DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Nags Head
Emergency Beach Nourishment
Dare County North Carolina

Submitted in Conjunction with the
National Environmental Policy Act and
Federal Review of Permit Application ID # *to be assigned*

APPLICANT:

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APRIL 2006

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1.0 PURPOSE AND NEED FOR ACTION

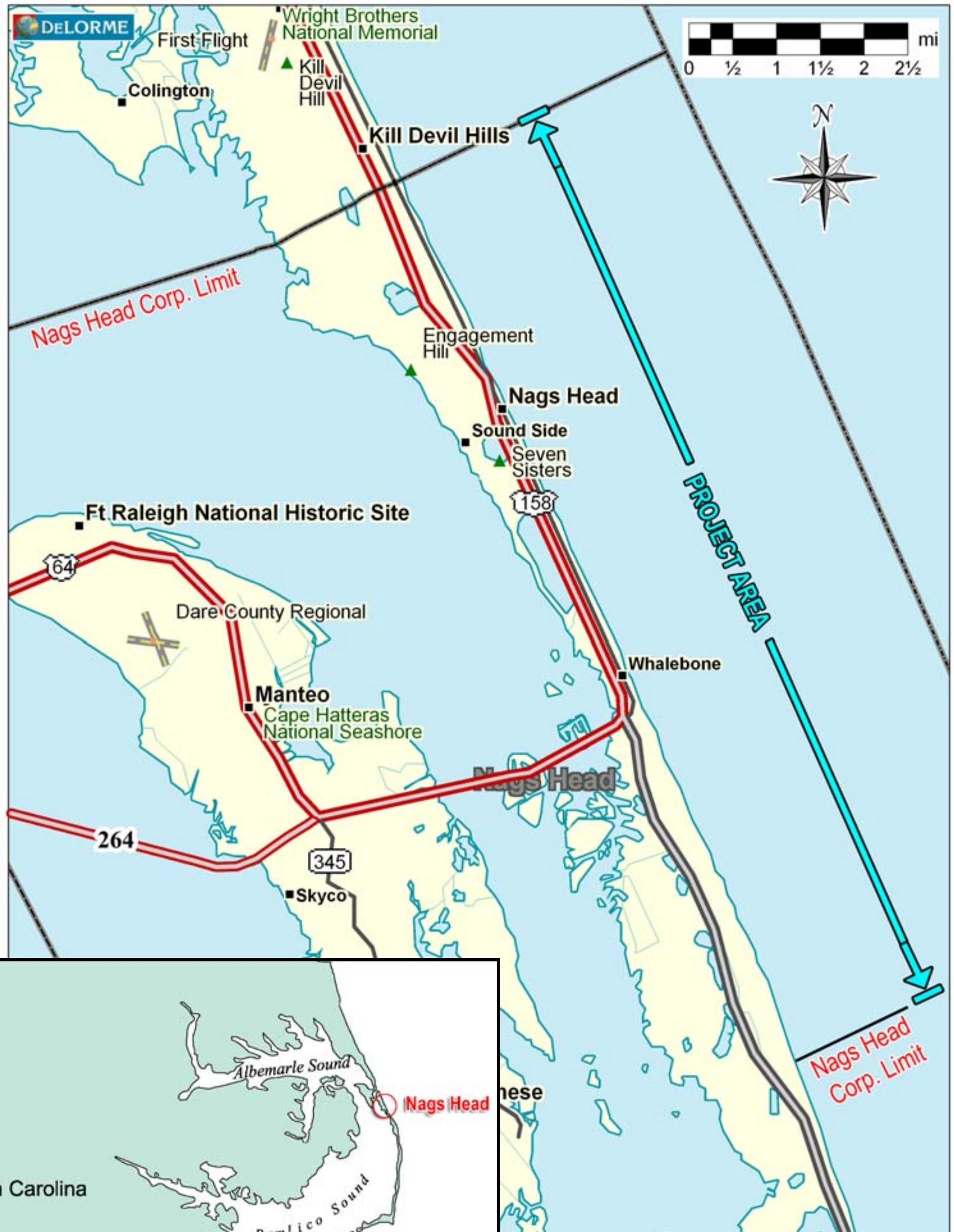
This Draft Environmental Impact Statement (EIS) is prepared in accordance with the National Environmental Policy Act of 1969 (as amended) to address environmental concerns associated with a proposed, emergency beach nourishment project along Nags Head, North Carolina (Figs 1.1, 1.2). The proposed project is being locally sponsored by the Town of Nags Head. Funding is proposed by a combination of locally generated revenue sources.

Nags Head has sustained chronic erosion over the past 50 years due to storms and sand losses to Oregon Inlet. Erosion rates upward of 10 feet per year (NCDENR 2002) have forced abandonment of property and left numerous buildings with no dune protection (Fig 1.3). Recent hurricanes, including *Isabel* on 18 September 2003, have exacerbated erosion and destroyed several oceanfront properties. Portions of the town's infrastructure (including Surfside Drive) were washed out, leaving no access to numerous properties.

FEMA authorized emergency dune restoration at 6–10 cubic yards per foot (cy/ft) after *Isabel* (ref: project worksheet PW 299 dated 28 September 2003). Between February 2004 and March 2005, nearly 365,000 cubic yards (cy) were hauled from an inland borrow source and placed along ~9 miles of dunes in Nags Head (CSE 2005–June). Despite this effort, damages continued along Surfside Drive in late 2005. Properties remain exposed and vulnerable to destruction during minor storm events (Fig 1.3, right).

During the past five years, a large portion of the Nags Head shoreline has been scraped by property owners or the town. Emergency dune reconstruction via truck-hauled sand or scraping has been implemented along ~85 percent of the shoreline in response to Hurricane *Isabel* (2003). Numerous properties have been scraped more than once. Emergency sand bags have been placed around some buildings and along oceanfront access roads such as Surfside Drive (Fig 1.4). New dunes have been sprigged with dune grasses by private owners and the town, only to be washed out in the next winter's storms. Many walkovers have been destroyed and then rebuilt in this same time.

The federal government has recognized that portions of Dare County, particularly Nags Head, are severely eroded. Under a resolution adopted 1 August 1990 by the US Congress, the Army Corps of Engineers was authorized to undertake a study of Dare County beaches. The Wilmington District performed a beach condition survey in 1994 and completed a *Final Feasibility Report and Environmental Impact Statement on Hurricane Protection and Beach Erosion Control* in September 2000 (USACE 2000). The EIS found justification for a 14.2-mile nourishment project of which 10.1 miles ("South Project Area") are contained within the town limits of Nags Head.



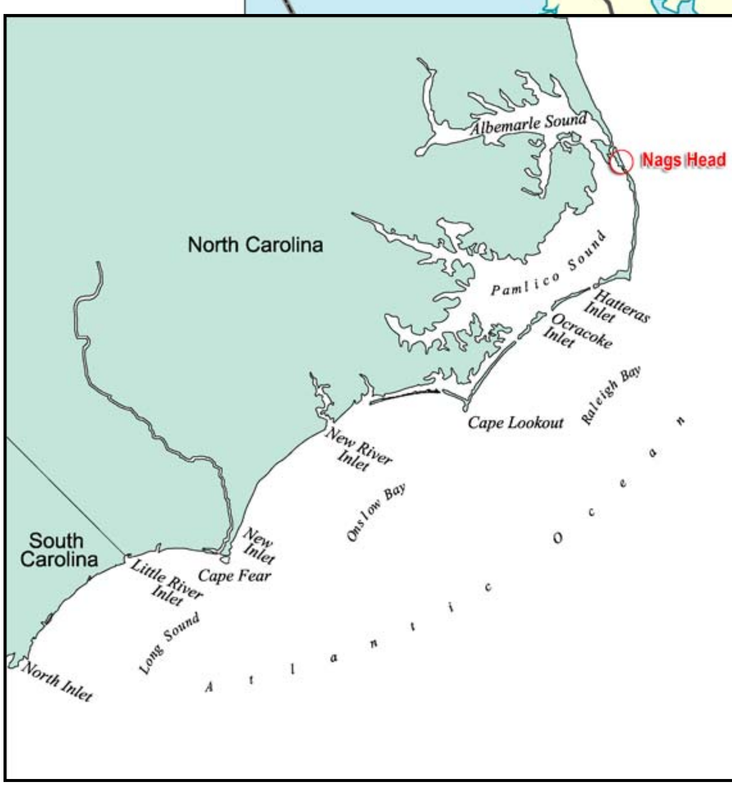


FIGURE 1.1.

Location of Nags Head, North Carolina.

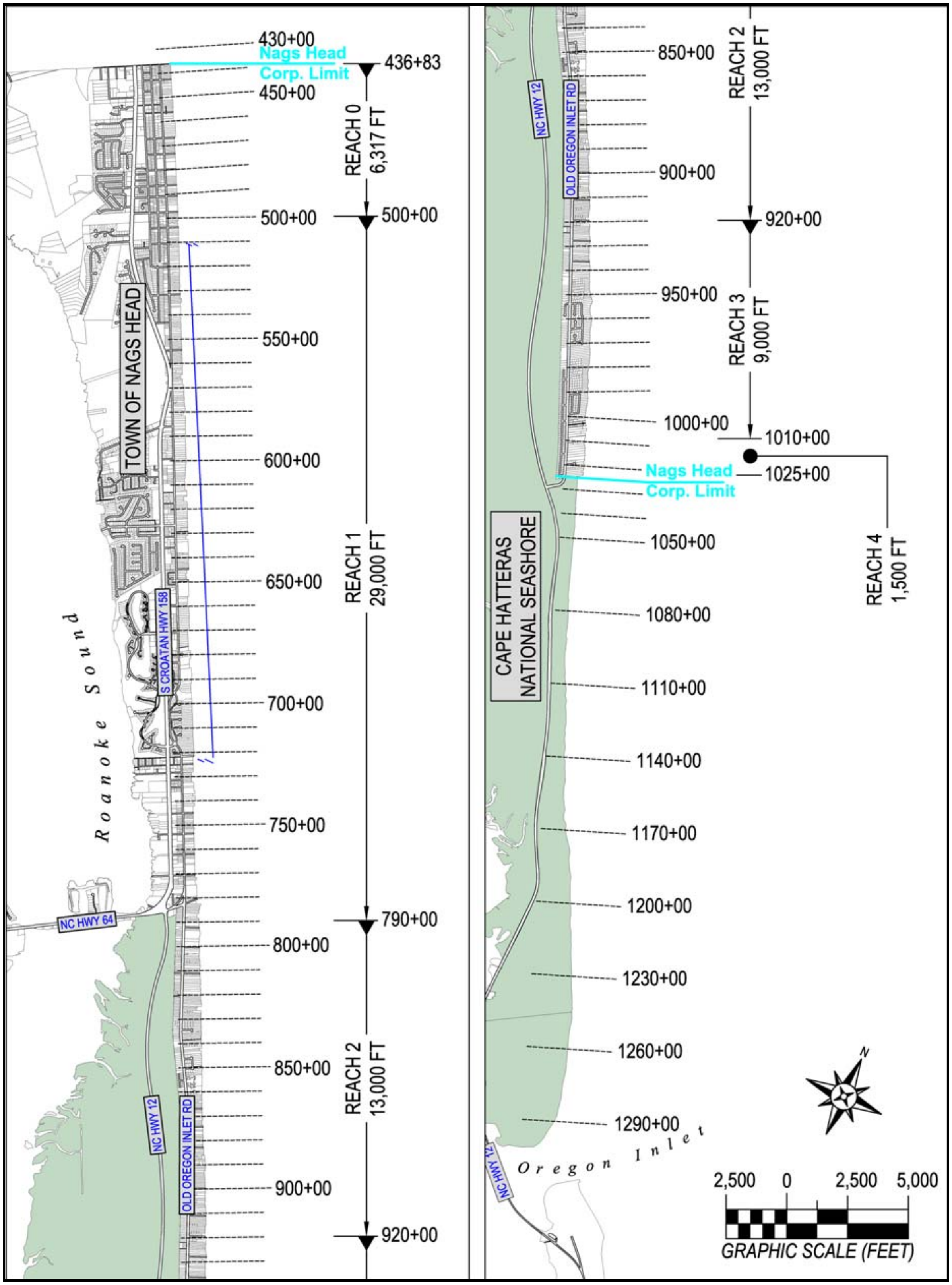


FIGURE 1.2. Site location map of project area for Nags Head emergency beach restoration showing the 10.1-mile project length with five reaches defined in the EIS. Stationing is consistent with USACE (2000).

FIGURE 1.3. Nags Head at mid tide (December 2003) showing structures situated in the surf zone with virtually no protection. Erosion at up to 10 ft/yr has damaged or destroyed properties and has directly impacted roads, septic lines, and related infrastructures. FEMA authorized (PW 299) emergency dune construction after Hurricane *Isabel* (September 2003). Despite reconstruction of dunes, many areas have already lost the small volumes of sand authorized by FEMA and remain vulnerable to damage. These areas also lack any recreational beach at high tide.
(Left) Station 955+00 – December 2003 *(Center) Station 947+40 – December 2003* *(Right) February 2005*

FIGURE 1.4. *(Left) February 2005 (Right) December 2003*
Emergency sand bags, which further degrade the beach while providing only limited protection to houses and infrastructure, have been placed around some buildings under NC CAMA permits.

The 50-year federal plan calls for initial nourishment totaling ~8,040,000 cy, and average annual renourishment of ~965,000 cy (ie, up to 2.9 million cubic yards every three years) [USACE 2000]. Construction of the Nags Head reach was supposed to be accomplished in several phases beginning in November 2003 and completed by July 2006 (according to USACE 2000, Volume I, Plate 3, referenced on page 92). The estimated First Cost for the "South Project Area" (ie, Nags Head) is ~$48,961,000 of which 65 percent would be the federal share and 35 percent the local share (USACE 2000, pg 92).

Periodic renourishment under the federal plan is estimated to cost $19,668,000 and is "expected to be required at intervals of about three years for each beach segment" (USACE 2000, pg 93). The federal and nonfederal costs of renourishment would be split 50/50. Under the federal plan, Nags Head would potentially receive upward of 11–14 million cubic yards over the initial ten-year period (ie, First Cost volume totaling ~8,040,000 cy plus 1–2 renourishments totaling 2.9–5.8 million cubic yards).

Construction of the federal project has been delayed while the USACE awaits an appropriation by Congress for construction funds. The Dare County project (north and south areas) requires an appropriation of $46,588,000 for the federal share and ~$25,086,000 for the nonfederal share to cover First Costs. In the present fiscal year (FY2006), only ~$105 million have been appropriated for federally sponsored beach nourishment projects nationwide (source: US Congress, federal budget). Thus, the federal cost of the Dare County project represents nearly 45 percent of the nationwide budget in 2006 for beach restoration projects.

The US Army Corps of Engineers informed the Town of Nags Head that the earliest possible construction start date is now fall 2008 for the initial phase of the "South Project Area" (S Haggett, Wilmington District, pers comm, 27 January 2006). Construction of Nags Head under the federal plan was to be accomplished in three phases over a three-year period (FY2004 to FY2006 – USACE 2000, Plate 3). Present plans now call for construction in three phases between FY2008 and FY2010 (source: USACE, Wilmington District, January 2006). Thus, the federal project construction will be delayed at least four years from its original start date.

The nationwide demand for beach restoration has never been greater. During 2004 and 2005, an unprecedented number of hurricanes impacted the U.S. coast. The year 2005 set the all-time record for tropical storms in one season with 27 named events. Federal expenditures associated with Hurricane *Katrina*, as well as demands for funding the war in Iraq, have limited the federal government's ability to fund the majority of beach nourishment projects. Projects scheduled for maintenance have been postponed or, in many cases, turned over to local sponsors for completion (eg, Hunting Island, SC, USACE–Charleston District, letter to SC Department of Parks Recreation & Tourism, August 2004). This trend is likely to continue into the foreseeable future. Numerous communities (eg, Myrtle Beach SC 1985-1987, Pine Knoll Shores NC 2001-2002, Emerald Isle NC 2003-2004) have chosen to fund 100 percent locally sponsored projects while waiting for federal funding. These interim or emergency projects have:

- Provided demonstrated storm protection and damage reduction benefits.
- Limited the proliferation of seawalls or sand bags in some jurisdictions.
- Enhanced recreation for the community.

Given the severely eroded condition of Nags Head, the value of properties at risk, the decline of recreation values, and the uncertainty of securing federal appropriations, the Town of Nags Head is pursuing an emergency beach restoration project. The purpose of the project is to restore the recreational beach and its associated habitats, provide protection to the foredune (much of which remains vulnerable to damage during minor storm events), and eliminate the need for frequent beach scraping, rebuilding of dune walkovers or installation of emergency sand bags.

The emergency project as outlined herein will replace sand lost during the period of delay in the startup of the federal project and help preserve property values and the tax base of Dare County. Importantly, it will provide a base upon which the federal project can be constructed, thereby increasing the renourishment interval.

As much as possible, the proposed project is consistent with the "South Project Area" of the federal project and calls for use of the same sand source and placement along the same shoreline reaches. Certain elements differ from the federal plan based on recent experience with similar projects. For example, the Dare County project (USACE 2000) anticipates construction can be accomplished by cutterhead suction dredge. This plan was prepared before there was any experience in North Carolina using offshore borrow areas. Experience at Kure Beach (2000) and Bogue Banks (2001-2004) indicates that hopper dredges will be more suitable and safer to operate offshore in the wave climate of the northern Outer Banks. Changes such as this are detailed in the present document.

1.1 ORGANIZATION OF THE DOCUMENT

This draft EIS for Nags Head follows NEPA and SEPA requirements and includes the following sections.

1.0 Purpose and Need for the Action
– Coordination with federal and state regulatory and resource agencies

2.0 Project Description and Setting
– Social and economic development

3.0 Potential Physical and Environmental Impacts
– Areas of controversy

4.0 Existing Environment

5.0 Analysis of Alternatives

6.0 Environmental Consequences

7.0 Cumulative Impacts

8.0 Mitigation

It draws on the Dare County EIS by the Wilmington District– US Army Corps of Engineers (USACE 2000) which was partially funded by the citizens of Nags Head. The Dare County project calls for nourishment by hydraulic dredge along Nags Head using an offshore borrow area. The present project proposes nourishment along Nags Head using the same offshore borrow area. The major difference between the proposed project and the federal project is scale and duration. The Town of Nags Head is proposing a one-time emergency nourishment project at approximately half the scale of the initial federal project. Environmental issues associated with the proposed emergency project are expected to be the same as those anticipated for the federal project. Where applicable, the present document provides copies of pertinent correspondence, comments, and responses associated with the Dare County project.

1.2 COORDINATION WITH FEDERAL AND STATE REGULATORY AND RESOURCE AGENCIES

The applicant has met with representatives of the following government agencies, prior to completion of this document, and has discussed the proposed plan and solicited input prior to submission of a permit application. Certain elements of the proposed plan incorporate informal recommendations of those agencies to facilitate review and approval.

US Army Corps of Engineers (USACE) – Wilmington District	Sharon Haggett
US Army Corps of Engineers (USACE) – Field Research Facility at Duck	Bill Birkemeier
US Fish & Wildlife Service (USFWS) – Raleigh	Howard Hall
National Marine Fishers Service (NMFS) – Beaufort	Ron Sechler
NC Department of Environment and Natural Resources (DENR) – Raleigh	
NC Department of Water Quality (DWQ)	Kyle Barnes
NC Wildlife Resources Commission (WRC)	Maria Tripp
NC Division of Marine Fisheries (DMF)	Sara Winslow
NC Division of Coastal Management (CAMA) – Elizabeth City	Lynn Mathis
NC Coastal Resources Commission (CRC) – Raleigh	Jeff Warren
Dare County Board of Commissions	Ray Sturgis

2.0 PROJECT DESCRIPTION AND SETTING

The proposed emergency beach nourishment project is being sponsored by the Town of Nags Head. Funding is proposed by a combination of locally generated revenue sources. No state or federal funding assistance is currently included.

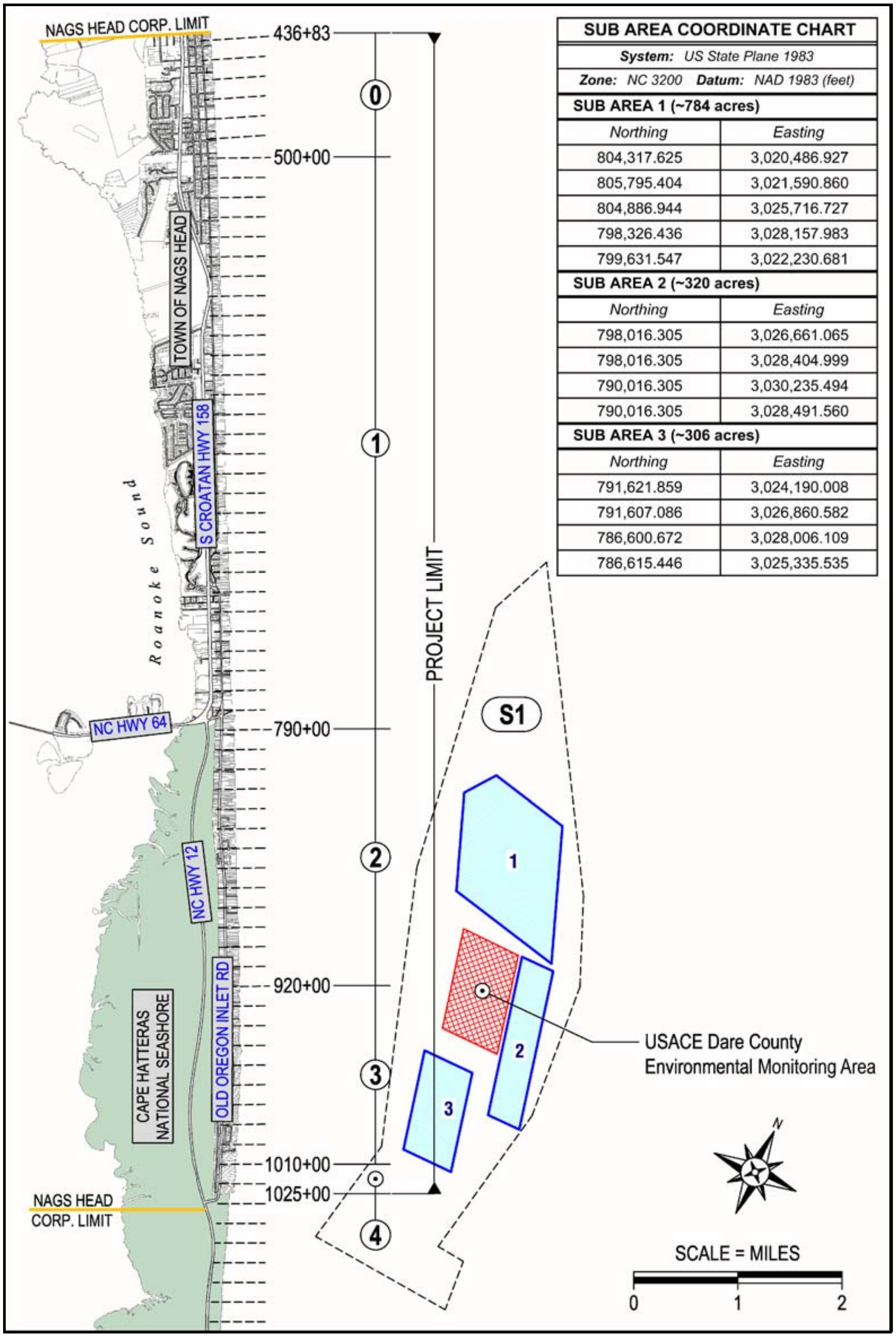
2.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed project (Fig 2.1) consists of excavating by hydraulic dredge up to 4.6 million cubic yards of beach-quality sediment from ocean borrow area(s) situated ~2–3 miles offshore of the project area. Sediment would be pumped onto the beach between the toe of the existing dune and the low water line and shaped by bulldozers into a profile that closely matches the contours and elevations of the natural beach. Approximately 50 percent of the excavations would be deposited by run-out from the discharge point between mean low water and the outer bar (~500 ft offshore). Typical fill sections would add ~60–160 cubic yards per linear foot (cy/ft) of beach and advance the shoreline 50 to 125 ft. The work would be performed continuously, covering all or portions of each of four designated reaches according to the following plan (subject to local funding availability).

- ***Reach 1*** – Stations 500+00 to 790+00 – 5.5 miles – up to 1.74 million cubic yards*
- ***Reach 2*** – Stations 790+00 to 920+00 – 2.5 miles – up to 1.3 million cubic yards*
- ***Reach 3*** – Stations 920+00 to 1010+00 – 1.7 miles – up to 1.44 million cubic yards*
- ***Reach 4*** – Stations 1010+00 to 1025+00 – 0.3 miles – up to 120,000 cy*

[*Volumes per reach may be adjusted by ±15 percent according to conditions at the time of construction. Maximum overall volume will not exceed 4.6 million cubic yards.]

The proposed borrow areas are portions of offshore area S1, the boundary of which is designated by the USACE (2000) in the federal Dare County project. Several sub areas within S1 have been sampled and tested for sediment compatibility (detailed results in later section of this EIS). Sediments have been confirmed over a 2–3 square-mile area within area S1 (~10 square miles) to a section thickness averaging ~8 ft. This yields potentially >20 million cubic yards of beach-quality sediment with overfill ratios (R_A's, CERC 1984) averaging under 1.5. Water depths in borrow areas are ~40–55 ft, well beyond the estimated depth of closure for littoral profiles in this setting. The anticipated optimal equipment for excavations will be ocean-certified, self-contained hopper dredges. Such equipment typically excavates shallow trenches (~2-3 ft of section) in each pass (leaving narrow undisturbed areas at the margin of each cut), then travels to a buoyed pipeline anchored close to shore. Discharge to the beach is via submerged pipeline across the surf zone, then by way of shore-based pipe positioned along the dry beach. Only a small portion of borrow area S1 will be required to provide up to 4.6 million cubic yards of beach quality material.



SUB AREA COORDINATE CHART	
System: US State Plane 1983	
Zone: NC 3200 *Datum:* NAD 1983 (feet)	
SUB AREA 1 (~784 acres)	
Northing	*Easting*
804,317.625	3,020,486.927
805,795.404	3,021,590.860
804,886.944	3,025,716.727
798,326.436	3,028,157.983
799,631.547	3,022,230.681
SUB AREA 2 (~320 acres)	
Northing	*Easting*
798,016.305	3,026,661.065
798,016.305	3,028,404.999
790,016.305	3,030,235.494
790,016.305	3,028,491.560
SUB AREA 3 (~306 acres)	
Northing	*Easting*
791,621.859	3,024,190.008
791,607.086	3,026,860.582
786,600.672	3,028,006.109
786,615.446	3,025,335.535

FIGURE 2.1. Proposed emergency beach nourishment project limits for Nags Head using borrow sand from offshore area S1 (designated by USACE 2000). Work would consist of excavation and placement of up to 4.6 million cubic yards by hydraulic dredge within Reach 1 through Reach 4 (~10 miles). Subareas 1, 2, and 3 contain >20 million cubic yards of beach-quality sediment to ~8 ft. Final borrow area selection will be in coordination with the USACE so as to avoid federal environmental monitoring stations. Only a portion of subareas 1, 2, or 3 would be used in the project, leaving undisturbed subareas for future projects.

The applicant is coordinating the specific area for use in the proposed project with the US Army Corps of Engineers with the following understanding:

- The final borrow area required for the emergency nourishment project can be limited to the equivalent of a 0.9-square-mile (~575 acres) area.
- The borrow area used will be contiguous rather than a series of small impact areas.
- Once used, the borrow area will no longer be available for use, consistent with the federal Dare County project.
- The borrow area will be delineated so as to avoid ongoing biological monitoring stations established by the USACE in connection with the Dare County project.

The project will be built in ~1–2 mile sections, optimizing the disposition of pipeline. Sections will be pumped into place with the aid of temporary dikes pushed up by bulldozer in the surf zone. Daily operations will directly impact ~ 500–1,000 ft of shoreline as work progresses in either direction from the submerged pipeline. Upon completion of a section, the submerged pipe and beach-building equipment will be shifted to the next section.

As construction progresses, sections will be graded to final contours, dressed to eliminate low areas, and opened for use by the community. Support equipment will be shifted out of completed sections as soon as practicable, such that construction activities in a given reach will disrupt normal beach use for only a month or so at any locality. The finished sections will be allowed to adjust to natural processes for several months. Then in applicable areas, dune fencing and/or dune plantings will be installed.

2.2 PROJECT SETTING

The Town of Nags Head encompasses ~11 miles of ocean shoreline on Bodie Island (NC) (Figs 1.1, 2.1), a barrier island at the northern end of North Carolina's Outer Banks. The proposed project totals ~10 miles of shoreline beginning ~1 mile from the town's northern limit and extending south to the town line adjacent to the Cape Hatteras National Seashore. The Town of Nags Head faces east to northeast and is bordered by the Town of Kill Devil Hills to the north and Cape Hatteras National Seashore to the south. The town is surrounded by Roanoke Sound to the west and Atlantic Ocean on the east. Oregon Inlet, the closest inlet to Nags Head, is located ~5.2 miles south of the town line. The Town of Nags Head is becoming one of the most densely developed towns along the Outer Banks due to its accessibility and the demand for coastal property. Proceeding south from Nags Head, the next nearest beach development is Rodanthe, about 15 miles away.

Dare County encompasses ~89 miles of ocean shoreline from the Town of Duck to Hatteras Inlet. The northern 30 miles (on Bodie Island) includes the towns of Duck, Southern Shores, Kitty Hawk, Kill Devil Hills and Nags Head (from north to south). There is a 5-mile undeveloped portion of Cape Hatteras National Seashore at the southern end of Bodie Island. The southern ~53 miles on Hatteras Island encompass Cape Hatteras National Seashore and the communities of Rodanthe, Salvo, Avon, Buxton, Frisco, and Hatteras. Approximately 16 miles are developed and 38 miles are undeveloped along the oceanfront. In total, 50 percent of Dare County's ocean shoreline is developed, and 50 percent is undeveloped and held in permanent trust by the Cape Hatteras National Seashore.

Portions of the Dare County barrier island shoreline have been breached in recent times, particularly near Cape Hatteras. However, there have been no breaches of Bodie Island in the past century (NCDENR 2002). Most of the island is well over 1 mile wide and contains dunes reaching elevations well over 25 ft above sea level. Jockey's Ridge in Kill Devil Hills and the dunes around Kitty Hawk (home of the Wright Brothers Memorial) exceed 80 ft in elevation.

Nags Head, Kill Devil Hills, and Kitty Hawk support a thriving commercial center and road system which support more remote areas of the Outer Banks. Nags Head is linked to the mainland via NC Highway 64, the major artery providing access from inland cities to Cape Hatteras National Seashore and the resort communities on Bodie and Hatteras Islands. An estimated 5 million visitors travel to Outer Banks beaches each year, and nearly all must use roads in Nags Head to get to their final destination.

Nags Head maintains at least 39 beach access locations with parking for the public with no residency restrictions. There are two public fishing piers remaining along Nags Head. Both have been shortened over the years due to erosion and repeated damage by storms.

2.3 SOCIAL AND ECONOMIC DEVELOPMENT

The oceanfront beaches and adjacent properties of Nags Head comprise a major social and economic resource for Dare County. Tourism is the largest industry in Dare County. The industry contributes ~$619 million annually to the economy of the county, with a travel- and tourism-generated payroll of more than $152 million and over 10,000 jobs. The majority of tourism in the county is centered on Bodie Island, the most accessible barrier island along the Outer Banks of North Carolina.

Nags Head represents less than 2 percent of Dare County's land area but accounts for 18 percent (over $3 billion of the county's $16 billion tax base) of Dare County's ad valorem property tax base (2005). About 41 percent of all locally generated revenues in the county derive from property taxes with the remainder from sales taxes, occupancy taxes, and fees. Nearly 33 percent of Dare County's tax levy funds Dare County schools. Out of 4,800 students in Dare County schools, 261 (~5 percent) reside in Nags Head (2006). Thus, property owners in Nags Head provide almost 20 percent of the funds for county schools but make up only ~5 percent of the school population. Any reduction of the effective subsidy derived from Nags Head property and economic activity would result in increased property taxes over the remainder of the county. Loss of the first row of oceanfront properties (which alone comprise nearly 7 percent of the county tax base) would result in a county-wide tax increase to make up for the reduced tax base.

While only 50 percent of Dare County's oceanfront is developed, nearly 100 percent of the Nags Head oceanfront is developed. Bodie Island includes a mix of residential, commercial, and governmental development that supports a year-round population of ~3,000 and a seasonal population of ~230,000. Much of the social fabric of Dare County and eastern North Carolina revolves around the tradition of renting houses and condominiums for a week or so every year and hosting family gatherings at the beach. This social tradition extends well beyond the county and draws visitors from many states and foreign countries. Generations of families living inland have been drawn to Nags Head for rest and relaxation. Tourism has grown exponentially along coastal North Carolina during the past century because of the coast's attraction, particularly along coastal counties such as Dare which have and maintain the infrastructure, housing, and beaches to support the demand for access to the shore.

The beaches of Dare County are a valuable ecological resource. Of nearly 89 miles of barrier island shoreline located in Dare County, only half the length is developed. The remainder, made up of south Bodie Island and the majority of Hatteras Island to Hatteras Inlet, will remain undeveloped in perpetuity as part of Cape Hatteras National Seashore. Nags Head and the communities on Bodie Island serve to draw human activity away from the less accessible beaches and ecosystems of Hatteras Island. Neighboring barrier islands to the west (such as Ocracoke) include another 25 miles of difficult to access wilderness preserves, giving the northern Outer Banks region a high ratio of undeveloped to developed barrier islands in North Carolina. The health of the beach environment is essential to a positive experience for the beach visitor. The damage associated with severe storms results in the loss of high oceanfront dunes, scrub and maritime forests.

The sportfishing industry in Dare County is the largest in the State of North Carolina. The health of those activities (including fishing, boat building, and outfitting and supply) is dependent on the health of the marine environment.

Project Planning Objectives – In undertaking the emergency beach nourishment project, Nags Head has several objectives that the project must meet. Those objectives are summarized as follows:

- Preservation of the environmental, cultural and aquatic resources of the town and the county.
- Provide an easily accessible recreational beach available to all citizens of the county.
- Provide protection of oceanfront property as a resource of tax revenues to the municipalities of the town and the county.
- Maintain the economic viability of tourism, the county's largest industry.

2.4 SUMMARY OF PROJECT NEED

Nags Head is the most easily accessible beach in Dare County, representing ~13 percent of the county shoreline and <2 percent of the county land area. Residential and business properties in Nags Head account for ~7 percent of the county tax base but receive a much lower percentage of county services and investments. Chronic erosion, occurring at moderate to high rates compared to many shorelines, has accelerated recently as a result of seven landfall hurricanes in quick succession since 1995. Loss of beach area and a general sand deficit have left nearly all of the oceanfront vulnerable to damage during even minor storms. The most recent hurricane (*Isabel* 2003) caused damage in the county between $20 and $25 million. Nags Head experienced significant damages where the beach is narrowest. Little or no property damage occurred along sections of Dare County (such as the northern end of Hatteras Island adjacent to Oregon Inlet) which had a much wider beach as a result of nourishment.

Erosion poses an immediate threat to property, infrastructure, and the county tax base. Loss of oceanfront properties to erosion would result in tax increases for Nags Head residents.

Tourism, the county's primary industry, will decline if the beach continues to erode. Presently, there is less recreational beach area for the public than ten years ago. Property owners have increased the frequency of beach scraping to rebuild foredunes and protect imminently threatened homes. Associated with erosion and dune scraping has been a decline in beach habitats for nesting sea turtles and other organisms.

A citizens' Beach Nourishment Committee (meeting frequently since 2005) determined that the only viable alternative is to rebuild the beach via nourishment. Nourishment over a range of periods results in lower costs compared to the “no-action” alternative or “property abandonment and retreat” alternative.

The proposed emergency nourishment project is estimated to require up to 4.6 million cubic yards to provide a minimal protective beach and restore sand losses during the period of delay while the county waits for a federally sponsored nourishment project by the US Army Corps of Engineers (USACE 2000). This level of effort would add 60–160 cubic yards per foot (cy/ft) along ~10 miles of beach encompassing 90 percent of Nags Head and would widen the recreational beach 50–125 ft. The project would restore eroded areas to a condition that would be able to sustain chronic erosion and the short-term impact of storms for at least 4–5 years (the period of delay caused by lack of funding for the federal project).

Viable beach-quality sand with composite overfill ratios around 1.1–1.50 exists in strategic offshore areas close to the shoreline. Preliminary estimates indicate that these deposits can be excavated and placed on the beach via hydraulic dredge at a cost of approximately $25–30 million. Other potential borrow sources (including shoals in Oregon Inlet) are considered less cost effective because of their distance to the project area and their finer quality material. Inlet sand surveys and sediment compatibility analyses indicate that it would take 5–10 times more material from the inlet to yield the same nourishment performance as offshore sand from borrow area S1 (USACE 2000, CSE 2005–August).

The proposed project (in total) will require ~7–10 months to construct if only one dredge is available. The applicants desire to complete the project at the earliest time and in the shortest time practicable. The earliest period of construction is now estimated to be March through November 2007. Construction activities will directly impact a particular property for only a few days as nourishment proceeds section by section at an average rate of about 300 feet per day. The project will be monitored carefully after construction to quantify its longevity and document environmental change. As the first large nourishment along the northern Outer Banks, it will necessarily serve as a prototype for future beach maintenance efforts.

3.0 PROJECT CONCERNS

3.1 AREAS OF CONTROVERSY

Beach nourishment typically involves three primary areas of controversy: (1) funding, (2) physical impacts, and (3) environmental impacts.

3.1.1 Funding

The proposed project will be funded locally. The Town of Nags Head is currently investigating alternative funding mechanisms for the project. No federal funds will be expended for the emergency project.

3.1.2 Physical Impacts

Nourishment should be considered as a shoreline protection measure which would serve as a first line of defense against hurricanes and northeasters that occur along the coast. The success of nourishment depends on the frequency and intensity of storms and on the background erosion rate and long-term processes controlling shoreline change at the particular site. The nourished beach is expected to act just as a natural beach would and adjust to daily and seasonal variations in waves, tides, and shallow-water processes.

Most of the controversy and debate regarding the success of nourishment relates to:

- Insufficient post project documentation of physical change.
- Wide disparities in background erosion rates and nourishment sediment quality.
- Use of different criteria for evaluating success.
- The quality of the sediments used for fill and the compatibility of the fill material with the native beach sediments.

These controversies are common among most nourishment projects that occur along the east coast of the United States and are expected to continue with this project.

Presently, the Town of Nags Head has no experience with nourishment and has limited quantitative data on which to define the background erosion rate or project erosion rates after nourishment. Current erosion rates, proposed project fill overview and project geographic location are explained below:

- Several independent erosion estimates suggest that 10-year volumetric losses have averaged ~5 cy/ft/yr, a rate that is moderate (USACE 2000, CSE 2005–August). This is much higher than long-term erosion rates at Myrtle Beach, SC (1.6 cy/ft/yr, Kana et al 1997) but only a fraction of Hunting Island, SC (~25 cy/ft/yr, Kana and Mohan 1998).

- The Town of Nags Head beach faces eastward toward the open ocean. This geographic position exposes the town's beach to damaging winds and waves from northeasters during the winter months and hurricanes during the summer and early fall months.

- Net erosion rates are lower than average along the northern end and much higher than average along the southern end of Nags Head. This variation may be related to the presence of Oregon Inlet and its tendency to draw sand off the beach and into the inlet.

- The proposed project length of 9.94 contiguous miles would make it the longest nourishment project ever attempted in the northern Outer Banks. Numerous studies have proven that nourishment longevity is proportional to the **square** of the length of the project (NAS 1995).

- The proposed borrow area (S1) contains sediments that are comparable in quality to the native beach and much coarser than the Oregon Inlet shoal sediments that were proposed as an alternate borrow source. Coarse sediment tends to hold a wider dry beach and require less material for the underwater portion of the profile (Dean 1991, NAS 1995).

- The proposed quantity of nourishment (up to ~4.6 million cubic yards over the project length) varies from reach to reach because of varying erosion rates. The volume is equivalent to ~4–5 years worth of nourishment under the Dare County project plan (USACE, 2000). This quantity would replace losses sustained along Nags Head during the period of delay in executing the federal project.

- The proposed project will be surveyed yearly from the dune line to beyond the outer bar and compared against the prenourishment conditions using volumetric calculations. Performance will also be evaluated based on persistence of a dry beach. Success will be defined in relation to how closely the postnourishment volume erosion rate compares with the estimated prenourishment volume erosion rate.

Not all physical impacts are predictable prior to construction. It is widely recognized that isolated erosion "hot spots" sometimes develop after nourishment as "packages" of sediment accumulate in one area, leaving nearby deficits. Sometimes, nearshore bars evolve, form runnels and outlets, and create related nearshore cell circulation which may locally cause scour of the berm. Such features occur on unnourished as well as nourished beaches. Regardless of the cause of physical changes, the proposed project area is expected to undergo the same transformations as a natural beach, but to do so with the ocean displaced about 85 ft seaward. By artificially increasing the average separation distance between development and the ocean, private property damage will be reduced for any return-period storm, and the tax base of the county will be preserved for another several years or longer, until such time as the federal project can be constructed. The emergency project will provide useful information on performance for final design of the federal project. It will also reduce the overall volume of sand that must be placed under the 50-year Dare County project, thus saving federal tax payers money over the life of the project.

3.1.3 Environmental Impacts

The primary environmental impacts associated with this project relate to mortality of in-situ organisms, changes in habitat, mobilization of fine grained sediments, and turbidity associated with dredging and beach disposal.

3.1.3.1 *Mortality of In-situ Organisms*

The project requires excavation of sediments from predetermined borrow site(s) in the upper ~2–10 ft of the ocean floor and placement of the nourishment sediments along the beach. Most of the sessile organisms (predominately polychaete worms) excavated will die. As fill is placed on the beach, some in-situ organisms (eg, amphipods, Donax clams and emerita mole crabs) will be smothered.

The USACE's New York District (USACE 2001) conducted biological monitoring for the "Asbury Park to Manasquan Section Beach Erosion Control Project" and concluded that abundance, biomass, and taxa richness recovered quickly (<1 year) after dredging operations with no detectable difference between disturbed and undisturbed areas by the following spring. During the same project (1994-2000), the Corps reported no deleterious impacts to intertidal assemblages of organisms. The multi-year monitoring showed no indication of a difference in abundance between nourished beaches and the reference areas. The study documented short-term declines in abundance, biomass, and taxa richness, but recovery of intertidal assemblages was complete within 2–6.5 months (USACE 2001). Similar results are expected with the Nags Head project given the comparable conditions with the New Jersey project. Natural recovery is expected to be aided in this project by the following:

- Excavations will be via hopper dredge which makes shallow, narrow cuts and leaves undisturbed substrate between the furrows from which rapid recruitment takes place.

- Use of native beach quality sand from borrow site(s).

- The proposed borrow sand typically contains <1 percent mud (ie, silt and clay), which decreases turbidity plume durations and extent.

3.1.3.2 *Change in Habitat*

Offshore Borrow Area – The narrow, shallow cuts made by the hopper dredge will expose older sediments on the ocean floor. These sediments will be less reworked by organisms but contain similar sediment textures and nutrients as the removed sediments. As such, they will leave an unoccupied niche habitat that is expected to become recolonized at time frames comparable to the life cycles of various species. Some North and South Carolina studies have demonstrated that recolonization of borrow areas may occur in a few months or less (eg, Jutte et al 1999a), while other studies show recolonization occurring over 1-2 year periods (eg, CSA 2005). The proposed borrow area and construction method will be similar to sites where recovery occurred rapidly (<1 year).

Beach – The beach fill will displace the shoreline and inshore topography about 85 ft seaward. This will create approximately 100 acres of beach habitat not currently existing, significantly reduce the need for dune scraping, and provide areas for natural reestablishment of dunes and beach vegetation. Frequent beach scraping is believed to cause mortalities and population reductions in surf-zone species. Existing littoral habitats will be displaced seaward but will be maintained in similar profile as the native beach. Nutrients introduced with the nourishment sediments will provide a food source to attract benthic organisms to the new foreshore. As previously mentioned in Section 3.1.3.1, recovery of intertidal assemblages often occurs in 2–6.5 months (Van Dolah et al 1992, Jutte et al 1999b, USACE 2001), whether the project area is north or south of Nags Head.

3.1.3.3 *Sediment Suspension/Dispersion*

Suspension of sediments during dredging operations is unavoidable. Turbidity plumes created by dredging and beach disposal are dependent on the following factors; sediment composition, type of dredge equipment, and existing sediment transport processes. Dispersion of the plume occurs as it drifts with the nearshore and longshore currents.

Borrow Area – This project will employ hopper dredges for excavation and disposal of beach fill material. A hopper dredge consists of one, two, or more drag arms and attached drag heads mounted on a ship-type hull or barge with hoppers to hold the material dredged from the bottom (Herbich and Brahme 1991). As the drag head is lowered to the bottom, it is towed along with the vessel. Jets of water ahead of the drag head mobilize sediments so they can be sucked up by hydraulic pumps and discharged into the hopper. As the drag heads travel along the sea floor, sediments become suspended and disperse after the drag head passes.

A second source of suspended sediment occurs when the hopper overflows and the finer fractions of the dredged material sediments are reintroduced to the water column. Turbidity plumes associated with hopper dredging are generally confined to the immediate borrow area but they may extend for great distances if the material contains high fractions of clay-sized particles. Silts and clays produce greater and longer-lasting turbidity plumes, which will impact larger areas of the sea floor compared to coarser, sand-sized material (USACE 2002). In these cases, deposition of fine-grained suspended sediments and turbidity plumes in offshore environments is not limited to the immediate dredged area. The slow settling of clay sediments will impact marine environments including benthic and finfish communities (discussed in Section 6.0). Where borrow sediments are predominantly coarse sand with only 1–2 percent silts and clays, turbidity plumes will be highly localized and short-lived (Hanes 1994).

Beach – Elevated levels of turbidity are expected in the surf zone at the effluent discharge point on the beach. Schubel et al (1978) discovered that 97–99 percent of discharged slurry settled to the bottom within a few tens of meters from the discharge point. Other studies have found that the distribution of turbidity was confined to the environs of the discharge point (Nichols et al 1978, USACE 2001). Turbidity created will interfere with feeding habits of different organisms that feed by sight and will generate feeding problems with filter feeders. However, turbidity during similar construction at other sites has been shown to be short-lived (hours to days) and below the natural variations in turbidity observed between storms and calm days (Naqvi and Pullen 1982; Van Dolah et al 1992, 1994; USACE 2001).

3.1.3.4 *Pollution Due to Accidental Spills*

Federal and state regulations place a high burden on contractors to prevent accidental spillage of fuel, grease, and related substances used in the operation of hydraulic or mechanical equipment. Zero releases are unattainable, but detectable discharges are rare. The contractor will be required to meet or exceed all applicable regulations related to spills of contaminants.

3.2 UNRESOLVED ISSUES

An unresolved issue as of this writing is what portion of borrow area S1 will be made available to the Town of Nags Head.

3.3 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

This submittal is of an Environmental Impact Statement (EIS), but at a later date an application will be made for state and federal permits. It is anticipated that the permit application will be made prior to completion of EIS review. (Federal permit application review will run concurrently with EIS review by the state.)

3.3.1 Federal

The Town of Nags Head (with assistance by CSE) submits an application for an individual permit along with copies of the EIS to the USACE for review by federal agencies. The Corps then coordinates review of the individual permit application by federal agencies. Federal review includes Corps review for compliance with Section 10 of the Rivers and Harbors Act of 1899 for work within navigable waters. The Corps also reviews for compliance with Section 404 of the Clean Water Act, covering discharge of dredged materials into navigable waters.

The Corps distributes copies of the EIS and permit applications to other federal agencies, including the Environmental Protection Agency, National Marine Fisheries Service, and US Fish and Wildlife Service. These agencies review and comment on the EIS, and these comments must be received and considered by the Corps prior to the coordinated federal response to the EIS. Likewise the responses of these agencies must be received and considered prior to issuance of a federal permit. The Corps must meet the requirements of NEPA.

3.3.2 State

North Carolina Division of Coastal Management (NCDCM) coordinates the review process of state agencies. State approvals required include certification of compliance with the Coastal Area Management Act, Dredge and Fill Law, Water Quality Certification (Section 401), and Easement in Public Trust Areas.

For both the EIS review and the permit-application review, NCDCM distributes copies to state agencies that include the Wildlife Resources Commission, the Department of Administration, the Department of Transportation, and Divisions of Water Quality, Land Quality, Marine Fisheries, Environmental Health, Archives and History, and Community Assistance. NCDCM receives and reviews comments from these agencies prior to approval of Finding of No Significant Impact (FONSI) or a requirement for changes in this plan.

This project requires compliance with SEPA. This EIS is the document being submitted to demonstrate such compliance. Based on the review, NCDCM either issues the FONSI or requires amendments to this plan.

3.3.3 Local

The plan outlined in this EIS is in compliance with the local Land Use Plan for the Town of Nags Head.

4.0 EXISTING ENVIRONMENT

4.1 LAND USE

4.1.1 Character of Nags Head

The Town of Nags Head is located along the Outer Banks on Bodie Island, situated between Kill Devil Hills to the north and the Cape Hatteras National Seashore to the south. The town faces east to slight northeast toward the Atlantic Ocean and is backed by the Roanoke Sound to the west. Nags Head's Historic Cottage Row District, listed on the National Register of Historic Places since 1977, stretches a mile along the town's shoreline. Defined by weathered wooden shingles, sweeping gable roofs, single full-width dormers, and protruding benches built into the arms of porches, this simple architecture is the patina of Old Nags Head (Roundtree 2001).

The town is ~11 miles long, from north to south, and is becoming one of the highest developed towns along the Outer Banks. Less development occurs in the southern section of town, mainly due to the shortage of land which fronts a section of Cape Hatteras National Seashore south of Whalebone Junction (ie, where Hwy 64 meets Hwy 12).

4.1.2 Typical Development

The Town of Nags Head is relatively densely developed with a mix of commercial businesses, hotels, single-family houses, and condominiums. Along some sections of the oceanfront, small motels dating from the 1950s and 1960s have been torn down and replaced by several, large single-family houses, some of which have 6–8 bedrooms. The majority of single-family houses are available for rent during the tourist season.

Setbacks for oceanfront construction are established by regulations of the NC Division of Coastal Management (NCDCM). Residential construction setbacks for structures less than 5,000 square feet are 30 times the long-term erosion rate as established by maps prepared by NCDCM. Maps currently in use were updated in 1998. The setback for large commercial or permanent structures in excess of 5000 square feet is 60 times the long-term erosion rate. The minimum setback is 60 ft in areas with long-term erosion rates less than 2 ft. The line for measurement of setbacks is the first line of stable vegetation. In locations where vegetation is sparse, the line is interpolated from adjacent areas where vegetation exists. The measurement line is typically established in the field by NCDCM personnel as part of the CAMA permitting process.

4.2 WETLANDS

There are no areas of 404 wetlands or coastal wetlands identified in the project area.

4.3 AGRICULTURAL LANDS

No agricultural land is in or adjacent to the project area. Low water-retention capacity of the sandy barrier island soils preclude establishment of agricultural crops.

4.4 LITTORAL PROCESSES

Nags Head is subject to littoral processes typical of the northern North Carolina coast. The Outer Banks in this area is exposed to ocean swell waves originating from the southeast and storm waves associated with northeasters. Highest waves are generally associated with tropical storms and may occur in phase with hurricane surges. Spring tide range is ~3.7 ft (NOAA-NOS 1994), and tides are semi-diurnal. Previous studies and geomorphic evidence suggest that net longshore transport (ie, sand movement in the littoral zone) is predominantly southerly (Inman and Dolan 1989). This section of the EIS details littoral processes affecting the project area and addresses certain questions regarding the potential impact of the project on these processes.

Use of an offshore borrow area can influence waves, thereby modifying local sand transport rates. Depending on the geometry of the borrow area, the excavation may effectively reduce wave heights in part of the affected area as well as cause wave heights to increase in others. To quantify the changes in waves due to the borrow area and potential impact on sediment transport, wave refraction over the potential borrow site is analyzed to compare predredged conditions to postdredged conditions. Sediment transport is examined to determine how local increases in wave energy density due to the presence of the borrow area might affect the large-scale transport potential.

The placement of nourishment sand on the beach may potentially impact sediment transport along other strategic locations, including nearby inlets. Oregon Inlet (to the south of Nags Head) may see an increase in sand into its system because of the addition of sand on the project beach.

Closure depth (the approximate limit of measurable bottom change over particular time scales) is examined at Nags Head because it is an important consideration in locating the borrow site. It is beneficial for borrow sites to be located offshore of the depth of closure location, so they will be independent of the littoral system. Borrow site locations shoreward of the closure depth position may simply shift sediment within the littoral zone and have very little impact on the net sand volume change.

4.4.1 Waves

The USACE Field Research Facility (FRF), located in Duck (NC), has been monitoring littoral processes for over 30 years. Because of its proximity to Nags Head, the wave data collected at FRF is used to approximate wave conditions at Nags Head. A previous study by Vandever and Miller (2003) suggests that the wave climate summaries collected at FRF are representative of the wave climate as far away as Oregon Inlet, nearly 25 miles to the south (Fig 4.4-1).

Wave data collected at the Waverider Buoy 630 are used to summarize the wave climate at Nags Head. Buoy 630 is located ~2.4 miles offshore of the FRF site in ~55 ft of water. From recorded wave data, it computes mean wave direction, significant wave height, and wave period. A three-year record (from 01 January 2003 to 01 January 2005) was used to determine the recent wave climate at Nags Head. There are numerous previous studies on record that summarize wave climate prior to 2003. Leffler et al (1996) reported that the Outer Banks wave climate is among the highest on the US East Coast. Over 20 storms per year produce significant wave heights in excess of 2 meters (m).

Dolan et al (1988), based on storm reports from 1942 to 1988, reported winds of sufficient velocity to generate deep-water wave heights in excess of 1.6 m, on average, every ten days. For the same period, winds that can generate wave heights in excess of 3.4 m occur, on average, every 90 days and in excess of 7.0 m every 25 years. The current data (2003-2005) agree fairly well with the findings of Dolan et al and of Leffler et al.

During the three-year record, there was an annual average of 59 events (1 every 6 days) that had significant wave heights in excess of 1.6 m. Wave heights were in excess of 1.6 m for a total duration of 158 days (annual average of 52.6 days). There was an annual average of 5.3 storm events that produced wave heights in excess of 3.4 m (1 event every 68 days). Wave heights remained in excess of 3.4 m for a total duration of 5.6 days (annual average of 44 hours). One storm event in the three-year record produced wave heights in excess of 7 m. Hurricane *Isabel* made landfall several miles south of Cape Hatteras on 18 September 2003 and produced significant wave heights in excess of 8 m at the FRF. Wave heights were in excess of 7 m for ~8 hours during this storm.

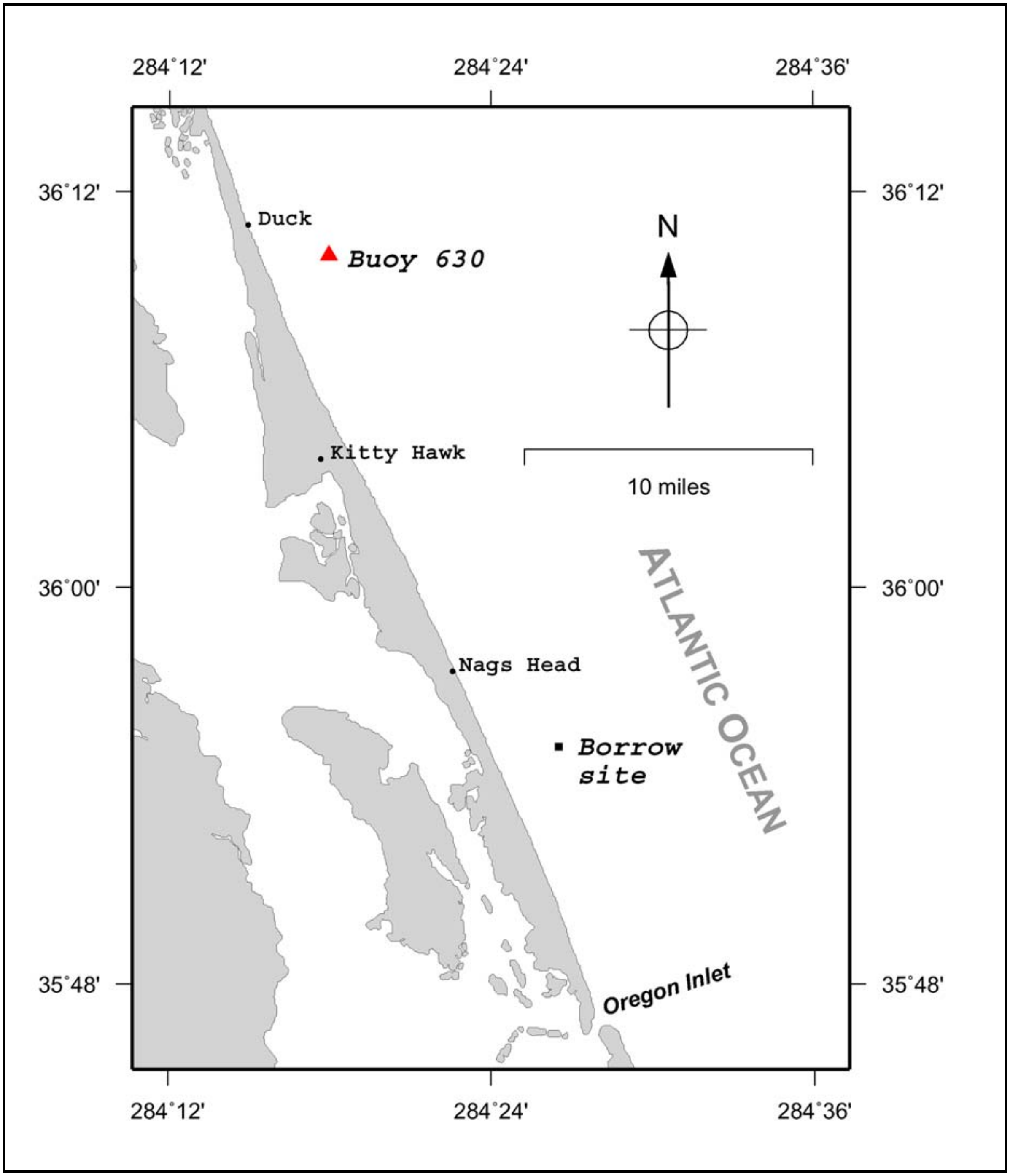


FIGURE 4.4-1. Location of Nags Head(NC) and surrounding area. Note location of proposed borrow area and Waverider Buoy 630.

The waves measured at Buoy 630 from January 2003 to December 2005 were predominantly from the east (Fig 4.4-2). Significant wave heights, associated wave periods, and wave direction at Buoy 630 are summarized in Table 4.4-1 along with their probability of occurrences based on the three-year record. Waves are summarized in 10° increments beginning 10° from north and ending at 150° from south. These wave directions account for 98.6 percent of the waves in the record. Half of the waves in the three-year record are from between 80° and 120° (measured from north). The highest-energy waves originate from the northeast. Waves originating from the northeast (between 10° and 70° from north) have an average significant wave height of 1.30 m, while the remaining waves have an average significant wave height of 0.90 m.

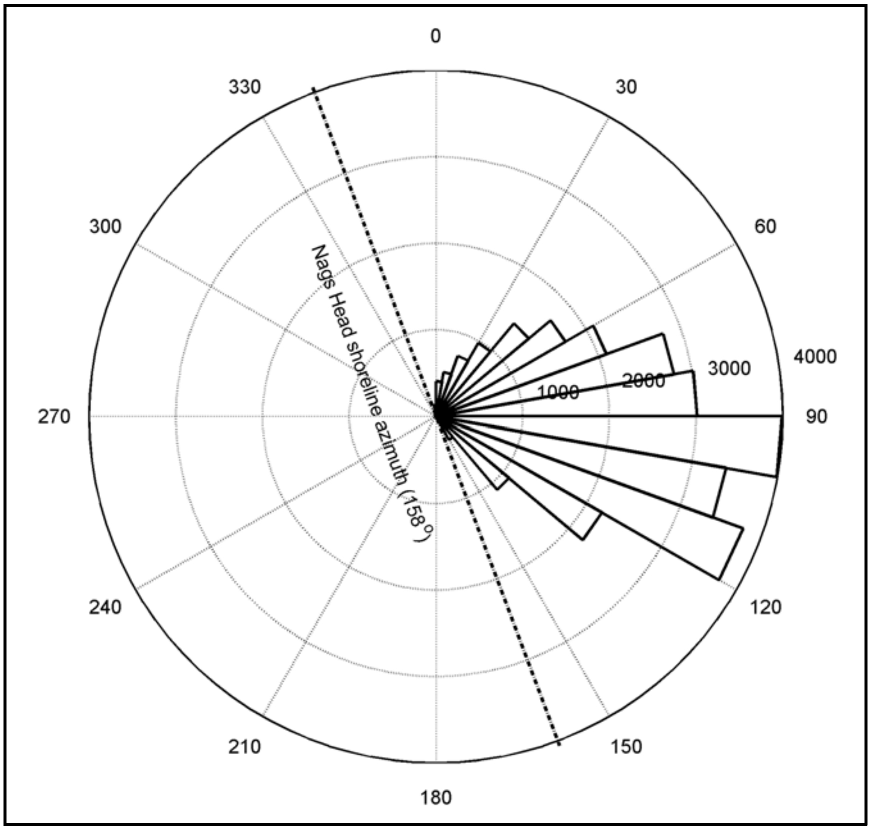


FIGURE 4.4-2. Polar histogram of wave directions at Buoy 630 at Duck (NC) for 2003–2005. The azimuth of the Nags Head coastline is superimposed.

TABLE 4.4-1. Change in wave energy density, E, is calculated from significant wave data, H_s and T_p, by direction for dredge depths of 4 ft, 6 ft, and 8 ft. The expected length of shoreline affected is also given.

H (m)	T (s)	Wave direction (°N)	P(event)	4 ft Cut		6 ft Cut		8 ft Cut	
				%ΔE	Shoreline Affected (ft)	%ΔE	Shoreline Affected (ft)	%ΔE	Shoreline Affected (ft)
1.23	4.6	10-20	1.82	5.97	3,151	8.35	3,243	10.34	3,305
1.24	4.9	20-30	2.61	3.66	2,904	5.13	2,935	6.38	2,966
1.25	5.8	30-40	3.44	4.28	2,626	6.19	2,688	7.95	2,718
1.27	6.4	40-50	4.92	3.84	2,255	5.60	2,317	7.24	2,348
1.37	7.6	50-60	6.06	3.95	1,853	5.83	1,884	7.62	1,915
1.31	9.4	60-70	7.36	4.04	1,359	5.94	1,390	7.81	1,421
1.11	10.5	70-80	9.80	3.78	834	5.54	834	7.30	865
1.10	10.1	80-90	10.60	3.42	278	5.03	278	6.64	278
0.87	9.7	90-100	14.04	3.42	278	5.03	278	6.44	278
0.79	9.2	100-110	11.96	3.50	834	5.11	834	6.66	865
0.88	8.3	110-120	13.27	3.62	1,359	5.34	1,390	6.97	1,390
0.80	7.5	120-130	7.78	3.95	1,853	5.83	1,884	7.62	1,915

4.4.2 Wave Refraction Over Borrow Area

Some typical dimensions of the borrow area were assumed to assess potential impacts on wave refraction over the borrow area. For this illustration, a borrow area was assumed as roughly rectangular with a longshore length of 5,120 ft and a cross-shore length of 3,098 ft. The floor of the borrow area is at an average depth of –45 ft (NGVD). Dredge depths are expected to extend to 4–8 ft below the floor.

Waves that shoal over the borrow area will refract according to Snell's Law. The wave crest will change direction, and the waves will take a more longshore approach to shore as they move into the suddenly deeper water of the borrow area. Shoaling and refraction effects will also impact the wave height over the borrow area. As the wave continues over the shoreward edge of the borrow area, the wave height will again change in response to the abrupt decrease in depth. The change in wave energy density is unaffected by the placement of the borrow area except at the ends of the borrow area when the refracted waves are shifted downdrift and converge with the unrefracted wave segment outside of the borrow area.

The convergence of the refracted wave ray and the unrefracted ray causes the wave energy to focus on its approach to the beach. Because energy is conserved, the upstream end of the borrow area will tend to spread the wave ray refracted by the borrow area and the adjacent ray unaffected by the borrow area. The increase in distance between the wave rays at the upstream end will cause a decrease in energy density between the two subject rays. The decrease in energy density may result in less erosive behavior at the shore relative to the rest of the wave crest. However, where the wave rays converge at the opposite end, erosive behavior is likely to increase. This effect is amplified by wave direction. A more oblique approach over the borrow area will result in more of an increase in energy density in the focused region than will a more shore-normal approach. An approach that is normal to the long axis of the borrow area (ie, meets the borrow area at a 90° angle) will not produce a focussed energy density region because the waves are not refracted.

Snell's Law is used to determine how the wave and wave direction are affected by the placement of the borrow area.

The Automated Coastal Engineering System (ACES) is a suite of algorithms that is used to determine fundamental physical characteristics of coastal waves. One aspect of ACES is that it can solve Snell's Law to determine wave attributes upon refracting over ranging bathymetry. For this study, ACES' Snell's Law routine was used to determine the refracted angle of approach, ά, based on the original angle of approach, α (Fig 4.4-3). For each of the 14 angles examined (10°-150°), the distance between orthogonal wave rays, b_1, is determined. Because wave power is assumed to be constant between the wave rays, the increase in energy density can be determined from the decrease in width between the orthogonals upon refracting over the borrow area.

Snell's Law assumes straight and parallel contours. While this is rarely the case in nature, borrow area dimensions that include a flat, constant depth bottom are a good approximation when discussing closely spaced orthogonal rays.

Wave power transmitted between two orthogonals is written:

$$P = E_b C_g \quad (1)$$

where E = wave energy

$$= \rho g H^2/8 \quad (2)$$

b = distance between orthogonals

C_g = group speed of the wave

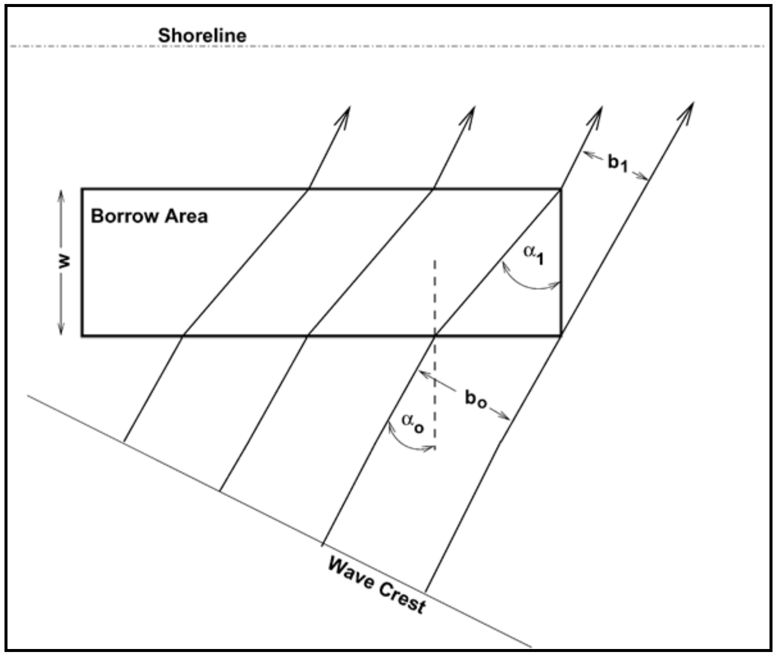


FIGURE 4.4-3. Borrow area wave refraction geometry. Wave energy is focussed as a result of refracting over the downdrift end of the borrow area.

The constants, *ρ* and *g*, are mass density of water and gravitational acceleration (respectively). Because P_0 is equal to P_1, the ratio of b_0 and b_1 is the ratio in the change in energy density. That is:

$$\% \Delta E = b_0 / b_1 \times 100\% \tag{3}$$

where subscript 0 means before refraction over borrow area and subscript 1 means after.

The change in energy density following refraction over the borrow area was estimated for borrow area depths of 4, 6, and 8 ft. From ACES, Snell's Law was used to determine the refracted approach angle given the borrow unrefracted angle of approach. Using the refracted angle, the wave approach geometry can be constructed.

From the wave approach geometry, the distance between unrefracted rays can be determined:

$$b_o = w \cdot \tan \alpha_o \cdot \cos \alpha_r \tag{4}$$

where *w* is the cross-shore dimension of the borrow area, α_r is the incident direction of the wave, and α_o is the refracted angle of the wave.

This distance between the refracted ray and its adjacent unrefracted ray can be determined by :

$$b_1 = w \cdot \tan\alpha_o \cos\alpha_o \tag{5}$$

Percent change in energy density can then be determined by Eq(3). Assuming parallel depth contours and no longshore changes in depth, the width of shoreline affected by the changes in energy density can be estimated by b_1, where the affected shoreline length is directly related to the width of the borrow area. A wider borrow area will increase energy density over a longer shoreline reach than will a narrower one. Results are tabulated in Table 4.4-2.

TABLE 4.4-2. Sediment transport rates, Q_ℓ, calculated from significant wave data H_s and T_p. The probability of each wave event is given as well as breaking wave characteristics used for sediment transport calculations. The (–) symbol indicates direction to the north.

H_s (m)	T_p (s)	P(event)	Wave Direction (°N)	a (°)	H_b (m)	h_b (m)	h_b/H_b	C_{gb} (m/s)	a_b (°)	P_{ls}	Q_l
1.23	4.6	1.82	10-20	55	1.45	1.80	1.24	4.20	27.24	82	106,101
1.24	4.9	2.61	20-30	45	1.52	1.88	1.24	4.29	22.53	115	148,608
1.25	5.8	3.44	30-40	35	1.71	2.09	1.22	4.53	17.03	160	206,803
1.27	6.4	4.92	40-50	25	1.84	2.23	1.21	4.68	12.21	202	261,122
1.37	7.6	6.06	50-60	15	2.13	2.57	1.21	5.02	7.44	223	287,397
1.31	9.4	7.36	60-70	5	2.25	2.68	1.19	5.13	2.42	101	130,681
1.11	10.5	9.80	70-80	-5	2.03	2.42	1.19	4.87	-2.28	-98	-126,825
1.10	10.1	10.60	80-90	-15	2.06	2.44	1.18	4.89	-6.79	-325	-418,924
0.87	9.7	14.04	90-100	-25	1.76	2.09	1.19	4.53	-10.40	-439	-566,920
0.79	9.2	11.96	100-110	-35	1.71	2.03	1.19	4.46	-14.13	-464	-599,051
0.88	8.3	13.27	110-120	-45	1.94	2.33	1.20	4.78	-19.22	-933	-1,203,446
0.80	7.5	7.78	120-130	-55	2.32	2.81	1.21	5.25	-25.39	-1,070	-1,380,870

A recent study by Byrnes et al (2003) examined the effects of borrow area mining in the Nags Head vicinity. The borrow area sites suggested for that study are farther offshore and in deeper water (50-80 ft) than the borrow site examined for the current study. Byrnes et al employed STWAVE (a spectral wave foundation model using historical wave climate variability) to determine the impact of the borrow area. The borrow area was found (1) to reduce wave heights shoreward and within the longshore limits of the borrow area and (2) to increase wave heights shoreward at the outer limits of the borrow area. A greater wave climate (ie, higher wave heights) was found to have greater reduction inside the borrow area limits as well as a greater increase in wave height in the focused area at the extent of the borrow area. The reduced and increased waves are expected to defuse alongshore as they propagate to the beach.

4.4.2.1 *Wave Refraction Results*

The higher energy waves in the three-year record approach shore from among the most oblique angles in the record.

From 10° to 20° (70°–80° normal to borrow area), the average significant wave height is 1.23 m and has an associated period of 4.65 seconds. Increases in wave energy density relative to the depth of the dredge cut are as follows:

	Percent Increase in Wave Energy Density	Shoreline Length Affected (ft)
4-ft Dredge Cut Depth	5.97%	3,151
6-ft Dredge Cut Depth	8.35%	3,243
8-ft Dredge Cut Depth	10.34%	3,305

Waves progressing from the southeast produce similar results. Waves from 140° to 150° (50°–60° normal to borrow area) will cause an increase in energy density as follows:

	Percent Increase in Wave Energy Density	Shoreline Length Affected (ft)
4-ft Dredge Cut Depth	5.51%	2,657
6-ft Dredge Cut Depth	8.07%	2,749
8-ft Dredge Cut Depth	10.55%	2,811

Conversely, an approach more normal to the long axis of the borrow area will produce much milder results. From 80° to 90° (0°–10° normal to borrow area), there is an increase in energy density as follows:

	Percent Increase in Wave Energy Density	Shoreline Length Affected (ft)
4-ft Dredge Cut Depth	3.42%	278
6-ft Dredge Cut Depth	5.03%	278
8-ft Dredge Cut Depth	6.64%	278

Although the more oblique approaches cause more extreme focussing of energy density and affect longer stretches of shoreline, they occur much less often than their less oblique, lower magnitude counterparts. The waves approaching from 10° to 20° and from 140° to 150° from north have probabilities of occurrence of 1.82 percent and 1.07 percent (respectively). The waves from 80° to 90° from north have a probability of 10.60 percent of occurring. As the wave approaches become more oblique, the stronger the relative effect they have, but the probability of occurrence tends to become lower.

4.4.3 Longshore Sediment Transport Potential

Sediment transport potential was evaluated along the coast of Nags Head using the wave climate from 2003 to 2005 at Duck (NC). Refracted wave heights at breaking are used to satisfy the longshore energy flux factor proposed by CERC (1984). Potential transport rates were originally based on small-amplitude wave theory. The assumed relationship between longshore transport and energy flux requires that energy flux be evaluated at breaking depth, where small amplitude theory is less valid. Because of inconsistencies in nearshore slope along Nags Head, it is more useful to calculate the transport rate at the depth of wave measurement. The rate at which wave energy is transmitted per unit width of the wave perpendicular to the direction of the wave is a derivation of the small amplitude wave energy flux factor using the assumption that breaking speed is given by solitary wave theory (Galvin and Nelson 1967). It is given by:

$$P_{ls} = 0.0707 \cdot \rho g^{\frac{3}{2}} H_{sb}^{\frac{5}{2}} \cdot \sin 2\alpha_b \qquad (6)$$

where H_{sb} and α_b are the significant wave height and wave angle (respectively). Here, α_b is the angle between the wave crest and the shoreline (CERC 1984). The immersed-weight transport rate is calculated with:

$$I_l = KP_{ls}$$

where K is the refraction coefficient equal to: $\sqrt{\frac{\cos\alpha_o}{\cos\alpha_b}}$

The volumetric longshore transport rate is then calculated as:

$$Q_l = \frac{I_l}{(s-1)\rho g a'} \qquad (7)$$

where s is the specific gravity of the sand and α' is the void ratio of the sediment.

4.4.3.1 *Longshore Transport Results*

Based on wave data from 2003-2005, the net longshore transport rate is 541,000 cubic meters per year to the north. The bulk of this net sand transport is caused by waves that come from 70°–130° (ie, from the east-southeast) where the three-year probability of these waves is ~48 percent. The low amplitude, long period waves from these directions account for 90 percent of the northerly transport and roughly 52 percent of the gross transport. The three-year wave climate produced a gross transport of 3.27 million cubic meters per year where 58 percent of the sand is transported to the north.

Inclusion of the borrow area is expected to increase transport in the areas of the beach affected by the focussed wave energy by between 3 and 10 percent. The total length of the beach expected to be affected by increased wave heights caused by an 8-ft dredge depth may exceed 3,300 ft. However, this is likely to be balanced out at the large scale by decreased wave heights occurring simultaneously over a wider shoreline.

4.4.3.2 *Comparison with Existing Studies*

The current study compares favorably with recent studies that show net longshore sediment transport was northerly under recent wave climates at Nags Head. Byrnes et al (2003) predict net northerly transport based on the spectral wave model STWAVE at 250,000 cubic meters per year (m^3/yr). Despite the consistency in these recent results, historical estimates and morphological evidence suggest that long-term transport is southerly. Inman and Dolan (1989) concluded that net sand transport between False Cape (VA) and Cape Hatteras is southerly. Everts (1985) also suggested that transport is net southerly between Nags Head and Cape Hatteras. Previous estimates of transport rates in this region (Jarrett 1978, Birkemeier et al 1985, Inman and Dolan1989) conclude that nearly 1.5 million cubic meters per year of sand move southward mainly during the fall and winter storm seasons. The net, long-term transport is found to be southerly at 700,000 m^3/yr.

4.4.4 Offshore Limits of the Littoral Zone (Depth of Closure)

To better understand the dimensions of the active zone, it is important to determine the offshore limit of measurable bottom change. The depth where waves and currents have no measurable impact on bottom elevations is called the closure depth. The standard definition offered by Hallermeier (1978) is the depth beyond which there is active seabed motion for only a maximum of 12 hours per year.

Several methods are used to estimate the depth of closure at Nags Head (NC).

4.4.4.1 *Depth of Closure Using Nearshore Wave Data*

Closure depth is computed from wave data at the nearby USACE Field Research Facility (FRF) at Duck, North Carolina. The 8-meter array observations of wave height and period are used to determine the closure depth at Nags Head. A three-year record of hourly data is used in closure depth calculations. Hurricane and large storm waves are filtered from the data.

Hallermeier (1981) proposed that closure depth, h_c, can be reasonably estimated with the extreme wave height adjusted for steepness.

$$h_c = 2.28\, H_e - 68.5\, (H_e^2/gT_e^2) \quad (8)$$

where:

h_c = closure depth (in meters)

H_e = the extreme wave height, that is, the nearshore wave height exceeded only 12 hours per year (in meters)

T_e = the wave period associated with the extreme wave height

Following a study of profile variations at FRF, Birkemeier (1985) proposed that the closure depth be defined similarly with different coefficients:

$$h_c = 1.75\, H_e - 57.9\, (H_e^2/gT_e^2) \quad (9)$$

The proximity of the FRF at Duck to Nags Head suggests Equation (9) would apply more readily to the closure depth estimated at Nags Head.

For the three-year hourly wave data at Duck, H_e was observed to be 3.5 meters (m). T_e was determined by the mean of the periods associated with wave heights between 3.0 and 4.0 m. For the wave record, T_e was found to be 11.3 seconds (s). The closure depth associated with this wave record is 7.3 m (Equation 8) and 5.5 m (Equation 9).

4.4.4.2 *Closure Depth Measured from UNC Modeled Storm Wave*

At the University of North Carolina, Roessler (1998) transformed deep-water WIS data (USACE station 46) using RefDif, a phase-resolving parabolic refraction-diffraction model for ocean-surface wave propagation. Roessler examined potential sediment transport near Nags Head based on model results. Additionally, storm conditions resulting from Hurricanes *Bonnie* and *Fran* provided 3.0 m wave height and 15-second period. Predicted closure depths for this wave are 6.6 m (Equation 8) and 5.0 m (Equation 9).

4.4.4.3 *Measured Closure Depths at Duck, North Carolina*

Birkemeier (1985) used measurements of changes in seabed morphology to determine closure depth at Duck. The results (Fig 4.4-4) suggest that Equation 8 tends to over-predict closure depth while Equation 9 (based on the profile variations at Duck) better fits the measured data. Results indicate a range of closure depths between 3.9 and 6.4 m for Duck, about 25 miles north of the Nags Head project site.

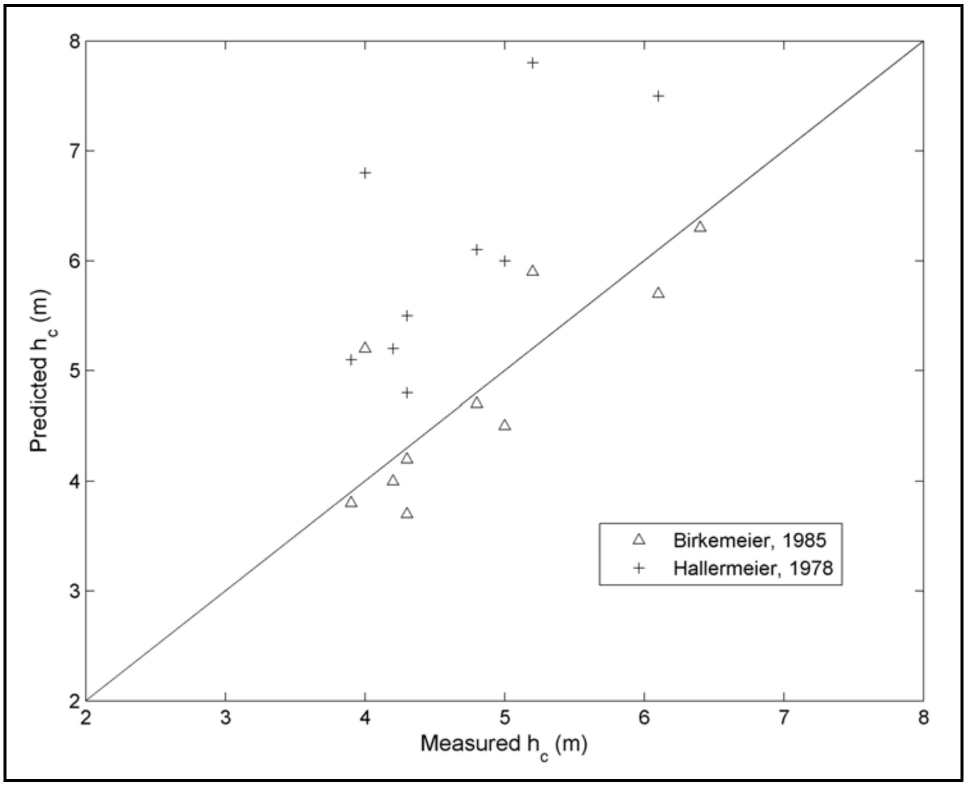


FIGURE 4.4-4. Closure depth comparison between Hallermeier (1978) and Birkimeier (1985).

4.4.5 Conclusions

Wave data from the FRF 8-m wave array suggest a closure depth of 5.5 m at Nags Head using the Birkemeier (1985) formulation. The closure depth using Hallermeier's (1981) formulation is 32 percent greater than the Birkemeier formulation. Because Birkemeier's formula was based on data observed at Duck, the nearness of Nags Head to Duck suggests that Birkemeier (1985) is a better prediction of closure depth at Nags Head.

Hurricane-induced waves provide for similar closure depth as the extreme waves (exceeded for only 12 hours per year), suggesting hurricane waves may be a good prediction of closure depth. Measured closure depth and predicted closure depth, based on field measurements, range from 3.9 m to 6.4 m at Duck (NC) and are used to suggest a closure depth with this range at Nags Head, North Carolina.

Measured waves at Duck (NC) between 2003 and 2005 yield a net northerly transport. Northerly transport in this region is counter to historical findings, which suggest southerly transport dominates, based on many more years of hindcast wave data. The present study yields a comparable net transport rate for recent time periods as was noted in a study by Byrnes et al (2003). This study, like others, confirms high gross transport potential and comparatively much lower net transport rates.

4.5 PUBLIC LANDS

Public access to the beach strand has been developed extensively by the Town of Nags Head. As part of implementation of this project, the town is developing public access that will meet USACE guidelines for public access to federally maintained beaches. Before construction begins, the county will require that all municipalities within the project limits meet USACE guidelines for public access. During construction, all public access areas will be maintained for the good of the public.

Principal elements of the town's infrastructure are the streets and water lines owned and maintained by the Town of Nags Head. Over 1,385 ft of water main and half a mile of 24-ft-wide paved road have been destroyed by recent northeasters and hurricanes. FEMA has helped cover damages that occurred during hurricanes, but the town has to fund any repairs due to northeasters. Some of the water-main damages that occurred during hurricanes have been washed out several more times by northeasters and cannot be replaced. The houses that depend on this water main are now condemned due to lack of water supply. As erosion continues, more streets and water mains will be destroyed, which will lead to a decline in property values and tourism in the area.

4.6 RECREATIONAL AND SCENIC AREAS

The beach along the Town of Nags Head is part of what is known as the Outer Banks of North Carolina. An estimated 5 million tourists visit each year to participate in the various scenic and recreational activities available to the public. Popular activities include, but are not limited to, surf fishing, swimming, surfing, scuba diving, walking, shell hunting, sunbathing, bird watching, and boating.

Currently, there is significant loss of dry beach due to erosion, which limits many beach activities to low-tide periods. The proposed project would create dry beach, extending on average ~85 ft seaward from the existing dry beach. This would make the beach more accessible during the year, particularly during times of high tide.

4.7 AREAS OF ARCHAEOLOGICAL OR HISTORICAL SIGNIFICANCE

The name, Nags Head, is believed by some to have originated with a band of shipwrecked sailors from a town with the same name in England. It is also rumored that pirates would tie lanterns around the necks of old nags and allow them to roam along the beach in hopes of luring unsuspecting ships into the shallow waters. After the ships were lured into the shallow waters, they would run aground where the waiting pirates would then go out and pillage the wreckage. The actual settlement history traces back to ~160 years ago when a plantation owner came to Nags Head, bought ~200 acres of land, and built the first beach cottage. Twenty years after the first settlement in the area, Nags Head had become a seaside resort.

The Nags Head offshore area is part of the infamous "Graveyard of the Atlantic" which has claimed many shipwrecks and their crews. The earliest known shipwreck, James E Newsome, happened before 1728. Since then, there have been over 190 documented shipwrecks offshore of Dare County.

Mid-Atlantic Technology and Environmental Research Inc (MATER) of Castle Hayne (NC) completed the report, "Phase 1 Upland and Underwater Archaeological Survey of the Dare County Beaches and Borrow Areas" under contract to the USACE (MATER 1999, in USACE 2000). The scope of the survey was to locate, identify and assess the significance of any upland and underwater cultural material in the project areas. Archaeological survey equipment included marine magnetometer and sidescan sonar to identify any submerged cultural resources within proposed borrow areas. The upland survey included a terrestrial reconnaissance along Dare County beaches to identify any exposed shipwreck remains. Details of the surveys and report of findings are included as part of this EIS in Appendix B.

4.8 AIR QUALITY

The Air Quality Section of the North Carolina Department of Environment and Natural Resources (NCDENR) has jurisdiction over air quality in Dare County. According to the Washington (NC) district office, ambient air quality in Dare County is in compliance with the National Ambient Air Quality Standards (NAAQS).

4.9 WATER QUALITY

Coastal waters offshore of Nags Head are classified as "SB" waters by the State of North Carolina (NCDEM 1989). Usages of "SB" waters include swimming, primary recreation, all activities stated for class "SC" waters (fishing, secondary recreation, fish and wildlife propagation), and all other uses requiring lower quality waters (NCDEM 1991).

4.10 GROUNDWATER RESOURCES

Dare County has had problems in the past finding sources of drinking water for the Nags Head area. Since there are no shallow freshwater aquifers that can adequately support the area's consumption, the county has used a freshwater pond near Wanchese. In recent years, the county has located a suitable groundwater source, Yorktown Aquifer, at ~280–680 ft below sea level. At present, the Yorktown Aquifer supplies ~5 million gallons per day of suitable drinking water to the northern part of Dare County, including Nags Head.

4.11 INTRODUCTION OF TOXIC SUBSTANCES

No chemical analysis of the borrow area materials has been done to date. It is unlikely that the borrow area sediments have accumulated any toxic or hazardous substances regulated by CERCLA or RCRA. There have been no known spillage, storage, treatment or disposal of regulated toxic materials within the borrow areas. There are no known discharges to the offshore or nearshore areas of Bodie Island that could be a source of contaminants. For this reason, it is doubtful that chemical analysis of the borrow area material would contain heavy metals exceeding the EPA standards. The borrow area sediments consist of medium to coarse sands with shell fragments and mud percentages averaging well under 2 percent. These types of inert mineral materials do not typically trap contaminants. Clay-sized material that has potential to adsorb pollutants is generally absent from the borrow area.

4.12 NOISE LEVELS

Noise levels in the project area are relatively low. No commercial or industrial activities that create increased ambient noise levels exist in the project area. Generally, noise levels in the project area are those associated with public use. The residential nature of ocean shoreline areas generally equates to low ambient noise levels.

4.13 WATER SUPPLY AND WASTEWATER SYSTEMS

4.13.1 Water Supply

The potable water supply for Nags Head is provided by municipal water systems that are owned and operated by Dare County. The water source for all systems is deep wells tapping into the Yorktown Aquifer. A surface water plant is used by the town as a backup water source only in the times of peak usage (ie, Fourth of July weekend). The Town of Nags Head buys the water from the county and, in turn, sells it to the residents of the town.

4.13.2 Wastewater Systems

Wastewater treatment and disposal on Nags Head are regulated by the Dare County Environmental Health Department for systems under 3,000 gallons per day and by NCDENR's Division of Water Quality for systems larger than 3,000 gallons per day. Treatment and disposal of wastewater on Nags Head are accomplished in many conventional and innovative ways. Single-family residential systems are nearly all conventional septic tanks. In some areas, where soils are not suitable for conventional septic systems, on-site, low-pressure-pumped (LPP), subsurface-disposal septic tanks are used. Multi-family residential developments and hotels utilize collection systems with centralized treatment and disposal facilities. Treatment is generally by package plants utilizing extended aeration and on-site, subsurface LPP disposal. There are no known direct effluent discharges to the Atlantic Ocean from the wastewater treatment facility.

4.14 MARINE RESOURCES

Marine waters within the vicinity of the proposed beach nourishment area and offshore borrow sites provide habitats for a variety of ocean organisms and are important for both commercial and recreational fisheries. Offshore areas also provide habitat for benthic flora and fauna. Kingfish, spot, bluefish, weakfish, spotted sea trout, flounder, red drum, king mackerel, and Spanish mackerel are actively fished from boats, or the surf, and local piers (USACE 2000). Some of the offshore areas are over-wintering grounds for the striped bass fishery and other migratory fish populations. Nearshore areas, such as the surf zone, support a diverse array of benthic, epibenthic and finfish that use this location for feeding and as a nursery area.

Most organisms living in the surf zone are considered to be very resilient creatures that would least likely be detrimentally affected by beach nourishment. Thompson (1973) noted that organisms dwelling in beaches are accustomed to a dynamic habitat and adapt to daily changes associated with tides, waves, and turbulent processes in the littoral zone. He also observed that most species in beach habitats are capable of escape from or have lengthy resistance to adverse conditions (Thompson 1973).

The intertidal zone within the proposed project disposal area serves as habitat for invertebrates such as mole crabs, coquina clams, amphipods, isopods, and polycheate worms. All of theses species are adaptive to high energy and sandy beach environments, and they tend to undergo rapid recovery following sudden changes in the substrate brought about by storms, erosion, deposition, or artificial nourishment. These organisms are not of direct commercial or recreational importance, but they serve as an important food source for finfish and shorebirds.

4.14.1 Offshore Resources

Offshore areas in North Carolina have been described as more stable than the nearshore zone, because of the limited sediment motion by waves. USEPA (1983) describes the offshore region as fine sand with low-to-moderate relief ridges, interspersed with areas of hard bottom. Studies by USACE (2000) indicate there is plentiful sand in and around borrow area S1 and that much of the surficial sand is in the medium to coarse size range (ie, 0.25–1.0 mm). Corps studies found no evidence of exposed hard bottom, cultural resources (with the exception of several shipwrecks close to shore), or rock outcrops in borrow area S1 or along the project beach.

Offshore topography in borrow area S1 is generally stable but is subject to bottom drift upward of 1 meter per second in storm events (B Birkemeier, personal communication, January 2006). Research by investigators at the USACE Field Research Facility pier at Duck (NC) noted high velocities associated with Hurricanes *Isabel* (2003) and *Ophelia* (2005) in water depths greater than 40 ft. Such currents are likely to account for the low percentage of mud observed on the bottom by CSE divers (CSE 2005–August).

Hard bottom exists in isolated areas of the inner continental shelf off the northern Outer Banks (Swift et al 1973). The closest hard bottom to the proposed project area is thought to be situated at least three miles away from any portion of the proposed offshore borrow area S1. Southeast Monitoring and Assessment Program–South Atlantic Bottom Mapping Group (SEAMAP-SA 2001) located a hard bottom in the project's vicinity (Appendix B, Cultural Resources Survey). Details of these findings and the potential impacts to them are discussed in Section 6. [Offshore sediment characteristics in the proposed borrow area are summarized in Section 4.16 and are described in detail in Appendix D.]

4.14.1.1 *Sediment*

There have been numerous studies of sediments offshore of the project area (including those by JJ Fisher, JW Pierce, DJP Swift, S Riggs, SD Heron Jr, and OH Pilkey Jr, to name a few). Swift et al (1973) describe ridge and swale topography and oblique trending bars off the northern Outer Banks and Cape Henry. It is speculated that these ridges represent previous barrier island positions. Others (eg, McBride and Moslow 1991) have attributed similar oblique trending ridges to the signature of relict, migrating ebb-tidal deltas, which leave deposits trending obliquely to the coast as sea-level rises and the inlet shifts position in the alongshore direction. Regardless of origin, surficial sediments offshore tend to be dominated by quartz sand with lesser constituents of feldspar, heavy minerals, and shells (calcium carbonate).

The offshore area of northern North Carolina tends to have larger accumulations of Holocene and Quaternary sand near the surface in contrast to the southern North Carolina coast where deposits are thinner and hard bottom outcrops are common (Riggs et al 1995). The USACE (2000) identified an ~10-square-mile area (S1) off Nags Head as having upward of 100 million cubic yards of beach quality material in the upper 10 ft of substrate. Similar deposits are found in federal offshore areas off the Outer Banks, based on reconnaissance surveys by Snyder (1993) and ongoing research sponsored by the US Geological Survey, Minerals Management Division (eg, Hoffman 1998, Boss & Hoffman 2001). Hoffman (1998) identified upward of 77 million cubic yards of sand resources in four areas off Nags Head seaward of the three-mile limit (ie, in federal waters). These data suggest there are sand resources offshore of the project area that dwarf the needs of the proposed emergency project or the 50-year federal project.

4.14.1.2 *Biology*

Biological resources in the offshore regions of the Carolinas have been categorized as having low biomass, high diversity, and large seasonal variability (USEPA 1983). Offshore marine waters serve as habitat for the spawning of many estuarine-dependent species. According to the NMFS, these species comprise ~75 percent of commercially and recreationally important catches of fish and invertebrates in North Carolina. Seasonal variability has a significant impact on monitoring plans and is the reason for performing same-season surveys for projects of this type.

4.14.1.3 *Vertebrates*

The fish and crustacean communities of the northern Outer Banks change seasonally as well as daily, so it is difficult to assess project impacts and distinguish them from natural variations in populations. The USACE (2000) initiated studies (c/o Versar Inc) to monitor vertebrate populations in the offshore region. Sampling has been focussed on potential borrow areas N1/N2 situated off Kitty Hawk but similarly situated as area S1 off Nags Head.

Seasonal trawl sampling was conducted at the N1/N2 borrow site and the borrow reference site in 2005 to characterize seasonal densities of fish species. The spring sampling event had the highest collection of individuals at both sites with 342 organisms, which accounted for 75 percent of the yearly collection (Versar 2006, reprinted as Appendix C in this EIS). Summer and fall sampling events resulted in low-catch-per-unit effort, while the winter sampling event was the lowest. Second-year preconstruction monitoring by the USACE (c/o Versar Inc) is currently in progress at the S1 borrow site. (See Figure 2.1 for general location of USACE environmental monitoring studies by Versar Inc.)

4.14.1.4 *Invertebrates*

Because the benthic community offshore changes across the seasons, it is appropriate to sample in multiple seasons both before and after a nourishment project to assess impacts and recovery. Resident fauna are utilized by commercial and recreational fish as a means of food. Because nourishment activities under the federal project are likely to take place from spring through fall, the USACE initiated sample collection in 2005 to establish baseline conditions before construction. The initial set of samples was collected by Versar (2006) in fall 2005. This collection of samples, taken prior to any disturbance from nourishment, will provide fall baseline data to characterize the benthic invertebrate community at the prospective offshore borrow sites and at nearby control sites that will not be mined.

A description of results from an analysis of a subset of those initial samples is included herein as Appendix C (Versar 2006). Also included is an analysis of the composition of surface sediment samples in each of the borrow sites and control sites, so as to characterize the sedimentary habitat in which invertebrates live. Sedimentary habitat is a prime factor in controlling abundance and composition of soft-bottom invertebrate communities (NRC 1994).

Results from the 2005 preconstruction monitoring of the N1/N2 borrow site and borrow reference site are summarized in Table 3-5 and Table 3-9 of Appendix C (Versar 2006). Results suggest that very few mobile invertebrates were collected in the first-year efforts. Versar (2006) noted that squid were the most frequent invertebrates collected at borrow and reference sites during spring and fall sampling events. Two species of shrimp were found with brown shrimp collected at the borrow site in the summer and sand shrimp collected at both sites in the spring. The lady crab was collected at the reference site in the fall and accounted for 23 percent of the total catch that season (Versar 2006).

Benthic sampling resulted in the collection of 168 infauna and epifauna taxa from the borrow and reference sites. Data show that the N1/N2 borrow areas were mainly comprised of polychaete worms. The top ten dominant taxa by weight consisted of six polychaete worm species, but also included some species of snails, clams, and sand dollars (Versar 2006). It is believed that the S1 borrow site has the same assemblages and densities of organisms because habitat conditions at N1/N2 borrow areas are similar to the reference and S1 borrow sites.

4.14.2 Nearshore Resources

The nearshore zone is defined herein as the zone from low-tide wading depth to ~75 ft depths. The inner part of this zone is the active littoral profile which includes a longshore bar that persists off Nags Head approximately 300–800 ft offshore. The outer part of this zone extends well beyond the normal limits of sand exchange under surf-zone processes.

4.14.2.1 *Sediment*

While there are high variations in mean grain size in the nearshore zone, most samples immediately seaward of the low waterline off Nags Head tend to fall in a fairly narrow range between ~0.17 millimeters (mm) to 0.23 mm; these are typical values just inside, on top of, and just offshore of the bar (CSE 2005–August). Sediments actually become coarser proceeding seaward in water depths >30 ft approaching area S1 about 1–3 miles offshore. These sediments are thought to be relict deposits associated with the former inlets and barrier ridges from earlier sea-level stands. While the nearshore zone is highly dynamic with exchange of sand between the bar and the beach, the predominant sediment type is fine sand. Specific trends in sediment quality along the beach are given in more detail in Section 4.16.

4.14.2.2 *Biology*

Quantification of submarine organisms inshore of the borrow area is currently being studied by Versar under contract to the USACE. Versar (Byrnes et al 2003) has also conducted environmental monitoring studies of four potential borrow areas in federal waters off Nags Head which are ~0.5–2 miles seaward of borrow area S1. Benthic surveys of three nearshore areas near Virginia Beach were conducted for the Minerals Management Service in 1996 and 1997 (Cutter and Diaz 1998). They found the overall composition to be typical for sandy shallow continental shelf habitats and similar with species composition for similar depths and sediment types reported by Day et al (1971) for North Carolina.

A baseline study of benthos in nearshore waters of South Carolina by Van Dolah and Knott (1984) found that infaunal assemblages in nearshore subtidal areas were more complex than those found in intertidal areas. Based on their sampling, 243 species (representing 24 major taxa) were found. Dominant species were polychaetes and amphipods with oligochaetes, pelecypods, and decapods highly represented. Benthos identified included species which are essential in marine food chains and whcih serve as food for commercially important species. Commercially important species include adult spots which are benthic feeders, primarily eating polychaetes and benthic copepods, and Atlantic croaker which are also bottom feeders preying on polychaetes and bivalves. Pink and white penaeid shrimp also prefer benthos (USFWS 1992a). The nearshore benthic communities offshore of North Carolina have been characterized by infaunal assemblages with low abundance and high diversity (USEPA 1983). Benthic assemblages in the proposed project's nearshore area are expected to be similar to the previously mentioned studies.

Finfish utilize the surf zone primarily for foraging on the intertidal benthos. Studies by Ross and Lancaster (1996) indicate that juveniles of certain species may have high site fidelity and extended residence in the surf zone which may indicate that the surf zone could be functioning as a nursery area. Versar (2006) noted more species were found in higher abundance in the surf zone, indicating that the surf zone may be an important habitat for fish throughout the year.

4.14.3 Intertidal Resources

4.14.3.1 *Sediment*

The intertidal zone is considered as being the area between mean low tide landward to the high tide mark. Grain sizes are very coarse in this area due to the direct exposure to high wave energy. In a preliminary coastal engineering analysis (Appendix D), CSE (2005–August) reported mean grain sizes in the swash zone at Nags Head averaging >1 mm. Swash zone samples tend to exhibit the widest range of grain sizes. Details are also given in Section 4.16.

4.14.3.2 *Biology*

Vertebrates – Because of the very intermittent nature of fish densities in the narrow intertidal zone, no sampling of fish has been planned under the Dare County project or the present emergency project.

Invertebrates – Organisms in high-energy sandy intertidal zones include mole crabs, coquina clams, amphipods, isopods, and polychaetes. Although none of these species are commercially important, they serve as an important food source for surf-feeding fish and shore birds. One year of monitoring has taken place to serve as the preconstruction monitoring data for intertidal invertebrates along Nags Head's beach. These data were collected by Versar (2006) along Kitty Hawk's beach for the USACE's proposed Dare County beach restoration project. The invertebrate community of the intertidal beaches is strongly seasonal. The USACE is monitoring populations before and after the federal project with sampling initiated in 2005 (Versar 2006).

Intertidal beach organisms were collected in several seasons using a ponar grab in two different habitats (swash and shallow subtidal). Results showed that more infauna organisms were collected in the spring and mean infauna abundance declined through the summer, fall and winter sampling periods (Versar 2006). It was also noted that *Donax variabilis*, which is sometimes an indicator species of recovery rates after nourishment projects (Peterson et al 2000), was not abundant in the swash area at either the USACE proposed impact beach or the reference beach. Results from the 2005 preconstruction impact beach (USACE proposed area) and the reference beach monitoring are summarized in Table 3-1 of Appendix C (Versar 2006).

4.14.4 Beach and Terrestrial Resources

4.14.4.1 *Sediments*

The width of the berm at the base of the dune system varies considerably with location along the town's beach and with season. Along most of the project area, the winter berm is non existent, because of the continuing erosion. Dune habitat is now decreasing due to erosion of the base or toe of the dunes by waves that travel unimpeded over the eroded wet beach to directly attack dunes. As a result of the nourishment project, the beach is the one resource area that is expected to have beneficial impacts to the species present, primarily due to increased habitat area. The proposed emergency nourishment project will directly impact the dry beach area, increasing this habitat for species such as ghost crabs.

4.14.4.2 *Biology*

Beach and terrestrial communities are considered sparsely populated due to the harsh conditions including salt spray, wind, shifting sands, and soils with low water retention. Coastal development is another factor that could limit species diversity and abundance. Vegetation along the uppermost dry beach, recorded by the USACE (2000), included beach spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile edentula*), and pennywort (*Hydrocotyle bonariensis*). The foredune tends to mark a more stable vegetation line and includes the species: American beach grass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), sea oats (*Uniola paniculata*), broom straw (*Andropogon virginicus*), and salt meadow hay (*Spartina patens*). Beaches are used by shorebirds which feed on intertidal invertebrates such as mole crabs (*Emerita talpoida*), coquina clams (*Donax variabilis*), and supralittoral resident ghost crabs (*Ocypode quadrata*). The beach and dune system serves as an important nesting and food-source area for certain shorebirds (USFWS 1992a).

A bird survey, by Versar (2006) for the Dare County project, revealed that there were no visible differences between the impact and reference beaches. The study showed that shorebird and waterbird abundance followed similar patterns of high abundance in spring and fall, and lower abundance in the summer and winter months (Appendix C, Figs 3-25 and 3-28, Versar 2006). The first-year study also concluded that birds in the area favor beach habitat and are generally not found in the dunes (Appendix C, Fig 3-24a, Versar 2006).

4.15 THREATENED AND ENDANGERED RESOURCES

A number of threatened and endangered species of plants and animals potentially occur in the project vicinity. The following table lists these species (USACE 2000).

Common Name	Scientific Name	Status	Habitat Present?	Known Observation*
Mammals				
Finback whale	*Balaenoptera physalus*	E	no	no
Humpback whale	*Megaptera novaeangliae*	E	no	no
Right whale	*Eubaleana glacialis*	E	yes	no
Sei whale	*Baleanoptera borealis*	E	no	no
Sperm whale	*Physeter catodon*	E	no	no
West Indian manatee	*Trichechus manatus*	E	yes	no
Birds				
Piping plover	*Charadrius melodus*	T	yes	yes
Roseate tern	*Sterna douglallii*	E	no	no
Artic peregrine falcon	*Falco peregrinus tundrius*	T	no	no
Bald eagle	*Haliaeetus leucocephalus*	E	no	yes
Red-cockaded woodpecker	*Picoides borealis*	E	yes	yes
Reptiles				
Green sea turtle	*Chelonia mydas*	T	yes	yes**
Hawksbill sea turtle	*Eretmochelys imbricata*	E	yes	yes**
Kemp's ridley sea turtle	*Lepidochelys kempi*	E	yes	yes**
Leatherback sea turtle	*Dermochelys coriacea*	E	yes	yes**
Loggerhead sea turtle	*Caretta caretta*	T	yes	yes
Fish				
Shortnose sturgeon	*Acipenser brevirostrum*	E	no	no
Plants				
Seabeach amaranth	*Amaranthus pumilus*	T	yes	yes

KEY: **Status** **Definition**

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

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

SR — State designation. Species designated as being very rare, generally with 1-20 populations in the state. These species are not considered in the biological assessment.

* — Observation according to NC Natural Heritage Program data.

** — Although no known record of individuals nesting in project area, species is known to migrate along the coast of NC (Wynne 1999).

Because the Nags Head beach restoration project area does not contain any freshwater or forested areas, the shortnose sturgeon is not likely to be found at this site. Listed species that could potentially be found at Nags Head are whales, West Indian manatee, piping plover, sea turtles, and seabeach amaranth. Other federally listed endangered or threatened species would not be affected.

4.15.1 Mammals

4.15.1.1 *Whales (Right, Finback, Humpback, Sei, and Sperm)*

These whale species all occur infrequently in the ocean off the coast of North Carolina. Of these, only the right whale routinely comes close enough inshore to encounter the project area. Right whales swim very close to the shoreline and are often noted only a few hundred meters offshore (Schmidly 1981). This species feeds primarily on copepods and euphausids (Schmidly 1981). While this whale usually winters in the waters between Georgia and Florida, it can on occasion be found in the waters off North Carolina. Sighting data provided by the Right Whale Program of the New England Aquarium indicate that 93 percent of all North Carolina sightings between 1976 and 1992 occurred between mid-October and mid-April (Slay 1993). Part of the proposed work will likely occur during this time period. The right whale could be in the vicinity of the project area during proposed actions.

4.15.1.2 *West Indian Manatee*

The manatee is an occasional summer resident of the North Carolina coast. The species can be found in shallow (5 ft to usually <20 ft) slow-moving rivers, estuaries, saltwater bays, canals, and coastal areas (USFWS 1991). The West Indian manatee is herbivorous and eats aquatic plants such as hydrilla, eelgrass, and water lettuce (USFWS 1999a). During winter months, the U.S. manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm-water outfalls as far north as southeast Georgia. They are sighted frequently in southeastern North Carolina with most records occurring in July, August, and September as they migrate up and down the coast (Clark 1993). However, scattered records of this species in the region span all seasons.

The USFWS draft Coordination Act report, as cited in the Dare County FEIS (USACE 2000), showed that the species had been reported in 11 coastal counties of North Carolina, including nine sightings from Dare County. Open-ocean reports include single sightings off Avon and Kitty Hawk, both in Dare County. Manatees have been reported in the state during nine months, with most sightings in the August-September period. Within Dare County, manatees have been reported from Pamlico Sound (June 1975, September 1983, October 1983), Albemarle Sound (September 1983, October 1983), Collington Bay near

Kitty Hawk (September-October 1986), Wanchese Harbor (September 1983), and the vicinity of Rodanthe (September 1987).

Based on these data, the manatee is considered a year-round resident with a maximum population in the late summer months. Manatee population trends are poorly understood, but deaths have increased steadily. A large percent of mortality (especially of calves) is due to collisions with water crafts. Another closely related factor in their decline has been the loss of suitable habitat through incompatible coastal development, particularly destruction of sea-grass beds by boating facilities. Since most of the proposed construction will occur in the spring and summer months, the manatee may be found in the vicinity of the project.

4.15.2 Birds

4.15.2.1 *Piping Plover*

The Atlantic Coast piping plover population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean (USFWS 1996). Since being listed as threatened in 1986, the population has increased from ~800 pairs to almost 1,680 pairs in 2003, although most of this increase may be attributable to an increase in surveying intensity.

Piping plovers nest above the high tide line on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes (USFWS 1996). Feeding areas include intertidal portions of ocean beaches, washover areas, mud flats, sand flats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline. The USFWS has designated a critical habitat for the piping plover that extends from the southern portion of Bodie Island to the northern portion of Pea Island. Any emergent sand bars south and west of Oregon Inlet are included. All of these areas are at least two miles south of the proposed project area.

4.15.2.2 *Roseate Tern*

Roseate terns breed primarily on small offshore islands, rocks, cays, and islets. Rarely do they breed on large islands. They have been reported nesting near vegetation or jagged rock, on open sandy beaches, close to the waterline on narrow ledges of emerging rocks, or among coral rubble (USFWS 1999b). This species is primarily observed south of Cape Hatteras, particularly at Cape Point within Cape Hatteras National Seashore, during the months of June through August. There have been rare occurrences of the tern in Dare County; however, no sites have been specified. There are no records of the species nesting in the project area (USFWS 1999c).

4.15.2.3 *Arctic Peregrine Falcon*

According to the USACE (2000), the Arctic peregrine falcon is a regular fall migrant along Dare County's beaches. This species is believed to be a resident of Greenland and contiguous areas during the spring and summer months. The peak number of peregrine falcons typically migrates through Dare County in late September to early October. An average of two peregrine falcons has overwintered in Dare County over the past 20 years (USACE 2000).

4.15.2.4 *Bald Eagle*

The bald eagle is the second largest North American bird of prey with an average wing span of 7 ft. They are opportunistic foragers and their diet varies based on the availability of prey species. This species prefers fish, but will eat a variety of mammals, amphibians, crustaceans, and birds. The range of the bald eagle covers the entire United States including Alaska, but it favors areas with aquatic habitats. There are no known roosting or nesting areas within the project's vicinity. The species have been recently (the past 20 years) observed in Dare County. The bald eagle was proposed to be delisted after a population survey was complete in 1997, but after further review, the decision was made that additional data were needed before taking this action.

4.15.2.5 *Red-cockaded Woodpecker*

Red-cockaded woodpeckers have been observed in Dare County within the past 20 years, but no occurrences have been documented in the project area. The typical nesting/roosting habitats for these birds are open stands of longleaf pines 60 years old or older. This species is commonly found in the southeastern U.S. with its range being correlated to the distribution of southern pines (http://www.fws.gov/rcwrecovery/rcw.htm).

4.15.3 Reptiles

4.15.3.1 *Hawksbill Sea Turtle and Leatherback Sea Turtle*

Leatherback and hawksbill sea turtles are found mainly in tropical waters of the Atlantic, Pacific and Indian Oceans. Nesting in the U.S. for these species occurs in spring and is generally restricted to Florida. Although neither species is considered common along the North Carolina coast, they may be found in North Carolina waters all year and can be present in inshore waters April through December (Epperly et al 1995).

The leatherback is an open-ocean species that sometimes moves into shallow bays, estuaries, and even river mouths. Their preferred diet is jellyfish and may also include sea urchins, squid, shrimp, fish, blue-green algae, and floating seaweed. The hawksbill is found along submerged rocky areas, reefs, shallow coastal areas, lagoons of oceanic islands, and narrow creeks (USFWS 1991). It is not often seen in water over 65 ft deep. Its diet includes algae, fish, mangrove, barnacles, clams, sponges, snails, and sea urchins.

4.15.3.2 *Kemp's Ridley Sea Turtle*

Kemp's ridley sea turtles inhabit shallow coastal and estuarine waters, often in association with subtropical shorelines of red mangrove. The entire population nests on ~15 miles of beach in Mexico between the months of April and June (USFWS 1991). Outside of nesting, the major habitats for adult Kemp's ridleys are the nearshore and inshore waters of the northern Gulf of Mexico, especially Louisiana waters. However, immatures have been observed along the Atlantic coast as far north as Massachusetts. The Kemp's ridley has been documented to nest in North Carolina only once. However, juveniles of the species are known to migrate in estuarine and oceanic waters off the North Carolina coast (Schwartz 1977, Epperly et al 1995). Over-harvesting of both eggs and adults for food and the skin has been a major factor in their decline. Currently the major threat in North Carolina is drowning when inadvertently caught in shrimp nets. Presently, there are ~3,000 nests per year; however, the total population is currently unknown because juveniles and males do not come ashore (NOAA 2000).

4.15.3.3 *Loggerhead Sea Turtle*

The loggerhead turtle is considered to be a resident of North Carolina waters, primarily during nesting season (April-October). Off the Carolina coast these turtles commonly occur at the edge of the continental shelf where they forage around coral reefs, artificial reefs, and boat wrecks. They are primarily carnivorous and feed mostly on benthic invertebrates including mollusks, crustaceans, and sponges (Morrimen 1982). They have also been found to eat fish, clams, oysters, sponges, jellyfish, shrimp, and crabs when near shore.

Research has shown that the turtle populations have greatly declined in the last 20 years due to loss of nesting habitat along the beachfront and by incidental drowning in shrimp trawl nets. Dredging activities in the warmer months of the year could impact the sub-adults but this has not been well documented. It appears that the combination of poorly placed nests coupled with acute erosion and unrestrained human use of the beach by auto and foot traffic has impacted this species greatly. Eroding steep beach escarpments, lights, sand fences, and other physical barriers (debris) often cause the mature females to select poor nesting sites at the toes of dunes which causes higher nestling mortality rates. In addition, juveniles are known to migrate in estuarine and oceanic waters off the North Carolina coast (Schwartz 1977, Epperly et al 1995).

4.15.3.4 *Green Sea Turtle*

With an estimated population of no more than 100,000 nesting females worldwide, the green turtle exists in both tropical and temperate seas and oceans (USFWS 1992b). The North American distribution ranges from Massachusetts to Mexico and from British Columbia to Baja California. Green sea turtles generally favor protected waters inside reefs, bays, estuaries, and inlets. Primary habitats appear to be lagoons and shoals supporting an abundance of marine grass and algae. These turtles are predominantly herbivorous, feeding upon marine algae and shallow beds of marine grasses. However, additional food sources may include mollusks, sponges, crustaceans, and jellyfish.

While there are relatively large numbers of green turtles worldwide, their numbers are declining because of over-exploitation of eggs and meat for food, commercial fishing and dredging operations, and nesting habitat destruction associated with beach development (USFWS 1992b). Green sea turtle nesting habitat consists of open beaches with a sloping platform and minimal human disturbance. Eastern U.S. nesting is limited primarily to Florida's east coast (300–1,000 nests reported annually). Occasional nesting has been documented as far north as North Carolina, although only one nest has been observed in Dare County. Because of this limited occurrence, the species cannot be considered to be a regular nester within the project area (USACE 2000). However, juvenile greens are known to migrate in estuarine and oceanic waters off of the North Carolina coast (Schwartz 1977, Epperly et al 1995).

4.15.4 Fish

4.15.4.1 *Shortnose Sturgeon*

This species ranges along the Atlantic seaboard from southern Canada to northeastern Florida (USFWS 1999d). The shortnose sturgeon feeds on invertebrates and the stems and leaves of macrophytes. From historical accounts, it appears that this species was once fairly abundant throughout North Carolina waters; however, many of these early records are unreliable because of confusion between this species and the Atlantic sturgeon (*Acipenser oxyrhynchus*). There have been four unconfirmed occurrences of shortnose sturgeon in Oregon Inlet: Holland and Yelverton (1973), Gruchy and Parker (1980), Dadswell et al (1984), and Gilbert (1989). No data on population dynamics exist in the project area (NMFS 1998). Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults.

4.15.5 Plants

4.15.5.1 *Seabeach Amaranth*

Seabeach amaranth is an annual herb occuring on beaches, lower foredunes, and overwash flats (Fussell 1996). Weakley (1986) found that in North Carolina the plant is most common on overwash flats on accreting ends of barrier islands. This species occupies elevations ranging 0.2–1.5 meters (m) above mean high tide (Weakley and Bucher 1992). Historically, seabeach amaranth has been found from Massachusetts to South Carolina. But according to recent surveys (USACE 1992-1995), its distribution is now restricted to North and South Carolina with several populations on Long Island (NY). The decline of this species is caused mainly by development of its habitat (inlet areas and barrier islands) and increased off-road vehicles and human traffic which trample the plants (Fussell 1996). Surveys conducted by the USACE (1997–1998) did not identify any populations of seabeach amaranth in the project area. The species absence from the area is likely due to a lack of suitable habitat or seed source (USACE 2000). Amaranth surveys were performed at Bogue Banks (NC) before and after nourishment. Over an ~20-mile length of shoreline, the number of plants observed in August 2001 prior to nourishment was under 35. After nourishment, seabeach amaranth increased to over 5,000 plants as mapped in August 2002, August 2003, and August 2004 (CSE 2004) (Fig 4.15-1, Table 4.15-1).

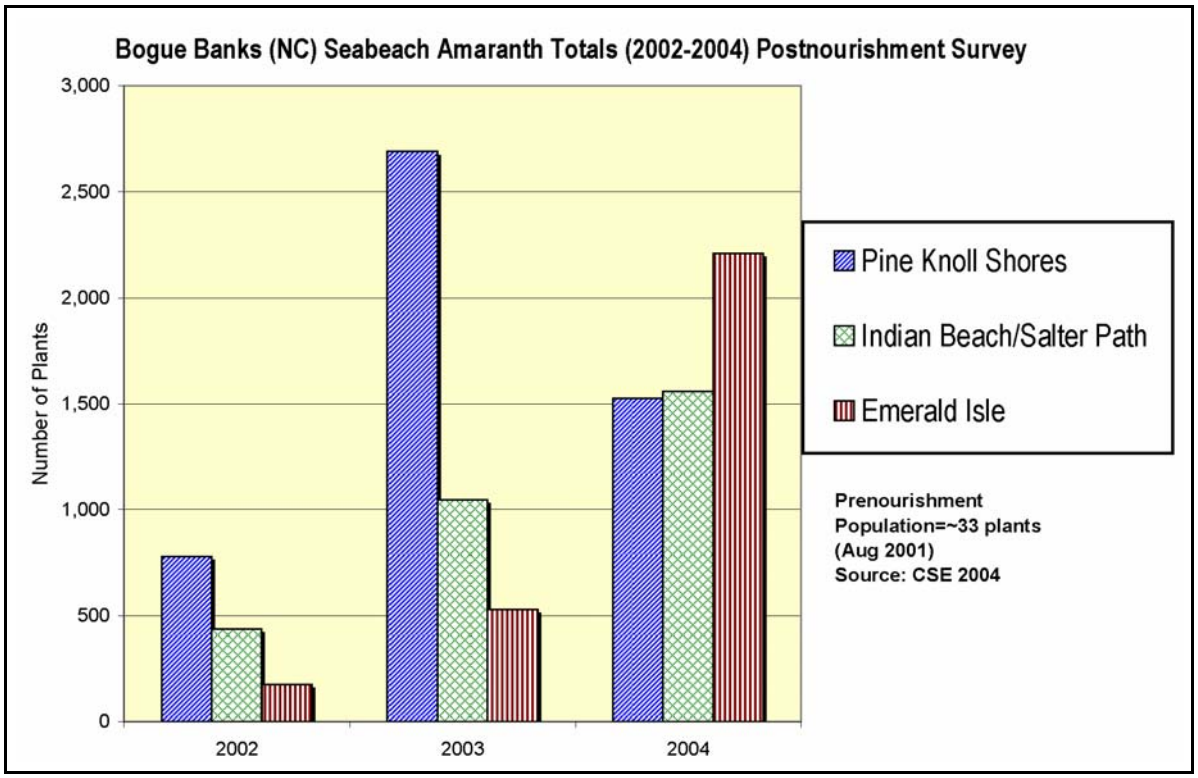


FIGURE 4.15-1. Survey of seabeach amaranth plants at Bogue Banks after beach nourishment (2002–2004). Source: CSE 2004. Prenourishment plant total was ~35 individuals along the ~20-mile survey area.

TABLE 4.15-1. Seabeach amaranth plants surveyed along Bogue Banks (NC) after nourishment of Pine Knoll Shores and Indian Beach in 2002 and Emerald Isle in 2003.

Plant Location	Number of Plants		
	Aug-02	**Aug-03**	**Aug-04**
Pine Knoll Shores	779	2,690	1,524
Indian Beach/Salter Path	437	1,047	1,558
Emerald Isle	175	530	2,210
Total Plants	**1391**	**4267**	**5292**

4.16 SEDIMENT CHARACTERISTICS (specific to the proposed project)

4.16.1 Summary of Native Beach Sediment Quality

CSE analyzed the quality of sediments on the native beach using similar sampling protocols as the draft recommendations of the NC Coastal Resource Commission (NCCRC 2005). In the present case, eight samples per transect (rather than 12) were analyzed. Composites of all samples, as well as a more limited grouping across the active beach zone were evaluated (CSE–recommended criteria for the present project). Based on 110 samples encompassing the length of Nags Head between the foredune and 15-ft depth contour, the CSE (2005–August) study found:

- There is a high degree of variation in mean grain size from station to station and from position to position across the profile.

- The mean grain size of dune samples (dune, toe dune) averages between 0.3 mm and 0.36 mm but individual samples exhibit a range of ~0.2 mm to >0.7 mm.

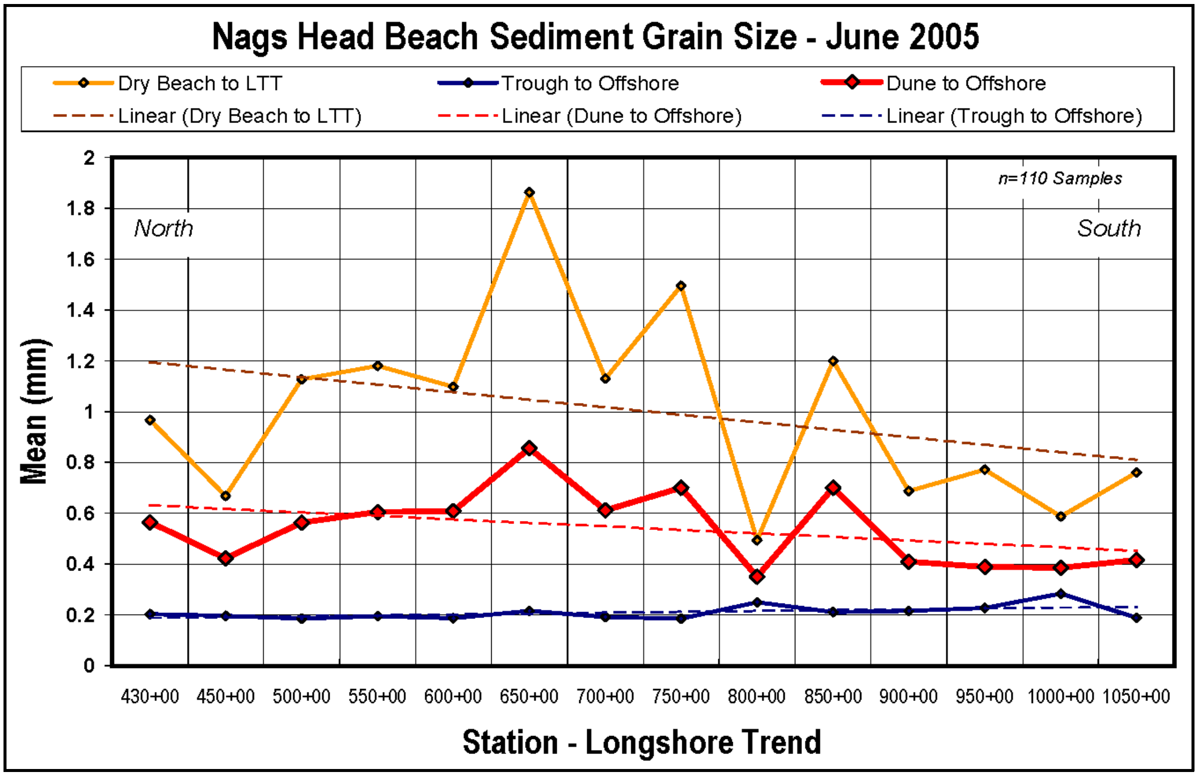
- The mean grain size of dry beach and swash zone samples (dry berm, MHW, LTT) average around 1.0 mm, but individual samples span a range from 0.27 mm to >3.5 mm.

- Underwater samples (trough, bar, outer) show mean grain sizes that average 0.19 mm to ~0.23 mm, with the range for individual samples between ~0.17 mm and >0.3 mm.

The alongshore and cross-shore trends in mean grain size are shown in Figure 4.16-1. The upper portion of the graphic shows the alongshore trend for three groups of samples:

- Dry beach to low-tide terrace (LTT) (ie, the breaker and swash zone)
- Underwater (ie, trough, outer bar, and offshore)
- All samples combined (ie, dune to offshore)

The results illustrate how coarse the swash zone samples are compared with the offshore samples. Offshore samples tend to be relatively uniform in mean grain size (around 0.2 mm). Swash zone samples, even when combined, still exhibit a wide range of grain sizes. Combining all samples (red line in Figure 4.16-1, upper) smooths the trend and suggests an (arithmetic) average range of mean grain sizes of the order ~0.45–0.65 mm. Mean sediment grain size tends to become finer toward the south, consistent with previous studies (cf, USACE 2000).



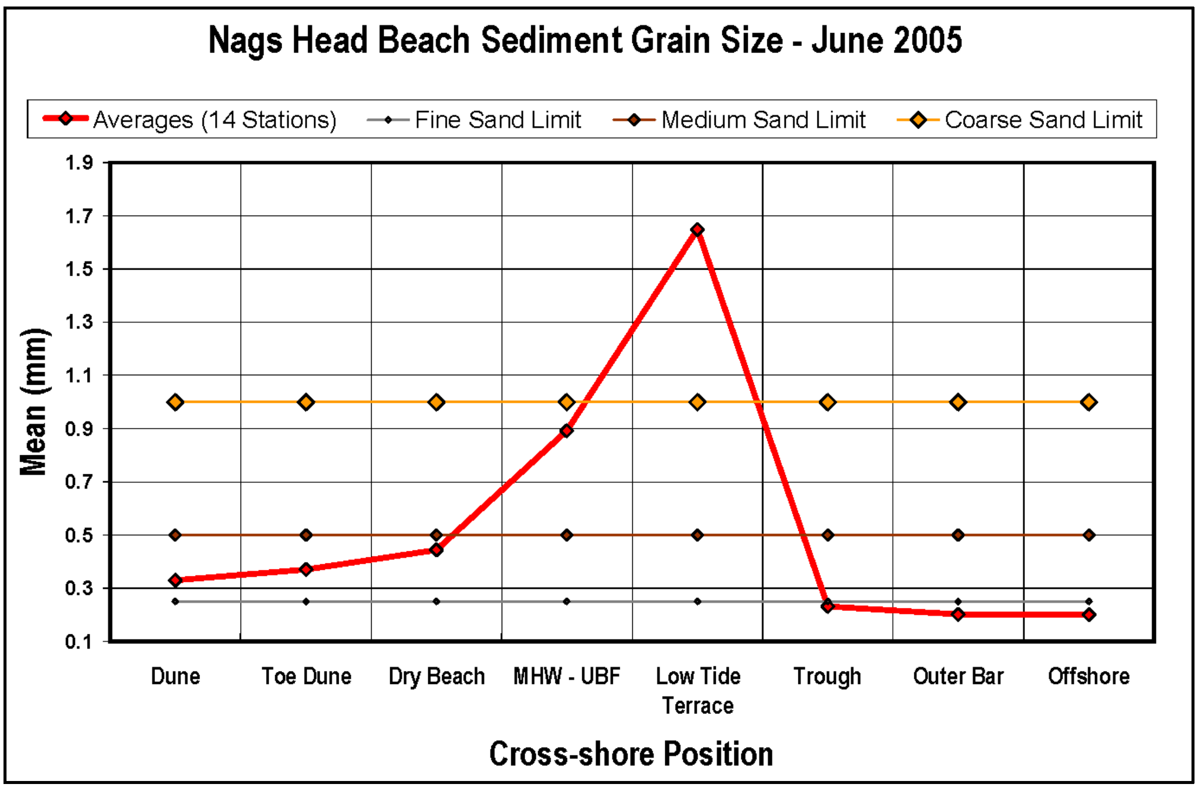


FIGURE 4.16-1. Overall trends in mean grain size by station and position across the profile. Red lines pool all samples. Trend line (dashed red line in upper graph) shows decrease in mean grain size from north to south. [From CSE 2005–August]

Figure 4.16-1 (lower) shows the cross-shore trend in mean grain size, giving the average of all samples from a particular position along the profile. The cross-shore trend shows a characteristic coarsening from the dune to the low-tide terrace (near wave plunge point), then a rapid fining of sediment seaward of the inner breaker zone.

For purposes of continued project planning, CSE elected to adopt two "native beach" size distributions for Nags Head, using results compiled in "Preliminary Coastal Engineering Analyses for Large-Scale Beach Restoration at Nags Head (CSE 2005–August, Section 2). Figure 4.16-2 shows the characteristic size distribution curves for the two composites. The upper graph shows a composite native-size distribution based on toe of dune, dry beach, mean high water, low-tide terrace, and trough samples, consistent with CSE's prior practice (CSE–Stroud 2001). The lower graph shows a composite based on foredune to outer (offshore) samples, similar to draft NCCRC (2005) sampling guidelines. Resulting mean grain sizes are 0.47 millimeters (mm) (CSE criteria) and 0.36 mm (approximate NCCRC criteria).

4.16.2 Borrow Area Investigations

Two potential borrow areas for nourishment were considered for the proposed project:

1) Offshore area "S1" as delineated by USACE (2000) for the federal Dare County project (Fig 4.16-3).

2) Oregon Inlet channels and shoals.

Area S1 was chosen for investigation because of previous studies and recommendations by the USACE (2000) as well as the fact that there is an existing EIS for the area. Based on ~32 borings, the Corps (USACE 2000) first delineated the nearly ten-square-mile S1 area, estimating that it contains as much as 100 million cubic yards of beach-quality sand within the upper 10 ft of the bottom. CSE (2005) collected 60 additional borings and further evaluated its sediment quality. In anticipation of an ~4 million cubic yard project for Nags Head, only a small fraction of S1 would be required.

Oregon Inlet was considered as a potential borrow area for Nags Head because of ongoing federal dredging of the channel and the possibility of piggy-backing on the federal project via Section 933, or some other funding means. Section 933 projects, under federal regulations, allow a local sponsor to obtain dredged material for the difference in cost between what the federal government would pay for nearby disposal and what it costs to place the spoil on the local beach.

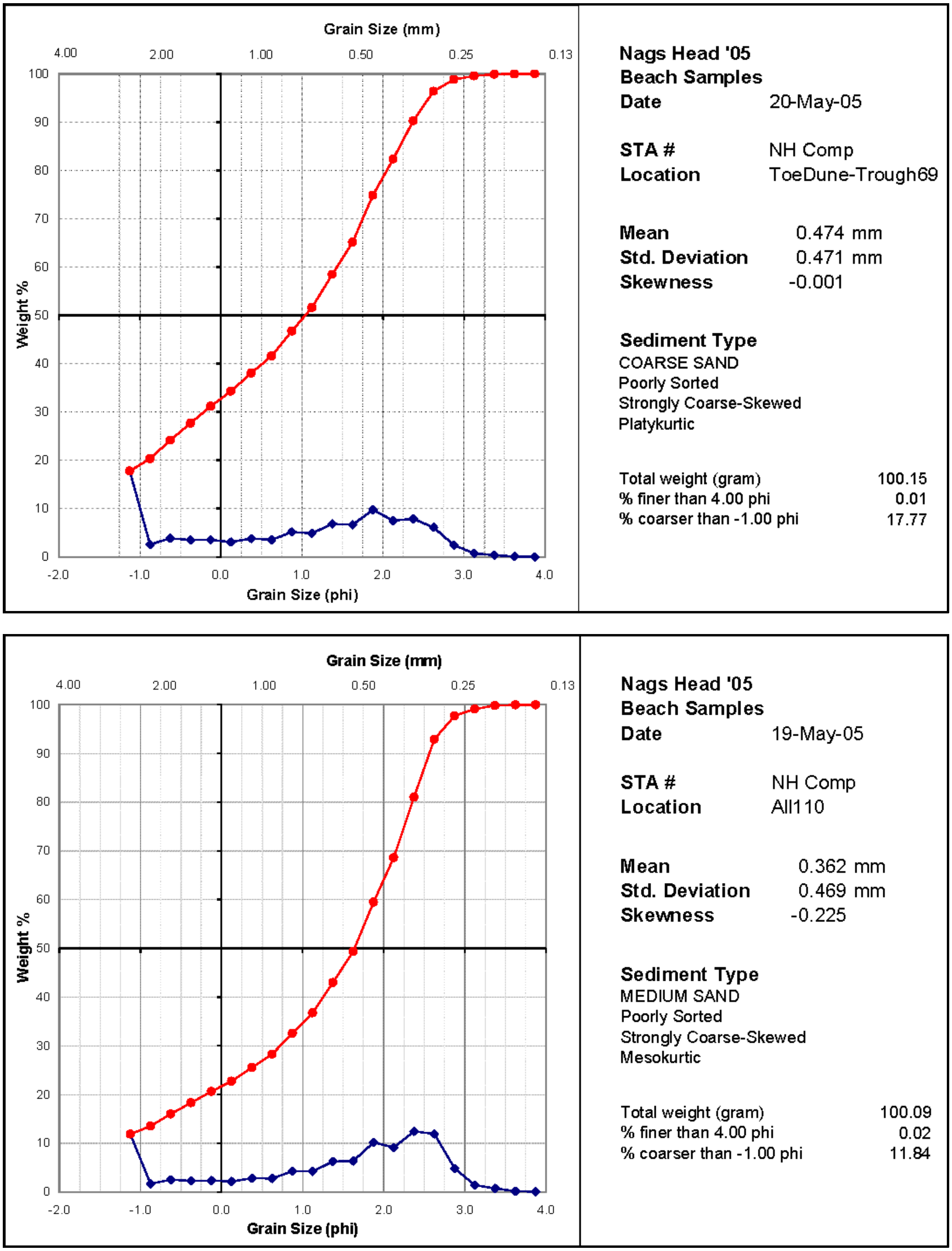


FIGURE 4.16-2. Nags Head composite grain-size distributions for the "native beach" as adopted herein. The lower graph (based on all samples) approximately follows the draft NCCRC (2005) sampling protocols. The upper graph shows the result for a more limited zone of sampling between the toe of dune and trough. [From CSE 2005–August]

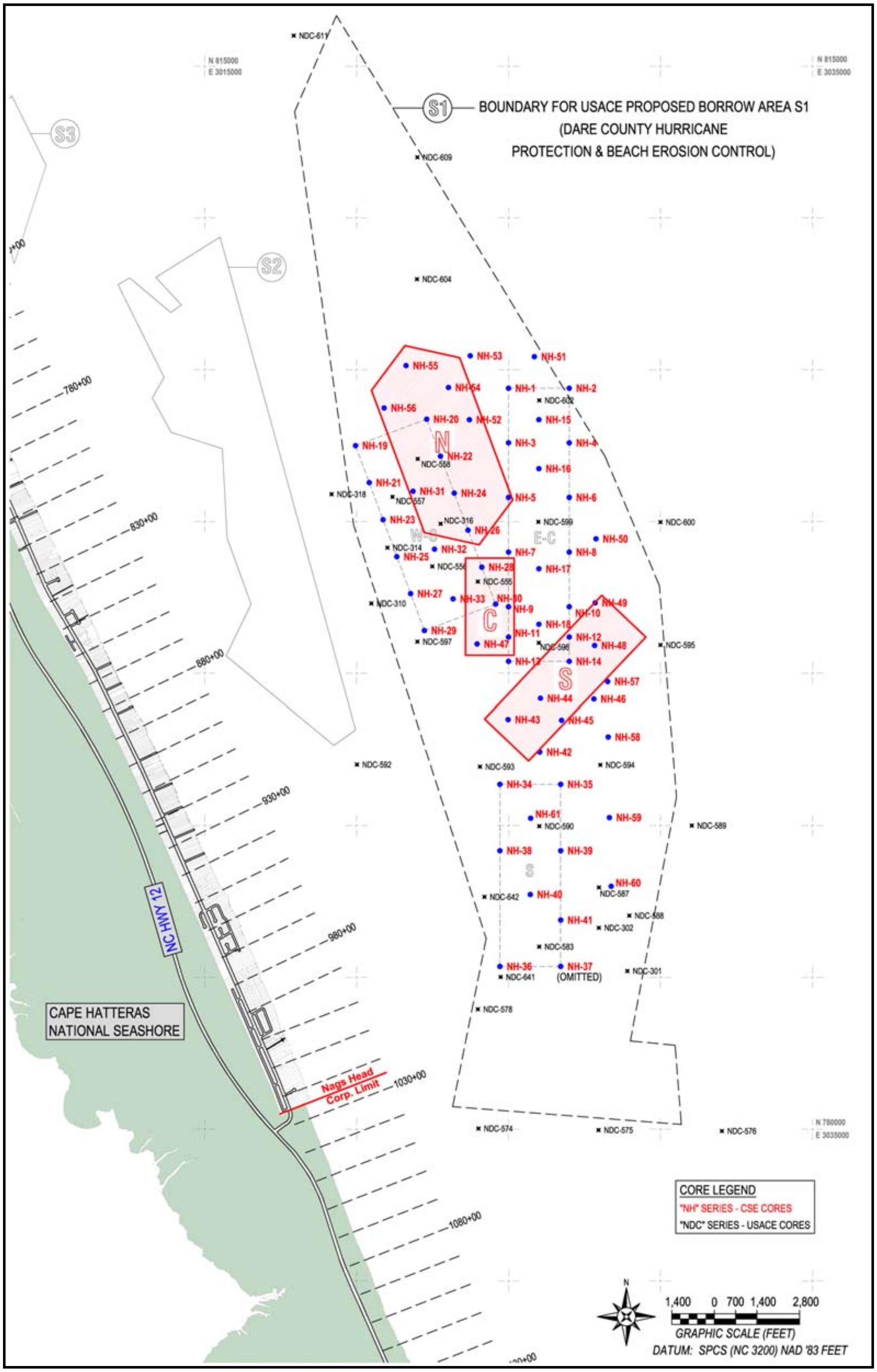


FIGURE 4.16-3. Location of offshore area S1 (delineated by USACE 2000), various subareas, and the grid of cores obtained in CSE's (2005–August) study. Subareas W–C, E–C, and S were the basis of CSE's survey grid. Subgroups N, C, and S (red) were delineated based on sediment test results. [From CSE 2005–August]

Oregon Inlet is dredged on a regular basis, and material is usually disposed along Pea Island about one-half mile downcoast of the channel. Because of these ongoing activities and the fact that the inlet is situated less than five miles from Nags Head, it may provide an economic source of sand. As part its study, CSE (2005–August) obtained sediment samples and short borings from sites in the inlet and on the Pea Island disposal area for purposes of evaluating sediment quality.

4.16.3 Comparison of Potential Borrow and Native Sediments

CSE (2005–August) analyzed about 150 sediment samples from offshore area S1 and Oregon Inlet for compatibility as nourishment material. Compatibility was evaluated by means of the overfill factor R_A (CERC 1984), which provides a measure of how a particular sediment will perform as beach nourishment. R_A's of less than 1.5 are generally preferred, with ideal being equal to 1.0. To apply the method, a native sediment size must be assumed. In this case, two possible native size distributions were applied:

1) "Composite 69" representing the sediments found between the toe of dune and trough along Nags Head.

2) "Composite 110" representing all available beach samples (dune to offshore) roughly following draft recommendations and criteria of NCCRC (2005).

In the first case, the mean grain size (Mz) is 0.474 mm. In the second case, Mz=0.362 mm.

CSE subdivided ~125 samples from offshore area S1 into three subgroups (S, C, N) meeting the following approximate criteria:

- Coarse sand (mean grain size ~0.5 mm or greater)
- Represents upper 2 ft or deeper substrate
- Similar sediment quality in adjacent cores

On the basis of subgroups S, C, and N, CSE (2005–August) determined that portions of area S1 will yield highly favorable sediments comparing the two native distributions (Fig 4.16-4). Resulting R_A's were in the range 1.02–1.3 for subgroups S, C, and N. By comparison, R_A's for Oregon Inlet sediments average >7.0, meaning nearly seven times more Oregon Inlet sand would be required to equal the performance of S1 sand.

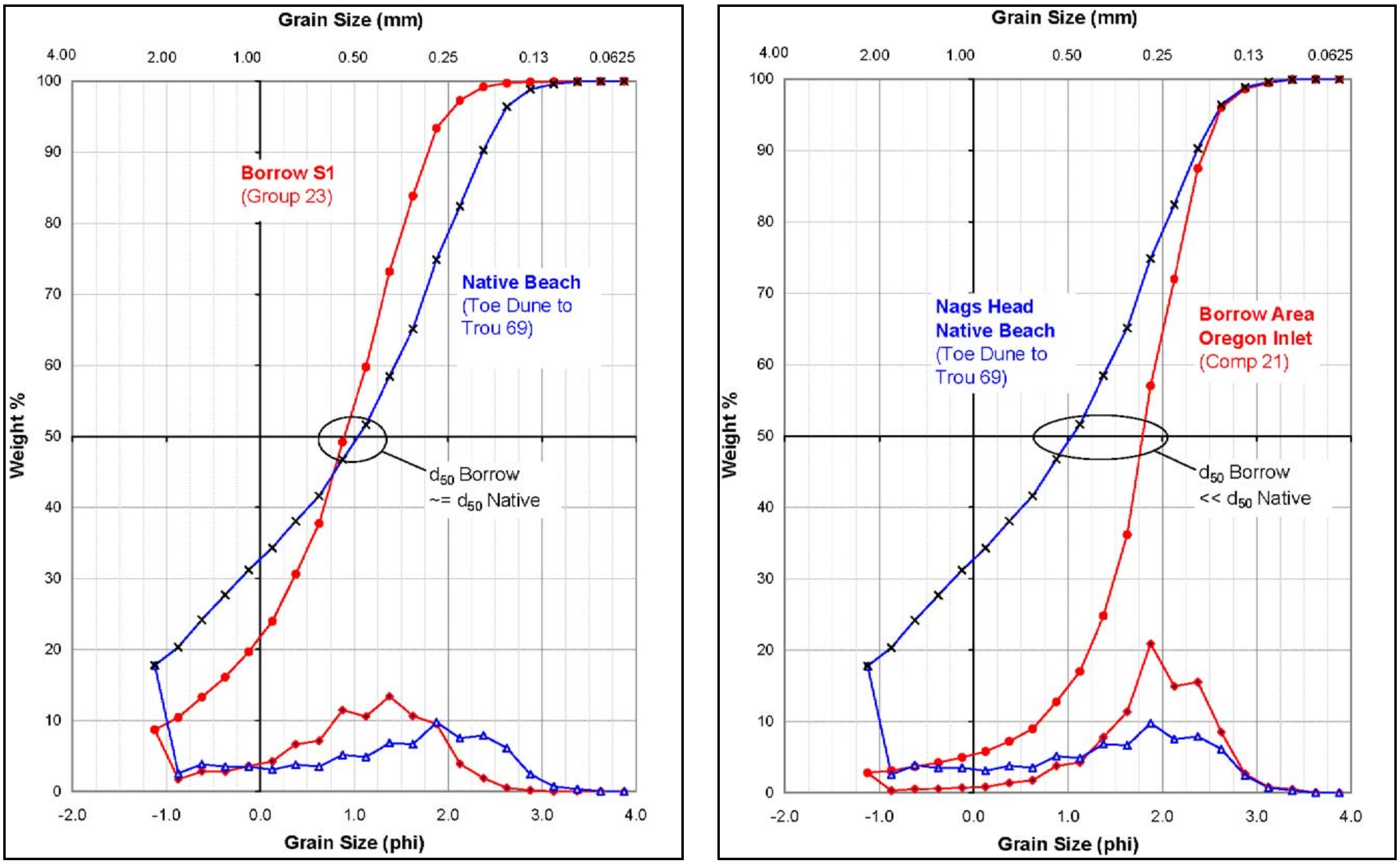


FIGURE 4.16-4. **[LEFT]** Comparison of borrow area S1 (subgroup 23) composite vs Nags Head native beach (Comp 69) (ie, CSE recommended criteria). **[RIGHT]** Comparison of Oregon Inlet sediments vs native (Comp 69) showing much finer texture (ie, unstable for use as nourishment sediment along Nags Head). [From CSE 2005–August]

Subsequent to identification of several potential subareas of S1 for borrow sediment, CSE and town officials met with USACE representatives and discussed requirements for the town to utilize a portion of area S1. The Town of Nags Head and CSE understand the following:

- The USACE has not finalized its preferred section of S1 for use in the federal project.

- The USACE is conducting baseline environmental monitoring in a limited area of S1 which will likely not be available for use by the Town of Nags Head in a locally funded project.

- Any area of S1 used in a particular dredging event will no longer be available for redredging during the 50-year federal project.

Based on the results of borings and sediment compatibility analyses to date, the applicant believes that large areas of S1 contain beach-quality material and that an emergency project involving up to 4.6 million cubic yards can be accomplished using the equivalent of no more than 1 square mile of ocean bottom (ie, ~640 acres). The anticipated area for the Nags Head emergency nourishment project is within subareas 1, 2, or 3 as shown on Figure 2.1 (Section 2). These three subareas surround the present environmental monitoring area designated by the USACE under the Dare County project. Subareas 1, 2, and 3 generally overlap the herein-referenced subareas N, C, and S as shown in Figure 4.16-5.

An unresolved issue as of this writing is what portion of S1 will be made available to the Town of Nags Head.

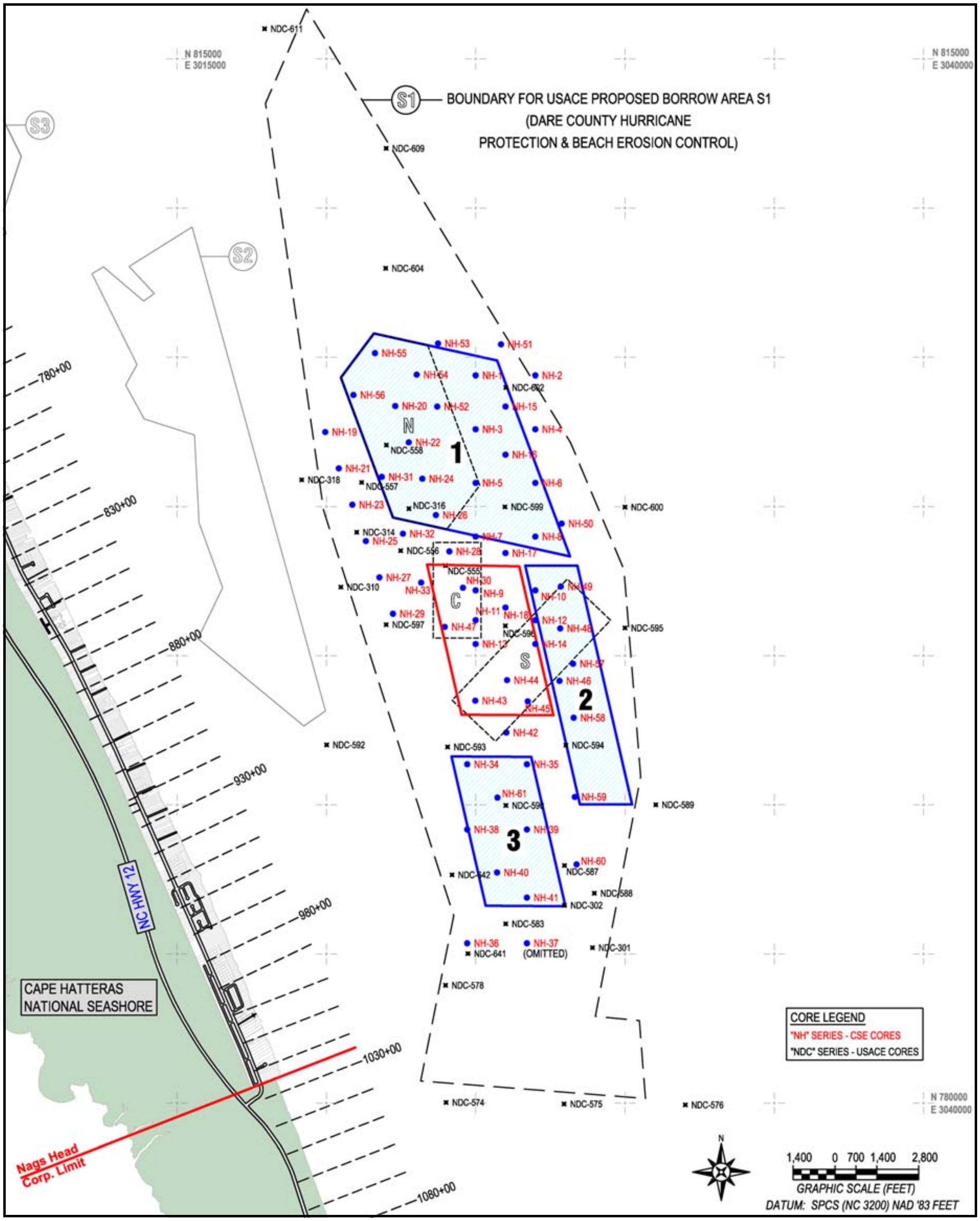


FIGURE 4.16-5. Various subareas of offshore borrow area S1 targeted for use in the proposed emergency nourishment project subject to approval of the USACE which is reserving portion(s) of the borrow area for the initial federal project. Subareas 1, 2, and 3 represent ~1,400 acres. Only about 550–600 acres will be impacted by the proposed emergency nourishment project. The unlabeled (red) box is an ongoing environmental monitoring area of the USACE Dare County project.

4.17 ECONOMIC AND SOCIAL ENVIRONMENT

Dare County's Commercial and Tourism-Based Economy

The economic environment of Dare County is shaped by its geography and can be seen in the commercial and tourism-related economies of the county. The county's economy, while diverse, is driven primarily by tourism and tourism-related jobs. The commercial and manufacturing segments of the economy are relatively small. The five largest employers are:

Dare County Schools	~900 employees
County of Dare	~800 employees
East Carolina Health Inc	~400 employees
Coastal Staffing Service Inc	~240 employees
Food Lion LLC	~200 employees

Tourism is, by far, the largest industry in Dare County. The industry contributes an average of $619 million annually to the economy of Dare County, with a direct payroll of more than $152 million to over 10,000 workers. During 2004, unemployment in the county ranged from 9.7 percent in January to 2.9 percent in June. During 2003 and 2004, retails sales varied from a low of $44,000,000 in March 2003 to a high of $238,000,000 in August 2004, reflecting the seasonal nature of Dare County's economy and the importance of tourism. Beaches and beach-related activities are the principal attraction to the county. These resources account for ~5 million visitors and tourism expenditures in excess of $1.5 billion annually.

Approximately 34 percent of all tax revenues generated in Dare County derive from sales taxes, occupancy taxes, fees, etc. Dare County has a 3 percent occupancy tax. Occupancy taxes in fiscal year 2003-2004 contributed over $12 million to the operating budgets of the county and municipal governments. As mandated in the enabling legislation, occupancy tax revenues must be used for tourism-related activities. In Dare County, 1 percent of occupancy tax revenues is used to market the county's tourism attractions and to operate and maintain the Outer Banks Visitors Bureau. Approximately $1 million of occupancy taxes collected in 2005 were from rental of oceanfront properties or hotel occupancy on Nags Head.

5.0 ALTERNATIVES

5.1 OVERVIEW OF ALTERNATIVES

Under existing federal and state laws, there are only three alternatives for dealing with erosion along the Town of Nags Head: (1) no action; (2) abandon property, retreat, and relocate; (3) nourish the beach.

Structural shore protection involving seawalls, revetments, and bulkheads is not allowed under present North Carolina coastal zone management (CZM) regulations. Semi-hard solutions involving sand-retaining structures, such as groins and detached breakwaters, plus nourishment are not recommended in areas of low erosion rates away from inlets (NAS 1995). In general, present CZM policies along ocean coasts favor beach nourishment because it is ". . . the **only** engineered shore protection alternative that directly addresses the problem of sand budget deficit . . ." (NAS 1995, pg 1).

Of the three primary alternatives, all have large costs associated with them as described below, and whether nourishment is the lowest cost alternative depends on a combination of four main factors:

1) Existing sand deficit with respect to the desired scale of the beach.
2) Average, long-term erosion rate at the site.
3) Density and value of developed property at risk.
4) Proximity of beach-quality borrow sediments and their cost of transportation to the project area.

> *Beach nourishment can provide protection from storm and flooding damage when viewed within human time scales (decades not centuries) in those situations where its use is technically feasible, provided that:*
> *• erosion rates are effectively incorporated into project design . . .*
> *• . . . engineering standards are used for planning design and construction, and*
> *• projects are maintained . . .*
> *. . . Beach nourishment may not be technically or economically feasible or justified for some sites, particularly those with high rates of erosion. Government authorities with responsibility for coastal protection should view beach nourishment as a valid alternative for providing natural shore protection and recreational opportunities, restoring dry beach area that has been lost to erosion.* (NAS 1995, pg 3)

[NOTE: Signatories to this statement include Dr. R.J. Seymour, chair, Scripps; Dr. Robert G. Dean, University of Florida; Dr. Paul Komar, Oregon State University; Dr. Orrin H. Pilkey, Duke University; and Dr. Robert L. Wiegel, University of California Berkeley; among others.]

5.2 DO-NOTHING ALTERNATIVE

The do-nothing or no-action alternative is evaluated based on whether the alternative considered meets the project planning objectives. In terms of these objectives, the no-action alternative is not a viable plan of action for Dare County. Discussions of each objective are provided below.

5.2.1 Planning Objective: Preservation of the Environmental, Cultural, and Aquatic Resources of the County

The no-action alternative would not meet this objective given the current state of the beach. Continued erosion will increase the frequency of dune scraping. Forty acres of vegetation and its associated habitat will be lost. Turtle nesting habitat will be eliminated because of steep escarpments and unstable back beach areas subject to wave uprush.

5.2.2 Planning Objective: Provide an Easily Accessible Recreational Beach Available to All Citizens of the County

The no-action alternative would not meet this objective. Significant recreational beach has been lost due to erosion of the shoreline. In many locations, recreational use is limited to low tide periods. In portions of southern Nags Head, erosion has taken two rows of houses and the third row is now threatened. When structures are permitted to fail due to erosion of the beach, the costs of demolition and removal are often borne by the municipality, and the municipality and county no longer derive taxes from that property. The taxes paid by those property owners is lost and must be made up by the remaining property owners in the town and county.

An analysis was performed to estimate loss of oceanfront residential units over the ten-year projected life of the proposed nourishment project. If erosion continues at the current rate (NCDCM published erosion rates) for the next ten years (the analysis period) without addition of sand to the beach, it is estimated that there will be a loss of $117,584,694 in present worth (2006 dollars) (Table E-5, Appendix E). The properties identified as potentially lost were taken from aerial photographs with the DCM erosion rates applied over the various reaches of the town's shoreline. The baseline used was the crest of the restored dune from the 2004 post-*Isabel* dune restoration project.

Without a protective berm, there are annual repair and dune scraping costs borne by property owners along the oceanfront. After Hurricane *Isabel*, CSE personnel observed that approximately 50 percent of the oceanfront properties were scraped to push up a protective dune. It was also observed that approximately 50 percent of beachfront structures sustained damage and required significant repair. Based on building permits issued by the Town of Nags Head for years 2003 through 2005 (identified specifically for repair or replacement of beachfront structures), the average cost of repairs is $2,800 per permit.

Average cost of dune scraping is $500 per lot. If these costs are included in the ten-year analysis, including inflation of the cost each year by the average increase in the CPI since 1996 (2.55 percent), there is a net present worth associated with repairs of $9,394,000 and a present worth for beach scraping of $1,677,500. These values may be skewed because they represent post-*Isabel* approximations. But based on the experience in North Carolina at Atlantic Beach, Pine Knoll Shores, Indian Beach and Emerald Isle, the need for beach scraping and structure repairs following storms is virtually eliminated by a nourished berm.

5.2.3 Planning Objective: Provide Protection of Oceanfront Property as an Economic Resource for Tax Revenues to the Town and County

The no-action alternative would not achieve this objective. The estimated tax revenue losses to Dare County and the Town of Nags Head, in present value, are $1,775,000 (Table E-6, Appendix E). This is a very conservative estimate since it is assumed that the tax rate remains constant over the ten-year analysis period, the property values used as tax values, and the annual appreciation rate for real estate is 4.8 percent.

These revenue losses would have to made up by other taxpayers in the town and county by increasing ad-valorem taxes on non-oceanfront properties and, in the case of the county, by additional taxes levied on properties located in Kitty Hawk, Kill Devil Hills, properties south of Nags Head, and other county properties not on the Outer Banks.

5.2.4 Planning Objective: Maintain the Economic Viability of Tourism, the County's Largest Industry

The no-action alternative would not meet this objective. Healthy beaches providing suitable recreational beach are the main attraction of the tourism industry. Loss or degradation of that attraction would have a significant impact on the tourism industry. Loss of oceanfront properties would eliminate indefinitely the rental income and associated economic activity generated by such income. For only the economic factors evaluated, there will be significant economic losses for the do-nothing alternative. Those are summarized as follows:

Total Economic Costs for No-Action Alternative (10 Years)	
Loss of value of condemned properties	**~$117,584,000**
Loss of property tax revenues by town and county	**~$1,775,263**
Cost of repairs of beach front structures and beach scraping	**~$11,071,500**
Total	**$130,430,763**

Estimates are present worth of escalated annual costs. Details of determination of costs are presented in Appendix E.

The herein-listed estimates have been determined for a ten-year project life. Given the marginal condition of the beach today, it is likely that the cost of repairs will increase faster than the rate of inflation and faster than the above estimates because shoreline damage increases geometrically with decreasing distance to the waterline. In the analysis of Appendix E, it is assumed that costs occur equally in each of the ten years for each cost category. Additionally, escalation rates for real estate used in the analyses are 4.8 percent annually compared to a historic appreciation in market value of 10–15 percent annually. Therefore, estimates are very conservative. No economic loss is provided for decreased rates in property appreciation, reduction of tourism visitation, and subsequent loss of tourism revenues due to continued deterioration of the beach. Estimation of these losses is possible, but beyond the scope of the analyses provided in this EIS.

5.3 RETREAT/RELOCATION ALTERNATIVE

This alternative involves moving oceanfront structures that are threatened by erosion of the shoreline. Based on an analysis of aerial photographs of the town beachfront and upon the NCDCM annual erosion rates, 137 single-family oceanfront properties are identified as being potentially lost over the ten-year period from 2006 to 2016. These properties would be condemned due to beach erosion. There are tax revenue losses accumulated to Dare County and the Town of Nags Head in addition to the substantial loss of property value to the individual property owners.

The retreat/relocation alternative is evaluated based on whether the alternative plan meets the project planning objectives. In terms of those objectives, the retreat/relocation alternative is not a viable plan of action for the Town of Nags Head. Discussions of each objective follow.

5.3.1 Planning Objective: Preservation of the Environmental, Cultural and Aquatic Resources of the Town

The retreat/relocation alternative would not meet this objective given the current condition of the beach. Continued erosion will increase the frequency of the need for beach scraping. Many acres of vegetation and its associated habitat will be lost. Turtle nesting will be eliminated because of steep escarpments and unstable backbeach areas subject to wave uprush.

5.3.2 Planning Objective: Provide an Easily Accessible Recreational Beach Available to All Citizens of the Town and County

The retreat/relocation alternative would not meet this objective. Significant recreational beach has been lost due to erosion of the shoreline. In many locations, recreational use is limited to low-tide periods. Additionally, with the loss of oceanfront properties, there is loss of viable beach access areas. In Nags Head, beach access is provided at locations where public street rights-of-way dead end at the back of the dunes. Loss of the ocean-front property will include loss of these beach access areas.

In addition to the loss of recreational beach areas, there are significant costs associated with maintaining protective dunes and beach access structures in the absence of a protective beach. These costs are presented herein under the do-nothing alternative (Section 5.2).

5.3.3 Planning Objective: Provide Protection of Oceanfront Property as a Resource for Tax Revenues to the Town and County

The retreat/relocation alternative would not achieve this objective. Details of the evaluation are provided in Appendix E. The total losses are evaluated and expressed herein in terms of the net present worth in year 2006. The evaluation includes annual escalation of construction costs and land values. The losses include the costs of property lost, costs of property that must be purchased to relocate a structure, and the costs of relocation. The analysis addresses only single-family residential properties. Commercial and multi-family properties typically cannot be moved, and the loss of the property is not recoverable. Costs are distributed equally over the ten-year study period with escalations included for real estate value and construction costs.

The analysis of the retreat/relocation alternative is shown in Table E-8 and Table E-9 in Appendix E. The present worth of the retreat/relocation alternative is $491,779,000 compared to the project costs for beach nourishment of some $30,000,000. Both represent year 2006 costs. [Note: This does **not** count the costs associated with the no-action alternative, many of which will also apply under the retreat/relocation alternative.]

5.3.4 Planning Objective: Maintain the Economic Viability of Tourism, the Largest Industry in Nags Head and Dare County

The retreat/relocation alternative will not meet this objective. Healthy beaches providing suitable recreational beach are the main attraction of the tourism industry. Loss or degradation of that attraction would have a significant impact on the tourism industry. As with the no-action alternative, loss of vacation rental revenues is not quantified in this EIS. Loss of oceanfront properties would eliminate indefinitely some rental properties and reduce the remaining number of viable the rental properties, thereby reducing rental incomes and associated economic activity generated in the town and county.

5.4 THE COSTS OF DOING NOTHING – SUMMARY

The costs associated with doing nothing or adopting a retreat/relocation strategy are similar and are additive. When a property is threatened by erosion, the current default strategy is a combination of doing nothing and relocating structures where feasible. In the past 20 years, there have been substantial losses of properties along the Nags Head shoreline. The costs associated with these losses become more significant when considered in terms of current real estate values and construction costs.

When costs associated with doing nothing and adopting a retreat relocation strategy are considered in combination, the numbers are very large. The estimated costs (in 2006 dollars, present value) presented above are summarized as follows:

Loss of property tax revenues by town and county	**~$1,775,263**
Cost of repair of beachfront structures	**~9,394,000**
Cost of beach scraping	**~$1,677,500**
Cost of retreat/relocation including loss of economic value of condemned properties ($117,584,694)	**~$491,779,000**
Total	**$504,625,763**

5.5 PREFERRED ALTERNATIVES

The preferred alternative is beach nourishment at a level which fully restores the profile deficit with respect to a "healthy" beach and provides advance nourishment to accommodate the background erosion rate while the town waits for implementation of the federal project. Nourishment is the only practical solution that will offset the sand deficit, maintain the recreational beach, and protect developed property and community infrastructure. There are many ways beach nourishment can be accomplished. This section of the EIS outlines the main implementation alternatives with respect to sand sources, beach fill design, methods of construction, construction schedule, and maintenance.

5.5.1 Alternate Borrow Areas

Based on previous practice along the U.S. East Coast, the following classes of borrow sources have been used for beach nourishment (CERC 1984):

– Lagoon sediments	– Offshore deposits	– Inland deposits
– Inlet shoals (inshore)	– Recycled spoil sediments	– Freshwater pond deposits
– Inlet shoals (offshore)	– Accreting spits/beach deposits	– Fillets at jetties
– Nearshore bars	– Attached bar deposits	– Imported material

In general, economics favor the borrow source(s) that matches the native beach quality, involves the shortest transportation distance, and minimizes environmental impacts. Large-scale projects such as the Nags Head emergency nourishment project require large volumes of material which may not be available in only one deposit.

5.5.1.1 *Unacceptable Sources*

The following sediment sources are considered unacceptable for the project.

Lagoon Deposits in Roanoke Sound – Generally much too fine compared to native beach sand and would not provide sufficient quantities of beach-compatible sediment.

Nearshore Bar(s) Along the Project Area – Part of the active profile and important for wave energy dissipation, therefore inappropriate as a borrow source; sediments too fine for the dry beach in this setting.

Accreting Spits/Beach Deposits – There are deposits of sand in spits and ebb tidal shoals adjacent to Oregon Inlet. Dredging of these deposits involve significantly more environmental consequences and are more expensive to transport to the beach than the offshore deposits.

Inland Deposits – Material imported from sand mines in Currituck County were used for building dunes in Nags Head and Kitty Hawk. Sufficient quantities of these materials do not exist to complete the Nags Head Beach project. Additionally, based on the history of truck-hauling projects on the Outer Banks (Nags Head and Kitty Hawk), the costs associated with transporting the material to the beach are three to four times the costs of dredging offshore deposits.

Freshwater Pond Deposits – There are no known freshwater ponds nearby that require maintenance excavations or that could provide the quantities of beach compatible sediment required for the project.

5.5.1.2 *Acceptable Sources*

The following sediment sources were evaluated in more detail because of their likelihood of providing acceptable material (Appendix D).

Offshore Deposits – Suitable sand deposits were identified by the Corps of Engineers in the Dare County Beaches EIS and confirmed by CSE studies described in Section 4.0 of this EIS. These deposits are located directly offshore of the Nags Head beaches and amount to in excess of 100 million cubic yards of beach-compatible sand. The texture of the material and proximity of the deposits to the project area make the material the most feasible source of sand for the project.

Inlet Shoals (Inshore) – There is a significant accumulation of sand in the flood-tidal shoals of Oregon Inlet. The shoals are located inshore of the Oregon Inlet Bridge and are generally 5–6 miles (pipeline distance) from the southern town limits and up to 16 miles from the northern limits of the project. Sand form the shoals would have to dredged by hydraulic dredge incorporating a number of booster pumps to move the material for use over the entire project area. The pumping distances are not economically viable when compared to sand available from the offshore borrow areas. Additionally, the ephemeral flood tidal shoals are habitat for a number of shore bird species that are highly protected. The environmental consequences, level of coordination required, and the potential for dis-approval by regulatory agencies make this source of sand not feasible when compared to the offshore borrow sources.

Inlet Shoals (Offshore) – There are significant deposits of sand available from the ebb-tidal deltat shoals of Oregon Inlet. This material has been dredged recently as part of channel maintenance activities by the USACE. The material was deposited on the beach at the northern end of Pea Island adjacent to Oregon Inlet. CSE determined the location of the placement of the dredge spoil, sampled the material, and analyzed the sand samples for texture and suitability for beach nourishment. The material is generally fine-grained sand, acceptable for beach nourishment under the sand compatibility criteria recommended for approval by the NCCRC. However, the overfill ratio associated with the material, a measure of the size similarity of the material to the native beach sand is ~7.0. This means that as much as 7 cy of sand from the flood-tidal shoals are required to last as long on the beach as one yard of native sand. This makes the total volume required for construction of a stable beach non feasible when compared to the sand available from the offshore borrow areas.

Recycled Spoil Sediments – There are no feasible sources of dredge spoils available to be pumped to the beaches of Nags Head.

5.5.2 Alternate Methods of Construction

There are two basic methods for nourishing beaches: (1) via land-based equipment and mechanical placement or (2) via hydraulic equipment (ie, dredges). In either method, mechanical equipment (such as dozers, graders, etc) is used to spread the material in a controlled manner. Some projects involve combinations of hydraulic and mechanical transfer. The preferred method depends on the scale of the project, proximity of the borrow area, and type of borrow area. Hydraulic dredges involve high initial costs to cover the setup of discharge pipeline, etc. Land-based equipment (such as trucks or scraper pans) can be mobilized at low cost. After mobilization, the unit costs of sand placement depend on transportation distance. In general, unit costs of hydraulic fills are lower because of efficiencies in production and placement. Therefore, large-scale nourishments such as the proposed project tend to be more cost effective if constructed by hydraulic dredge.

5.5.2.1 *Methods Considered Unsuitable*

The following excavation and sand transfer methods are considered unsuitable for the present project.

Over-Road Trucks – It is not economically feasible to move sand from sand mines in Currituck County, western Dare County, or Roanoke Island to the beach.

Mechanical Conveyor Belt – None of the designated borrow areas are situated close enough to the project area for this technique to be economic.

Dragline – None of the designated borrow areas are situated close enough to the project area for this technique to be economic.

Traditional Hydraulic Cutterhead Dredges – Ocean-certified dredges are required by the U.S. Coast Guard for any excavations seaward of the COLREGS line. Generally, ocean-certified hydraulic dredges are the largest of their kind due to the certification requirements. Such dredges require a minimum operational depth of ~20 ft and work most efficiently if excavations remove at least a 10-ft-deep section. Hydraulic dredges may be used for the Nags Head project but have operational limitations due to wave conditions that may make their use impractical compared to other methods available. When wave heights exceed 3–4 ft, hydraulic dredges cannot operate because of the potential for damage to equipment.

Miscellaneous Methods – Bucket dredging and transfer by barge are not cost-effective for offshore area S1 and are generally not allowed seaward of the COLREGS line. Split-hull barges are not considered feasible because they require a minimum water depth of the order 20 ft for discharge. This depth would place the material too far seaward to achieve the project goals.

5.5.2.2 *Methods Considered Suitable*

Ocean-Certified Hopper Dredge – Self-propelled hopper dredges with built-in pumpout capability are feasible for borrow area S1. Ocean-certified equipment typically requires ~25 ft minimum operational depth and is efficient for excavating shallow cuts of the order 1-4 ft. During excavation and loading, the slurry drains via scuppers discharging some fines in situ and leaving coarser material in the hopper compared to the excavated material. When loaded, the dredge travels to a temporary mooring and submerged pipeline near the project site. It hooks up to the pipeline and pumps the material from the hopper to the beach where it is spread mechanically by dozers.

Ocean-Certified Suction Dredge Equipped for Shallow Cuts – One such dredge exists among U.S. companies which has been specially designed for shallow cuts. This "dust-pan" dredge (so nicknamed) is presently owned by Weeks Marine Inc (NJ) and is used primarily for beach nourishment involving thin borrow areas offshore (P Lamourie, Aug'99, pers comm). The dredge works most efficiently if the borrow area is close to the project area (eg, excavations paralleling the beach less than one mile offshore). The slurry is pumped directly to the beach via submerged pipeline and distributed with the aid of dozers and other land-based equipment. In contrast to self-contained hopper dredges, the excavations are pumped only once and therefore transfer more fines to the beach according to the quality of the sediment in the borrow area. Unit costs may be substantially lower than all other methods if the pumping distances are short. This method is considered feasible for borrow area S1.

5.5.3 Alternate Construction Schedule

The proposed project involves a substantial volume of sand (up to 4.6 million cubic yards). Based on project experience elsewhere, one ocean-certified dredge can excavate and place on the order of 15,000-40,000 cy in a 24-hour period. The average production per day varies widely according to transportation distance and specifications of the project. In any case, a substantial period of time will be required to complete the project. For example, if production averages 20,000 cy per day, at least 225 calendar days (~7.5 months) will be required.

A major factor that must be considered for work along the shoreline of the Outer Banks is weather. Wind and wave conditions characteristic of winter weather (November to March) would present a hazard to both hopper and hydraulic dredging operations. Frequent northeasters will require that the dredging equipment seek refuge at Chesapeake Bay (Tidewater, Virginia) safe harbor locations when storms are predicted to impact the project area. The downtime associated with shutdown and redeployment of the dredges represents a significant economic impact on the project. Permitting the dredges to work over the warm weather months would relieve this risk to man and machine and provide conditions where the work could be completed in a much smaller time period, thus reducing the duration of environmental impacts.

The following general construction schedules were considered (including advantages and disadvantages).

5.5.3.1 *Construction Anytime Based on Dredge Availability and Lowest Bid*

Advantages – Likely results in lowest construction cost and substantial financial savings to the community because the contractor controls the schedule around other workload and weather and only mobilizes once. Yields the earliest project completion and initiation of improved storm protection and recreational benefits.

Disadvantages – Likely encroaches on high biological productivity periods, nesting seasons, and tourist season.

5.5.3.2 *Construction During Limited "Environmental" Windows Between ~November and ~April*

Advantages – Direct environmental impacts occur during periods of lowest biological productivity. Avoids prime tourist season. Yields significant economic benefits if the project can be initiated in the shortest possible time period.

Disadvantages – Weather conditions predominant in the project area during the winter months will increase safety risks and potential downtime while dredging equipment seeks safe harbor during severe weather periods. The result is a longer construction period, prolonged environmental impacts, and increased project costs.

5.5.3.3 *Construction During Two Seasons Within Limited "Environmental" Windows*

Advantages – The only viable schedule in the event only one dredge is available for the project. Generally similar environmental advantages but produces direct impacts over two seasons rather than one (not along the same project reaches).

Disadvantages – Will require at least two mobilizations, increasing the project costs. Postpones project benefits (wider beach, improved storm protection, etc.) for the areas uncompleted during the first window. Causes disruption to habitats over two seasons instead of one.

Other schedules considered but found not acceptable were:

- Yearly fills for limited reaches – result in much higher construction costs because of multiple mobilizations and repeated environmental impacts and disruption to normal beach use; delays project benefits along reaches constructed last.
- Multiple, smaller scale fills – result in much higher construction costs because of multiple mobilizations and the additional labor required to place "thin" nourishment sections; produce repeated environmental impacts and delay natural recovery of biological populations; do not fully restore the deficit, leaving property and backshore habitats insufficiently protected during storms.
- Medium scale fill with maintenance renourishment – essentially the same disadvantages as multiple, smaller scale fills.

5.5.4 Requested Construction Schedule

From the above list of options, 5.5.3.2 and 5.5.3.3 are proposed – namely, construction during environmental windows which may extend through the summer and include the fall and spring. Specifically, permission is requested to commence construction as early as 1 March and continue construction as late as the end of November, and during multiple years, if necessary.

It is expected that reviewing agencies will specify environmental monitoring. Based on our understanding to date, the following is proposed:

1) Ecological species monitoring aboard each dredge during all hours of operation, except in January and February. Any encounters with endangered or threatened species will be recorded and reported to the appropriate agencies.
2) Sea turtle crawl and nest monitoring will take place each morning on the nourishment beach between the calendar dates specified by the agencies. Nest relocation will be performed by qualified personnel prior to construction of that project section.
3) The beach sampling, benthic sampling, and fish trawls as listed in the program outlined in Appendix C.
4) Sampling for mud content in the placed nourishment sand.
5) Other environmental sampling specified as conditions in the permits.

6.0 ENVIRONMENTAL CONSEQUENCES

6.1 LAND USE

Nourishment of Nags Head's beach will not change the land use patterns. Development of the shoreline is governed by zoning regulations of the municipalities, Dare County, and CAMA Land Use Plans approved for each governmental entity. Oceanfront development will remain primarily single family residences with patches of multi-family and hotel development. The beach nourishment project is consistent with the approved CAMA Land Use Plans for Dare County and the Town of Nags Head.

6.2 WETLANDS

No impacts to existing coastal wetlands or 404 wetlands will result from this project. No fill will be placed in 404 or coastal wetlands as part of this project.

6.3 UNIQUE AGRICULTURAL LANDS

The beach nourishment project will result in no impacts to agricultural lands, unique or otherwise.

6.4 LITTORAL PROCESSES

The project area is subject to tropical and extratropical cyclones (ie, hurricanes and northeasters). With a shoreline azimuth averaging 338° (relative to true north), nearly 95 percent of waves approach Nags Head from 10° to 130° (relative to true north). At decadal scales, net longshore transport is southerly (Inman and Dolan 1989) at rates variously estimated from ~500,000 to 1 million cubic meters per year (m^3/yr) [~650,000–1,300,000 cubic yards per year (cy/yr)]. Morphologic evidence of spit growth and shoaling in Oregon Inlet (~5 miles south of Nags Head) confirm the net southerly drift in this setting over long time periods.

Studies by the US Minerals Management Service (Byrnes et al 2003) and the present study show that net longshore transport may be directed north in some years. Byrnes et al and the present analysis (Section 4.4 and Appendix A) show net northerly transport along Nags Head during recent years ranging from ~250,000 m^3/yr (~325,000 cy/yr, Byrnes et al 2003) to ~540,000 m^3/yr (~700,000 cy/yr, this report). During all time periods, there is moderate-to-high wave energy directed south and north under the influence of northeasters and the prevailing southeasterly swell.

Following are some specific findings of littoral processes analyses in the present study and the potential impact of the project on them (supported by results in Inman and Dolan, 1989, USACE 2000, Byrnes et al 2003).

6.4.1 Wave Climate

Waves that approach from 10° to 130° (from north) comprise nearly 94 percent of the waves at Nags Head (NC) in a three-year record (2002-2005). Mean significant waves range from 2.0 ft and 7.55 seconds (s) from the southeast to 5.2 ft and 8.1 s from the northeast based on the analysis of hourly records for station WR630, ~10 miles north of Nags Head (USACE, unpublished date).

The proposed project will not change the incident wave climate. However, the borrow area has the potential to increase wave energy density at the beach due to shoaling and refraction over changed bottom conditions. The present analysis shows the range of increase is 3.4–10.3 percent.

Wave energy density is dependent on the borrow area dimensions. A 2-ft increase in depth has the potential to increase the energy density at the beach by ~2.4 percent and increase the length of shoreline affected by ~90 ft for the given borrow area dimensions and wave climate.

The shoreline affected is dependent on the width of the offshore excavation. For a borrow area width of 3,098 ft, the energy density increase can range form 278 ft to 3,303 ft for the three-year wave climate indicated.

Local increases in wave energy density in some sections of shoreline will be offset by decreases in adjacent reaches such that there will be no measurable modifications of wave energy density when integrated over the entire project length. Further, the zone of increased wave energy density will not remain constant, but will shift along the shoreline with changes in wave direction. Given the relatively small length of the borrow area in the longshore direction (order of one mile) and its close proximity to shore (order of 2–3 miles), only a small portion of the project area will be directly in the cone of influence of modified waves. This is expected to produce an insignificant effect on net sediment transport and erosion along the beach and have no effect outside the cone of influence (ie, along northern Nags Head or Cape Hatteras National Seashore).

6.4.2 Profile Closure Depth

The proposed borrow area is situated about 2–3 miles offshore in water depths ranging from ~45 ft to 60 ft. Excavations in the borrow area are expected to have no impact on the active littoral profile. Several methods were used to estimate a profile closure depth range for Nags Head beach. Using Hallermeier (1978) and Birkemeier (1985) formulas:

- Closure depths were found to be between 5.5 m and 7.3 m (18 ft and 24 ft) in this setting.

- A modeled storm wave provided an estimate of closure between 5.0 m and 6.6 m (16 ft and 21 ft).

- Measured closure depths from profiles at nearby Duck (NC) were found to be between 3.9 m and 6.4 m (12.8 ft and 21 ft).

For purposes of project planning and fill design, a profile closure depth of 24 ft is adopted, consistent with USACE (2000).

6.4.3 Impact on Shoaling in Oregon Inlet

The proposed project length is ~10 miles with its southern terminus about 5.2 miles north of Oregon Inlet. Analyses of coastal processes indicate there will be no measurable impact on incident waves or net sediment transport as a result of the proposed project. Localized, small-scale increases in wave-energy densities landward of the borrow area will be balanced by nearby decreases. Over the project length scales involved, there will be no discernable affect on sediment transport or erosion of the fill. Recently, Nags Head has eroded at an average of 5.2 cy/ft/yr with much higher rates of loss at the southern end. After the project, erosion losses are expected to be comparable. The applicant seeks to place sand, which is slightly coarser than what exists now, along the southern end of Nags Head. This same material will be slightly finer than what exists at the northern end of the project area. This potentially may reduce the rate of sand loss (incrementally) at the southern end of Nags Head. Such an effect would reduce shoaling in Oregon Inlet. Because such effects are expected to be subtle and difficult to distinguish from present sediment transport conditions, it is concluded that the project will have a neutral impact on shoaling in Oregon Inlet.

6.5 PUBLIC LANDS

The project will not reduce the existing public rights or use of beach resources. The Public Trust Doctrine and the State Property Sovereignty Rules preserve the rights of all citizens of North Carolina for use of resources located below the mean high waterline. Additionally, the Town of Nags Head will obtain permanent easements from oceanfront property owners within the project limits. The easements will grant access for construction and measurement, and establish permanent rights for the public to cross lands above the mean high waterline if those lands are created by filling operations financed with public funds.

Principal elements of the town's infrastructure are streets and water lines that are owned and maintained by the Town of Nags Head. Continued erosion, increased at times by hurricanes and northeasters, has made these important elements irreplaceable and has been responsible for some beachfront houses being condemned. The project will help protect the town's infrastructure from future storms.

6.5.1 Public Access to Beach Resources

Public access to the beach has been developed extensively by the Town of Nags Head. The town will maintain all beach access points more or less according to set specifications of the USACE for public access to federally maintained beaches during nourishment projects. If, during the project, any vehicle access points are blocked by pipelines, ramps are to be installed to facilitate continued use.

6.6 RECREATIONAL AND SCENIC AREAS

Project construction will produce ~100 acres of dry beach for recreational use. The newly nourished, dry-beach area will enhance the beach by providing areas for activities during all tidal conditions. This is a tremendous benefit to the Town of Nags Head, which relies on the beach and on opportunities for beach activities to attract visitors.

The fall season is the peak period for surf fishing on Nags Head with activities tapering off during November and December. The beach nourishment operations are scheduled to occur between the months of March through December. Surf fishing will not be limited along the beach except in the immediate vicinity of the discharge pipe and earthmoving equipment.

The Town of Nags Head has proposed to use the project as an eco-tourism attraction during the months of high visitation. This strategy can actually increase visitors to the area so they may have a first-hand account as to what happens during a nourishment project.

6.7 CULTURAL RESOURCES

Pursuant to provisions of the Abandoned Shipwreck Act of 1987 and Section 106 of the National Historic Preservation Act, the USACE–Wilmington District consulted with the Underwater Archaeology Unit of the North Carolina Division of Archives and History to assess potential impacts of beach nourishment on maritime research (USACE 2000). The consultation led the USACE to contract with Mid–Atlantic Technology and Environmental Research Inc (MATER). During the summer of 1997 and fall of 1998, proposed borrow and fill areas for the Dare County project were surveyed by marine magnetometer, side-scan sonar, and terrestrial reconnaissance (visual). The surveys resulted in no findings of any cultural resources and recommended clearance for the proposed project (Appendix B, MATER 1999).

If required by state or federal resource agencies prior to the emergency project construction, the Town of Nags Head will contract with a qualified, cultural resource survey company to provide reconfirmation of no presence of historical artifacts. Such work will be conducted in coordination with the North Carolina Division of Archives and History per provisions of the National Historical Preservation Act.

6.8 AIR QUALITY

Discharges of pollutants into the air will occur as a result of the operation of dredging equipment offshore and earthmoving equipment on the beach. The discharges will be temporary and localized, and will not result in any significant impact to ambient air quality standards along Nags Head or in Dare County.

6.9 WATER RESOURCES

Temporary increases in turbidity are expected in the immediate dredging and fill areas. The sediments from borrow area S1 (subareas 1, 2, and 3) are highly beach compatible with only minor amounts of find-grained sediment. Without significant mud in the borrow area (composite mud is <2 percent), turbidity plumes will be limited to the immediate borrow and fill areas. A study conducted by the New York District (USACE 2001) revealed that with respect to spatial and temporal scales, the effects of beach fill operations on turbidity conditions appear to be limited to a relatively narrow swath (less than 500 m) of beachfront and time periods measured in hours or less. Dispersal of suspended sediments is prominent in the swash zone in the immediate vicinity of the operation and can be traced into nearshore bottom waters (USACE 2001). Turbidity cannot be prevented, but is expected to be minimized by using compatible beach fill material. Once pumping ceases, turbidity levels are expected to return in hours to ambient conditions.

Van Dolah et al (1992) concluded that dredging and nourishment appeared to have little effect on average turbidity levels observed at borrow sites or in the surf zone adjacent to newly nourished beaches. The only notable increase in turbidity levels tends to occur in the immediate vicinity of the pipeline discharge (scales of hundreds of meters of shoreline affected). During the 1993 Folly Beach (SC) nourishment project, Van Dolah et al (1994) concluded that although dredge effluent increases turbidity levels in the immediate vicinity of the outfall, there are many other factors such as local weather and wave energy that also produce elevated turbidity (NRC 1995). Van Dolah et al also noted that “the turbidity levels found at Folly Beach during nourishment and the dispersal of the sediment plume were not considered unusual or severe relative to normal fluctuations and background levels."

6.10 GROUNDWATER QUALITY

No action proposed as part of this project will have an impact on surficial or deep aquifer groundwater.

6.11 INTRODUCTION OF TOXIC SUBSTANCES

No action proposed as part of this project will cause an intentional discharge of hazardous materials into the environment. Insignificant discharges of hazardous substances could possibly occur as a result of operation of mechanical equipment on the dredging platform or by earthmoving equipment operating on the beach. State and federal regulations place a high burden of responsibility on the owner and operator of such equipment to prevent hazardous discharges. Regulations for reporting and dealing with discharges are administered by the U.S. Coast Guard. As part of their normal operations, Coast Guard personnel will conduct safety inspections of vessels and equipment operating in coastal waters. Such inspections include identification of possible discharges of hazardous substances.

6.12 NOISE LEVELS

Dredging equipment in the ocean and earthmoving equipment on the beach will result in increased noise levels in the vicinity of the equipment during beach nourishment operations. Beach filling and shaping operations will progress down the beach at a rate of about 300 ft per day, ensuring that no single location will experience increased noise levels for more than a few days.

6.13 WATER SUPPLY AND WASTEWATER SYSTEMS

There are no activities associated with this project that will directly impact existing wastewater collection, treatment, or disposal systems. No activities of this project will impact potable water well sources or distribution systems in the Town of Nags Head or Dare County. Placement of sand and construction of a wider beach will provide additional protection to certain water supply and wastewater systems positioned close to the beach (indirect impact).

6.14 MARINE RESOURCES

6.14.1 Offshore Resources

Postproject monitoring studies of borrow areas from six different nourishment projects in South Carolina (Folly Beach, Seabrook Island, Edisto Beach, Hunting Island, Hilton Head–Joiner Bank, Hilton Head–Gaskin Bank) revealed that the majority of sites were infilling with clean sands that would be suitable for future nourishment projects, and complete refilling of these sites would require 5.5–11.8 years (Van Dolah et al 1998). The proposed offshore borrow area(s) (S1) for Nags Head are in depths between 45–60 ft mean low water (MLW). Potential subareas located in borrow site S1 have been identified and delineated according to sediment characteristics (Appendix D). These areas are subject to currents which can move sediment during extreme events Thus, the conclusion is that the borrow areas will gradually infill over time as sediment from the immediately adjacent area sloughs into dredge cuts. This infilling process is expected to take years (similar to South Carolina experience). As per management plans under the federal Dare County project, the specific area(s) dredged within subareas 1, 2, or 3 will not be available for future dredging.

6.14.1.1 *Sediment*

The proposed borrow areas and sediment quality are shown on the map of Figure 4.16-5. Beach fill material taken from borrow area will be replaced by natural processes and similarly textured material from the immediate adjacent areas. Further, the excavations will expose similarly sized material. Thus, the borrow area used in the proposed project is not expected to change character after dredging. Newly exposed sediments will release nutrients into the water column and promote recolonization.

6.14.1.2 *Biology*

There are several environmental issues relating to the benthic habitat and resources that arise in considering a beach nourishment project. The most significant include:

1) Impacts to and recovery of the benthic invertebrate community at the borrow sites.

2) Potential impacts to commercially or recreationally important demersal fishes and crustaceans, in part, because of these effects on their benthic invertebrate prey.

3) Impacts to and recovery of the benthic invertebrate community on the intertidal and shallow subtidal beach.

4) Potential impacts to commercially and recreationally important fishes in the surf zone and/or shorebirds, in large part, because of these effects on their benthic invertebrate prey and because of enhanced turbidity along the shoreline.

The biological monitoring program set forth by the USACE (2000) and Versar (2006, Appendix C in this EIS) summarized herein is intended to address each of these issues.

6.14.1.3 *Vertebrates*

Fish, plankton, and other motile animals in the vicinity of the borrow area during dredging are least likely to be affected during dredging, because of their ability to avoid the disturbed areas. Fish species have been observed to leave the area temporarily during dredging operations and return when dredging ceases (Pullen and Naqvi 1983). A study of nearshore borrow areas after dredging offshore of South Carolina revealed no long-term impacts to fisheries, both fish and planktonic organisms, as a result of the dredging (Van Dolah et al 1992). Dredging of the bottom sediments in the borrow areas can be expected to attract fish (after the dredge leaves) as a result of suspension of bottom material as observed in other areas (Naqvi and Pullen 1982). Impacts to anadromous fish and other estuarine-dependent organisms are not expected to be significant, because construction-related activities in the offshore borrow area will be localized.

The New York District's biological monitoring after the "Asbury Park to Manasquan Section Beach Erosion Control Project" concluded that no large-scale change in the composition or abundance of the organism assemblage occurred in relation to dredging of offshore borrow areas [USACE (Burlas et al) 2001].

6.14.1.4 *Invertebrates*

Benthic organisms in the immediate area being dredged will be largely eliminated during dredging. However, initial recolonization of the dredged areas by opportunistic species is expected to occur soon after cessation of any dredging activities. Further recovery is expected from recolonization by migration of benthic organisms from adjacent areas and by larval transport. Monitoring studies of postdredging effects and recovery rates of borrow areas indicate that most borrow sites show significant recovery by benthic organisms approximately one year after dredging (Naqvi and Pullen 1982, Bowen and Marsh 1988, Van Dolah et al 1992).

The nature of hopper dredging in narrow cuts tends to encourage recolonization by organisms from undisturbed substrates. The borrow areas will not be swept clean; furrows of undredged materials will remain. The proposed project's primary environmental impact on the substrate in the borrow area will be uncovering of buried sediments and fresh nutrients in the dredged furrows, resulting in an increase in biological activity. A surface and benthic turbidity plume study conducted by Coastline Surveys Limited (CSL1999) concluded that disturbance of sediments by dredging may release extra organic materials to enhance the species diversity and population density of organisms outside the immediate zone of deposition of particulate matter.

Monitoring of impact and control areas is being performed by Versar Inc for the USACE Dare County project. Samples from impact areas will be compared with those from control areas both before and after the sand is removed. Control areas will have no sand removed, but will otherwise be affected by non-project impacts (ie, storms, shrimping, etc, that affect the impact area). Samples taken before the removal of the sand will be compared with samples taken after the nourishment to evaluate impacts. The monitoring plan calls for seasonal sampling both before and after the removal of sand to assess the seasonal component (Versar 2004).

6.14.2 Nearshore Resources

6.14.2.1 *Sediment*

Nourishment sediment will be placed on the upper part of the beach, but will flow into the surf-zone region. The placed sediments are a close match in size to the sandy beach sediments, but with lower carbonate content and <2 percent mud (Section 4.16 and Appendix D).

6.14.2.2 *Biology*

There are three direct impacts from nourishment projects:

1) Very short-lived substantial increases in turbidity during the placement operation (ranging from a couple of hours to a few days at each location) alter the water column conditions sufficiently that it causes most mobile species to leave the area; however, return is generally rapid. A study conducted by the USACE (2001, Asbury Park to Manasquan Section Beach Erosion Project) revealed that no differences in prey biomass/filled stomachs were distinguishable for any fish species in 1998 and 1999. Those data suggested that some fish species were attracted to the active beach fill location during some sampling periods (USACE 2001).

2) Burial of benthic organisms essentially destroys the community present, but Van Dolah et al (1992) reported rapid recovery of benthic communities in the nearshore area. This was probably due to the similarity of fill material to existing sediments.

3) Alteration of sediment type necessarily results in changes in type and densities of species. Numerous monitoring studies recommend that the key to minimizing impact is to match the sediment types as closely as possible (Thompson 1973, Naqvi and Pullen 1982, Van Dolah et al 1994, ACRE 1999). This is why the proposed emergency nourishment project weights the native sediment type according to the sediment quality in the surf zone. If fine-grained sand matching the outer bar were placed in the surf zone

of Nags Head, it would change the character of the substrate, impact the assemblage of organisms, and erode faster.

6.14.3 Intertidal Resources

6.14.3.1 *Sediment*

During project construction, surf-zone turbidity will increase in the immediate area of sand deposition. Most of the fine material in the beach fill is expected to be washed seaward and migrate to the outer bar during construction. The presence of fine-grained material in suspension may cause temporary displacement of various species of sport fish. This will cause a minimal impact to surf and pier fishing in the area of deposition. A study of the effects of beach nourishment on nearshore macrofauna concluded that beach nourishment projects using offshore dredged material have no long-term harmful effects, provided that the sediments are similar to those where they are placed (Saloman and Naughton 1984).

6.14.3.2 *Vertebrates*

In view of the high mobility of fish, it is expected that fish will leave the areas under active construction. Impact on fishing resources in the intertidal zone will be minimized simply by the fact that sand-placement operations will take place at any one location for only a few days and then move further along the beach. Studies have shown that most of these animals have the ability to migrate from an undesirable environment and reappear when disposal ceases (O'Connor et al 1976, Courtenay et al 1980). Quantitative impacts on fish will be judged from offshore tow counts planned under the federal Dare County project (c/o Versar Inc).

6.14.3.3 *Invertebrates*

Impacts on intertidal macrofauna in the immediate vicinity of the nourishment project are expected as a result of discharges of nourishment sediment on the beach. A study by Baca et al (1991) concluded that adverse impacts to intertidal and high-subtidal macroinvertebrates were confined to a short-term period (~3 months). They also noted that the success of a nourishment project may be attributed to the utilization of compatible beach-fill material. Parr et al (1978) noted that when nourishment ceases, the recovery of macrofauna is rapid, and complete recovery typically occurs within one or two seasons.

6.14.4 Beach and Terrestrial Resources

6.14.4.1 *Sediments*

During and after construction, the beach sediment will be sampled and analyzed by the Town of Nags Head. The primary purpose will be to determine how closely the nourishment sediment matches the native sediment.

6.14.4.2 *Biology*

Because the project is being constructed seaward of the toe of the dune, there will be little impact on the upper (dune) portion of the beach. Project construction may result in disturbance of some of the existing vegetation on the seaward side of the dune, particularly species that propagate by spread of rhizomes down the dune face. Dune stabilization may be performed in some areas after project construction by planting native vegetation on the dunes landward of the beach fill. According to USACE (2000–EIS), planting stocks for the federal project will consist of sea oats and American beach grass. The Town of Nags Head anticipates using American beach grass and will attempt other species appropriate to the site subject to availability. The vegetative cover will extend from the landward toe of the dune to the landward intersection with the nourishment berm. American beach grass is expected to be the predominant plant utilized.

The Reilly and Bellis (1983) study at Bogue Banks (NC) encompassed dry-beach sampling. They concluded that most species, including all of the larger organisms such as ghost crabs, recruited from pelagic larvae and thus recovered rapidly (one or two seasons). Currently, the USACE has a monitoring plan in place for the northern section of the federal project, but not for the southern section because both sections undergo similar processes (pers communication, Ward Slocum, Versar field chief, 01/31/2006). Borrow area S1 contains ~100 million cubic yards of compatible beach-fill material that is uniform; therefore, it was determined by USACE that the S1 borrow area will not warrant separate monitoring events for each borrow subarea. Preconstruction monitoring data collected for the Corps' Dare County project has been deemed applicable by the USACE for use on this project. The proposed project is not expected to have any adverse impacts on wildlife found along the beach or dune areas.

6.15 THREATENED AND ENDANGERED RESOURCES

Under Section 7 of the Endangered Species Act of 1973, as amended, federal agencies have a responsibility to assess the effects of proposed actions on listed species. Based on the USACE's EIS, a separate biological assessment (BA) will not be prepared for the Nags Head beach restoration project. This EIS will serve as the project BA and as a request to both the USFWS and the NMFS for their concurrence with CSE's "no affect" determinations and to request biological opinions for species that may be affected. As by request from the NMFS and the NCDMF, a draft Essential Fish Habitat assessment has been written to address any potential impacts to Habitat Areas of Particular Concern (HAPC), Essential Fish Habitats (EFH), and threatened and endangered species in the project vicinity. This EFH is included herein as Appendix F. The USACE (2000) BA of anticipated project impact is as follows.

6.15.1 Mammals

6.15.1.1 *Whales (Right, Finback, Humpback, Sei, and Sperm)*

Right whale – Of the five whale species listed, the right whale is the only species that would occur during the project. The main concern for this species is possible collisions with the hopper dredges and other vessels in the project area. All hopper dredges are required to have trained observers on board during periods of whale migrations (USACE 2000). If whales are spotted, project vessels will take necessary conservative protection measures until the species is out of the project vicinity. Food supplies and habitat conditions for the species will not be altered by the project. In addition, protective measures implemented for species establish that the project will not adversely affect the right whale.

Finback, humpback, sei, sperm whales – The habitat and food supplies for the these whales will not be affected by the project. The protective measures implemented for the project ensures that these species will not be adversely affected by project activities.

6.15.1.2 *West Indian Manatee*

In recent years, the West Indian manatee has been reported near the project area, and there is no way of predicting its occurrence there again during any given time period (USACE 2000). The project is not expected to alter food sources or habitats nor do vessel collisions pose any direct threat to this species. Due to the slow moving nature of the hopper dredges (2-3 mph) and the significant amount of noise generated from the process on board coupled with the species rare occurrence in the area, it has been determined that this project will not adversely impact the manatee.

6.15.2 Birds

6.15.2.1 *Piping Plover*

Project construction is proposed to take place during the nesting season of the piping plover (April 1–July 31); however, there are no anticipated direct impacts (ie, loss of nests) as a result of construction since the species is not known to nest in the area. Temporary disruption of the piping plover foraging habitat is expected as a result of sand placement. The USFWS (1996) has designated a critical habitat for the piping plover that extends from the southern portion of Bodie Island to the northern portion of Pea Island plus any emergent sand bars south and west of Oregon Inlet are included. Food resource disruptions should be temporary and of minor significance. While any impacts to piping plovers are expected to be minor, they cannot be avoided (USACE 2000). It has been determined that the project may affect the piping plover.

6.15.2.2 *Roseate Tern*

This species is rarely observed in Dare County, and specific nesting locations are unknown. Construction of the project will not affect nesting areas for this species nor will it significantly affect food resources for which it depends during migratory periods (USACE 2000). There will be no adverse effects inflicted on the roseate tern from the project.

6.15.2.3 *Arctic Peregrine Falcon*

The arctic peregrine falcon utilizes the beach/dune complex as a habitat, mainly during the migrating period (September–November). The project will stabilize the dune systems, creating a better habitat for this species. Temporary localized disruptions in food resources are expected, but should not significantly diminish the availability of shorebirds, the primary food source for the peregrine in the area. It has been determined that the project will not affect the species.

6.15.2.4 *Bald Eagle*

As stated in Section 4.15.2, there are no known roosting or nesting areas in the project vicinity. This species prefers to feed on fish, but it will eat a variety of mammals, amphibians, crustaceans, and birds. It is expected that the availability of food will not be significantly impacted. For these reasons, it is determined that this project is not likely to adversely impact the bald eagle.

6.15.2.5 *Red-cockaded Woodpecker*

As stated previously (Section 4.15.2), there have been no occurrences of this species in the project area. The nesting and roosting areas are found in open stands of longleaf pines 60 years old or older which are located away from the project area. For these reasons, it is determined that this project is not likely to adversely impact the red-cockaded woodpecker.

6.15.3 Reptiles

6.15.3.1 *Hawksbill, Leatherback, Kemp's Ridley Sea Turtles*

There have been known incidental takes of sea turtles by hopper dredges used for various dredging activities. In agreement with the USACE (2000) Dare County beach restoration project EIS, it is proposed that all hopper dredging for this project be conducted under a Regional Biological Opinion (RBO) issued by the National Marine Fisheries Service for hopper dredging in the southeastern U.S. All provisions of this RBO, or any issued subsequently, will be strictly followed.

6.15.3.2 *Loggerhead and Green Sea Turtles*

The loggerhead and green sea turtles are considered to be the only species most likely to nest in the project area. The primary adverse impact to these species would be alteration of their nesting habitat. This project poses a higher threat to these species due to the timing of the project (March–October 2007) which overlaps with the nesting season.

Any beach disposal operations begun before November 16 of any given year will require nest monitoring and nest relocation to assure that the area to receive sediment is clear of incubating sea turtle nests (USACE 2000). Additionally, any beach disposal operations extending into the spring (past April 30) will also require implementation of a nesting monitoring/relocation program. Every protective measure will be made to limit any adverse impacts to these species.

After nourishment construction, the beach will be monitored for compaction by CSE. If the beach hardness exceeds 500 cone penetrometer units, the beach will be tilled. Tilling will continue until beach compaction is that of the native beach before construction.

Dredging offshore may temporarily affect the foraging habits by removing food resources. This impact is considered insignificant because the availability of foraging habitat is much greater than the dredged area.

Beach construction will occur during nesting season for these species. Due to the timing of the project and the possibility of breaking eggs during nest relocation, it has been determined that the project may affect both the loggerhead and green sea turtles.

6.15.4 Fish

6.15.4.1 *Shortnose Sturgeon*

This species is considered to be a very hardy species because of its ability to survive under extremely stressful conditions (NMFS 2000). Pollution and overfishing have been considered to be the principal causes of the decline of the species (USACE 2000). The shortnose sturgeon is considered to be riverine, and its occurrence in the project area is not expected. For this reason, it is determined that the project will not affect the shortnose sturgeon.

6.15.5 Plants

6.15.5.1 *Seabeach Amaranth*

Seabeach amaranth is an annual herb found along Atlantic Ocean beaches. The typical areas where this plant is found are beaches, lower foredunes, and overwash flats (Fussell 1996). The greatest concentration of this species has been found near inlet areas on the overwash flats of accreting barrier islands. Placement of beach fill material can result in burial of the species; however, an examination of seabeach amaranth distribution indicates that the species thrives in many beach disposal sites, possibly because the disturbance generated by disposal actions mimics the natural disturbances found in its preferred habitat (USACE 2000).

Surveys conducted by the USACE in September 1997 and July 1998 did not identify any populations of seabeach amaranth in the project area (USACE 2000). Surveys will be conducted prior to construction to verify no colonization of seabeach amaranth. There is a low probability that there will be any colonization due to the existing eroded beach conditions in the project area. If seabeach amaranth is found in the project area, Section 7 coordination with USFWS would be reinitiated.

Based on the absence of the species in the project area, we have determined that the project would not adversely affect the seabeach amaranth. There is evidence from other nourishment sites in North Carolina (eg, Bogue Banks, CSE 2004) that seabeach amaranth may be favorably impacted by the construction of a wider dry beach and addition of ~100 acres of new beach habitat.

7.0 CUMULATIVE IMPACTS

The Council of Environmental Quality defines cumulative impacts as:

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

After Hurricane *Isabel* (2003), FEMA (ref: project worksheet PW 299 dated 28 September 2003) authorized an emergency dune restoration project which added 6–10 cy/ft above 7 ft NGVD on the beach along ~9 miles of the Nags Head shoreline. The project utilized an inland borrow source (~365,000 cy) for dune construction (CSE 2005–June). There were no significant environmental impacts associated with this project.

No previous nourishment events have taken place along Nags Head's oceanfront. The proposed project is a single nourishment event which will encompass ~10 miles of shoreline. The time between the FEMA emergency dune restoration project and the proposed nourishment project (~2–3 years), combined with the fact that the nourishment project will impact the recreational beach and underwater profile (not the dune), suggests there will be no cumulative impacts of these two projects.

Cumulative impacts are expected to occur if the USACE's Dare County project is constructed and renourishment is performed according to the federal schedule at ~3-year intervals. The Town of Nags Head does not anticipate renourishing the beach under a locally sponsored project for at least ten years, given budget constraints and other criteria. Cumulative impacts of the federal project are addresses in more detail in USACE (2000). The schedule for implementation of the initial federal project and its planned renourishment intervals is not available at this time.

8.0 MITIGATION

To minimize potential impacts to the project area, the following mitigation measures will be implemented:

- Follow NMFS and USACE hopper dredging protocol (Appendix G) to minimize the impacts of hopper dredging. Currently, there are no known seasonal restrictions for dredging along the northern Outer Banks.

- Full-time observer(s) will be present on the hopper dredge(s) to document visible sea turtle activity, monitor any takes of sea turtles, and watch for and alert the dredge operator of whales in the area. Observers will be on the bridge from the beginning of hopper dredge use through the end of project construction for daytime observations.

- Ensure that turtle deflector dragheads are used properly.

- A standardized turtle nest monitoring and relocation plan will be implemented. This program will include daily patrols of active beach disposal areas at sunrise, relocation of any nests identified in areas to be impacted by fill placement, and monitoring of hatchling success of the relocated nests.

  – Sea turtle nests will be relocated to an area suitable to USFWS and NCWRC.

- Borrow sand of similar grain size to the existing beach will be used to reduce any changes in physical characteristics of the beach that may affect turtle nest survival. Sand quality is expected to meet or exceed the NCCRC's "sediment criteria for nourishment and dredged material disposal projects on North Carolina oceanfront beaches" (2005).

- Beach compaction will be monitored and tilling will be conducted in areas where the post-disposal beach is harder than 500 CPUs to reduce the likelihood of impacting sea turtle nesting and hatchling activities.

- Seabeach amaranth populations will be surveyed in the proposed project area by the applicant to monitor recolonization of the plants after project completion. Within a few monitoring seasons, the data will help predict ultimate impacts of beach nourishment on seabeach amaranth at Nags Head and will be made available to the Corps' monitoring program of the plant. The proposed project will occur on areas suffering from erosion and should ultimately expand potential habitat for the amaranth.

- The applicant will perform periodic surveys of the project area so as to estimate the volumetric erosion and provide updated design criteria for application in the federal project.