APPENDIX F

CUMULATIVE EFFECTS ASSESSMENT

FIGURE EIGHT ISLAND SHORELINE MANAGEMENT PROJECT
CUMULATIVE EFFECTS ASSESSMENT

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FIGURE EIGHT ISLAND SHORELINE MANAGEMENT PROJECT
DRAFT CUMULATIVE EFFECTS ASSESSMENT

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The Council on Environmental Quality (CEQ) defines cumulative effects as *the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other action* (40 CFR 1508.7). The following report describes the methods, rationale, and results of the Cumulative Effects Assessment for the proposed Figure Eight Island Shoreline Management Project, Alternative 5D (Terminal Groin at a More Northerly Location with Beach Fill from Nixon Channel and Other Sources), in terms of the eleven (11) step process identified by the CEQ (CEQ, 1997).

Table 1. Steps included in the Cumulative Effects Analysis

Environmental Impact Assessment Components	**Cumulative Effects Analysis Steps**
Scoping	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.
	2. Establish the geographic scope for the analysis.
	3. Establish the time frame for the analysis.
	4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
Describing the Affected Environment	5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses.
	6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.
	7. Define a baseline condition for the resources, ecosystems, and human communities.
Determining the Environmental Consequences	8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
	9. Determine the magnitude and significance of cumulative effects.
	10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
	11. Monitor the cumulative effects of the selected alternative and adapt management.

As suggested by the CEQ, it is the goal of this report to “tease from the complex networks of possible interactions those that substantially affect the resources” (CEQ, 1997).

1. Significant Cumulative Effects Issues and the Assessment Goals

The goal of the National Environmental Policy Act (NEPA) process is to reduce adverse environmental effects, including cumulative effects. Cumulative effects analysis is an iterative process in which consequences are assessed repeatedly following incorporation of avoidance, minimization, and mitigation measures into the alternatives considered Monitoring is the last step in determining the cumulative effects that ultimately results from the action. The significance of cumulative effects depends upon the ecosystem, resource baseline conditions, and relevant resource stress thresholds (CEQ, 1997).

Cumulative impacts result from spatial (concentration of a multiple impacts in a given area) and temporal (repeated occurrence of impacts in a given area) crowding of environmental perturbations. In general, many environmental effects could be considered as cumulative and almost all systems have already been modified, degraded or enhanced, through anthropogenic forces.

Resource Issues and Assessment

The proposed project, in addition to past projects and any reasonable foreseeable future actions (RFFA), primarily affects the following resources: human community, beach, infaunal species, shorebirds, sea turtles, intertidal flats and shoals, salt marshes, the water column, hardened structures, and cultural resources

Human Community Resource

In general, shoreline protection projects involving beach nourishment and the construction of hardened structures have intermediate to long-term impacts on the human community. These projects interrupt natural and anthropogenic induced erosion and recession of the shoreline. They provide storm protection to dwellings and infrastructure while increasing coastal recreational such as fishing, boating, and sunbathing. These projects facilitate development of the coast where it is permitted. These positive impacts for the human community can have negative impacts on other resources whose habitats or life stage activities are directly or indirectly impacted through human activity.

Beach Resource and Associated Shorebird, Infaunal, and Sea Turtle Resources

The beachfront shoreline is comprised of three main systems: dune, dry beach, and wet beach. Sand dunes and vegetation that comprise the dune system provide protection to structures from storm surge, and habitat for wildlife. The dry beach, located between the toe of dune or scarp and the Mean High Water Line (MHWL) provides recreational areas for humans and nesting sites for sea turtles and shorebirds. The wet beach (between Mean Low Water Line (MLWL) and MHWL provides recreational areas for humans, habitat for infauna and foraging areas for shorebirds, crustaceans and fish.

Inlet Intertidal Flats and Shoals Resource

The intertidal flats and shoals found within inlet complexes provide habitat for migratory shorebirds, colonial waterbirds, marine mammals, sea turtles, crustaceans and fish. These habitats represent a dynamic ecosystem to which the above species have adapted and in some cases depend on. These habitats will be directly impacted (through removal) and indirectly by the proposed project and other current and foreseeable future projects (including maintenance dredging every five years). Of the 21 inlets found along the North Carolina coast, 11 are federally maintained for navigational purposes. The intertidal flats and shoals located within the 10 inlets that are not federally maintained do not experience the same level of direct impacts.

Water Column Resource

Natural conditions support fluctuating turbidity and total suspended solids (TSS) levels in the nearshore and offshore water columns, especially with inlets and along the oceanfront intertidal swash zones. Frequent storm events are known to increase these levels due to resuspension of sand and fine materials from strengthened wind, wave, and current actions. However, these increase levels generally occur in short durations during storm events. Anthroprogenic activities, such as dredging and beach fill activities have increased the frequencies of higher turbidity and TSS levels where those activities are taking place and tend to be a longer duration, ranging from 2-4 months depending on the size of the project. Impacts to the water column associated with these activities tend to be localized at the cutterhead or hopper dredge operating locations and at the fill disposal sites. With the increase need to provide oceanfront shoreline protection, the implementation of beach nourishment projects have been the primary means of protective measures.

The dredging of Nixon Channel and the transport of material from the dredge disposal sites along with the placement of this material on the ocean and estuarine shoreline as well as the construction of the terminal groin would result in the suspension of silt and fine fractions in the water column. The low sit/clay content of the material within the areas being dredged would result in relatively low concentrations of suspended sediment outside the immediate area of deposition. The low concentration of suspended sediment indicates that turbidities are likely to remain low during dredging and placement of material on the beaches. Turbidity and TSS measurements were recorded in association with previous beach nourishment projects on Figure Eight Island. In 2001, a permit was issued for nourishment on the north end of the island. A condition of this permit required the implementation of a monitoring program to track the impact of nourishment-induced changes in surf zone water quality during the project's duration. The turbidity concentration and the amount of TSS were determined weekly at five sites along the project area during a ten-week period. The effects of fill operations on short-term turbidity appeared to be limited to a narrow zone in the vicinity of the sediment slurry discharge point (Cleary and Knierim, 2001). Eight of the fifty turbidity measurements exceeded the State's standard for turbidity. The discharge site was the only site where an elevated average reading was recorded that exceeded the standard. Measured TSS concentrations were highest for the discharge site. The TSS values ranged from 1.0-

301.0mg/l with an average of 73.1mg/l (Cleary and Knierim, 2001) at the discharge site. The State standard for turbidity is 25 NTU while TSS does not have a defined standard.

During the Bogue Inlet Channel Erosion Response Project, turbidity levels were shown to remain within ambient conditions (9.7 to 35.2 NTUs) during the dredging operations. Any increase in turbidity associated with the excavation of the channels to the oceanfront shoreline should be of short duration. Natural conditions support fluctuating turbidity levels in the nearshore and offshore water column of the Permit Area. Storm events are known to increase these levels due to the resuspension of sand and fine materials. These fluctuating turbidity levels would continue with or without the dredging efforts proposed with these alternatives.

Many species of fish and crustaceans utilize the water column to migrate through inlets in North Carolina as part of their reproductive strategy. Penaeid shrimp, for example, are reported to spawn offshore, moving into estuaries during post-larval stage during the early spring. As the shrimp grow larger in size, they migrate to higher salinity environments. In late summer and fall, they return to the ocean to spawn (NCDMF, 2005). While the planned dredging activity may have some impact on flows in Nixon Channel, dredging within Nixon Channel would not significantly alter the hydrology of the inlet complex. Furthermore, the tidal flow through Nixon and Green Channels are anticipated to maintain their relative proportional amounts as predicted by Delft3D modeling for existing conditions. The relatively small changes in tidal prism will allow for the tidal exchange to continue within Rich Inlet, Nixon Channel, and Green Channel thereby maintaining baseline.

Hardened Structure Resources

Hardened structures constructed along the marine and estuarine shorelines are often used to help stabilize a discrete length of shoreline and protect the landward side of the structure from erosion. Currently there are several major hardened structures in place in the ocean and inlet marine environment within North Carolina. These include the rock revetment at Fort Fisher, the north and south jetties at Masonboro Inlet, the terminal groin at Pea Island, the terminal groin at Fort Macon, the Cape Lookout harbor of refuge breakwater, the Carolina Beach revetment, and the geo-tube groin field on Bald Head Island. Most recently, an unnamed inlet that was opened following Hurricane Irene in 2012 has been armored with rip-rap. Of the approximate 320 miles of ocean coastline in North Carolina, the deployment of these structures has impacted approximately 16 miles of shoreline in proximity to the 5 inlets with hardened structures. This constitutes approximately 5% of the entire North Carolina coastline. During the initial construction of these structures, several biological resources were directly impacted including the wet and dry beach which serves as roosting, nesting, and foraging grounds for a wide variety of water birds and shore birds. The dry beach is also an important nesting habitat for sea turtles. The infaunal communities, which are often a prey source for foraging birds, are directly impacted within the wet beach during the construction. Following construction, the width of the shorelines adjacent to the structures have been maintained or widened resulting in increased recreational opportunities, additional dry beach habitat for nesting sea turtles, and roosting areas for birds. In the foreseeable future, an additional 4 terminal groins may be built in North Carolina as a result of the passage of Senate Bill 110. This includes the structure proposed at Figure Eight Island.

2. Geographic Scope

This analysis will focus on the applicable geographic range per resource. The North Carolina oceanfront and inlets have been defined as the geographic range per resource. This delineation is derived from the predominant migratory routes; habitat ranges of species' potentially affected by the proposed project, oceanic circulation patterns and demographics.

Human Community Resource
The United Nations Atlas of the Oceans reports that "In the United States, around 53% of the population lives near the coast and since 1970 there have been 2000 homes per day erected in coastal areas." (UN, 2006). The primary objective of the proposed project is coastal protection of the northern portion of the Figure Eight Island shoreline. The cumulative effects of past, present and reasonable foreseeable future projects (RFFPs) are to facilitate human coastal habitation, recreation, and commerce. The geographic scope for this resource (humans) is the North Carolina oceanfront coastal shoreline.

Beach Resource and Infaunal Species Resource
The geographic scope for the beach resource (dune, dry beach and wet beach) and affiliated organisms is the North Carolina oceanfront coast, including all inlets.

The geographic scope for breeding, overwintering and/or foraging areas for federally threatened (piping plover (*Charadrius melodus*) and endangered roseate tern (*Sterna dougallii*) shorebirds and for State designated threatened species (gull-billed tern [*Sterna nilotica*]) or species of special concern in North Carolina, (Wilson's plover [*Charadrius wilsonia*], eastern painted bunting [*Passerina ciris ciris*], common tern *[Sterna hirundo*], American oystercatcher [*Haematopus palliates]*, and black skimmer [*Rynchops niger*]) is the oceanfront coast of North Carolina, including all inlets, and migratory coastal routes north and south of the State.

Five species of sea turtles utilize the waters of North Carolina for breeding, feeding, and development. These species include: the loggerhead sea turtle (*Caretta caretta*); green sea turtle (*Chelonia mydas*); hawksbill sea turtle (*Eretmochelys imbricata*); Kemp's Ridley sea turtle (*Lepidochelys kempii*); and the leatherback sea turtle (*Dermochelys coriacea*) (Epperly *et al*., 1990; USFWS, 2003a). The USFWS North Carolina Office reports that the presence of hawksbill and Kemp's ridley sea turtles along the North Carolina coast is rare (USFWS, 2008a); therefore these species are not expected to be present in the study area. The geographic scope for nesting sites for these sea turtle resources is coastal North Carolina.

Inlet Intertidal Flats and Shoals Resource
The geographic scope for the intertidal flats and shoals resource is the inlet complexes along the North Carolina coast.

Water Column Resource

The geographic scope for the water column resource is the nearshore and offshore waters in the vicinity of developed beaches along the North Carolina oceanfront coastline.

Hardened Structure Resources

The geographic scope for the hardened structure resources is developed coastal beaches and inlets along the North Carolina oceanfront coastline.

3. Time Frame

This CEA considers known past, present and RFFP dredge and fill projects that have, may, or will occur in the geographic scopes. For this CEA, our timeframe, with the exception of the Hardened Structure Resources, will consist of actions occurring within the past 50 years, current projects, and projects that may be implemented over the next 50 years. For Hardened Structure Resources, all existing structures regardless of when they were constructed were included in the assessment. This approach was taken due to the relatively low number and to adequately address their cumulative effects on the shorelines of North Carolina. For other actions, the past 50-year time period was chosen as it covers the initial nourishment of Wrightsville Beach in 1965. Since that time, numerous dredge and fill projects have occurred within the geographic scope of this proposed project. A CEA time frame extending within the next 50 years would capture current Federal projects where planning and implementation includes a 50 year period. For most private projects, it is considered immoderately speculative when extending beyond a 10 year period due to the availability of suitable nourishment and renourishment material, cost of projects, and demographics. For the purposes of this analysis, the lengths of beaches nourished along the North Carolina oceanfront coastline were analyzed. In areas where initial nourishment and subsequent renourishments have occurred, the greatest length of beach affected was considered for this CEA.

4. Other Actions Affecting Resources of Concern

Anthropogenic actions affecting resources of concern are inlet management and maintenance, maintenance of navigation channels, beach (re)nourishment projects, beach scraping, dune enhancement, placement of hard structures along shoreline, placement of soft structures along shoreline, population increase, continued residential, commercial, and light industry development on barrier islands, and commercial and recreational fishing activity.

Natural actions affecting resources of concern are seasonal and sea level rise, and natural barrier island and inlet processes influenced by wind, currents and tidal energy. The potential for the increase in the rate of damaging storms and hurricanes in light of global climate change has been the source of debate within the scientific community. The International Panel on Climate Change (IPCC, 2007) concluded that global mean sea level rose at an average rate of about 1.7 ± 0.5 mm/year during the twentieth century. Recent climate research has documented global warming during the twentieth century, and has predicted either continued or accelerated global warming for the twenty-first century and possibly beyond (IPCC, 2007). This rate is anticipated to increase over the next 100 years. Rahmstorf (2007) predicts that global sea level in 2100 may rise 0.5 m (1.6 ft) to 1.4 m (4.6 ft) above the 1990 level. According to www.tidesandcurrents.noaa.com, the regional trends in North Carolina show an increase of 0 to 3 mm/yr (0 to 0.00984 ft/yr), or a 0 to 1 ft/century. With measured rates of shoreline change ranging between 2 and 5 ft per year, sea level has very little impact on shoreline change. In 2012, the State of North Carolina passed legislation (House Bill 819) declaring that only "historic rates of sea-level rise may be extrapolated to estimate future rates of rise but shall not include scenarios of accelerated rates of sea-level rise unless such rates are from statistically significant, peer-reviewed data and are consistent with historic trends." As such, the State of North Carolina has not adopted a planning benchmark for sea level rise, and no such benchmark is currently under consideration.

The minimal impact of increased sea level rise has been noted through the performance of the Wrightsville Beach and Carolina Beach federal storm damage reduction projects. Both of these projects have been in existence since 1965 and have been subjected to the same rate of sea level rise applicable to Figure Eight Island. A review of the nourishment rates for these two projects shows no significant changes in the volume or frequency of periodic nourishment needed to maintain the projects.

The following is a summary of activities that have or potentially could impose cumulative impacts on Rich Inlet and the oceanfront shoreline of Figure Eight Island and the adjacent islands.

Relocation and Maintenance of Mason Inlet

Mason Inlet is a tidal inlet connecting the Atlantic Ocean and Mason Creek between Wrightsville Beach and Figure Eight Island. The relocation project involved the excavation of a new inlet through Figure Eight Island and the maintenance of the new location for 30 years in order to protect threatened properties. The relocation of the inlet approximately 3,500 feet to the northeast was completed on March 7, 2002 and the old channel was closed on March 14, 2002. In addition to channel relocation, the project also involved nourishing portions of Figure Eight Island and Wrightsville Beaches with portions of the dredged material as well as opening up Mason Creek for increased tidal flushing. The relocation of the inlet and enhancement of the tidal creek resulted in saltmarsh habitat loss in the area and a mitigation plan for saltmarsh impacts was implemented to compensate for those loses. Inlet maintenance is scheduled every three years and includes dredging and placing the material along the southern half of the beach on Figure Eight Island and the north end of Wrightsville Beach. Thus far, Mason Inlet has been dredged for maintenance purposes in the fall of 2005 and the spring of 2009. Mason Creek and a portion of the AIWW were also dredged in the spring of 2006.

Maintenance of the AIWW

The USACE is responsible for maintaining the AIWW to an authorized depth of 12 feet below MLW over a width of 90 feet. Generally, the material removed to maintain the channel is deposited in existing upland disposal sites. As a result of agreements reached between the USACE, New Hanover County, and the Figure "8" HOA through the permitting process for the Mason Inlet Relocation Project, beach compatible material shoaling at that location is stored in Cameron Island, a disposal island owned by the Figure "8" HOA, located adjacent to the intersection. On one occasion, the Figure "8" HOA removed this stored material and deposited it along the southern half of Figure Eight Island.

Maintenance of Banks Channel

In 1969, during the early development of Figure Eight Island, Banks Channel was dredged to a depth of -5.5 m (-18 ft.), a width of 91.4 m (300 ft.), and length of 457.3 m (1500 ft) with most of the 1.3 million cubic yards removed used to elevate the southern half of the island (Cleary & Jackson, 2004). Maintenance of the navigation channel in Banks Channel since 1985 has removed approximately 2.16 million cubic yards of shoal material with the majority of the material placed on the Figure Eight Island shoreline south of Bridge Road. The equivalent annual rate of disposal of the Banks Channel material is around 108,100 cubic yards per year or about 9.8 cubic yards/lineal foot of beach/year.

Nixon Channel Maintenance

The dredging footprint within Nixon Channel is 7.4 acres and is located behind the northern tip of Figure Eight Island. The six (6) dredging events carried out in Nixon Channel since 1993 removed a total of 1,748,000 cubic yards. The volume of material for each event was generally limited to less than 300,000 by the Figure 8 HOA in order to avoid the establishment of a static vegetation line.

5. Resource Response to Change and Capacity to Withstand Stresses

Human Community Resource

For some coastal stakeholders (residences, businesses), a response to the loss of coastal frontage (beach system) is demonstrated by instituting protection measures ranging from placement of engineered walls made of riprap, groins, revetments, beach nourishment projects, beach scraping, and inlet channel management. Very few have demonstrated a willingness to abandon or relocate dwellings or businesses. In some cases, parts of North Topsail Beach, Holden Beach, the Outer Banks, and Ocean Isle Beach, structures have been condemned and demolished and have been prohibited from rebuilding. Currently, approximately 160 miles, or 50% of the North Carolina oceanfront coastline remains undeveloped while the other 50% is developed with residential homes and other associated infrastructure. Coastal visitors/customers will seek out alternative coastal communities having beaches suitable for recreational activity when coastal amenities are preserved.

Beach Resource and Associated Shorebird, Infaunal, and Sea Turtle Resources

The beach system will respond to sediment starvation, potential sea level rise and the destruction of dune binding vegetation by retreating. The system's capacity to withstand destabilization and erosional stresses is limited to the system's ability to reposition available sediment. The placement of engineered walls made of riprap, groins, and revetments do not provide replacement sediment required to mitigate erosional stress. Beach nourishment and certain inlet management activities may increase the beach system's ability to withstand erosional stress through the transfer of sand into the active beach system and via erosional abatement. With the presence of approximately 160 miles of undeveloped beaches and 7 unmanaged inlets, some of the more mobile biological resources are able to adapt and find other suitable habitat for foraging, resting, and nesting.

Shorebirds utilize wetlands, beaches, overwash features, and intertidal flats and shoals for breeding, foraging and overwintering. Coastal development and human activity have reduced the availability of these habitat areas. This resource's response has historically been lead to a decrease in population size and a withdrawal to habitat in less impacted areas such as designated National Seashores and Wildlife Refuges, where development is not permitted.

Infaunal species inhabit a highly dynamic environment. Infaunal species respond to shoreline erosion and accretion by migrating with shoreline spatial fluctuations. When hard structures (i.e. seawalls, revetments) prevent further shoreline retreat, the infaunal species' habitat is reduced or eliminated. Beach nourishment buries infaunal species, however, research indicates beach nourishment results "in short-term declines in abundance, biomass, and taxa richness" (Burlas, *et al.*, 2001). Infaunal organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels (Nelson, 1985). Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. Recovery of infauna occurs within 2 to 6.5 months after completion of nourishment projects (Burlas *et al*., 2001), which occur, in most cases, during winter months when populations are at their lowest or are located further offshore.

Sea turtle world-wide populations have been declining in response to over-harvesting (eggs and adults), bycatch, ingestion of and/or entanglement with manmade products and pollutant induced disease. As settlement of coastal areas increased, harvesting of nesting turtles and eggs also increased until legislation and education were implemented and a sense of stewardship developed. Placement of some types of coastal protection structures along eroding, developed shorelines reduced or eliminated nesting habitat. Sand nourishment of eroding shorelines has restored nesting habitat along developed coastlines. Considering the relatively low fecundity of these species and their vulnerability to bycatch and manmade products and pollutants, it is probable that even with enhancement and protection of nesting habitat these species will remain threatened.

Inlet Intertidal Flats and Shoals Resource

Intertidal flats and shoals are dynamic features within the inlet complex. This resource responds to changes imposed by anthropogenic and natural forces by altering composition (volume, grain size, infauna, vegetative cover) and spatial location. Of the 21 inlets in North Carolina, 11 are periodically maintained for navigational purposes. Federal authorization requires that maintenance occur within the deepest water of the channel, so realignment of the ebb tidal channel is not authorized. This requirement reduces direct impacts to intertidal flats and shoals. Each channel has its own authorized dimensions and range from 6-feet to 40-feet in depth and delegated widths ranging from 90-feet to 600-feet. The maintenance of these channels is generally annual, pending available funds. Species which utilize this habitat have generally adapted to the natural range of environmental conditions experienced in this habitat. This resource continually seeks to achieve dynamic equilibrium with the natural or man-induced forces affecting it. The construction of a terminal groin along the northern portion of Figure Eight Island is expected to allow for the continuation of sand bypassing into the inlet thereby allowing for the formation of additional flats and shoals.

Shorebirds that utilize the intertidal flats and shoals within the inlet complex have demonstrated the ability to respond to disturbances. In 2002, Mason Inlet was relocated approximately 3,000 ft. to the north. Piping plover spring migrants (but not winter residents) in the Mason Inlet area were disrupted by the construction phase of the relocation project, but these birds apparently continued on to Rich Inlet before stopping to rest and forage. Migrants appeared to have an aversion to the Mason Inlet area the following autumn (four months later), but numbers then returned to preconstruction levels by the beginning of winter (eight months later). By 2003, Mason Inlet had become an important foraging and resting site for migrating and over-wintering piping plovers (Webster, 2005).

The benthic organisms which reside in the intertidal and subtidal areas in proximity to the inlets demonstrate the ability to recover following dredging operations. Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. Dredging from the inlet borrow area will result in a direct mortality of all organisms present within the dredged material (Posey and Alphin, 2002). Although the recruitment pattern is altered, the recovery of species after sediment removal is relatively quick, depending upon the opportunistic nature of the species (Street *et al*., 2005; Posey and Alphin, 2002). This rapid recovery is important as foraging fin fish utilize these resources as prey.

At this time, there is limited research regarding impacts to fish passage through inlets during maintenance events. Anecdotally, recreational fishing opportunities remain viable following maintenance activity and therefore there is a high likelihood that these fish continue to utilize inlets during and after maintenance events.

<u>Water Column Resource</u>

The water column resource is a dynamic and complex system; the quality of which is influenced by anthropogenic and natural inputs. In the nearshore environment and within inlets, this resource’s quality is affected by nutrient loading, suspended sediment, and pollutant inputs. The capacity of the water column to accommodate inputs is related to the rates of flushing, exchange, and mixing. Within the inlets, a tidal prism functions to transport suspended sediment and turbidity originating from dredging events and other stresses. The relatively large sediment size of the material suspended by dredging operations within the inlet reduces the duration of the material in the water column and therefore reduces the duration of suspended material and turbidity.

Water column within inlet systems and along the ocean shoreline swash zone do experience frequent seasonal storms, along with routine strong winds, that constantly elevate TSS levels and increase turbidity. These environments are accustomed to higher ranges and are adaptable to natural increases, but these events have shorter duration periods than dredge and fill activities associated with channel maintenance and beach nourishment activities. Even with these activities, which operate as long as a 4-month period, sediment has shown to settle quickly due to the coarser material generally found in these environments and turbidity tends to be of short duration.

Hardened Structure Resources

The potential rise in sea level over time may impact the effectiveness of the proposed terminal groin. According to www.tidesandcurrents.noaa.com, the regional trends in North Carolina show an increase of 0 to 3 mm/yr. (0 to 0.00984 ft./yr.), or a 0 to 1 ft/century. Several monitoring stations within proximity to Figure Eight Island contain this level of data including stations located in Beaufort, Wilmington, and Southport. The rate of increase in sea level rise in Beaufort is 0.84 ft./century while the rate in Wilmington and Southport are both 0.68 ft/century. The first 400 feet of the proposed terminal groin is designed with a top elevation of +6 feet NAVD and would slope down to a top elevation of +3.5 feet on the seaward end. Therefore, the elevation of the structure would be sufficient as to remain above the sea level for the foreseeable future regardless of anticipated sea level changes. The rubble mound structure is expected to uphold its structural integrity through storm conditions. The closest hardened structure to Figure Eight Island is approximately 9 miles south and is the jetty at Masonboro Inlet which is also rubble mound designs on both sides of the inlet. These structures have remained structurally sound since constructed in 1966 and 1980. The same can be stated with the terminal groin structure at Beaufort Inlet which is approximately 65 miles north of Figure Eight Island.

6. Stresses in Relation to Regulatory Thresholds

The Coastal Barrier Resource System (CBRS) was established in 1982 with the Coastal Barrier Resource Act (CBRA) and modified in 1990 with the Coastal Barrier Improvement Act (CBIA) in order to prevent the Federal Government from taking any action that could ultimately encourage or facilitate development on barrier island segments located within the CBRS. The Acts do not prevent private actions by municipalities or individuals. Coastal areas are considered desirable places to inhabit. As population continues to increase it is anticipated that the demand for coastal development will increase.

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

7. Resource Baseline Conditions

Human Community Resource

The population in North Carolina increased substantially over recent decades. Between 2000 and 2010, North Carolina grew at rate of 18.5% from 8,049,313 to 9,535,483. New Hanover County experienced a rapid rate of growth during the same time frame as the population has increased by 26.4% (US Census Bureau, 2012). The rate of population increase has reduced, however, over the recent years. Tourism continues to remain at high levels within New Hanover County as reflected by increases in the county's Room Occupancy Tax. Many tourists visiting the county visit beach communities and utilize the area beaches for recreational activities. Tourists and residents alike utilize the inlets within the state to access the Atlantic Ocean for fishing, SCUBA diving, and other recreational opportunities.

The project area is considered a developed coastline comprised primarily of residential dwellings. With the exception of temporary sandbags protecting 20 homes, no hard shoreline protection structures are currently present along the coastline of the project area. At least 31 shoreline protection projects have occurred along Figure Eight Island since 1977 either by Figure Eight Island Homeowners Association or individual homeowners. These projects have included beach nourishment events, beach scraping (bulldozing to form protective berms and dunes), bulkheading, and the installation of sandbags. The material utilized for the majority of the beach nourishment projects was acquired from the maintenance of Mason Inlet, Nixon Channel, the Intracoastal Waterway (AIWW), and Banks Channel.

Nourishment activities have increased since the mid to late 1990's due to changes to Mason and Rich Inlet systems, the frequency of storm activity, and the increase of home construction on the island. However, the change to the orientation of Rich Inlet and frequency of recent storm activity has exasperated the long-term chronic erosion occurring on the island. Specifically, these erosional areas are located along the northern extremity of the developed oceanfront downdrift of Rich Inlet, the southern 2,500 ft of developed shoreline updrift of Mason Inlet, and the 1,000 ft long developed estuarine shoreline fronting Nixon Channel (Cleary and Jackson, 2004).

In response to the accelerated erosion rates, the Figure Eight HOA nourished the area north of Bridge Road six (6) times between 1993 and 2011, with the cumulative volume of all six (6) fills totaling approximately 1.8 million cubic yards utilizing material obtained from a portion of Nixon Channel. The timeframe of these recent events corresponds with the start of the increased erosion rate associated with the shifting of the ebb tide channel to a more northerly direction. Due to the extremely high erosion rates just south of Rich Inlet, the beach fills placed in this area did not provide long-lasting protection and eventually forced the ocean front property owners on Surf Court, Inlet Hook Road, and Comber Road to install temporary sandbag revetments. Based on the permit conditions, all of the temporary sandbag revetments were to be removed by April 2008; however, legal challenges to the permit condition have delayed their removal.

Beach Resource and Associated Shorebird, Infaunal, and Sea Turtle Resources

In developed areas along the North Carolina coastal shorelines, the stability of some of the dunes and native vegetative cover has been compromised through the building of structures. In some areas dune formations have been destroyed to permit construction of buildings. However, due to CAMA regulatory restrictions, these problems have been reduced over time, and present and future pressures from development to the oceanfront dune systems should continue to decline with restrictions in place. In other areas, nourishment, renourishment, dune protection and management programs have been implemented for shoreline protection and have enhanced or helped sustain dunes and vegetative cover. It is outside the scope of this CEA to quantify the extent these conditions are present along the Atlantic east coast and Gulf coast shorelines. In undeveloped areas where anthropogenic activity is prohibited, limited or controlled, natural dune systems exist in dynamic equilibrium and support various flora and fauna dependent on these systems. Management, protection, and restoration measures have achieved varying degrees of stability for this resource along most developed shorelines. As shown in Table 2, approximately 131 of the 320 miles of North Carolina oceanfront shoreline have been or are expected to be nourished in the foreseeable future to help protect the dune system.

Table 2. Summary of cumulative mileage of North Carolina Ocean beach that could be impacted by beach nourishment and/or navigation disposal activities.

Project Type	Total Miles Impacted	% NC Beach
Federal and Non-Federal Beach Nourishment	112	35
Federal Authorized Beach Disposal	19	6
TOTAL	**131**	**41**

The aforementioned 31 shoreline protection projects constructed along Figure Eight Island since 1977 have placed well over 4 million cubic yards of material along the oceanfront shoreline along Figure Eight Island. Along with these activities, the placement of sandbags and beach scraping events has served to protect or augment the existing dunes along portions of the northern part of the island. Much of the primary dune system and associated vegetation remains intact.

Seabeach amaranth (*Amaranthus pumilus*), a Federal and State threatened species, is a 'fugitive' species which grows on barrier island beaches in areas recently disturbed by storms or beach nourishment. Historically, seabeach amaranth occurred in 31 counties in nine states from Massachusetts to South Carolina. The species is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. It prefers overwash flats at accreting ends of islands and lower foredunes and upper strands of noneroding beaches. It does not compete well with other dune vegetation which supports a positive association with beach nourishment projects (NCFWS, 2006; Nash, 2002).

There are 55 known plant populations, of which 34 are found within North Carolina with the remaining smaller plant populations outside of North Carolina. North Carolina is considered to be the only State to have large populations of seabeach amaranth and although the North Carolina populations reached historic lows in 2000 (Jolls *et al*., 2003), the Endangered Species Bulletin (Randall, 2002) reported that the numbers of seabeach amaranth are increasing. This has been shown through post-construction monitoring efforts on Bogue Banks, Brunswick County Beaches, as well as Figure Eight Island.

Seabeach amaranth is frequently found in large numbers on Figure Eight Island and Hutaff Island. Between 2002 and 2010, 1,505 and 1,130 plants were found on Figure Eight Island and Hutaff Island, respectively. Seabeach amaranth experiences a great deal of natural population variability from one year to the next, as evidence by annual survey results on both islands. In 2008 and 2009, no plants were observed on Figure Eight Island while 656 and 768 plants were observed during 2004 and 2005, respectively.

Multiple assessments of infaunal abundance, biomass and taxa richness from Maine to Florida suggest that infaunal abundance will be similar to that reported from other Atlantic coast beaches (Burlas *et al*., 2001). On oceanfront beaches, most benthic organisms in the intertidal zone consist of infaunal burrowing forms, particularly polychaete worms (Phylum ANNELIDA), coquina clams (*Donax variabilis*) and mole crabs (*Emerita talpoida*) (USFWS, 2002).

While several species of amphipods and polychaetes populate the intertidal and shallow subtidal beaches of North Carolina, their contribution to the total biomass of benthic infauna is low due to their small body size. Therefore, mole crabs and coquina clams dominate the benthic infaunal community due to their biomass (Peterson *et al.*, 2000).

Baseline data depicting the infaunal species populations occurring within the specific project area is unavailable; however the information regarding pre-construction and post-construction monitoring at Bogue Inlet is applicable. Prior to the relocation of the channel within Bogue Inlet, infaunal species were dominated by various worms, crustaceans, snails, intertidal insects, and bivalves. Overall, the species richness and abundance increased during post-construction sampling events. Results showed that natural disturbances in the area may have equaled project related effects as the inlet environment remains dominated by physical stress (Carter, 2008). Similar results were found following the monitoring of infaunal communities in proximity to Mason Inlet, Topsail Island, and Bald Head Island beach nourishment activities.

Piping Plover (Charadrius melodus)

The piping plover Atlantic coast population is federally listed as threatened with a population estimated at less than 1,400 pairs (USFWS, 2004). This species is ranked globally as G3, considered rare throughout its range (NCNHP, 2006) and listed as threatened throughout their wintering range (USFWS, 1996). Critical Habitat designation for North Carolina wintering piping plover includes a total of 18 distinct units. These include:

Unit NC-1: Oregon Inlet
Unit NC-2: Cape Hatteras Point
Unit NC-3: Clam Shoals
Unit NC-4: Hatteras Inlet
Unit NC-5: Ocracoke Island
Unit NC-6: Portsmouth Island-Cape Lookout
Unit NC-7: South Core Banks
Unit NC-8: Shackleford Banks
Unit NC-9: Rachel Carson
Unit NC-10: Bogue Inlet
Unit NC-11: Topsail
Unit NC-12: Figure Eight Island
Unit NC-13: Masonboro
Unit NC-14: Carolina Beach Inlet
Unit NC-15: Ft. Fisher
Unit NC-16: Lockwood Folly Inlet
Unit NC-17: Shallotte Inlet
Unit NC-18: Mad Inlet

Rich Inlet in Unit NC-11, which is described by the USFWS as follows (USFWS, 2001):

> *The entire area is privately owned. This unit extends southwest from 1.0 km (0.65 mi) northeast of MLLW of New Topsail Inlet on Topsail Island to 0.53 km (0.33 mi) southwest of MLLW of Rich Inlet on Figure Eight Island. It includes both Rich Inlet and New Topsail Inlet and the former Old Topsail Inlet. All land, including emergent sandbars, from MLLW on Atlantic Ocean and sound side to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur. In Topsail Sound, the unit stops as the entrance to tidal creeks become narrow and channelized.*

Eight of these critical habitat units include inlets that are federally managed with maintenance dredging occurring on a regular basis, pending available monies: Oregon Inlet, Hatteras Inlet, Bogue Inlet, New Topsail Inlet, Masonboro Inlet, Carolina Beach Inlet, Lockwood Folly Inlet, and Beaufort Inlet. Oregon and Beaufort Inlets have terminal groin structures and Masonboro has a jetty structure.

The southern subpopulation of the U.S. Atlantic Coast Population includes Delaware, Maryland, Virginia, South Carolina and North Carolina. The North Carolina coastline is important to piping plovers since it provides habitat for wintering, breeding, and migration. In 1996, the USFWS (2006g) counted 1,348 breeding pairs in the Atlantic Coast population. In 2001, U.S. breeding pair populations showed a 10% gain with a total pair count of 1,280, while the total U.S. Atlantic Coast population had increased by 13% to 1,525 breeding pairs (USFWS, 2007b). The 2002 Atlantic Coast population had 1,690 nesting pairs of piping plovers, while nesting pairs in North Carolina totaled 23 (USFWS, 2007b). These numbers were comparable to the 2000 to 2001 Annual Status Update for the U.S. Atlantic Coast Piping Plover Population (USFWS, 2002a). Nesting pair estimates for the Atlantic Coast population as reported to the USFWS were: 1,660 in 2004, 1,632 in 2005, and 1,743 in 2006 (USFWS 2007; 2007a; 2007c). The 2006 abundance estimate illustrates a 29% increase from 1996 to 2006 in the number of breeding pairs of the Atlantic Coast population.

Wilson's Plover (Charadrius wilsonia)
The Wilson's plover is designated by the State of North Carolina as Significantly Rare. This is a peripheral species (North Carolina lies at the periphery of this species range) requiring monitoring by the North Carolina Natural Heritage Program. There is no federal status for this species, and it is considered globally secure (G5 rank) (NCNHP, 2006). Wilson's plover breed in eastern and southern coastal areas of the United States and overwinter along the Florida Atlantic coast and Gulf coasts to northern South America (GAMNH, 2000).

Gull-Billed Tern (Sterna nilotica), Common Tern (Sterna hirundo), and American oystercatcher (Haematopus palliatus)
The gull-billed tern, common tern, and American oystercatcher are designated by the State of North Carolina as threatened. There is no federal status for these species, and they are considered globally secure (G5 rank).

Common terns seem to be undergoing a decline in the southeast and are therefore listed as a species of regional concern (Hunter et al., 2001). They have been observed on Figure Eight Island and Hutaff Island on a semi-regular basis. American oystercatchers have also been observed in or near the Permit Area during the April to June breeding period (Cameron, pers. comm., 2007). An average of two (2) American oystercatchers were observed during each of the daily surveys conducted along the northern portion of Figure Eight Island in April, 2011 (Webster, pers. com., 2011).

Eastern Painted Bunting (Passerina ciris ciris) and Black Skimmer (Rynchops niger)
The Eastern painted bunting and black skimmer are State-listed as a Species of Special Concern. The eastern population of painted bunting breeds in a restricted range within the Atlantic Coastal Plain, from North and South Carolina to Georgia and Florida. In North Carolina, eastern painted bunting breeding habitats are found in a narrow range along marine coasts and waterways (Audubon North Carolina, 2007b). There is no

federal status for these species, although the both species are considered globally secure (G5 rank) (Kushlan et al., 2002).

Red Knot (Calidris canutus)

The red knot was designated as a candidate species in 2006. At nine to ten inches long, the red knot is a large, bulky sandpiper with a short, straight, black bill. Large numbers of red knots rely on Atlantic stopover habitats during the spring and fall migration periods. Red knots winter at the southern tip of South America and breed above the Arctic Circle. These small shorebirds fly more than 9,300 miles from south to north every spring and reverse the trip every autumn, making the red knot one of the longest-distance migrating animals. Migrating red knots break their spring migration into non-stop segments of 1,500 miles or more, converging on just a few critical stopover areas along the way. Large flocks of red knots arrive at stopover areas along the Atlantic coast each spring, with many of the birds having flown directly from northern Brazil. Red knots are faithful to these specific sites, stopping at the same locations year after year. Mole crabs (*Emerita talpoida*) and coquina clams (*Donax sp.*) are an important food source for migrating knots in North Carolina. Birds arrive at stopover areas with depleted energy reserves and must quickly rebuild their body fat to complete their migration to Arctic breeding areas. During their brief 10 to 14-day stay in the mid-Atlantic, red knots typically double their body weight.

Red knots do utilize habitat within and around the Permit Area during their migration. Surveys conducted during 2007 by Audubon North Carolina revealed a total of 878 red knot individuals observed along Mason Inlet, Rich Inlet, Lea Island, and Hutaff Island. The maximum counts at each location on an individual survey was 188, 258, 6, and 20, respectively at each location (Mangiameli, pers. comm. 2008).

Sea Turtles

The leatherback sea turtle and the green sea turtle are listed as Federally endangered, while the loggerhead sea turtle is listed as threatened. "The estimated world population of nesting leatherbacks is 35,860; nesting greens is 88,520 (CCC, 2003); and nesting loggerheads is 44,560. There are approximately 320 miles of ocean-facing sandy beaches in North Carolina that provide suitable nesting habitat for sea turtles. To date, loggerheads, green turtles, leatherbacks and rarely Kemp's ridleys sea turtle nests have been recorded on North Carolina beaches. By far the most common nesting species is the loggerhead. In 2010 and 2011, there was a total of 967 and 883 loggerhead sea turtle nests observed along the North Carolina oceanfront coastline, respectively (NCWRC, 2012). The vast majority of sea turtle nests observed in North Carolina occur below Cape Lookout. According to data supplied by Dr. Webster of UNCW and Mr. Golder of the Audubon Society, no green sea turtle nests have been observed in the study area on either Figure Eight Island or Hutaff Island (Webster, pers. comm., 2011; Golder, pers. comm., 2008). The NCWRC reported a leatherback false crawl in North Carolina in 2007 (Everhart, 2007). Loggerhead sea turtles, however, do actively nest within the Permit Area. Nesting data for the study area on Figure Eight Island and Hutaff Island has been recorded since 2001. Between 2001 and 2010, there has been an average of 11.7 nests per year for the study area located on Figure Eight Island and Hutaff Island (Webster, pers. comm., 2011; Godfrey, pers. comm., 2011; Golder, pers. comm., 2008).

On July 10, 2014, the USFWS designated 1,102 km. of the western Atlantic and Gulf of Mexico coastlines as terrestrial critical habitat for the Northwest Atlantic Ocean Distinct Population Segment (NWA DPS) of loggerhead sea turtles. Critical habitat is designated on sandy beaches capable of supporting a high density of nests in North Carolina (Brunswick, Carteret, New Hanover, Onslow and Pender counties), South Carolina (Beaufort, Charleston, Colleton, and Georgetown counties), Georgia (Camden, Chatham, Liberty, and McIntosh counties), and Florida (Bay, Brevard, Broward, Charlotte, Collier, Duval, Escambia, Flagler, Franklin, Gulf, Indian River, Lee, Manatee, Martin, Monroe, Palm Beach, Sarasota, St. Johns, St. Lucie, and Volusia counties). The designation also includes non-continuous sections of coastline from Alabama and Mississippi. Department of Defense lands are exempt from critical habitat designation. Maps of the specific terrestrial critical habitat locations may be found in the FWS Final Rule (79 FR 39756). Loggerhead sea turtle critical habitat unit LOGG-T-NC-01 includes all of Hutaff Island which lies within the Permit Area of the proposed project.

Additionally, on July 10, 2014 the National Marine Fisheries Service (NMFS) designated marine critical habitat within the Atlantic Ocean and the Gulf of Mexico for the NWA DPS of the loggerhead sea turtle. Open water critical habitat was designated for nearshore reproductive habitat, breeding habitat, migratory habitat, and winter habitat and is located along the U.S. Atlantic coast from North Carolina south to Florida and into the Gulf of Mexico. Critical habitat is designated offshore of the U.S. Atlantic coast coincident with the Gulf Stream to the edge of the U.S. Exclusive Economic Zone (EEZ) stretching from approximately 38° North latitude, 71° West longitude south to the Gulf of Mexico-Atlantic border. Detailed descriptions and maps may be found in the NMFS Final Rule for critical habitat designation (79 FR 39856). Unit LOGG-N-02 is the critical habitat unit closest to Figure Eight Island.

Intertidal Flats and Shoals Resource

Along developed and undeveloped Atlantic and Gulf coast beaches adjacent to inlets, this resource changes spatially and temporally in response to forcing functions (tide, current, and weather conditions). In developed areas this resource is influenced by anthropogenic activities including dredging. Most of the inlet complexes in North Carolina include a vast network of intertidal flats and shoals. One exception would be Masonboro Inlet, a federal navigational channel. This inlet is bound by a jetty for the purpose of reducing shoaling by limiting the amount of sediment entering the inlet. For Rich Inlet and other non-structural inlets, the tidal prism provides a means for material to be transported into the inlets and allows for the development of dynamic intertidal flats and shoals.

Water Column Resource

The quality of the water column resource is related to the presence or absence of inputs (anthropogenic or natural). Natural conditions support fluctuating turbidity levels in the nearshore and offshore water column within the state of North Carolina. Storm events are known to increase these levels due to the resuspension of sand and fine materials. These fluctuating turbidity levels would continue with or without the dredging efforts.

Ambient TSS and turbidity levels have been monitored within several inlets in North Carolina. Cleary and Knierim (2001) monitored the turbidity and TSS from several sites in conjunction with a beach nourishment project. The effort included two control sites, which were located several hundred meters from the margins of the beach fill project. The turbidity levels averaged 7.8 and 7.6 NTUs respectively at the two sites which is well below the North Carolina state standard of 25 NTUs. The TSS values measured at the two control sites ranged from 33.1 to 124.2mg/l. There is no state standard for TSS in North Carolina.

The tidal prism within the inlets of North Carolina varies primarily as a function of inlet dimensions. For example, Beaufort Inlet has a tidal prism of approximately 1.4×10^8 m^3 (Jarrett, 1976) while the tidal prism in Rich Inlet has been estimated to be 1.8×10^7 m^3 (Cleary, 2009). Fish passage and larval transport utilize the flow of water through the inlets.

Hardened Structure Resources

The ocean front shoreline of North Carolina contains relatively few major structures. This is partly due to a 1985 State law prohibiting hardened structures along the entire oceanfront and inlet shorelines. The only exception in this law was the installation of structures for navigational purposes. Structures in North Carolina include the Fort Fisher Revetment, the Carolina Beach Revetment, the jetties at Masonboro Inlet, the Fort Macon State Park terminal groin and revetment, the Pea Island/Oregon Inlet terminal groin, the Bald Head Island geo-tube groin field, and the Cape Lookout harbor of refuge breakwater. In total, these structures impact approximately 7.7 miles of shoreline, or 0.02% of the approximate 320 miles of oceanfront shoreline in North Carolina.

The Fort fisher revetment was constructed in 1996 and spans 3,040 feet of shoreline. This structure was constructed to provide erosion protection to a civil war-era earthenmound fortification originally built to guard one of the entrances into the Cape Fear River. This revetment was constructed with stone and STA-POD® units along the toe of the structure.

The Carolina Beach revetment was constructed to provide erosion protection for upland development on the north end of island. This structure was constructed in two stages beginning in 1971 and completed in 1974. This 2,075 foot-long structure is constructed of stone.

The jetties at Masonboro Inlet were constructed to stabilize the federal navigation channel within the inlet. The north side of the jetty was completed in 1966 while the south side was completed in 1980. The northern structure contains a landward portion extending 1,739 feet and is constructed of concrete sheet pile with a 1,900-foot rubblemound seaward portion. The 3,450-foot long southern section is comprised of a shore anchorage section and a seaward portion. The 800-foot long shore anchorage section is constructed of concrete sheet pile with stone protection. The 2,650-foot long seaward portion was constructed with a concrete sheet pile core covered by a rubblemound. The jetty serves to stabilize the channel by maintaining the southern 7,000 feet of shoreline along Wrightsville Beach and 2,500 feet of shoreline along the northern portion of Masonboro Island. Portions of Masonboro Island have been affected by the southern jetty.

The Fort Macon State Park terminal groin was initially constructed in 1961 with subsequent construction in 1968 and 1970. This structure was designed to protect Fort Macon against erosion caused by the westward migration of Shackleford Point. The total length of the stone structure is 2,280 feet including a 750-foot sloping revetment on the landward end and a 1,500-foot rubblemound portion on the seaward end. The accretion fillet formed by the terminal groin extends approximately 2,500 feet west of the structure.

The Village of Bald Head Island installed a series of sixteen soft groins constructed of geotextile material and sand fill (geotube-style structures) along western South Beach in 1996. These groins extend seaward and range in length from 200'-350'.

The Cape Lookout harbor of refuge breakwater was constructed in 1917 to provide sailing vessels protection from coastal storms. It is a 4,800-foot long rubblemound structure.

The 3,125-foot long Pea Island/Oregon Inlet terminal groin was constructed between 1989 and 1991. This stone structure was designed to prevent the continued southward migration of Oregon Inlet and provide protection for the south end of the Bonner Bridge. The accretion fillet formed by the terminal groin extends approximately 4,500 feet to the south of the structure along the Pea Island shoreline.

8. Identification of Important Cause and Effect Relationships

The proposed action is a shoreline protection project incorporating the construction of a terminal groin and associate beach nourishment utilizing material from Nixon Channel and three dredged material disposal sites. The proposed project is scheduled for winter construction.

<u>Human Community Resource</u>
This and similar nourishment projects, which have occurred since 1962, and those which are scheduled to occur in the reasonable foreseeable future, facilitate the occupation and development of the coastal shoreline. Shoreline protective measures have provided stabilization and protection of properties on barrier islands from minor and severe storm events. With protective shorelines, private, local, state and federal infrastructure (roads, bridges, houses, utilities, etc.) will continue to be in place to facilitate access to and use of the coastal environment and to help sustain the local and state economies. Out of the 160 miles of developed oceanfront shoreline in North Carolina, no new widespread oceanfront development is expected. Most of North Carolina's barrier islands have been developed for residential and/or commercial use. With some exceptions, few of the

islands have untouched or undeveloped properties in their natural state. The majority of the undeveloped properties consist of individual lots. Outside of the municipality controlled islands, many miles of oceanfront shoreline is protected from development within the foreseeable future due to its ownership by Federal, state, and non-profit organizations. Most of these oceanfront shorelines are expected to remain or be managed in their natural state. For inlet areas, boating traffic and use of adjacent shoreline is expected to continue, but with only a slight increase in use due to limited and reducing boat launching access points.

Beach Resource and Associated Shorebird, Infaunal, and Sea Turtle Resources

This and similar projects compensate for retreat of the shoreline as a result of sediment starvation and sea level rise if it occurs at predicted rates. This and other projects have the potential to create suitable habitat for dune vegetation and provide shoreline protection. The proposed project will cause the sandy beach to be widened seaward of existing structures

The increasing demand for coastal dwellings and recreation areas by the migration and increase in the human population is and will continue to impose additional stresses on the coastal ecosystem, including the infaunal communities, fishery resources, and bird species.

Infaunal communities are negatively impacted by repeated beach nourishment projects and the maintenance of inlet channels and the construction of hardened structures. With the implementation of the State Sediment Criteria, material used for present and future nourishment projects are expected to be compatible with native beach material. The utilization of fill material that closely mimics the natural beach sediment will reduce recovery times for infauna in the nearshore and intertidal zones. Impacts will be short-term in nature, and as long as beach projects continue to be scheduled with spatial and temporal breaks between them and during times when biological activity is at its lowest, the infaunal communities will likely recover due to migration from other areas and by larval recruitment. The temporary loss of infaunal communities does have the potential to limit food sources for fish species that may be present during the period of benthic recovery.

For bird resources, hunters were considered to be the primary cause for the population decline in all three geographic breeding regions for the piping plover (Atlantic Coast population, Northern Great Plains population, Great Lakes population) until the Migratory Bird Treaty Act was implemented in 1918. From the 1940's until now, habitat loss, increased predation, and disturbance from humans and pets has been cited as major contributing factors for the decline of the Atlantic Coast population (USFWS, 1996). These factors have also been the contributing cause of decline for other shorebird species that utilized oceanfront and inlet habitats.

Along the Atlantic Coast, the loss of bird migration habitats in the coastal zone has been extensive. Shoreline armoring has reduced intertidal habitats used by piping plovers and other shorebirds for foraging, roosting and nesting. The loss of Atlantic Coast piping plover habitat has largely been attributed to the development of permanent structures, which can alter natural beach processes and prevent natural overwash events. Structures that have been identified as having significant effect on nesting habitat include seawalls, jetties, piers, homes, parking lots, and other interfering structures. Animal and human disturbances, depending upon duration and proximity of perceived threat, may result in adults leaving eggs or chicks exposed to predators or inclement weather and may result in disruption of nesting, foraging, and roosting behaviors.

Adult mortality has been identified as a key determinant in population trends, while nest sites and clutch size were not found to cause early populations to decline (Burger, 1987; 1991). Juvenile mortality may not have as strong of an effect on populations as adult mortality; however reproductive success is lower in areas with high human disturbance (Burger, 1987; 1991). While piping plovers illustrate acclimation to human disturbances via flexible habitat use (i.e., the ability to forage in a different habitat e.g. backbay or ocean) abandonment of native habitats often results (Burger, 1994).

While the numbers of breeding pairs have increased nationally, the North Carolina breeding population had experienced a decline through the 1990's. The number of piping plover breeding pairs decreased from 55 pairs in 1989 to 20 pairs in 2004 (USFWS, 2005) (Figure 1). However, since that time, the number of observed breeding pairs has steadily increased to over 60 within recent years (Schweitzer, pers. comm., 2012). In 2011, a total of 59 breeding pairs were observed during the State's annual breeding pair monitoring effort conducted along 21 islands between June 1 and June 9. Of these, 41 pairs were observed on the Cape Lookout National Seashore and 13 were observed along the Cape Hatteras National Seashore (Schweitzer, pers. comm., 2012). The majority of all nesting pairs were observed near the ends of the islands in proximity to their foraging grounds near an inlet. It should be noted that maintenance dredging operations occur within most inlets in North Carolina on a sporadic basis. Hatteras Inlet, which is part of the Cape Lookout National Seashore, however, is not maintained. Despite this recent increase in nesting pairs within the state, this relatively low productivity rate leaves North Carolina vulnerable to problems associated with very small, sparsely distributed populations (e.g., difficulties finding mates) (USFWS, 2004).

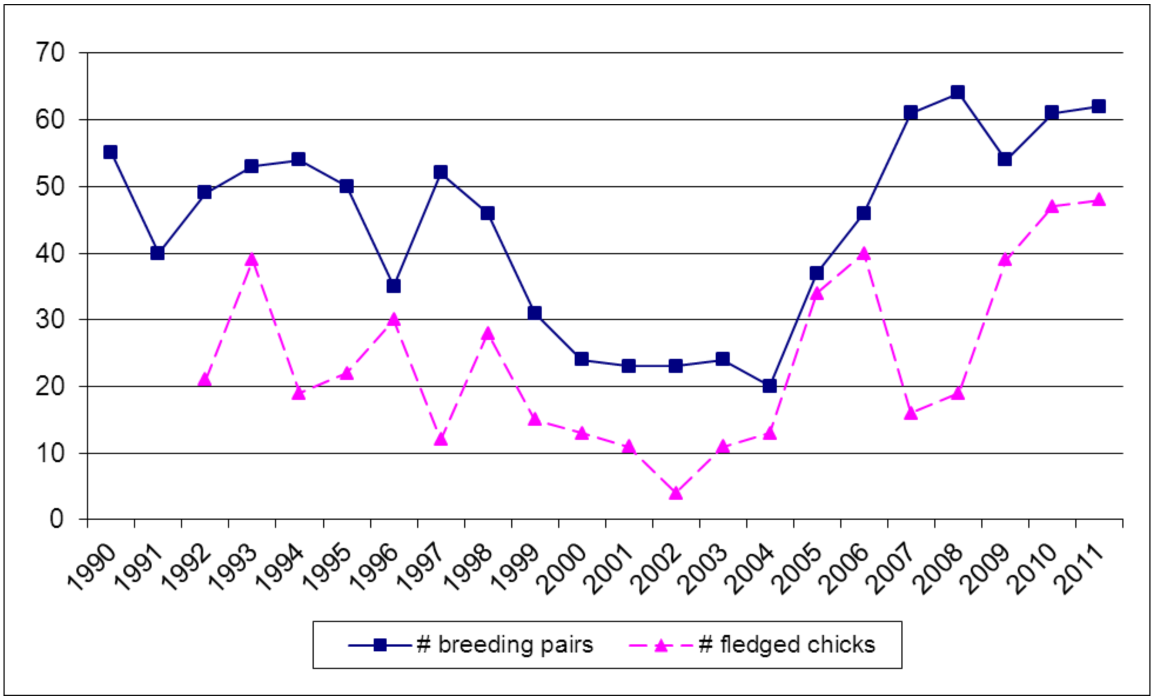

Figure 1- Numbers of Piping Plover breeding pairs and fledged chicks in North Carolina from 1990 to 2011.

For sea turtle nesting, beach nourishment projects generally widen the beach seaward of existing dune system, which increase the area available for sea turtle nesting activity. Sediment compatibility standards, wintertime dredging, and other minimization and avoidance measures have and are expected to reduce impacts to nesting sea turtles. Sea turtles are most vulnerable during dredging operations, whether associated with navigation and/or beach fill projects. Deaths tend to occur when dredging is conducted by hopper plants, which are mobile dredges and work offshore or within inlet channels. While hopper dredges are periodically used, most maintenance and beach nourishment activities are conducted by cutterhead dredges. These plants are anchored and stationary, mainly working at a single location within the inlet or nearshore. Although no sea turtle takes have been reported with the use of a cutterhead dredge, the risk for potential takes remains. While sea turtles have been incidentally taken during dredging operations, these takes have been low in number along North Carolina and have had little impact on populations.

<u>Intertidal Flats and Shoals Resource</u>

It is difficult to determine how activities in the past 50 years have affected this resource. For earlier projects, particularly for navigational purposes, it can be presumed that the removal or preventing the movement, of intertidal flats and shoals were considered the objective for improving recreational and commercial navigation. For present and future projects, these habitats are more carefully considered when designing or planning work within an inlet and along adjacent shorelines in order to reduce their impacts. Most current projects, as well as future actions, are expected to be conducted in a way not to modify the tidal prism. Also, it is generally not the intention to remove material from the littoral system that may result in a depletion or reduction in the sediment budget.

Dredging work or the construction of terminal groin structures does have the potential to indirectly affect intertidal flats and shoals by shifting them within inlet complexes over time. This has the potential to impact foraging birds and fin fish which rely on infaunal and benthic organisms that inhabit these areas. The proposed project will not have any direct impacts to these resources, but is expected to impact these intertidal areas closer to the groin structure. Even with this loss, the habitat is expected to shift and redevelop northward along Hutaff side of the inlet.

<u>Water Column Resource</u>

Turbidity and TSS levels naturally fluctuate throughout the year within the inlet and along the ocean shoreline swash zone; and this fluctuate can at times be dramatic. However, beach nourishment and dredging activities are known to have increased these levels during project operations. These higher turbidity and TSS levels tend to be concentrated and localized within the dredging area and the beach discharge location, but can be more widespread if onsite weather conditions are not optimal. Elevated turbidity levels could potentially lead to the clogging of fish gills or disrupt larval transport, especially if operations are being conducted during peak biological activity.

<u>Hardened Structures</u>

Hardened structures along the North Carolina coastline have been used in the past to alleviate shoreline erosion to protect property, infrastructure, navigation, and recreational opportunities. The effect of placing these hardened structures, including rock revetments and terminal groins, have helped accomplish these goals. In some cases, these structures have been shown to increase shoreline erosion in other areas while protecting their intended target area. There has not been any data to suggest that the terminal groins located on Pea Island and at Fort Macon have impeded the influx of larvae through the inlets nor has research suggested that fish passage has been reduced.

9. Determine the Magnitude and Significance of Cumulative Effects

This section describes a qualitative assessment of factors associated with positive, negative or neutral (not discernible) effects related to the resource.

<u>Human Community Resource</u>

The proposed project as well as past and future nourishment/renourishment projects and the construction of hardened structures facilitates continuing human occupation (dwelling, recreation, and development) of coastal areas. With local, county, and State governments understanding the need, sometimes collectively, to protect properties, infrastructure, and the commerce value along the oceanfront beaches, dredging and beach nourishment activities have dramatically increased over the last decade. This understanding is also expected to result in an increased rate of these type projects in the foreseeable future. Beach shoreline protection and navigational improvement projects have occurred recently, and are being planned, all along the developed sections of North Carolina oceanfront; from Nags Head to Holden Beach. Even during times where government budgets have had shortfalls and/or have reduced spending, government entities in North Carolina have continued to finance and implement these types of projects to protect oceanfront shoreline beaches and to maintain navigational channels. Recently, the State has expanded its desire to protect shorelines by changing a long standing prohibition on oceanfront hardened structures. This would potentially allow up to four (4) terminal groin structures in North Carolina. With the local, county, and State's overall awareness and recognized need for shoreline and inlet projects, the human community is expected to be maintained, and in some circumstances, improved as it pertains to protection of property, recreational beaches, local and State commerce, and recreational and commercial boat use. Other human resource use, such as bird watching, aesthetics, and undisturbed vistas, may temporarily be interrupted by dredging and beach nourishment projects, but this interruption will tend to be localized and short-term.

Even with their continuation, dredging, inlet, and beach nourishment activities are generally not conducted on an annual basis for each beach or barrier island and/or inlet. Nor are these activities occurring along the North Carolina coastline simultaneously. Project cost and essential planning tend to keep the number of implemented actions low and on an as-needed basis, pending storm activities and beach conditions. Also, due to cost and funding constraints, it is generally expected that only projects with crucial needs will likely be constructed. As discussed earlier, most of North Carolina barrier islands, under a local or county municipalities' jurisdiction, have been developed for residential and/or commercial use, especially oceanfront properties. Outside of the municipality controlled islands, approximately 57 miles, or 18% of North Carolina's oceanfront shoreline is protected from development within the foreseeable future due to its ownership by Federal, state, and non-profit organizations. Most of these oceanfront shorelines are expected to remain or be managed in their natural state.

The number of past, present, and future projects overall have and are expected to greatly enhance and maintain human resource uses along the oceanfront shoreline and within inlets. These benefits will significantly impact individual, local, county, and State entities. Other human resource uses that may be temporarily affected are expected to be maintained for future generations due to the amount of undeveloped and long-term protected North Carolina oceanfront shoreline.

<u>Beach Resource and Associated Shorebird, Infaunal, and Sea Turtle Resources</u>
Adding sand to the shoreline system and retaining it enhances the beachfront resource's ability to sustain itself. As explained above, oceanfront shoreline protection measures will likely continue to be implemented. These measures, by their very design, are expected to protect and maintain the physical conditions of the beach shoreline: dune, dry beach, and wet beach. The identified biological resources within these habitats, such as infaunal species, fin fish, shorebirds, nesting sea turtles, and dune vegetation, have shown to be adaptable to nourishment and renourishment projects and to the presence of the human community in the following ways:

<u>Infaunal communities:</u> Although oceanfront projects (beach fill and groin structures) directly increase infaunal mortality via burial, most of these shoreline activities are conducted during winter months when the biological activity is lowest and/or at the time infaunal tend to migrate offshore. The timing of these actions and the long periods

between beach renourishment events on a single stretch of beach serves to reduce the impacts and allows potential affected infaunal resources to fully recovery.

Research indicates that infaunal species populations recover within 2 to 6.5 months after completion of nourishment projects. Recovery rate is influenced by temporal and spatial recruitment parameters such as distance to adjacent populations and season of project activity (Burlas *et al*., 2001). Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. This supports the observation that some organisms withstand burial up to 10 cm (3.9 in). Other studies reported by Maurer (NRC, 1995) supported the burial tolerance of nearshore species, which found that these species are capable of burrowing through sand up to 40 cm (15.8 in). Rakocinski *et al.* (1996) found that the mole crab population density exhibited a pattern of initial depression after sedimentation but fully recovered in less than one (1) year after beach nourishment. Outside of emergency situations or as a result of a tropical storm, the frequency of most beach fill activities generally occur no more than one event per four years on any single stretch on beach. It is not anticipated that a single action, as with Figure Eight's proposal, or simultaneous beach nourishment actions up and down the North Carolina oceanfront will cumulatively impact infaunal resources for long durations or over a wide geospatial landscape.

<u>Shorebird Resources</u>: The cumulative effect of beach nourishment projects on shorebird resources is related to the species' ability to adapt to displacement or avoid disturbance associated with developed shorelines. All shorebirds considered for the purpose of this CEA, with the exception of the piping plover, are globally ranked as G4 (apparently globally secure) or G5 (globally secure).

The limited populations of the shorebirds described in the Resource Baseline Conditions section is likely attributable to being on the periphery of their global range or an inability to adapt to habitat displacement and disturbance associated with coastal development. Shorebirds utilize the oceanfront beaches for nesting, resting and feeding on the infaunal species within the wet beach, with most bird activity occurring between early April and late November. The oceanfront areas for shorebird use also include the beachfront shorelines closest to inlets. There are 15 (out of 18) designated Critical Habitat Areas for piping plover along the North Carolina coastline that encompass beachfront habitat adjacent to inlets. Out of the 15, only five inlet areas include federally maintained inlet channels that have active oceanfront beach disposal within or adjacent to Critical Habitat Areas. The beginning point for beach placement of the dredged material is a minimum 1,000 linear feet from the inlet and excludes the more heavily used areas for piping plover as well as other shorebirds. With some exceptions, this disposal boundary is generally outside the Critical Habitat area.

For oceanfront structures, 2 terminal groins and 1 jetty have been constructed within or adjacent to Critical Habitats; and 3 additional terminal groins being proposed. The existing structures have been in place for several decades, with Oregon Inlet groin being the most recent at 23 years old. As explained earlier, the installation of these structures are for the purpose of building up the oceanfront shoreline and can be effective for protecting the targeted area. The magnitude of cumulative oceanfront impacts on bird resources are difficult to document due to impacts from other non-beach, inland related activities. On-going monitoring along the North Carolina coastline by private, local, and State entities has shown the presence of shorebirds continuing to use the oceanfront beach resources. This is occurring even with more recent beach fill activities and the presence of existing structures. Much of this can be attributed to more public awareness of the species, an expected shortened recovery time for their benthic community food source, the presence of adjacent undisturbed protected beaches, and the inclusion of beach fill moratoriums. These factors are also part of the Figure Eight proposal and if implemented, should reduce any potential cumulative impacts on shorebird resources.

Nesting Sea Turtles: The proposed project, as well as past and future nourishment/renourishment and terminal groin projects, has the cumulative effect of countering the erosive effects of more frequent intensive storms, and if occurs as predicted, the long-term impacts from sea level rise. Along the developed barrier islands in North Carolina, approximately 37% of the oceanfront properties (not including the CBRA shorelines) have been built-out containing residential and commercial structures. With the presence of these structures, it is likely that protective measures will continue to be implemented. General means of protection consist of promoting a wider beach berm and maintaining the dune system. Beaches where width is maintained or widened appear to facilitate turtle nesting. Nesting data trends reported by the Fish and Wildlife Research Institute for Florida indicate “Regression of log-transformed nest numbers show no trend in annual loggerhead nesting (r = 0.41)” for the period 1989 to 2005. “A regression of log-transformed nesting in combined two-year groups 1990 to 2005 reveals a significant upward nesting trend (r = 0.97)” for green turtle nests. “A regression of log-transformed nest numbers reveals a significant increase in leatherback nesting over the 17 years period (r = 0.92)” for the period 1989 to 2005 (FWRI, 2006). Preceding and during this period, Florida, where significant turtle nesting occurs, has constructed the greatest number and length of beach nourishment/renourishment projects along the Atlantic east coast and Gulf coast shorelines (Finkl *et al*., 2006 data set).

The study of the effects of beach renourishment on sea turtle nesting was examined on the 24-mile long barrier island of Bogue Banks, which has received sand frequently from beach nourishment events over the past decade. Between 2002 and 2007, there were 349 nesting activities (nests and false crawls), or an average of 58 nests per year on Bogue Banks. There were a total of 167 nests (an average of 28 per year), and all but three were laid by loggerhead sea turtles. In 2005, there were 2 leatherback nests and one green turtle nest observed on Bogue Banks. Between 1996 and 1999, prior to the implementation of the County’s large scale beach nourishment project, these nesting numbers were slightly reduced. A total of 195 nesting events were documented during this period (an average of 49 nesting events) with a total of 114 successful nests (an average of 29 per year). When examining the nesting rates along nourished and unnourished beaches, results showed that there was no discernible impact of nourishment on nesting behavior or hatching success for loggerhead sea turtles (Holloman and Godfrey, 2008). For Figure Eight Island, there has been an average of 11 loggerhead sea turtle nests along the island since 2001. During this time, at least seven nourishment events of various size and locations have occurred on the island.

Based on indications from the State of Florida where (1) significant turtle nesting occurs; (2) extensive nourishment/renourishment projects have taken place for several decades and (3) stewardship of this resource is encouraged through research, education, and volunteer activities, it appears that the cumulative effect of these activities is neutral to significantly positive. Considering the magnitude of nesting by this resource in North Carolina, the cumulative effect of similar activities is likely to be neutral or positive since turtles have appeared to adapt to man-made beach berms and their nesting habitat area will be maintained or increased through future nourishment and renourishment projects. Furthermore, dredging and fill placement activities will be conducted during winter months when sea turtle nesting does not occur. Other factors that influence successful nesting is the use of beach compatible material. With the requirements identified in State Sediment Criteria, probability of incompatible material placed on the beaches is lowered, which is expected to ensure continuation of successful nesting.

The human community must be aware of and willing to accommodate the habitat requirements of all these resources. The cumulative effects of beach nourishment and terminal groin projects are maintaining and sustaining the beach resource, creating additional area of dry beach habitat, creating the potential for dune vegetation habitat and sustaining wet beach habitat. As previously stated, although approximately 41% of North Carolina's oceanfront shoreline has been or is scheduled for nourishment, the temporal and geographic spacing of these projects is likely that adjacent un-impacted and/or recovered portions of beach will be available to support the dependent species (i.e. surf zone fish, shore birds, etc.) and facilitate recovery of individual project sites to pre-project conditions.

As depicted in Table 3, approximately 41%, or 131 miles of oceanfront shoreline in North Carolina has been or will be nourished in the foreseeable future. Relevant activities such as inlet maintenance by the U.S. Army Corps of Engineers has occurred within numerous inlets including Shallotte Inlet, Lockwood Folly Inlet, Cape Fear River, Carolina Beach Inlet, New Topsail Beach Inlet, New River Inlet, Beaufort Inlet, and Oregon Inlet. The vast majority of beach nourishment and inlet maintenance activities have occurred from the proximity of the South Carolina/North Carolina border to Cape Lookout (or central North Carolina). The spatial and temporal separation of these projects (Refer to Table 3 and Table 4) can be expected to permit recovery of beach and borrow area infaunal species. Accordingly, the magnitude and significance of the cumulative environmental consequences of the proposed Figure Eight beach nourishment project are considered to be localized, short-term, and minimal. The temporal spacing of at least five years between renourishment events for this project will allow for the recovery of these resources at the dredged area and beach fill placement locations.

Table 3. Summary of federal and non-federal beach nourishment projects in North Carolina that have recently occurred, are currently underway, or will occur in the reasonably foreseeable future. (This list is not entirely comprehensive and does not include all small scale beach fill activities (i.e. dune restoration, beach scraping, etc.). (* - federal or non-federal projects which may utilize the same borrow sources and/or overlap beach placement locations).

Federal / Non-Federal	Project	Source of Sand for Nourishment	Beachfront Nourished	Approximate Length of Shoreline (miles)	Approximate Distance From the Figure Eight Island Project Area (miles)
Federal	*Dare County Beaches, NC Bodie Island (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Kitty Hawk and Nags Head Beaches	14	180
	Dare County Beaches, NC Hatteras to Ocracoke Portion	NA	Hatteras and Ocracoke Island (Hot Spots)	10	160
	Cape Lookout National Seashore -East Side of Cape Lookout Lighthouse	Channel	East Side of Cape Lookout Lighthouse	1	80
	*Beaufort Inlet Dredging - Section 933 Project (Outer Harbor)	Beaufort Inlet Outer Harbor	Indian Beach, Salter Path, and Portions of Pine Knoll Shores	7	65
	*Beaufort Inlet and Brandt Island Pumpout - Section 933 (Dredge Disposal to Eastern Bogue Banks)	Beaufort Inlet Inner Harbor and Brandt Island Pumpout	Fort Macon and Atlantic Beach	4	70
	*Bogue Banks, NC (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Communities of Bogue Banks	24	65
	Surf City and North Topsail Beach - (Coastal Storm Damage Reduction)	Offshore Borrow Areas	Surf City and North Topsail Beach	10	30
	*West Onslow Beach New River Inlet (Topsail Beach) (Coastal Storm Damage Reduction)	Offshore Borrow Areas	North Topsail Beach	6	40
	Wrightsville Beach (Coastal Storm Damage Reduction)	Masonboro Inlet and Banks Channel	Wrightsville Beach	3	10
	Carolina Beach and Vicinity, NC Carolina Beach Portion (Coastal Storm Damage Reduction)	Carolina Beach Inlet	Carolina Beach	2	20
	Carolina Beach and Vicinity, NC Kure Beach Portion (Coastal Storm Damage Reduction)	Wilmington Harbor Confined Disposal Area 4 and an Offshore Borrow Area	Kure Beach	2	25

	*Brunswick County Beaches, NC - Oak Island, Caswell, and Holden Beaches (Coastal Storm Damage Reduction)	Frying Pan Shoals	Caswell Beach, Yaupon Beach, Long Beach, Holden Beach	30	40
	*Wilmington Harbor Deepening (Section 933 Project) - Sand Management Plan	Wilmington Harbor Ocean Entrance Channels	Bald Head Island, Caswell Beach, Oak Island	4	35
	*Holden Beach (Section 933 Project)	Wilmington Harbor Ocean Entrance Channels	Holden Beach	2	40
	*Oak Island Section 1135 - Sea Turtle Habitat Restoration	Upland Borrow Area - Yellow Banks	Oak Island	2	40
	Ocean Isle Beach, NC (Coastal Storm Damage Reduction)	Shallotte Inlet	Ocean Isle Beach	2	40
Non-Federal	*Town of Nags Head - Beach Nourishment Project	Offshore Borrow Areas	Nags Head	10	180
	*Emerald Isle FEMA Project	Offshore Borrow Areas - Morehead City Port Shipping Channel (ODMDS)	Emerald Isle	4	60
	*Bogue Banks FEMA Project	Offshore Borrow Areas – Morehead City Port Shipping Channel (ODMDS)	Emerald Isle (2 segments), Indian Beach, Salter Path, Pine Knoll Shores	13	65
	*Bogue Banks Restoration Project – Phase I – Pine Knoll Shores and Indian Beach Joint Restoration	Offshore Borrow Areas	Pine Knoll Shores and Indian Beach	7	65
	*Bogue Banks Restoration Project – Phase II – Eastern Emerald Isle	Offshore Borrow Areas	Indian Beach and Emerald Isle	6	60
	*Bogue Banks Restoration Project – Phase III– Bogue Inlet Channel Realignment Project	Bogue Inlet Channel	Western Emerald Isle	5	60
	*North Topsail Dune Restoration (Town of North Topsail Beach)	Upland borrow source near Town of Wallace, NC	North Topsail Beach	NA	30

	*North Topsail Beach Shoreline Protection Project	New River Inlet Realignment and Offshore Borrow Area	North Topsail Beach	11	30
	*Topsail Beach - Beach Nourishment Project	New Topsail Inlet Ebb Shoal and Offshore Borrow areas	Topsail Beach	6	20
	Figure Eight Island	Banks Channel and Nixon Channel	North & South Sections of Figure Eight Island	3	0
	Rich Inlet Management Project	Relocation of Rich Inlet	Figure Eight Island	NA	0
	Mason Inlet Relocation Project	Mason Inlet (new channel) and Mason Creek	North end of Wrightsville Beach and south end of Figure Eight Island	2	5
	Bald Head Island Creek Project	Bald Head Creek	South Beach	0.34	35
	Bald Head Island - Beach Nourishment	Offshore Borrow Area - Jay Bird Shoals	West and South Beach of Bald Head Island	4	35
	*Holden Beach East & West	Upland Borrow Source (Truck Haul)	Extension of 933 Project	3	40
	*Holden Beach East & West	Upland Borrow Source (Truck Haul)	Extension of 933 Project	3	40

Table 4. Summary of dredged material disposal activities on the ocean front beach associated with navigation dredging. Projects listed and associated disposal locations and quantities may not be all encompassing and represent an estimate of navigation disposal activities for the purposes of this cumulative impacts assessment. (* - Navigation disposal sites which may overlap with existing Federal or Non-Federal beach nourishment projects).

PROJECT		DISPOSAL LOCATION	APPROVED DISPOSAL LIMITS	ESTIMATED ACTUAL DISPOSAL LIMITS	ESTIMATED QUANTITY (CY)
Outer Banks	**Avon**	Begins at a point 1.15 miles south of Avon Harbor and extends north 3.1 miles	3.1 miles (16,368 lf)	0.4 miles or 2,000 linear feet	<50,000 every 6 yrs
	Rodanthe	Extends from rd to Rodanthe Harbor south 700' to south end of beach disposal area (straight out from existing dirt road). North end at Wildlife Refuge Boundary (PINWR)	.91 miles (4,800 lf)	0.4 miles or 2,000 linear feet	<100,000 every 6 yrs
	Ocracoke Island	Begins at a point 5,000 linear feet south of Hatteras Inlet and extends southward about 3,000 linear feet.	0.6 mile (3,000 lf)	0.4 mile or 2,000 linear feet	<100,000 every 2 to 3 years
	Rollinson (Hatteras)	Begins at a point 0.85 miles south of Hatteras Harbor and extends north 5.85 miles to a point north of Frisco, NC	5.85 miles (30,888 lf)	0.4 miles or 2,000 linear feet	<60,000 every 2 years
	Silver Lake (Teaches Hole/Ocracoke)	From a point 2,000' NE of inlet and extending approximately 2,000 linear feet (0.4 miles) to the NE (Ocracoke Island)	0.4 miles (2,000 lf)	0.4 miles or 2,000 linear feet	<50,000 every 2 yrs

	Oregon Inlet	Pea Island National Wildlife Refuge (PINWR)	3 miles(15,840 lf)	1.5 miles or 7,920 linear feet	300,000 Annually
	Drum Inlet	Core Banks. From a point 2,000 feet on either side of inlet extending for 1 mile in either direction	2 miles (10,560 lf)	1 mile or 5,280 linear feet	298,000 initial, 100,000 maint. (Assume 8 year cycle)
Beaufort	***Morehead City (Brandt Island)**	2,000 ft west of inlet, Fort Macon and Atlantic Beach to Coral Bay Club, Pine Knoll Shores	7.3 miles (38,300 lf)	5.2 miles or 27,800 linear feet	3.5 million every 8 yrs
	***AIWW Section I, Tangent B**	Pine Knoll Shores, vicinity of Coral Bay	2 miles (10,500 lf)	0.4 miles or 2,000 linear feet	<50,000 every 5 yrs
Swansboro	***AIWW Bogue Inlet Crossing Section I, Tangent-H through F**	Approx. 2,000 feet from inlet going east to Emerald Point Villas, Emerald Isle (Bogue Banks)	1mile (5,280 lf)	0.4 miles or 2,000 linear feet	<100,000 annually
Browns Inlet	**AIWW Section II, Tangents-F,G,H**	Camp Lejeune, 3,000 feet west of Browns Inlet extending westward	1.58 miles (6,000 lf)	1 mile or 5,280 linear feet	<200,000 every 2 yrs
New River Inlet	***AIWW, New River Inlet Crossing Section II, Tangents I & J, Channel to Jax. Section III, tangents 1&2**	N. Topsail Beach, 3,000 feet west of inlet extending westward to Maritime Way (Galleon Bay area)	1.5 miles (8,000 lf)	0.8 miles or 4,000 linear feet	<200,000 annually

New Topsail Inlet (Hampstead)	***AIWW, Sect. III**	Topsail Island, Queens Grant	0.6 miles (2,500 lf)	0.6 miles or 2,500 lf	<50,000 every 6 yrs
	***AIWW, Topsail Inlet Crossing & Topsail Creek**	Topsail Beach, from a point 2,000 feet north of Topsail Inlet	1 mile (5,280 lf)	0.4 mi or 2,000 ft	<75,000 annualy
Wrightsville Beach	**AIWW Sect. III,Tang 11&12 Mason Inlet Crossing**	Shell Island (north end of Wrightsville Beach from a point 2,000 feet from Mason Inlet	0.4 miles (2,000 lf)	0.4 mi. or 2,000 lf	<100,000
	***Masonboro Sand Bypassing**	At a point 9,000 feet from jetty extending southward midway of island	1.2 miles (6,000 lf)	1 mile 5,280 lf	500,000 every 4 years
Carolina Beach	**AIWW, Section IV, Tangent 1**	Southern end of Masonboro Island at a point 2,000 linear feet from Carolina Beach Inlet extending northward to Johns Bay area	1.3 miles (7,000 lf)	0.4 miles (2,000 linear feet)	<50,000 annualy
	AIWW, Section IV, Tangent 1	North end of Carolina Beach at Freeman Park			
Caswell Beach	***Caswell Beach**	Beachfront on eastern end of island	4.7 miles (25,000 lf)	4.7 miles or (25,000 linear feet)	1.1 million every 6 years
Bald Head	***Bald Head**	Beach front on eastern and western shoreline	3.0 miles (16,000 lf)	3.0 miles or 16,000 lf	1.1 million every 2 years (except every 6th when it goes to Caswell)
Holden Beach	**AIWW**	Beach front on eastern end of the shoreline			

Ocean Isle	**AIWW**	Beachfront on eastern end of the island within the vicinity of Shallotte Blvd			

Inlet Intertidal Flats and Shoals: Many Inlets along North Carolina coastline have been deepened and widened to improve navigation, and in some incidence for flushing. As previously stated, 12 of the 21inlets in North Carolina are federally authorized for maintenance to improve both recreational and commercial navigation. Maintenance operations are conducted by cutterhead plants, which are stationary, and sidecast dredges, which suction the bottom sediment and disposes it approximately 100-150 feet to the side via on deck discharge arm or pipe. Within these 12 inlets, Bogue Inlet has had its ebb tide channel realigned over 1,000 feet away, via authorized permit action for the Town of Emerald Isle; New River Inlet may have its ebb channel realigned in the near future, via authorized permit action for the Town of North Topsail Beach; and Lockwood Folly Inlet is currently being evaluated for the installation of a terminal groin structure by the Town of Holden Beach. For the remaining nine inlets, four have never been dredged and five have been dredged however not within the past 15 or more years. It is unlikely that intertidal flats or shoals will be directly impacted by federal channel maintenance. To reiterate a previous discussion, authorized federal channels are allowed to only follow the deepest part, or thalweg, of the channel. Indirect and cumulative effects by these activities to intertidal flats and shoals are less discernible for each inlet, and even more so when all inlets are considered, especially for the inlets where dredging has taken place over several decades. For more recent projects, like Bogue Inlet Ebb Channel Relocation and Mason Inlet Relocation, a slightly better affects determination could be made, but even with these projects, overall impacts were somewhat inconclusive. Through aerial habitat mapping, results showed some acreage losses occurring at Bogue Inlet during the inlet adjustment period, but leveling off around two years. It was inconclusive to how much loss was attributed to the project and how much was related to seasonal storms and the breakthrough of a side channel. During that period, Hurricane Ophelia had passed through the area and it was difficult to determine with the available information to what extent affected the habitat. For Mason Inlet, long-term monitoring results and the inclusion of mitigation has shown that the overall impact to intertidal flats and shoals were minimal.

With the five inlets containing hardened structures, only the most recent terminal groin at Oregon Inlet has included monitoring. This monitoring effort’s main focus was on erosion rates for oceanfront shorelines along Bodie Island and Peas Island. Inlet intertidal flats and shoals were not part of the monitoring effort. For the proposed Figure Eight terminal groin, models do show some loss of intertidal flats and shoals on the south side of Rich Inlet while the north and west areas are expected to redevelop these habitats over a 5-year period. It appears that the influence of sediment transport around inlets, which help form and reform intertidal flats and shoals, depends largely on the size and design of the structure. Jetty structures and groins extending greater seaward distances would tend to capture more sediment and disrupt movement into the inlet gorge or throat. These structures, like Masonboro Inlet and Beaufort Inlet, were constructed for navigational purposes to keep sediment out of the inlet, thus reducing the development of inlet intertidal flats and/or shoals. Of the five inlets with hardened structures in North Carolina, only one of those includes a jetty and one a geo-tube field. However, four additional inlets, including Figure Eight proposal at Rich Inlet, could be constructed in the foreseeable future. Although it is difficult to discern the overall cumulative effects of the current structures, with the exception of the Masonboro jetty, the potential future terminal groin structures will likely require detailed monitoring and a full assessment of any impacts to intertidal flats and shoal areas.

In assessing the inlet dredging activity and inlet structure features, impacts to fishery resources and birds using intertidal flats and shoals appear to be on a small scale, short-term, and localized. While habitat may be indirectly affected in a certain area of an inlet complex, it tends to redevelop or expand in other areas of the inlet. At this time and with the current available information, it is difficult to quantify and qualify cumulative effects on these habitats from all past, present, and potential future projects, including the Figure Eight proposal.

Water Column: It has been demonstrated that inlet dredging and beach fill activities do increase turbidity and TSS levels. These elevated levels are expected to continue with current dredging projects and any future maintenance events, including this proposed project. Many factors contribute to the levels of turbidity and TSS for each project and are the following: the type of material being dredged, type of equipment used, site location, time of dredging and beach fill, weather and tide conditions, and duration of the dredging event. Any impacts to fishery resources associated with dredge and fill work will also be depended on the factors above, especially the time of year. Many of these events, particularly beach nourishment actions, occur during the winter months when the biological activity, including fish passage and larval transport, is at their lowest or absent.

With the exception of duration, the increased levels of past, current, and future projects would not be considered outside the natural range of effects associated with high wave energy and storm events. Most turbidity and TSS levels are localized, settle to the bottom, and are generally dispersed and reduced quickly in the currents or tidal cycle.

For dredging in inlets and structure placement along inlet shorelines, tidal flows may be affected by disrupting the amount of current exchange during tidal events. Some inlets, like Masonboro Inlet, have been dramatically altered by past actions, and it can be assumed that the tidal prism has been altered. Some inlets, like Old Topsail and Madd Inlets, naturally open and close periodically as result of storm events. It is not known to what extent, if any, past and current inlet maintenance dredging has had on inlet tidal prisms. It is expected to be minimal since these events following the existing channel thalweg. In most cases, the channels refill to pre-maintenance conditions within 6 months to a year. For ebb tide channel relocation projects, reference to post construction tidal change can be made to the former Bogue Inlet Channel Relocation Project and future New River Inlet Channel Relocation Projects, which both are also federally authorized navigation channels. Both were modeled and analyzed for tidal prism changes and whether relocating the ebb tide channel within the inlets would disrupt the flows. Targeted new channel depths were -18 & -19 feet, respectively. Results from the modeling showed minimal change to the tidal prism. For Figure Eight's proposal, the tidal exchange within Rich Inlet was also modeled and analyzed. No significant changes in the tidal flow through Rich Inlet were predicted. Also, Delft3D model results indicate that the distribution of flow through Nixon Channel and Green Channel with a terminal groin in place on the north end of Figure Eight Island was essentially the same as those for existing conditions with between 47% and 49% of the flow passing through Nixon Channel and 38% and 39% of the flow passing through Green Channel compared to 49% through Nixon and 39% through Green for existing conditions.

The magnitude and significance of any impacts to the Water Column are difficult to discern, especially for older projects. Considering all the factors stated above, it is expected that the magnitude and significance of environmental consequences associated with the more recent, current, and foreseeable future projects are considered to be neutral or unappreciable. Although turbidity and TSS levels can and have been measured, effects of those levels are considered minor due to the time of year most actions are conducted. Also as shown above, the tidal prism within the inlet Water Column will generally not be modified, and if some changes do occur, the extent of those changes are not expected to be significant.

<u>Hardened Structures</u>
As described in the baseline conditions of Step 7, there are nine hardened structures along the North Carolina oceanfront that have an effect on approximately 7.7 miles of shoreline. Of the nine, three are terminal groins, one is a jetty, and one is a groin field that is in proximity of the mouth of the Cape Fear River. Recent State Legislation has lifted the ban on oceanfront hardened structures by allowing four future terminal groins, which the current Figure Eight is proceeding to be one of those four. Prior to the law change, the North Carolina State Legislators mandated a study to determine the full extent of consequences on the shorelines of adjacent properties and the surrounding environment. In early 2010, the State of North Carolina explored the environmental impacts attributable to a series of five (5) terminal groins located in Florida and North Carolina within the "North Carolina Terminal Groin Study Final Report" (NCDENR, 2010). This report included a review of past scientific, engineering, and publicly accessible information and data related to the five terminal groin projects. Environmental natural resources evaluated included benthic resources, shorebirds and waterbirds, fisheries, coastal habitats and associated biota, and federally protected species, such as sea turtles and piping plovers. Amongst the conclusions drawn from the report, it stated that "the environmental effects of a terminal groin structure alone could not be assessed for the sites without considering the associated beach nourishment activity" (NCDENR, 2010).

Of the five terminal groins presented in the NCDENR report, the Oregon Inlet structure had the most comprehensive data for evaluating shoreline effects of a terminal groin structure over the longest period of time. Initial construction of the 3,125-foot long groin took place in 1989 to provide protection from erosion occurring along the base of the Herbert C. Bonner Bridge, which spans the Oregon Inlet and connects Hatteras Island to the mainland, in Dare County. Permit stipulations required regular monitoring of the physical conditions to determine shoreline changes along a six mile segment of the shoreline extending south from the terminal groin. This post-monitoring was initiated after the completion of the terminal groin in 1991. As of June 2, 2011, results have shown that the project erosion rates are much less than historical rates in the first four miles of the study area (Overton, 2011). There are sections were the rates are closer to the historical rate; however, they do not exceed the historical rate at any point. Overton (2011) points out that the construction of the groin has not appeared to have caused adverse impacts to the shoreline over the six-mile study area. It should be noted that since 1991, a total of 4.3 million cubic yards of material from the dredging of Oregon Inlet by the USACE has been placed on the beach or immediately offshore of the beach within the study area. It is presumed that the placement of the terminal groin has help retain a net of 18.7 million cubic yards of material on the beaches within the study area (Overton, pers. comm.). In summary, as stated above, the construction of the groin does not appear to have caused an adverse impact on the shoreline over the six mile study area (Overton, pers. comm.; Overton, 2011). Also, it may be presumed that some of this decrease of erosion can be attributed to the placement of the material along this stretch of shoreline. Even though biological monitoring was not included in the Oregon Inlet study, bird monitoring was conducted at the site by the North Carolina Wildlife Resource Commission. Results showed that piping plover nesting activity increased following the construction of the terminal groin. This was most likely associated with the development of an ephemeral pool created by NCDOT at the site, which provided foraging habitat. Once much of this ephemeral pool filled in and became vegetated, the piping plover numbers returned to pre-construction levels (Cameron, pers. comm., 2007).

Three (3) potential terminal groin structures, including Figure Eight's proposal, that may be constructed in the foreseeable future are currently being evaluated for State and Federal authorization. One (1) terminal groin structure is currently being built at Bald Head Island. State law automatically requires each of these structures to be monitored and assessed to determine if significant physical impacts to the adjacent shorelines are occurring. Additionally, the State law mandates that each groin structure must be supplemented with beach nourishment, which is the case with Figure Eight's proposal. By this same law, the removal of each structure will be required if significant impacts are verified. With the long-term data from the Oregon Inlet groin study coupled with the State law requirements, cumulative impacts from Figure Eight are not anticipated and should be minimal. If not, measurements are in place to mitigate for those impacts, which again may include removal. Also, the proposed structural length of each will be much shorter than the current groin and jetty structures in place which should reduce further potential effects.

10. Modify or Add Alternatives to Avoid, Minimize, or Mitigate Significant Cumulative Effects

The private shoreline protection projects (beach nourishment, ebb tide channel relocation, and/or channel dredging) that have occurred in the last decade or are planned for the foreseeable future include avoidance and minimization strategies. These actions incorporate measures to protect the natural resources through various measures including limiting the timing of construction to the winter months when biological activity is at its lowest, improved dredge and construction methods designed to avoid or minimize environmental impacts, implementation of species conservation measures, and the use of compatible beach nourishment material. These practices, along with educating dredge operators, utilizing marine mammal and turtle observers, and modifying equipment, have improved over the past decade or so and are expected to continue to improve as technology advances. These improvements have served to further the avoidance and minimization of adverse impacts to the natural resources found along the coastline of North Carolina. Chapter 6 of the Environmental Impact Statement describes these actions and measures in greater detail.

11. Monitor the Cumulative Effects of the Selected Alternative and Adaptive Management

As stated in Step 10, private beach nourishment projects that have recently occurred or are planned for the foreseeable future include avoidance and minimization strategies which include biological monitoring efforts. This section identifies existing monitoring programs that include surveys of significant resources within the impact area. While several potential monitoring components have been discussed for the proposed Figure Eight Island Shoreline Management Project, a monitoring plan continues to be developed as consultation with State and Federal agencies is initiated.

<u>Human Resources and Hardened Structures</u>
The legislation passed by the NC General Assembly in June 2011 authorizing the permitting of terminal groins at 4 inlets in North Carolina carried with it the requirement to provide a plan for managing inlet and the estuarine and ocean shorelines likely to be under the influence of the inlet. The legislation requires the management plan to include the following:

1. A monitoring plan.
2. A baseline for assessing adverse impacts and thresholds for when adverse impact must be mitigated.
3. A description of mitigation measures to address adverse impacts.
4. A plan to modify or remove the terminal groin if adverse impacts cannot be mitigated.

Chapter 6 of the EIS includes technical details of this shoreline monitoring plan.

<u>Beach Resource and Associated Shorebird, Infaunal, Sea Turtle Resources, Intertidal Flats and Shoals, Salt Marsh and Water Column Resources</u>
The monitoring programs described below include surveys of significant resources within the impact area.

Bird Monitoring
The North Carolina Wildlife Resource Commission and North Carolina Audubon Society (NCAS) have performed breeding surveys for colonial nesting waterbirds within proximity of the Permit Area on a regular basis since 1977. Specifically, surveys have been conducted within the northside of Mason's Inlet and the Southside of Rich Inlet, flanking Figure Eight Island (Mangiameli, pers. comm.). Surveys have also been conducted along Hutaff Island (including the northside of Rich Inlet) as well as the

southside of New Topsail Inlet, and Old Topsail Inlet. Surveys for breeding piping plovers have been conducted since 1989 at the same locations. Opportunistic surveys for non-breeding piping plovers have been conducted in more recent years. These ongoing surveys include observations from breeding and non-breeding seasons for several listed bird species as well as other shorebirds and waterbirds.

Along with the effort described above, the University of North Carolina at Wilmington (UNCW), under the direction of Dr. David Webster, conducts shorebird and colonial waterbird monitoring throughout the year along the beachfront of Figure Eight Island and the areas surrounding Mason and Rich Inlet. This monitoring is expected to continue for the foreseeable future (Webster, pers. comm.).

Seabeach Amaranth (Amaranthus pumilus)
Since 2002, UNCW has conducted regular monitoring along the entire beachfront of Figure Eight Island for the presence of seabeach amaranth. This monitoring is anticipated to continue for the foreseeable future (Webster, pers. comm.). NCAS also reports upon the occurrence of seabeach amaranth along the beachfront on Hutaff Island (Mangiameli, pers. comm., 2008).

Sea Turtles
Since 2001, sea turtle nesting activity has been monitored on a daily basis throughout the nesting season along the Figure Eight Island beachfront by UNCW under the direction of Dr. David Webster (Godfrey, pers. comm.). This monitoring begins on approximately May 1 and continues through the last hatch date each year. NCAS performs a similar monitoring effort throughout nesting season on Hutaff Island, however this monitoring is not conducted on a daily basis.

Habitat Mapping
It is anticipated that the implementation of the proposed project has the potential to impact a number of biological resources found within the inlet complex. These include resources such as submerged aquatic vegetation (SAV), shellfish habitat, salt marsh and supratidal, intertidal, and subtidal habitats. Determining the baseline conditions of these resources prior to construction is a fundamental step in quantifying changes in response to the implementation of the inlet management plan. Existing data and newly acquired data were utilized to delineate and characterize habitats and select species within the inlet complex. Data gathered from these activities provided the baseline conditions of a number of biological resources. A report, entitled "Baseline Assessment of Biological Resources" was submitted to the USACE in April 2009. The purpose of the baseline habitat mapping effort was to identify the current extent of the biological resources within the area prior to the construction of the ocean bar channel and will serve as the baseline assessment of these resources. Subsequent habitat mapping efforts will be utilized to assess the extent of change to these habitats following construction activities. This plan was developed in response to the concerns expressed by the USACE, USFWS, NMFS and the NCDENR. See Chapter 6 of the EIS for technical details of the mapping plan.

Construction Observations
Several initiatives will be undertaken by F8 HOA, the Engineer, or his duly authorized representative to monitor construction practices. Construction observation and contract administration will be periodically performed during periods of active construction. Most observations will be during daylight hours; however, random nighttime observations may be conducted. The F8 HOA, the Engineer, or his duly authorized representative will provide onsite observation by an individual with training or experience in beach nourishment and construction observation and testing, and that is knowledgeable of the project design and permit conditions. The project manager, a coastal engineer, will coordinate with the field observer. Multiple daily observations of the pumpout location will be made by the F8 HOA, the Engineer, or his duly authorized representative for QA/QC of the material being placed on the beach. Information pertaining to the quality of the material will periodically be submitted to the USACE and NC DCM for verification. If incompatible material is placed on the beach, the USACE and NC DCM will be contacted immediately to determine appropriate actions.

Material Color- The F8 HOA, the Engineer, or their duly authorized representative, will collect a representative sub-surface (6 in below grade) grab sediment sample from each 100-ft long (along the shoreline) section of the constructed beach to visually assess grain size, wet Munsell color, granular, gravel, and silt content. Each sample will be archived with the date, time, and location of the sample. Samples will be collected during beach observations. The sample will be visually compared to the acceptable sand criteria (Table 6.1). If determined necessary by the Engineer, or his duly authorized representative, quantitative assessments of the sand will be conducted for grain size, wet Munsell color, and content of gravel, granular and silt. A record of these sand evaluations will be provided within the Engineer's daily inspection reports and submitted to USACE and NC DCM for verification.

Escarpments- Visual surveys of escarpments will be made along the beach fill area immediately after completion of construction. Escarpments in the newly placed beach fill that exceed 18 inches for greater than 100 ft shall be graded to match adjacent grades on the beach. The decision for escarpment removal will be determined upon consultation with USACE and NC DCM. Removal of any escarpments during the sea turtle hatching season (May 1 through November 15) shall be coordinated with the North Carolina Wildlife Resources Commission (NCWRC), USFWS, and the USACE – Wilmington District.

Water Quality- Turbidity monitoring during construction will be managed by the contractor. The contractor will be responsible for notifying the construction engineer in the event that turbidity levels exceed the State water quality standards.

See Chapter 6 of the EIS for technical details of the construction observation plans.

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