion on adjacent shorelines (Cleary and Pilkey, 1986). The Permit Area contains various habitat types such as salt marsh, upland hammocks, intertidal flats, shoals, dunes, and beaches (Figure 4.3).

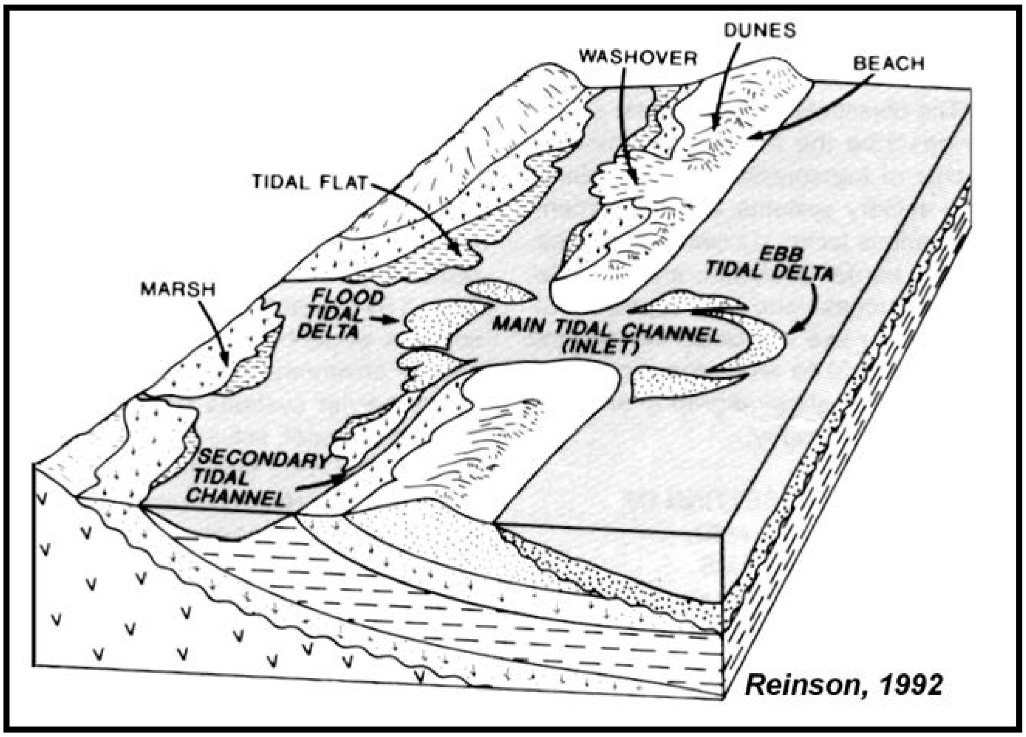


Figure 4.3. Schematic depicting various habitats associated with a barrier island

A. Estuarine Habitats

While estuaries are also often known as bays, lagoons, harbors, inlets, or sounds, the defining feature of an estuary is the mixing of fresh and saline water (32 to 36 parts per thousand [ppt]). Flush with nutrients and inhabited by resilient organisms, estuaries are among the most productive ecosystems on earth. They provide rich feeding grounds for coastal fish and migratory birds, and spawning areas for fish and shellfish (NPS, 2007). This section will characterize the following estuarine communities that are found, or have potential to be found, within the Permit Area including salt marshes, submerged aquatic vegetation (SAV), and shellfish areas.

1. Salt Marsh Communities

These community types are found in relatively flat and poorly drained topographic areas found along the North Carolina coastline and are subject to regular and irregular tidal flooding. These systems are extremely important for water filtration and water storage during flood events, as well as supplying food and providing habitat for a wide-array of flora and fauna. Coastal wetlands within the project vicinity include tidal salt marshes, and occur along the shoreline and island fringes along the backside of Figure Eight and Hutaff Island. These areas generally fall under the regulatory permitting authority of both the State of North Carolina and the U.S. Army Corps of Engineers.

Salt Marsh Communities

In eastern North Carolina, salt marsh communities can be found along 4,500 miles of coastal shoreline, which encompasses 2.1 million acres of estuarine habitat (NCCF, 2007).

Estuarine systems, such as those characterized within the Figure Eight Island Permit Area, have been designated as AEC by the CRC. These areas have been identified as "sensitive and productive coastal lands and waters where uncontrolled development might cause irreversible loss of property, public health and the natural environment" (NCDCM, 2006b). Section 15A NCAC 07H .0205 of the North Carolina Administrative Code defines coastal wetlands 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 shall not include hurricane or tropical storm tides (NCDCM, 2008a). There are four kinds of coastal marsh habitats found in North Carolina; low marsh, high marsh, brackish marsh, and freshwater marshes. Of these kinds, the Permit Area contains low and high marsh.

Low salt marsh environments are regularly flooded with the tides and are characterized by organic mats with smooth cordgrass (*Spartina alterniflora*) as the dominant vegetative species. *S. alterniflora* marshes occur within the intertidal zone along the sounds and tidal creeks, and provide valuable nursery habitat for commercially valuable species of marine and estuarine organisms. The zonation of vegetation in salt/brackish marsh is largely determined by variations of salinity and drainage of sediment porewater. Some species are restricted in the low marsh because of high porewater salinity, frequent inundation, and high-sulfide porewaters associated with frequent inundation (Deaton et al., 2010). Smooth cordgrass can tolerate a wide range of environmental conditions, including pH levels from 5.4 to 7, salinities from 3% to 5%, and a water table four inches above ground level (ANHP, 2004). The majority of the salt marsh habitat within the Permit Area is located between the AIWW and the back sides of Figure Eight and Hutaff Islands. There have been 1,007 acres of low marsh delineated within the Permit Area, as determined through interpretation of high resolution aerial photography.

Cowardin (1979) classifies high marsh as an estuarine intertidal emergent wetland or palustrine, emergent wetland. High salt marsh environments are irregularly flooded lands where plant species such as saltmeadow cordgrass (*S. patens*), glasswort (*Salicornia* Spp.), salt (or spike) grass (*Distichlis spicata*), and sea lavender (*Limonium carolinianum*) may be found. Saltmeadow cordgrass grows at the seaward edge of the high marsh, just above the high water line, providing habitat for a variety of waterfowl and songbirds, as well as other types of wildlife indigenous to the area. This environment is important in stabilizing the shifting sands of the barrier islands. Eventually, over time, the high marsh habitat can transform as it becomes vegetated with dominant shrub species such as marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*). Thirty acres of high marsh have been delineated within the Permit Area, as determined through interpretation of high resolution aerial photography. This includes an area of high marsh that is located along the northern tip of Figure Eight Island situated between the sand spit and the residential development.

For both low and high salt marsh, the benthic communities consist of many faunal species. A 2007 wildlife utilization study conducted in the low salt marshes within the Bogue Inlet complex revealed high numbers of macroinvertebrates including fiddler crabs (*Uca puglator*), periwinkle snails (*Littorina irrorata*), oysters (*Crassostrea virginica*), and unidentified species of mud crabs, clams, and mussels (Rosov and York, 2007). Other common macroinvertebrates in the salt marsh include blue crabs (*Callinectes sapidus*) and grass shrimp (*Palaemonetes* species) (Meyer, 1991).

<u>Benefits of Salt Marsh Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds</u>
Due to their biological productivity, estuaries provide ideal areas for migratory birds to rest and forage during their long migratory journeys. Various species of shorebirds utilize marsh habitats for wintering, as well as feed on fish, shrimp and fiddler crabs found in the salt marsh. Along with a number of shorebirds and waterbirds, various waterfowl including dabbling ducks, diving ducks, geese, swans and coots utilize the salt marsh (Cowardin 1979).

Colonial waterbirds that utilize marsh habitat include black skimmers, gull-billed terns, common terns, least terns, egrets (*Egretta* spp.), and green herons (*Butorides virescens*). Most of these species prefer sandy beaches and shoaling habitats for nesting. The green heron is a habitat generalist, frequenting most coastal freshwater bodies as well as some saltwater bodies. The green heron nests in coastal shrub thickets, upland and swamp forests, and salt marshes, as well as in suburbs where habitat is deemed suitable. This species is less colonial than other wading birds, and although it often nests in mixed colonies with other herons and ibis (*Plegadis falcinellus* and *Eudocimus albus*), the green heron will frequently nest singly or in colonies of a few pairs. Nests are typically elevated in trees or shrubs between five and 30 ft off the ground (Alsop, 2002).

Willets (*Catoptrophorus semipalmatus*), American oystercatchers *(Haematopus palliatus)*, piping plovers, Wilson's plovers, and killdeers (*Charadrius vociferous*) usually nest above the high tide line on coastal beaches, on sand flats at the ends of sand spits, in blowout areas behind dunes and in overwash areas. However these various shorebirds also utilize various estuarine habitats including intertidal-emergent and submerged vegetated areas, intertidal-unvegetated, managed wetlands, as well as inland habitats for feeding (Hunter *et al*., 2001; Brown *et al*., 2001).

A variety of other waterbird species that are not classified as shorebirds or colonial waterbirds can also be found utilizing different estuarine habitats. For example, species such as red-breasted mergansers (*Mergus serrator*), clapper rails (*Rallus longirostris*) and ospreys (*Pandion haliaetus*) can be found in and surrounding inlet habitats such as Rich Inlet. Many waterbirds are piscivorous and forage by surface diving, some are aquatic gleaners, while others are herbivores that feed on submerged aquatic vegetation. These waterbirds can be found in estuaries, marshes, and in the vicinity of Rich Inlet year-round or part of the year. However, they are mainly present during spring and fall migrations, as well as during the winter.

<u>Benefits of Salt Marsh Habitat to Terrapins</u>

The Carolina diamondback terrapin is the only North American turtle found in brackish waters, and are common in salt marsh environments. Juveniles use matted *Spartina* and other marsh grasses as cover. The marshes behind Figure Eight and Hutaff Islands provide suitable habitat for diamondback terrapins (LeGrand, pers. comm., 2008).

<u>Benefits of Salt Marsh Habitats to Fishery Resources</u>

Finfish and shellfish using salt/brackish marsh habitats fall into several categories based on location and timing of use (Deaton et al., 2010). Essential Fish Habitat (EFH) species that are expected to occur in estuarine emergent wetlands of North Carolina include the penaeid shrimp, summer flounder, and others. Year-round residents of the marsh include small forage species such as killifish (*Fundulus confluentus, F. luciae, F. majalis, Lucania parva, Fundulus heteroclitus*), sheepshead minnows (*Cyprinodon variegates*), grass shrimp (*Palaemonetes pugi*), bay anchovies (*Anchoa mitchilli*), and silversides (*Membras martinica, Menidia* spp.). Transient species include those spawning near the marsh, and those spawned in deeper waters using marsh habitat as nursery or foraging areas. Among transient species, some prefer the edge of salt/brackish marsh (i.e. flounder) while others are found near the marsh edge on non-vegetated bottom (i.e., spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*)). Some species are not found in the marsh, but derive substantial food resources from marsh plants as detritus (i.e., menhaden (*Brevoortia* spp.)) or from microalgae produced on the marsh surface. Of the fishery species in North Carolina, penaeid shrimp and red drum are considered critically linked to marsh edge habitat (SAFMC, 1998).

Red drum spawning occurs in the fall (August through October) in estuaries and around coastal inlets with optimal temperatures being between 22^0 C and 30^0 C (72^0 to 86^0 F) (NCDMF 2005). In North Carolina, spawning adults were reported to be common in salinities above 25 ppt in Bogue Sound and the Cape Fear River. Spawning adults were present, but not frequently encountered in Pamlico Sound and the New River (ASMFC, 2002).

Penaeid shrimp are reported to spawn offshore, moving into estuaries during post-larval stage during the early spring. As the shrimp grow larger in size, they migrate to higher salinity environments. In late summer and fall, they return to the ocean to spawn (NCDMF, 2005). It is during the July through October period that approximately 77% of the North Carolina shrimp harvest (for all waters) is landed, 66% of which is taken from ocean sub-areas <3 mi offshore and south of Cape Hatteras (NCDMF, 2005). In a NCDMF juvenile brown, white and pink shrimp sampling program (1999 – 2003) the majority of shrimp were "collected in close proximity to shallow wetland systems, such as salt marsh.

- Brown Shrimp

Brown shrimp spawn in the deep ocean during February and March. Larval immigration to estuaries peaks from mid-March through mid-April. Brown shrimp prefer peat and muddy bottoms as habitat (NCDMF, 2005).

- Pink Shrimp

Pink shrimp spawn in ocean waters from April to July. Post larvae immigrate to estuaries from May to November. Juvenile pink shrimp are reported to over-winter in North Carolina estuaries. Pink shrimp prefer foraging in shallow waters among marine plants. They are nocturnal feeders but may feed during the day in turbid water (NCDMF, 2005).

- White Shrimp

White shrimp spawn at depths greater than 30 feet in the ocean from March to November. Post larvae immigrate to estuaries two to three weeks after hatching when they become benthic. Juvenile white shrimp prefer muddy bottoms in low to moderate salinity estuarine waters and brackish waters. White shrimp migrate south from estuaries during fall and early winter. "Some of the slower-growing individuals overwinter in the estuaries, but usually do not survive in North Carolina" (NCDMF, 2005).

2. Submerged Aquatic Vegetation (SAV)

SAV habitat occurs along the entire east coast of the United States, with the exception of South Carolina and Georgia, where high freshwater input, high turbidity, and large tidal amplitude (vertical tide range) inhibit their occurrence. Along the Atlantic coast, North Carolina supports more SAV than any other state, except for Florida (Funderburk et al. 1991; Sargent et al. 1995). The 2005 CHPP reported that, based on interpretation and field verification by NOAA of remotely-sensed imagery taken during 1985-1990, the total area of visible SAV in North Carolina was approximately 134,000 acres (Ferguson and Wood 1994). Since 2005, some additional mapping efforts have added over 20,000 acres of mapped vegetated areas, suggesting SAV habitat covers over 150,000 acres in coastal North Carolina (Deaton, et al., 2010).

Submerged Aquatic Vegetation

North Carolina is in a "transitional area which represents the southernmost extension for some cold-adapted species and the northernmost extension of warm-adapted species.

Rosov, 2008

In North Carolina, Submerged Aquatic Vegetation (SAV) is defined as "estuarine waters vegetated with one or more species of submerged vegetation such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*) and widgeon grass (*Ruppia maritime*). These vegetation beds occur in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas (Deaton et al., 2010). In North Carolina the dominant seagrass is *Z. marina*. *H. wrightii* is also observed in North Carolina; however it is not as abundant. Seagrass meadows are now much reduced, probably due to elevated nitrogen and increased sedimentation (Mallin *et al*., 2000).

Dr. Don Field of the Applied Ecology and Restoration Research Laboratory at the National Oceanic and Atmospheric Administration (NOAA) Center for Coastal Fisheries and Habitat Research identified potential occurrences of SAV within the Permit Area via interpretation from April 2006 aerial photography. Similarly, limited presence/absence data collected by Dr. Wilson Freshwater of UNCW in 2003 and 2004 from areas within the Rich Inlet complex was obtained. Each of the 47 potential SAV beds identified by Dr. Field and Dr. Freshwater were groundtruthed on September 15, 17, and 22, 2008 (Figure 4.4). Of these, three were confirmed to contain SAV resources. Two contained sparse patches of *Z. marina* (eelgrass) while one site contained a dense to sparse bed of *Z. marina* and *R. maritima* (widgeon grass). The remaining sites were identified as dark sandy bottom, shellfish shells, macroalgae, or other substrate types devoid of seagrass. Utilizing the three SAV beds identified through groundtruthing efforts as confirmed SAV resources, an additional 17 sites with similar color signatures were extrapolated from the 2008 high resolution aerial photographs (Figures 4.4, 4.5a and 4.5b). In total, seven (7) acres of SAV habitat have been identified within the Permit Area.

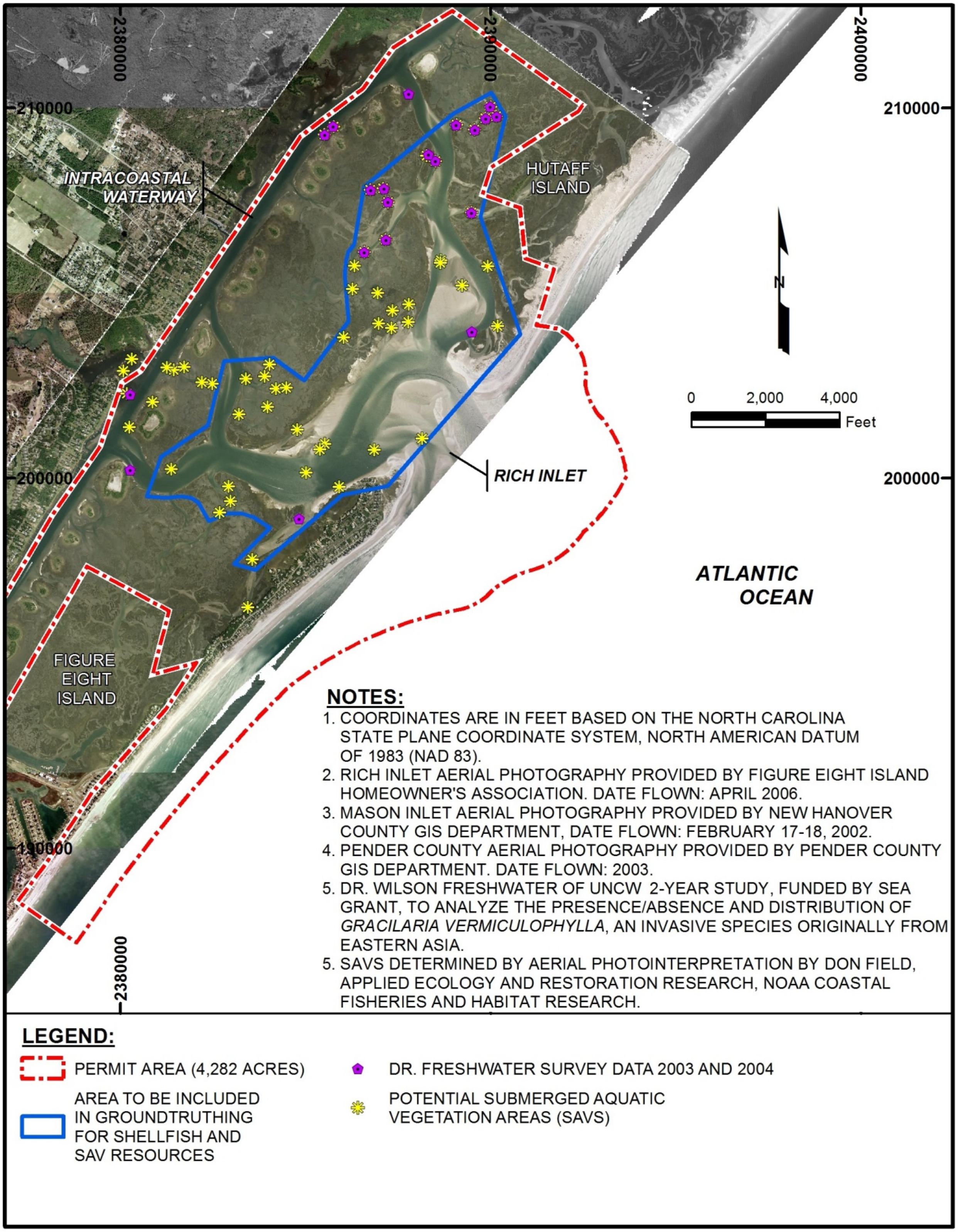


Figure 4.4. Potential Submerged Aquatic Vegetation (SAV) Locations

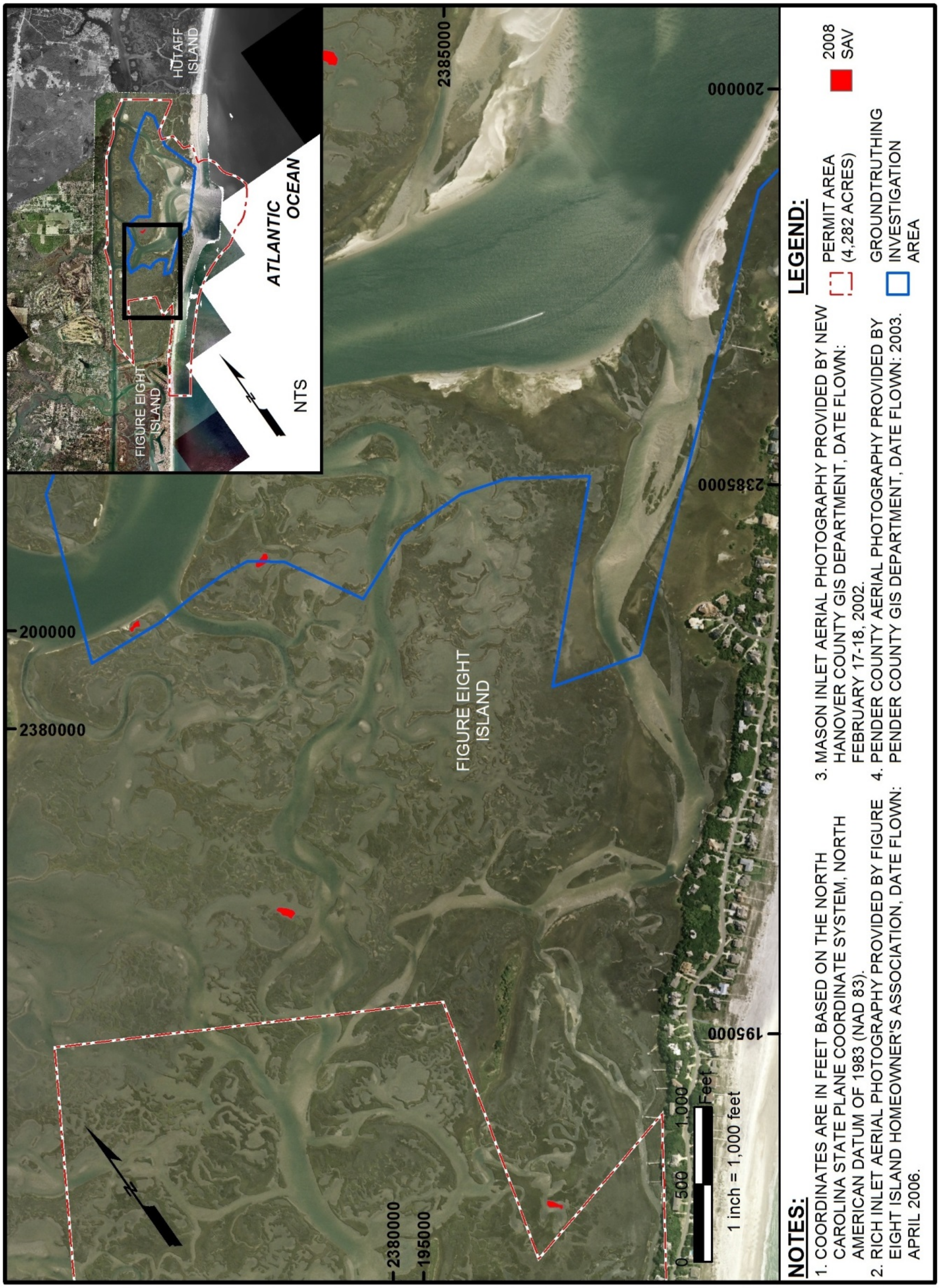


Figure 4.5a. Identified SAV Resources within the Permit Area

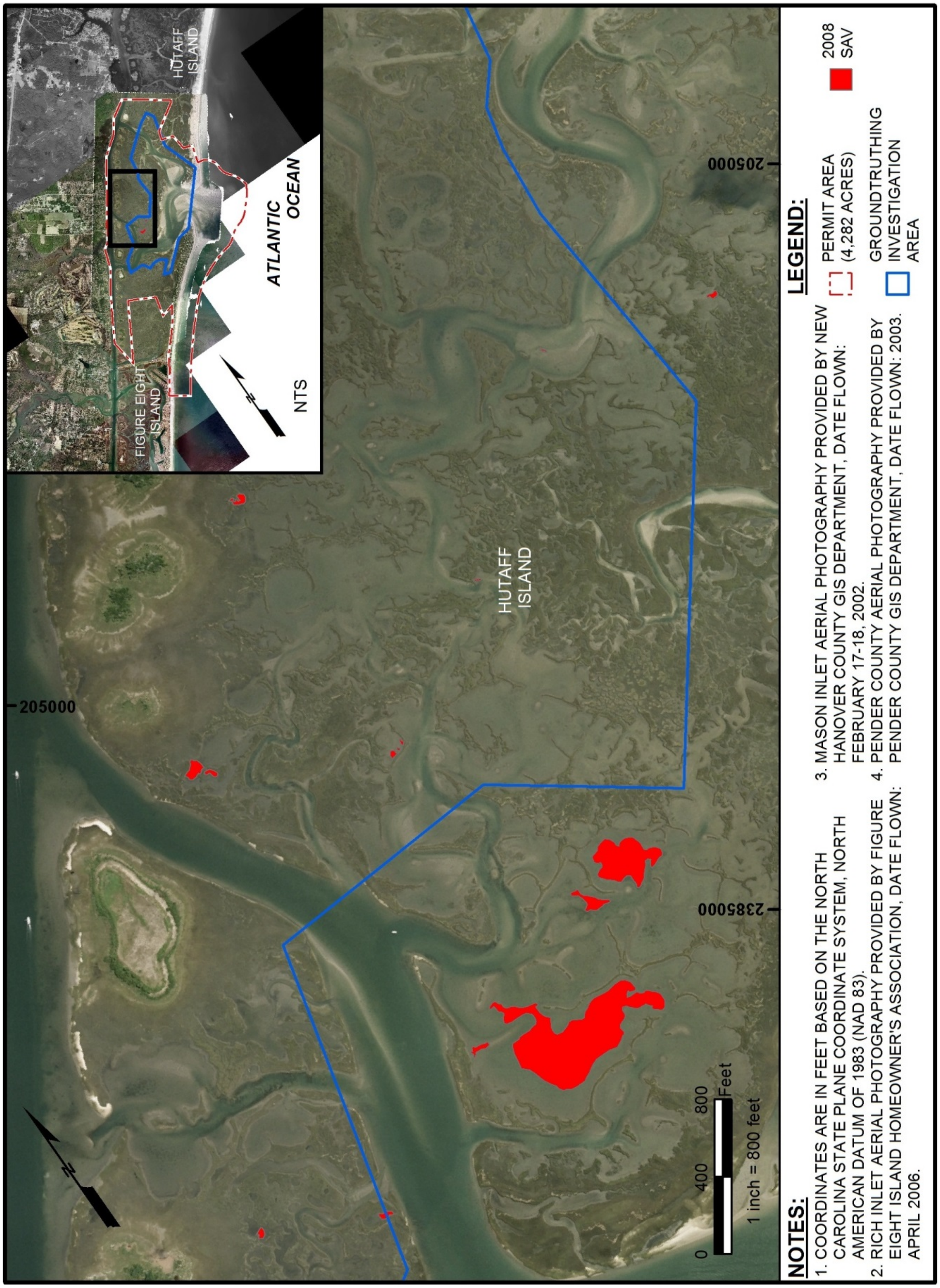


Figure 4.5b. Identified SAV Resources within the Permit Area

Benefits of SAV Areas to Fishery Resources

Submerged aquatic vegetation provides important structural fish habitat and other important ecosystem functions in estuarine and riverine systems in coastal North Carolina. Submerged aquatic vegetation is recognized as an essential fish habitat because of five interrelated features – primary production, structural complexity, modification of energy regimes, sediment and shoreline stabilization, and nutrient cycling. Water quality enhancement and fish utilization are especially important ecosystem functions of SAV relevant to the enhancement of coastal fisheries.

SAV are utilized by larval and juvenile fishes for foraging and escape from predation. Commercial and sport fishes in their larval and juvenile stages, such as; gag grouper (*Mycteroperca microlepsis*), gray snapper (*Lutjanus griseus*), bluefish (*Pomatomus saltatrix*), flounder species (*Paralichthys* sp.), fish of the Clupeidae family and others, are found in seagrass beds in the early spring and summer. Bay scallops (*Argopecten irradians concentricus*) are also typically found in SAV habitat. Because of its use for foraging, spawning and shelter, SAV is designated as Habitat Areas of Particular Concern (HAPC). The red drum (*Sciaenops ocellatus*) is one species for which SAV serves as a HAPC.

3. Shellfish

The shellfish industry is a large economic industry for North Carolina coastal areas. Three species of shellfish found in coastal waters include eastern oysters (*Crassostrea virginicus*), hard clams (*Mercenaria mercenaria*), and bay scallops (*Argopecten irradians concentricus*).

> **Shellfish**
>
> Common terms used to describe shell bottom habitats in North Carolina are “oyster beds,” “oyster rocks,” “oyster reefs,” “oyster bars,” and “shell hash.”

Shellfish are also an important resource in the estuarine environment within the permit area. The structures that shellfish create, such as beds and reefs, are used by many species of fish and invertebrates (Burrel, 1986). The SAFMC defines this habitat as “the natural structures found between (intertidal) and beneath (subtidal) tide lines, that are composed of oyster shell, live oysters and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mudflats, and from wave-formed shell windrows” (SAFMC, 1998). The SAFMC has designated oyster reefs as EFH for red drum (NMFS, 1999). NCDMF has designated two Oyster Management Areas (OMA) within the Permit Area and one adjacent to the southwestern boundary (Figure 4.6).

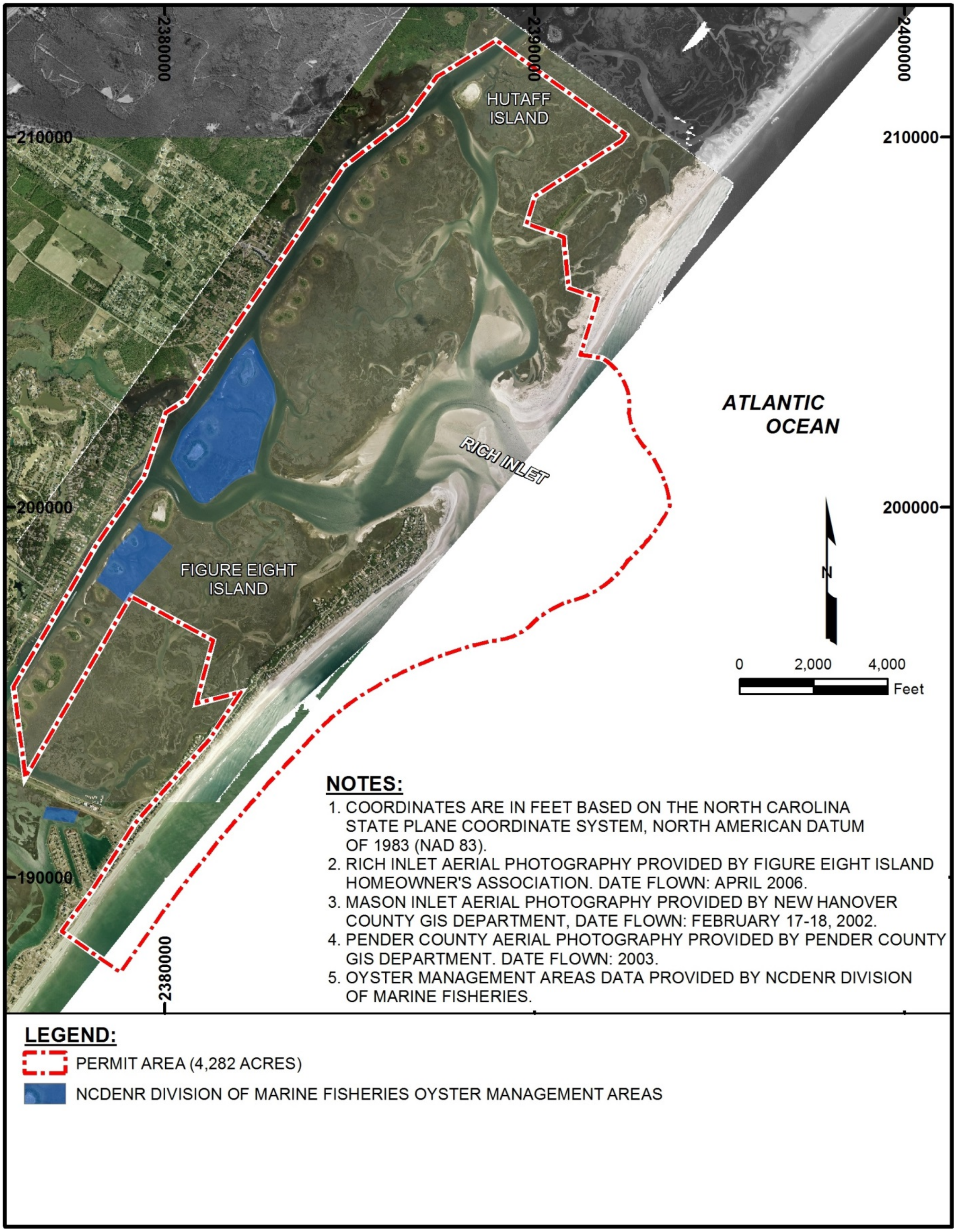


Figure 4.6. Oyster Management Areas within and in proximity to the Permit Area

Table 4.1 below summarizes the spawning seasons for the three shellfish species typically found within the Permit Area.

Table 4.1. Spawning Seasons for Shellfish

SPECIES	SPAWNING SEASONS
Hard Clam (*Mercenaria mercenaria*)	May through November
Eastern Oyster (*Crassostrea virginica*)	May through September
Bay Scallops (*Argopecten irradians*)	August through December

The NCDMF Shellfish Mapping Program was developed using a stratified random sampling design that delineates all bottom habitats (or strata) and samples the density of oysters, clams, and bay scallops in these areas (Deaton *et al*., 2010). Benthic habitat surveys in Rich Inlet and the estuarine habitats behind Figure Eight Island and Hutaff Island were conducted by the NCDMF in 1991 (Conrad, pers. comm.). Shellfish were found within strata R (intertidal firm, vegetated without shell), strata S (intertidal firm, non-vegetated with shell), strata T (intertidal firm, non-vegetated without shell), and strata W (intertidal hard, non-vegetated with shell) (Conrad, pers. comm.). Figures 4.7 and 4.8, created by the NCDMF Shellfish Mapping Program, illustrates the distribution of the various habitats within proximity of the Permit Area. The number and density of clams (*M. mercenaria*), oysters (*C. virginica*), and scallops (*A. irradians*) present within these strata are listed in Tables 4.2 and 4.3. Stratum W is the habitat containing the highest densities of shellfish in this area. No scallops were observed in these sampling surveys.

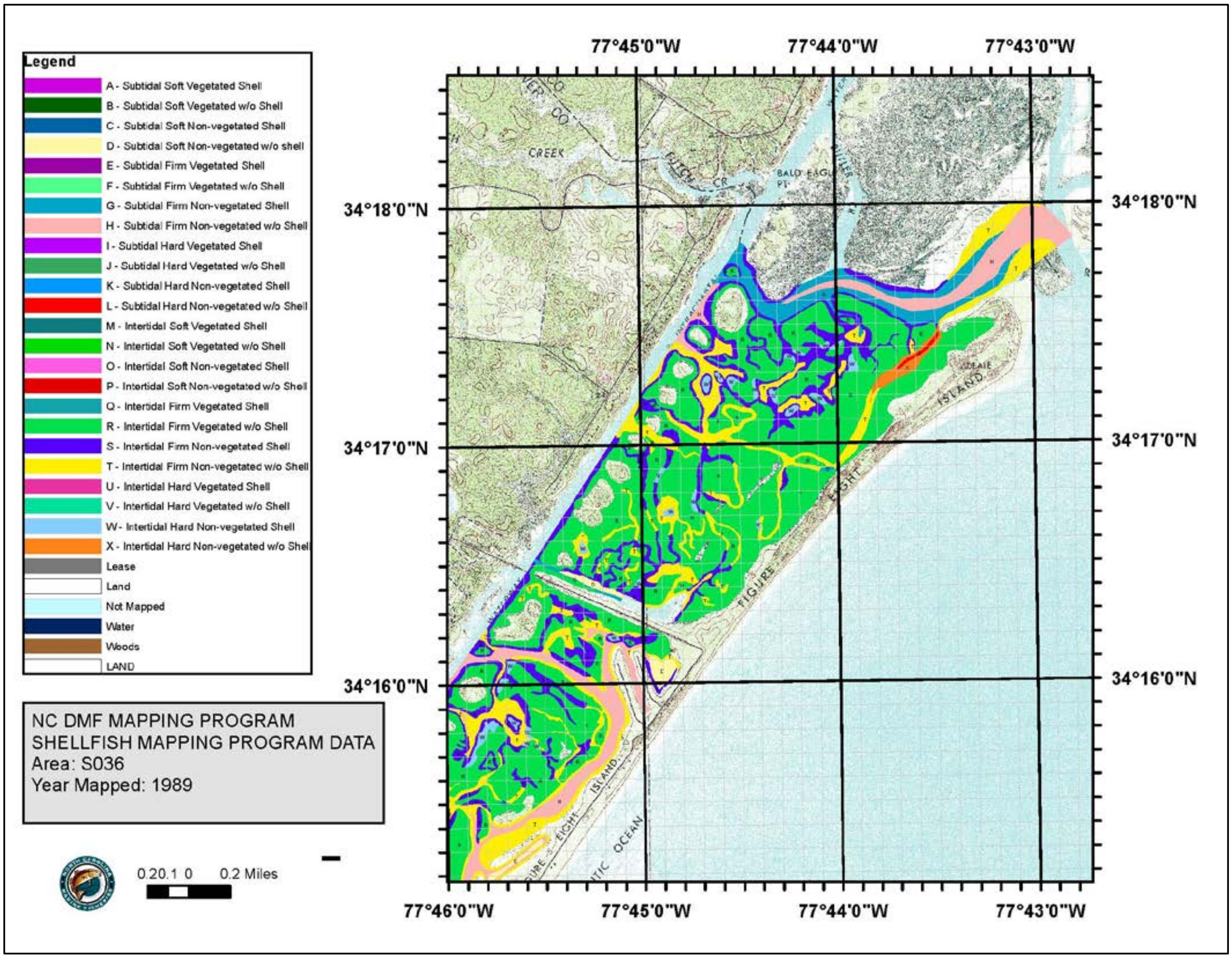


Figure 4.7. NCDMF Shellfish Mapping Program – Area SO36

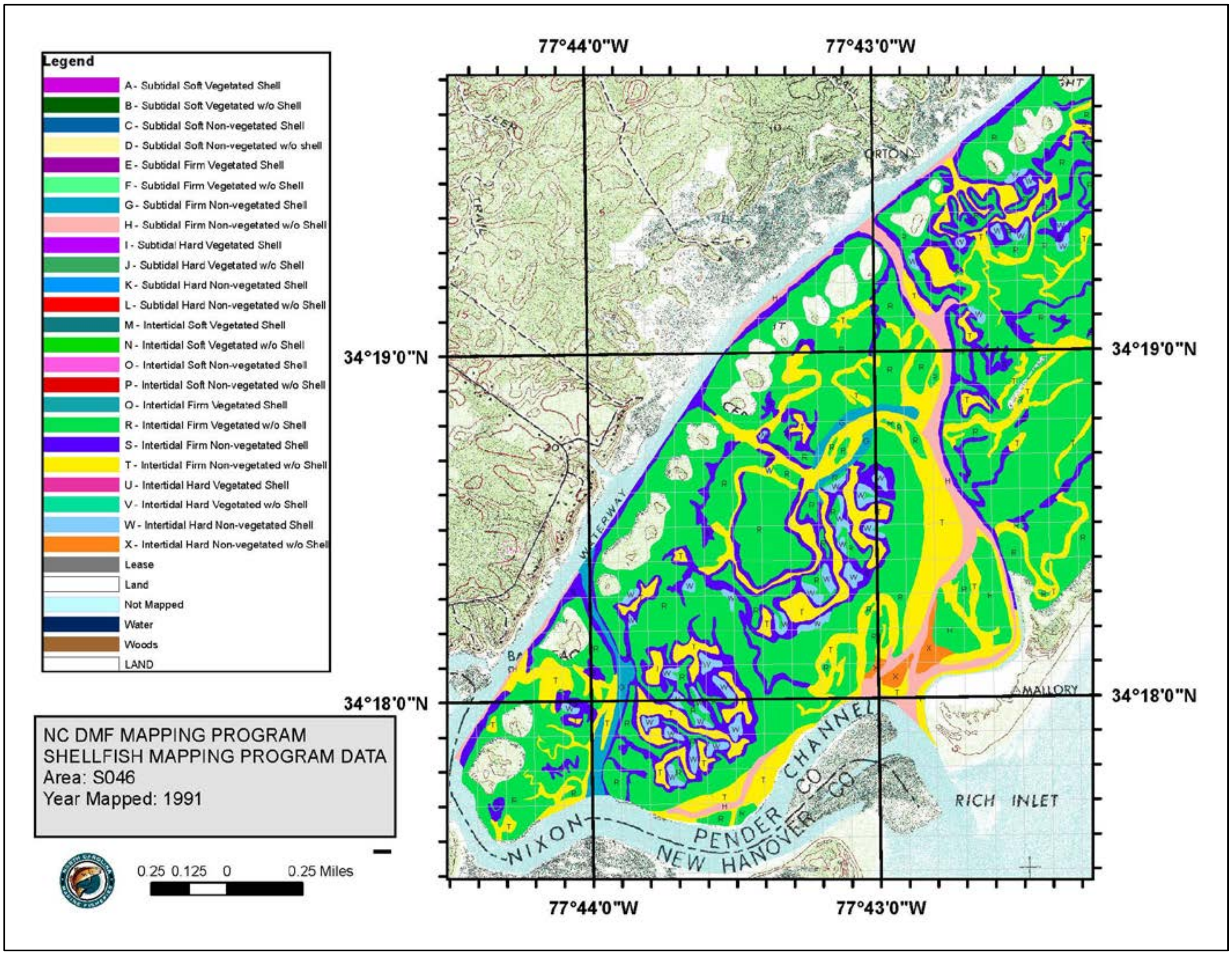


Figure 4.8. NCDMF Shellfish Mapping Program – Area SO46

Table 4.2. Shellfish density data for Area SO36. Surveys conducted by NCDMF between 1989 and 1991

Strata	Number of Samples	Area Sampled (Square meters)	Collection Number	Density (Shellfish per square meter)
S036				
			CLAM	
D	15	13.50	0.00	0.00
G	19	17.10	0.00	0.00
H	25	22.50	0.00	0.00
L	15	13.50	0.00	0.00
R	105	105.00	2.00	0.02
S	56	55.20	75.00	1.36
T	44	43.60	13.00	0.30
W	21	20.40	69.00	3.38
X	15	14.50	0.00	0.00
			OYSTER	
D	15	13.50	0.00	0.00
G	19	17.10	0.00	0.00
H	25	22.50	0.00	0.00
L	15	13.50	0.00	0.00
R	105	105.00	1,176.00	11.20
S	56	55.20	4,469.00	80.96
T	44	43.60	1.00	0.02
W	21	20.40	5,354.00	262.45
X	15	14.50	0.00	0.00
			SCALLOP	
D	15	13.50	0.00	0.00
G	19	17.10	0.00	0.00
H	25	22.50	0.00	0.00
L	15	13.50	0.00	0.00
R	105	105.00	0.00	0.00
S	56	55.20	0.00	0.00
T	44	43.60	0.00	0.00
W	21	20.40	0.00	0.00
X	15	14.50	0.00	0.00

Table 4.3. Shellfish Density Data for Area SO46. Surveys conducted by NCDMF between 1989 and 1991

Strata	Number of Samples	Area Sampled (Square meters)	Collection Number	Density (Shellfish per square meter)
S046				
		CLAM		
G	15	13.50	0.00	0.00
H	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
S	39	39.00	114.00	2.92
T	15	15.00	3.00	0.20
W	15	15.00	45.00	3.00
X	15	15.00	0.00	0.00
		OYSTER		
G	15	13.50	0.00	0.00
H	15	13.50	0.00	0.00
R	15	15.00	79.00	5.27
S	39	39.00	6,506.00	166.82
T	15	15.00	0.00	0.00
W	15	15.00	6,413.00	427.53
X	15	15.00	0.00	0.00
		SCALLOP		
G	15	13.50	0.00	0.00
H	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
S	39	39.00	0.00	0.00
T	15	15.00	0.00	0.00
W	15	15.00	0.00	0.00
X	15	15.00	0.00	0.00

The NCDMF shellfish habitat maps contain 23 individual polygons representing the W stratum within the limited area within the Permit Area. Field investigations were conducted on 15, 17, and 22 September 2008 by CPE-NC staff biologists to visually groundtruth these potential shellfish areas within the Permit Area that may receive impacts due to project related activities. Coordinates of the center point of these polygons were obtained and GPS was utilized to navigate to each location. Water clarity was generally poor with visibility less than 2 ft; therefore snorkelers utilized both visual cues and tactile cues to assess the presence or absence of shellfish resources. The spatial extents of discrete shellfish beds were determined by following the boundary while periodically recording GPS coordinates. These coordinates were then converted to a Geographic Information System (GIS) shapefile using ArcView 9.3 software and overlaid upon high resolution aerial photography. The boundaries of the mapped shellfish beds were then refined through visual interpretation of the aerial photos. Additional shellfish resources within the entire Permit Area were then identified via extrapolation of areas with similar color signature in the 2008 high resolution (<2 feet) geo-referenced aerial photography. These areas were groundtruthed to determine the size and extent of shellfish beds within this area. Of the 23 potential shellfish sites groundtruthed, nine were confirmed to contain live shellfish. Each of these confirmed areas contained scattered patches of live shellfish (primarily *C. virginica*) fringing along the edge of a salt marsh and were not considered to be a discrete shellfish bed. Therefore it was not possible to determine distinct boundaries utilizing GPS. The remaining sites were identified as muddy substrate or scattered shellfish shells.

CPE-NC located and delineated one additional discrete shellfish bed that had not been identified by the NCDMF. Utilizing this site as a confirmed shellfish bed, an additional three sites with similar color signatures were extrapolated from the 2008 high resolution aerial photographs (Figures 4.9 and 4.10). In total, 0.1 acres of shellfish bed habitat have been identified within the Permit Area.

Figure 4.9. Identified shellfish resources within the Permit Area

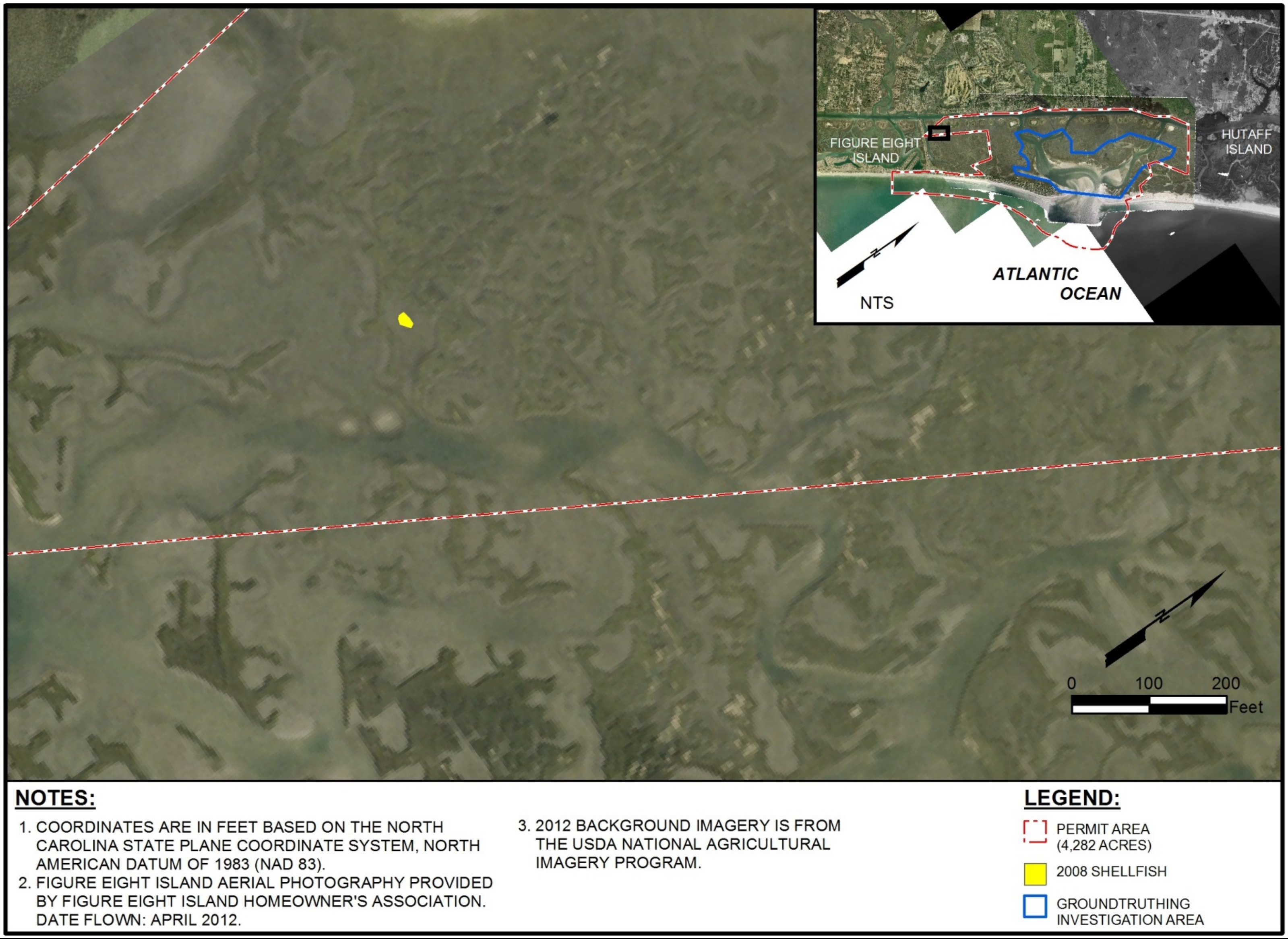


Figure 4.10. Identified shellfish resources within the Permit Area

- <u>Hard Clams</u>

Hard clam

According to the NCDMF, the stock status of hard clams (*Mercenaria mercenaria*) is unknown because there is no data available to assess the population size (NCDMF, 2001). Hard clams are an estuarine-dependent mollusk found primarily in sandy and vegetated bottoms. Increased fishing, poor water quality, and habitat loss have impacted this fishery (NCDMF, 2003a). The EFH for the hard clam, as designated by the SAFMC, includes subtidal and intertidal flats, oyster reefs and shell banks, and SAV (NCDMF, 2001). A State Fishery Management Plan was updated in 2008.

Hard clams are suspension feeders that subsist primarily on phytoplankton. Growth of hard clam larvae is quickest at temperatures found between 22.5 and 36.5ºC (72.5 and 97.9°F) with salinities of 21.5 to 30.0 ppt (Eversole, 1987). They spawn from May through November, when water temperatures reach 20ºC (68°F). Salinities above 25 ppt significantly affect normal embryonic development while temperatures too low will not allow maturation and spawning (Eversole, 1987). Hard clams can be found in nearly all of the sheltered marine waters of North Carolina. Based on research examining clam landings per trip, the NCDMF found that the harvest of clams appeared to be particularly stable (NCDMF, 2001). Results from the 1991 surveys conducted by NCDMF indicated that clams were present in the permit area.

- <u>Eastern Oysters</u>

Eastern oyster

Eastern oysters (*Crassostrea virginica*) are long-lived (approximately 40 years) and are capable of forming large reefs. According to the NCDMF, the eastern oyster has a stock status designation of concern due to a long-term decline most likely caused by over harvesting, habitat disturbances, and pollution. Oysters require a relatively clean, firm substrate to attach to and can be found in intertidal or subtidal estuarine environments. Spawning in North Carolina occurs from May through September. Vast intertidal reefs formed by oysters are significant biological and physical formations in the estuaries of North Carolina. Fish, crabs, and shrimp utilize oyster beds as refuge and as a source of food. The intertidal oyster beds also provide habitat for various infaunal and epifaunal species.

The eastern oyster is a very successful estuarine bivalve and can tolerate a wide variety of salinities, temperatures, currents, and turbidities. The preferred habitat for eastern oysters is from just below MLW to 1 m (3.28 ft) above MLW (Burrel, 1986). The eastern oyster is a prolific bivalve, whose stocks have been depleted, which identified a need for a State Fishery Management Plan (updated in 2008) in parallel with the Hard Clam Fishery Management Plan.

Results from the 1991 surveys conducted by NCDMF indicated that eastern oysters were present in the permit area.

- <u>Bay Scallop</u>

The NCDMF lists the bay scallop (*Argopecten irradians*) as a species of concern based on poor recruitment and low abundances. NCDMF has developed a fisheries management plan for the bay scallop in 2007. *A. irradians* is an estuarine-dependent bivalve found in seagrass (mainly eelgrass) beds. Bay scallops are rarely found attached, although they do have the ability to attach by byssal threads, mainly as juveniles, but as they mature, scallops sink to the bottom and continue to grow (Fay *et al*., 1983). Adult scallops prefer calm waters, secluded from high winds, storms, with tides and depths of 0.3 to 10 m (0.98 to 32.8 ft). Environmental factors, such as temperature and rainfall, play a critical role in scallop abundance (NCDMF, 2003b). They spawn between August and December when water temperatures are approximately 15.5°C (60ºF). No scallops were present during the 1991 surveys conducted by the NCDMF. However, habitat with the potential to support scallops was identified within the Permit Area.

Bay Scallop

<u>Benefits of Shellfish Habitat Areas to Fishery Resources</u>

Shell bottom provides critical fisheries habitat not only for oysters, but also for recreationally and commercially important finfish, other mollusks, and crustaceans. The SAFMC has designated oyster reefs as EFH for red drum (*Sciaenops ocellatus*). The ecological functions of oyster reefs related to oyster production are well known and accepted. These functions include aggregation of spawning stock, chemical cues for successful spat settlement, and refuge from predators and siltation. Oysters have also been described as “ecosystem engineers” that create reef habitat important to estuarine biodiversity and fishery production. Several studies have found higher biological abundance and diversity on shell bottom than adjacent softbottom, particularly pinfish (*Lagodon rhomboides*), blue crabs (*Callinectes sapidus*), and grass shrimp (*Palaemonetes pugio*) (Deaton et al., 2010).

B. Upland Hammock Habitat

Maritime hammocks, also known as maritime forests, tropical hammocks or coastal hammocks, are characterized as narrow bands of forest that develop almost exclusively on stabilized backdunes of barrier islands, inland of primary dunes and scrub. This habitat type is typically dominated by species of broad-leaved evergreen trees and shrubs, maritime hammocks are climax communities influenced heavily by salt spray. Figures 4.1 and 4.2 depict the upland hammock habitat and designates the area as “scrub-shrub” and “upland forest”. The dominant wind direction and influence of salt spray is usually evidenced

Upland hammock

These forested systems are typically dominated by live oak (*Quercus virginiana*), loblolly pine (*Pinus taeda*), and red cedar (*Juniperus virginiana*) trees with an understory of shrub thicket which can support such species as swamp bay (*Persea palustris*) and sweetbay (*Magnolia virginiana*).

by the sculpted vegetation (Texas Cooperative Research Unit, 2002). Twenty-seven (27) acres of upland hammock as well as 67 acres of scrub-shrub habitat have been delineated within the Permit Area, as determined through interpretation of high resolution aerial photography from 2006.

Benefits of Upland Hammocks to Colonial Waterbirds

Colonial waterbirds utilize a variety of habitats for foraging, roosting, and nesting, which includes estuaries, oceanfronts, open dunes, inland areas, and intertidal shoal habitats. These birds also use a variety of habitats for nesting. Some colonial waterbirds such as green herons and yellow-crowned night herons utilize vegetated, upland environments. These three colonial waterbird groups prefer trees, shrubs, and grass lands for nesting and, as a result, may utilize the upland hammocks identified within the Permit Area.

C. Inlet Dunes and Dry Beach Habitats

This section identifies and discusses the dune and beach communities within the Rich Inlet complex. These habitats are present around the periphery of the inlet. Inlet dunes and inlet beaches are similar to coastal dunes and coastal beaches, however, as a result of episodic overwash, these habitats are typically not as established as coastal beaches and often lack the vegetation common on the coastal beach and dune systems. Inlet dunes are defined as any hill, mound, or ridge of sand along the inlet coastline created by natural or artificial forces. The inlet dry beach habitat is defined as the portion of the ocean beach in proximity to the inlet that is between mean high water and the toe of the dune. These inlet dunes and beaches are also susceptible to forecasted sea level rise.

Benefits of Inlet Dunes and Dry Beaches to Shorebirds, Colonial Waterbirds, and Other Waterbirds

Most shorebirds are long distance migrants, who migrate through and winter in North Carolina en route to find suitable breeding sites in the Arctic. To complete these flights, shorebirds must obtain a large food reserve. The inlet dunes and beaches in proximity to Rich Inlet provides migration stop-over areas used by shorebirds to replenish food reserves and accumulate fat needed for the long flights. There are few places that have the necessary combination of resources. In some areas, between 50% and 80% of the entire population of a species may visit a single site (MCCS, 2003). Migratory arctic-bound shorebird species that may be found during the non-breeding season within inlets of North Carolina include the red knot (*Calidris canutus rufa*), dunlin (*Calidris alpine)*, western sandpiper (*Calidris mauri)*, and sanderlings (*Calidris alba*). Many arctic breeding species are experiencing declines, including the red knot, which was recently listed as a candidate for protection under the Endangered Species Act. Surveys conducted during 2007 by Audubon North Carolina revealed a total of 878 red knot individuals observed along Mason Inlet, Rich Inlet, Lea Island, and Hutaff Island. The maximum count at each location on an individual survey was 188, 258, 6, and 20, respectively at each location (Mangiameli, pers. comm., 2008).

Shorebirds utilize these inlet dunes and beaches for breeding, wintering and migrating. Many species rely on a few, key stopover sites to complete their annual migratory cycle. The Outer

Banks of North Carolina constitute a prime example of a potentially important area for which only limited information on migratory birds is available (Dinsmore, *et al*., 1998).

Some species of waterbirds, such as terns and black skimmers, nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as increased vegetation or storm events. In selecting nesting habitat, waterbirds recognize the area and past success, but mainly adhere to group dynamics. This type of grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds.

1. Overwash Habitats

One type of dry inlet beach habitat that is an important feature is overwash areas. Natural processes, such as storms, create overwash features behind primary sand dune areas. A total of 7 acres of overwash habitat has been delineated within the Permit Area. Overwash areas are usually created during strong storm events when tides wash over portions of the beach and move sand back towards the sound, creating new habitat. Overwash areas are characterized by the low sand flats left where storm waves have washed across a barrier island. This includes loose sand, perhaps piled into dunelets and/or divided by sluiceways, and usually scattered weedy shrubs and herbs. After the site has gone for an extended period without storm scouring, the vegetation may develop into a dense mat of vines and grasses. Island overwash is an important natural process in maintaining coastal barrier islands. Large man-made dunes may limit the occurrence of overwash features. When overwash occurs, the net volume of sand is often maintained and the island migrates landward (Donnelly *et al.,* 2006). Barrier islands naturally migrate landward as a result of sea level rise. This is accomplished through overwash events where sediments are pushed to the sound side, which contributes to building marsh on the sound side.

Benefits of Overwash Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds

Overwash features are not unique to inlets; however, the dynamic and productive microhabitats formed as a result of inlet migration are very important to both breeding and non-breeding waterbirds. Overwash habitats include ephemeral pools and bayside mudflats which are important feeding areas to piping plovers at the start of the nesting season and throughout the year (Fraser, 2005; USFWS, 1996). Overwash habitat is utilized by wildlife, particularly shorebirds, colonial waterbirds and other waterbirds as they provide suitable foraging and nesting habitat for these birds. Overwash events usually occur during storm events or in low areas during spring high tide conditions when seawater flows through the primary dune line, spreading out sand from the beach and dunes. Recently created overwash fans are generally unvegetated and function similar to the dry beach community. Willets, American oystercatchers, piping plovers, Wilson's plovers, and killdeers usually nest on open areas such as above the high tide line on coastal beaches, on sand flats at the ends of sand spits, and along blowout areas behind dunes and in overwash areas. These open habitats are utilized by breeding and non-breeding colonial waterbirds. In particular, the Wilson's plover and the federally threatened piping plover are both dependent on hurricanes and storms to provide the overwash needed for nesting habitat (Deaton et al., 2010).

D. Intertidal Flats and Shoals

Intertidal flats and shoals

These habitats areas are considered to be important feeding areas to shorebirds at the start of the nesting season and throughout the year. This includes the federally protected piping plover (Fraser, 2005; USFWS, 1996).

Intertidal flats and shoals are defined as non-vegetated, soft sediment habitats, found between mean high-water and mean low-water spring tide datum (Dyer et al. 2000) and are generally located in estuaries and other low energy marine environments. Mean high water is defined as the average elevation of all high waters recorded at a particular point or station over a considerable period of time. Mean low water is defined as the average elevation of all low water at a particular location also over a considerable period of time. Intertidal flats and shoals are distributed widely along coastlines world-wide, accumulating fine-grain sediments on gently sloping beds, forming the basic structure upon which coastal wetlands build. The tidal flats and shoals of North Carolina are habitat to a variety of migratory shorebirds, colonial waterbirds, marine mammals, reptiles, fish and macro-infauna. For this reason, these habitats are considered to be a valuable natural resource. These habitats have developed into a dynamic inlet system and, therefore tend to be ephemeral in nature, especially with regard to dynamic island formation within the inlet. A total of 206 acres of intertidal flats and shoals are located within the Permit Area, mainly within the inlet complex.

<u>Benefits of Tidal Flats and Shoals to Shorebirds, Colonial Birds and Other Waterbirds</u>

During all months of the year, Rich Inlet provides important foraging, roosting and nesting habitats for shorebirds, colonial birds, and other waterbirds. The intertidal shoals and sand flats provide sheltered and isolated habitat for roosting and foraging. Prey resources for shorebirds include mainly invertebrates and small fish. Most shorebirds are aquatic and terrestrial probers/gleaners that can wade in the surf of intertidal areas. Breeding and non-breeding federally endangered species and species of special concern also utilize intertidal flats and shoals. Therefore, Rich Inlet's habitats and the shorebirds that utilize them are a very important natural resource to the coast of North Carolina. Intertidal flats and shoals, particularly low-energy wet sand flats and shoals, are essential to many species of migrating and wintering shorebirds (Colwell 2010).

<u>Benefits of Tidal Flats and Shoals to Benthic Macroinfaunal Community</u>

These tidal flats and shoals in the inlet complex provide habitat for the macroinfaunal community due to their softbottom consistency. Softbottom habitats are comprised of unconsolidated sediment and defined as "unvegetated", lacking visible structural habitat. However, this "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Deaton et al., 2010).

Macroinfaunal species are resident to the upper 1 m (3.28 ft) of the substrate due to the available oxygen content and aeration properties; although some larger species may live deeper in the seabed (USFWS, 2002). Dominant macroinfaunal species typical of the bays and sounds of North Carolina include bivalves, decapods, polychaetes, and amphipods.

Macroinfaunal species are a primary food source for several migratory and resident shorebirds, waterbirds, as well as for many commercially and recreationally important fish. Bird species can be found utilizing the Inlet and surrounding estuarine environments as a stop-over feeding station while traveling to their wintering and nesting grounds. Migratory fish species utilizing the inlet depend upon the macroinfaunal community as a food reserve, en route to upstream seagrass beds and estuarine habitats.

Benefits of Tidal Flats and Shoals to Fishery Resources

As stated above, these habitat areas host an abundance of macro species which are food sources for many fishery resources. The tidal flats and shoals of North Carolina are habitat to a variety of, anadromous, estuarine, and marine fish species (USFWS, 2002), such as cobia (*Rachycentron canadum*), lane snapper (*Lutjanus synagris*), red drum (*Sciaenops ocellatus*), red grouper (*Epinephelus morio*), spadefish (*Chaetodipterus faber*), gag (*Mycteroperca microlepis*), king mackerel (*Scomberomorous cavalla*), white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), southern flounder (*Paralichthys lethostigma*), and summer flounder (*Paralichthys dentatus*). These species benefit from tidal flats and shoals as the habitat is used for refuge, corridor, nursery, and spawning purposes (Deaton, 2010).

E. Oceanfront Dry Beach and Dune Habitats

1. Oceanfront Dune Communities

The primary dune extends landward to the lowest elevation in the depression behind that same mound of sand (commonly referred to as the dune trough). Frontal dunes are defined as the first mound of sand located landward of the ocean beach having sufficient vegetation, height, continuity and configuration to offer protective value (NC DCM, 2008b).

> **Oceanfront Beach and Dune Habitats**
>
> Section 15A NCAC 7H .0305(c) of the North Carolina Administrative Code defines primary dunes as the first mounds of sand located landward of the ocean beaches having an elevation equal to the mean flood level (in a storm having a one percent chance of being equaled or exceeded in any given year) for the area plus six feet.

Dunes and their associated plant species are important in providing shorefront protection against coastal storms and supplying sand to the beach system during periods of erosion. A total of 60 acres of dune communities are located within the Permit Area primarily the oceanfront shoreline along Figure Eight Island and Hutaff Island behind the dry beach habitat. This habitat is also found within the back side of the inlet system.

Benefits of Oceanfront Dune Communities to Plant Species

High temperatures, strong winds, and varying wet and dry conditions typical of a dune environment provide unique conditions for plant species with specific adaptations. These specific adaptations include plant species that grow extensive root systems, allowing for prolific growth in unconsolidated beach sand. Perennial grasses are the primary stabilizers of frontal dune systems along beaches and dunes. North Carolina is located in a vegetation transition zone, between American beach grass (*Ammophila breviligulata*) to the north, and sea oats (*Uniola paniculata*) to the south.

2. Oceanfront Dry Beach Communities

Eroded material from the dune system contributes to the dry beach located between the toe of dune or scarp and mean high water (MHW) line. The dry beach area is susceptible to wind and storm surge, which supports less vegetation than the dune community. However, this habitat type provides recreational areas for humans and nesting grounds for sea turtles and shorebirds. A total of 75 acres of dry beach communities are located along the ocean shoreline on Figure Eight Island and Hutaff Island within the Permit Area.

Benefits of Oceanfront Dry Beach Habitats to Sea Turtles

Five species of sea turtles nest on North Carolina beaches: the green sea turtle, loggerhead sea turtle, leatherback sea turtle, hawksbill sea turtle and Kemp's Ridley sea turtle. Sea turtles prefer to nest on wide sloping beaches or near the base of the dunes. Dry beaches must allow for the following in order for nesting to be successful: beach areas above the mean high water line must be wide enough to allow nesting to occur; access to the dry beach must be devoid of obstructions (i.e. fencing, seawalls); the sand compaction must allow for digging, and; the nesting area to be located away from areas of inundation throughout the nesting season. The composition, color, and grain size can affect the incubation time, gender, and hatching success of turtle hatchlings (Deaton et al., 2010).

Benefits of Oceanfront Dry Beach Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds

Beach-nesting birds that utilize dry beach habitats for nesting include terns, black skimmers, Wilson's plovers, piping plovers and American oystercatchers. Terns and black skimmers nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as increased vegetation. Waterbirds use group dynamics to select suitable nesting areas. This grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds (Cameron, pers. comm., 2007). This is one reason why it is important that these birds have a number of suitable nesting, foraging, and roosting sites along the coast. For colonial waterbirds such as black skimmers and gulls, they utilize estuarine habitats, oceanfront shorelines, open dunes, inland areas, and dry beach habitats for foraging, roosting, and nesting.

The undeveloped beaches along Hutaff Island have been identified by the NCWRC as one of the most important migratory stop over sites and wintering sites for the federally threatened piping plover. Portions of the Permit Areas are regulated under a Critical Habitat listing as identified in the Endangered Species Act.

Wet beach with scarp formed on Figure Eight Island (March 18, 2008)

(Jarrett, 2008)

F. Wet Beach Communities

The intertidal zone of oceanfront barrier island beaches or wet beach communities are areas that are periodically exposed and submerged by waves, varying with frequency and with lunar tidal cycles. Like intertidal shoals, these areas are comprised mainly of sandy bottoms and shell hash and are influenced by tidal changes and are susceptible to storms. This high energy area is habitat to many benthic organisms and foraging grounds for birds and finfish. A total of 96 acres of wet beach habitat are found primarily along the oceanfront shoreline of Figure Eight Island and Hutaff Island within the Permit Area.

1. Benthic Infaunal Community

On oceanfront beaches, most benthic organisms in the intertidal zone consist of infaunal burrowing forms, particularly polychaete worms (Phylum Annelida), coquina clams (*Donax variabilis and D. paruvula*) and mole crabs (*Emerita talpoida*) (USFWS, 2002). Many benthic organisms are filter feeders, which pump large amounts of water through their bodies. As they pump water, they remove sediments and organic matter, thus filtering the water. Some of the organic matter filtered from the water is not used and instead deposited in the sediment. These nutrients can later be recycled by benthic organisms and dispersed back into the water column, making them available to other organisms. Thus, benthic organisms are critical in maintaining the high production rates of estuaries.

While several species of amphipods and polychaetes populate the intertidal and shallow subtidal beaches of North Carolina, their contribution to the total biomass of benthic infauna is low due to their small body size. Due to their short life spans and frequent reproduction events and despite their relatively low biomass, these species are important to the benthic infaunal community in regard to their contribution to primary and secondary productivity. Therefore, mole crabs and coquina clams dominate the benthic infaunal community due to their biomass (Peterson *et al.*, 2000).

- Mole Crab

Mole crabs (*Emerita talpoida)* live at depths above 5 cm under sand in shallow water in the swash zone or marine intertidal areas (Bowman and Dolan, 1985). *E. talpoida* is a very mobile species and is highly adaptable to the harsh and dynamic swash zone environment. Mole crabs have the color of rippled sand at the water's edge and live mostly buried in the sand, with their antennae reaching into the water forming a "V" shaped obstacle in the water as the wave recedes. These antennae filter plankton and organic debris from the water. Mole crabs also eat the tentacles of Portuguese man o' war (*Physalia physalis*), which are collected by winding the tentacle around the mole crab's leg. Camouflage protects the mole crab from predators, primarily fish and birds. Males are smaller than females, only reaching 20 mm, making the sexes easy to tell apart when fully grown. Females grow to 35 mm in length and carry their bright orange colored eggs under their telson until they are ready to hatch. Recruitment can occur year round, but large numbers of recruits are found in early summer and in early fall. Diaz (1980) found that most recruitment occurred in September as a result of summer spawning. Amend and Shanks (1999) also found that the reproductive season ended in late September.

Female mole crabs do not rely on tidal cues to time larval release; instead, larvae are released at sunset regardless of the time of the tide. Since larval release occurs within the intertidal zone, the physical wave motions and currents are most likely strong enough to transport larvae away from the shoreline to coastal areas for development (Ziegler and Forward, 2005). Amend and

Shanks (1999) reported that larval release is also influenced by wave height during rough seas where larvae are rapidly transported offshore away from adult habitat and predation.

As the swash zone changes with the tide, so does the location of the mole crabs. The mole crabs move up and down the beach with the tides. In the winter, storms carry them offshore possibly into sandbars; however, when the sand is transported back onshore in the spring, the mole crabs travel with it. Bowman and Dolan (1985) found that the overwintering populations migrate onshore in April during a period of rapidly increasing water temperatures. These population fluctuations are an important consideration when using *E. talpoida* as an indicator species for assessing environmental impacts.

- Coquina Clam

Coquina clams (*Donax variabilis)* are small, generally less than 2.5 cm in length, and possess wedge-shaped shells (Ruppert and Fox, 1988). Like most bivalves, coquinas are filter feeders, ingesting phytoplankton, bacteria, and other small suspended particles in the surf zone. The wet beach environment is extremely dynamic, eroding and accreting several times in a period of months. Although many organisms feed in the surf zone, this clam has unique adaptations to this habitat type, making the coquina clam a key habitat indicator species.

Donax variabilis migrates shoreward with the incoming tide and seaward with the outgoing tide (Ellers, 1995). While these clams spend most of their time buried in the sand, they emerge several times per tidal cycle to ride waves. Ellers (1995) named this method of movement "swash-riding" where each clam emerges from the sand and the flow from waves drags it to a new position to maintain optimum position at the sea's edge. Coquina clams actively migrate up and down the beach during spring and summer; however these tide-related migrations cease in winter as *D. variabilis* eventually moves into the subtidal zone in late fall. The fluctuation of the location of populations in relation to the changing tides is an important consideration when assessing this species and one should expect variation if sampling at different tidal levels.

Both males and females are required for reproduction. Spawning occurs subtidally in winter and juveniles recolonize the intertidal beach in late winter (Ruppert and Fox, 1988). The typical lifespan of coquina clams is two years.

The temporal pattern of presence and recruitment of macroinvertebrates of the South Atlantic Bight are depicted in Table 4.4 below.

Table 4.4. Temporal presence and major recruitment periods of surf zone invertebrates of the South Atlantic Bight (Hackney, et al., 1996).

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Coquina Clams (Donax variablis)	P	P	P	P	H	H, R	H,R	H	H	H	P	P
Ghost Crabs (Ocypode quadrata)	P	P	P	P	P	P, R	P, R	P, R	P, R	P	P	P
Beach Hoppers (Orchestiodea)	?	?	P	P	P	P	P	P	P	P	P	P
Sand Hoppers (Talorchestia)	?	?	P	P	P	P	P	P	P	P	P	P
Worms (Polychaetes)	P	P	P, R	H, R	H, R	H, R	H, R	H, R	H, R	H	P	P
Mole Crabs (Emerita taploidea)	P	P	P	P	H	H	H	H, R	H, R	H	P, R	P, R

P = present, H = periods of peak abundance, R = periods of recruitment

Benefits of Wet Beach Habitats to Fishery Resources

Many infaunal species are important food sources for demersal predatory fishes and mobile crustaceans. Some of the species that forage on benthic invertebrates in the swash zone include inshore lizardfish (*Synodus foetens*), Florida pompano (*Trachinotus carolinus*), pigfish (*Orthopristis chrysoptera*), pinfish *Lagodon rhomboides*, spot (*Leiostomus xanthurus)*, kingfish (*Menticirrhus littoralis, M. americanus*), red drum (*Sciaenops ocellatus*), Atlantic croaker (*Micropogonias undulates*), northern sea robin (*Prionotus carolinus*), summer flounder (*Paralichthys dentatus*), weakfish (*Cynoscion regalis*) and penaeid shrimp (Deaton et al., 2010). Many of these species use the high energy environment as protection from other predatory species, as well as for feeding grounds.

Benefits of Wet Beach Habitats to Shorebirds, Colonial Waterbirds, and Other Waterbirds

Many infaunal species are important food sources for a variety of bird species, especially the beach-nesting birds. Colonial waterbirds, such as black skimmers that utilize estuarine habitats, oceanfront shoreline, open dunes, and inland areas also utilize wet beach habitats for foraging, roosting, and nesting. These colonial waterbirds can alter their location in response to changes in environmental conditions.

G. Marine Habitats

Cowardin (1979) classifies marine habitats as open ocean waters overlying the continental shelf and its associated high energy coastline where salinities exceed 30 ppt. With this broad classification, many habitats or community types fall within the definition and have previously been, or will be, discussed in other sections of this EIS. This section, however, will focus on soft and hardbottom communities that are considered marine habitats. Marine nearshore softbottom communities are found in the intertidal zone as well as the subtidal zone. Marine intertidal and subtidal zones along the shoreline are highly affected by tides and bottom friction. North Carolina’s tidal amplitude along ocean shoreline is greatest where the continental shelf is widest in the southern coastal area; average tidal height is approximately 2 ft (0.6 m) near Cape Hatteras and 4.3 ft (1.3 m) near Cape Fear (Deaton et al., 2010).

1. Softbottom (Unconsolidated) Communities

Softbottom habitat is the unvegetated bottom sediment in all coastal systems, and includes features such as inlets, shoals, channel bottoms, intertidal ocean beaches, and cape shoals. Softbottom plays a key role in primary productivity in shallow estuarine and marine systems. This habitat strongly influences the water column through dynamic cycling processes, storing and releasing nutrients and chemicals over time. Other ecosystem functions of softbottom include the reduction of physically destructive storm effects on oceanfront beaches, and providing sand sources for barrier island and inlet migration.

Softbottoms consist of both mud and sand substrates. Mudflats are sedimentary intertidal habitats created by deposition in low energy coastal environments, particularly estuaries and other sheltered areas and therefore are not pervasive in marine habitats. The sediments generally consist of silts and clays with a high organic content" (NMFS, 2006 - Mudflats). Sand bottoms consist of materials with grain sizes more coarse than silt (>0.0625 mm) (Anderson, 2006).

Periodic storms can affect benthic communities along the Atlantic coast to depths of approximately 35 m (115 ft). As a result, softbottom communities tend to be dominated by opportunistic taxa which have adapted to relatively quick recovery from disturbance (Deaton et al., 2010). Seasonal climatic changes can also influence the diversity and abundance of macroinfaunal species in these areas. Species abundance during the late winter and early spring is typically higher with densities of over 3,500 per 100cm^2 commonly observed (Mallin *et al*., 2000), although individual species vary considerably in their abundance throughout the year.

Generally, inadequate data are available to clearly indicate the current condition of softbottom habitat. Fortunately this habitat is relatively resistant to a changing environment. This is the most abundant submerged coastal fish habitat. This "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Deaton et al., 2010). Intertidal shoal, marine intertidal (wet beach) and subtidal areas in the Permit Area provide a total of 2,580 acres of possible habitat for softbottom communities.

Benefits of Softbottom Communities to Fishery Resources

Muddy bottoms are not pervasive in the marine environment and, rather, are located primarily in the estuarine habitats behind Figure Eight Island and Hutaff Island. Sandy substrates dominate the marine softbottom communities located off the ocean shoreline.

Softbottom habitat is used to some extent by almost all native coastal fish species in North Carolina. Certain species are better adapted to this shallow non-vegetated bottom. Flatfish, rays and skates are well suited for utilization of softbottom. Juvenile and adult fish species that forage on the rich abundance of macroalgae, detritus and small invertebrates are highly dependent on the softbottom. Softbottom habitat is particularly important as a foraging area for all size ranges of bottom feeding fish and invertebrates, such as blue crabs, shrimp, flounders, striped mullet, spot, croaker, and kingfish. Burrowing mollusks (e.g., hard clams, coquina clams), flatfishes (e.g., southern flounder, hogchoker) and baitfish (e.g., striped mullet) are highly associated with shallow softbottom, while larger benthic feeding predators (e.g., weakfish, coastal sharks, sturgeons) typically utilize deeper softbottom areas. Valued fishery species that depend on healthy softbottom habitat include hard clams, shrimp, blue crabs, southern flounder, Atlantic croaker, striped mullet, kingfish, and spot. Of these, the NCDMF stock status of Atlantic and shortnose sturgeons, southern flounder, and coastal sharks was overfished. Striped mullet and Atlantic croaker were listed as Concern. The Atlantic sturgeon, which is classified as Overfished, has been under a fishing moratorium since 1991 but has not shown signs of recovery.

Offshore sand bottom communities along the North Carolina coast are relatively diverse habitats containing over a hundred polychaete taxa (Posey and Ambrose, 1994). Tube dwellers and permanent burrow dwellers are important benthic prey for fish and epibenthic invertebrates.

2. Hardbottom (Consolidated sediment) Communities

The term “hardbottom” refers to areas of rock or consolidated sediments in temperate, subtropical, and tropical regions, generally located in the ocean rather than in the estuarine system. Hardbottom habitats are also called “livebottom” due to the variety and abundance of invertebrates and plants that attach to or bore into these hard substrates. The topography of these habitats can vary from a relatively flat, smooth surface to a scarped ledge with stepped relief. Hardbottom habitats include shallow kelp-covered areas in rocky headlands, rock outcrops, submarine canyon walls, and the deep-water plateau. Along the south Atlantic states, hardbottom ranges from the shoreline and nearshore (within the state’s 3-mi jurisdictional limit) to beyond the continental shelf edge (>200 m deep). It typically occurs in clusters across the shelf in specific areas. Estimates of the percent cover of hardbottom vary greatly along the south Atlantic coast between Cape Canaveral and Cape Hatteras (NOAA, 2007; Deaton et al., 2010).

Benthic water temperatures at hardbottom habitats in the ocean off North Carolina range from approximately 52.8° to 80.6° F (11° to 27° C). Salinity is typically around 35 ppt with little fluctuation. The composition of invertebrate, algal, and fish communities varies with temperature, depth and season.

Dr. William Cleary identified two areas of potential hardbottom resources located offshore Figure Eight Island and Hutaff Island (Cleary, 2000) (Figure 4.11). In order to verify the presence of hardbottom communities within the project area, a sidescan sonar survey was conducted off Figure Eight Island on 24 April 2009 (Figure 4.11). Following analysis and interpretation of the sidescan sonar data, a groundtruthing investigation of eleven (11) sites was conducted on 30 June 2009 (See Appendix D). A number of sorted bedform features were identified through sidescan interpretation and verified through groundtruthing. Several areas generically interpreted as "bottom morphology of interest" were found to be sandy areas with abundant sand dollars. Other areas interpreted as "bottom morphology of interest" were found to be areas where fluidized mud had covered the existing bottom substrate. No rock outcrops or hardbottom communities were observed at any of the eleven (11) locations either exposed or buried; therefore, no hardbottoms are likely to be present within the Permit Area.

Samples of material acquired during hardbottom investigations

Course Material

Fine Material

Fluidized Mud

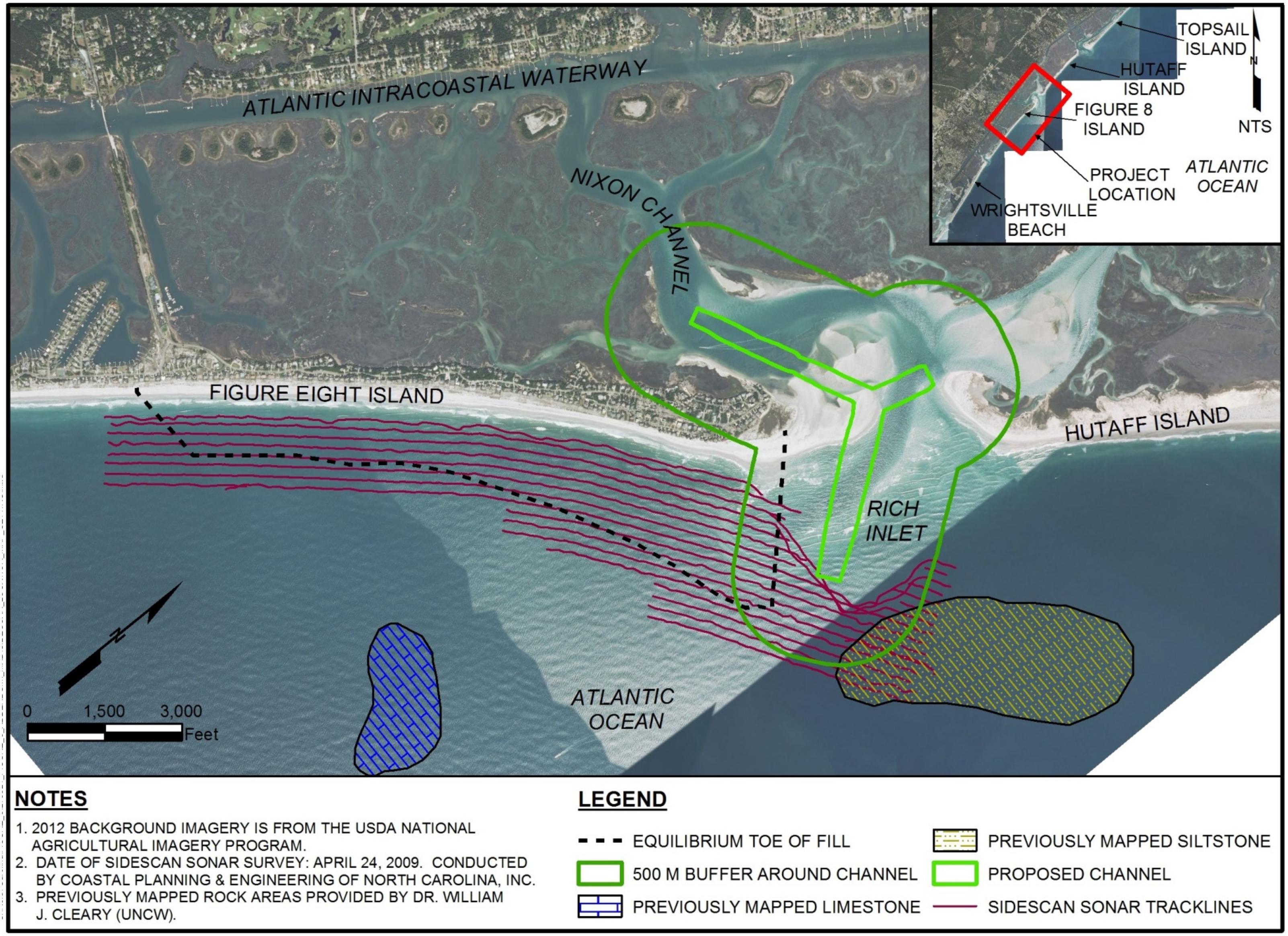


Figure 4.11. Map depicting sidescan sonar survey area. Note the tracklines cover the area within 500 meters of the proposed channel and the shoreface out beyond the point of equilibrium toe of fill.

H. Water Column

Water column is a conceptual column of water from its surface to bottom sediments. The concept of water column is important, since many aquatic processes are explained by the vertical mixing of chemical, physical or biological parameters. The depth of water column varies greatly throughout the Permit Areas. Within the waterbodies of Nixon and Green Channels, the depth ranges from less than 1 foot to approximately 18 feet; and the water column depth from the inlet gorge to the outer bar channel of Rich Inlet ranges from approximately 5 feet to nearly 30 feet. Along the ocean shoreline, the water column ranges from approximately 2 feet deep within the surf zone to approximately 25 feet deep. Conditions that influence the water column are hydrodynamic flow processes and salinity levels. The water column encompasses approximately 2,580 surface acres within the Permit Area.

Water column

Water column habitat is defined in North Carolina's Coastal Habitat Protection Plan (CHPP) as "the water covering a submerged surface and its physical, chemical, and biological characteristics" (Street *et al.,* 2005). It connects all other aquatic habitats, and is the "medium of transport for nutrients and migrating organisms between river systems and the open ocean" (SAFMC, 1998).

1. Hydrodynamics and Salinity

Hydrodynamic flows in nearshore, shallow environments, including the surf zone, are different from coastal and deep-ocean flows mainly because of the shoreline barrier, shallow depths, bathymetric features associated with the continental shelf, and nearshore inputs of freshwater. Moreover, flows in nearshore waters tend to be more complex than in the deep and coastal ocean because many processes operate there, including surface gravity waves, buoyancy driven flows, wind-forcing, surface and internal tides, large-amplitude internal waves and bores, and boundary-layer effects (Pineda et al, 2007). These differences between nearshore and coastal/open ocean hydrodynamics are important for larval transport.

Ocean tides on Figure Eight Island are semi-diurnal (occurring approximately every 12 hours), with a spring-neap variation of 28 days. Tidal ranges inside the AIWW range from 3.2 to 3.6 ft. The tidal range in the throat of the inlet is approximately 3.7 ft. The tidal prism through the throat of Rich Inlet is approximately 560,000 cubic feet.

In the throat of the inlet and Green Channel, the tidally influenced currents are flood-dominated, which means that water flows are greater as the water flows from the ocean through the inlet. In Nixon Channel, the currents appear to be ebb-dominated, meaning that the water flows are greater as the water flows from the inlet toward the ocean. In the throat of the inlet, the peak currents were 3.2 feet/second during flood and 2.7 feet/second during ebb, with a principal axis of 319º/139º. In Green Channel, the peak currents were 3.0 ft/sec during flood and 2.0 ft/sec during ebb, with a principal axis of 341º/161º. In Nixon Channel, the peak currents were 1.7 ft/sec during flood and 1.8 ft/sec during ebb, with a principal axis of 280º/100º. For more information regarding the tides and tidal flow within the Permit Area, refer to the Engineering Analysis (Appendix B).

The principal direction of waves along the beaches of Figure Eight Island and Hutaff Island are from the east-southeast and the southeast. The highest waves occur in February during the northeaster season and in August and September during hurricane season. During the summer, waves tend to approach from the south-southeast, driving the sediment transport towards the northeast. During the winter, waves tend to approach from the east-southeast, driving the sediment transport towards the southwest. For more information regarding the wave climate within the Permit Area, refer to the Engineering Analysis (Appendix B).

Rich Inlet is a sediment sink that gains 100,000 to 200,000 cy of sand material each year. The source of this material alternates between the adjacent beaches on Figure Eight Island and the adjacent beaches on Hutaff Island depending on the orientation of Rich Inlet. The present source is Hutaff Island.

Near the northern end of Figure Eight Island, there is a nodal point, at which eroding sediments spread towards both the northeast and the southwest. This nodal point has shifted towards the northeast since 1999, but currently lies near Inlet Hook Road. Along the middle of Figure Eight Island, sediment transport can occur in either direction. The present sediment transport direction is towards the southwest. On the southern end of Figure Eight Island, the predominant sediment transport is towards the southwest. Sediment transport rates at the south end of Beach Road vary from 50,000 to 250,000 cy per year. Given the present and past erosion patterns within a mile of Rich Inlet, the northeasterly sediment transport on Topsail Island (USACE, 2006), and the southwesterly transport near Mason Inlet, Rich Inlet probably functions as a regional nodal point.

A primary factor affecting the distribution of estuarine-dependent fish and shellfish is salinity. Marine waters of the Permit Area vary on a daily basis in current and salinity conditions due to fresh water inflow, tides, and wind.

The North Carolina Recreational Water Quality Program (RWQ) also tests coastal waters. Their mission is to protect the public health by monitoring the quality of N.C.'s coastal recreational waters and notifying the public when bacteriological standards for safe bodily contact are exceeded. The coastal waters monitored include the ocean beaches, sounds, bays and estuarine rivers. RWQ tests for *Enterococci* bacteria, an indicator organism found in the intestines of warm-blooded animals. While *Enterococci* will not cause illness itself, its presence is correlated with that of organisms that can cause illness. The program tests 241 ocean and sound-side areas, most of them on a weekly basis. Lower-use beaches are tested twice a month.

Three RWQ sampling stations are located within the Permit Area. These stations include Station 50 (located in the AIWW between Mason’s Creek and Pages Creek), 50A (located in Middle Sound at the south end of Figure Eight Island), and 50B (located in Nixon’s Channel). Information taken at the stations includes salinity readings. In 2007, measurements obtained by RQW within stations 50, 50A, and 50B averaged 35.7 ppt, 36.0 ppt, and 35.9 ppt, respectively. No additional measurements since 2007 are available due to the State’s discontinued use of monitoring these sites. These salinity levels support a wide range of fishery resources that are typical in inlet and estuarine complexes similar to Rich Inlet and associated water bodies.

Benefits of Water Column to Fishery Resources
Estuarine and marine water column environments in the Permit Area include the beach areas and surf zones of Figure Eight Island, Hutaff Island, Rich Inlet, Nixon Channel, Green Channel, and Middle Sound. Fish that utilize the water column of North Carolina include: anadromous fish, which can be found in coastal waters but migrate into rivers to spawn in freshwater (e.g. striped bass, Atlantic and shortnose sturgeon, herring); estuarine-dependent species (e.g. flounder, blue crab, panaeid shrimp, red drum); permanent resident species (e.g. black sea bass, Atlantic bumper, lizardfish); and seasonal migrant species (e.g. bluefish, Spanish and king mackerel, cobia, spiny dogfish). The transport of larval fish from the offshore water column to the estuarine nursery areas through inlets plays a vital role in the life cycle of many fish species.

2. Larval Transport
Larval transport is defined as the horizontal translocation of a larva of any species between points (Pineda, et al, 2007). In the southeastern USA, many species of estuarine-dependent fishes spawn offshore and their larvae are transported into estuaries. The dispersal and subsequent retention of larvae back into the estuary is regulated by a number of factors including astronomical and meteorological tides. Some larvae have the capability to actively migrate horizontally and vertically in the water column to utilize the stratification, tidal currents, flows, and other physical properties of the aquatic environment to help regulate their transport from spawning grounds to settlement areas.

Larvae utilize inlets as the conduit between the open ocean and the estuarine environment. Rich Inlet, a relatively large inlet separating Hutaff Island from Figure Eight Island to the southwest, drains an expansive marsh-filled lagoon where two large, relatively deep tidal creeks, Nixon and Green Channels, connect the inlet to the AIWW. The tidal prism for Rich Inlet has been estimated at approximately 560,000 cubic feet (Appendix B). This mass of flowing water acts as a conduit for larvae found within the water column in proximity to the inlet. Settle *et al.* (2005) estimated that the larval fish concentrations in close proximity to Bogue Inlet ranged throughout the water column between 0.5 and 5.0 larvae per cubic meter. Assuming that there is similar larval concentration in proximity to Rich Inlet, Rich Inlet would serve as an important pathway for numerous species of zooplankton into the estuary.

3. What are the characteristics of the federally threatened, endangered, and State listed species found within the project area?

Federal and State Listed Species
The following section describes the Federal and State listed species that occur, or have the potential to occur in the Permit Area, as listed in Table 4.5.

Table 4.5. Federal and State listed species found or have the potential to be found within the Permit Area

Common Name	Scientific Name	Federal Status	State Status
Reptiles			
Green Sea Turtle	*Chelonia mydas*	Threatened	Threatened
Hawksbill Turtle	*Eretmochelys imbricate*	Endangered	Endangered
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Endangered	Endangered
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	Endangered
Loggerhead Sea Turtle	*Caretta caretta*	Threatened	Threatened
Carolina Diamondback Terrapin	*Malaclemys terrapin centrata*	None	Species of Special Concern
Mammals			
West Indian Manatee	*Trichechus manatus*	Endangered	Endangered
North Atlantic Right whale	*Eubaleana glacialis*	Endangered	Endangered
Sei whale	*Balaenoptera borealis*	Endangered	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered	Endangered
Finback whale	*Balaenoptera physalus*	Endangered	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered	Endangered
Fish			
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered	Endangered
Atlantic sturgeon	*Acipenser oxyrinchus*	Endangered	Species of Special Concern
Vascular Plants			
Seabeach amaranth	*Amaranthus pumilus*	Threatened	Threatened
Birds			
Piping Plover	*Charadrius melodus*	Threatened	Threatened
Wilson's Plover	*Charadrius wilsonia*	None	Species of Special Concern
American Oystercatcher	*Haematopus palliatus*	None	Species of Special Concern
Common Tern	*Sterna hirundo*	None	Species of Special Concern
Gull-billed Tern	*Sterna nilotica*	None	Threatened
Black Skimmer	*Rynchops niger*	None	Species of Special Concern
Eastern Painted Bunting	*Passerina ciris ciris*	None	Species of Special Concern
Red Knot	*Calidris canutus*	Threatened	None

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."
Species of Special Concern-	Any species of wild animal native or once native to North Carolina that is determined by the Wildlife Resources Commission to require monitoring but that may be taken under regulations adopted under the provisions of Article 25

A. Reptiles

1. Sea Turtles

Sea turtles are large marine reptiles that spend most of their lives in marine or estuarine habitats. Sea turtles can be found in subtropical and temperate oceans as well as in sub-arctic seas around the world (Musick and Limpus, 1997). Several studies have shown that the beaches adjacent to inshore and offshore waters along the Atlantic Coast of the United States are important foraging and developmental habitats for many threatened and endangered species of sea turtles (Shoop and Kenney, 1992; Ehrhart, 1983; Keinath *et al*., 1987).

Although sea turtles spend most of their lives in the ocean, female turtles must return to land to nest (Miller, 1997). Therefore, oceanfront beaches, such as those found along Figure Eight Island and Hutaff Island, provide an important habitat for sea turtle survival. Female sea turtles show nest site fidelity by returning to the nesting beach where they hatched (Limpus *et. al*., 1984; Limpus, 1985). Nesting females prefer beaches with limited lighting and open-water access, while other factors such as elevation from water inundation, dune vegetation, beach slope and the moisture and compaction of the sand may also influence site selection (Hendrickson, 1982; Mortimer, 1982). Female sea turtles typically emerge from the water at night, select a nest site, and excavate a chamber to deposit her eggs. Females cover the nest and return to sea allowing the eggs to develop for 6 to 13 weeks depending upon the species of sea turtle and the temperature of the nest (Miller, 1985). Hatchlings will emerge at night and migrate from the nest to the ocean where they begin their offshore migration into the open ocean.

Five species of sea turtles utilize the waters of North Carolina for breeding, feeding, and development. These species include: the loggerhead sea turtle (*Caretta caretta*); green sea turtle (*Chelonia mydas*); hawksbill sea turtle (*Eretmochelys imbricata*); Kemp's Ridley sea turtle (*Lepidochelys kempii*); and the leatherback sea turtle (*Dermochelys coriacea*) (Epperly *et al*., 1990; USFWS, 2003a). Sea turtles can be found in offshore as well as inshore waters at all times of the year, although they are more common inshore during the spring, summer and fall months (Epperly *et al*., 1995a). Immigration of sea turtles into North Carolina's sounds and estuaries occurred most frequently in the spring with dispersal throughout the sounds as the waters warmed. Emigration out of inshore occurred during the latter part of fall when the waters began to cool. Although the exact numbers and frequencies of species inhabiting the inshore and offshore waters of North Carolina are not available, it is known that these habitats are used at various times throughout the year by all five sea turtle species discussed (Epperly *et al*., 1990). Species composition of turtles captured by fisherman in the inshore waters of North Carolina consisted of loggerheads (71%), greens (17%), and Kemp's ridley (12%) (Epperly *et al*., 1995b). Public sightings reported all five species in inshore waters with leatherbacks and hawksbills being observed infrequently (Epperly *et al*., 1995a).

- *Green Sea Turtle*

Green sea turtle

Breeding populations of green sea turtles (*Chelonia mydas*) along Florida and the Pacific coast of Mexico have been federally listed as endangered, while all other populations have been listed as threatened under the Endangered Species Act since July 28, 1978. Additionally, a green sea turtle Critical Habitat was designated for the coastal waters surrounding Culebra Island, Puerto Rico (NMFS, 2006). Green sea turtles are mid- to large-sized sea turtles that reach an average weight of 136.2 kg (303 lbs) (Pritchard, 1997). Feeding habitats for adults are specific to seagrasses and marine algae, while hatchlings may be found feeding on various plants and animals. Green sea turtles are generally found near seagrass habitats in shallow aquatic environments, such as nearshore reefs, bays and inlets. Coral reefs and rocky patches may also be utilized for shelter and feeding when seagrass is not available (Hirth, 1997).

The green sea turtle is globally distributed with an estimated population of 600,000 adults (USFWS, 2003e). While green sea turtle populations generally range throughout warm tropical and temperate waters of more than 140 countries, their nesting and feeding grounds are predominantly located along coastal areas between 30° North and 30° South. The green sea turtle nesting season of southern U.S. populations generally occurs between June and September, but varies depending upon its locality. Hatchling incubation time and sex determination are both temperature dependent (Mrosovsky, 1995). Green sea turtle hatchlings emerge at night and migrate offshore spending several years feeding and growing in oceanic current systems (USFWS, 2003e).

Along the U.S. beaches of the Atlantic, green turtles primarily nest in Florida. Less significant nesting populations have been identified in the U.S. Virgin Islands, Puerto Rico, Georgia, South Carolina, and North Carolina (USFWS, 2003e). NCDENR reports that the green sea turtle has been observed in Brunswick, Carteret, Dare, Hyde, New Hanover, Onslow, and Pender Counties. While green sea turtles have been sighted, primarily from spring through fall, along the entire North Carolina coastline, nesting activities have only been observed in Onslow, Brunswick, and Hyde Counties. According to data supplied by Dr. Webster of UNCW and Mr. Golder of Audubon North Carolina, no green sea turtle nests have been observed in the study area on either Figure Eight Island or Hutaff Island (Webster, pers. comm., 2011; Golder, pers. comm., 2008).

- *Hawksbill Sea Turtle*

The Hawksbill sea turtle (*Eretmochelys imbricata*) was listed as endangered in 1970. The hawksbill is also internationally protected under Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (NMFS, 2007). A Critical Habitat designation has also been identified for the waters surrounding Mona and Monito Islands of Puerto Rico. These islands provide primary foraging habitat for several life stages for this species (NMFS, 2007; USFWS, 2003c).

Hawksbill sea turtle

Hawksbill turtles are usually found in tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans occurring from 30°N to 30°S latitude (NMFS, 2007). These turtles are widely distributed in the Caribbean and the western Atlantic Ocean. Hawksbill turtles prefer the clear shallow waters of coral reefs, creeks, estuaries and lagoons in tropical areas. Their diet primarily consists of sponges but also includes algae, fish, mollusks, and other benthic species found in the nearshore zone. Adults may reach up to 0.9 m (3 ft) in length and weigh on average about 136 kg (300 pounds) (USFWS, 2003c).

Hawksbill neonate behavior is similar to other sea turtles; they remain pelagic for several years before returning to coral reef habitats. Juveniles move from pelagic to coastal habitats at a much smaller size than other turtles (20 to 25 cm [to 10 in] carapace length) (Lutcavage and Musick, 1985). Juveniles are not often seen in waters deeper than 19.8 m (65 f) (Witzell, 1983), however they are frequently associated with floating *Sargassum* in the open ocean (Musick and Limpus, 1997).

Within the U.S., hawksbill turtles are most common in the waters surrounding Puerto Rico, U.S. Virgin Islands and Florida (NMFS, 2007). Hawksbills are recorded in the continental U.S. from all the Gulf states and from the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare (NMFS, 2007). The U.S. Fish and Wildlife Service North Carolina Office reports that the presence of hawksbill sea turtles along the North Carolina coast is rare (USFWS, 2007c); therefore, none are expected to be present in the study area.

The hawksbill has experienced major population decline with only five regional nesting populations remaining in the Seychelles, Mexico, Indonesia, and two in Australia (USFWS, 2003c). Nesting females lay on average 3-5 nests per season which contain 130 eggs per nest (NMFS, 2007). Nesting season varies with locality, but most nesting occurs sometime between April and November (USFWS, 2003c). There are no reported nesting activities of hawksbill sea turtles on the beaches within the study area (Godfrey, pers. comm.).

- *Kemp's Ridley Sea Turtle*

The Kemp's ridley sea turtle (*Lepidochelys kempii*) has been listed as endangered under the Endangered Species Act since December 2, 1970 (USFWS, 2003d). The range of Kemp's ridley includes the Gulf coast of Mexico, the Atlantic coast of North America as far north as Newfoundland and Nova Scotia, and the Gulf coast of the U.S., especially Padre Island, Texas (USFWS, 2003d). Kemp's ridley is the smallest of the eight species of sea turtles, averaging 35-45 kg (78-100 lbs) with an average length between 56 and 76 cm (22 and 30 in) (Marquez, 1994; USFWS, 2003d). As juveniles, Kemp's ridley turtles feed primarily on crabs, clams, mussels, and shrimp and are most commonly found in productive coastal and estuarine areas. Recruitment from pelagic habitats occurs at a carapace size between 20 and 25 cm (7.9 and 9.8 in) (Lutcavage and Musick, 1985).

Kemp's ridley sea turtle

Hatchlings are dispersed within the Gulf and Atlantic by oceanic surface currents. According to the U.S. Fish and Wildlife Service, rare nesting events have been recorded in Florida, South Carolina and North Carolina (USFWS, 2003d). Most sea turtle species are widely distributed; however, the Kemp's ridley is mostly restricted to the Gulf of Mexico (Miller, 1997). They have also been sighted in shallow coastal waters along the east coast of the United States.

As reported by the USACE (2006):

> *..Kemp's ridley sea turtle is commonly observed migrating within North Carolina inshore waters during the spring and fall, but has been documented to nest only once in North Carolina, on Oak Island in 1992* (Godfrey, pers. comm.).

Kemp's ridley turtles are also occasionally found stranded on the beaches of North Carolina (Mihnovets, 2003). These strandings may be attributed to the juvenile sea turtles getting caught in the southern Gulf of Mexico loop current that eventually moves these turtles east and north up the eastern Atlantic coast (Musick and Limpus, 1997). Conservation measures initiated in the late 1970's are thought to be contributing to the Kemp's ridley population recovery; however, the Kemp's ridley sea turtle still remains the rarest sea turtle in the world (Pritchard, 1997). Four Kemp's ridley sea turtles were taken by a hopper dredge working off of Bogue Banks in December 2001, but there were no turtles taken during the relocation of Mason's Inlet in 2000 (Sugg, pers. comm.). Since monitoring began, only one (1) Kemp's ridley nest has been observed within in the project area. This nest was observed during the 2010 nesting season on Figure Eight Island (Godfrey, pers. comm.).

- *Leatherback Sea Turtle*

The leatherback sea turtle (*Dermochelys coriacea*) was listed as an endangered species on June 02, 1970 (under a law that preceded the Endangered Species Act of 1973), and then listed as endangered throughout its range in the United States under the Endangered Species Act of 1973 (NMFS, 2007). A Critical Habitat designation is listed for Sandy Point, St. Croix, U.S Virgin Islands and surrounding waters (NMFS, 2007; USFWS, 2003b).

Nesting leatherback sea turtle

The U.S. range of the leatherback extends from Nova Scotia south to Puerto Rico and the U.S. Virgin Islands. Small nesting populations occur in Florida, St. Croix, and Puerto Rico (USFWS, 2003b). Although nesting in the State of North Carolina is rare, Rabon *et al*. (2003) confirmed seven leatherback turtle nests between Cape Lookout and Cape Hatteras. The nesting frequency included two nests in 1998, four nests in 2000, and one nest in 2002. Leatherback sea turtles nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests. The average inter-nesting interval is about 9-10 days (USFWS, 2003b). While infrequently found in inshore waters, Epperly *et al*. (1995) reported that, on average, 15 leatherback sea turtles per year were sighted in inshore waters (within three miles of shore) of North Carolina between 1989 and 1992. According to Epperly *et al*. (1995) these inshore sightings coincided with the appearance of jellyfish and leatherback sightings diminished by late June. The NCWRC (Everhart, 2007) reported a leatherback false crawl in North Carolina in 2007. No leatherback sea turtle nests have been reported within the project area within recent years (Godfrey, pers. comm.).

- *Loggerhead Sea Turtle*

The loggerhead sea turtle (*Caretta caretta*) has been listed in the Federal Register as threatened throughout its range since July 28, 1978 (USFWS, 2003f). Loggerheads are large reddish-brown turtles weighing between 91-159 kilograms (200-350 lbs) (Pritchard, 1997). Adult loggerheads nest at night along sandy beaches and may nest from one to seven times within a nesting season (USFWS, 2003f). The average

Loggerhead sea turtle

nest depth for loggerhead sea turtles is 61 cm (24 inches). Loggerhead sea turtles are the only marine sea turtles that have been reported to nest predominantly outside of the tropics (Bolten and Witherington, 2003).

Hatchling loggerheads migrate offshore into circular oceanic current systems (gyres) and are often found in drifting masses of *Sargassum* macroalgae until they have grown to be much larger juveniles (Carr, 1967; Fletmeyer, 1978). Loggerhead sea turtles will remain within the gyre for several years before leaving their pelagic habitats to return to their coastal foraging and nesting habitats (Klinger and Musick, 1995; Bolten *et al*., 1993). Recruitment into coastal habitats occurs when their carapace length is between 25 and 70 cm (9.8 and 27.5 in) (Lutcavage and Musick, 1985; Bolten *et al*., 1993).

Five nesting subpopulations in the western North Atlantic have been identified through genetic DNA analysis and include: 1) the Northern subpopulation from North Carolina to Northeast Florida; 2) the South Florida subpopulation north of Cape Canaveral, following the eastern coastline south and around to Sarasota on Florida's west coast; 3) the Dry Tortugas, Florida, subpopulation; 4) the Northwest Florida subpopulation, found along the panhandle of Florida's northwest coast; and 5) the Yucatán subpopulation, which includes the eastern Yucatán Peninsula, Mexico (USFWS, 2003f).

Eighty percent of all loggerhead nesting that occurs in the southeastern U.S. takes place in Florida. Loggerhead sea turtle nesting occurs to a lesser extent on suitable beaches on islands off the Gulf states and along the entire North Carolina coastline, including New Hanover and Pender Counties where the study area is located (USFWS, 2003f). The Fish and Wildlife Service reported that although declines in nesting since the 1970's have been documented, no long-term trend data is available for the Northern subpopulation (USFWS, 2003f). Bolten and Witherington (2003) reported that studies on the Northern subpopulation from 1989 to 1998 illustrated a stable or declining population trend.

The USFWS and NMFS has designated portions of North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles. A portion of the Permit Area is located within Critical Habitat Unit LOGG-T-NC-04 (Figure 4.12). As described in the Federal Register Notice, this unit includes Onslow Beach, Topsail Island, and Hutaff Island. The unit contains nearshore reproductive habitat only. Specifically, the unit consists of nearshore area from Browns Inlet to Rich Inlet (crossing New River Inlet and New Topsail Inlet) from the MHW line seaward 1.6 km. This unit contains areas of high density nearshore reproductive habitat (Topsail Island) as well as areas adjacent to high density nearshore reproductive habitat (Onslow Beach and Hutaff Island).

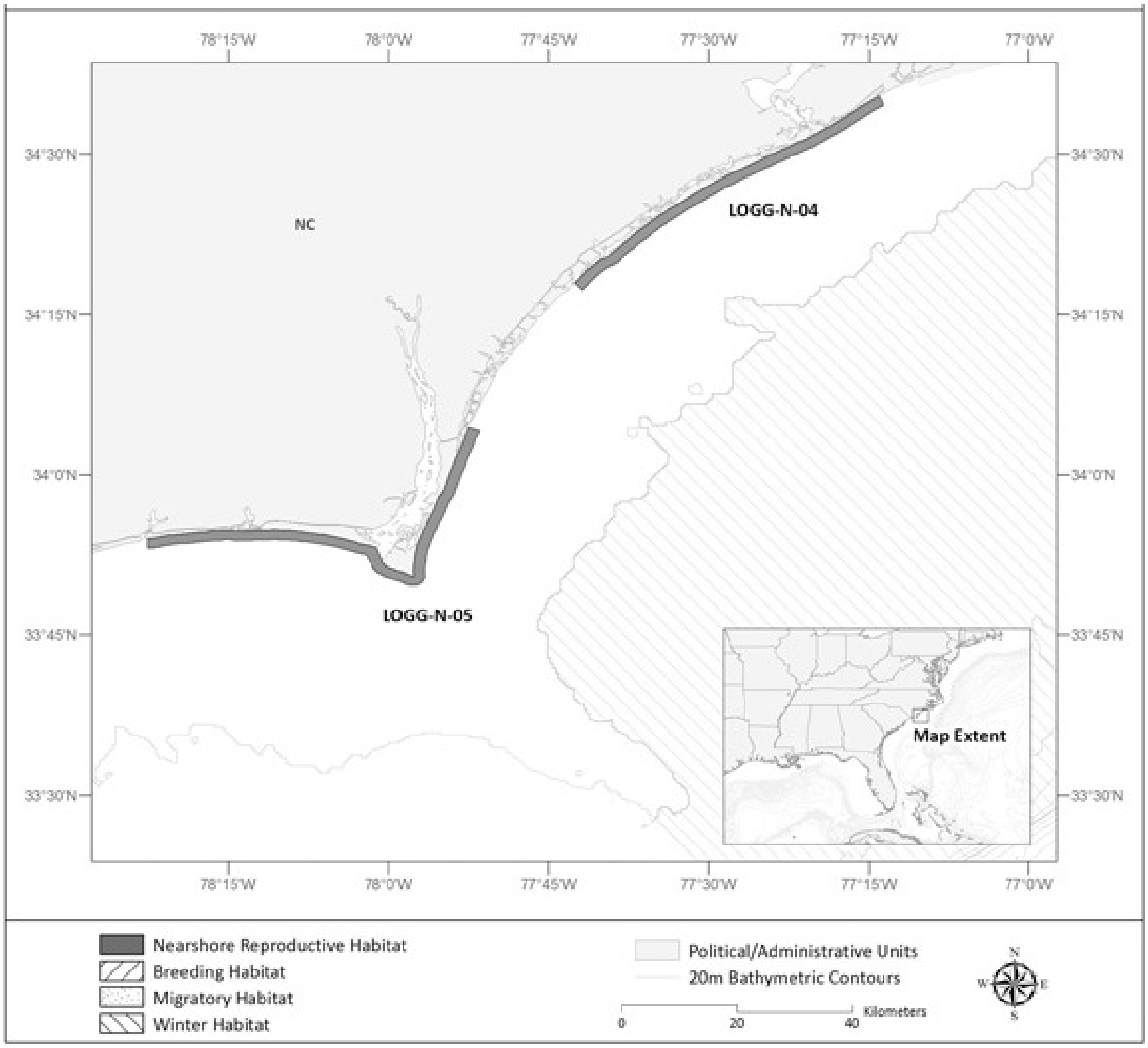


Figure 4.12. Designated Loggerhead Sea Turtle Critical Habitat: LOGG-N--04

Over the fourteen year time-span between 2001 and 2014, sea turtle nest monitoring efforts along Figure Eight Island has revealed an average of 10 loggerhead sea turtle nests laid, on average, within the Permit Area (Table 4.6). On Hutaff Island, nests were laid less frequently within the Permit Area (which includes a much smaller stretch of oceanfront shoreline) with only 0.4 nests observed per year (Table 4.6) (Webster, 2016). Figures 4.13 - 4.26 depict the distribution of these nests along the beaches within and in proximity of the Permit Area. Godfrey (pers. comm.) expressed the difficulties in reporting sea turtle population and nesting trends since the availability of observers and consistency in data collection can contribute to the unreliability of the data.

Table 4.6. Number of Loggerhead sea turtle nests documented in defined Permit Area, Figure Eight Island, NC, 2001 to 2014.

Loggerhead Sea Turtle (*Caretta caretta*)		
Year	**Figure Eight Island**	**Hutaff Island**
2001	5	0
2002	3	0
2003	22	0
2004	8	0
2005	4	0
2006	5	0
2007	2	0
2008	12	0
2009	2	1
2010	8	0
2011	20	0
2012	19	1
2013	25	3
2014	2	0

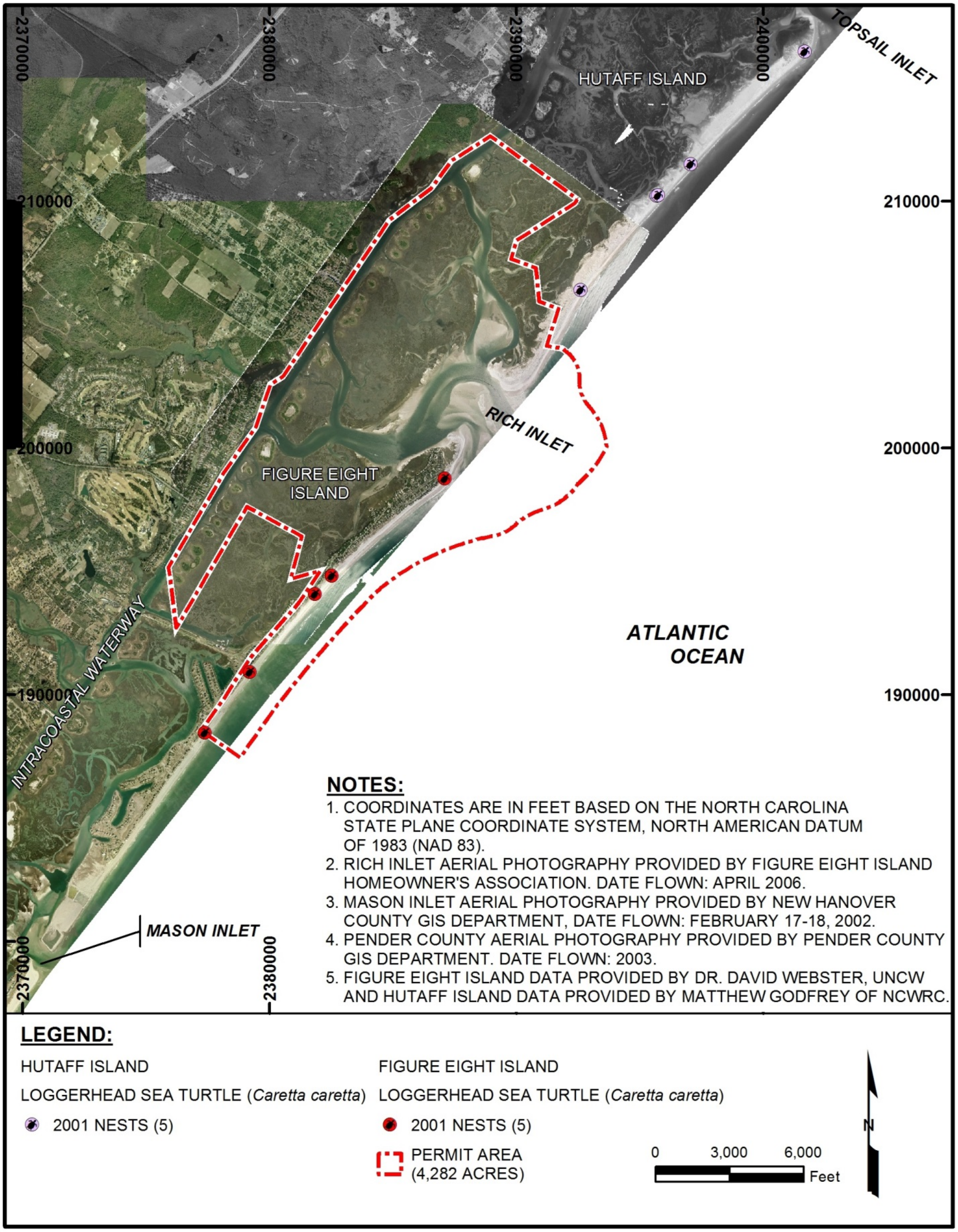


Figure 4.13. 2001 Loggerhead sea turtle nests within the Permit Area

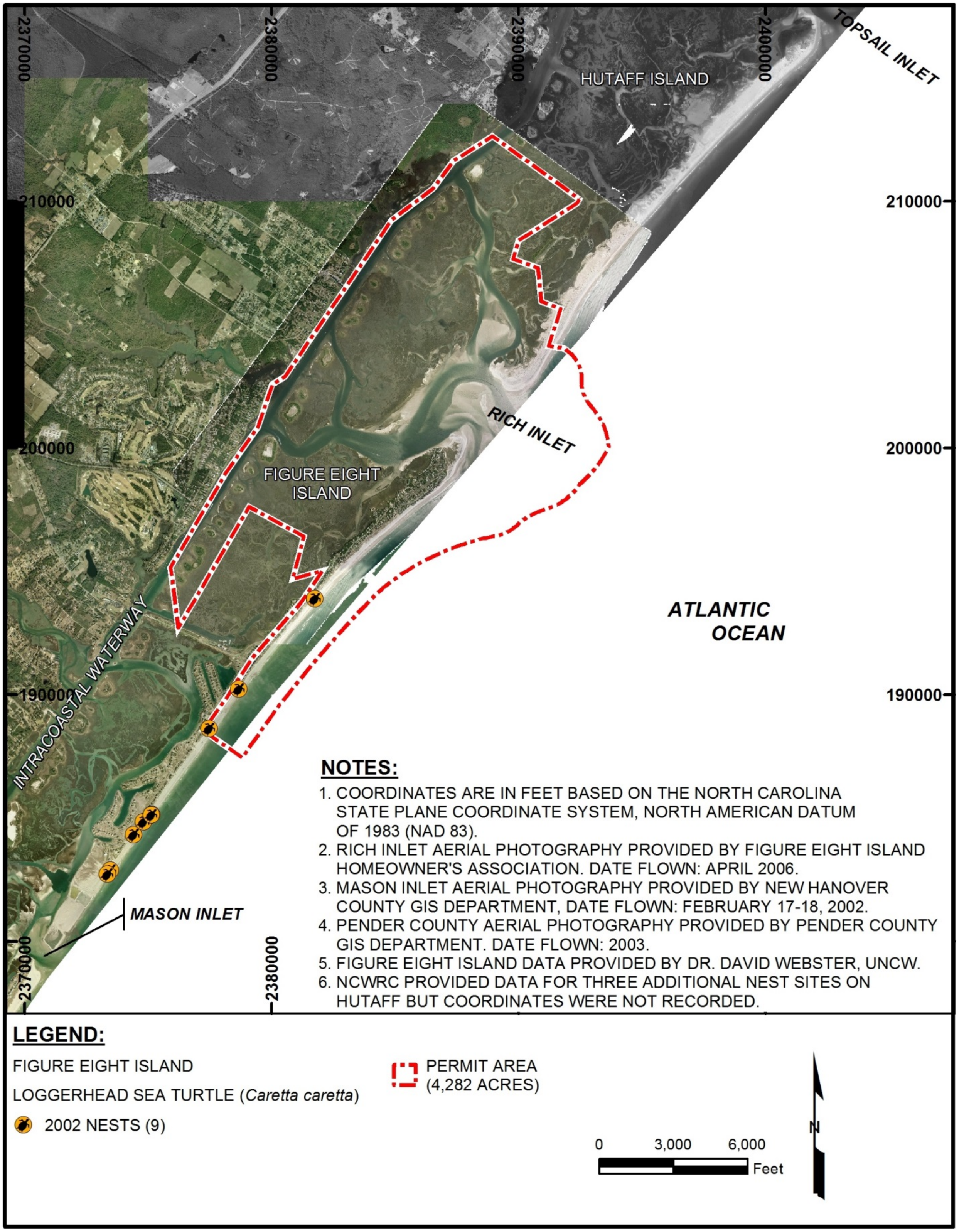


Figure 4.14. 2002 Loggerhead Sea Turtle Nests within the Permit Area.

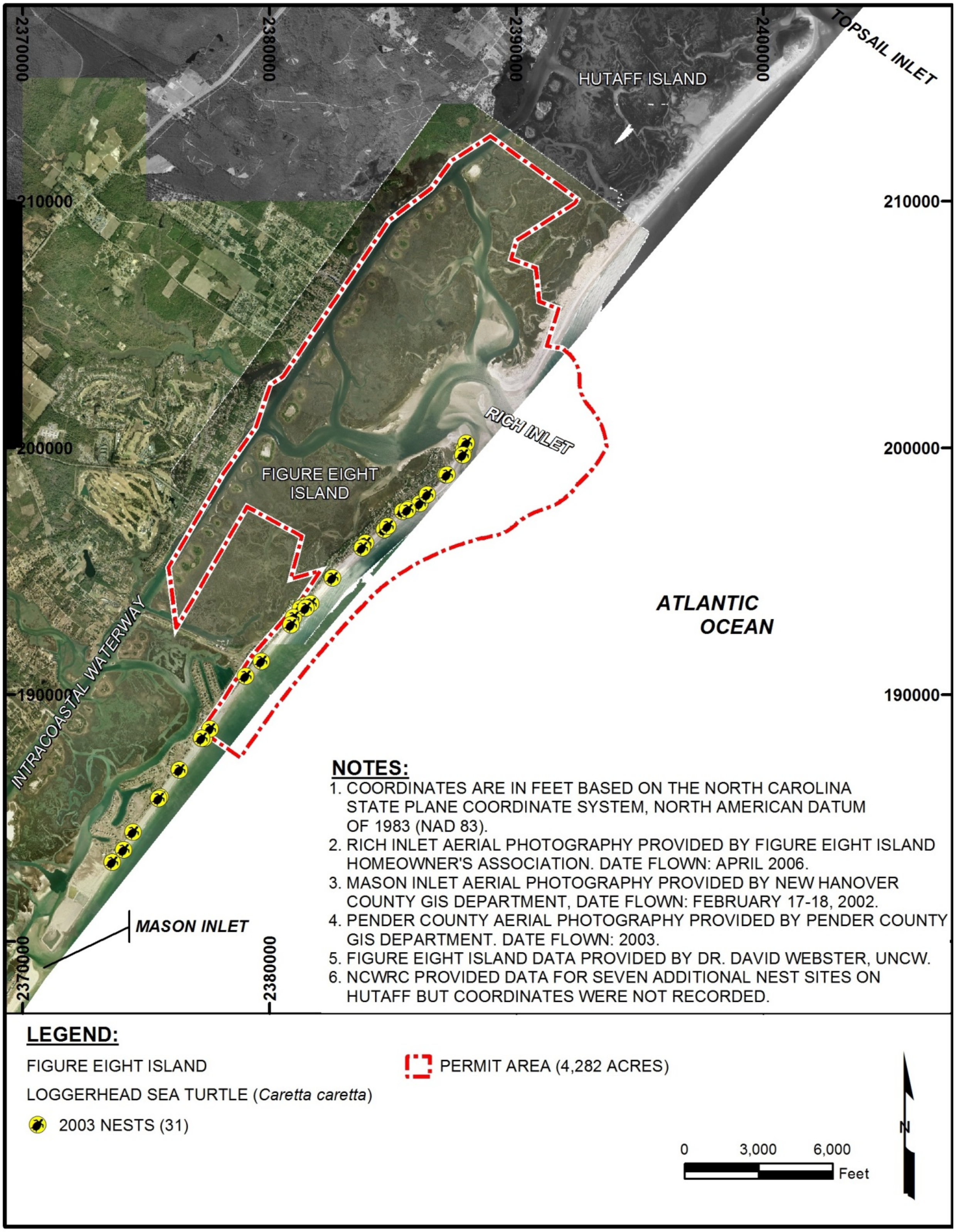


Figure 4.15. 2003 Loggerhead Sea Turtle Nests within the Permit Area.

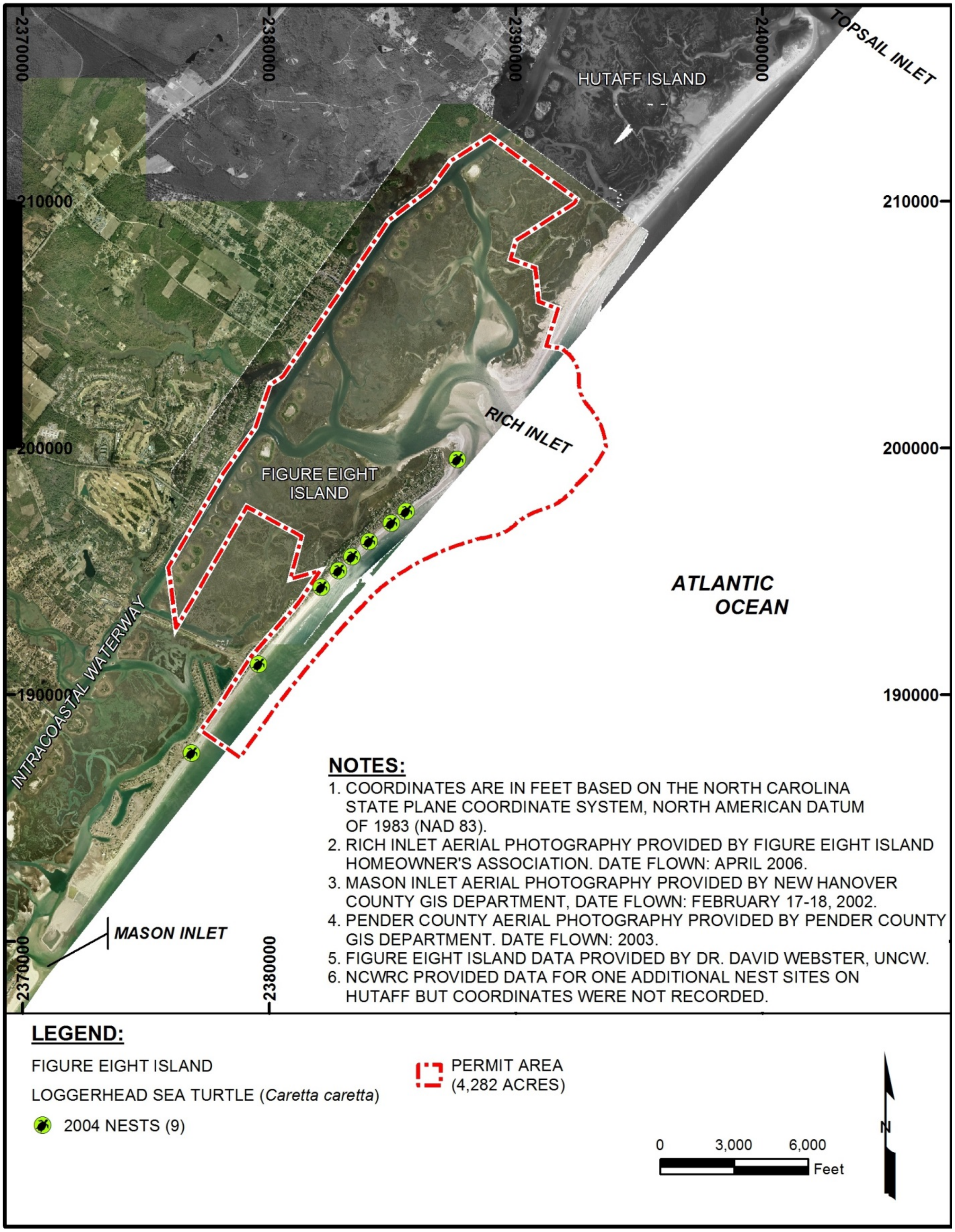


Figure 4.16. 2004 Loggerhead Sea Turtle Nests within the Permit Area.

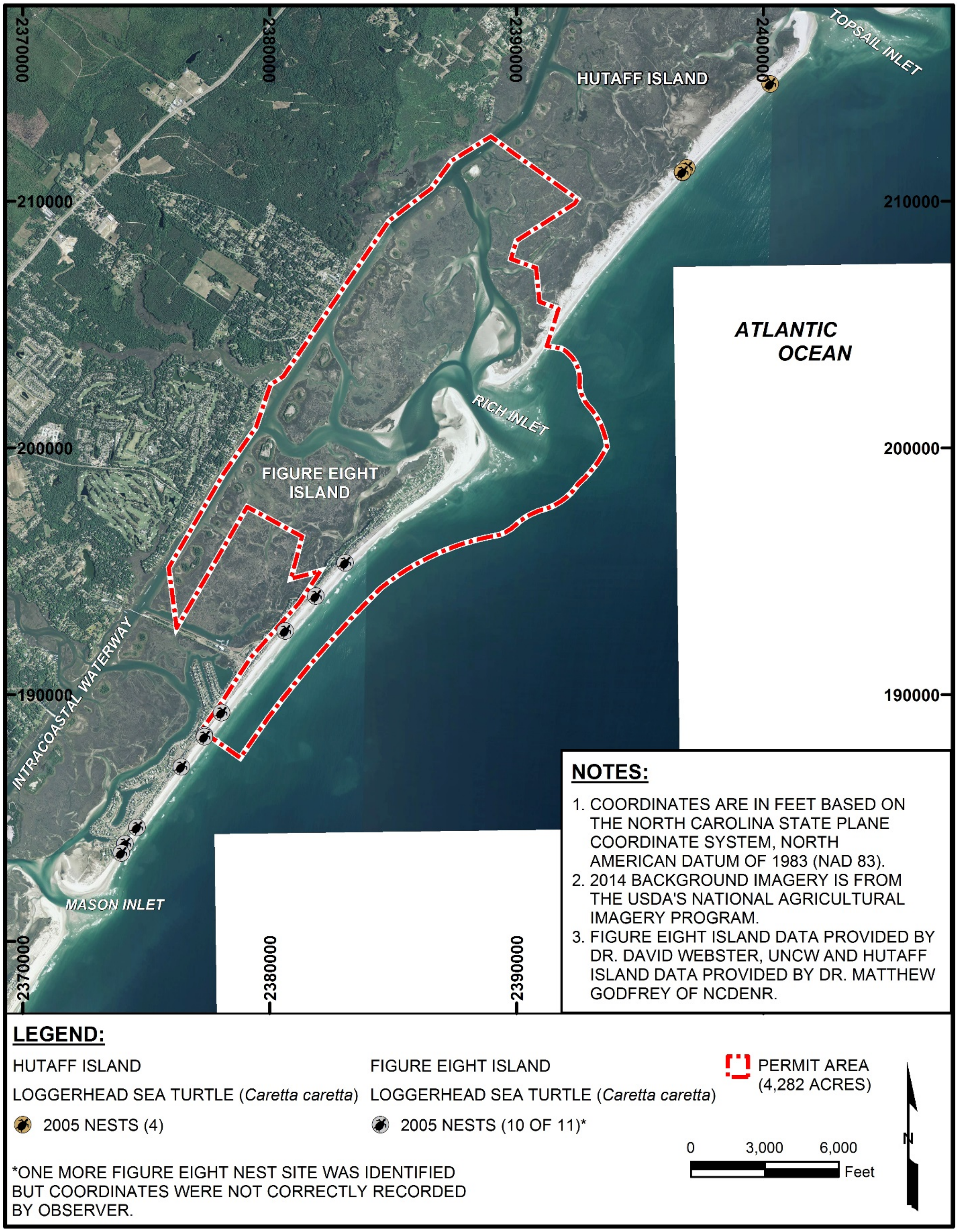


Figure 4.17. 2005 Loggerhead sea turtle nests within the Permit Area. Note that additional nests were observed on Figure Eight Island, however coordinates were not accurately recorded.

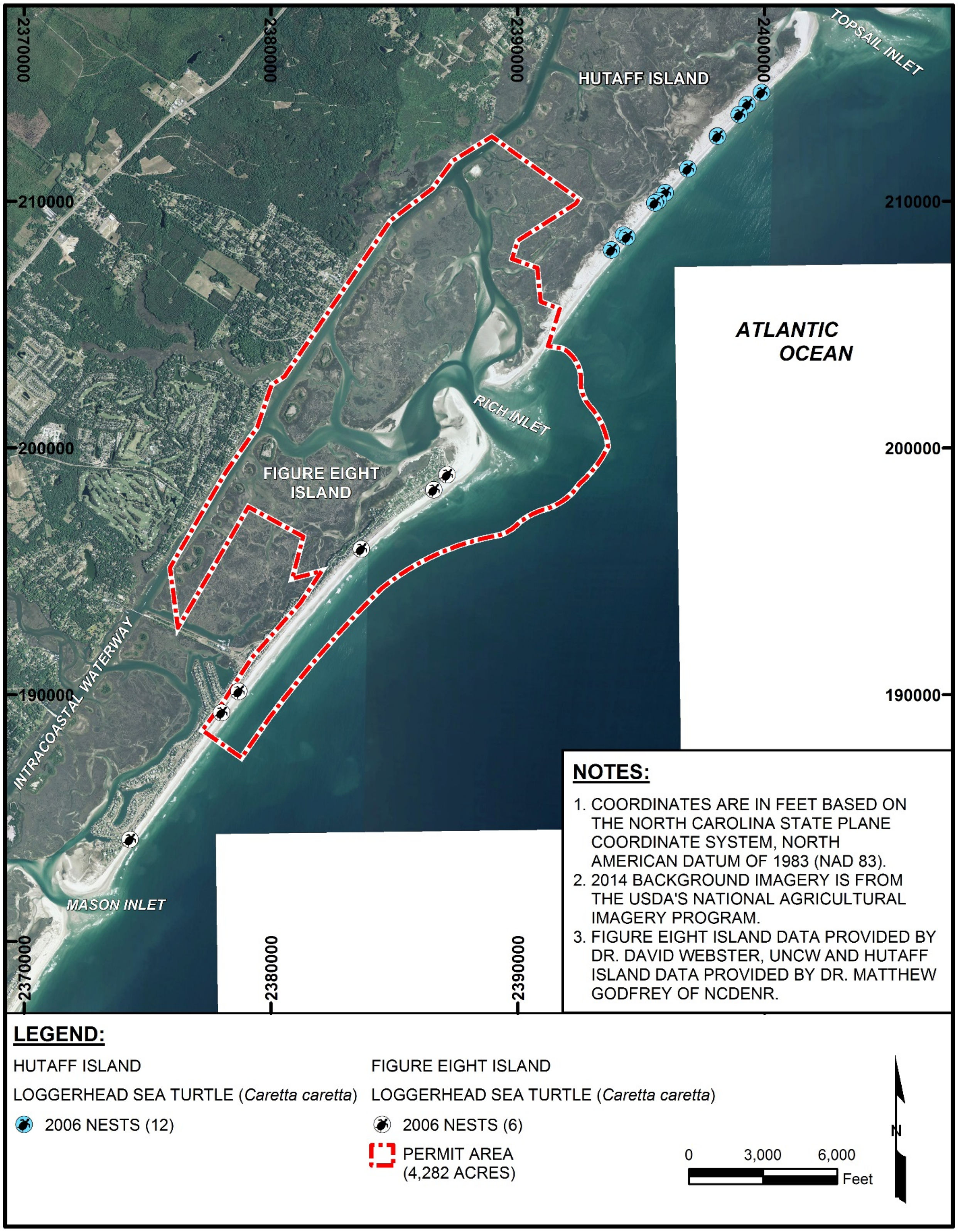


Figure 4.18. 2006 Loggerhead Sea Turtle Nests within the Permit Area.

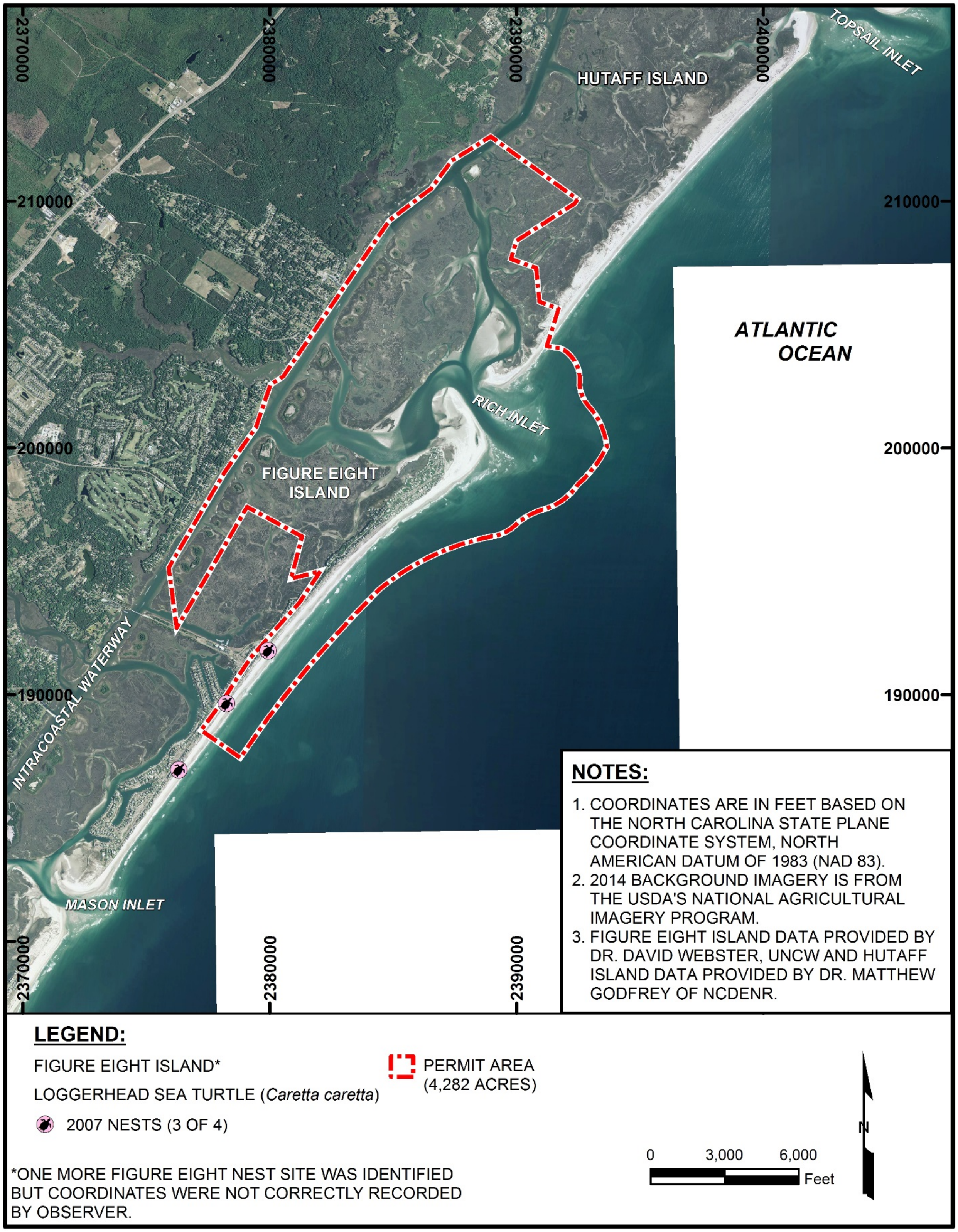


Figure 4.19. 2007 Loggerhead Sea Turtle Nests within the Permit Area. Note that additional nests were observed on Figure Eight Island, however coordinates were not accurately recorded.

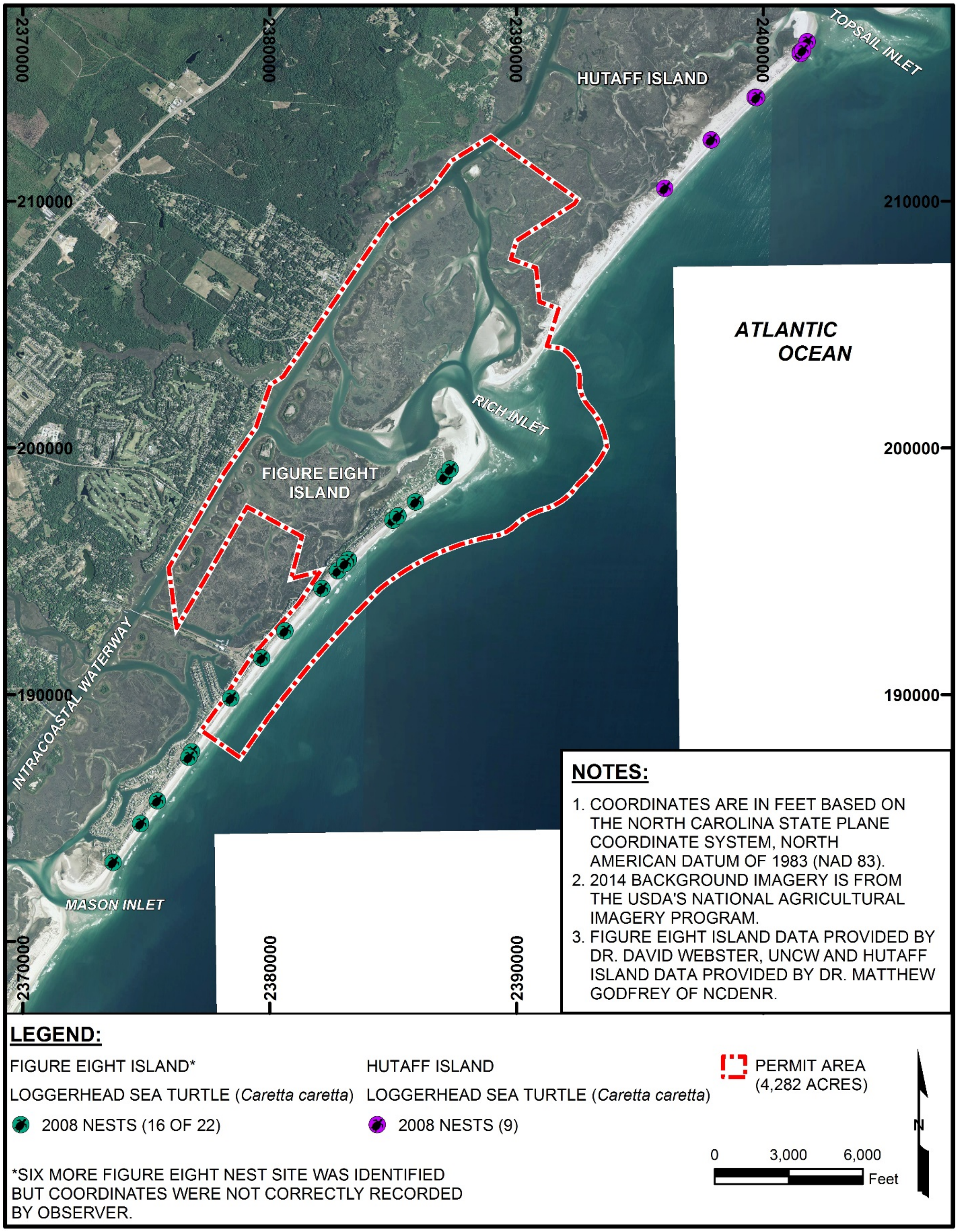


Figure 4.20. 2008 Loggerhead Sea Turtle Nests within the Permit Area. Note that additional nests were observed on Hutaff, however coordinates were not accurately recorded.

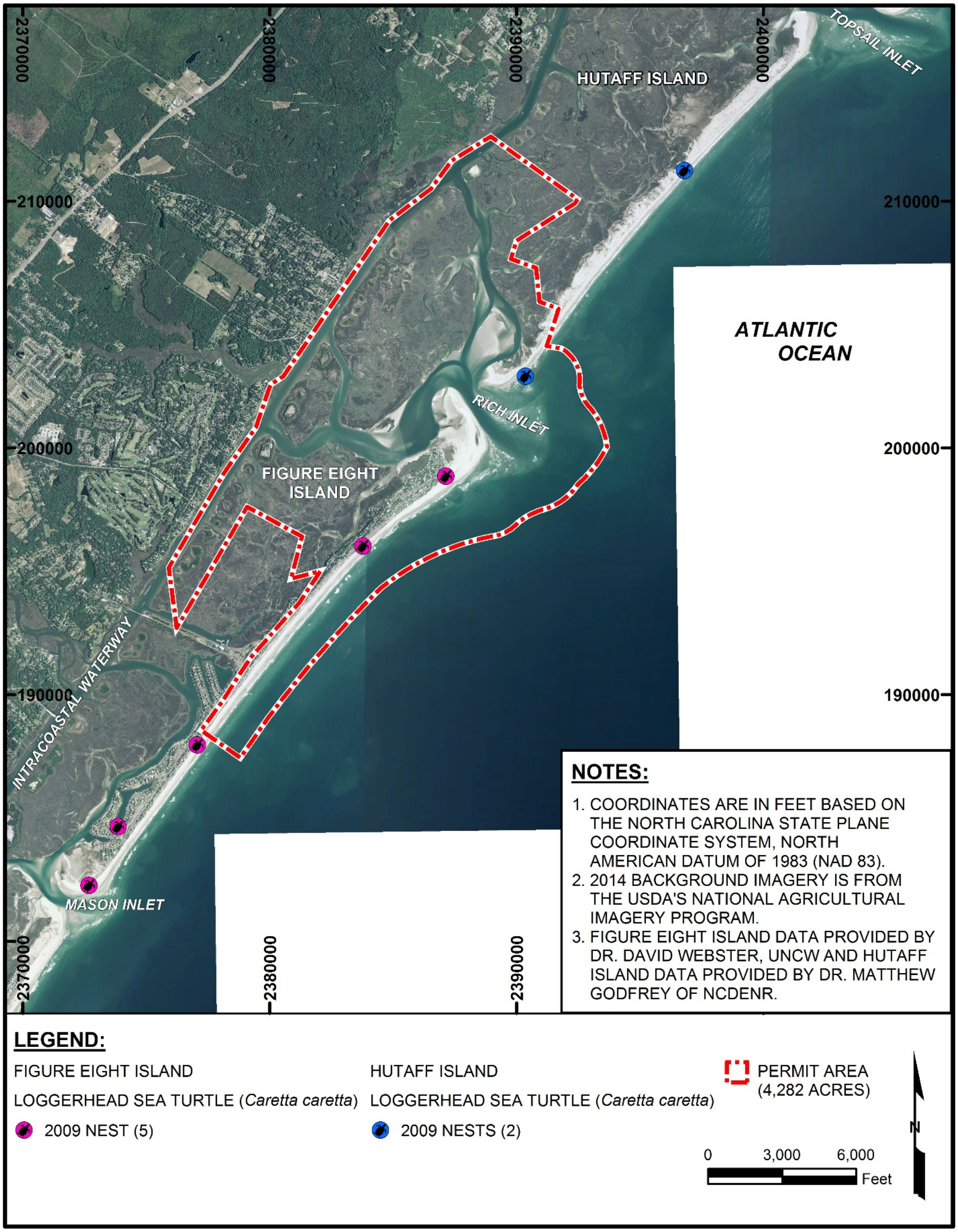


Figure 4.21. 2009 Loggerhead Sea Turtle Nests within the Permit Area.

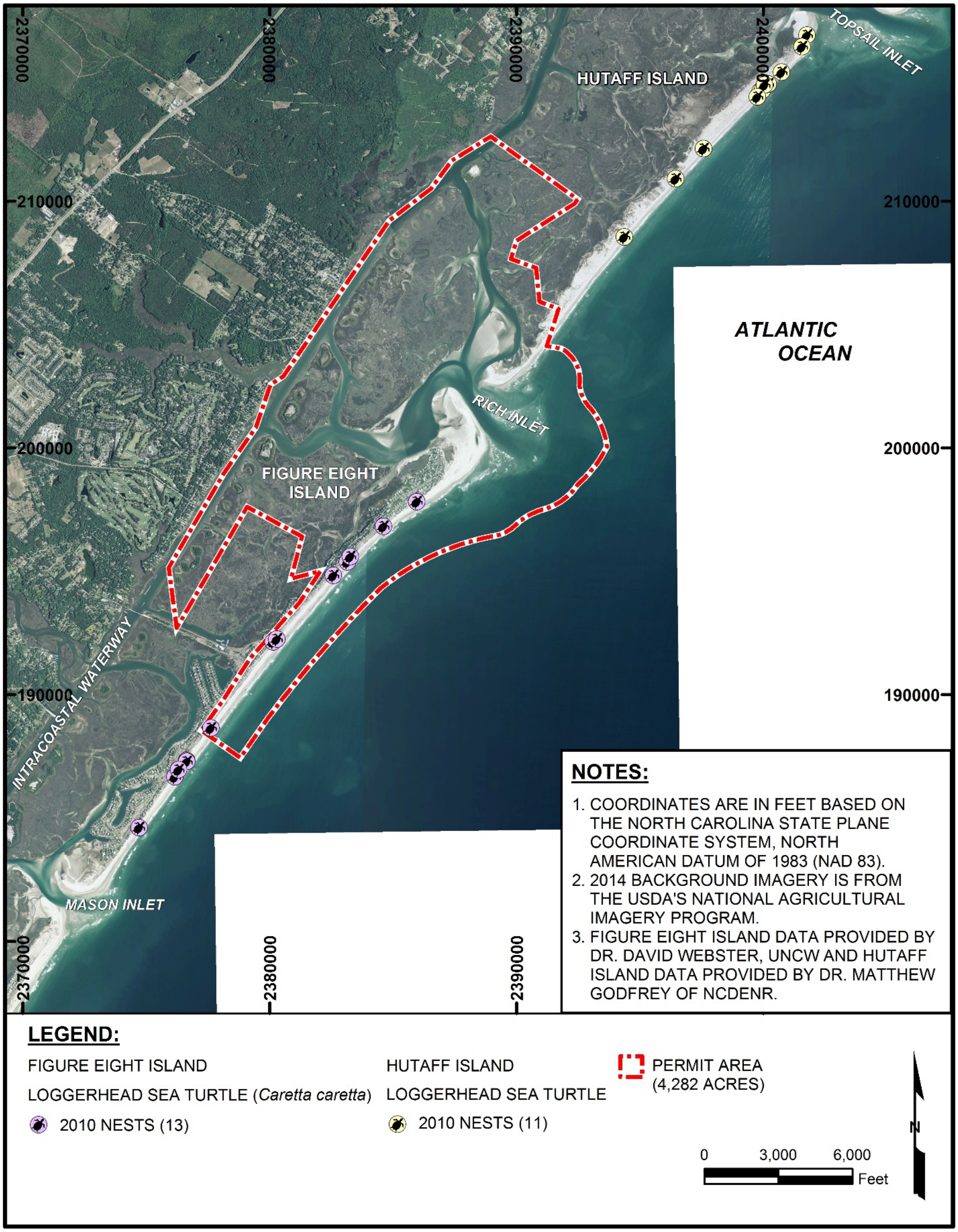


Figure 4.22. 2010 Loggerhead Sea Turtle Nests within the Permit Area.

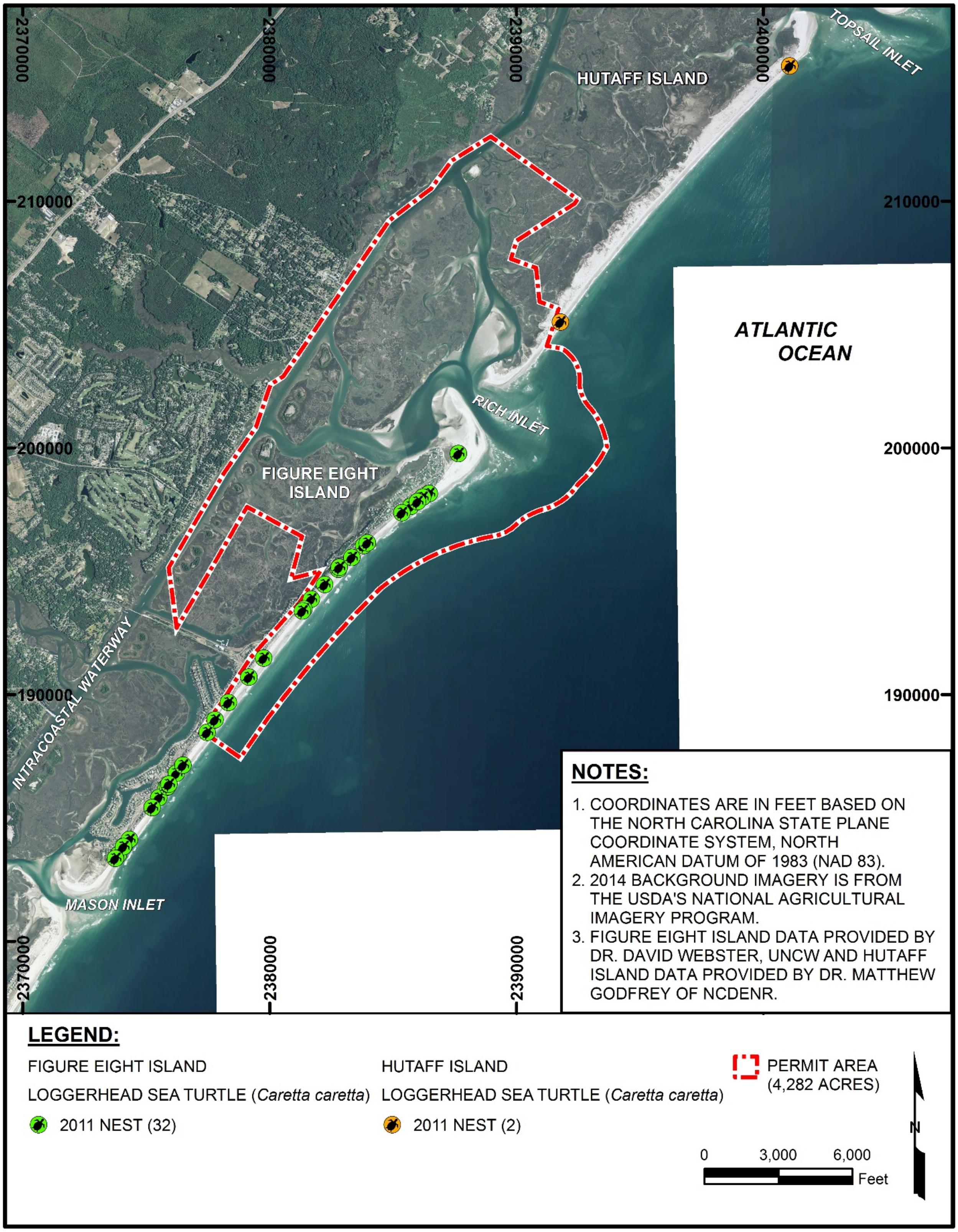


Figure 4.23. 2011 Loggerhead Sea Turtle Nests within the Permit Area.

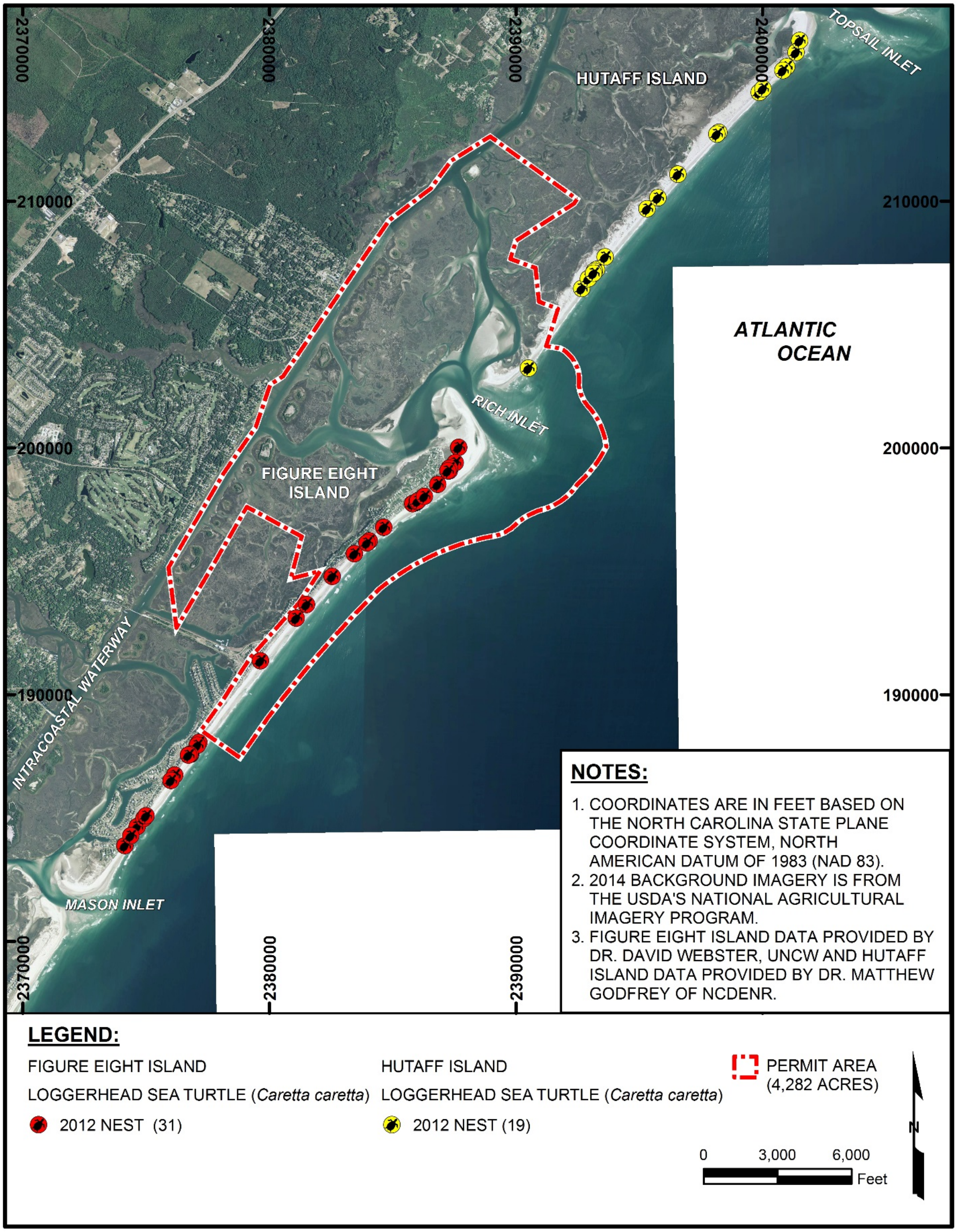


Figure 4.24. 2012 Loggerhead Sea Turtle Nests within the Permit Area.

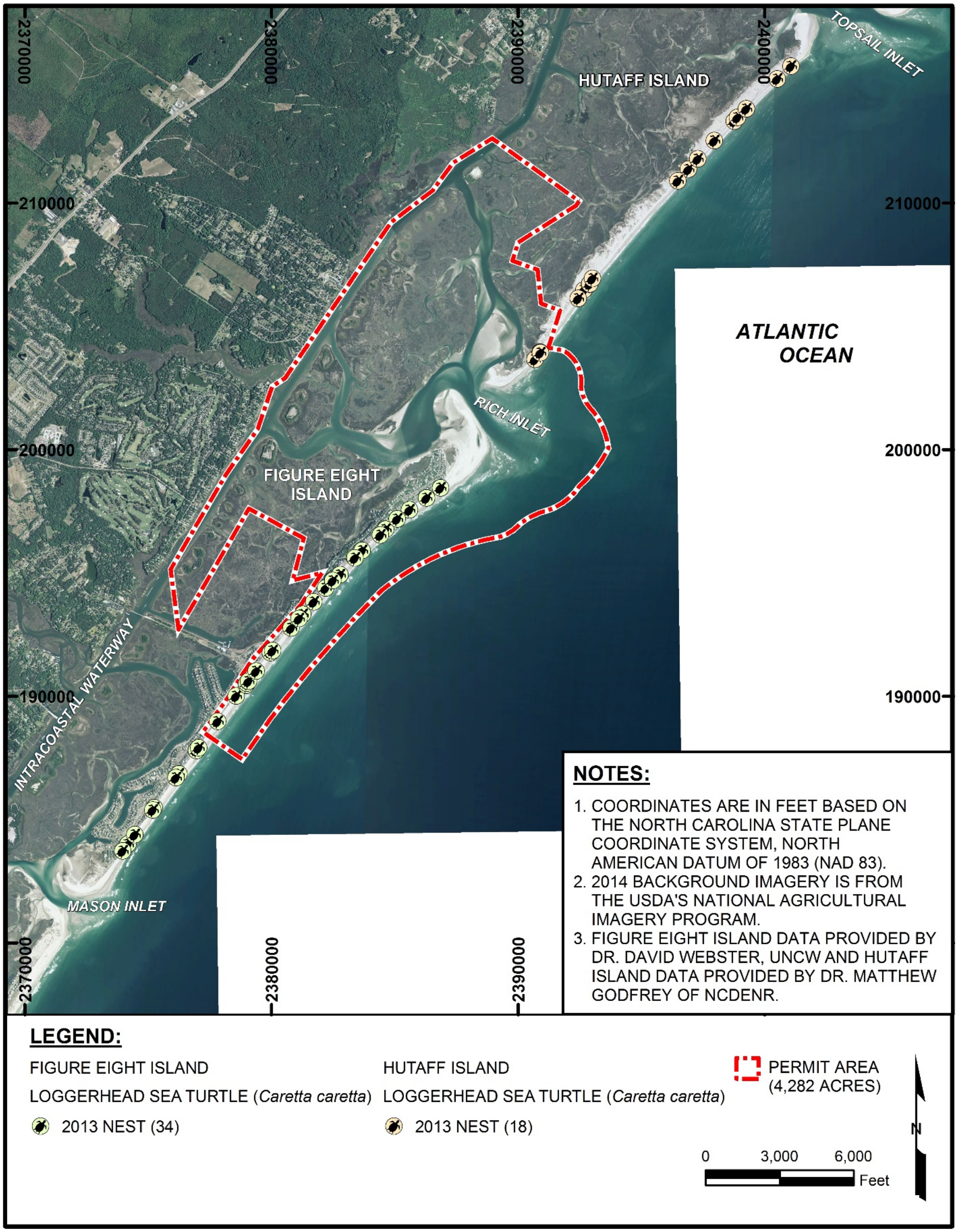


Figure 4.25. 2013 Loggerhead Sea Turtle Nests within the Permit Area

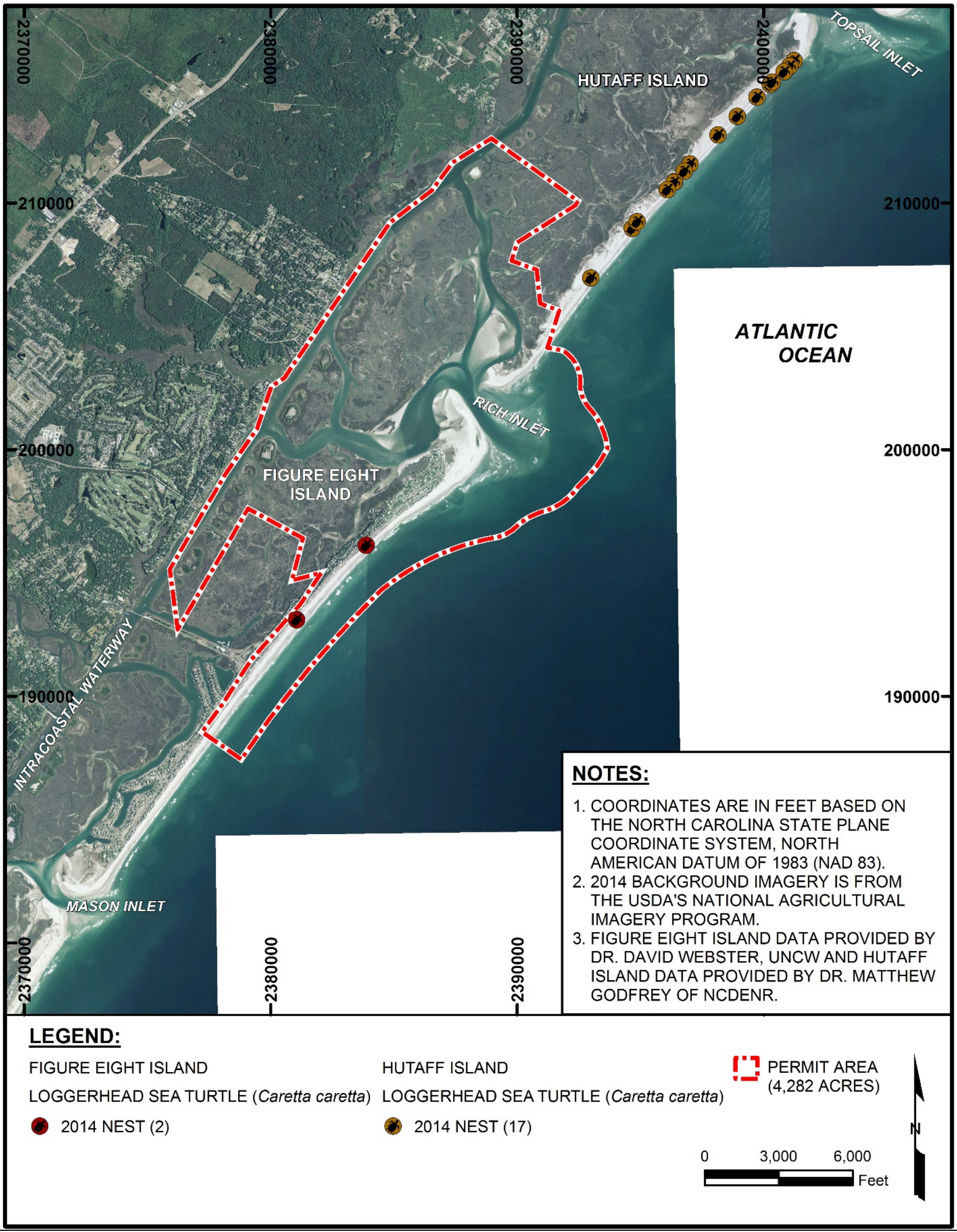


Figure 4.26. 2014 Loggerhead Sea Turtle Nests within the Permit Area.

2. Terrapins

The Carolina diamondback terrapin (*Malaclemys terrapin centrata*) is State and federally listed as a Species of Special Concern. They are commonly found within the inshore waters of North Carolina. This subspecies ranges from Cape Hatteras to northeastern Florida and tolerates a wide range of salinities (Robinson and Dunson, 1975). They are the only North American turtle species native to brackish waters and are commonly found in salt marshes, impoundments, tidal creeks, lagoons and mud flats. These areas serve as central feeding grounds for this species throughout most of the year. Carolina diamondbacks are primarily carnivorous, feeding upon crabs, snails and nereid worms.

Carolina diamondback terrapin

During the winter months, Carolina diamondback terrapins hibernate in the muddy burrows along the embankments of tidal creeks. Nesting typically occurs after the mating season in May. Females build nests in sandy substrates above the high tide mark during the months of May and June and eggs are left to incubate for 60 to 120 days depending upon temperature conditions within the nest (Martof *et al*., 1980). Unlike sea turtles, emergence takes place during the day and hatching diamondback terrapins move to the surrounding vegetation rather than out to sea. It has been reported that juvenile terrapins (2.5 to 7 mm [1 to 3 in]) spend their time out of water living beneath surface debris and matted *Spartina grasses*, rarely entering open water. Adult terrapins spend their summer months in full marine conditions and other times of the year are spent in submerged mud and brackish water (Davenport, 1992).

The NC WRC has compiled numerous sightings of the Carolina diamondback terrapin in coastal New Hanover County, particularly in the area of Wrightsville Beach southward. There has been one recorded sighting on Hutaff Island in July of 1981 (LeGrand, pers. comm.). Despite the paucity of data from this area, the marshes on the sound side of Figure Eight Island and Hutaff Island provide habitat for the Carolina diamondback terrapin.

B. Mammals

1. West Indian Manatees

The West Indian manatee (*Trichechus manatus*) is listed as a federally protected species under the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. The average size of an adult manatee is 10 feet, weighing approximately 2,200 lbs and typically referred to as the "sea cow".

West Indian manatee

West Indian Manatees are rare visitors to the Figure Eight Island area, however, recent manatee sightings have been reported in the AIWW approximately 50-60 miles north of Figure Eight Island including observations north of State Highway 101, July 2000; Beaufort waterfront and near Calico Creek, August 1999; Hammocks

Beach State Park, June 1998; Sportsman Pier in Atlantic Beach, August 1994; US Coast Guard Station at Fort Macon, August 1994; Barden Inlet, November 1992; Peletier Creek, October 1990; and the west end of Shackleford Banks, August 1983. All of these observations occurred in Carteret County. Though none of these sightings occurred within the project vicinity, it is likely that manatees transit through the region since sightings occurred north and south of Figure Eight Island. Due to a lack of existing literature on the number of manatees utilizing the coastal waters of North Carolina, it is difficult to determine the number of manatees utilizing the nearshore waters of the Cape Fear region and the study area.

2. Whales

Blue, finback, humpback, North Atlantic right, sei, and sperm whales all occur infrequently in the ocean off the coast of North Carolina. Of these, only the North Atlantic Right (NARW) and the humpback whale may come close enough inshore within the Permit Area, therefore the following discussion will only consider these two species in greater detail.

- *Humpback Whales*

Though other whale species sometimes occur off the coast of North Carolina, only the humpback whale and the right whale regularly come close enough inshore to encounter the study area. Both species are federally listed as endangered.

Humpback whale

Humpback whales (*Megaptera novaeangliae*) were listed as federally endangered throughout their range on June 2, 1970 under the Endangered Species Act and are considered “depleted” under the Marine Mammal Protection Act. The North Atlantic population of the humpback whale is estimated at 10,600 individuals (Waring et al., 1999), however the minimum population estimates for the Gulf of Maine stock is 647 individuals (NMFS, 1991a).

Humpbacks are found in protected waters over shallow bars and shelf waters, which are used for breeding and feeding. They migrate towards the poles in the summer and toward the tropics in the winter to breeding and birthing grounds. Humpbacks visit the North Carolina coast during the migratory season, especially between the months of December and April (Conant, 1993). Migrating humpbacks can be found nearshore, but probably migrate well offshore of the study area to their principal wintering range (NMFS, 1991a). On December 6, 2011, a 30 foot humpback whale was sited inshore in proximity to Masonboro Inlet, approximately 7 miles south of the Permit Area.

- *Right Whales*

Right whale and calf

The right whale (*Baleana glacialis*) is considered the world's most endangered large whale, with a total population of only around 300 individuals, and recent models predict this population will be extinct in less than 200 years (NMFS, 2006). The North Atlantic right whale utilizes six (6) major habitats or congregation areas including 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. The southeastern United States (Charleston, SC to the east coast of Florida) is considered Critical Habitat for the right whale because of these calving grounds (NMFS, 1991b). A Critical Habitat designation recognizes specific areas "that are essential to the conservation of a listed species, and that may require species management considerations or protection". During late winter and early spring, right whales begin moving north past the North Carolina coast (this includes cow/calf pairs and others wintering south of Cape Hatteras). Southerly migration to wintering areas south of Cape Hatteras begins as early as October (NMFS, 1991b). Right whales have been documented along the North Carolina coast between December and April with the majority of sightings reported between mid to late March. It is unclear as to the frequency with which right whales occur in offshore waters in the southeastern United States (NMFS, 1991b). The Right Whale Program of the New England Aquarium reported that 93% of all North Carolina sightings between 1976 and 1992 occurred between mid-October and mid-April (Slay, 1993). Typically, when spotted, right whales are observed very close to the shoreline only a few hundred meters offshore (Schmidly, 1981).

C. Fish

1. Shortnose Sturgeon

Shortnose Sturgeon

The shortnose sturgeon, *Acipenser brevirostrum*, was listed as endangered on March 11, 1967 under the Endangered Species Preservation Act of 1966 (a predecessor to the Endangered Species Act of 1973). NMFS later assumed jurisdiction for shortnose sturgeon under a 1974 government reorganization plan (38 FR 41370) (NOAA, 2007). Shortnose sturgeon is the smallest of the three sturgeon species that are found in eastern North America, rarely exceeding a length of 1.1 m (3.5 ft) and a weight of 6.4 kg (14 lbs) (NYSDEC, 2007). Shortnose sturgeon are bottom feeders, typically feeding on crustaceans, insect larvae, worms, mollusks, and some plants (NMFS, 1998). They appear to feed in either freshwater riverine habitats or near the freshwater/saltwater interface. This species is anadromous, primarily utilizing riverine and estuarine habitats, migrating between freshwater and mesohaline river reaches. Spawning occurs in upper, freshwater areas, typically in January and February, while feeding and overwintering activities may occur in both fresh and saline habitats. Aside from seasonal migrations to estuarine waters, this species rarely occurs in the marine environment (NMFS, 1998; NCWRC, 2007; USFWS, 2007e).

The shortnose sturgeon inhabits lower sections of rivers and coastal waters along the Atlantic coast from the St. John River in New Brunswick, Canada to the St. Johns River, Florida (NOAA, 2007). The NMFS federal recovery plan (1998) for the endangered shortnose sturgeon identifies 19 distinct population segments, each defined as a river/estuarine system in which these fish have been captured within the generation time of the species (30 years). This species is significantly more common in northern portions of its range than it is in the south. Shortnose sturgeon are found in rivers, estuaries, and the sea, but populations are most often confined to natal rivers and estuaries (NMFS, 1998). Those shortnose sturgeon captured in the ocean are usually taken close to shore, in high salinity environments; there are no records of shortnose sturgeon in the NMFS database for the northeast offshore bottom trawl survey (NMFS, 1998).

There are few confirmed historical reports of shortnose sturgeon captures. Because fishermen and scientists often confuse shortnose sturgeon with Atlantic sturgeon, there are no reliable estimates of historical population sizes (NMFS, 1998). There are several reports of shortnose sturgeon taken in North Carolina in the early 1800s, but the distribution and status of this species has not been fully documented in North Carolina. No shortnose sturgeon were reported in North Carolina waters between 1881 and 1987. Since then, several shortnose sturgeon have been caught in the Brunswick and Cape Fear rivers by commercial fishermen, a single fish was caught in the Pee Dee River, and it is now believed that a shortnose sturgeon population may also exist in western Albermarle Sound (NCWRC, 2007). With this discovery, the species is once again considered to be a part of the state's fauna; however, because of the lack of suitable freshwater spawning areas in the proposed project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults (NMFS, 1998).

<u>2. Atlantic Sturgeon</u>

In 2009, the Natural Resources Defense Council (NRDC) petitioned NMFS to list the Atlantic sturgeon (*Acipenser oxyrinchus*) under the Endangered Species Act of 1973 (ESA). As a result of the petition, the Carolina Distinct Population Segment (DSP) for Atlantic sturgeon has been designated as endangered under the ESA. Although Critical Habitat for Atlantic sturgeon has yet to be designated, the Permit Area for this project are not within any of the proposed boundaries.

Atlantic sturgeon are similar in appearance to shortnose sturgeon (*Acipenser brevirostrum*), but can be distinguished by their larger size, smaller mouth, different snout shape, and scutes (NMFS, 2011). The Atlantic sturgeon is a long-lived, estuarine dependent, anadromous fish. They are benthic feeders and typically forage on invertebrates including crustaceans, worms, and mollusks. Atlantic sturgeon can grow to approximately 14 feet (4.3 m) long and can weigh up to 800 lbs (370 kg) (NMFS, 2011). They are bluish-black or olive brown dorsally (on their back) with paler sides and a white belly. Spawning adults migrate upriver in spring, beginning in February-March in the south, April-May in the mid-Atlantic, and May-June in Canadian waters. In some areas, a small spawning migration may also occur in the fall. Spawning occurs in flowing water between the salt front and fall line of large rivers (NMFS, 2011). Atlantic sturgeon spawning intervals range from 1 to 5 years for males and 2 to 5 years for females (NMFS, 2011).

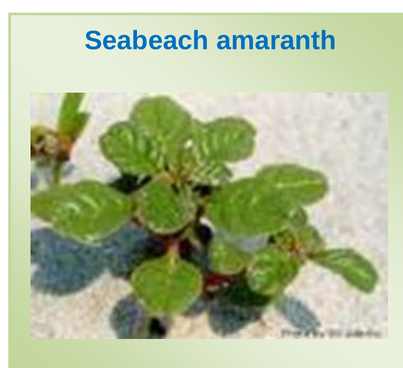
Adults range from Hamilton Inlet, Labrador (Scott and Scott, 1988) south to the St. Johns River in Florida (Vladykov and Greeley 1963). Following spawning, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks. Juveniles move downstream and inhabit brackish waters for a few months and when they reach a size of about 30 to 36 inches (76-92 cm) they move into nearshore coastal waters (Smith, 1985).

Tagging data indicates that these immature Atlantic sturgeon travel widely once they emigrate from their natal (birth) rivers. Although Atlantic sturgeon are regularly caught in North Carolina, details of their distribution patterns and habitat preferences are unknown (Ross et al., 1988). Atlantic sturgeon have been reported in the Atlantic Ocean off South Carolina in months of low water temperatures (November–April) from nearshore to well offshore in depths up to 40 m (Collins and Smith, 1997). Moser et al. (1998) obtained sturgeon records from federal, private, and state surveys and documented use of nearshore Atlantic Ocean habitats from the North/South Carolina state line to off the mouth of Chesapeake Bay. Stein et al. (2004) found peak Atlantic sturgeon captures along the coast in 10–50 m depths. A study conducted between 1988 and 2006 examined the offshore distribution of Atlantic sturgeon based on incidental captures in winter tagging cruises conducted off the coasts of Virginia and North Carolina, including in and near extensive sand shoals adjacent to Oregon Inlet and Cape Hatteras. A total of 146 juvenile Atlantic sturgeon were captured during this investigation by bottom trawling in depths from 9.1 to 21.3m (Laney et al, 2007). Many of the fish were captured over sandy substrate which coincides with results observed in several other studies (Laney, 2007). In a tagging study conducted my Moser and Ross (1995), 100 juvenile Atlantic sturgeon were captured within the Cape Fear River. Of these, four fish were observed moving from the river into the ocean and were caught in gill nets set from shore at Carolina Beach, Kure Beach, and Ft. Fisher (Moser and Ross, 1995).   Therefore, these fish are known to frequent nearshore waters in proximity to the Cape Fear River.

D. Plants

1. Seabeach Amaranth

Seabeach amaranth (*Amaranthus pumilus*) is federally and State-listed as threatened. It grows in low clumps comprised of sprawling, fleshy, reddish branches with dark leaves. The plant is profusely branched and generally grows to 1 m (39 in) in diameter. Historically, this species was found from Massachusetts to South Carolina, but according to USACE surveys between 1992 and 2004 (unpublished data), its distribution is now limited to North and South Carolina with some populations on Long Island, New York (USACE, 2006).



Seabeach amaranth is an effective sand binder, building dunes where it grows. A single large plant may be capable of creating a dune up to 60 cm high, containing 2 to 3 cu m of sand, although most are smaller (Weakley and Bucher, 1992). The plant is typically found at elevations from 0.2 m to 1.5 m (0.6 ft to 4.9 ft) above mean high tide (Weakly and Bucher, 1992). Seabeach amaranth appears to function in a relatively natural and dynamic manner, allowing it to occupy suitable habitat as it becomes available (USFWS, 1993).

Figure Eight Island has been surveyed by UNCW for seabeach amaranth from 2002 to 2015 (Webster, pers. comm.) while Hutaff Island has been monitored by field representatives of Audubon NC between 2005 and 2010 (Mangiameli pers. comm.,; Suiter, pers. comm.). A total of 1,600 plants (ranging from 0 to 768 each year) have been recorded on Figure Eight Island during that time period (Table 4.7 and Figure 4.27 – 4.35) (Webster, pers. comm.,; Suiter, 2011). Specific locations of individual seabeach amaranth plants from the 2011-2015 surveys were not provided and, therefore, figures for these years were not included. A total of 1,130 plants were found on Hutaff Island, with observations ranging between 14 and 1,011 between years. Seabeach amaranth data does not exist for Hutaff Island prior to 2005 (Golder, 2007). In 2015, Audubon NC performed additional seabeach amaranth surveys strictly along the northern end of Figure Eight Island. Result from those surveys, conducted on September 3, 4, and 7, 2015 resulted in the identification of 262 plants within this area (Addison, pers. comm) (Figure 4.36).

Seabeach amaranth experiences a great deal of natural population variability from one year to the next, as is evident by Dr. Webster's and Audubon North Carolina survey results (Table 4.7). These natural fluctuations can be attributed to a number of factors, such as erosion, storms and seed dispersal.

Table 4.7. Figure Eight Island (Webster, pers. comm.) and Audubon North Carolina annual Seabeach amaranth data (2005 to 2007) on Hutaff Island, North Carolina

Year	Seabeach amaranth (*Amaranthus pumilus*)	
	Figure Eight Island	**Hutaff Island**
2002	72	No Data
2003	3	No Data
2004	656	No Data
2005	768	1011
2006	No Data	47
2007	2	21
2008	0	14
2009	0	19
2010	4	18
2011	17	No Data
2012	0	No Data
2013	31	No Data
2014	17	No Data

2015	30	No Data
Totals	**1600**	**1130**

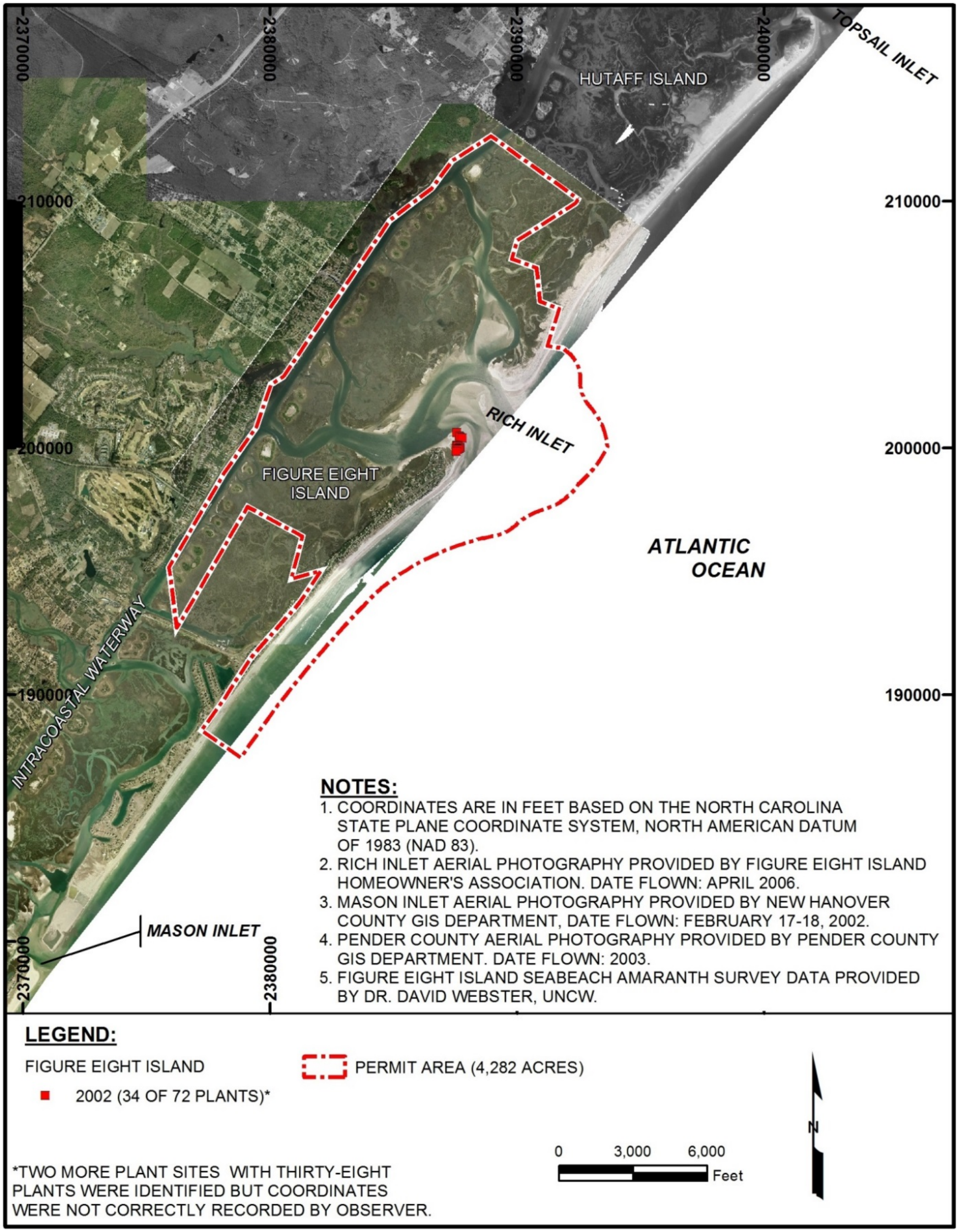


Figure 4.27. 2002 Seabeach amaranth distribution within the Permit Area

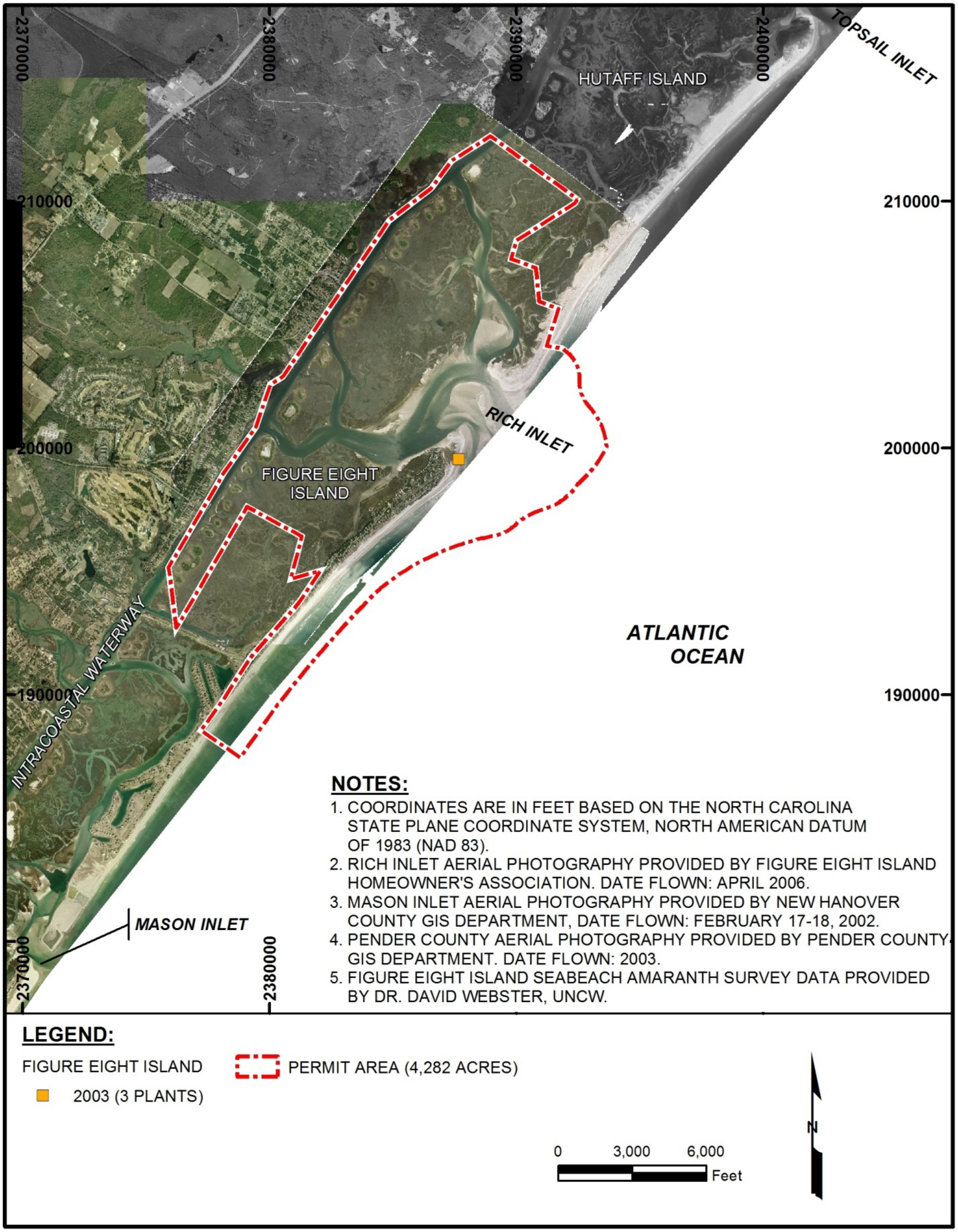


Figure 4.28. 2003 Seabeach amaranth distribution within the Permit Area

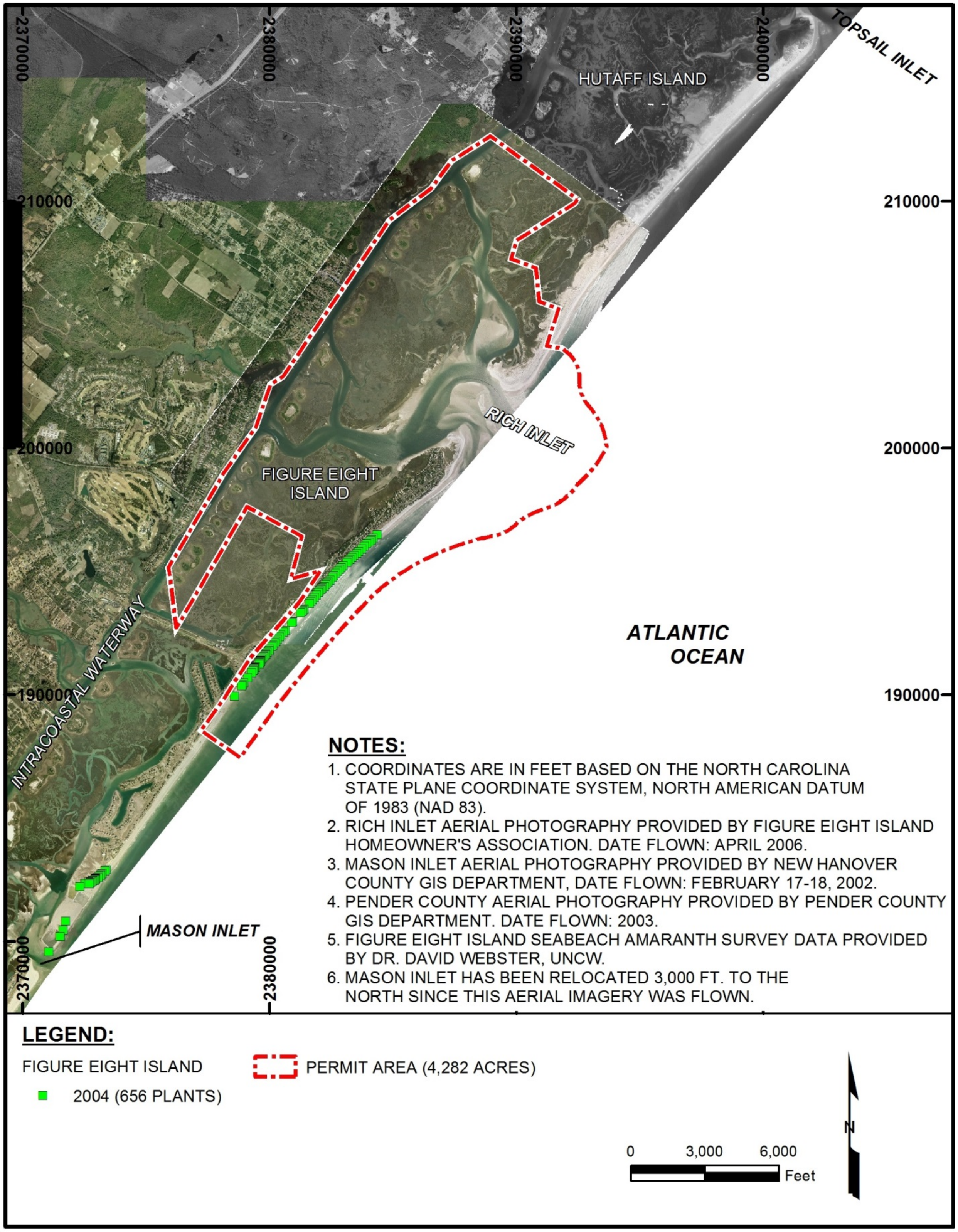


Figure 4.29. 2004 Seabeach amaranth distribution within the Permit Area

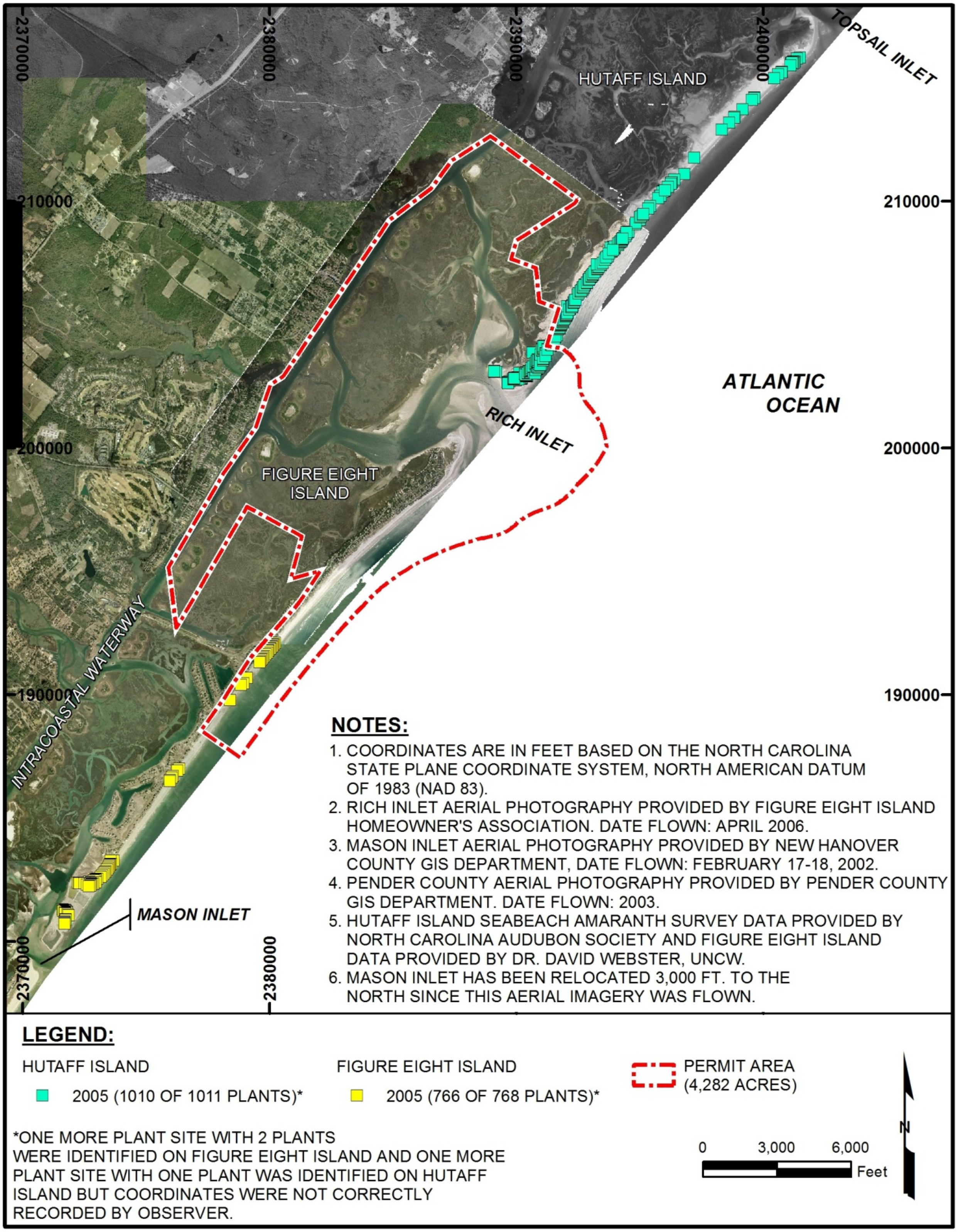


Figure 4.30. 2005 Seabeach amaranth distribution within the Permit Area

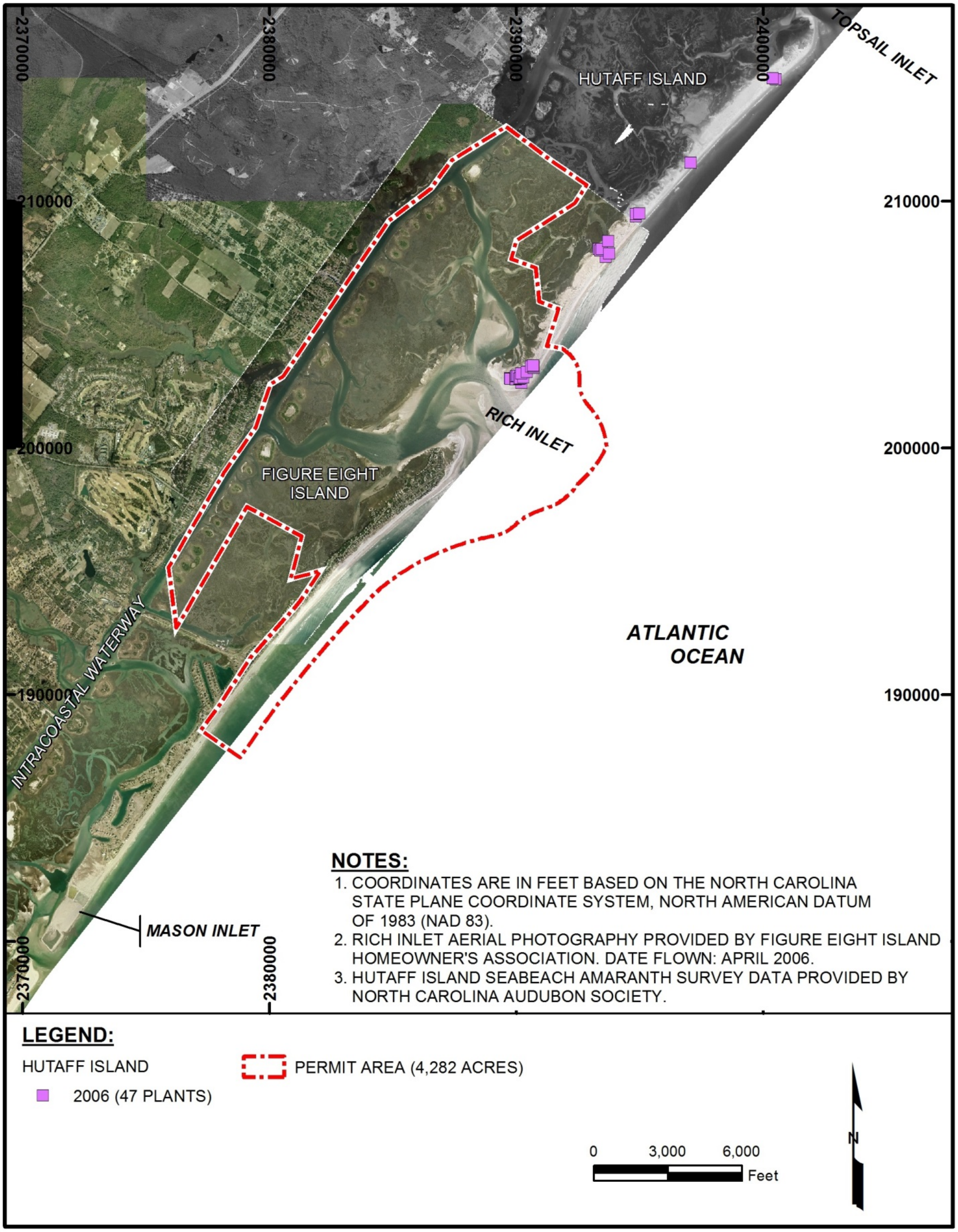


Figure 4.31. 2006 Seabeach amaranth distribution within the Permit Area

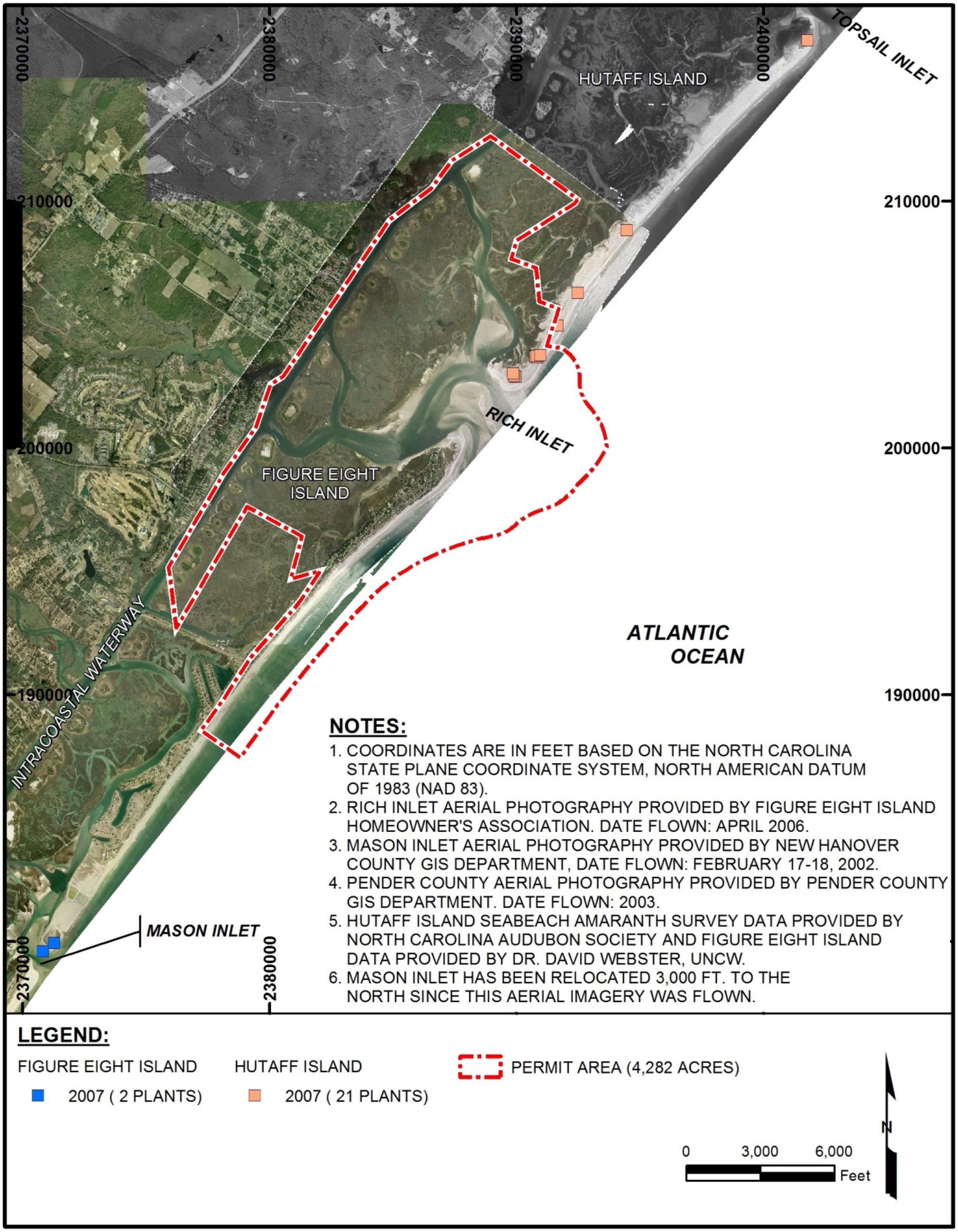


Figure 4.32. 2007 Seabeach amaranth distribution within the Permit Area

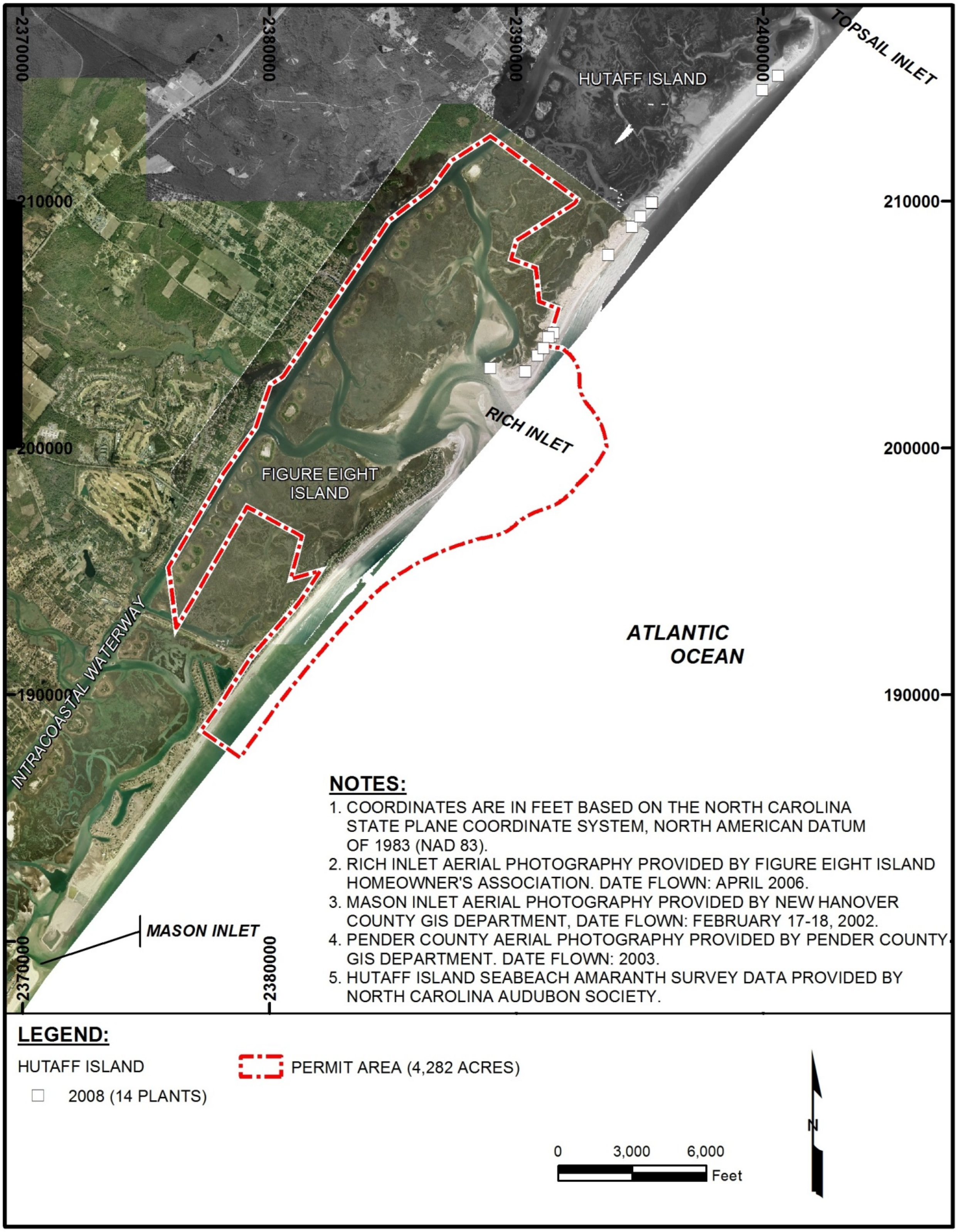


Figure 4.33. 2008 Seabeach amaranth distribution within the Permit Area

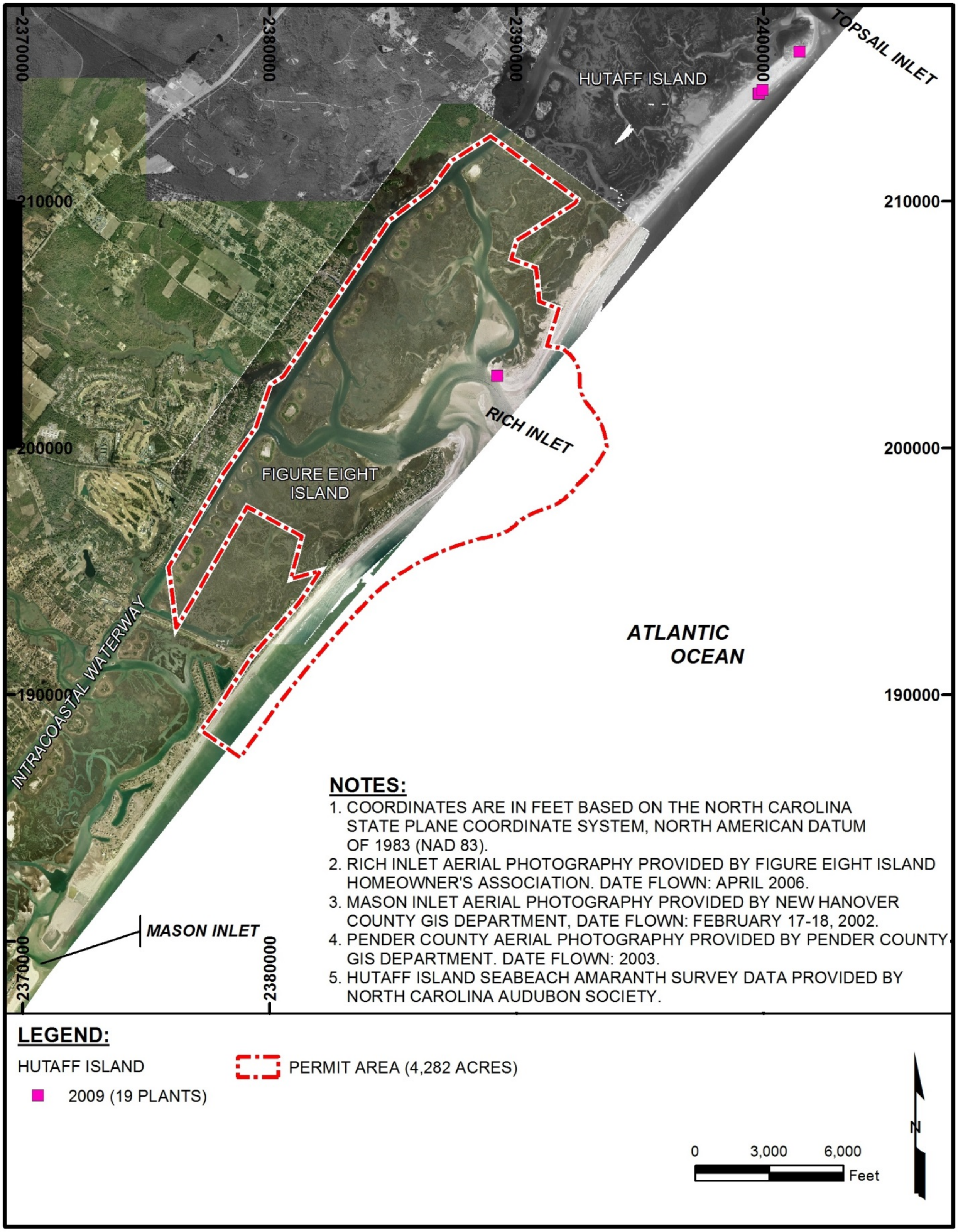


Figure 4.34. 2009 Seabeach amaranth distribution within the Permit Area. Note that more than one plant was observed at several sites.

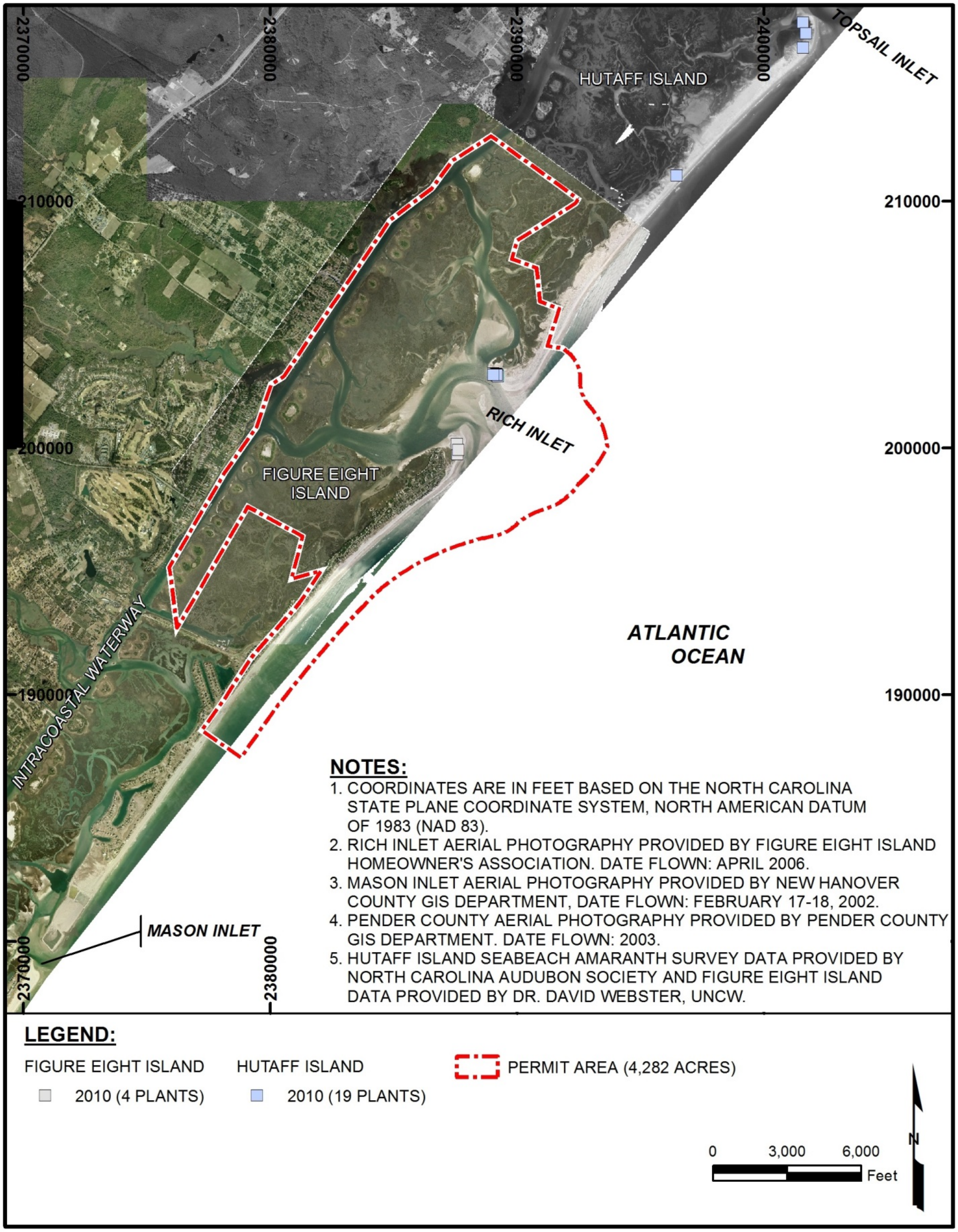


Figure 4.35. 2010 Seabeach amaranth distribution within the Permit Area.

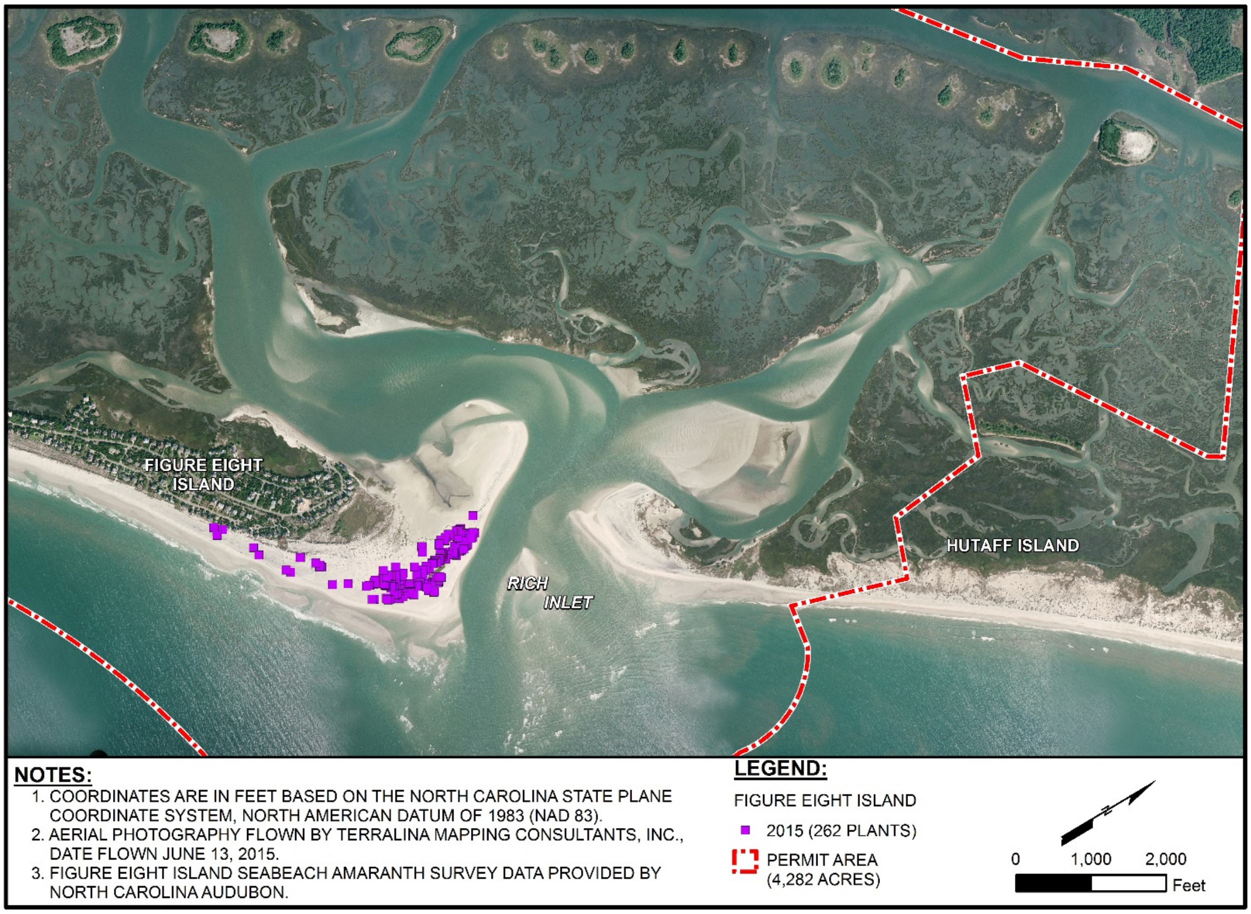


Figure 4.36. 2015 Seabeach amaranth observed by Audubon NC in 2015 along the north end of Figure Eight Island.

E. Birds

The following section reviews and describes threatened and endangered bird species, both breeding and non-breeding, that have been documented within the Permit Area and/or within the vicinity of the project site. Bird species of special concern and of high conservation priority in North Carolina are also listed and discussed.

The North Carolina Wildlife Resource Commission and Audubon North Carolina have performed breeding surveys for colonial nesting waterbirds within proximity of the Permit Area on a regular basis since 1977. Specifically, surveys have been conducted within the north side of Mason’s Inlet and the Southside of Rich Inlet, flanking Figure Eight Island. Surveys have also been conducted on Hutaff Island as well as the Southside of New Topsail Inlet, the northside of Rich Inlet, and Old Topsail Inlet. Surveys for breeding piping plovers have been conducted since 1989 at the same locations. Surveys for non-breeding piping plovers have been conducted in more recent years. These surveys include data from breeding and non-breeding seasons for several listed bird species as well as other shorebirds and waterbirds.

In 2011, researchers with UNCW conducted daily bird surveys on Figure Eight Island in between April 1 and April 14. These surveys occurred along the northern portion of the island between Nixon Channel and Inlet Hook Court, which are within the Permit Area. Surveys were performed at various times of the day and at various tidal stages. A total of 54 bird species were observed during the fifteen (15) surveys, including at least thirty (30) species per survey (Webster, pers. com.). The most commonly observed species were, in order, the Ring-billed gull, Double crested cormorant, Laughing gull, Herring gull, Least tern, and Brown pelican (Webster, pers. com).

Audubon North Carolina performed bird surveys within the greater Rich Inlet area on a monthly basis on a monthly basis beginning in the winter of 2007 and transitioned to a weekly schedule in March 2008. Thereafter, surveys were conducted on a weekly basis during shorebird migration (March-May and July-November) and bi-weekly during winter (December-February). Surveys were suspended in June, at the height of the nesting season when use by migrants is minimal. The domain of the survey area encompassed approximately 2.9km2 and included the south end of Hutaff Island, the north end of Figure 8 Island, and Rich Inlet proper (which encompasses the marsh and dredge island shoreline in Nixon and Green Channels, the large intertidal shoal in Green Channel (Green Shoal), the large intertidal shoal in the middle of the main inlet channel (Rich Shoal), and any other emergent shoals or sandbars in the inlet system. Between January 2010 and September 2014, a total of 228,823 birds, representing 90 species were observed within this area. Individuals of 26 species represented 96% of all birds observed at Rich Inlet (Addison and McIver, 2014). Of the 90 species observed at Rich Inlet, 27 species (30%) are of conservation concern, either as federally listed species, state-listed species or identified as declining or otherwise vulnerable.

1. Piping Plover

The piping plover (*Charadrius melodus*) was federally listed in 1986 under the Endangered Species Act of 1973, as amended with three separate breeding populations in North America: 1) the Atlantic Coast population (threatened), 2) the Northern Great Plains population (threatened), and 3) the Great Lakes population (endangered). Piping plovers are also listed as threatened throughout their wintering range (USFWS, 1996). All three populations migrate to the coastal shorelines of the South Atlantic, Gulf of Mexico and the beaches of the Caribbean Islands to winter (USFWS, 2007c).

Piping plover

The habitat for wintering piping plover is protected under a Critical Habitat listing as identified by the ESA. On July 10, 2002, 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas were designated as Critical Habitat for wintering piping plover. Critical Habitat designation for North Carolina wintering piping plover includes Rich Inlet in Unit NC-11, which is described by the USFWS as follows (USFWS, 2001):

> *The entire area is privately owned. This unit extends southwest from 1.0 km (0.65 mi) northeast of MLLW of New Topsail Inlet on Topsail Island to 0.53 km (0.33 mi) southwest of MLLW of Rich Inlet on Figure Eight Island. It includes both Rich Inlet and New Topsail Inlet and the former Old Topsail Inlet. All land, including emergent*

sandbars, from MLLW on Atlantic Ocean and sound side to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur. In Topsail Sound, the unit stops as the entrance to tidal creeks become narrow and channelized.

While overwintering piping plovers have Critical Habitat within the Permit Area, this species also nests in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. Their nests are comprised of sand and shell material making them well camouflaged, with an average clutch size of three to four eggs (USFWS, 1996).

In 1990 the USFWS (2008) counted fewer than 1,000 piping plover nests in the Atlantic Coast population (including Canada). By 1996, 1,348 breeding pairs were documented. The number of breeding pairs has continued to steadily increase, reaching 1,438 pairs in 2000 and 1,690 pairs in 2002 (USFWS, 2008). The number of piping plover breeding pairs in North Carolina decreased from 55 pairs in 1989 to 24 pairs in 2003. However, estimates indicate a slight increase occurred in breeding pairs to 37 in 2005 and 46 in 2006 (USFWS, 2008).

The North Carolina coastline is important to piping plovers since it provides habitat for wintering, breeding, and migration. Piping plovers have been documented arriving on their breeding grounds in North Carolina beginning as early as mid-March. By mid-July, adults and young may begin to depart for their wintering areas. The piping plover is present year round in North Carolina and utilizes the coastal habitats for foraging, roosting, nesting, wintering and migrating (Cameron pers. comm., 2007).

The UNCW, NCWRC, Audubon North Carolina and partners have conducted piping plover surveys along portions of Figure Eight Island, Rich Inlet and Hutaff Island. Only two (2) breeding pair were observed in 1996 and two (2) in 2014 on Figure Eight Island. Hutaff Island, however, appears to be an important breeding area based upon the annual observations of breeding pairs. Since 1989, the peak number of breeding pairs observed on Hutaff was ten (10) (Cameron pers. comm., 2007).

Data collected within the Rich Inlet area includes observations of piping plovers along the ebb bar in Rich Inlet near the northern end of Figure Eight, bars in Nixon and Green Channels, and the southern tip of Hutaff Island. Although the exact location of individuals within this complex was not noted in the data set; it is presumed that some of the individuals could have been or were foraging on the ebb bars during low tide. The greatest number of individuals noted in this area at one time was twenty-one (21) during the fall migration in 2006 (Cameron pers. comm., 2007).

Despite the lack of regular monitoring during the non-breeding season, data suggests that the area around Rich Inlet is valuable for migrating and wintering piping plovers. Surveys conducted by North Carolina Wildlife Resources Commission (NCWRC) and their partners observed approximately 192 piping plovers which included 31 breeding pairs between 2000 and 2007 surveys (Table 4.8) (Cameron pers. comm., 2007). Between 2011 and 2014, 33 additional observations of individual piping plovers and 5 breeding pairs were made during NCWRC surveys (Table 4.8). It is important to mention that although 225 piping plovers and 36 breeding pairs were observed over the course of these surveys, it is possible that some individual birds were observed during multiple surveys and therefore summating these numbers may not be indicative of the actual number of distinct piping plovers found within the permit area.

In 2011, UNCW observed numerous piping plovers along the northern end of Figure Eight Island during a two week survey. Daily observations ranged from one (1) to nine (9) piping plovers (Webster, pers. comm., 2011) with an average of over five (5) per survey. No breeding pairs of piping plovers were observed on Figure Eight Island during the breeding season, however two nesting pairs were observed on Hutaff Island during breeding season (Schweitzer, pers. comm., 2011). During the 2013-2014 migratory season (fall, winter, and spring), a total of 176 piping plovers were observed along the north and south ends of Figure Eight Island. A total of 242 piping plovers were observed during the 2014-2015 migratory season (Webster, pers. comm.). Two piping plover nests were laid on the north end of Figure Eight Island in 2014 and another in 2015 (Webster, pers. comm.).

Between 2010 and 2014, Audubon North Carolina reported a total of 1,514 observations of piping plovers were made within Rich Inlet (Addison and McIver, 2014). While sightings were made in every month of the year, the greatest numbers were observed during fall migration (July-November). In some years piping plovers nested on Hutaff Island (2 pairs 2008, 1 pair 2009, 2 pairs 2010) or Figure Eight Island (1 pair 2014) (Addison and McIver, 2014). Piping plovers were observed throughout the Rich Inlet system using all areas of the inlet: the shoals in the main channel and Green Channel, beaches and spits on the northern and southern sides of the inlet mouth, and, much less frequently, beach or sandbar areas at the back of the inlet. Of the 1,514 piping plover sightings at Rich Inlet, 909 (60.0%) were of foraging birds, 515 (34.0%) were of roosting birds, and 90 (6.0%) were of birds performing another activity such as preening or agonistic behavior. Of the 909 sightings of foraging Piping Plovers at Rich Inlet, 458 (50.4%) were on shoals or sandbars in Rich Inlet; 201 (22.1%) were on Hutaff Island, typically in the swash zone at mid or low tide, and 250 (27.6%) were on North Figure 8 Island, typically on the low-energy sound side (Addison and McIver, 2014).

Table 4.8. Piping Plover survey data (1987-2007, 2011-204) for Figure Eight Island & Hutaff Island.

Year	Season	Number of birds	Number of breeding pairs
1987	Winter	0	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1988	Winter	No Data	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1989	Winter	8	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	1	
1990	Winter	9*	
	Spring Migration	0	

Year	Season	Number of birds	Number of breeding pairs
	Breeding	No Data	No Data
	Fall Migration	No Data	
1991	Winter	14*	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
1992	Winter	No Data	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1993	Winter	No Data	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1994	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
1995	Winter	No Data	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1996	Winter	16	
	Spring Migration	No Data	
	Breeding	10	5
	Fall Migration	No Data	
1997	Winter	19*	
	Spring Migration	No Data	
	Breeding	4	2
	Fall Migration	No Data	
1998	Winter	0	
	Spring Migration	No Data	
	Breeding	7	3
	Fall Migration	No Data	
1999	Winter	No Data	
	Spring Migration	No Data	
	Breeding	11	4
	Fall Migration	6	
2000	Winter	No Data	
	Spring Migration	No Data	
	Breeding	8	3
	Fall Migration	11*	
2001	Winter	18*	
	Spring Migration	9*	
	Breeding	10	4
	Fall Migration	19*	
2002	Winter	5*	

Year	Season	Number of birds	Number of breeding pairs
	Spring Migration	6*	
	Breeding	4	2
	Fall Migration	2*	
2003	Winter	4*	
	Spring Migration	3*	
	Breeding	20	10
	Fall Migration	2*	
2004	Winter	No Data	
	Spring Migration	No Data	
	Breeding	6	3
	Fall Migration	4*	
2005	Winter	No Data	
	Spring Migration	2*	
	Breeding	8	4
	Fall Migration	13*	
2006	Winter	2*	
	Spring Migration	8*	
	Breeding	0	0
	Fall Migration	21*	
2007	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
2011	Winter	1	
	Spring Migration	16	
	Breeding	8	2
	Fall Migration	No Data	
2012	Winter	No Data	
	Spring Migration	No Data	
	Breeding	2	0
	Fall Migration	No Data	
2013	Winter	No Data	
	Spring Migration	No Data	
	Breeding	2	1
	Fall Migration	No Data	
2014	Winter	No Data	
	Spring Migration	No Data	
	Breeding	4	2
	Fall Migration	No Data	

*** These values represent the greatest number of individuals observed during a single sampling event. This designation has been utilized for those years where sampling events were conducted often and multiple counts of the same individuals in a single season are likely. This method of data reporting may lead to an underestimation of individuals found in these areas in a season. Given the frequency of data collection, it was determined that adding all of the observations in a single season for this data set would result in a gross overestimation of actual individuals would not be an appropriate way to present the data.**

2. Wilson's Plover

The Wilson's plover (*Charadrius wilsonia*) is designated by the State of North Carolina as a Species of Special Concern. There is no Federal status for this species, and it is considered globally secure (G5 rank) (NCNHP, 2006). However, Wilson's plovers are listed as species of high conservation concern in the US Shorebird Conservation Plan (Brown et al., 2001). This species breeds in North Carolina and has a current breeding range extending into northern Virginia in the Delmarva Peninsula; its historic range reached New Jersey (Corbat and Bergstrom 2000). Complete surveys were conducted in 2004 and 2007 along Hutaff Island and the inlet areas flanking Figure Eight Island. Additional surveys were conducted from 1989 and 2001 (Table 4.9). The number of Wilson's plovers recorded during this period ranged from 10 to 54 individuals and 5 to 27 breeding pairs (Cameron, pers. comm. 2007). In 2007, Audubon North Carolina observed 27 breeding pairs of Wilson's plovers on Hutaff Island (Mangiameli, pers. comm., 2008). An average of nearly two (2) Wilson's plovers were observed during each of the daily surveys conducted along the northern portion of Figure Eight Island in April, 2011 (Webster, pers. comm., 2011). In 2012, there were 25 defended territories, indicating 25 nesting pairs and 46 defended territories in 2011 (Audubon unpublished data).

Wilson's plover

Table 4.9. Wilson's Plover survey data observed 2000-2007

Location	Year	Season	Number of Birds	Number of Breeding Pairs
Figure Eight Island	1989*	Breeding	48	24
Hutaff Island	1989*	Breeding	51	23
Figure Eight Island	2001*	Breeding	28	14
Hutaff Island	2001*	Breeding	22	11
Figure Eight Island	2004	Breeding	10	5
Hutaff Island	2004	Breeding	52	26
Figure Eight Island	2007	Breeding	2	1
Hutaff Island	2007	Breeding	54	27

*Incomplete survey

3. <u>American Oystercatcher</u>

American oystercatchers *(Haematopus palliatus)* are State listed as a Species of Special Concern. However, the American oystercatcher is considered stable globally (G5), and is not federally listed under the ESA. Along the western Atlantic coast, the eastern race of the American oystercatcher breeds from Massachusetts to Florida, with the highest concentrations from Virginia to Georgia (Humphrey, 1990). As indicated in Table 4.10, this species has been observed in or near the Permit Area during the April to June breeding period (Cameron, pers. comm., 2007). In addition, the species is known to utilize Rich Inlet during migration, particularly in the spring when numbers increase as breeding and local birds' numbers are augmented by migrants (Audubon, 2012). An average of two (2)

American oystercatcher

American oystercatchers were observed during each of the daily surveys conducted along the northern portion of Figure Eight Island in April 2011 (Webster, pers. comm., 2011).

Table 4.10. American Oystercatcher Survey Data Observed 2000-2007

Location	Year	Season	Number of Birds	Number of Breeding Pairs
Figure Eight Island	2001	Breeding	8	4
Hutaff Island	2001*	Breeding	10	5
Figure Eight Island	2004	Breeding	10	5
Hutaff Island	2004	Breeding	26	13
Figure Eight Island	2007	Breeding	4	2
Hutaff Island	2007	Breeding	24	12

***Incomplete survey**

4. Common Tern

The common tern (*Sterna hirundo*) is designated by the State of North Carolina as Species of Special Concern (species which are determined by the NCWRC to require monitoring). There is no Federal status for this species, although the common tern is considered globally secure (G5 rank). Common terns seem to be undergoing a decline in the southeast and are therefore listed as a species of regional concern (Hunter et al., 2001).

Common tern

Complete surveys were conducted along Hutaff Island and the inlet areas flanking Figure Eight Island by the NCWRC and Audubon North Carolina in 1977, 1983, 1988, 1993, 1995, 1997, 1999, 2001, 2004, and 2007. A total of 495 nests were observed through this period (Table 4.11). Common terns have experienced dramatic population declines in North Carolina and are currently down from their long-term average by 66% (Cameron et al. 2004). Common terns move frequently in response to changes in their highly ephemeral nesting habitat. The area along Hutaff Island and Figure Eight Island provides potentially important nesting habitat for common terns.

An average of nearly twenty (20) common terns were observed during daily surveys conducted along the northern portion of Figure Eight Island in April 2011 (Webster, pers. comm., 2011). In the spring of 2012, as many as 463 common terns were counted on shorebird surveys, and in the fall as many as 670 were counted (Audubon 2012a). These flocks are often observed on the shoals in the mouth of Rich Inlet.

Table 4.11. Number of common tern nests observed 1977-2007

Site Name	Survey Date	Number of Nests
Figure Eight Island	1977	7
Hutaff Island	1977	9
Figure Eight Island	1983	0
Hutaff Island	1983	96
Figure Eight Island	1988	11
Hutaff Island	1988	34
Figure Eight Island	1989	13*
Hutaff Island	1989	35*
Figure Eight Island	1990	51*
Figure Eight Island	1993	16
Hutaff Island	1993	0
Figure Eight Island	1995	5
Hutaff Island	1995	25
Figure Eight Island	1997	1
Hutaff Island	1997	52
Figure Eight Island	1999	0
Hutaff Island	1999	67
Figure Eight Island	2001	20
Hutaff Island	2001	38
Figure Eight Island	2004	0
Hutaff Island	2004	15
Figure Eight Island	2007	0
Hutaff Island	2007	0

***Incomplete survey**

5. <u>Gull-Billed Tern</u>

Gull-billed tern

The gull-billed tern (*Sterna nilotica*) is designated by the State of North Carolina as threatened. There is no Federal status for this species, and it is considered globally secure (G5 rank). However, these terns are listed as species of high conservation concern (Kushlan et al., 2002). Surveys were conducted along Hutaff Island and the inlet areas flanking Figure Eight Island by the NCWRC and Audubon North Carolina in 1977, 1983, 1988, 1993, 1995, 1997, 1999, 2001, 2004, and 2007. Although only nine (9) nests were observed in proximity to Figure Eight Island and two (2) along Hutaff following 10 years of complete surveys spanning 30 years, Sue Cameron of the NCWRC noted that the habitat type within the Permit Area makes these areas potentially important nesting sites (Table 4.12). No gull-billed terns were observed during each of the daily surveys conducted along the northern portion of Figure Eight Island in April 2011 (Webster, pers. comm., 2011).

Table 4.12. Number of gull-billed tern nests observed 1977-2007

Site Name	Survey Date	Number of Nests
Figure Eight Island	1977	0
Hutaff Island	1977	0
Figure Eight Island	1983	0
Hutaff Island	1983	0
Figure Eight Island	1988	0
Hutaff Island	1988	0
Hutaff Island	1989	1*
Figure Eight Island	1990	9*
Figure Eight Island	1993	0
Hutaff Island	1993	0
Figure Eight Island	1995	0
Hutaff Island	1995	0
Figure Eight Island	1997	0
Hutaff Island	1997	0
Figure Eight Island	1999	0
Hutaff Island	1999	1
Figure Eight Island	2001	0
Hutaff Island	2001	0
Figure Eight Island	2004	0
Hutaff Island	2004	0
Figure Eight Island	2007	0
Hutaff Island	2007	0

***Incomplete survey**

6. Black Skimmer

The black skimmer (*Rynchops niger*) is designated by the State of North Carolina as a Species of Special Concern (species which are determined by the NCWRC to require monitoring). There is no Federal status for these species, although the black skimmer is considered globally secure (G5 rank) (Kushlan et al., 2002).

Black skimmer

Complete surveys were conducted along Hutaff Island and the inlet areas flanking Figure Eight Island by the NCWRC and Audubon North Carolina in 1977, 1983, 1988, 1993, 1995, 1997, 1999, 2001, 2004, and 2007. A total of 562 nests were observed during this time (Table 4.13).

Of the fifteen (15) daily surveys conducted by UNCW along the northern portion of Figure Eight Island in April 2011, black skimmers were observed on only two dates. These included observations of fifty (50) and twelve (12) individuals (Webster, pers. comm., 2011). In the fall, black skimmers use Rich Inlet for staging. Audubon reports that in 2012 the peak spring count was 132 and the peak fall count was 1,500 (Audubon 2012a). Also like the common terns, black skimmers use the emergent shoal in the mouth of Rich Inlet, as well as the islands' spits to roost in these large groups.

Table 4.13. Number of Black Skimmer Nests Observed 1977-2007

Site Name	Survey Date	Number of Nests
Figure Eight Island	1977	0
Hutaff Island	1977	52
Figure Eight Island	1983	0
Hutaff Island	1983	38
Figure Eight Island	1988	20
Hutaff Island	1988	16
Figure Eight Island	1989	1*
Hutaff Island	1989	41*
Figure Eight Island	1990	48*
Hutaff Island	1991	25*
Figure Eight Island	1993	14
Hutaff Island	1993	0
Figure Eight Island	1995	0
Hutaff Island	1995	42
Figure Eight Island	1997	0
Hutaff Island	1997	24
Figure Eight Island	1999	0
Hutaff Island	1999	27
Figure Eight Island	2000	20
Figure Eight Island	2001	40
Hutaff Island	2001	67
Figure Eight Island	2004	0
Hutaff Island	2004	87
Figure Eight Island	2007	0
Hutaff Island	2007	0

***Incomplete survey**

7. Eastern Painted Bunting

The Eastern painted bunting (Passerina ciris ciris) is State-listed as a Species of Special Concern. The eastern population of painted bunting breeds in a restricted range within the Atlantic Coastal Plain, from North and South Carolina to Georgia and Florida. In North Carolina, eastern painted bunting breeding habitats are found in a narrow range along marine coasts and waterways (Audubon North Carolina, 2007b). NCWRC Biologist Dave Allen described their habitat as "…early succession habitat such as shrubby areas with occasional shrubs, edge habitat and even marsh edges or marsh interior if some shrubs or trees are nearby. This includes some residential area" (Allen, pers. comm., 2007).

A volunteer monitoring program has been established for the painted bunting in partnership between UNCW, SCNDR, USFWS, and the North Carolina Museum of Natural Sciences. This goal of this program, called the Painted Bunting Observation Team (PBOT), is to observe, record, and catalogue sightings of painted buntings. PBOT has reported twelve (12) sightings from four (4) locations on Figure Eight Island in 2011. Several hundred additional observations were made along the landward area of New Hanover and Pender County in proximity to the AIWW, (Painted Bunting Observer Team, 2011).

8. Red Knot

Red Knot

The red knot was designated by the USFWS as threatened in 2014. At nine to ten inches long, the red knot is a large, bulky sandpiper with a short, straight, black bill. Large numbers of red knots rely on Atlantic stopover habitats during the spring and fall migration periods. Red knots winter at the southern tip of South America and breed above the Arctic Circle. These small shorebirds fly more than 9,300 miles from south to north every spring and reverse the trip every autumn, making the red knot one of the longest-distance migrating animals. Migrating red knots break their spring migration into non-stop segments of 1,500 miles or more, converging on just a few critical stopover areas along the way. Large flocks of red knots arrive at stopover areas along the Atlantic coast each spring, with many of the birds having flown directly from northern Brazil. Red knots are faithful to these specific sites, stopping at the same locations year after year. Mole crabs (*Emerita talpoida*) and coquina clams (*Donax sp.*) are an important food source for migrating knots in North Carolina. Birds arrive at stopover areas with depleted energy reserves and must quickly rebuild their body fat to complete their migration to Arctic breeding areas. During their brief 10 to 14-day stay in the mid-Atlantic, red knots typically double their body weight.

Red knots do utilize habitat within and around the Permit Area during their migration. Surveys conducted during 2007 by Audubon North Carolina revealed a total of 878 red knot individuals observed along Mason Inlet, Rich Inlet, Lea Island, and Hutaff Island. The maximum count at each location on an individual survey was 188, 258, 6, and 20, respectively at each location. (Mangiameli, pers. comm., 2008). Surveys conducted by Audubon North Carolina between 2008 and 2014 revealed that banded red knots were observed on 55 occasions, representing at least 26 individuals. Since not all knots' bands codes could be read completely, and since not all red knots have unique bands, the number of individuals is likely underrepresented by this count (Addison and McIver, 2014). The majority of red knots observed during this study roosted on the sound side of Figure Eight Island, with additional roosts on Hutaff Island and Green Shoal. Foraging red knots used the ocean beaches of Figure Eight Island and Hutaff Island, as well as Green Shoal.

Lead by Dr. David Webster, personnel from the UNCW monitored Figure Eight Island for red knots beginning in 2010. Monitoring activities were conducted on a weekly basis on both the north and south ends of the island. Each survey was approximately 2 km in length, including beachfront, inlet, and tidal flat habitats. On 28 March 2010, approximately 45 red knots were observed on Figure Eight Island, migrating northward. None were banded. Thirteen were observed migrating northward on Figure Eight Island on 2 April 2011; none were banded. A single red knot (banded) was observed on Figure Eight Island on 5 February 2012. This bird was banded as a juvenile on 9 September 2011 at Monomoy Refuge, Massachusetts. Approximately 100 red knots were observed on Figure Eight Island migrating northward on 17 April 2012; none were banded. Approximately 300 red knots were observed migrating southward on 21 October 2012; one had two tags on the left tarsometatarsus (yellow over green) and a yellow flag above an orange band on the right leg. On 10 March 2013, 57 red knots were observed migrating northward on Figure Eight Island. Approximately 75 red knots were observed on Figure Eight Island migrating northward on 6 April 2014; none were banded. Seventeen Red Knots were observed on Figure Eight Island migrating southward on 16 November 2014; none were banded.

4. What are the public interest factors within the project area?

Public Safety

A total of 215 boating accidents were recorded in North Carolina by the NCWRC in 2005 (including personal watercraft), 14 of them fatal. The U.S. Coast Guard (USCG) Boating Statistics for 2005 ranked the waters of North Carolina as number 11 out of the 56 bodies of water owned by the U.S., for the total number of boats operating in North Carolina waters. In 2005 a total of 362,784 boats were registered in North Carolina. This number increased to 370,291 in 2006 (USGC, 2006). Between 2002 and 2006, the number for boating accidents has steadily risen from 138 to 175. Within the same time period, there was an increase of boat accident related mortalities; from 11 in 2002 to 24 in 2006. In 2005, NCWRC reported 10 boating accidents in New Hanover County resulting in eight injuries and two fatalities. Ten accidents were also reported in Pender County with nine injuries and one fatality. In 2007, a boating accident injured three occupants of a vessel which crashed into the Figure Eight Island bridge as it traveled in the AIWW. On May 26, 2008 a small recreational vessel capsized in proximity to Rich Inlet leading to one drowning fatality. The waters in North Carolina, including those found within the Permit Area are policed by the North Carolina Marine Patrol administered through the Officers of the Wildlife Resources Commission. Their jurisdiction includes all coastal waters, extends to 3 miles offshore, and ranges to 200 miles offshore for some federally regulated species. Officers monitor 2.5 million acres of water and over 4,000 miles of coastline. Currently, the Marine Patrol has 59 officers that work in three law enforcement districts along the North Carolina coast. In addition to checking commercial and recreational fishermen, officers patrol waterways, piers, and beaches in coastal areas. Officers use a variety of different size boats, aircraft, helicopters, and patrol vehicles to accomplish these tasks.

Figure Eight Island is a privately owned island and access from the mainland by way of Bridge Road is restricted to residents and their guests limiting public entrance. Public access to Hutaff Island, which has no mainland access, is by boat only. Therefore public access to beaches in the Permit Area is somewhat restricted limiting potential compromises to public safety on the islands' beaches. Public safety is expected to be more focused toward boat use, particularly during peak summer months.

Aesthetic Resources

Figure Eight Island covers approximately 526.1 ha (1300 ac) and is approximately 8.0 km (5.0 mi) long and approximately 0.6 km (0.4 mi) wide. Figure Eight Island is a private, gated residential barrier island situated amongst the Atlantic Ocean, the AIWW, and vast expanses of salt marsh and wetlands. The island is bordered to the south by Mason Inlet and Wrightsville Beach and to the north by Rich Inlet and Hutaff Island, an undeveloped, privately-owned island. The Permit Area includes a wide diversity of estuarine and nearshore habitat types supporting diverse ecosystems typically associated with a developed and undeveloped barrier island system in southeastern North Carolina, and provides uninterrupted to slightly interrupted natural vistas to both residents and non-residents. Because of its private nature, Figure Eight Island is a suitable place for wildlife conservation.

Recreational Resources

The terrestrial and aquatic environment within the Permit Area offers a number of recreational opportunities. Bird watching, surfing, fishing, sunbathing, boating, and swimming are offered to both tourists and local residents. Due to the restricted access to both Figure Eight Island and Hutaff Island, many of these recreational opportunities are limited to residents of Figure Eight Island and boaters. However, during peak summer periods, Nixon Channel, Green Channel, Rich Inlet, along with the adjacent shoreline beaches are routinely utilized by boaters for watersports and sunbathing.

Table 4.14 depicts the recreational boat usage of four specific areas in proximity to Rich Inlet: The northern spit of Figure Eight Island, defined as the sand accreted north of development on the island and also along the back side of the island above the mean high water line, the intertidal shoals within the flood tide delta of Rich inlet that is exposed during low tide, the Hutaff Island area along the shoreline in proximity to Rich Inlet, and all open waters within Rich Inlet, Nixon Channel, and Green Channel.

Eighteen (18) historical aerial photographs were analyzed within the Rich Inlet complex (including Nixon Channel and Green Channel) for recreational boat usage dating back to November 2004. Aerial photos were obtained from the USACE Wilmington District Office, New Hanover County GIS Department, and Google Earth. Photos represent a one-time snapshot at a particular time of the day. The photos provided by the USACE were all taken between 9:30 and 11:00am and represented both high and low tides. Each photo was viewed and boats were counted. Although this is not a statistically defendable analysis, the simple observation of boat usage during different times of the year and during high and low tides is intended to provide a reasonable assessment of boater usage including high usage times. As shown in Table 4.14, the predominant usage areas were along Hutaff Island and the open waters within the vicinity of Rich Inlet with a total of 88 and 77 boats observed, respectively. A total of 44 boats, or half the number of boats observed at Hutaff Island, were located along the northern spit on Figure Eight Island. In total, seasonal usage was highest in the fall and summer time periods.

Table 4.14. Recreational boat usage in proximity to Rich Inlet as observed via select aerial photographs.

Date	Figure Eight Northern Spit	Intertidal Shoal	Hutaff Island	Open Water
Sunday, November 14, 2004	0	1	2	1
Monday, October 17, 2005	1	0	3	1
Monday, June 13, 2005	4	0	2	2
Tuesday, April 19, 2005	0	0	0	0
Thursday, April 06, 2006	0	0	0	3
Friday, June 30, 2006*	14	1	16	10
Friday, September 01, 2006	24	0	24	8
Monday, December 18, 2006	0	0	0	1
Sunday, September 30, 2007	0	0	0	7
Thursday, April 24, 2008	0	0	1	3

Wednesday, June 25, 2008	0	1	1	4
Thursday, April 16, 2009	0	0	0	0
Saturday, May 30, 2009	2	1	12	1
Saturday, October 09, 2010	2	2	13	15
Friday, October 22, 2010	0	0	5	13
Jan-10	1	4	8	8
Thursday, July 28, 2011	0	0	1	0
Total # of Boats	**48**	**10**	**88**	**77**

Seasonality Usage	Dec-Feb	March-May	June-August	Sept-Nov
# of Images Evaluated	1	5	5	6
Total # of Boats	**1**	**23**	**77**	**122**

***- Holiday (Labor Day) weekend**

Navigation

Rich Inlet serves as the access point for numerous recreational and fishing vessels year round. During the year, especially during peak tourist season, the Inlet can experience intense recreation navigation usage. Despite this frequent usage, Rich Inlet and surrounding waters are not maintained by federally authorized dredging activities. Masonboro Inlet is the closest maintained inlet which is located approximately 9.5 miles to the south. Although smaller recreational vessels can typically navigate through Rich Inlet into the ocean, larger vessels will generally access the ocean through Masonboro Inlet. Nixon Channel serves as the primary connecting waterway between the inlet and the AIWW. Outside the area that is periodically dredged, the inlet channel depth ranges from approximately 5 to 10 feet. Green Channel experiences high rates of shoaling and infilling and therefore is not utilized as frequently as Nixon Channel. The depth of Green Channel ranges from approximately 4 to 6 feet NAVD making it difficult to navigate larger vessels.

Socio-Economic Resources

New Hanover County has a diverse economic base relying on tourism, trade, pharmaceuticals/healthcare, manufacturing, and government. As the population continues to grow, the area becomes more attractive to national retailers and companies. Figure Eight Island, located in New Hanover County, is primarily a residential community with limited commercial and retail facilities. Figure Eight Island contains 463 homes with 93 undeveloped lots. In 2004, the market value of these homes ranged from nearly $1,000,000 to over $7,500,000. Between March 2003 and March 2004, 14 homes sold on the island ranging in price between $825,000 and $2,000,000 with an average listing price of $1,418,266. The average selling price of these homes was $1,244,583. Since this time, the housing market has decreased within the region; however the average selling price of homes on Figure Eight Island has increased. During 2011, 13 homes were sold on the island for an average price of $1,757,514. Commercial activity on the island consists of home construction contractors and associated sub-contractors, landscapers, home cleaning services, and general residential and commercial services.

Land Use

The Coastal Area Management Act (CAMA) requires Counties, Cities and Towns within the 20 coastal counties to periodically prepare Land Use Plans to protect and manage the health of the coastal environment and economy. The North Carolina Division of Coastal Management requires that these counties keep the Land Use plans up to date. The most recent plan for Wilmington and New Hanover County was updated in 2006. The primary focus of the plan has been protection and appropriate development of coastal areas of environmental concern on a countywide perspective.

Figure Eight Island is located on the northeast end New Hanover County, in southeastern North Carolina, approximately eight miles north of Wilmington. It is a private, gated residential barrier island with 463 homes and 93 undeveloped lots. The island is bordered to the south by Mason Inlet and Wrightsville Beach; and to the north by Rich Inlet and Hutaff Island, an undeveloped, privately-owned island.

As a small residential community, the Figure Eight Island has limited land use compatibility problems when compared with larger urban municipal areas. The amount of commercial activity in community is extremely limited. There are no large manufacturing, industrial or mining type operations in community.

Infrastructure

World War II had a tremendous impact on the migration of immigrants to the United States in the mid to late 1900's. North Carolina began to notice the effects of this migration as evidenced by the steady increase in infrastructure and development in the 1970's (NCDCM, 2006b). This increase in population and development was most noticeable along the North Carolina coastline. The New Hanover County 2006 Land Use Plan found a high rate of increase in population growth within the county between 1940 and 2000 (NCDCM, 2006b). Figure Eight Island contains 463 homes providing primary and vacation residences for its owners.

A swing bridge, installed in 1980, provides access to the island via Bridge Road. Beach Road spans the entire length of the island providing access to homes, along with several side roads, to the north and the south. Residential homes utilize individual septic tanks to manage waste water; however there is a Type V onsite wastewater system that serves the yacht club, offices, pool and restaurant facility. This system is maintained and operated by a private management entity and is inspected by the New Hanover County Health Department on an annual basis (Timpy, 2011).

Storm water management on Figure Eight Island falls under the New Hanover County stormwater ordinance and the Sediment and Erosion Control Local Program. However, the majority of the impervious on the island predates the County ordinance that went into effect in September 2000. Therefore, the permitting for stormwater management is currently managed through NCDENR only.

Solid Waste

New Hanover County has no solid waste collection system, requiring County residents and businesses, including those on Figure Eight Island, to contract directly with private vendors for waste collection. The New Hanover County Department of Environmental Management oversees an integrated solid waste disposal system. Through waste-to-energy, recycling and lined landfilling techniques, the resulting system minimizes the use of land resources for burying waste, and minimizes the potential risks for contaminating the area's groundwater. The County's present solid waste management system is a direct result of long-term planning put in motion in 1981. The resulting system accomplishes the primary goals set in 1981, which were to minimize our reliance on landfilling as a means of managing solid wastes, and to minimize the potential impacts of managing solid wastes on the area's coastal environment. With proactive planning and maintenance, the community has a solid waste system that can provide environmentally sound disposal well into the future.

Since 1990, the use of recycling has increased as a solid waste management tool. In 1990, the City of Wilmington instituted a curbside recycling program, with the Town of Wrightsville Beach, Town of Carolina Beach and the County starting drop-off collection programs. The Town of Carolina Beach began collecting recyclables at the curb in 1992, with the Town of Kure Beach beginning its drop-off program the same year. The Town of Kure Beach began curbside recycling in 1997. A cardboard recovery operation was put in place in 1997 that nearly doubled the amount of material recycled through the County's operations. In 2004, the County's landfill received 207,000 tons of waste. In the same time period over 10,000 tons of materials came to the facility to be recycled. Figure Eight Island residences utilize drop-off collection facilities to manage recyclable goods.

Drinking Water

The New Hanover County Water and Sewer District operates a public water system in the Unincorporated County. All of the County systems depend on groundwater for potable water and are withdrawn from the Pee Dee aquifer, the Castle Hayne aquifer and the surficial aquifer. The existing County well system consists of 27 small, developer built systems that have been acquired by the County over the last decade. Three of the 27 wells have been abandoned, while 24 wells are active. In 2004, the County had an average day water demand of 2.35 mgd. This average day demand does not include Porters Neck and Figure Eight Island.

Drinking water on Figure Eight Island is provided from public water supply wells administered by Figure Eight Utilities. This supply is also maintained and operated by a third party who submits sample results to the Public Water Supply Section of the Division of Water Resources (Timpy, 2011).

Select North Carolina Primary Surface Water Classifications

HQW: Rated excellent based on biological and physical/chemical characteristics.

SA: Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses.

SB: Tidal salt waters protected for all SC uses in addition to primary recreation such as swimming.

SC: All tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact.

Noise Pollution

Since Figure Eight Island is a private primarily residential area, ambient levels of human-induced noise in the area are relatively low. Natural noise levels, such as wind and pounding surf, does vary and is sporadic. During storm events, decibel levels can increase.

Water Quality

Many of the waterways within and in proximity to the Permit Area are designated as either High Quality Waters (HQW) or Outstanding Resource Waters (ORW) by the North Carolina Division of Water Quality (NCDWQ). NCDWQ defines HQW as:

> *waters which are rated excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission*

ORW waterways are described by the NCDWQ as:

> *a subset of High Quality Waters. This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance. To qualify, waters must be rated Excellent by DWQ and have one of the following outstanding resource values:*

- *Outstanding fish habitat and fisheries,*
- *Unusually high level of waterbased recreation or potential for such kind of recreation,*
- *Some special designation such as North Carolina Natural and Scenic River or National Wildlife Refuge,*
- *Important component of state or national park or forest, or*
- *Special ecological or scientific significance (rare or endangered species habitat, research or educational areas).*

Middle Sound, located north of the Hutaff Island complex, is designated as ORW along with Green Channel, Nixon Channel, Cedar Snag Creek, and Butler Creek. Portions of the AIWW (between the eastern mouth of Old Topsail Creek to the western mouth of Howe Creek) are designated as ORW as well. Futch Creek, located to the west of the Permit Area, is designated as HQW.

The North Carolina Department of Environmental and Natural Resources, Division of Marine Fisheries, Shellfish Sanitation Section is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption. Recommendations are made to the Division of Marine Fisheries to close those waters that have the potential for causing illness and opening those that are assured of having clean, healthy shellfish. All shellfish growing areas are surveyed every three years to document all existing or potential pollution sources to assess the bacteriological quality of the water and to determine the hydrographic and meteorological factors that could affect water quality. Water samples are collected at least six times a year from each growing area and tested for fecal coliform bacteria, which are an indicator that human or animal wastes are present in the water. A number of waterways in close proximity to Figure Eight Island have been closed for shellfishing due to poor water quality. These include the waters surrounding Figure Eight Harbor, Figure Eight Island Marina, Mason's Landing Yacht Club, Scott's Hill Marina, and portions of Futch Creek (NCDENR Shellfish Sanitation, 2008) (Figures 4.37 and 4.38).

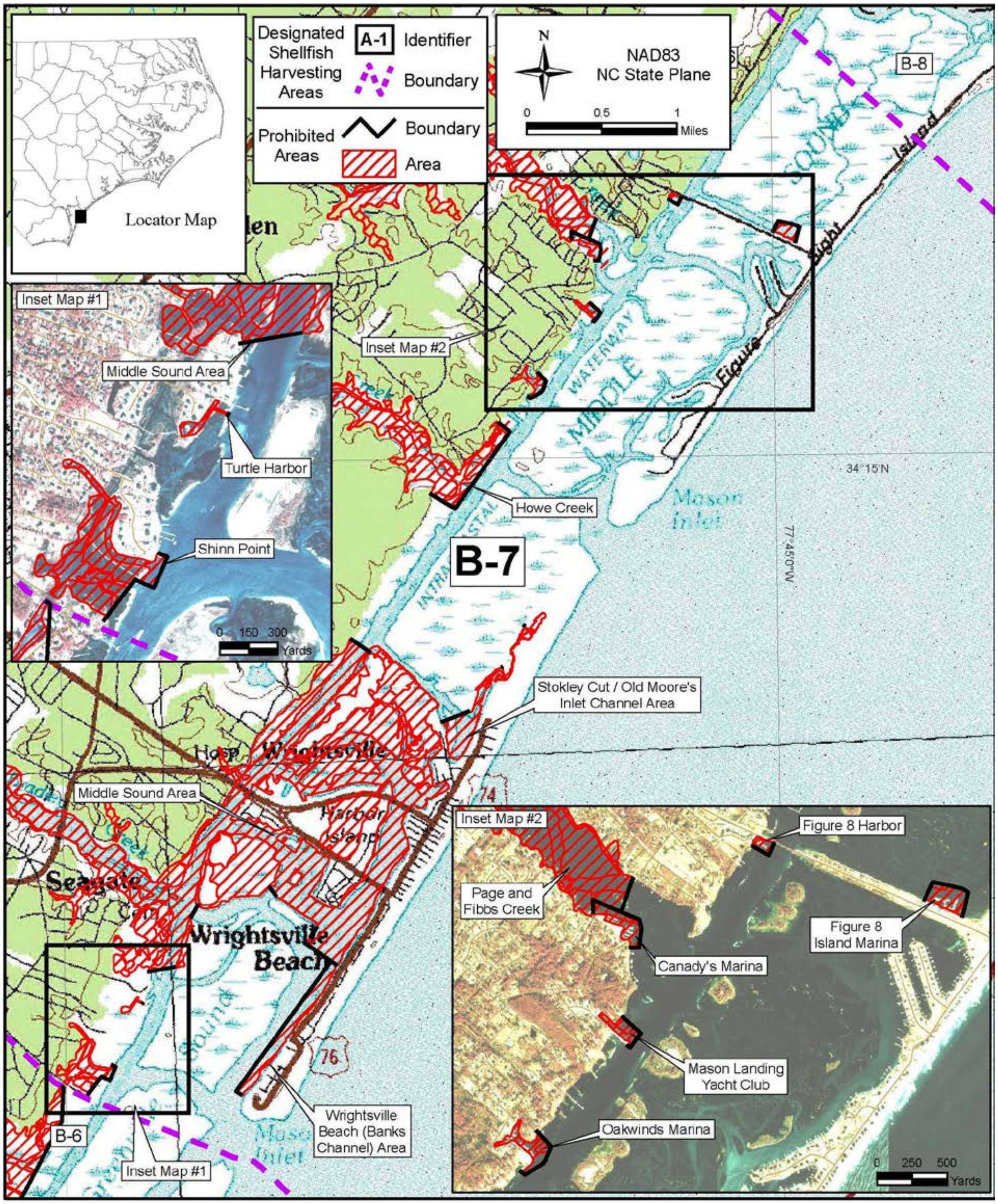


Figure 4.37. NCDENR Shellfish Sanitation Map of Shellfish Closures in Proximity the Figure Eight Island Permit Area

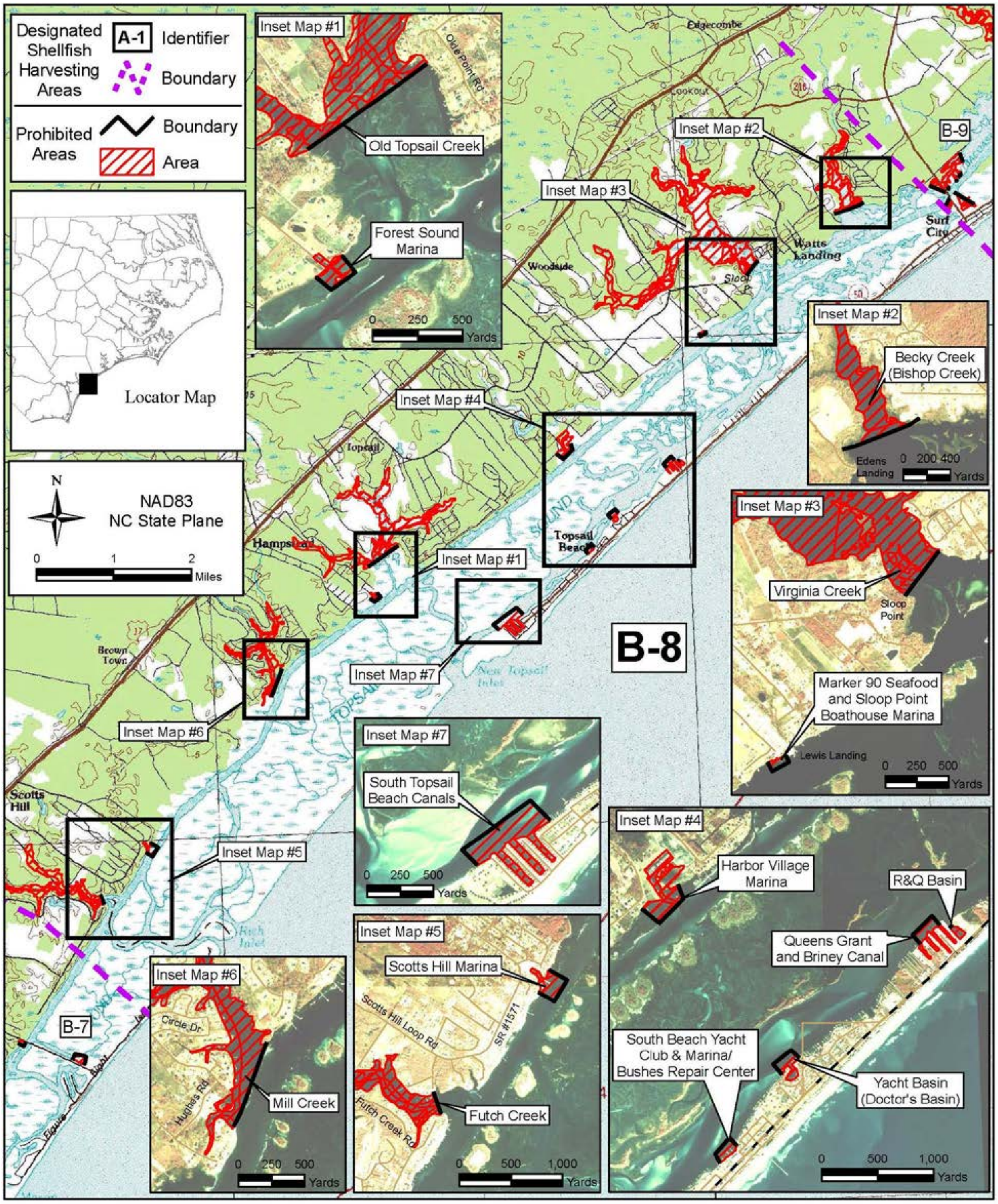


Figure 4.38. NCDENR Shellfish Sanitation Map of Shellfish Closures in Proximity the Figure Eight Island Permit Area

CPE-NC performed preliminary water quality monitoring at 13 sites within the Permit Area on March 30 and 31 of 2007 (Figure 4.39). Physical parameters collected included depth, temperature, specific conductivity, dissolved oxygen, pH, and turbidity. All dissolved oxygen observations were above the State Standard of 5.0 mg/l with an average value of 8.2 mg/l.

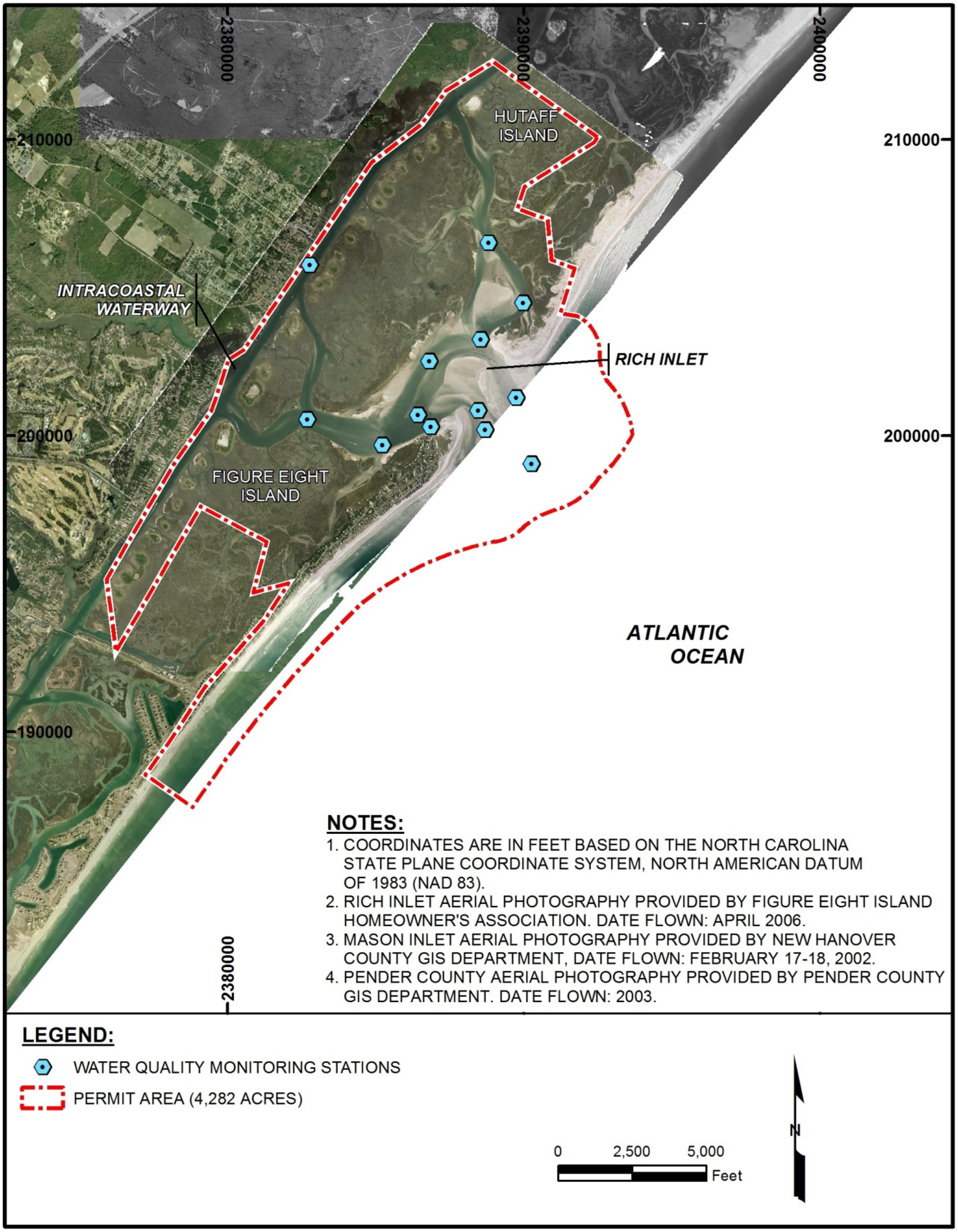


Figure 4.39. CPE-NC water quality monitoring sites

Until 2007, three RWQ sampling stations were located within the Permit Area and monitored. These stations included Station 50 (located in the AIWW between Mason's Creek and Pages Creek), 50A (located in Middle Sound at the south end of Figure Eight Island), and 50B (located in Nixon's Channel). These stations, designated as Tier 2, used for recreational purposes, were sampled on average three times per week. Tier 2-single sample maximum for *Enterococci* bacteria is 276 Colony Forming Units (CFU) per 100 ml water or a running monthly average (geometric mean) of 35 CFU per 100 ml water. In 2007, zero (0) samples from these stations contained *Enterococci* levels beyond the Federal standard. Currently, there are no active RQW sampling stations within the Permit Area.

Water quality monitoring has been conducted monthly within Futch Creek and Pages Creek by the University of North Carolina at Wilmington (UNCW) (between 1996 and 2006) and CPE-NC (in 2007 to present). Results have determined that these waterways often contain levels of *Enterococci* and fecal coliform bacteria above the State standards, particularly following a significant rain event. Subsequently, Futch Creek and Pages Creek have been listed on the 303(d) list for impaired waters. These tidal creeks flush into the AIWW in proximity to the Permit Area.

1. Turbidity and Total Suspended Solids (TSS)

Turbidity, expressed in Nephelometric Turbidity Units (NTU), quantitatively measures the light scattering properties of the water. However, the properties of the material suspended in the water column that create turbid conditions are not reflected when measuring turbidity. The two reported major sources of turbidity in coastal areas are very fine organic particulate matter, and sand sized sediments that are re-suspended around the seabed by local waves and currents (Dompe and Haynes, 1993). In Class SA waters, North Carolina State guidelines limit turbidity to values under 25 NTU above ambient levels outside turbidity mixing zones (NCDWQ, 2003).

Total Suspended Solids (TSS) are basically solids that are present anywhere in the water column. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. Currently, there are no standards associated with TSS in North Carolina. Turbidity measurements were recorded by CPE-NC during preliminary water quality monitoring from 13 sites within the Permit Area in March of 2007. The average turbidity was 0.6 NTU, well below the State standard of 25 NTU.

2. Nutrients

Nutrients in the waters within the Permit Area are influenced from the inland tidal creeks, AIWW, and the marsh environment. Non-point source pollution including stormwater runoff provides a conduit for nutrients entering these waterbodies which can influence their levels. Nutrient data in the form of nitrate/nitrite and orthophosphate has been collected within Futch Creek and Pages Creek on a monthly basis since November 2007 by CPE-NC. Although a standard has not been developed for nutrients in North Carolina, the levels observed following eight months of sampling have been within typical ranges observed at other tidal creeks in New Hanover County which is approximately 0.01-0.03 mg/l for nitrate/nitrite and orthophosphate. Therefore these waters are not considered to be eutrophic.

<u>Non-Relevant Resources</u>

<u>1. Hazardous, Toxic, and Radioactive Waste</u>
There are no known hazardous, toxic, or radioactive wastes in the Permit Area that would be affected by a proposed project.

<u>2. Energy Requirements and Energy Conservation</u>
A proposed project within the Permit Area would not be expected to utilize an unusual amount of energy beyond typical construction needs.

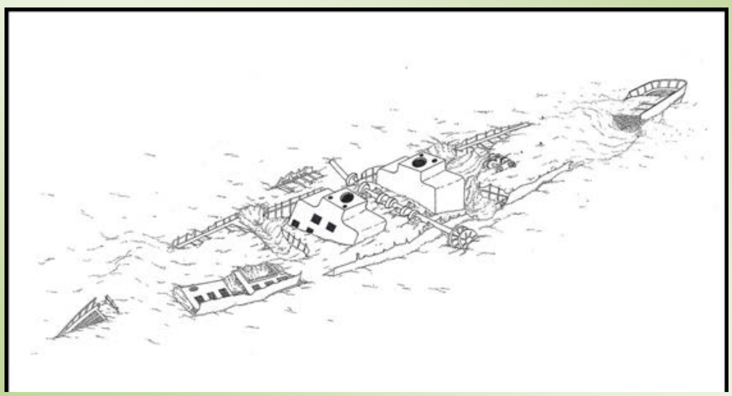
<u>3. Air Pollution</u>
It is not expected that any activities associated with the proposed project alternatives would significantly contribute to air pollution within the Permit Area.

5. How would cultural resources be affected by the project?

<u>Historical Properties and Cultural Resources</u>

<u>1. Rich Inlet Cultural Resources</u>
CPE contracted Tidewater Atlantic Research, Inc. (TAR), of Washington, North Carolina to carry out a remote sensing survey to determine the exact position of the Civil War blockade-runner *Wild Dayrell* located in proximity to Rich Inlet. The remote sensing survey conducted by TAR was successful in identifying the remains of the *Wild Dayrell* and generating an accurate geographical position for the wreck site.

Wild Dayrell



Refer to Appendix C- Submerged Cultural Resources Remote Sensing Survey for more information regarding the wreck of the *Wild Dayrell*.

An additional cultural resources survey in proximity to the proposed terminal groin will be conducted under a methodology approved by NCDCR as stated in an email dated 15 September 2009. This survey has not been conducted at this time, however, it has been suggested that a magnetometer survey of the upland and submerged area in proximity to Rich Inlet. This survey is expected to be conducted prior to the construction of this proposed project.