## 3.0 PROJECT ALTERNATIVES

NEPA and the CEQ regulations for implementing the NEPA (40 CFR 1500 *et. seq.*) require the identification and evaluation of reasonable alternatives that meet the purpose and need and are practical or feasible from a technical and economic standpoint. This section describes the alternatives that were considered and evaluated during the NEPA process associated with this EIS, including alternatives that were identified as reasonable and carried forward for full analysis, as well as those that were initially considered and eliminated from further consideration.

### 3.1 Identification and Screening of Alternatives

A wide range of potential alternatives were identified and considered during the EIS scoping process; including options identified by the County as part of its effort to develop the proposed MBNP, alternatives identified through coordination with the USACE and BOEM, and no action alternatives as required by CEQ regulations. Potential alternatives were evaluated and screened, and five alternatives were determined to be "reasonable" on the basis of being "practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant", as defined by CEQ regulations (40 CFR 1500 *et. seq.*). Other factors considered in determining the reasonability of an alternative included its ability to meet the basic purpose and need and its consistency with NC's coastal management policies. The Bogue Banks Beach and Nearshore Mapping Program has provided extensive physical shoreline change data through long-term (since 1999), comprehensive annual beach profile monitoring along ~122 transects spanning the length of the island (Figure 3.1). Prior to identifying any specific management options, the County conducted extensive engineering studies to evaluate historical erosion trends, establish baseline shoreline conditions, and determine the long-term nourishment requirements for Bogue Banks in terms of reach-specific volumes and intervals [see the proposed MBNP (Appendix F)]. Information provided by the physical monitoring program and engineering analyses was one of the principal tools used to evaluate the effectiveness of the alternatives in meeting the purpose and need for shore protection along Bogue Banks. Another invaluable resource was the wealth of physical data amassed by the USACE through engineering studies and geotechnical surveys related to the Morehead City Harbor (MCH) and Bogue Inlet federal navigation projects and efforts to develop the federal Bogue Banks CSDR project. Additional information regarding the resources employed in evaluations of specific alternatives is provided throughout the remainder of this section.

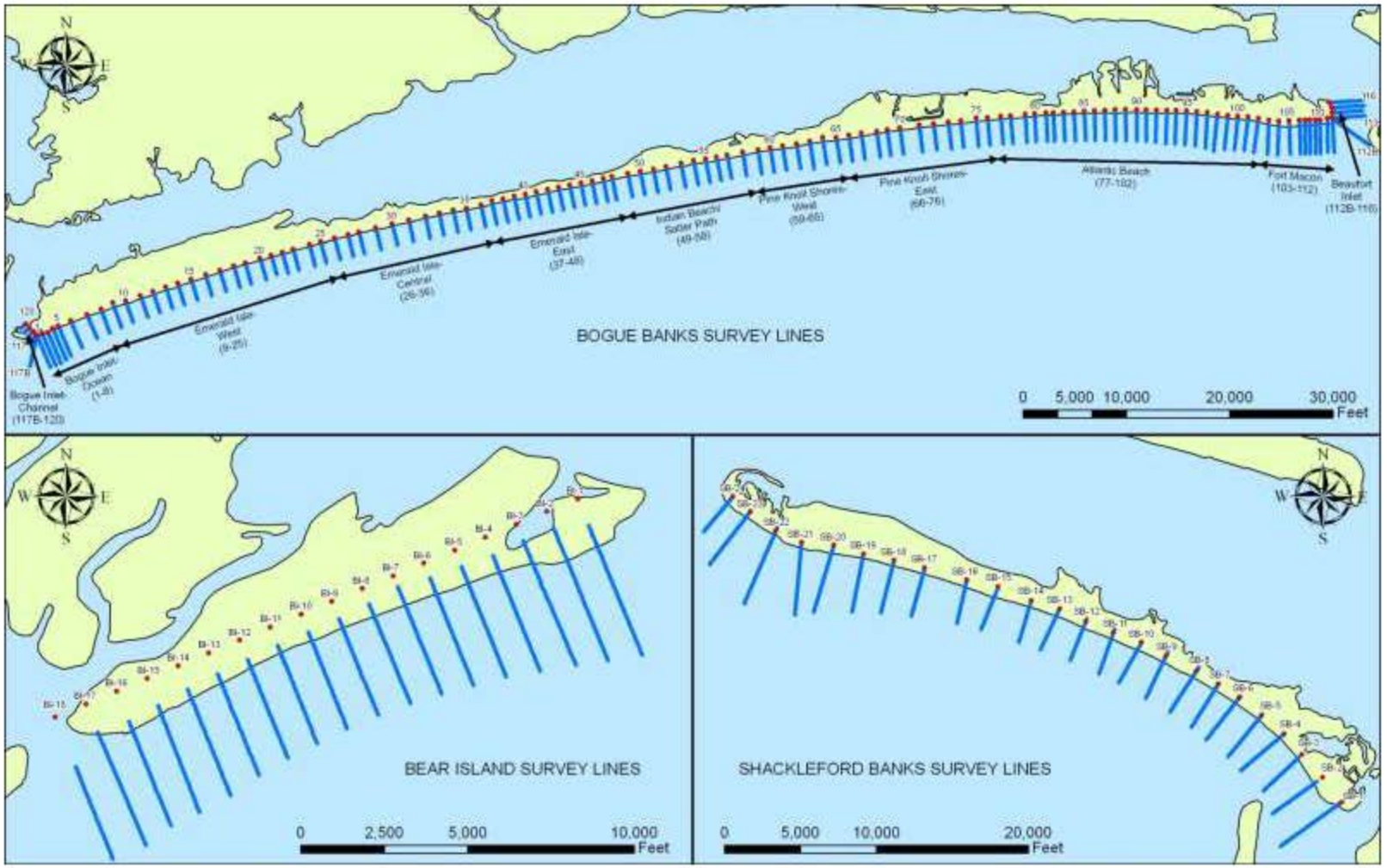



**Figure 3.1. Bogue Banks Beach Profile Monitoring Transects**

## 3.2 Preliminary Alternatives Eliminated from Further Evaluation

Based on an initial screening-level evaluation, the following alternatives were determined to be unreasonable and were excluded from further consideration in this EIS.

*Inlet Sand Transfer Plant*

Sand transfer plants are sediment collection systems that are positioned at inlets to transfer sand from the updrift beach to the downdrift beach via a fixed dredge pump and pipeline system, thereby bypassing the sand trapping effects of the inlet. Transfer plants typically have a relatively moderate transfer efficiency rate of approximately 50 percent. A sand transfer plant and sediment trap could potentially be constructed along the updrift (east) side of Beaufort Inlet (on Shackleford Banks) to partially offset any unknown inlet-related longshore transport deficit along Bogue Banks. The plant would require a pipeline under the inlet to a discharge point approximately three to four miles west of the inlet, where the discharged sediment could be carried by longshore currents to downdrift beaches. This option was eliminated as unreasonable based on the following: 1) Nearly all currently operating sand transfer plants are located at shallower inlets where longshore transport rates are lower than the shoaling rates in MCH. Larger plants similar to the one that would be needed at Beaufort Inlet require significant infrastructure to house the jet pumps that transport the material to the necessary downdrift beach locations, resulting in significantly higher costs that could total up to $50-75M with annual operating costs of up to $5-10M. The cost to construct, maintain, and operate such a system is considered financially prohibitive and unreasonable; 2) A smaller less expensive plant would not be reasonable given that the material would need to be pumped up to three to four miles to provide any benefit to downdrift beaches and prevent the material from being carried back into Beaufort Inlet; and 3) it is unlikely that the installation of a sand transfer plant on NPS land (i.e. Shackleford Banks) would be allowed, as the NPS is generally opposed to artificial shoreline stabilization projects. In fact, the NPS has rejected prior proposals for a small terminal groin and beach placement of navigation dredged material on the island. Although this structure is not a groin, it would likely include some type of trestle feature with accompanying pump systems that would protrude from the shoulder of Shackleford Banks. Based on these factors, a sand transfer system would have limited efficiency and is determined to be unreasonable.

*Nearshore Berm*

Nearshore berms can potentially function as a source of sand for eroding beaches and provide a limited measure of storm protection to oceanfront property through wave energy attenuation. Berm construction usually entails the placement of material in shallow water just off the beach to create a nearshore sand feature that functions in the same manner as a natural sandbar. The construction of such a berm along Bogue Banks could be completed using compatible sand from an inlet or offshore borrow source such as the MCH ODMDS. Dredging technology allows

for berm construction in water depths as shallow as 15 ft, and the dissipation of waves as they pass over the berm during normal water levels may provide some mitigation of background shoreline erosion. However, during storm events when water levels are elevated; storm waves would pass over the berm, erode the beach, and present a threat to upland property. In addition, although some sand may be transferred from the berm to the beach, the volumetric extent of transfer would be insufficient to maintain a functional recreational beach and adequate shoreline protection. The 2016 MCH DMMP identifies "nearshore placement areas" (potentially equivalent to a "nearshore berm") as potential disposal areas associated with future USACE MCH maintenance dredging, and these types of features have been used in the past. However, past studies and surveys of these berms have shown that these features are located too far offshore to have any measureable effect on the beaches and littoral system. Thus, nearshore berms are not a reasonable option, as they do not reliably or sufficiently, in and of themselves, preserve the beach-dune system. For these reasons, this alternative does not meet the overall purpose of shoreline protection and was eliminated from further consideration.

*Submerged Breakwaters*

Submerged breakwaters are offshore detached shore-parallel structures that are intended to reduce shoreline erosion through the attenuation of wave energy. A variety of designs have been employed along the Atlantic Coast; including prefabricated concrete reefs, sills, reef balls, and sand-filled geotextile tubes. In 1995, an experimental 1,260-meter (m) submerged breakwater consisting of inter-locking concrete units was installed for shore protection in Palm Beach, Florida. However, the structure was removed after monitoring revealed erosion rates 2.3 times higher than those before the project (Browder et al. 1996). A recent evaluation of submerged breakwaters along the US Atlantic Coast by the USACE Coastal and Hydraulics Laboratory found that most breakwaters have not performed well in open coast settings unless they were mounted on hardbottom (Morang et al. 2014). Furthermore, NC coastal management regulations currently prohibit the use of offshore submerged breakwaters. Based on the noted insufficiencies of submerged breakwater structures in environmental settings that are similar to that of Bogue Banks, and considering the prohibition of such hardened structures by the State of North Carolina, this alternative was deemed unreasonable and eliminated from further consideration.

*Restrictions on New Development (Beach Rezoning or Construction Moratorium)*

Restricting or limiting future construction along eroding beaches through rezoning or a construction moratorium can effectively limit the exposure of new structures to potential storm damage. if implemented under suitable or applicable conditions. In the case of Bogue Banks, most of the developable upland areas are approaching full build-out and are not conducive to such rezoning measures, particularly in regard to oceanfront and second-row lots. Rezoning would not provide any substantial reduction in the storm damage risk to structures and upland property on the island, and implementing these types of measures would not address the long-term protection needs of the island's existing infrastructure and homes. Any restriction on new

development would fail to protect the shoreline and would be economically infeasible; therefore, this alternative was deemed unreasonable and eliminated from further consideration.

*USACE CSDR Project*

USACE CSDR projects are large 50-year recurring nourishment projects that are specifically authorized by Congress through Water Resource Development Acts (WRDAs). Congress has authorized the USACE to conduct studies for the potential development of a CSDR project encompassing Atlantic Beach, Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle. The USACE completed a feasibility study that included the development of a tentative National Economic Development (NED) plan based on a cost/benefit analysis of beach nourishment and the associated economic value provided by shore protection and recreation. The tentative NED plan would encompass a 2.45 MCY initial construction event, followed by recurring placements of approximately 1.1 MCY of sand every three years. In total, approximately 19.55 MCY of material would be placed over the 50-year life of the project to offset projected background erosional losses. If authorized and part of a regularly funded rotation, the Bogue Banks CSDR project could potentially meet the purpose and need for shore protection as it pertains to background erosion. However, the CSDR project would not address additional sand losses attributable to major storms. Furthermore, based on the current trend of drastically declining federal funding for shore protection projects, it is questionable whether the CSDR project will ever be implemented. With such uncertainty, it is difficult for the County and local municipalities to be proactive and pre-plan for nourishment events in a timely manner while depending on allocations of federal monies. In circumstances where federal funds are not appropriated and the island has experienced severe erosion or frequent storms; the County and local governments would have difficulty in planning, designing, and implementing a timely project. The inclusion of construction windows adds to the difficulty of implementing projects in a timely and efficient manner when the County and towns are attempting to make up for the shortfall of federal funds. Due to the dependency of the project on uncertain future federal monies, the CSDR project precludes the County from administering any type of individual proactive short- and/or long-term shoreline management program in an efficient and economical manner, and thus does not meet their overall needs. Therefore, this alternative would be infeasible and was eliminated from further consideration. .

*Alternative Terminal Groin Designs*

The evaluation of potential structural Bogue Inlet management options included analyses of three terminal groin designs consisting of short (1,000-ft), intermediate (1,250 ft), and long (1,500-ft) groin configurations. The alternative groin designs were evaluated for functional shore protection performance as well as adverse erosional effects on the updrift[1] shoreline to the east of Bogue Inlet. As described in the Engineering Report (Appendix G), various methods of analysis were employed; including calculations of shoreline changes associated with existing groins along the southeast coast, analytical predictions of shoreline change, and the use of the local 2D Bogue Inlet model to assess the effects of the groins on inlet morphology. The short groin was shown to have no beneficial shoreline displacement effect on the updrift Emerald Isle shoreline. The long-groin was shown to have significant beneficial shoreline displacement effects on the updrift Emerald Isle shoreline within ~5,000 ft of the groin, but analyses indicated measurable adverse erosional effects on the updrift shoreline beyond ~5,000 ft. Based on these results, showing that these alternative groin designs do not meet the long-term protection needs along the western end of Bogue Island, the short and long groins were not considered reasonable in meeting the overall project purpose due to the lack of providing a positive effect on adjacent shorelines. Therefore, these design options were eliminated from further consideration in this EIS.

## 3.3 Alternatives Carried Forward for Full Evaluation

The alternatives screening and evaluation process identified five alternatives (Table 3.1) as warranting full evaluation in this EIS; including two no action (Alternatives 1 and 2) and three action alternatives (Alternatives 3, 4, and 5). Pursuant to CEQ regulations, no action can be defined as the continuation of current management (i.e., Alternative 1) and/or as a without project scenario involving no federally permitted management activity (Alternative 2). Alternatives 3, 4, and 5 represent alternate long-term management scenarios for maintaining the beaches of Bogue Banks over the next 50 years. Management elements that are common to the Alternatives 3, 4, and 5 include recurring nourishment of the approximately 15 miles of beaches along Atlantic Beach, Pine Knoll Shores, Indian Beach/Salter Path, and eastern Emerald Isle; and the acquisition of beach fill from offshore borrow sites, AIWW disposal islands, and upland sand mines. The three action alternatives differ in their approaches to management of the remaining approximately eight miles of beaches along central and western Emerald Isle. Alternative 4, consisting of beach nourishment and non-structural Bogue Inlet management, is the applicant's preferred alternative.

[1] "Downdrift" refers to the direction of predominant longshore sediment transport along the beach, whereas "updrift" refers to the direction opposite that of predominant longshore transport.

**Table 3.1. Alternatives carried forward for full evaluation.**

| | |
|---|---|
| Alternative 1 | No Action (Status-Quo) |
| Alternative 2 | Relocation and Abandonment |
| Alternative 3 | Nourishment Only |
| Alternative 4* | Nourishment and Non-Structural Bogue Inlet Management |
| Alternative 5 | Nourishment and Structural Bogue Inlet Management |

*Alternative 4 is the Applicant's Preferred Alternative

### **3.3.1** No Action Alternative

Alternative 1 (No-Action) represents the continuation of shore protection management efforts over the next 50 years in the same manner as in the past. Continuing beach nourishment activities would include: 1) USACE placements of navigation dredged material on Fort Macon and Atlantic Beach via maintenance of the MCH navigation channels, 2) USACE placements of navigation dredged material on the west end of Emerald Isle via maintenance of the AIWW Bogue Inlet Crossing (Photo 3.1), 3) limited erosional hotspot response nourishment projects implemented by the individual municipalities using offshore borrow areas, 4) and limited relocations of the Bogue Inlet ebb channel (Figure 3.2, Table 3.2). Additional activities that would be expected to continue under Alternative 1 include beach bulldozing above MHW and temporary sandbagging by local municipalities and/or individual property owners.

The MCH federal navigation project provides deep draft commercial vessel access to the NCSPA berthing facilities at the Port of Morehead City. Since 1978, the USACE has placed navigation dredged material from the MCH channels on the beaches of Fort Macon and Atlantic Beach on 11 occasions. Differences in sediment characteristics divide the harbor channels into distinct inner harbor, outer harbor, and outer entrance channel sections. Sediments in the inner harbor and outer entrance channel generally consist of fine-grained material that is unsuitable for beach placement, while sediments in the outer harbor channels are generally composed of coarse-grained beach-compatible material. The inner harbor is maintained by pipeline or bucket-barge dredges, with disposal to the Brandt Island upland disposal site behind the east end of Bogue Banks or the southwest corner of the ODMDS. Historically, inner harbor material was placed on Bogue Banks via Brandt Island pump-outs; however, this practice ended in 2005 when excessive quantities of fines were detected in beach placed material. Beach disposal events since 2005 have been limited to direct beach placement of coarse-grained material from the outer harbor. The outer harbor and outer entrance channel are generally maintained annually by hopper or pipeline dredges. Disposal practices for coarse-grained outer harbor material have included placement on Bogue Banks, nearshore placement along the western margin of Beaufort Inlet, and placement in the ODMDS

**Photo 3.1. Pipeline dredging of the AIWW Bogue Inlet crossing.**


**Figure 3.2**. **Alternative 1 (No Action) Sand Placement Activities and Borrow Sites**

**Table 3.2. Alternative 1 (No Action) sand placement activities.**

| Placement Reach | Project Type | Beach Fill Source | Interval (years) | No. of Events | Per Event Placement Volume (cy)[1] | 50-Year Placement Volume (cy)[1] |
|---|---|---|---|---|---|---|
| Bogue Inlet (Stations 1-11) | USACE Navigation | AIWW Bogue Inlet Crossing | 3 | 16 | 60,600 | 969,600 |
| Bogue Inlet (Stations 1-11) Emerald Isle West (Stations 12-25) | County/Local | Bogue Inlet Channel Relocation | 20 | 2 | 850,000 | 1,700,000 |
| Emerald Isle Hotspot (Stations 37-48) | County/Local | Offshore AIWW Islands Upland Sites | 11 | 5 | 523,644 | 2,380,200 |
| Pine Knoll Shores Hotspot (Stations 59-76) | County/Local | Offshore AIWW Islands Upland Sites | 11 | 5 | 472,318 | 2,146,900 |
| Atlantic Beach (Stations 77-102) | USACE Navigation | MCH Channels | 3 | 16 | 494,835 | 7,917,360 |
| **Total** | | | | | | **15,114,060** |

[1] The sand placement volumes identified in this table represent the projected volumetric needs for the various reaches based on analyses presented in the Engineering Report (Appendix G). Actual placement volumes will vary depending on the specific volumetric requirements associated with individual federal navigation dredging projects.

in an area designated for beach-compatible material. Non-compatible dredged material from the outer entrance channel is placed in the ODMDS in an area designated for fine-grained material. In addition to the Fort Macon/Atlantic Beach placements, the USACE placed material from the MCH channels on ~7.2 miles of beaches within Indian Beach/Salter Path and Pine Knoll Shores through a federal 933 (Beneficial Use) project that was constructed in two phases in 2004 and 2007. The USACE recently finalized a new 20-year DMMP for MCH that provides for the placement of navigation dredged material on Atlantic Beach and Fort Macon every three years (USACE 2016a). In 2008, the USACE completed an IOP to address disposal practices during the MCH DMMP development process. NEPA requirements for the IOP were addressed through an EA that was completed in 2009 (USACE 2009). The IOP disposal regime is based on a three-year cycle of harbor maintenance dredging, and includes the placement of coarse-grained material on Bogue Banks during Year-1 and the placement of coarse-grained material in the nearshore disposal area during Years 2 and 3. Under the IOP, Bogue Banks received two placements of dredged material in 2010/2011 and 2014. The 2016 MCH DMMP provides for the placement of up to 1,200,000 cy of compatible dredged material on eastern Bogue Banks every three years. The 2016 DMMP established a "base" disposal area encompassing the ~6.1 miles of beaches along Fort Macon and Atlantic Beach (Stations 77 to 107). As described in the 2016 DMMP, the base disposal area would receive volumes sufficient to offset

erosional losses potentially attributable to the federal MCH project, with specific offset volumes determined through shoreline monitoring (USACE 2016a). Compatible material in excess of the offset volumes (if available) may also be placed along the base disposal reach and/or with local cost-sharing along Pine Knoll Shores. Under Alternative 1, it is assumed that beach disposal on Bogue Banks would occur in accordance with the 2016 DMMP. No implementation cost is incurred by the County or local municipalities for maintenance of the MCH channels and associated beach disposal activities on Fort Macon and Atlantic Beach.

USACE maintenance dredging of the AIWW Bogue Inlet Crossing channel and associated beach disposal along the west end of Emerald Isle has typically occurred every two to three years (Photo 3.2). The channel is maintained by pipeline dredges, which pump the dredged material directly onto the ~0.5-mile inlet/ocean beach along the westernmost end of Emerald Isle. Dredged material was placed on the beach 12 times between 1984 and 2010. NEPA requirements for the placement of inlet crossing dredged material on Bogue Banks were addressed through an EA that was completed in 1988 (USACE 1988). Under Alternative 1, it is assumed that AIWW inlet crossing beach disposal projects would continue to occur every two to three years, with placement volumes approximating the recent average of ~60,600 cy per event. No implementation cost is incurred by the County or local municipalities for inlet crossing dredging and associated beach disposal activities.

In addition to continuing maintenance of the AIWW Bogue Inlet Crossing channel, maintenance of the Bogue Inlet federal navigation project would also be expected to continue under Alternative 1. The Bogue Inlet shallow draft navigation project encompasses an inner channel six feet deep and 90 ft wide between the AIWW crossing channel and the inlet throat and an outer channel eight feet deep and 150 ft wide extending seaward from the inlet throat across the ocean bar. Dredging follows the deepwater channel that exists at the time of maintenance events, and the project does not authorize channel relocations or efforts to maintain a fixed channel alignment. The inlet was dredged 79 times between 1975 and 2010, with an average of 82,510 cy of material removed per dredging event. Dredging has been performed primarily by sidecaster dredges, with disposal of the dredged material to open waters adjacent to the navigation channel, thus providing no shore protection benefit for the adjacent beach and infrastructure (Photo 3.3).

Prior to 2002, no county or municipal sponsored nourishment projects were undertaken on Bogue Banks. As previously described, the first non-federal project consisting of the County/municipal sponsored Bogue Banks Restoration Project was constructed in three phases from 2002 to 2005. The ~17-mile project spanning Emerald Isle, Indian Beach/Salter Path, and Pine Knoll Shores was designed as an “engineered and maintained beach” project pursuant to FEMA disaster assistance eligibility requirements. The majority of the funding for the Project (~$30.6M) was provided via voter-approved bond referendums. Special oceanfront and non-oceanfront tax districts were established to create a fair and equitable method for funding the project. An additional $4.7M was provided by the State of North Carolina through the Division of Water Resources. Pursuant to FEMA requirements, a monitoring and maintenance plan was

**Photo 3.2. West end of Emerald Isle (Bogue Inlet shoreline) following 2014 USACE beach disposal event.**

**Photo 3.3. Bogue Inlet navigation channel sidecast dredging.**

put in place by each of the municipalities that took part in the restoration project (i.e., Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle). The successful establishment of an engineered and maintained beach has facilitated three FEMA-reimbursed County/municipal post-storm response projects along various reaches of Emerald Isle, Indian Beach/Salter Path, and Pine Knoll Shores over the last 12 years; including Post Hurricane Isabel in 2004 (~2.4 miles), Post Hurricane Ophelia in 2007 (~11.0 miles), and Post Hurricane Irene in 2015 (~6.6 miles). In total, ~12 miles of beaches were nourished under one or more of the three storm response projects. The three post-hurricane nourishment projects were fully financed by FEMA, although in the case of the post-Irene project the local municipalities financed the placement of additional material in excess of FEMA eligible replacement volume. Although referred to as "reimbursement," FEMA approvals of disaster assistance for sand replacement are typically based on cost estimates, with progress payments being made to the applicant as the work is completed. The Bogue Banks Restoration Project and the three FEMA storm response projects constitute all of the non-federal County/municipal sponsored projects that have occurred on the island.

Although there is no historical precedent for continuing hotspot nourishment projects under Alternative 1, there are known erosional hotspots along Emerald Isle and Pine Knoll Shores where it is clear that structures will be imminently threatened in the near future (Figure 3.3). It is assumed that an imminent threat to structures along these reaches would elicit a response by the individual municipalities in the form of localized hotspot response nourishment projects. Analysis of island-wide monitoring profile data from 2008-2015 was used to identify the known hotspot areas by calculating background erosion rates and subtracting out nourishment effects for the individual profiles. An annual loss rate of 90,542 cy was calculated for the combined hotspot reaches using procedures outlined in Section 4.2.2 of the Engineering Report (Appendix G). Based on the annual loss rates and considering the mobilization/demobilization costs of nourishment, it is anticipated that the hotspot reaches (together) would be nourished with ~1.0 MCY of sand every 11 years. The actual frequency and volumetric extent of these projects would vary according to background erosion rates and the extent of shore protection degradation along specific reaches, as well as the frequency and extent of storm damage and the availability of local shore protection funding. The implementation costs associated with these beach nourishment events would be fully funded by the local municipalities, potentially with assistance from the County. Although the majority of Atlantic Beach represents a major erosional hotspot (Figure 3.3), it is assumed that continuing USACE placements of navigation dredged material from the MCH channels would be sufficient to mitigate background erosion.

In the absence of a long-term engineered and maintained beach nourishment project to maintain eligibility for FEMA public assistance reimbursement, it is assumed that FEMA-reimbursed storm response projects would not occur on Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle. Atlantic Beach does not have an existing or planned engineered beach project and would also not be eligible for FEMA reimbursement projects under Alternative 1. Eligibility for FEMA public assistance is limited to "engineered and maintained beaches," which maintained

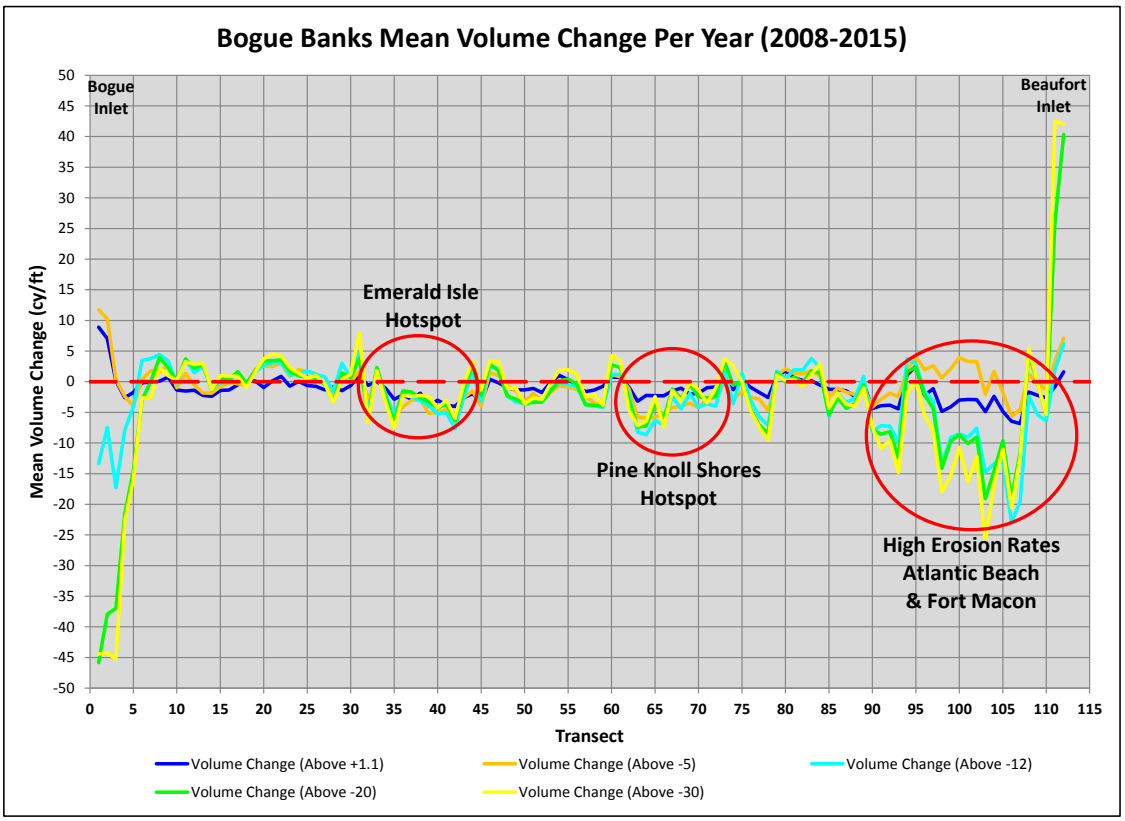



**Figure 3.3. Bogue Banks Erosional Hotspots**

are defined by FEMA as: 1) beaches that have been constructed to a designed elevation, width, and slope using imported sand of proper grain size and 2) beaches that are on a scheduled basis through periodic renourishment with imported sand [44 CFR §206.226(j)]. Although Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle are currently eligible based on the Bogue Banks Restoration Project, the failure to maintain the project under Alternative 1 would result in loss of eligibility. Although Atlantic Beach receives regular placements of sand from MCH, placements derived from federal navigation channels cannot qualify as an engineered beach under FEMA rules.

In addition to the hotspot renourishment events, Alternative 1 includes the relocation of the Bogue Inlet ebb tide channel to a more central location on an as-needed basis only. During the 1980s and 1990s, rapid eastward migration of the channel resulted in severe erosion of the west end Emerald Isle shoreline. The erosional threat to homes and infrastructure on the west end led to armoring of the inlet shoreline with sandbags, and the eventual relocation of the ebb channel to a mid-inlet position in 2005. The 2005 ebb channel realignment and nourishment project, which constituted Phase III of the non-federal Bogue Banks Restoration Project, moved the channel approximately 3,500 ft west towards Bear Island to alleviate the imminent erosional threat to the western tip of Emerald Isle. Approximately 690,868 cy of dredged material from

the new inlet channel was placed on the west end of Emerald Isle. The cost of the 2005 ebb channel relocation and nourishment project was approximately $10.9 M. Although an additional realignment event is not currently needed or planned, it is expected that the Town of Emerald Isle and/or the County would pursue such a project if erosional conditions similar to those preceding the 2005 project were to reoccur. It is anticipated that ebb channel realignments would follow the design and methods employed during the 2005 project. Accordingly, realignments would entail the construction of a channel ~6,000-ft-long with variable bottom widths ranging from 150 to 500 ft. Relatively shallow inlet depths would require the use of a cutterhead dredge to excavate the new mid-inlet channel. Channel excavation is anticipated to yield just over 1.0 MCY of beach compatible dredged material. It is anticipated that ~0.2 MCY of the dredged material from the new channel would be used to construct a closure dike across the old channel, with the remaining ~0.80 MCY of material being pumped directly onto the Western Beach of Emerald Isle. Excavation would proceed inland from the seaward terminus of the new channel, with dredged material initially being pumped onto the Emerald Isle beaches. As work nears the inshore terminus of the new channel, disposal would be redirected to the designated dike construction area in the old channel.

Throughout most of the period since the 2005 relocation, the ebb channel has migrated east at a rate of ~170 ft/yr; however, in recent years the rate has slowed to ~80-120 ft/yr. In total, the channel has migrated ~1,650 ft eastward over the 10-year period since the 2005 relocation project. The ebb channel is currently located 1,850 ft west of the nearest structure on Emerald Isle. At the current rate, the ebb channel could approximate the position of the 2005 pre-project channel in approximately eight to 13 years, in which case it is anticipated that plans for a realignment project would be initiated to protect the Emerald Isle shoreline. Although the number of realignment events that might be undertaken is not known, it is assumed that realignments would occur as a reactionary response to severe erosional conditions that present an imminent threat to homes and infrastructure. For impact analysis purposes, it is assumed that at least two channel realignment events would occur over the next 50 years. The implementation cost of realignments would likely be incurred by the Town of Emerald Isle and the County.

Additional management activities under Alternative 1 would be expected to include the installation of sandbags and beach bulldozing and by individual property owners and/or the local municipalities. Pursuant to NC Coastal Management Rules, sandbags and beach bulldozing are allowed as temporary measures to protect threatened structures. The use of sandbags is limited to structures that are within 20 ft of the MHW line, and the use of beach bulldozing to restore frontal dunes (without a federal Section 404 permit) is restricted to the movement of sand above MHW under NC Coastal Management Rules. As stated in Chapter 2, approximately 25 properties on Bogue Banks currently have sandbags, and it is expected that additional sandbags would be installed over time by individual property owners in order to temporarily protect their homes, especially along the hotspot reaches. Likewise, the use of beach bulldozing would be anticipated, especially as a post-storm emergency measure to repair damage to frontal dunes and berms.

Based on the analyses presented in the Engineering Report (Appendix G), the anticipated hotspot projects would cost approximately $62 million (M) in local monies over the next 50 years. The anticipated two inlet realignment events would cost an additional $23.2 M. Continuing USACE sand placement activities; including the disposal of navigation dredged material from the MCH channels on Atlantic Beach and beach disposal on the west end of Emerald Isle adjacent to Bogue Inlet via maintenance of the Bogue Inlet AIWW Crossing channel; would cost approximately $245.2M[2] in federal monies over the next 50 years.

### **3.3.2** Alternative 2 – Relocation and Abandonment

Under Alternative 2, the County and municipalities would not pursue a long-term beach management project, nor would they undertake any federally permitted actions to mitigate oceanfront shoreline erosion along Bogue Banks. Actions requiring a federal permit, and thus excluded under Alternative 2, would include beach nourishment, dredging, inlet management, and any other activities below MHW that require a federal Section 404/Section 10 permit. It is assumed that current USACE navigation dredging and beach disposal practices, which are not subject to Section 10 or 404 permit authorizations, would continue over the next 50 years; including maintenance dredging of the MCH channels with beach disposal to Atlantic Beach/Fort Macon, and maintenance of the AIWW Bogue Inlet Crossing channel with beach disposal to the west end of Emerald Isle (Figure 3.4, Table 3.3). Additionally, USACE maintenance of the Bogue Inlet navigation channel via sidecaster dredging with open water disposal would be expected to continue, as would additional USACE navigation dredged material disposal practices associated with the MCH project (i.e., disposal to the ODMDS, Brandt Island, and the designated Nearshore Placement Areas).

In the absence of a beach management plan, the County and local municipalities would coordinate with individual property owners in circumstances where a structure is damaged or threatened by erosion. However, the decision and responsibility to relocate or demolish a home would ultimately fall to the property owner, not the County or municipality unless the structure is deemed a safety hazard to the public. Prior to demolition or relocation, individual property owners may choose to protect structures by installing temporary sandbags or conducting beach bulldozing above the MHW line, which would not require federal authorization. The use of sandbags and bulldozing would be expected to delay structure relocations and demolitions, with the extent of the delay being contingent on site-specific erosion rates at the time. As previously described, sandbags are allowed by the state as a temporary measure to protect threatened structures that are within 20 ft of the MHW line, and the use of beach bulldozing to restore frontal dunes is restricted to the movement of sand above MHW. It is assumed that continuing

[2] The USACE costs for all alternatives are based on past placement volumes and recommended placement volumes under the 2016 MCH DMMP. Actual USACE costs will vary depending on the specific volumetric requirements and disposal/placement areas associated with individual federal navigation dredging projects.


**Figure 3.4. Alternative 2 - Relocation and Abandonment**

**Table 3.3. Alternative 2 sand placement activities.**

| Placement Reach | Project Type | Beach Fill Source | Interval (years) | No. of Events | Per Event Placement Volume (cy) | 50-Year Placement Volume (cy) |
|---|---|---|---|---|---|---|
| Bogue Inlet (Stations 1-11) | USACE Navigation | AIWW Bogue Inlet Crossing | 3 | 16 | 60,600 | 969,600 |
| Atlantic Beach (Stations 77-102) | USACE Navigation | MHC Harbor Channels | 3 | 16 | 494,835 | 7,917,360 |
| **Total** | | | | | | **8,886,960** |

USACE placements of navigation dredged material from the MCH channels would preclude the need for structure relocations or demolitions along Atlantic Beach over the next 50 years.

Based on the 2004 NCDCM long-term shoreline erosion rates, 451 oceanfront structures within the jurisdictions of Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle would eventually need to be relocated or demolished over the next 50 years (annual shoreline change raw rate multiplied by 50 years). It should be noted that the older 2004 NCDCM rates are considered to be more representative of erosional conditions under Alternative 2, as the newer rates incorporate the offsetting effects of nourishment under the Bogue Banks Restoration Project and the three FEMA-funded storm projects. There are currently 114 vacant oceanfront lots and ~1,500 vacant non-oceanfront lots on Bogue Banks that are potentially available for relocations.

Thus, 114 threatened structures could potentially be relocated to other oceanfront lots, while the remaining 337 at risk structures would need to be relocated to non-oceanfront interior lots. Relocation would involve the detachment and transport of the structure to a new lot, and the removal and transport of the existing foundation, driveway pavement, patio concrete, and any other remaining exterior features to an appropriate landfill. In the case of demolition, heavy equipment would be used to take down the structures, and all material would be hauled to an appropriate landfill. It is expected that all demolition work would require no more than two weeks to complete, depending on the size and number of structures to be demolished; however, longer completion periods would be expected in the case of larger multi-family complexes.

Based on the analyses presented in the Engineering Report (Appendix G), the cost of continuing USACE sand placement activities; including the disposal of dredged material from MCH on Atlantic Beach and the disposal of dredged material from the AIWW Bogue Inlet Crossing channel on the west end of Emerald Isle; would be approximately $245.2M over the next 50 years. The relocation of each structure would cost approximately $75,000, resulting in a total cost of $33.8M for all 451 structures that are projected to be at risk over the next 50 years..

### **3.3.3** Alternative 3 – Nourishment Only

Under Alternative 3, the County, through an interlocal agreement with all of the island municipalities, would manage the approximately ten miles of beaches along Pine Knoll Shores, Indian Beach/Salter Path, and eastern Emerald Isle through the implementation of a comprehensive 50-year beach nourishment project. Atlantic Beach is also a party to the interlocal agreement; however, it is the on-going recipient of regular USACE placements of navigation dredged material from the MCH channels and has been for nearly two decades. This material is expected to be sufficient in meeting the maintenance nourishment requirements of the ~5.0-mile Atlantic Beach management reach. Therefore, the County is not anticipating any maintenance sand placement on Atlantic Beach under its 50-year management plan. However, the County's 50-year plan would provide for interim maintenance nourishment events along Atlantic Beach should USACE MCH placements cease. Furthermore, the County's 50-year plan would provide storm-response nourishment for Atlantic Beach to address any storm-related needs in excess of the volumes placed by the USACE MCH project. Alternative 3 would not include any County or local efforts to manage the Bogue Inlet ebb channel in a manner similar to the 2005 relocation project or otherwise. Excluding Bogue Inlet as a sand source, the total volume of available beach fill from all other known feasible borrow sources would be just enough to meet the projected 50-year need of the 15-mile Atlantic Beach to eastern Emerald Isle reach. Consequently, Alternative 3 would not provide any management of the approximately eight miles of beaches along central and western Emerald Isle and Bogue Inlet.

The 50-year project would employ a regular and recurring cycle of nourishment events to continuously maintain beach profile sand volumes along the managed reaches at a 25-yr level of protection (LOP), which equates to protection for upland structures against a 25-year storm event. Nourishment events would be implemented according to 25-year LOP beach profile volumetric triggers. As described in the Engineering Report (Appendix G), volumetric triggers were developed by analyzing and adjusting design beach profiles in a series of iterative SBEACH numerical modeling runs. The final modeling results indicated appropriate volumetric triggers ranging from 211 - 266 cy/ft along various reaches of the approximately 10-mile project shoreline (weighted average = 233 cy/ft). Based on variability in the volumetric triggers, the project shoreline was divided into three management reaches ranging in length from 2.4 to 4.5 miles (Figure 3.5).

Maintenance of the 25-year LOP beach profile volumes along the managed reaches would involve: 1) regular recurring "maintenance" nourishment events to offset long-term, chronic background erosion (including hotspot erosion) and 2) periodic "storm response" nourishment events to offset sand losses incurred during hurricanes. Based on the SBEACH modeling results and observed background erosional loss rates along annually surveyed monitoring profiles, the three individual management reaches are expected to require recurring maintenance sand placements of ~0.2 to 0.5 MCY at approximate intervals of three (Emerald Isle East) or six (Pine Knoll Shores and Indian Beach/Salter Path) years to offset chronic

background erosion (Figure 3.5, Table 3.4). As indicated above, should the need arise for interim maintenance nourishment of Atlantic Beach, an additional ~5.0 beach miles would be nourished every three years under Alternative 3. Actual maintenance nourishment intervals would be expected to vary in response to background erosion rate variability over the course of the 50-year project. Depending on the actual reach-specific erosional loss rates, individual nourishment events may encompass multiple management reaches. Collectively, the three management reaches are projected to require maintenance placements totaling ~10.0 MCY over the 50-year life of the project. United States Army Corps of Engineers disposals of navigation dredged material on the west end of Emerald Isle via maintenance of the AIWW Bogue Inlet Crossing channel would be expected to continue under Alternative 3, contingent on available federal monies. Additionally, it is expected that USACE maintenance of the Bogue Inlet navigation channel via sidecast dredging and open water disposal would continue.

Additional storm-response nourishment requirements were projected at a broader island-wide scale based on data from the three FEMA-reimbursed post-hurricane nourishment projects that have occurred on Bogue Banks [Post-Isabel (2004), Post-Ophelia (2007), and Post-Irene (2013)]. The volumetric losses incurred during these storms and the intervals between the associated response nourishment projects indicate that future island-wide storm losses could require additional volumetric placements of 1.4 to 1.7 MCY as frequently as every three-to-four years. However, considering the unpredictability of storm events, it is conservatively assumed for planning purposes that storm-related losses would require placements of 1.7 MCY every three years. The placement of 1.7 MCY every three years would equate to 16 storm response placement events totaling ~27.2 MCY over the next 50 years (Table 3.4). As indicted above, the projected storm-response nourishment requirements apply to the island of Bogue Banks as a whole. Due to the unpredictability of site-specific storm effects, the specific storm-response needs of the three management reaches (Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle East) have not been projected. It is expected that the combined 50-year need of the three reaches, which have a combined length of ~10.1 miles, would be less than the overall projected ~25-mile island-wide need of ~27.2 MCY. However, as indicated above, the County project would also provide supplemental storm response nourishment on the ~5.0 Atlantic Beach reach to offset any storm-related needs that exceed USACE MCH placements. Storm-response projects would add to the maintenance events described above, increasing the overall number of nourishment events along the County management reaches and in some cases resulting in nourishment intervals shorter than the 3- to 6-year intervals indicated above for background erosion alone. Storm-response nourishment requirements for the management reaches would be provided under the County/municipal 50-yr project through FEMA-reimbursed projects and/or additional nourishment projects fully funded by the County/municipalities in the case of non-reimbursable storm losses (including storm losses along Atlantic Beach, which does not meet FEMA engineered beach eligibility requirements).

Beach fill for County maintenance and storm response nourishment events would be acquired from a combination of offshore borrow sites, AIWW disposal areas, and upland sand mines. Should the need arise for interim maintenance nourishment of Atlantic Beach, the County would


Note: Intervals do not include storm-related placements

**Figure 3.5. Alternative 3 - Nourishment Only**

**Table 3.4. Alternative 3 proposed sand placement activities.**

| Placement Reach | Project Type | Beach Fill Source | Interval (years) | No. of Events | Per Event Volume | 50-Year Volume (cy) |
|---|---|---|---|---|---|---|
| **County Maintenance Sand Placement** | | | | | | |
| Emerald Isle East (Stations 37-48) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 3 | 16 | 191,232 | 3,059,712 |
| Indian Bch/Salter Path (Stations 49-58) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 6 | 8 | 375,402 | 3,003,216 |
| Pine Knoll Shores (Stations 59-76) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 6 | 8 | 508,770 | 4,070,160 |
| **County Maintenance Total** | | | | | | **10,133,088** |
| **USACE Maintenance Sand Placement** | | | | | | |
| Bogue Inlet (Stations 1-11) | USACE Nav | AIWW Bogue Inlet Crossing | 3 | 16 | 60,600 | 969,600 |
| Pine Knoll Shores (Stations 59-76) | USACE Nav | MCH Channels | If available | 0 | 0 | 0 |
| Atlantic Beach (Stations 77-102) | USACE Nav | MCH Channels | 3 | 16 | 494,835 | 7,917,360 |
| **USACE Maintenance Total** | | | | | | **8,886,960** |
| **County/USACE Storm Response Sand Placement** | | | | | | |
| Emerald Isle, Indian Bch/Salter Path, Pine Knoll Shores, Atlantic Beach | County/FEMA<br>USACE Nav/Delta | ODMDS/Area Y/AIWW Islands/Upland Sources<br>MCH Channels | 3 | 16 | 1,700,000 | **27,200,000** |
| **Total Sand Placement (County Maintenance + USACE Maintenance + County/USACE Storm Response)** | | | | | | **46,220,048** |

use these same borrow sources while seeking supplemental authorization to add Beaufort Inlet as a borrow source under its 50-year management plan. A detailed account of the sand resource investigations that were used to identify the proposed sources of beach fill is provided in the Engineering Report (Appendix G). Collectively, the proposed offshore, AIWW, and upland borrow sites are estimated to contain ~25.1 MCY of beach compatible material. Approximately 90% (~22.5 MCY) of the total volume would come from offshore borrow sites along Bogue Banks; including the Old ODMDS, current ODMDS, and Area Y (Figure 3.5). A summary of available volumes and physical sediment characteristics at each of the proposed offshore borrow areas is provided in Table 3.5. The proposed offshore borrow site sediments were analyzed for native beach compatibility and determined to be suitable for placement on Bogue Banks in accordance with the NC Technical Standards for Beach Fill Projects (15A NCAC 07H.0312). Compatibility analyses used vibracore sediment data collected during several geotechnical sand resource investigations along Bogue Banks (Figure 3.6); however, the majority of the data (116 vibracores) was collected in 2012 in support of the current effort to develop a long-term beach management plan for Bogue Banks (Coastal Tech 2013).

The largest quantity of offshore material (~14.2 MCY) would come from the Old ODMDS (Table 3.5). The former MCH dredged material disposal facility is located just inside the 3-nautical mile OCS line in state waters along the northeast boundary of the current MCH ODMDS. The material proposed for placement is contained in a single large mound that has formed over time from the coalescence of numerous smaller deposits (Figure 3.7). The current ODMDS contains ~6.8 MCY of beach compatible material that is proposed for placement under Alternative 3. The current ODMDS dredged material disposal facility is located just seaward of the 3-mile OCS line in federal waters. The material proposed for placement is distributed among various separate disposal mounds in the northern third of the ODMDS (Figure 3.8, Table 3.5). The northern third of the facility is reserved for the disposal of coarse-grained beach compatible dredged material. Area Y is estimated to contain ~1.5 MCY of beach compatible sediment. Area Y is located inside the 3-nautical mile OCS line in state waters off the west end of Bogue Banks. The material proposed for placement is confined to two small areas in the northeast and southwest corners of Area Y (Figure 3.9, Table 3.5). The available volumes presented in Table 3.5 do not account for losses during the dredging/placement process; however, historical sand placement projects on Bogue Banks have consistently had relatively low loss rates of less than five percent. The recent Post-Irene project involving sand extraction from the ODMDS had a loss rate of less than one percent. Although low loss rates are expected, it is conservatively assumed that up to tem percent of the available volume could be lost during the dredging process.

Dredging operations at the ODMDS sites and Area Y borrow sites would most likely involve thin layer sediment removal by hopper dredges, but could also include the use of hydraulic cutterhead pipeline dredges. Extraction of the Old and Current ODMDS deposits would require the retention of a 2-ft vertical buffer of compatible disposal mound material above the underlying

**Table 3.5. Alternative 3 proposed offshore borrow site sediment characteristics and volumes.**

| Borrow Area | Mound ID | Sediment Characteristics | | | | | Available Volume (cy)[1,2] |
|---|---|---|---|---|---|---|---|
| | | Fines (<0.0625 mm) | Sand (0.0625 - 1.99 mm) | Granular (2.0 - 4.75 mm) | Gravel (4.76 - 75.0 mm) | Calcium Carbonate | |
| **NC Tech Stand.** | - | **≤6%** | - | **≤6%** | **≤6%** | **≤35%** | - |
| **Old ODMDS** | 1 | 0.5% | 96.0% | 2.1% | 1.3% | 13.6% | 13,138,307 |
| | 2 | 0.2% | 96.3% | 2.5% | 1.0% | 13.6% | 1,098,108 |
| **Current ODMDS** | 1 | 0.5% | 96.1% | 2.1% | 1.4% | 13.3% | 3,268,601 |
| | O-192 | 0.1% | 93.1% | 3.4% | 3.4% | 19.6% | 785,270 |
| | O-14 O-47 | 0.2% | 93.4% | 4.7% | 1.6% | 19.8% | 566,028 |
| | O-15 | 0.1% | 99.2% | 0.5% | 0.2% | 10.1% | 355,920 |
| | O-35 | 0.3% | 96.1% | 2.7% | 1.0% | 15.2% | 499,491 |
| | O-46 | 0.4% | 90.6% | 6.3% | 2.8% | 18.2% | 493,564 |
| | O-48 | 5.9% | 92.8% | 1.1% | 0.2% | 7.8% | 468,740 |
| | Contingency | - | - | - | - | - | 320,000 |
| **Area Y** | Y-80 | 2.4% | 97.6% | 0.1% | 0.0% | 1.9% | 1,079,853 |
| | Y-120 | 2.0% | 86.6% | 3.4% | 7.9% | 1.5% | 379,675 |
| **Total Available Offshore Volume** | | | | | | | **22,453,557** |

[1]Available volumes do not account for potential losses during the dredging/placement process. Depending on loss rates, actual placement volumes may be reduced by up to 10%.
[2]Old and Current ODMDS volumes account for the retention of a 2-ft vertical buffer of compatible material.

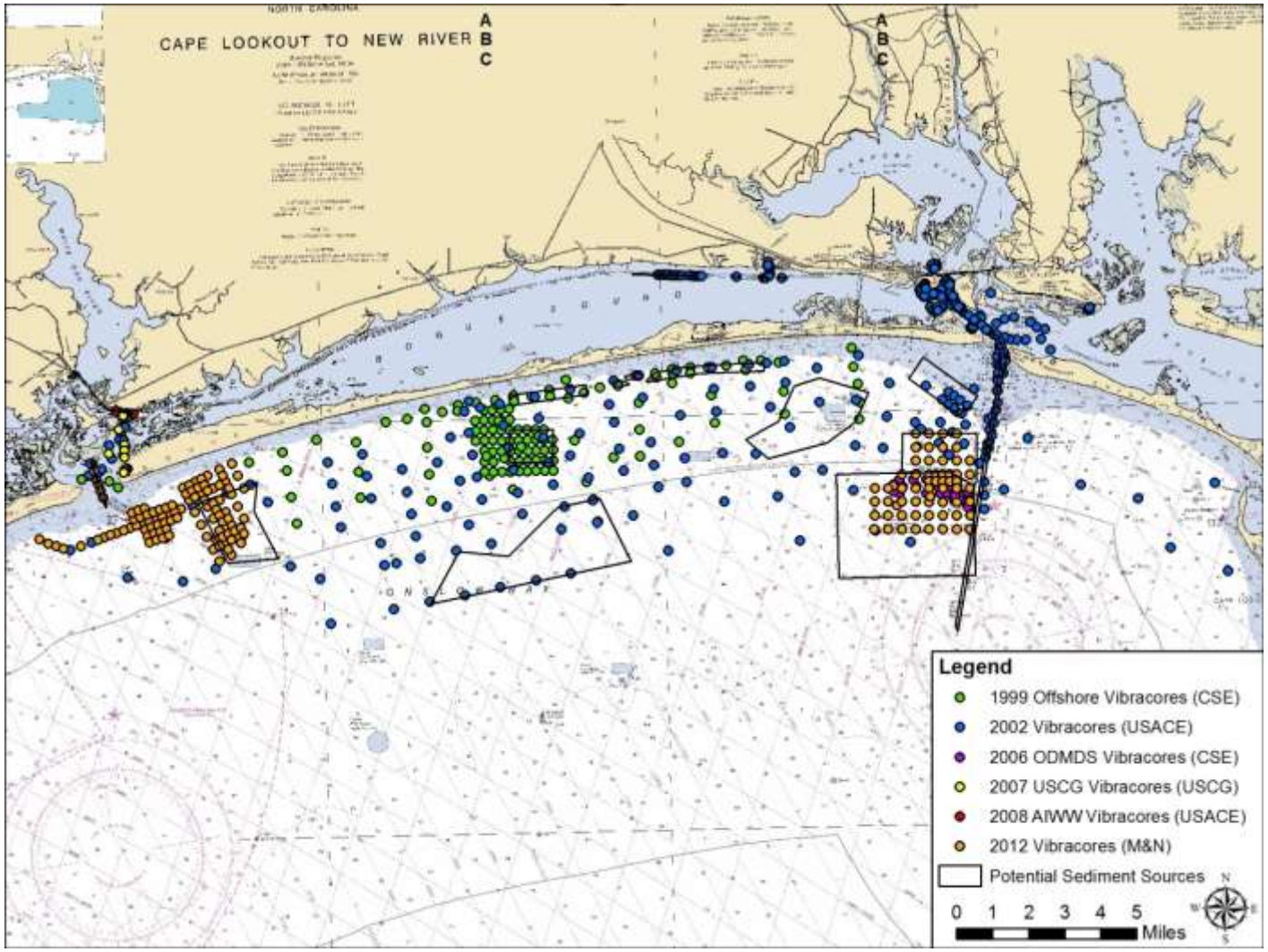
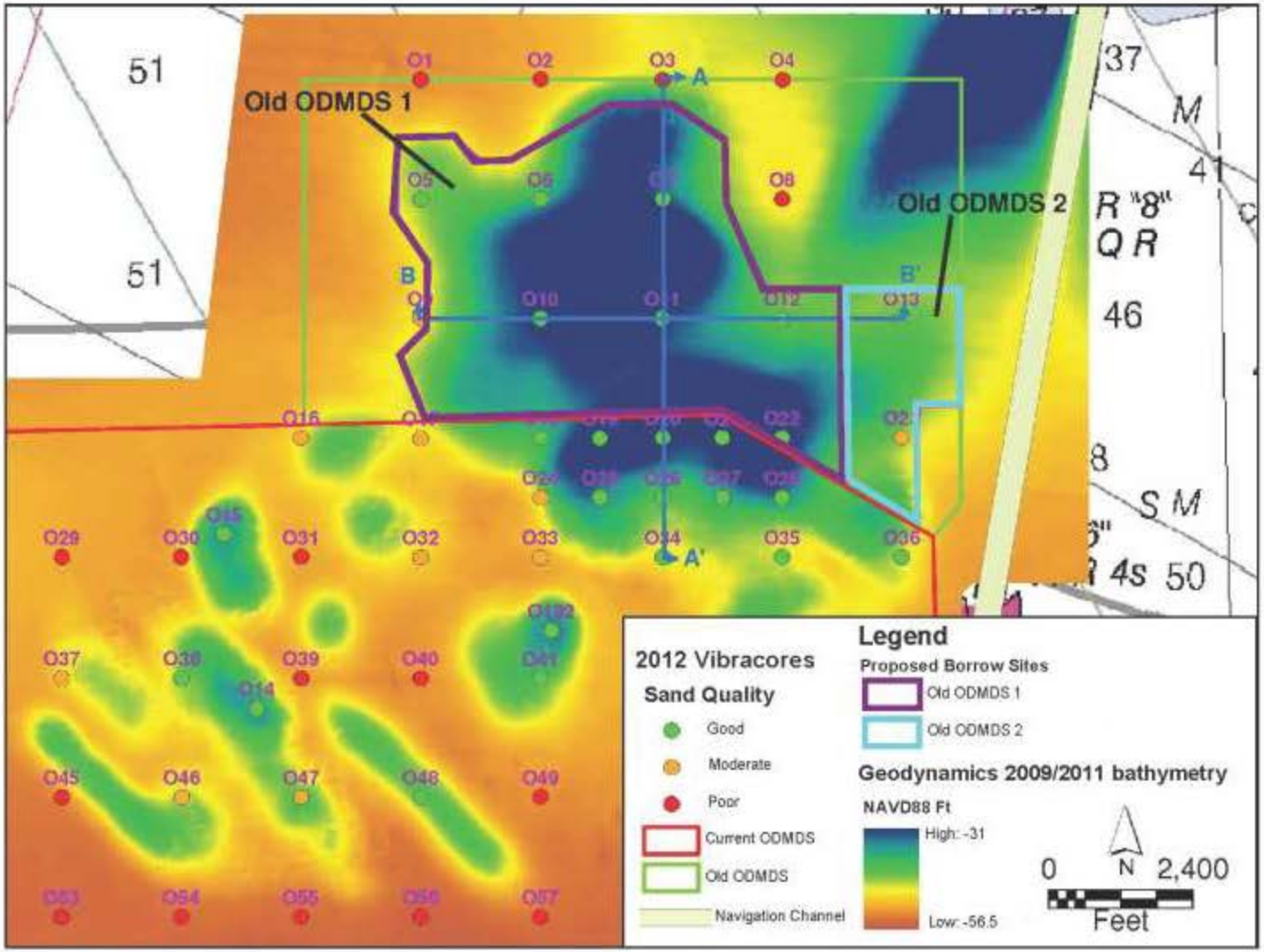
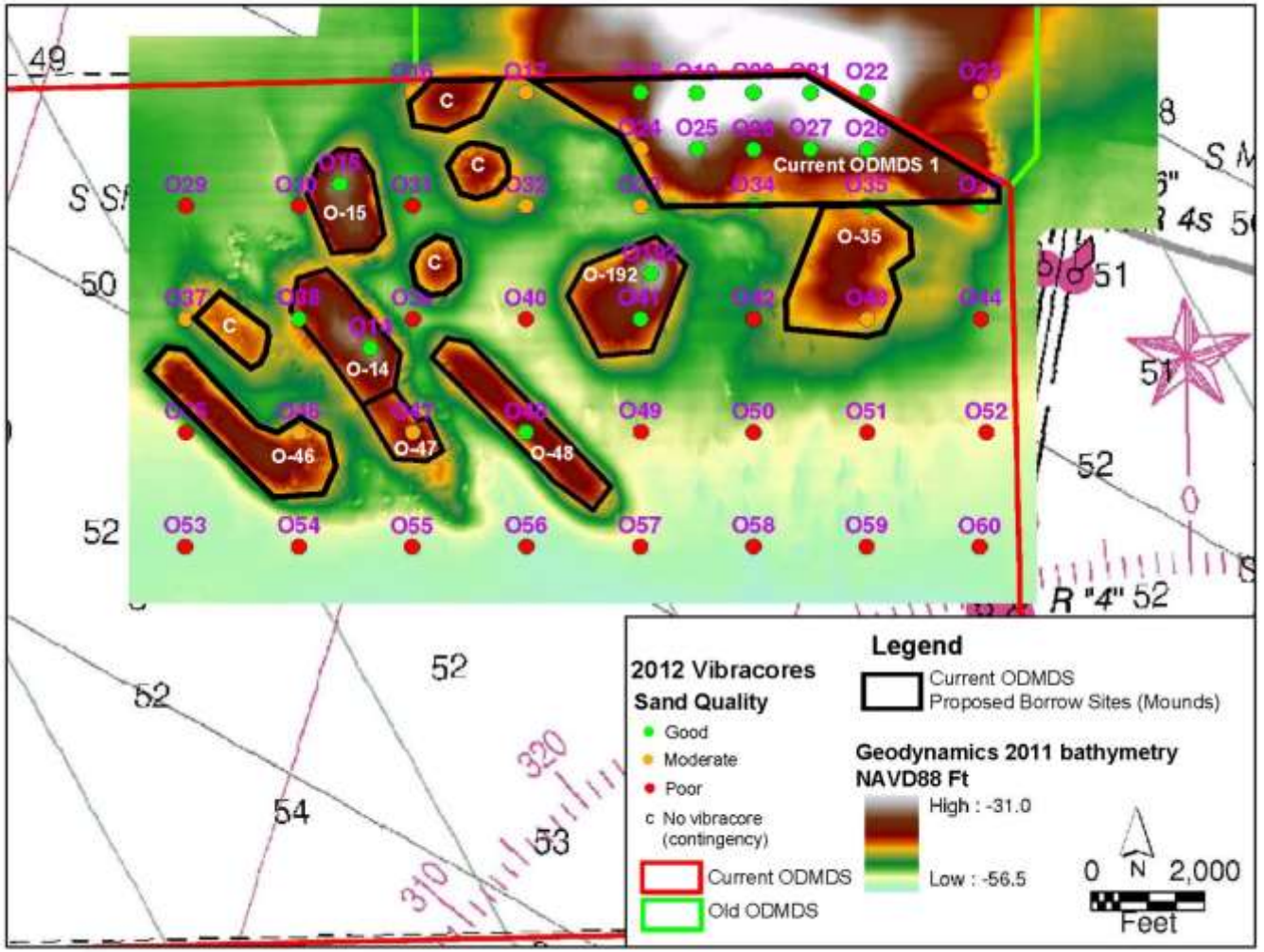



**Figure 3.6. Bogue Banks Sand Resource Investigation Vibracore Locations**



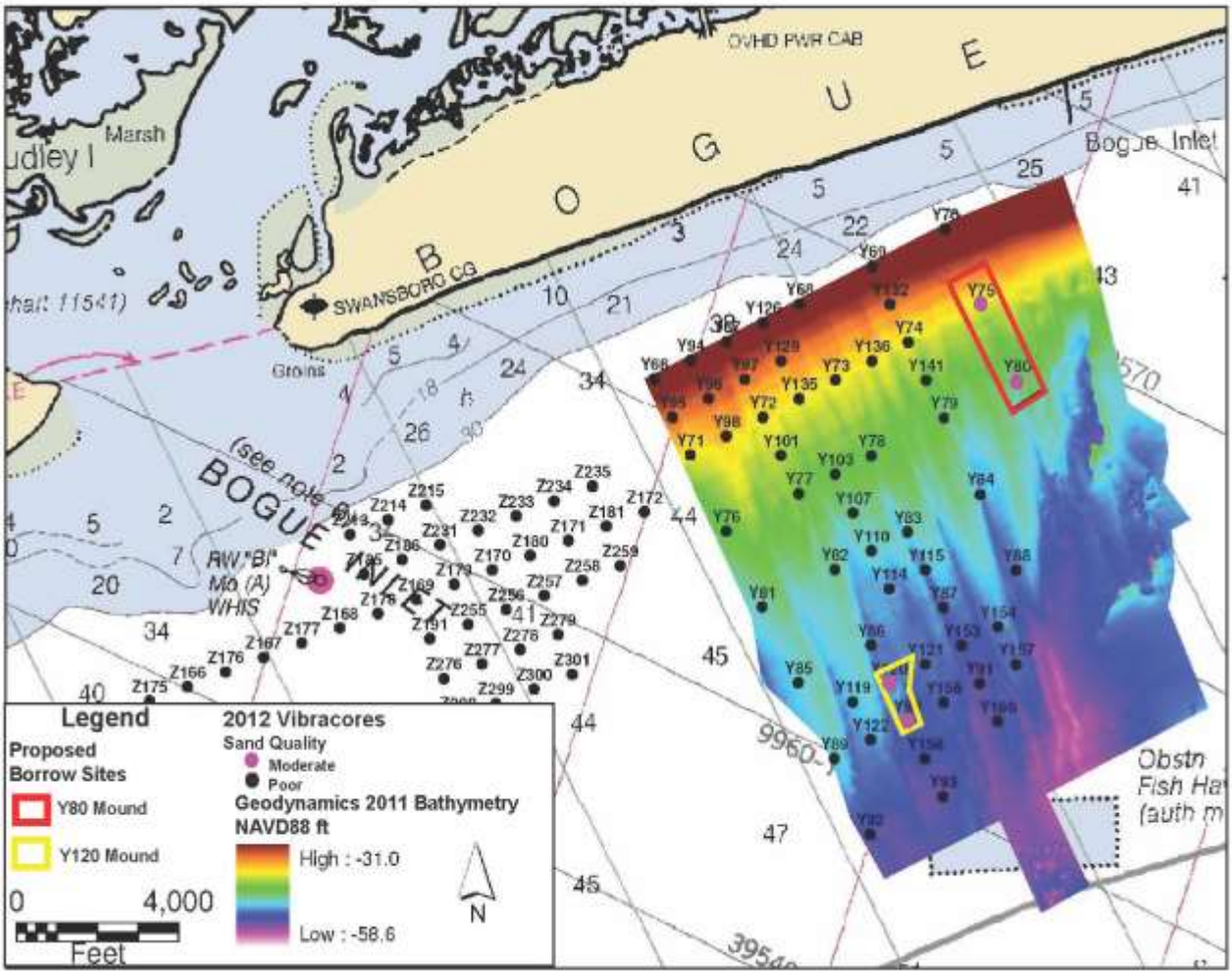

Source: Coastal Tech 2013)

**Figure 3.7. Proposed Old ODMDS Offshore Borrow Area**




Source: Coastal Tech 2013

**Figure 3.8. Proposed Current ODMDS Offshore Borrow Area**




Source: Coastal Tech 2013

**Figure 3.9. Proposed Area Y Offshore Borrow Site**

incompatible sediments, thus excavation would not extend to or below the original underlying seafloor. Note that the available ODMDS volumes presented in Table 3.5 account for the retention of this buffer. The use of hopper dred*g*es would involve sediment transport from the borrow sites to nearshore pump-out stations, where the material would be pumped from the dredge through a submerged pipeline leading to the recipient beach. Sand delivery by cutterhead dredges could involve direct pumping from the borrow site to the beach via submerged pipelines or dredged material transport from the borrow site to nearshore pump-out stations via barges or scows. Once the material is on the beach, bulldozers will likely be used to shape the beach to the target elevations.

Approximately ten percent of the total placement volume under Alternative 3 would be acquired from AIWW disposal areas (Figure 3.10, Table 3.6) and upland sand mines (Figure 3.11, Table 3.7). The proposed AIWW sources include ten USACE CDF disposal sites along the AIWW Bogue Inlet Crossing and adjoining AIWW channels behind Bogue Banks and Bear Island

These sites are active diked facilities that are used by the USACE for the disposal of dredged material from maintenance of the AIWW channels. The individual sites contain estimated volumes of compatible material ranging from 30,000 - 289,000 cy. Collectively, the ten sites are projected to provide for the placement of 1,432,000 cy of material. Beach fill extraction from the AIWW disposal sites would most likely involve pump-outs by a cutterhead dredge, with direct pipeline delivery to the beach or delivery via scows/barges and nearshore pump-out stations. The proposed upland sources include six permitted sand mines located in Carteret (4), Craven (1), and Onslow Counties (1). Collectively, the six upland sources are projected to provide 1,380,700 cy of material. The use of beach fill from upland sites would involve delivery via dump trucks, with beach access via public access points.

Based on the analyses presented in the Engineering Report (Appendix G), projected County/municipal maintenance nourishment events under Alternative 3 would cost approximately $140.4M over the 50-year life of the project. Storm losses are estimated to require additional placements totaling ~27.2 MCY over the next 50 years at a cost of $360.4M in federal reimbursement monies. Continuing USACE sand placement activities; including the disposal of navigation dredged material from the MCH channels on Atlantic Beach and beach disposal on the Pointe adjacent to Bogue Inlet via maintenance of the Bogue Inlet AIWW Crossing channel; would cost approximately $245.2M over the next 50 years.

### **3.3.4** Alternative 4 (Applicant's Preferred Alternative) – Nourishment and Non-Structural Bogue Inlet Management

Under Alternative 4, the County, through an interlocal agreement with all of the island municipalities, would manage all of the ~18 miles of beaches along Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle through the implementation of a comprehensive 50-year beach nourishment and non-structural inlet management project (Figure 3.12). Atlantic Beach

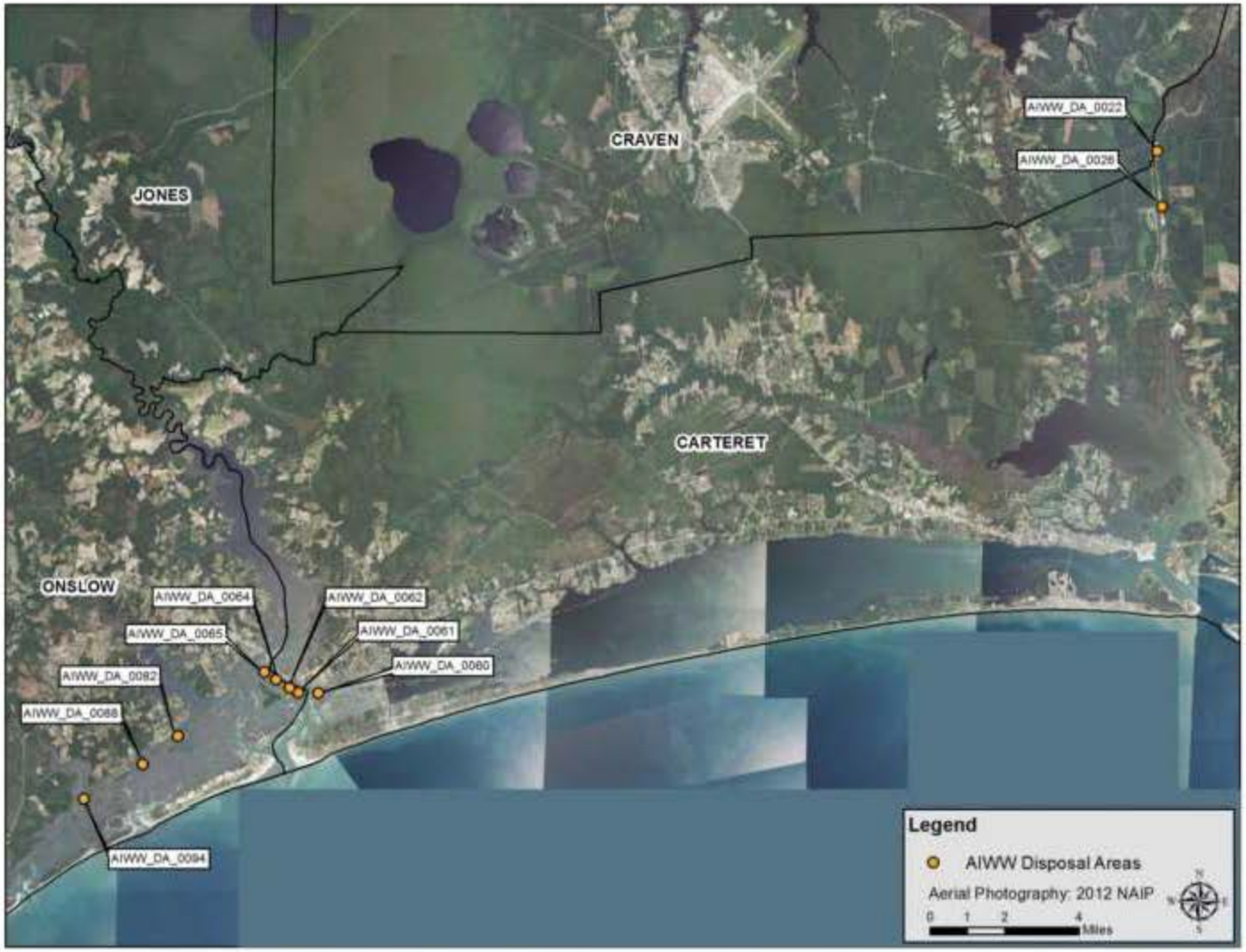



**Figure 3.10. AIWW Disposal Area Locations**

**Table 3.6. Alternative 3 proposed AIWW disposal area sand sources.**

| Disposal Area | Owner | Area (feet$^2$) | Thickness (ft) | Volume (cy) |
|---|---|---|---|---|
| DA 22 | Weyerhaeuser Company | 1,000,000 | 5 | 185,000 |
| DA 26 | The Baugus Family LLC | 1,541,000 | 5 | 285,000 |
| DA 60 | Jones, John R | 896,000 | 8.7 | 289,000 |
| DA 61 | Weeks, Haywood Jr. | 729,196 | 5 | 135,000 |
| DA 62 | Weeks, Haywood Jr. | 164,285 | 5 | 30,000 |
| DA 64 | Weeks, Haywood Jr. | 782,939 | 5 | 145,000 |
| DA 65 | Coderre, Shane Ronald | 582,865 | 5 | 108,000 |
| DA 82 | State of NC | 171,000 | 5 | 32,000 |
| DA 88 | State of NC | 552,000 | 5 | 102,000 |
| DA 94 | No Data | 652,000 | 5 | 121,000 |
| Total Volume | | | | 1,432,000 |
| **Total Placement Volume (90%)** | | | | **1,228,800** |

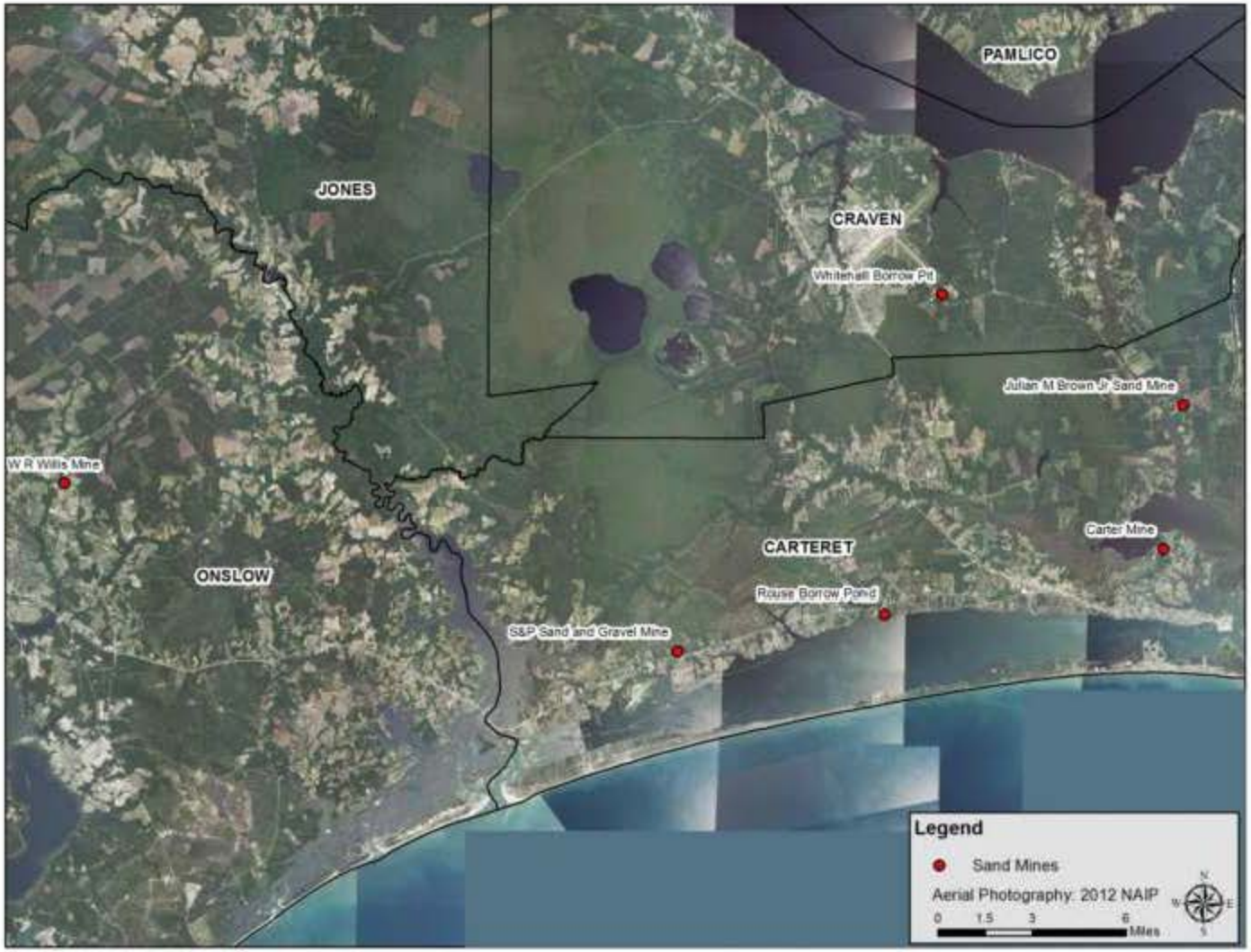



**Figure 3.11. Upland Sand Mine Locations**

**Table 3.7. Alternative 3 proposed upland sand sources.**

| Mine Owner | Location Name | County | Bonded Area (acre) | Latitude | Longitude | Volume (cy) |
|---|---|---|---|---|---|---|
| Julian M Brown Jr | Julian M Brown Jr Sand Mine | Carteret | 34 | 34.820 | -76.720 | 1,000,000 permitted |
| Sunland Builders | S&P Sand and Gravel Mine | Carteret | 23 | 34.712 | -77.006 | 80,700 |
| Carters Machine and Planer Fabrication | Carter Mine | Carteret | 3 | 34.754 | -76.733 | Unknown |
| Rouse's Septic Tank Services | Rouse Borrow Pond | Carteret | 5 | 34.727 | -76.890 | Unknown |
| Cieszko Construction Company | Whitehall Borrow Pit | Craven | 25 | 34.874 | -76.854 | 100,000 |
| W.R. Willis Trucking & Construction | W R Willis Mine | Onslow | 39 | 34.794 | -77.347 | 200,000 |
| **Total Available Volume** | | | | | | **1,380,700** |


**Figure 3.12. Alternative 4 - Nourishment with Non-Structural Inlet Management (Preferred Alternative)**

is also a party to the interlocal agreement; however, it is the on-going recipient of regular USACE placements of navigation dredged material from the MCH channels and has been for nearly two decades. This material is expected to be sufficient in meeting the maintenance nourishment requirements of the ~5.0-mile Atlantic Beach management reach. Therefore, the County is not anticipating any maintenance sand placement on Atlantic Beach under its 50-year management plan. However, the County's 50-year plan would provide for interim maintenance nourishment events along Atlantic Beach should USACE MCH placements cease. Furthermore, the County's 50-year plan would provide storm-response nourishment for Atlantic Beach to address any storm-related needs in excess of the volumes placed by the USACE MCH project.

The 50-year project would employ a regular and recurring cycle of nourishment events in combination with periodic realignments of the Bogue Inlet ebb channel to continuously maintain beach profile sand volumes at a 25-year LOP (i.e., protection against a 25-year storm event). The approximately ten miles of beaches encompassing the Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle East management reaches would be maintained according to beach profile volumetric triggers in exactly the same manner as described under Alternative 3. The additional approximately eight miles of beaches along central and western Emerald Isle and Bogue Inlet reaches would also be maintained in accordance with 25-year LOP beach profile volumetric triggers. As previously described under Alternative 3, the SBEACH numerical modeling results indicated appropriate volumetric triggers ranging from 211 - 266 cy/ft along Bogue Banks (weighted average = 233 cy/ft). Based on variability in the volumetric triggers, the additional ~8 miles of beaches along Emerald Isle were divided into three additional management reaches (Emerald Isle Central, Emerald Isle West, and Bogue Inlet) (Figure 3.12).

As in the case of the Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle East management reaches; maintenance of the 25-year LOP beach profile volumes along the Emerald Isle Central, Emerald Isle West, and Bogue Inlet management reaches would involve: 1) regular recurring "maintenance" nourishment events to offset long-term, chronic background erosion (including hotspot erosion) and 2) periodic "storm response" nourishment events to offset sand losses incurred during hurricanes. Based on the SBEACH modeling results and observed background erosional loss rates along annually surveyed monitoring profiles, the three additional management reaches are expected to require recurring maintenance sand placements of ~0.06 to ~0.23 MCY at intervals of six or nine years to offset chronic background erosion (Figure 3.12, Table 3.8). As previously described under Alternative 3, the Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle East management reaches are expected to require recurring maintenance sand placements of ~0.2 to 0.5 MCY at intervals of three or six years to offset background erosion (Figure 3.12, Table 3.8). As indicated above, should the need arise for interim maintenance nourishment of Atlantic Beach, an additional ~5.0 beach miles would be nourished every three years under Alternative 4. The combined projected erosional losses along all six management reaches (excluding Atlantic Beach) indicate that placements totaling ~12.7 MCY would be required under Alternative 4 to offset background

**Table 3.8. Alternative 4 proposed sand placement activities.**

| Placement Reach | Project Type | Beach Fill Source | Interval (years) | No. of Events | Per Event Volume | 50-Year Volume (cy) |
|---|---|---|---|---|---|---|
| **County Maintenance Sand Placement** | | | | | | |
| Bogue Inlet (Stations 1-11) | County | ODMDS/Area Y/AIWW Islands/Upland Sources Bogue Inlet | 6 | 8 | 147,912 | 1,183,296 |
| Emerald Isle West (Stations 12-25) | County | ODMDS/Area Y/AIWW Islands/Upland Sources Bogue Inlet | 9 | 5 | 57,006 | 285,030 |
| Emerald Isle Central (Stations 26-36) | County | ODMDS/Area Y/AIWW Islands/Upland Sources Bogue Inlet | 9 | 5 | 224,827 | 1,124,135 |
| Emerald Isle East (Stations 37-48) | County | ODMDS/Area Y/AIWW Islands/Upland Sources Bogue Inlet | 3 | 16 | 191,232 | 3,059,712 |
| Indian Bch/Salter Path (Stations 49-58) | County | ODMDS/Area Y/AIWW Islands/Upland Sources | 6 | 8 | 375,402 | 3,003,216 |
| Pine Knoll Shores (Stations 59-76) | County | ODMDS/Area Y/AIWW Islands/Upland Sources | 6 | 8 | 508,770 | 4,070,160 |
| Atlantic Beach (Stations 77-102) | County | ODMDS/Area Y/AIWW Islands/Upland Sources | If needed | 0 | 0 | 0 |
| **County Maintenance Total** | | | | | | **12,725,549** |
| **USACE Maintenance Sand Placement** | | | | | | |
| Bogue Inlet (Stations 1-11) | USACE Nav | AIWW Bogue Inlet Crossing | 3 | 16 | 60,600 | 969,600 |
| Pine Knoll Shores (Stations 59-76) | USACE Nav | MCH Channels | If available | 0 | 0 | 0 |
| Atlantic Beach (Stations 77-102) | USACE Nav | MCH Channels | 3 | 16 | 494,835 | 7,917,360 |
| **USACE Maintenance Total** | | | | | | **8,886,960** |
| **County/USACE Storm Response Sand Placement** | | | | | | |
| Emerald Isle, Indian Bch/Salter Path, Pine Knoll Shores, Atlantic Beach | County/FEMA USACE Nav/Delta | ODMDS/Area Y/AIWW Islands/Upland Sources MCH Channels | 3 | 16 | 1,700,000 | **27,200,000** |
| **Total Sand Placement (County Maintenance + USACE Maintenance + County/USACE Storm Response)** | | | | | | **48,812,509** |

erosion along the entire 18-mile project shoreline over the 50-year life of the project (Table 3.8). A conceptual 50-year schedule of nourishment events based on the projected intervals is provided in Table 3.9. However, actual maintenance nourishment intervals would be expected to vary in response to background erosion rate variability over the course of the 50-year project. Individual nourishment events would encompass multiple management reaches, including combinations of management reaches other than those listed in Table 3.8, as determined based on actual reach-specific erosional loss rates.

Additional storm-response nourishment requirements were projected at a broader island-wide scale based on data from the three FEMA-reimbursed post-hurricane nourishment projects that have occurred on Bogue Banks [Post-Isabel (2004), Post-Ophelia (2007), and Post-Irene (2013)]. The volumetric losses incurred during these storms and the intervals between the associated response nourishment projects indicate that future island-wide storm losses could require additional volumetric placements of 1.4 to 1.7 MCY as frequently as every three-to-four years. However, considering the unpredictability of storm return intervals, it is conservatively assumed for planning purposes that storm-related losses would require placements of 1.7 MCY every three years. The placement of 1.7 MCY every three years would equate to 16 storm response placement events totaling ~27.2 MCY over the next 50 years (Table 3.8). As indicted above, the projected storm-response nourishment requirements apply to the island of Bogue Banks as a whole. Due to the unpredictability of site-specific storm effects, the specific storm-response needs of the individual management reaches have not been projected. It is expected that the combined 50-year need of the six reaches, which have a combined length of ~18 miles, would be less than the overall projected ~25-mile island-wide need of ~27.2 MCY. However, as indicated above, the County project would also provide supplemental storm response nourishment on the ~5.0 Atlantic Beach reach to offset any storm-related needs that exceed USACE MCH placements. Storm-response projects would add to the maintenance events described above, increasing the overall number of nourishment events along the County management reaches and in some cases resulting in nourishment intervals shorter than the 3- to 9-year intervals indicated above for background erosion alone. Storm-response nourishment requirements for the management reaches would be provided under the County/municipal 50-year project through FEMA-reimbursed projects and/or additional nourishment projects fully funded by the County/municipalities in the case of non-reimbursable storm losses (including storm losses along Atlantic Beach, which does not meet FEMA engineered beach eligibility requirements).

Under Alternative 4, sources of beach fill and associated extraction methods would include all of those previously described under Alternative 3 (i.e., Old and Current ODMDS, Area Y, AIWW disposal islands, and upland borrow sites). Detailed information on these borrow areas; including location, volumetric availability, and sediment compatibility; is provided under Alternative 3. As in the case of Alternative 3, should the need arise for interim maintenance nourishment of Atlantic Beach, the County would use these same borrow sources while seeking supplemental authorization to add Beaufort Inlet as a borrow source under its 50-year management plan. As detailed below, an additional source of beach fill under Alternative 4

**Table 3.9. Alternative 4 conceptual 50-Year "maintenance" nourishment schedule.**

| Year | Management Reaches | Transects | Volume (cy) | Placement Miles |
|---|---|---|---|---|
| 2019 | Emerald Isle East | 37-48 | 191,232 | 2.5 |
| 2022 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2025 | Emerald Isle West | 12-25 | 473,085 | 8.96 |
| | Emerald Isle Central | 26-36 | | |
| | Emerald Isle East | 37-48 | | |
| 2028 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2031 | Emerald Isle East | 37-48 | 191,232 | 2.5 |
| 2034 | Bogue Inlet | 1-11 | 1,626,369 | 18.08 |
| | Emerald Isle West | 12-25 | | |
| | Emerald Isle Central | 26-36 | | |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2037 | Emerald Isle East | 37-48 | 191,232 | 2.5 |
| 2040 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2043 | Emerald Isle West | 12-25 | 473,085 | 8.96 |
| | Emerald Isle Central | 26-36 | | |
| | Emerald Isle East | 37-48 | | |
| 2046 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2049 | Emerald Isle East | 37-48 | 191,232 | 2.5 |
| 2052 | Bogue Inlet | 1-11 | 1,626,369 | 18.08 |
| | Emerald Isle West | 12-25 | | |
| | Emerald Isle Central | 26-36 | | |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2055 | Emerald Isle East | 37-48 | 191,232 | 2.5 |

**Table 3.9. (concluded).**

| Year | Management Reaches | Transects | Volume (cy) | Placement Miles |
|---|---|---|---|---|
| 2058 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |
| 2061 | Emerald Isle West | 12-25 | 473,085 | 8.96 |
| | Emerald Isle Central | 26-36 | | |
| | Emerald Isle East | 37-48 | | |
| 2064 | Bogue Inlet | 1-11 | 1,344,516 | 11.62 |
| | Emerald Isle East | 37-48 | | |
| | Indian Beach/Salter Path | 49-58 | | |
| | Pine Knoll Shores | 59-76 | | |

[1] Interim maintenance of Atlantic Beach would add 494,835 cy of placement along ~5 miles of beach every 3 years

would include compatible dredged material derived from realignments of the Bogue Inlet ebb channel. Over the 50-year project life, it is anticipated that ebb channel realignments would provide up to 4.3 MCY of compatible material for beach placement, thus providing the sand volume required to maintain a 25-year LOP along the Emerald Isle Central, Emerald Isle West, and Bogue Inlet management reaches. Bogue Inlet management would encompass periodic realignments of the ebb channel (via dredging) to a mid-inlet position approximately every ten to 15 years, with corresponding placement of dredged material on the beaches of Emerald Isle.

Unlike Alternative 1, the initiation of realignment projects under Alternative 4 would be based on the position of the ebb channel relative to the boundaries of an established “safe box” within the inlet throat. The ebb channel would be allowed to migrate freely so long as it remains within the boundaries of the safe box; however, migration beyond the eastern boundary of the safe box (towards Emerald Isle) would trigger a preemptive ebb channel realignment event. As described in the Engineering Report (Appendix G), the limits of the safe box were developed and evaluated through empirical analysis of historical inlet changes and supplemental numerical modeling. Historical ebb channel alignments and corresponding inlet shoreline positions were analyzed through GIS analysis of historical aerial photography, National Ocean Service (NOS) T-sheet maps, and LIDAR topographic maps. The results of the historical analysis indicate that during past periods of eastward migration, the ebb channel has exhibited a pattern of rapid acceleration as it nears the west end of Bogue Banks (i.e., Emerald Isle). Past migration rates and corresponding shoreline changes indicate that once this acceleration occurs, the migrating channel has the potential to threaten structures on Emerald Isle within two to three years. Based on the historical patterns, a safe box was established with boundaries corresponding to the location where acceleration of the ebb channel towards the west end of Emerald Isle has occurred in the past. The validity of the safe box boundaries were then evaluated by modeling a series of six idealized inlet configurations encompassing the range of most relevant historical

ebb channel alignments. As described in the Engineering Report (Appendix G), the Bogue Inlet local numerical model was developed for this purpose. The modeling results did not show any additional geomorphological indicators of an impending shift to accelerated migration that warranted modifications to the initial safe box or the original 2005 inlet channel design.

The limits of the proposed safe box are depicted in Figure 3.13 along with historical ebb channel alignments and the 2005 channel realignment footprint. Although the eastern boundary of the safe box is separated from the nearest structure on Emerald Isle by a considerable distance of ~1,100 ft, the eastern boundary marks the location where historical eastward migrating ebb channels have rapidly accelerated towards the shoreline. Based on past migration rates and corresponding shoreline impacts; once this acceleration occurs, the migrating channel has the potential to threaten structures within two to three years. Thus, the safe box limits are designed to trigger realignments two to three years in advance of anticipated impacts to infrastructure on Emerald Isle. Throughout most of the period since the 2005 relocation, the ebb channel has migrated east at a rate of ~170 ft/year; however, in recent years the rate has slowed to ~40-120 ft/year. In total, the channel has migrated ~1,840 ft eastward over the 11-year period since the 2005 relocation project. At the current rate, the ebb channel would surpass the eastern boundary of the safe box in approximately five to ten years. Figure 3.14 depicts the current channel alignment in relation to the safe box and the 2005 channel realignment footprint.

The mid-inlet channel design and associated construction methods would be the same as those employed during the 2005 ebb channel relocation project. The design of the 2005 mid-inlet channel was developed through GIS analysis of historical inlet geomorphological changes, hydrodynamic modeling of inlet tides and currents, and channel stability and shoaling analyses (Cleary 2003, CPE 2004). An analysis of inlet changes over the previous 30 years (1973 - 2001) indicated that ebb channel migration and changes in the ebb-tidal delta symmetry were dictating erosional and accretional trends along the inlet and flanking oceanfront shorelines of both Bogue Banks and Bear Island (Cleary 2003). Historical ebb channel alignments and corresponding shoreline positions indicated that an alignment approximating the 1976 and 1978 ebb channel configurations would provide optimal benefits for the inlet shoulders and flanking oceanfront shorelines on both Bogue Banks and Bear Island. The 2005 project used numerical modeling to evaluate the performance and stability of various channel designs in terms of flow, circulation, shoaling, and scour. Predicted hydrodynamic conditions in the design channels were compared with modeled baseline conditions in the existing channel, and iterative modeling runs were used to determine optimal cross sectional channel dimensions in terms of the ability to capture the majority of the flow through the inlet, while avoiding excessive shoaling or scour that might degrade channel stability. Based on bathymetric surveys of the existing channel, variability in cross sectional area was incorporated into the mid-inlet channel design by varying the bottom width of the channel at specific depths. Modeling analyses for the 2005 project indicated that the construction of a sand dike across the existing channel would forcibly redirect ebb flow through the new channel, thereby expediting infilling and abandonment of the former channel. Given the severe erosional threat to structures at the time, the dike was employed to expedite the mitigative effects of the project on the critically eroded Bogue Banks inlet shoreline.


**Figure 3.13. Proposed Bogue Inlet Safe Box with Historical Channel Locations and 2005 Ebb Channel Realignment Footprint**

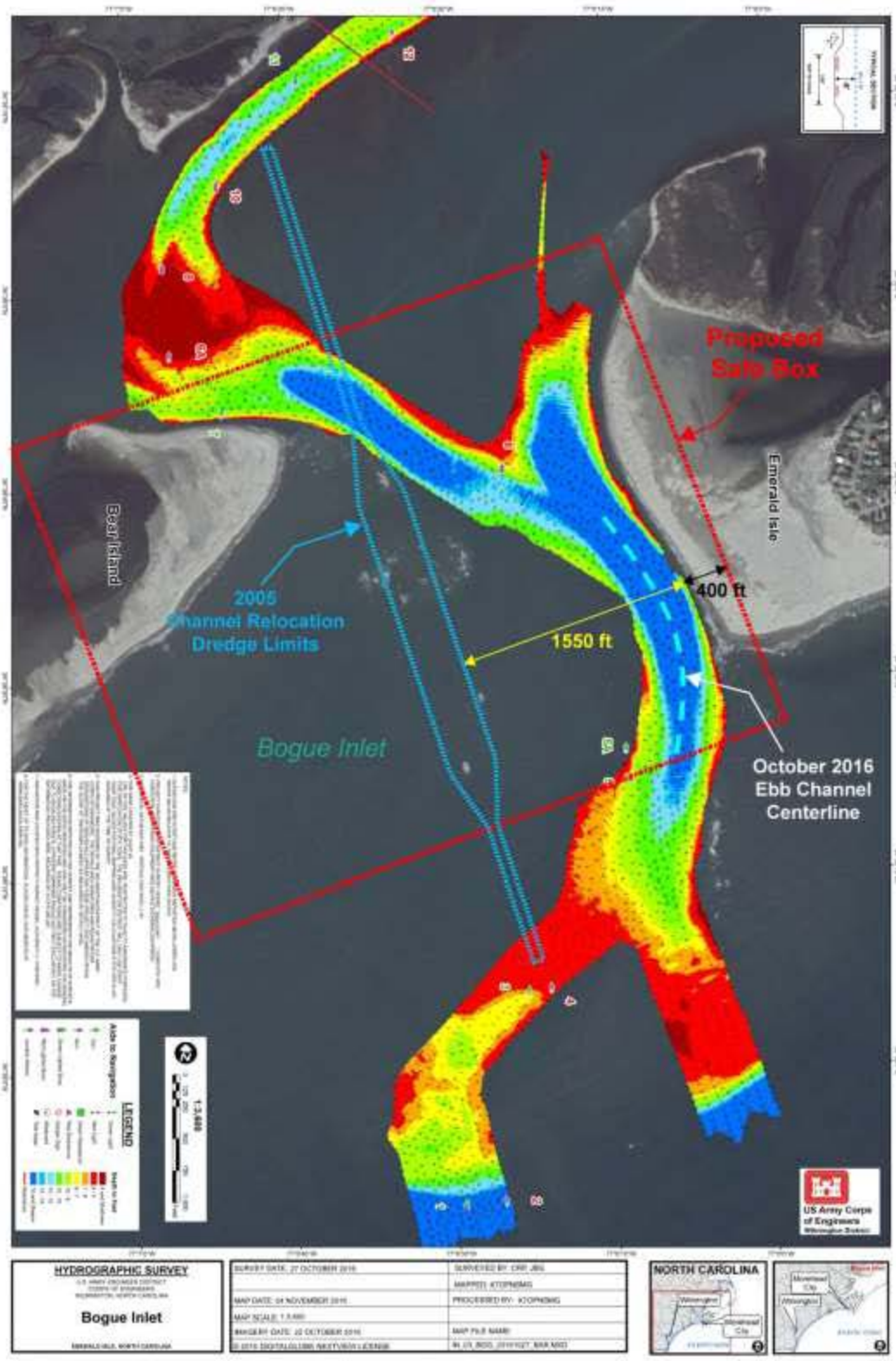
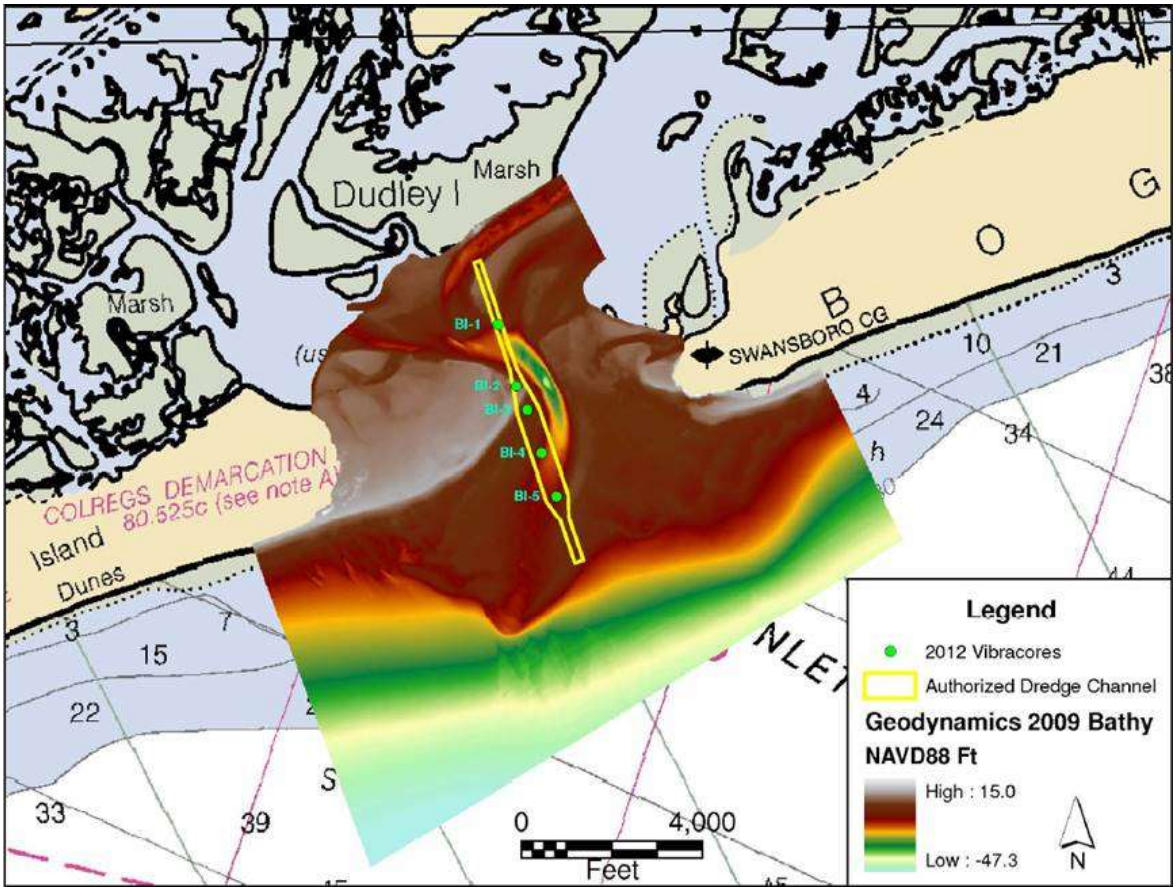



**Figure 3.14. Current Bogue Inlet Ebb Channel Alignment in Relation to the Safe Box and the Proposed Realignment Footprint**

The 2005 relocation project altered sediment transport patterns along both shoulders and prompted a significant reconfiguration of the ebb-tidal delta. The apex of the ebb delta began a shift to the west, and the eastern portion of the ebb delta shoal fronting Bogue Banks began a gradual collapse that would eventually infill the former ebb channel. Infilling and abandonment of the former ebb channel were delayed by the effects of Hurricane Ophelia in September 2005, which eroded the closure dike and reestablished a connection between the former ebb channel and the AIWW. However, by 2009, infilling of the former channel was nearly complete and the eastern segment of the ebb delta had been reconfigured in accordance with the new ebb channel alignment. Reorganization of the inlet shoal system was accompanied by spit development on the east end of Bogue Banks, and by October 2010 the developing Bogue Banks spit had prograded 1,830 ft westward into the inlet.

In accordance with the 2005 design, relocations under Alternative 4 would entail the construction of a channel ~6,000-ft-long with variable bottom widths ranging from 150 to 500 ft and project depths of approximately -16.5 ft NAVD (including overdredge). Relatively shallow inlet depths would require the use of a cutterhead dredge to excavate the new mid-inlet channel. Channel excavation is anticipated to yield just over 1.0 MCY of beach compatible dredged material, which would be pumped directly onto the Emerald Isle central and west management reaches. Due to the preemptive nature of realignment events, the need for a closure dike is generally not anticipated, as there would be sufficient time for the old channel to fill in before it presents a threat to Emerald Isle. However, in the event of extreme rapid ebb channel repositioning events (e.g., due to shoal breaching or hurricanes), the ebb channel could present an immediate threat to structures that would warrant the construction of a dike across the old channel to facilitate infilling. In such cases, it is anticipated that ~0.2 MCY of the dredged material from the new channel would be used to construct a closure dike across the old channel, with the remaining ~0.80 MCY of material being pumped directly onto the beaches of Emerald Isle. Excavation would proceed inland from the seaward terminus of the new channel, with dredged material initially being pumped onto the Emerald Isle beaches. As work nears the inshore terminus of the new channel, disposal would be redirected to the designated dike construction area in the old channel.

Based on the projected interval of ten to 15 years, a total of three to five realignment events would be expected over the 50-year life of the project. The three to five events would provide a total dredged material volume of approximately 2.6 to 4.3 MCY for beach placement, thus providing for maintenance of the 25-year LOP beach profile volumes along the Emerald Isle Central, Emerald Isle West, and Bogue Inlet management reaches. Based on vibracores taken in 2012 (Figure 3.15, Table 3.10), the proposed channel footprint contains beach compatible material consisting of fine grained, poorly sorted quartz sand with less than one percent fines and gravel and approximately 15% calcium carbonate in the form of shell hash (Coastal Tech 2013). The samples taken from the cores have a composite mean grain size of 0.33 mm, which is just slightly coarser than the native beach (0.30 mm), indicating that the material is likely derived from the surrounding beaches. The 201*2* sample results are consistent with the results




Source: Coastal Tech 2013

**Figure 3.15. Bogue Inlet Proposed Ebb Channel Realignment Footprint with Vibracore Locations**

**Table 3.10. Alternative 4 proposed Bogue Inlet Channel sediment characteristics**

| | Sediment Characteristics | | | | |
|---|---|---|---|---|---|
| | **Fines (<0.0625 mm)** | **Sand (0.0625 - 1.99 mm)** | **Granular (2.0 - 4.75 mm)** | **Gravel (4.76 - 75.0 mm)** | **Calcium Carbonate** |
| **NC Tech Stand.** | ≤6% | - | ≤6% | ≤6% | ≤35% |
| **Bogue Inlet[1]** | 0.15% | 96.61% | 2.40% | 0.84% | 14.96% |
| [1]Sediment data represent a composite of 5 vibracore samples collected in 2012. | | | | | |

Source: Coastal Tech 2013

of vibracore analyses conducted for the 2005 project, which characterized sediments in the proposed channel footprint as highly compatible fine sand (0.30-0.31 mm) with a very small fine sediment fraction of less than two percent (CPE 2003).

As described above, USACE disposals of dredged material from the MCH channels on Atlantic Beach would be expected to continue throughout the 50-year project. Additionally, depending on availability, excess material from the MCH channels may also be placed on Pine Knoll Shores in accordance with the new DMMP. USACE disposals of navigation dredged material on the west end of Emerald Isle via maintenance of the AIWW Bogue Inlet Crossing channel would also be expected to continue under Alternative 4, contingent on available federal monies. Additionally, USACE maintenance of the Bogue Inlet navigation channel via sidecast dredging and open water disposal would be expected to continue during the interim periods between inlet channel relocation events.

Based on the analyses presented in the Engineering Report (Appendix G), projected County/municipal maintenance nourishment and inlet realignment events under Alternative 4 would cost approximately $182.4M over the 50-year life of the project. Storm losses are estimated to require additional placements totaling ~27.2 MCY over the next 50 years at a cost of $360.4M in federal reimbursement monies. Continuing USACE sand placement activities; including the disposal of navigation dredged material from the MCH channels on Atlantic Beach and beach disposal on the Pointe adjacent to Bogue Inlet via maintenance of the Bogue Inlet AIWW Crossing channel; would cost approximately $245.2M over the next 50 years. The total combined cost of all nourishment would be approximately $787.9M over the next 50 years.

### **3.3.5** Alternative 5 - Nourishment and Structural Inlet Management

Under Alternative 5, the County, through an interlocal agreement with all of the island municipalities, would implement the 50-year beach nourishment project described under Alternative 3, with the addition of a structural Bogue Inlet management component consisting of a terminal groin on the west end of Emerald Isle (Figure 3.16). Nourishment parameters, regimes, and volumes for the Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle East management reaches, as well parameters for potential interim maintenance/supplemental storm nourishment of Atlantic Beach, would be the same as those previously described under Alternative 3 (Table 3.11). Furthermore, all sand sources for beach nourishment (i.e., Old and Current ODMDS, Area Y, AIWW disposal islands, and upland borrow sites) and associated methods of beach fill extraction would be the same as those described under Alternative 3. Alternative 5 would not include any efforts to manage the Bogue Inlet ebb channel through relocations or dredging. In the absence of Bogue Inlet ebb channel relocations as a sand source, the total volume of available beach fill from all other known feasible borrow sources would fall short of the projected island-wide 50-year need. Therefore, Alternative 5 would not provide for any sand placement on the approximately eight miles of beaches along central and


**Figure 3.16. Alternative 5 - Nourishment with Structural Inlet Management**

**Table 3.11. Alternative 5 proposed sand placement activities.**

| Placement Reach | Project Type | Beach Fill Source | Interval (years) | No. of Events | Per Event Volume | 50-Year Volume (cy) |
|---|---|---|---|---|---|---|
| **County Maintenance Sand Placement** | | | | | | |
| Emerald Isle East (Stations 37-48) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 3 | 16 | 191,232 | 3,059,712 |
| Indian Bch/Salter Path (Stations 49-58) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 6 | 8 | 375,402 | 3,003,216 |
| Pine Knoll Shores (Stations 59-76) | County | ODMDS/Area Y<br>AIWW Islands/Upland Sources | 6 | 8 | 508,770 | 4,070,160 |
| **County Maintenance Total** | | | | | | **10,133,088** |
| **USACE Maintenance Sand Placement** | | | | | | |
| Bogue Inlet (Stations 1-11) | USACE Nav | AIWW Bogue Inlet Crossing | 3 | 16 | 60,600 | 969,600 |
| Pine Knoll Shores (Stations 59-76) | USACE Nav | MCH Channels | If available | 0 | 0 | 0 |
| Atlantic Beach (Stations 77-102) | USACE Nav | MCH Channels | 3 | 16 | 494,835 | 7,917,360 |
| **USACE Maintenance Total** | | | | | | **8,886,960** |
| **County/USACE Storm Response Sand Placement** | | | | | | |
| Emerald Isle, Indian Bch/Salter Path, Pine Knoll Shores, Atlantic Beach | County/FEMA<br>USACE Nav/Delta | ODMDS/Area Y/AIWW Islands/Upland Sources<br>MCH Channels | 3 | 16 | 1,700,000 | **27,200,000** |
| **Total Sand Placement (County Maintenance + USACE Maintenance + County/USACE Storm Response)** | | | | | | **46,220,048** |

western Emerald Isle and Bogue Inlet. However, Alternative 5 would attempt to reduce sand losses along these reaches through the construction of a 1,250-ft-long terminal groin along the shoulder of Bogue Inlet.

The conceptual terminal groin design encompasses a 1,250-ft-long shore perpendicular stem/head segment extending seaward from the western end of Emerald Isle and a 600-ft-long "tie-back" anchor segment that extends landward along the back-barrier inlet shoreline in front of the existing homes before tying in to the Coast Guard bulkhead (Figure 3.17). The groin is designed to be a relatively low profile structure, both to maximize sand over-passing and to minimize impacts to beach recreation and aesthetics. The terminal groin would be constructed of three- to six-ft-diameter granite armor stone; and unlike traditional jetties, would not have a core component of smaller diameter stone. The use of only larger armor stone would allow for a large void ratio, thus providing the "leaky" characteristic that allows sand to pass through the structure. To prevent settlement of the stone, and if necessary to facilitate modification or removal of the groin, a base layer of geo-textile matting (one-foot thick) would be installed below grade prior to armor stone placement. The rubble mound (i.e., armor stone) component of the groin would have a variable crest width ranging from approximately seven to 15 ft and a variable base width of ~40 to 100 ft (Figure 3.18).

Land-based heavy equipment would be used to construct the groin by excavating the dry beach, installing the geo-textile matting and rock to design specifications, and covering the structure with the original excavated sand material. Construction areas would be stabilized with silt fencing and redressed where appropriate. For the section that extends below the MHW line, an elevated platform may be constructed depending on the depth of the water and the linear extent of the in-water groin component, as determined by the shoreline position when construction is initiated. Based on the 2015 shoreline position, approximately 550 linear feet of the groin structure would extend below the MHW line. It is anticipated that all of the stone for groin construction would be hauled in by trucks from the quarry site. Once the structure is in place, compatible beach fill material would be placed eastward of the terminal groin to form its fillet. The groin fillet would establish a gradual transitional shoreline between the oceanfront beach and the seaward terminus of the terminal groin. Fillet material for the initial construction event would be acquired from one of the proposed borrow areas or provided by USACE placement of navigation dredged material from the AIWW Bogue Inlet Crossing channel. Material for any future fillet maintenance events would consist of navigation dredged material from the inlet crossing provided by the USACE.

Based on the analyses presented in the Engineering Report (Appendix G), projected County/municipal maintenance nourishment events under Alternative 5 would cost approximately $140.4M over the 50-year life of the project. Construction of the terminal groin is estimated to cost approximately $4.4M. Storm losses are estimated to require additional


**Figure 3.17. Conceptual Terminal Groin Design Plan View**

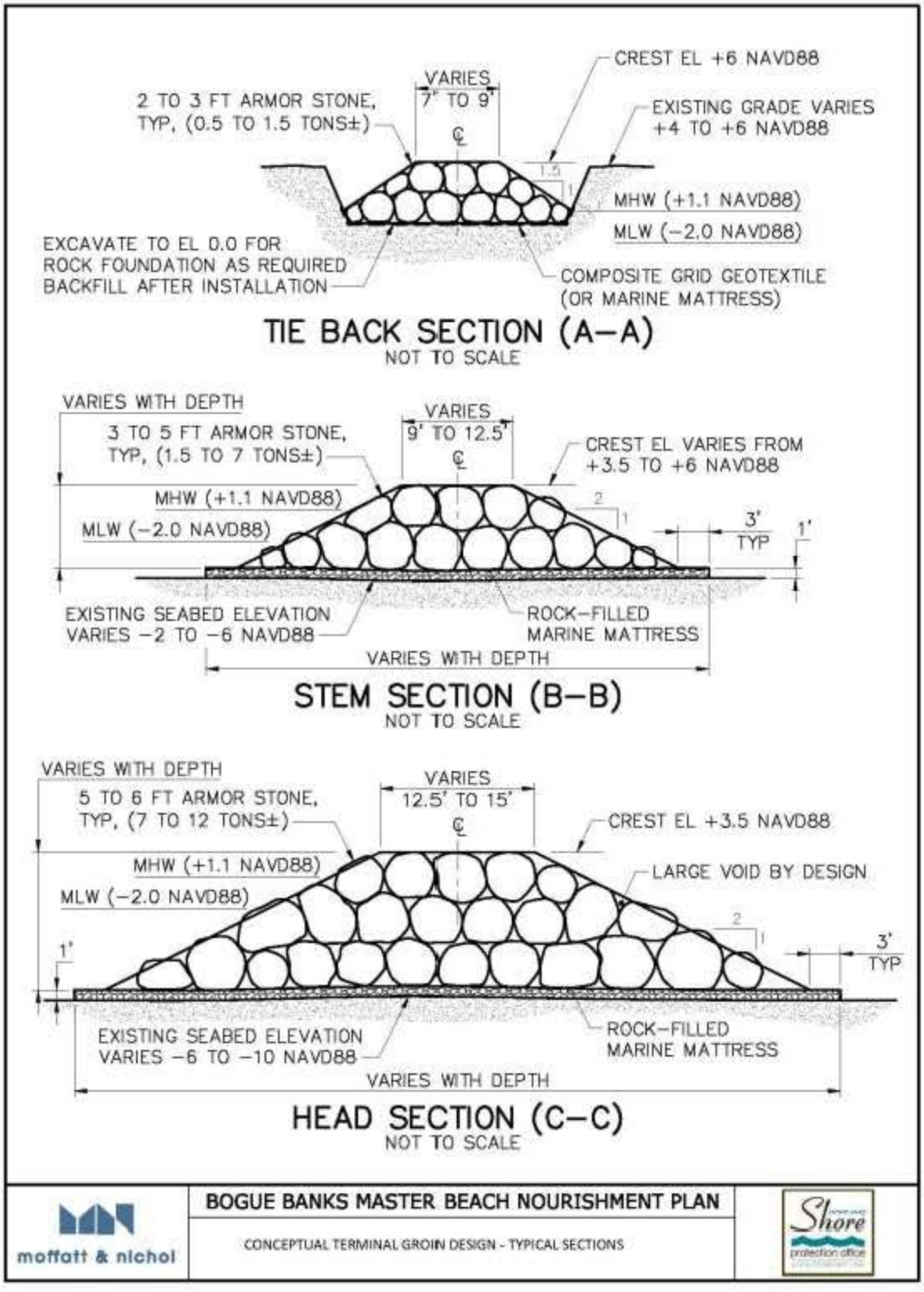



**Figure 3.18. Conceptual Terminal Groin Design - Typical Cross Sections**

placements totaling ~27.2 MCY over the next 50 years at a cost of $360.4M in federal reimbursed monies. Continuing USACE sand placement activities; including the disposal of navigation dredged material from the MCH channels on Atlantic Beach and beach disposal on the Pointe adjacent to Bogue Inlet via maintenance of the Bogue Inlet AIWW Crossing channel; would cost approximately $245.2M over the next 50 years. The total combined cost of all nourishment and groin construction would be approximately $750.4M over the next 50 years.

## 3.4 Alternative Implementation Cost Comparison

Table 3.12 summarizes the estimated implementation costs associated with each of the alternatives. The costs in Table 3.12 are strictly those associated with the implementation of proposed management actions, and do not reflect the economic impacts associated with shore protection or the lack thereof under the alternatives. The highest implementation costs are associated with Alternative 4, which encompasses recurring nourishment along ~18 miles of shoreline and periodic realignments of the Bogue Inlet ebb channel. Lower implementation costs under Alternatives 3 and 5 reflect more limited recurring nourishment along just ten miles of shoreline. Additionally, inlet management costs are reduced under Alternative 5 and absent under Alternative 3. The lowest implementation costs are associated with Alternative 2, which includes no County/municipal shoreline management efforts.

**Table 3.12. Alternative implementation costs**

| Alternative | Management Action | | | | | Total 50-Year |
|---|---|---|---|---|---|---|
| | Maintenance Nourishment | Storm Nourishment | USACE Beach Disposal | Structure Relocations | Terminal Groin | |
| **Alternative 1-No Action** | $85,242,025[1] | NA | $245,150,000 | NA | NA | **$330,392,025** |
| **Alternative 2-Abandon/Retreat** | NA | NA | $245,150,000 | $33,825,000 | NA | **$278,975,000** |
| **Alternative 3-Nourishment Only** | $140,413,488 | $360,400,000 | $245,150,000 | NA | NA | **$745,963,488** |
| **Alternative 4-Nourishment/Non-Structural Inlet Management** | $182,390,238[2] | $360,400,000 | $245,150,000 | NA | NA | **$787,940,238** |
| **Alternative 5-Nourishment/Structural Inlet Management** | $140,413,488 | $360,400,000 | $245,150,000 | NA | $4,375,000 | **$750,338,488** |

[1] Includes costs of limited Bogue Inlet ebb channel realignments and hotspot nourishment projects.

[2] Includes costs of preemptive Bogue Inlet ebb channel realignments and nourishment projects.