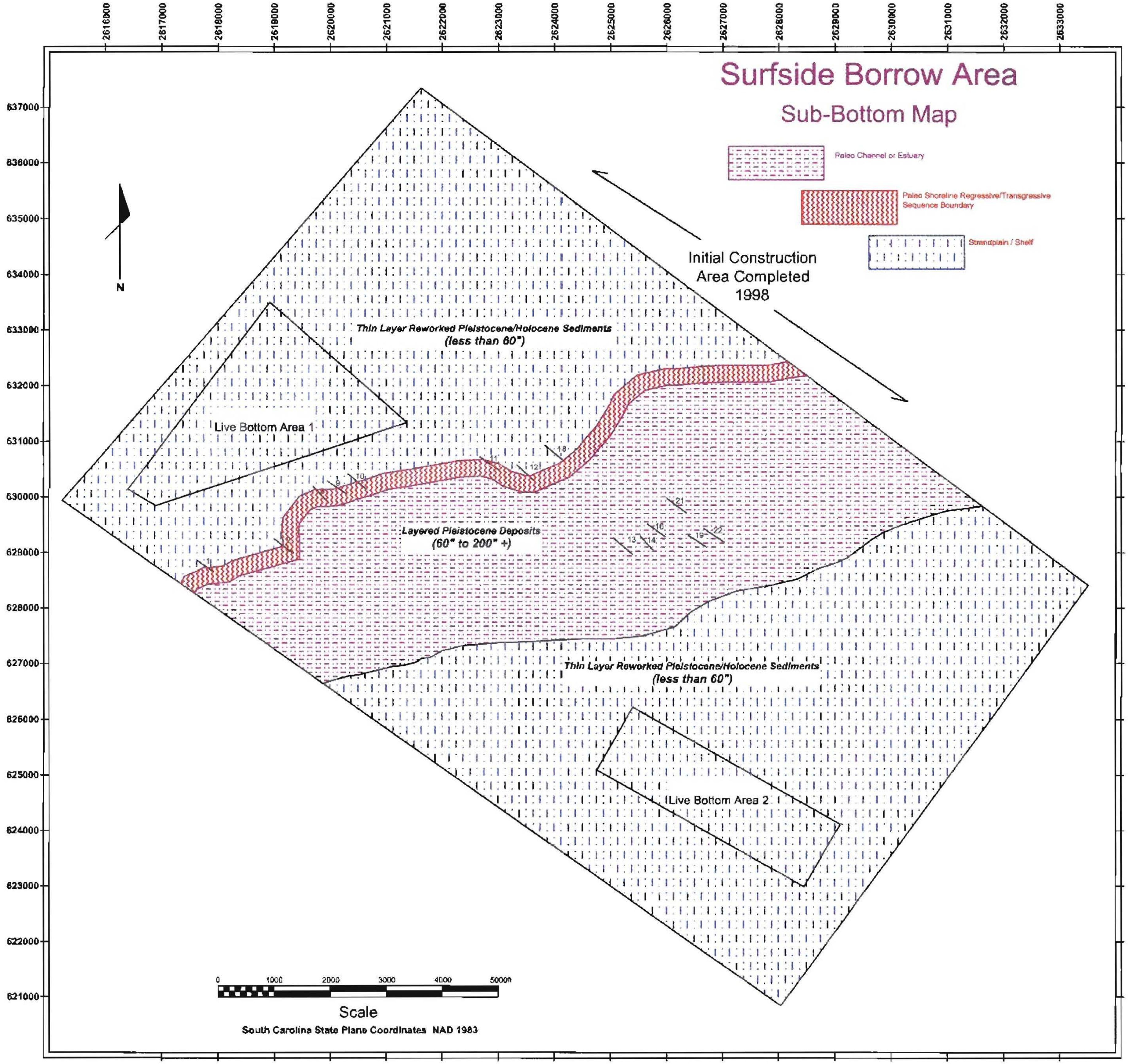

Figure 7. Surfside Borrow Area Sub-bottom Map.

Cane South Borrow Area
Low relief hard bottom was identified to the north of known "Live bottom" area within the northwest portion of Cane South Borrow Area. Below is a typical example side scan sonar images of low relief hard bottom in that vicinity (Figures 29 and 30).

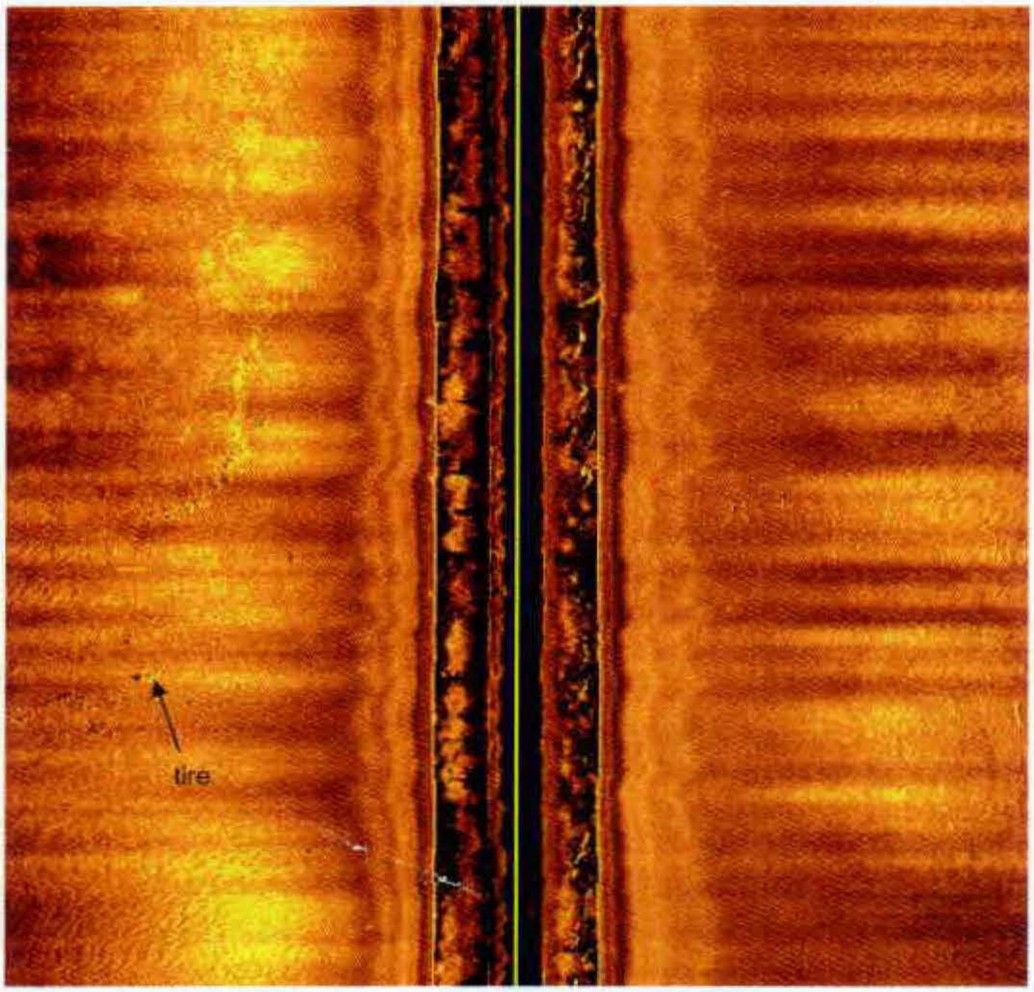

Figure 29. Cane South Borrow Area - Low Relief Hard Bottom.

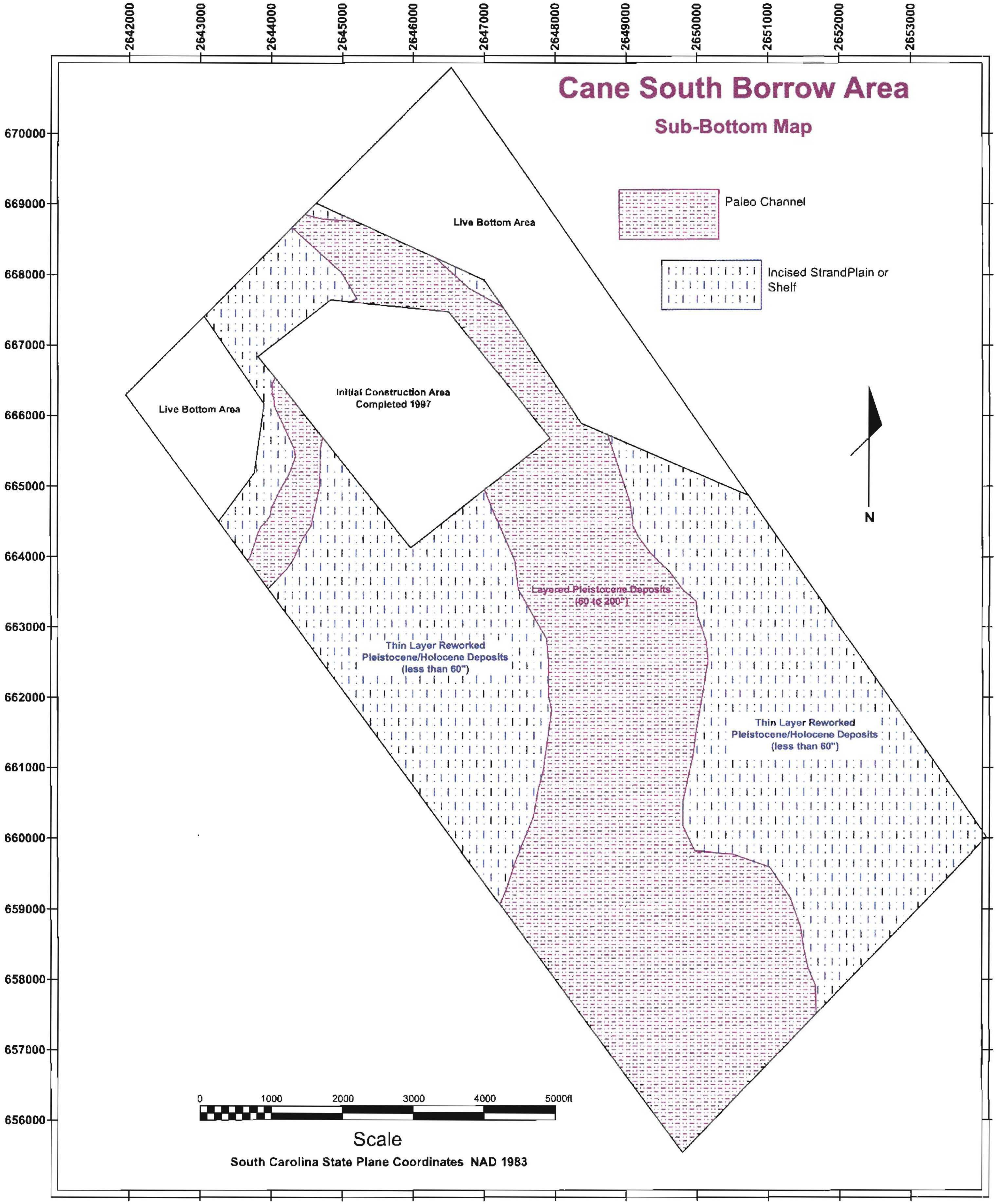

Figure 23. Cane South Borrow Area Sub-Bottom Map.

Little River Borrow Area
A single area of moderate and low relief hard bottom was identified mid southern portion of Little River Borrow Area. Below is a mosaic image of the moderate relief portion of hard bottom area (Figures 30 and 31).

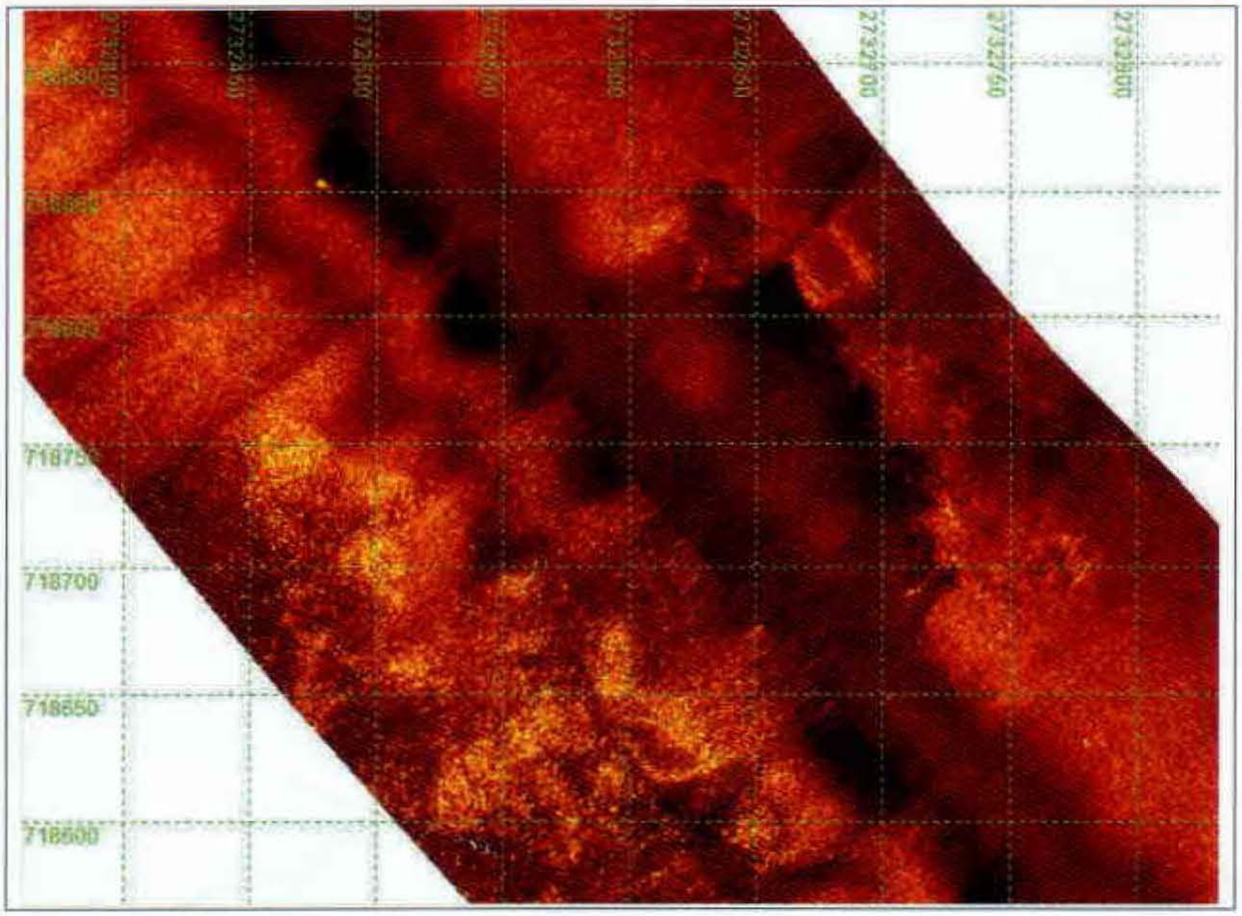

Figure 31. Little River Borrow Area – Moderate Relief Hard Bottom.

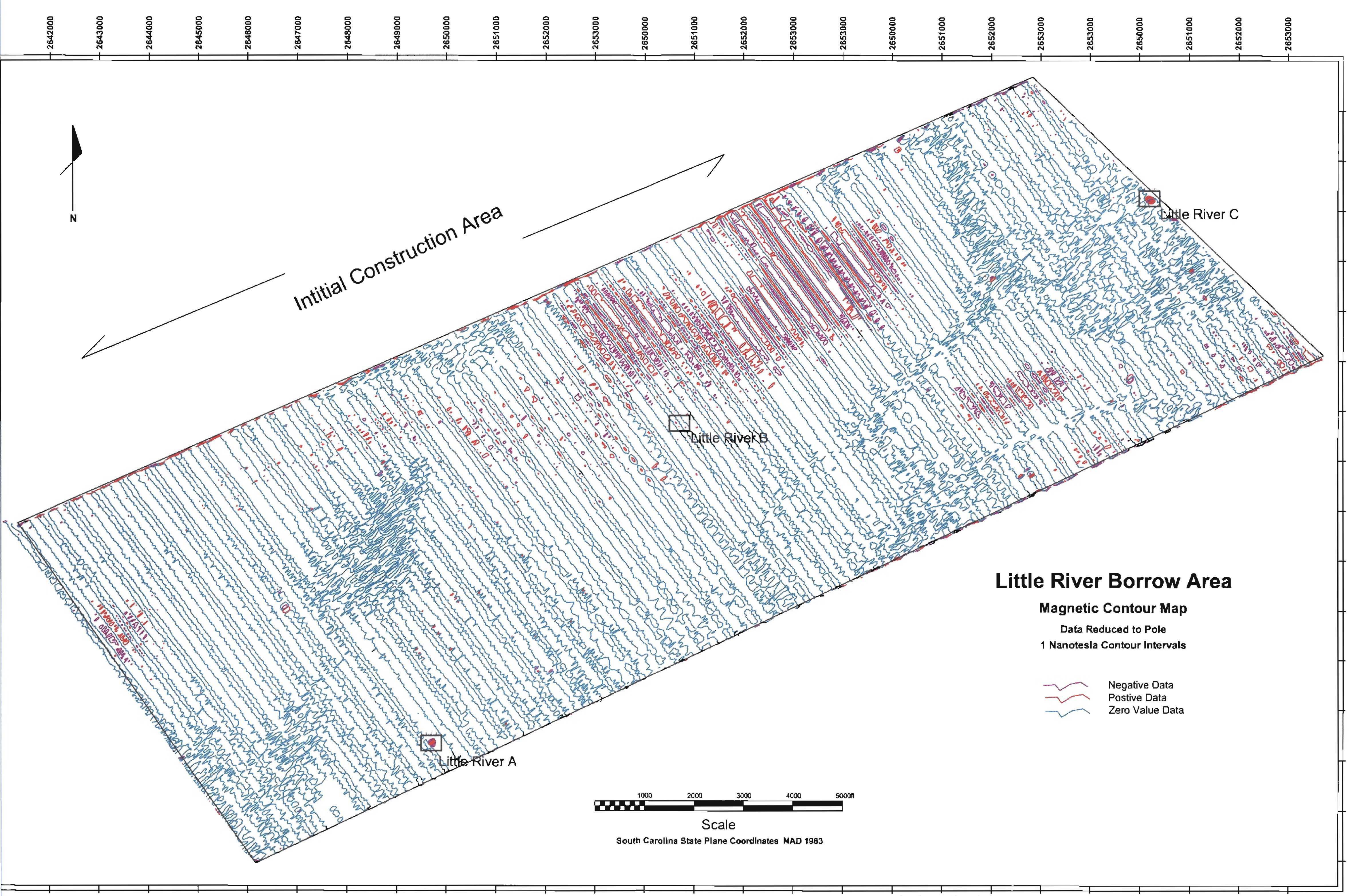

Figure 8. Cane South Borrow Area Magnetic Contour and Target Location Map.

Summary of Findings

A total of five remote sensing targets were identified within the three borrow areas. One target - Surfside A exhibits characteristics that may be associated with a significant submerged cultural resource. Additional underwater investigations to identify and assess Surfside A's potential as an archaeological resource are recommended. If underwater archaeological investigations are not an option, an avoidance buffer of at least 200 feet (radius) around the target coordinates should be established prior to dredging activities.

The remainder of the remote sensing targets identified during the survey of the three borrow areas (Cane South A, and Little River A, B, C) appear to have little potential to be associated with significant cultural resources. No additional underwater investigation or mitigation is recommended.

Analysis of sub-bottom records provide no indication of stratification or protected deposition of surficial (Late Pleistocene or Holocene) sediments that would contain or support any remnant evidence of human occupation or usage. No additional underwater archaeological investigations are recommended related to sub-bottom investigations within the three borrow areas.

Minor hard bottom areas were identified within each of the three borrow areas.

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Appendix: Known Shipwrecks in the general vicinity of Myrtle Beach

Vessel Name	Vessel Type	Date Lost	General Location	Comments
Prince Of Wales	Schooner-rigged blockade runner	1861	North Inlet	Ran aground at North Inlet some 9 miles from the entrance of Georgetown after being fired upon by Union blockading vessel 12/24/1861. Burned to prevent capture.
Liverpool	Schooner-rigged blockade runner	1862	North Inlet	Pursued by USS *Keystone State* and ran aground 04/10/1862 near North Inlet while attempting to reach Georgetown. Set afire and deserted to prevent capture. State site file 38GE64.
Rose	125-foot side-wheel steamer blockade runner	1864	Pawleys Island	Captured by Union forces after running aground near the south end of Pawleys Island 06/02/1864. Burned by crew of USS *Wamsutta*. State site file 38GE67.
Rover	Schooner-rigged steamer blockade runner	1863	Murrell's Inlet	Ran aground at Murrell's Inlet 10/19/1863 and burned to prevent capture.
Virginia Dare	Blockade runner	1861-1865	North Inlet	Sank while attempting to enter Georgetown through the blockade. State site file 38GE65.
Unknown	unknown	?	Litchfield Beach	Shipwreck on lot/beach at Litchfield Beach. State site file 38GE14.

Appendix 7

Water Quality Certification Documentation

D H E C

PROMOTE PROTECT PROSPER

C. Earl Hunter, Commissioner

Promoting and protecting the health of the public and the environment

March 30, 2007

U. S. Army Corps of Engineers
Attn: Mr. Shawn Boone
69A Hagood Avenue
Charleston, South Carolina 29403-5107

RE: Certification in accordance with Section 401 of the Clean Water Act, as amended.

MB Storm Reduction Project
beach nourishment
Atlantic Ocean
Horry County
P/N 92-2R-199

Dear Sir:

The Bureau of Water has reviewed the plans for this project and determined that there is a reasonable assurance that the proposed project will be conducted in a manner consistent with the Certification requirements of Section 401 of the Federal Clean Water act, as amended.

In accordance with provisions of Section 401, we certify that this project will continue to be consistent with applicable provisions of Section 303 of the Federal Clean Water Act, as amended, provided the project is subject to the conditions of the SC Department of Health and Environmental Control's November 19, 1992, certification, and any subsequent modifications, pursuant to Section 401, and the indicated conditions. We also hereby certify that there are no applicable effluent limitations under Sections 301(b) and 302, and that there are no applicable standards under Sections 306 and 307.

1. All necessary measures must be taken to prevent oil, tar, trash, debris and other pollutants from entering the adjacent waters or wetlands during construction

2. Only clean sand free of all potential sources of pollution must be used for beach nourishment.

3. Sand used for the project must consist of appropriate grain sizes to be compatible for beach nourishment.

4. Sand used must be at least 80 percent sand.

5. The permittee must adhere to any recommendations of the U.S. Fish and Wildlife Service and/or the S.C. Department of Natural Resources to protect any identified threatened and/or endangered species and the habitats of such species in the area of the proposed project.

The Department reserves the right to impose additional conditions on this Certification to respond to unforeseen, specific problems that may arise and to take any enforcement action necessary to ensure compliance with State water quality standards.

Sincerely,

Heather Preston

Heather Preston, Director
Division of Water Quality
Bureau of Water

cc: SC DHEC, Myrtle Beach EQC Office District Office
SC DHEC, Waccamaw District Office
OCRM

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201

November 19, 1992

U. S. Army Corps of Engineers
Attn: Mr. Jim Woody
P.O. Box 919
Charleston, SC 29402

Re: Certification in Accordance with Section 401 of the
Clean Water Act, as amended.

MB Storm Reduction Project
beach nourishment
Atlantic Ocean
Horry County
P/N 92-2R-199

Dear Sir:

We have reviewed plans for this project and determined there is a reasonable assurance that the proposed project will be conducted in a manner consistent with the Certification requirements of Section 401 of the Federal Clean Water Act, as amended. In accordance with the provisions of Section 401, we certify that this project, subject to the indicated conditions, is consistent with applicable provisions of Section 303 of the Federal Clean Water Act, as amended. We also hereby certify that there are no applicable effluent limitations under Sections 301(b) and 302, and that there are no applicable standards under Sections 306 and 307.

This certification is subject to the following conditions:

1. The applicant must follow the requirements of the USFWS biological opinion discussed in their August 17, 1992 letter.

2. The applicant must develop a monitoring plan to observe any biological and physical changes of the borrow areas. This plan should be coordinated with the appropriate resource agencies.

3. A buffer area should be established around all live bottom areas within and adjacent to the borrow areas. The applicant should coordinate with the appropriate resource agencies to determine the minimum buffer area necessary.

The S. C. Department of Health and Environmental Control reserves the right to impose additional conditions on this Certification to respond to unforeseen, specific problems that might arise and to take any enforcement action necessary to ensure compliance with State water quality standards.

Sincerely,

Chester E. Sansbury
Director, Division of Water Quality
and Shellfish Sanitation

CES:MRG
cc: Waccamaw District Office
S.C. Coastal Council

404(b)1 EVALUATION
BEACH EROSION CONTROL STUDY
MYRTLE BEACH AND VICINITY
GEORGETOWN AND HORRY COUNTIES, SOUTH CAROLINA

1. PROJECT DESCRIPTION

a. Location. The study area includes approximately 37 miles of South Carolina coastline between Hog Inlet to the north and Murrells Inlet to the south, an area known as the Grand Strand. With the exception of the Murrells Inlet area which is located in Georgetown County, the majority of the project is located in Horry County.

b. General Description.

(1) The Grand Strand is the state's top tourist area. Each year, thousands of visitors come to the area to participate in a variety of water oriented recreational activities. Shoreline erosion and increasing property damage caused by storms have become a serious concern to local officials and private and commercial development interests and those who utilize the beach for recreational purposes. In many areas, the erosion problem has been exacerbated by property owners constructing hard protection measures such as seawalls and groins in an effort to protect their investments.

(2) The selected plan involves storm damage protection for the beach in each of three reaches as described below to protect against a 5-year storm event.

(a) North Myrtle Beach (Reach 1). An 8.3 mile reach will be protected with approximately 750,000 cubic yards of sand obtained from an offshore borrow site (see the attached map). The area will be nourished from the same source with an estimated 400,000 cubic yards of material every eight years.

(b) Myrtle Beach (Reach 2). An 8.5 mile reach will be protected with approximately 1,400,000 cubic yards of sand obtained from an offshore borrow site (see the attached map). Nourishment will be required every eight years with approximately 400,000 cubic yards of sand obtained from the same source.

(c) Garden City/Surfside Beach (Reach 3). A 7.1 mile reach will be protected with approximately 2,700,000 cubic yards of sand obtained from an offshore borrow site (see the attached map). Nourishment will be required every eight years with approximately 400,000 cubic yards of sand obtained from the same source.

(3) Sand will be pumped from offshore borrow sites and placed above the low tide elevation in the beach fill area.

c. Authority and Purpose. The authority for construction of this project has been authorized by Congress. The purpose is for storm damage reduction.

d. General Description of Fill Material.

(1) General characteristics of fill material. Fill material will consist of sand with a grain size similar to that of the existing beach. The fill material will consist specifically of fine to medium sand 0.8 mm - 0.73 (composite mean) grain size from Little River Site; 0.45 mm (composite mean) from Cain patch and 0.73 mm (composite mean) from Surfside.

(2) Quantity of material proposed for discharge. Quantities of fill material that would be required for beach restoration and periodic nourishment are discussed in part 1(b)(2) above.

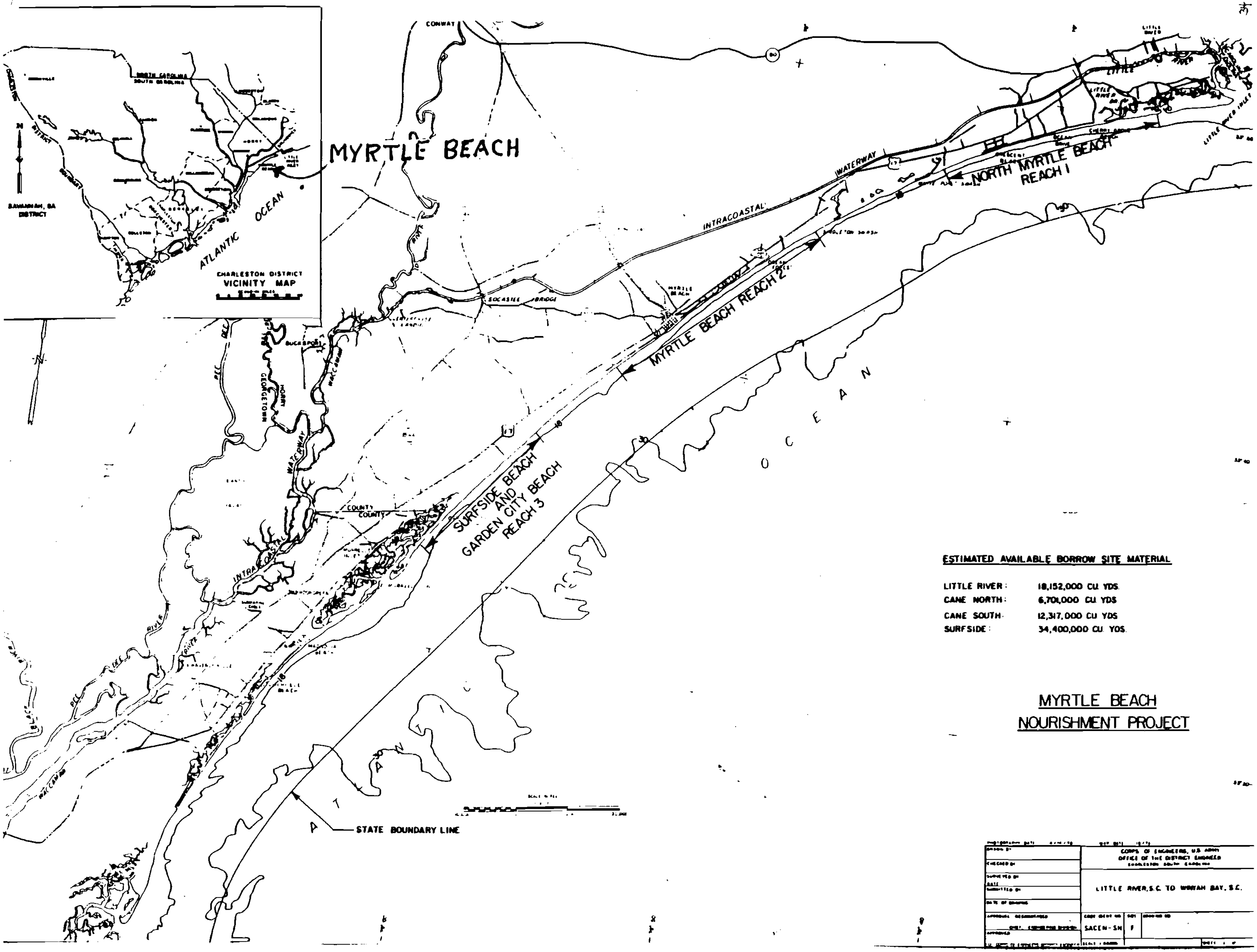
(3) Source of fill material. All beach nourishment material will come from offshore borrow areas. These borrow areas are located from 1.5 to 5 miles offshore from the beaches to be nourished. (An attached map locates the beaches to be nourished).

e. Description of the Proposed Discharge Site.

(1) Location and size. Locations and size of proposed discharge sites are described in part 1(b)(2) above. The exact location and size of periodic nourishment areas cannot be predicted due to varying rates of annual erosion.

(2) Type of site. The storm damage protection sites are all Atlantic Ocean coastal beaches composed of sand, silt, and shell particles which have been eroded by wind, waves, and currents, and by seasonal storms. In general terms, the intertidal portion of beaches in the study area are mildly sloping and of low elevation. This combination results in a relatively wide low tide beach, but often, a minimal to nonexistent high tide beach. In areas of sparse to no development, there generally is an active dune system. In developed areas, the dune system has often been replaced by buildings and hard shore protection structures. This combination generally results in no high tide beach and in some areas minimal to nonexistent low tide beach.

(3) Type of habitat. In general, fill areas contain three basic habitat types. Above the mean high water line (MHWL) there is loose dry sand and/or shore protection structures or development. Between the MHWL and mean low water line (MLWL) are frequently inundated sandy areas with a width dependent upon the eroded bottom slope. Below the MLWL is a sandy bottom shallow water habitat with depths varying according to the rate of erosion in each area. The area below



ESTIMATED AVAILABLE BORROW SITE MATERIAL

LITTLE RIVER:	18,152,000 CU. YDS.
CANE NORTH:	6,701,000 CU. YDS.
CANE SOUTH:	12,317,000 CU. YDS.
SURFSIDE:	34,400,000 CU. YDS.

MYRTLE BEACH NOURISHMENT PROJECT

the MHWL provides habitat for permanent bottom- burrowing filter feeders and permanent and transient benthic invertebrates that prefer shallow to periodically inundated beach areas. Beach areas also provide feeding areas for several species of mammals and shorebirds and may provide nesting habitat for sea turtles once initial construction is completed.

(4) Timing and duration of discharge. The initial beach restoration could potentially begin in the summer of 1995 and will require 2 to 4 years to complete. Periodic nourishment will be required at about 8-year intervals.

f. Description of Borrow Sites. Sand for nourishment of the beaches will come from 4 areas. These areas were identified through a process of vibra core sampling. Two hundred vibra core samples showed the areas to have sufficient sand reserves to initially construct the project and to maintain it over the project life (50 years). Once the sand sources were identified, live bottom habitat surveys were performed within the areas using side scan sonar and television cameras. Live bottom features were located so they could be avoided during borrow operations. The locations of these borrow areas are described below (map attached).

a. Little River - This site is between Cherry Grove Beach and Little River Inlet. The site extends from approximately 1.5 to 4 miles offshore and contains approximately 14 sq. miles of ocean bottom.

b. Cain Patch - These two sites are comprised of old buried channels offshore of Cain Patch Creek and north of Myrtle Beach. These channels are 1.5 miles off the beach and extends out to approximately 4.5 miles off the beach. The total area is approximately 4.5 sq. miles of ocean bottom.

c. Surfside Beach - This site is located from Surfside Beach south to the vicinity of Garden City Beach. The area extends from 2 to 5 miles offshore. This total area is approximately 6.0 sq. miles.

g. Description of Discharge Method. Sand fill material will be hydraulically pumped from offshore to beach areas where it will be moved around by scrapers and bulldozers to provide the necessary protection.

2. FACTUAL DETERMINATIONS

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. Intertidal portions of study area beaches are generally mildly sloping and of low elevation. This combination creates a wide low tide beach and a narrow to nonexistent high tide beach. In areas with limited or

no development, there is generally an active dune system. Along areas that are heavily developed, this dune system has often been replaced with hard shore protection structures.

(2) Sediment Type. Fine to medium sand 0.8 mm - 0.73 (composite mean) grain size from Little River Site; 0.45 mm (composite mean) from Cain patch and 0.73 mm (composite mean) from Surfside.

(3) Fill Material Movement. The sandy fill materials will be eroded away at varying rates and moved varying distances according to the severity of wave and current action and storms. Accurate forecasts of fill material movement are not possible due to unpredictable variations in intensity and frequency of sea and weather conditions.

(4) Physical Effects on Benthos. Benthic animals associated with high energy beaches are continually subjected to effects of erosion and accretion and major physical changes resulting from storms and hurricanes, beach nourishment and renourishment will not unduly stress beach and intertidal animals beyond their adaptive capabilities.

Monitoring studies conducted by Coastal Science and Engineering, for the City of Myrtle Beach permit support this conclusion. After three years of study, it was concluded that "biological effects caused by beach nourishment at Myrtle Beach were minimal. Furthermore, detrimental effects to a few common species which were detected during and immediately after nourishment were short-lived."

b. Water Circulation, Fluctuation, and Salinity Determination.

(1) Water column effects. Depths would be decreased somewhat in beach fill areas. Where water columns would be eliminated by fills, water columns at borrow sites would be increased by approximately 3 feet, the losses would be considered acceptable and desirable to meet the purpose and need for the project.

(2) Current patterns and circulation. No significant effect.

(3) Normal water level fluctuations and salinity gradients. No significant effect. Storm-tide flooding upland of the fill sites is expected to be decreased by the proposed actions.

c. Suspended Particulate/turbidity Determinations.

(1) Expected changes in suspended particulates and turbidity levels in the vicinity of the disposal site. The fill material would be similar to the receiving substrate, therefore, the area's waters would not experience a significant change in the type of suspended particulates. Turbidity levels in waters immediately adjacent to the beach fill areas would be increased slightly by wave wash as newly placed materials are inundated and distributed during each tidal cycle. Turbidity levels may also increase slightly for a short distance offshore of the surf zone. No significant adverse effects would be expected as a result of project induced turbidity increases.

(2) Effects on chemical and physical properties of the water column.

(a) Light penetration. Possible short-term reduction resulting from temporary increase in turbidity caused by filling activities.

(b) Dissolved oxygen. Possible short-term decrease with temporary increase in turbidity. Will return to normal when turbidity dissipates.

(c) Toxic metals, organics, and pathogens. None identified.

(d) Aesthetics. Appearance of water column would be temporarily degraded by turbidity at the restored and periodic nourishment sites.

(3) Effects on Biota.

(a) Primary productivity and photosynthesis. Temporary minor disruption possible with rapid recovery at the fill sites.

(b) Suspension/filter feeders. Minimal temporary disruption at fill sites possible, but with rapid recovery.

(c) Sight feeders. Minimal temporary disruption possible with rapid recovery. Most sight feeders are transient and can relocate until fill operations are complete. Many shore birds will feed on animals deposited by the hydraulic dredge during pumping operations.

d. Contamination Determinations. None identified.

e. Aquatic Ecosystem and Organism Determinations. The subject beaches and their adjacent shallow, sandy bottoms provide habitat for benthic organisms and feeding areas for aquatic animals and birds. These bottom areas support benthic organisms and typical intertidal beach animals, such as sand dollars, sea urchins, scallops, mollusks, crabs, shrimp, wedge shells, polychaete worms, sand bugs, amphipods, and isopods. There are no significant natural resources that would be adversely affected by this project. Sand borrow sites offshore have been surveyed for hard bottom habitat. Hard bottom areas will be avoided during dredging operations.

(1) Threatened and endangered species. Loggerhead Sea Turtles may be affected by this project during their nesting season. Impacts to this threatened species have been coordinated with the U.S. Fish & Wildlife Service. All reasonable and prudent measures necessary to prevent effects to the continued existence of this species will be employed. The presence of a slow moving hopper dredge in this area will pose no threat to migrating whales.

(2) Other Wildlife. No adverse effect.

f. Proposed Disposal Site Determinations.

(1) Mixing zone determination. No contaminants are known to be in the proposed fill material that would violate applicable water quality standards. The fill material is the same composition as the fill area substrate. In view of these conditions, a limited mixing zone in the immediate vicinity of the discharge site is allowed.

(2) Determination of compliance with applicable water quality standards. No conflict with applicable water quality standards for the discharge of fill material would be anticipated. Water quality impacts will be limited to a temporary increase in turbidity and possibly a slight reduction in dissolved oxygen in waters adjacent to the fill site.

(3) Potential effects on human use characteristics.

(a) Municipal and private water supplies. None

(b) Recreational and commercial fisheries. None

(c) Recreation activities. The desirable characteristics would be improved and maintained.

(d) Aesthetics. Improved and maintained.

(e) Coastal Zone Management programs. The proposed action is consistent with the S. C. Coastal Zone Management program.

(f) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. None

g. Determination of Cumulative Effects on the Aquatic Ecosystem. There will be a positive effect on the aquatic ecosystem. As fill materials become stabilized they will provide: additional habitat for important invertebrate species which inhabit the swash zone; additional feeding and resting areas for shorebirds; and more available food for fishes of commercial and recreational importance.

3. FINDINGS OF COMPLIANCE OR NONCOMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States.

c. The discharge of fill materials would not cause or contribute to, after consideration of disposal site dilution and dispersion, violations of any applicable State water quality standards. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The placement of fill material, in accordance with the U.S. Fish & Wildlife Service biological opinion, would not jeopardize the continued existence of any species listed as threatened or endangered or result in the destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

e. The placement of fill materials would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife would not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values would not occur.

4. FINDINGS

I find, based upon the above evaluations and conclusions, that the proposed discharge site for dredged magerial has been specified as complying with the requirements of the Section 404(b)1 Guidelines.

Mark Vincent

MARK E. VINCENT
Lieutenant Colonel, EN
Commanding

Appendix 8

Borrow Area Impact Analysis

Borrow Activity Impact Statement
for the
Myrtle Beach, South Carolina
Shore Protection Project

The project area, often referred to as the Grand Strand, lies on the northeastern Atlantic Ocean coast of South Carolina, or more properly on Long Bay, a concave indentation of the coast. The feasibility study of this project identified numerous potential sources of borrow material, both upland and offshore. After the initially recommended borrow sites along the Atlantic Intracoastal Waterway (AIWW) were no longer viable options, the original shore protection project made use of available offshore borrow sources. This re-nourishment project will focus on the same borrow sites relied upon for the initial project construction. The borrow areas (Little River, Cane South, and Surfside), originally identified and utilized for initial construction from 1997 to 1999, are between 1.52 and 4.98 miles offshore, with the Surfside borrow area being the farthest from land. Figure 1 identifies the borrow areas and the storm damage reduction project boundaries. Increasingly, beach compatible sediment sources are more difficult to locate within State waters and in proximities deemed acceptable for dredging activities. As such, more and more borrow sources are being identified farther offshore on the Federal Outer Continental Shelf (OCS). The resources of the OCS are managed by the U.S. Department of the Interior's Minerals Management Service (MMS). While it has not been determined that this project will require dredging in the OCS, the identified borrow areas do contain portions within the OCS. Therefore, it is necessary to provide documentation that the Federal mineral resources will be managed properly with respect to physical and biological oceanographic processes.

Renourishment of the three reaches (North Myrtle Beach, Myrtle Beach, and Garden City/Surfside) of the Myrtle Beach, South Carolina Shore Protection Project will require placement of approximately 2.9 million cubic yards of beach compatible sand from a total of three offshore borrow areas. This brief report will present background information regarding the identified borrow areas and will provide necessary evidence that the proposed dredging operations within these borrow areas will be carried out in such a way as to be consistent with responsible resource management and with negligible impact to oceanographic processes.

Background Information

The shoreline of the Grand Strand area, from Murrells Inlet in the south to Little River Inlet in the north, exhibits a gentle concave curve from west to east. In general, the intertidal beaches in this area have a relatively low elevation and mild slope, which results in a wide low tide beach and minimal high tide beach. The nearshore and inner shelf areas do not exhibit significant variations in bottom depth on a large-scale. Two exceptions are the Murrells Inlet ebb tide shoal and a shoal offshore of the northeastern edge of the Myrtle Beach fill area. Otherwise, sea floor formations landward of the -12 meter (-39 feet) contour are mostly localized. Seaward of the -12 meter contour, the sea floor features appear as a series of ridges and valleys.

Existing water depths for the proposed borrow areas vary between 29.5 and 39.4 feet below mean high water (MHW), with the Little River borrow area being the deepest. More detailed information is provided later in this section. Figure 1 illustrates the spatial relationship of each borrow area to each other and to the project areas.

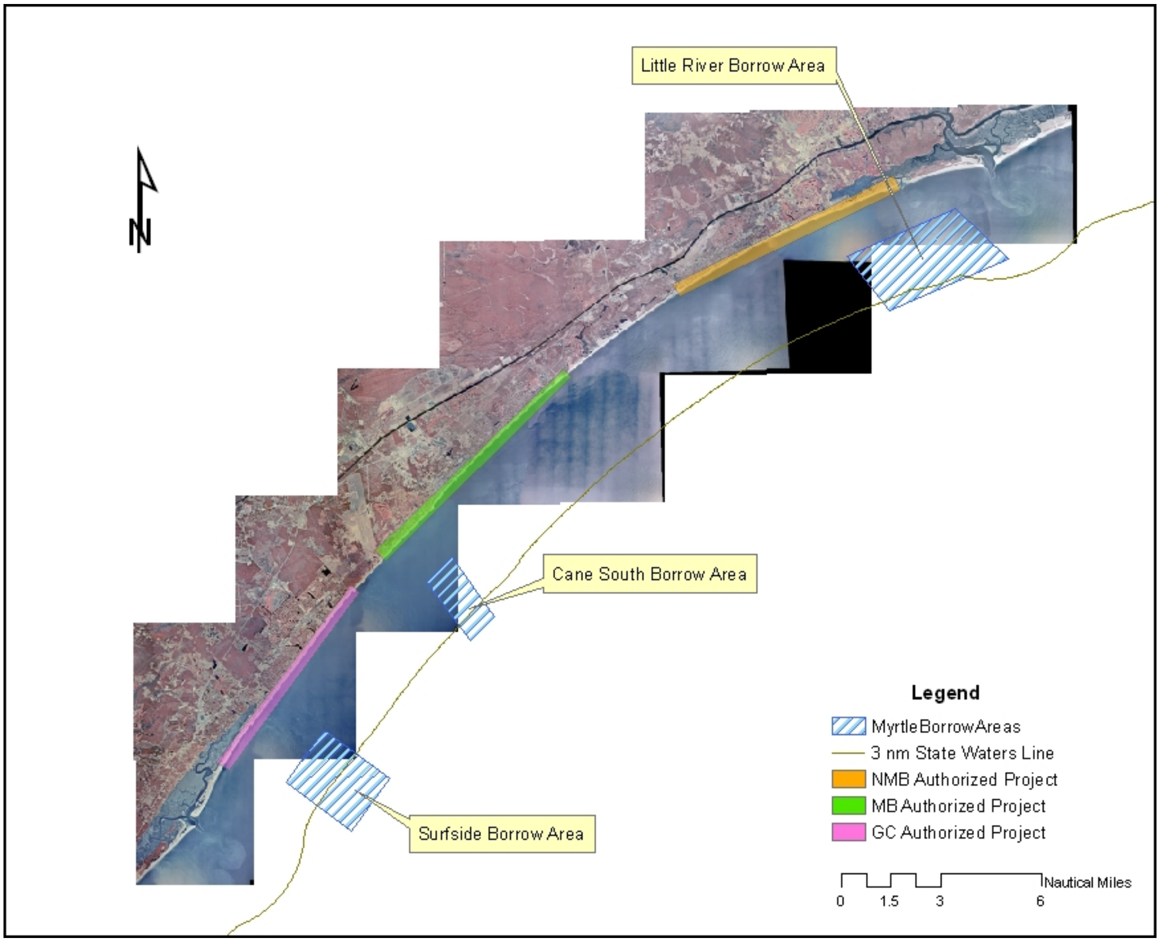


Figure 1: Location map of Myrtle Beach Storm Protection Project areas and associated offshore borrow areas.

Offshore investigations in 1991 concluded that there was sufficient compatible material in the identified borrow areas for the initial nourishment and all subsequent periodic re-nourishments for the 50-year life of the project. Recent borrow site investigations show that the Little River borrow area contains at least 11.2 million cubic yards of quality borrow material, the Cane South area contains at least 10.3 million cubic yards of quality material, and the Surfside area contains at least 15.2 million cubic yards. More material is available if less stringent quality comparison criteria are implemented. The current re-nourishment will require placement of approximately 0.7, 1.4, and 0.8 million cubic yards of beach compatible material, which will come from the Little River, Cane South, and Surfside Borrow areas respectively. Over the next 40 years, starting with this re-nourishment cycle to the end of the 50-year project life in 2047, it is estimated that 2.17, 3.31, and 2.30 million cubic yards will need to be placed on the Grand Strand beaches and come from the Little River, Cane South, and Surfside Borrow areas respectively.

Prior to initial construction in 1997, grab samples of the native beach sediments at eight standard, cross-shore locations along 33 profile lines were taken and compared to the results from a 1991 vibracore analysis for grain size and composition compatibility. It is worth noting that several beach fill projects by the local governments prior to and after Hurricane Hugo had altered the grain size of the native beach. The following paragraph serves as a brief summary of that comparison.

The composite mean grain size of the subaerial beach in North Myrtle Beach was 0.26 mm (1.93 phi) and the composite mean for all samples (subaerial and subaqueous) was 0.24 mm (2.09 phi). Correspondingly, the sediment in the Little River Borrow site was classified as a medium sand in the Unified Soil Classification System and had a composite mean grain size of 0.80 mm (1.16 phi). The differences in grain sizes and sorting between the North Myrtle Beach native material and the Little River Borrow site resulted in an overfill factor of 1.08. Ultimately, this means that, after sorting, approximately 1.08 cubic yards would be required from the borrow source in order to equal 1.0 cubic yards on the beach. In Myrtle Beach, the composite mean grain size of the subaerial beach was 0.44 mm (1.18 phi) and the composite mean for all samples was 0.47 mm (1.09 phi). The Cane South borrow area was also classified as medium sands and had a composite mean grain size of 0.73 mm (1.37 phi). The differences between the Myrtle Beach native material and the Cane South borrow material resulted in an overfill factor of 1.10. The Garden City and Surfside beaches had a subaerial composite mean grain size of 0.44 mm (1.21 phi) and a total composite mean of 0.42 mm (1.25 phi). Medium sand was also found in the Surfside Borrow area was characterized by a composite mean grain size of 0.60 mm (1.20 phi). These differences between the Garden City and Surfside native material and the Surfside Borrow area resulted in an overfill factor of 1.10.

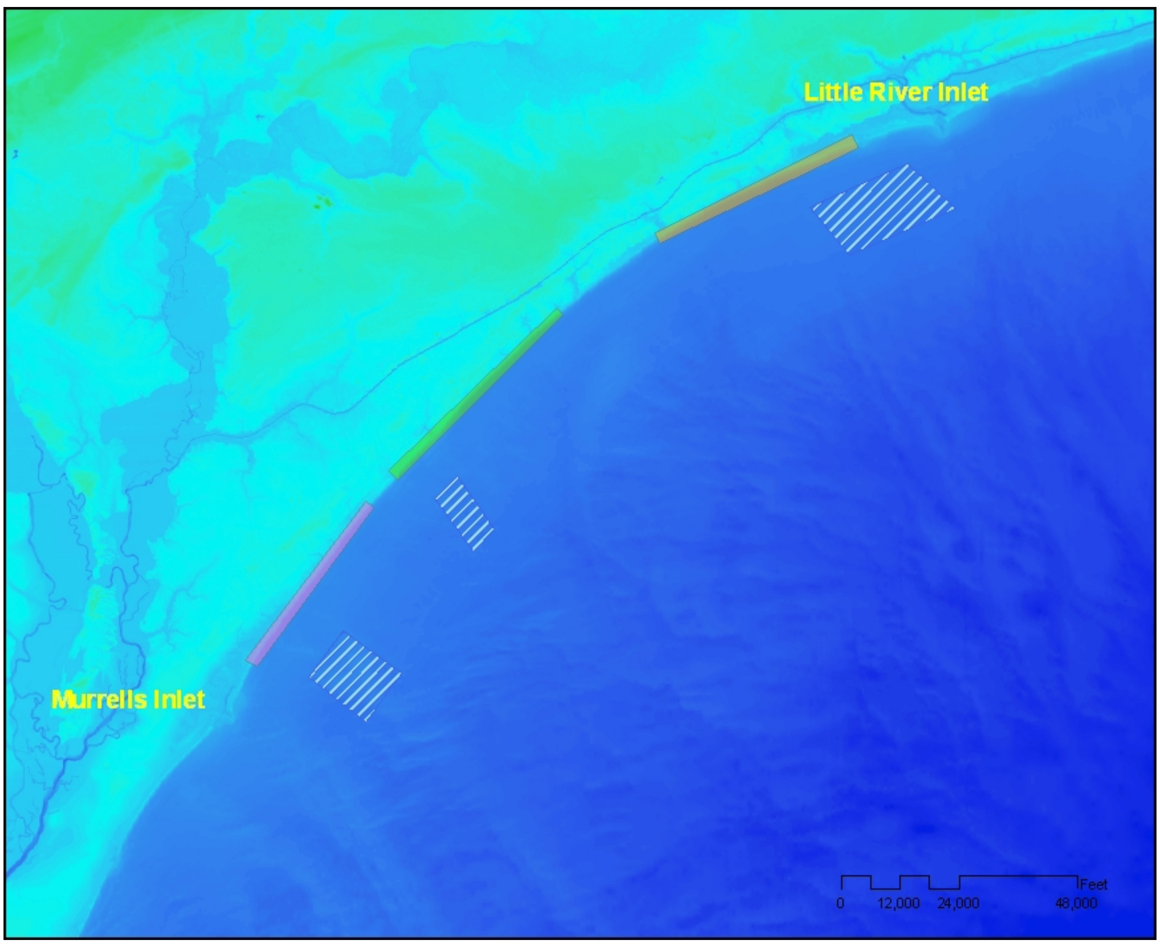


Figure 2: Topographic/Bathymetric Contour Map of the Grand Strand Area.

Prior to finalizing construction plans and specifications for the upcoming renourishment, recently collected vibracore samples are being analyzed to determine the anticipated quantity and configuration of available beach compatible sediment within the borrow areas. Based on preliminary results from this analysis, thicknesses of beach quality sediment vary between 1 and 4 feet in the Little River Borrow area with only 5 percent of the total area having deposits of at least 4 feet in thickness. Similarly, thicknesses of beach quality sand in the Cane South Borrow area range from 1 to 10 feet with approximately 50 percent of the total area having thicknesses of less than 6 feet. Finally, thicknesses of beach quality sand in the Surfside Borrow area vary from 1 to 9 feet and are equal to or less than 6 feet over approximately 50 percent of the total area. These results are consistent with observations during the initial construction activities.

Potential Impact Analysis

Physical Impacts to Hard Bottom Areas. The Grand Strand is not only characterized by idyllic sandy beaches, but also by shoreface, inner shelf, and offshore hard bottom habitat areas. A 4-year study by the Coastal Carolina University Center for Marine and Wetland Studies in association with the South Carolina Department of Natural Resources and the US Army Corps of Engineers concluded that offshore habitats had not been significantly impacted by the initial beach fill. The study found that while some areas of hard bottom experienced deposition and burial, other hard bottom habitats were uncovered due to erosion of their surface sediments. Consequently, the dredging and placement activities were found to have only marginally greater impacts on hard bottom habitat than the system's own natural variability (Ojeda et. al, 2001).

Construction of the re-nourishment project will incorporate several measures to limit the potential for impact to hard bottom habitat within and immediately adjacent to the fill areas and within the borrow areas. For example, a buffer zone of 600 feet has been placed around all hard bottom habitat areas within the borrow areas. In addition, the maximum allowable side slope in the borrow areas has been set at 3H:1V. Given the size of the buffer zone, the relatively shallow nature of the compatible sediment in the borrow areas, the use of a hopper dredge, and the limitation on side slopes, significant precautions have been taken to prevent adverse impacts on hard bottom habitat within the borrow areas. Finally, the dredge pipe will not be allowed to come onshore in the vicinity of shoreface or inner shelf hard bottom habitat.

Impacts to Coastal Processes. The following section will compare and contrast the existing plans for the Myrtle Beach renourishment to scientific findings from recent detailed studies of similar situations. Technologic advancements in numerical modeling of ocean and coastal processes along with increases in computing power and understanding of the effects of dredging operations have produced numerous applicable studies.

Assessing the potential impacts of the Myrtle Beach sand removal activities involved reviewing borrow area impact study reports for seven different states (on the East and Gulf Coasts) and eight different sets of borrow areas. Most of these reports were prepared for and in conjunction with the MMS and generally contained information on 1)the character of the offshore borrow areas; 2)circulation, wave, and sediment transport modeling and/or calculations; 3)potential impacts; and 4)conclusions. Table 1 summarizes the relevant parameters from each of the study reports as well as providing a quick glance at the relevant information for the upcoming Myrtle Beach project.

Though the inclusion of all the parameters in Table 1 was not consistent in each report, enough information was provided in order to draw reasonable comparisons to the Myrtle Beach project.

One of the parameters that would have been beneficial to have more information on is the distance of the borrow areas relative to the adjacent shorelines. The Myrtle Beach borrow areas compare reasonably well with those studies that did provide an offshore distance. The studies in Alabama and North Carolina are the most natural comparisons to Myrtle Beach in this regard. Only one of these eleven sites (S1, Dare County B in North Carolina) received a questionable rating with regard to adverse impacts. That sand resource area, S1 in Dare County, is generally closer to the shoreline than the Myrtle areas and has a deeper average sand layer thickness and much larger dredging needs than any of the Myrtle areas. Therefore, sand resource area S1 would create a much larger and deeper seabed depression closer to the shore than any of the identified Myrtle Beach borrow areas.

The water depth of the three Myrtle Beach areas is also very similar to the other studies in Table 1. Only the five sites in New York/New Jersey are significantly and consistently situated in deeper water. Due to the large fluctuation in surface areas between all the sites listed, it is difficult to qualify the relative importance of this parameter.

The available sand layer thicknesses in the Myrtle Beach borrow areas represent the low end of the spectrum when compared to the other sites. Because of the spatial variability of the beach quality sediment thicknesses in the Myrtle Beach borrow areas, the actual dredged depths, most likely between 3 and 6 feet, are anticipated to be similar to those in the New York/New Jersey study, between 2.3 and 5.9 feet. All five (5) sand resource areas in the New York/New Jersey study were found to be acceptable, low impact borrow scenarios.

The available volume of beach compatible sand in the Myrtle Beach borrow areas, 11.3 to 16.7 million cubic yards, is within the range exhibited in the other studies, 5.2 to 320 million cubic yards ("Sand Volume Est" in Table 1). Like the surface area parameter, the large fluctuation makes it difficult to qualify the importance of this parameter on its own. However, when combined with the surface area, sand layer thickness, and dredging needs, one can gain a more accurate understanding of the degree of borrow area depletion. The anticipated needs of the Myrtle Beach borrow areas over the remainder of the 50-year project life are relatively small when compared to most of the quantities for the other sand resource areas ("Dredging Needs" column in Table 1). In fact, of the fourteen (14) areas with less than 10 million cubic yards of sediment being removed, only one (1) received a questionable rating, area C1 (north) of the Central East Coast of Florida study. The Florida study came to the conclusion that a reduction in the maximum dredging depth would most likely reduce the site impacts. The minimum water depth of sand resource area C1 (north) was 25 ft NGVD, while the maximum dredge depth was 39.5 ft NGVD. This resulted in a maximum change in bed surface of 14.5 feet, significantly larger than any change possible in any of the Myrtle Beach borrow areas. Furthermore, all five (5) areas with less than 5 million cubic yards of sediment being removed were found to be acceptable borrow scenarios.

The mean wave height and period at the Myrtle Beach borrow areas were determined from appropriate Wave Information Study (WIS) hindcast locations and are similar to the other studies referred to in Table 1. The mean wave heights and periods at the Myrtle Beach borrow areas are certainly comparable to those listed for the other studies.

Wave Modeling

Numerical model simulations of wave transformation were required to evaluate changes in the magnitude and spatial variation of wave parameters due to the anticipated dredging activities within the Myrtle Beach borrow areas. The steady-state spectral wave model STWAVE (Smith, Sherlock, and Resio 2001) was applied for wave transformation modeling. STWAVE was forced with directional wave spectra based on typical and storm waves hindcast by the Wave Information Studies (WIS). This section describes the STWAVE wave transformation modeling approach, the model input, and model results.

Bathymetry Grids. Two STWAVE Cartesian grids were generated for this study. The first grid represents the existing condition bathymetry, while the second represents the Myrtle Beach borrow areas at the end of the 50-year project (or with-project condition). The with-project condition grid reflects the removal of 2.72 million cubic yards from the Surfside Borrow area, 4.73 million cubic yards from the Cane South Borrow area, and 6.45 million cubic yards from the Little River Borrow area. Each of these volumes is more than the estimated need for the remaining 40 years of the authorized project life. The removed volumes were determined by removing thicknesses of between 1 and 2 meters of material within sub-areas of each borrow area. The sub-areas were identified during the plans and specifications phase of the 2007 renourishment effort. Dredging in these areas are the only differences between the existing condition and with-project STWAVE grids.

The grid origin is x = 740543.56 m and y = 3733459.50 m in UTM NAD83 Zone 17, and the grid orientation is 131.93 deg (which is the orientation of the grid x-axis measured counter-clockwise from East). The grid domain is 40.7 km (cross shore, 407 cells) by 66.5 km (alongshore, 665 cells) with a resolution of 100 m. The offshore boundary of the grids is located in depths between 15 and 20 meters. Figure 3 shows the STWAVE grid and identifies the location of all three Myrtle Beach borrow areas.

Input Wave Conditions. Instead of selecting discrete time periods for wave simulation, this study used a 20-year hindcast record to develop a binned approach based on joint probability of wave direction, period and height. The offshore wave information for these simulations were hindcast by the Wave Information Studies (WIS) using the wave generation and propagation model WISWAVE (Hubertz 1992).

Wave conditions were taken from the latest WIS hindcast (1980-1999) at Station 325 (http://frf.usace.army.mil/cgi-bin/wis/atl/atl_main.html). WIS Station 325 is located at 33.49 deg North, 78.66 deg West in a water depth of 16 m, which is approximately on the offshore boundary of the STWAVE grids.

Table 1: Summary of previous borrow source impact analyses.

Study	Sand Resource Area	Distance Offshore (miles)	Water Depth (feet)	Surface Area (sq. mi.)	Sand Layer Thickness (feet)	Sand Volume Est (cu. yd)	Dredging Depth for Modeling (ft)	Dredging Needs (cu. yd)	Mean Wave Height (ft)	Mean Wave Period (sec)	Dominant Wave Direction	Modeling Conclusion
Alabama	1	3.4 - 7.5	28 - 48	16.0	3 - 14	170,000,000	9.8	7,590,000	-	-	150 - 175	Acceptable
	2	3.4 - 9.6	33 - 60	28.5	6.5	248,500,000	9.8	2,220,000	-	-	150 - 175	Acceptable
	3	3.1 - 7.5	28 - 60	26.0	12 - 15	320,500,000	13.1	6,150,000	-	-	150 - 175	Acceptable
	4	5.3 - 9.9	39 - 53	30	10	15,700,000	9.8	10,990,000	-	-	125 - 150	Acceptable
North Carolina	1	> 3	32 - 66	0.93	9.8	173,500,000	9.8	9,400,000	4.92	8.3	E-NE	Acceptable
Dare County A	2	> 3	32 - 66	0.75	9.8	44,900,000	9.8	7,590,000	4.92	8.3	E-NE	Acceptable
	3 (west)	> 3	32 - 66	0.32	9.8	64,700,000	6.6	3,270,000	4.92	8.3	E-NE	Acceptable
	3 (east)	> 3	32 - 66	0.27	6.6	64,700,000	9.8	1,800,000	4.92	8.3	E-NE	Acceptable
	4	> 3	32 - 66	0.45	6.6	23,200,000	6.6	3,000,000	4.92	8.3	E-NE	Acceptable
Dare County B	N1	0.5 - 2.0	35 - 45		8 - 10	5,192,000	8 - 10	4,300,000	-	-	E-NE	Acceptable
	S1	1.0 - 3.0	35 - 45		8 - 10	104,454,000	8 - 10	70,280,000	-	-	E-NE	Questionable
New Jersey	A-1	-	-	0.85	6.5 - 19	-	13.1	11,500,000	3.94	7.7	E-NE	Acceptable
	A-2	-	-	1.0	6.5 - 19	-	9.8	10,200,000	3.94	7.7	E-NE	Acceptable
	M8	-	-	1.5	6.5 - 19	-	6.5	10,500,000	3.94	7.7	E-NE	Acceptable
Virginia, SE	A	-	26 - 42	0.69	19.7	-	9.8	6,930,000	3.94	8.7	E-NE	Acceptable
	B	-	26 - 42	0.89	19.7	-	9.8	9,020,000	3.94	8.7	E-NE	Acceptable
Florida Cape Canaveral	2	9.3 - 12.4	23 - 46	1.9	10 - 16	-	17.1	34,000,000	4.27	9.3	E-NE	N/A
Florida	A1	7.5 - 9.3	26 - 46	2.1	10 - 14	-	-	17,800,000	4.27	9.3	E-NE	Questionable
Central East Coast	B1	7.5 - 9.3	26 - 46	1.8	6 - 8	-	-	14,400,000	4.27	9.3	60 - 90 deg	Acceptable
	B2	7.5 - 9.3	26 - 46	1.3	6 - 8	-	-	9,940,000	4.27	9.3	60 - 90 deg	Acceptable
	C1 (north)	7.5 - 9.3	26 - 46	2.0	10 - 22	-	-	7,590,000	3.94	9.1	30 - 60 deg	Questionable
	C1 (south)	7.5 - 9.3	26 - 46	1.8	6.6	-	-	11,500,000	3.94	9.1	30 - 60 deg	Questionable
	D2	7.5 - 9.3	26 - 46	0.87	-	-	-	5,360,000	3.61	8.8	30 - 60 deg	Acceptable
New York/New Jersey	H1	-	46 - 66	1.3	6.5 - 16.4	6,300,000	4.9	-	3.1	4.2	S	Acceptable
	H2	-	49 - 66	5.1	6.5 - 16.4	12,400,000	2.3	-	3.1	4.2	S	Acceptable
	3	-	62	3.6	5.9 - 10.5	14,700,000	3.9	-	3.2	4.3	S	Acceptable
	4W	-	52 - 66	4.7	5.9 - 10.5	25,900,000	5.2	-	3.2	4.3	S	Acceptable
	4E	-	52 - 66	3.6	6.2 - 15.1	21,800,000	5.9	-	3.2	4.3	S	Acceptable
South Carolina	Little River	1.5 - 3.9	32 - 39	10.4	2 - 4	11,800,000	≈3	2,170,000	3.08	5.25	SE	Acceptable
Myrtle Beach	Cane South	1.7 - 4.2	30 - 39	3.0	1 - 10	11,300,000	≈6	3,310,000	3.44	5.75	ESE	Acceptable
	Surfside	2.2 - 5.0	29 - 39	6.3	1 - 9	16,700,000	≈6	2,300,000	3.44	5.75	ESE	Acceptable

Table 2 below reports the percentages of the wave hindcast record at Station 325 which fall into the categories created by the corresponding rows and columns. The left-hand column lists the wave direction, as reported in meteorological convention with waves from the north at 0 deg and waves from the east at 90 deg. The subsequent column headings indicate the wave period (in seconds) and the cells below provide the percentage of the hindcast record that meet those criteria.

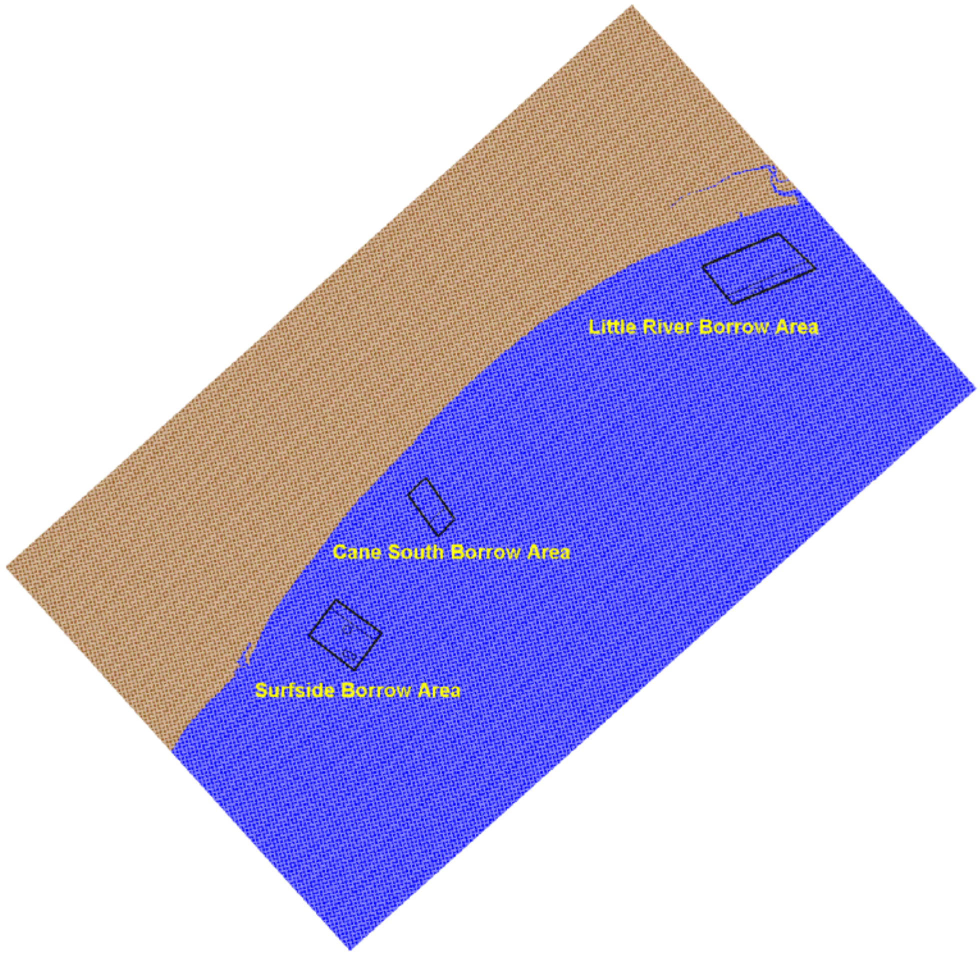


Figure 3: STWAVE Model grid overlaid with Myrtle Beach borrow areas.

For example, the dominant wave direction band, from 112.5 to 120.0 degrees, represents 12.89% of the total number of wave conditions within the 20-year hindcast record. Within the dominant wave direction band, 7.09% of the total number of wave conditions within the 20-year hindcast record have a period between 6 and 8 seconds. Similar tables were also produced for a selection of wave height intervals. Tables A2 through A10 in Appendix A give the percentages based on wave heights between 0 and 20 meters. These tables show that 94.6% of the 20-year hindcast record is characterized by waves between 0.0 and 2.0 meters.

The joint probability analysis was part of the information used to select the most appropriate wave conditions for input into wave transformation modeling. Ultimately, 18 wave direction bins were combined with 6 wave period bins and 7 wave height bins to create 489 height/period/direction combinations for wave transformation modeling. Table A1 in Appendix A summarizes the selected wave height/period/direction bands.

Input wave spectra are required to drive STWAVE on the offshore grid boundary. Parametric spectral shapes were used to generate the input spectra from the offshore wave parameters. The wave energy is distributed in frequency using the TMA spectral shape with a spectral peakedness parameter of 3.3 to 7 (Bouws et al. 1984) and in direction using a $\cos^{nn}(\alpha-\alpha_m)$ distribution, where α_m is the mean wave direction, with *nn* of 4 to 26. The input spectra have 30 frequencies, starting with 0.04 Hz and incrementing by 0.01 Hz. The directional resolution for all simulations is 5 deg.

Table 2: Probability table for all waves in 20-year hindcast record for WIS Station 325.

SUMMARY TABLE FOR ALL WAVES IN RECORD

ALL EVENTS: 20.00 years of data between: 01/01/1980 and 12/31/1999
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	3.21	0.01	--	--	--	--	--	--	--	3.22
30.0 - 45.0:	--	3.51	0.04	--	--	--	--	--	--	--	3.55
45.0 - 60.0:	--	4.00	0.03	--	--	--	--	--	--	--	4.03
60.0 - 75.0:	--	3.69	0.02	--	--	--	--	--	--	--	3.70
75.0 - 90.0:	--	2.75	0.30	0.12	0.00	0.00	--	--	--	--	3.18
90.0 - 97.5:	--	1.89	0.56	0.41	0.13	0.22	0.07	0.01	--	--	3.29
97.5 - 105.0:	--	1.86	0.77	0.23	0.02	0.02	0.00	0.00	--	--	2.90
105.0 - 112.5:	--	1.50	1.19	0.56	0.14	0.09	0.04	0.02	0.01	--	3.56
112.5 - 120.0:	--	2.53	7.09	2.80	0.35	0.09	0.03	0.01	--	--	12.89
120.0 - 127.5:	--	2.43	3.91	0.80	0.21	0.30	0.09	0.01	--	--	7.74
127.5 - 135.0:	--	2.01	2.17	0.69	0.21	0.12	0.11	0.04	0.01	--	5.34
135.0 - 142.5:	--	1.44	1.10	0.36	0.17	0.17	0.13	0.06	0.00	--	3.43
142.5 - 150.0:	--	1.18	0.73	0.31	0.08	0.05	0.01	--	--	--	2.37
150.0 - 157.5:	--	1.26	0.77	0.33	0.08	0.02	0.00	--	--	--	2.45
157.5 - 165.0:	--	1.44	0.70	0.29	0.03	0.00	--	--	--	--	2.47
165.0 - 172.5:	--	1.71	0.66	0.21	0.05	0.01	0.00	--	--	--	2.64
172.5 - 180.0:	--	1.82	0.71	0.24	0.13	0.00	--	--	--	--	2.90
180.0 - 187.5:	--	1.65	0.40	0.06	0.01	0.00	--	--	--	--	2.13
187.5 - 202.5:	--	3.19	0.50	0.09	0.01	0.00	--	--	--	--	3.79
202.5 - 217.5:	--	3.33	0.43	0.04	0.00	--	--	--	--	--	3.80
217.5 - 232.5:	--	2.76	0.22	0.02	--	--	--	--	--	--	3.01
232.5 - 247.5:	--	2.22	0.08	0.00	--	--	--	--	--	--	2.30
247.5 - 262.5:	--	1.63	0.02	0.00	--	--	--	--	--	--	1.65
262.5 - 277.5:	--	1.76	0.01	0.00	--	--	--	--	--	--	1.77
277.5 - 292.5:	--	1.53	0.01	0.00	--	--	--	--	--	--	1.54
292.5 - 307.5:	--	1.49	0.01	0.00	--	--	--	--	--	--	1.50
307.5 - 322.5:	--	1.50	0.00	0.00	--	--	--	--	--	--	1.50
322.5 - 337.5:	--	1.75	0.00	--	--	--	--	--	--	--	1.75
TOTAL:	--	66.63	22.46	7.57	1.62	1.08	0.49	0.14	0.02	--	100

Wave Modeling Results. Wave transformation results are computed and reported at every ocean grid cell within the STWAVE model domain. While such results are beneficial on a more global scale, capturing the results (wave height, direction and period) at discrete locations is more beneficial for visualizing impacts from specific features. Therefore, in addition to the full domain results, the STWAVE output was captured at multiple points immediately seaward of all three project reaches. These observation points are shown on the STWAVE grid in Figure 4 below. The model results at these observation points were recorded for both the existing and with-project conditions and were then compared to determine what degree of influence the dredging activities within the borrow areas might have on the nearshore wave climate. The existing condition wave heights and directions were subtracted from the with-project heights and directions so that increases in wave heights would result in positive numbers and decreases would result in negative numbers.

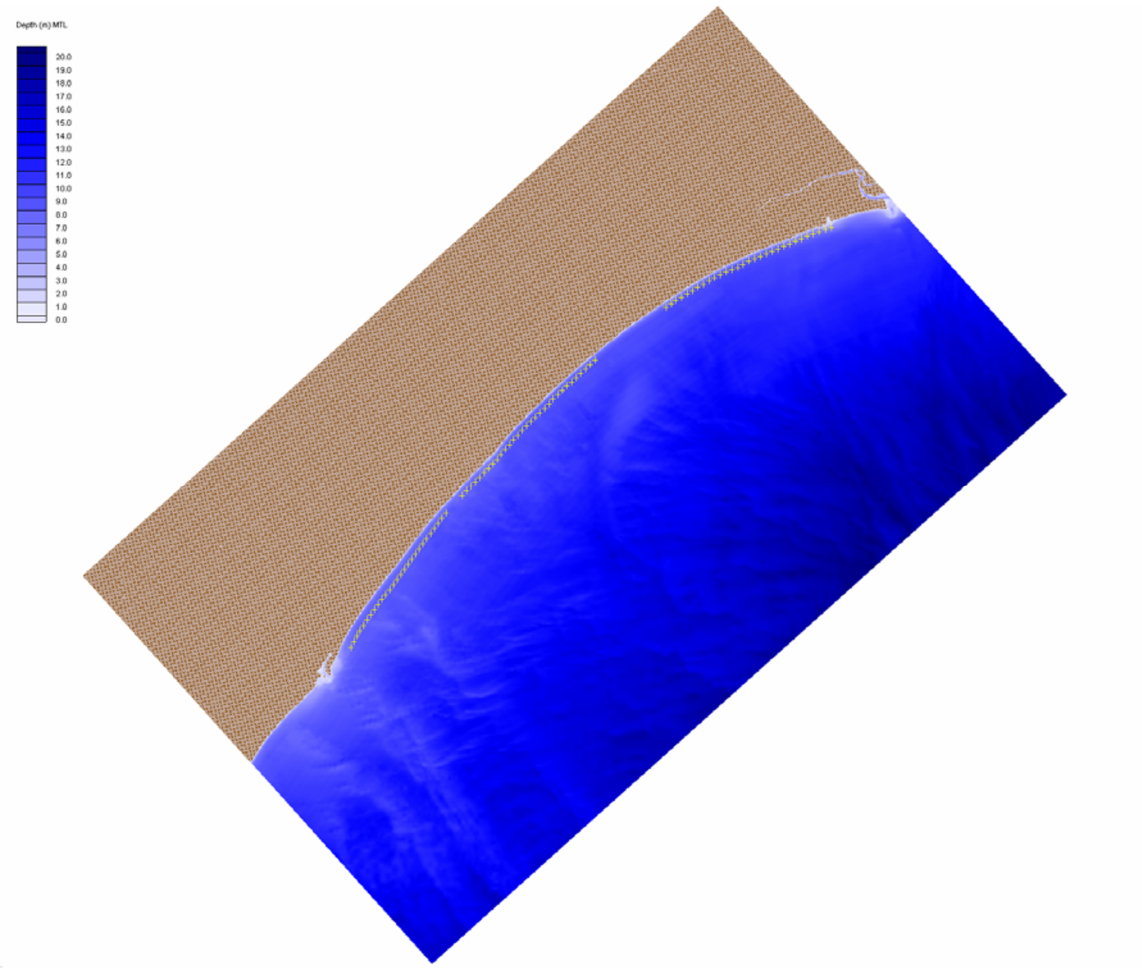


Figure 4: STWAVE grid showing depth (in meters) relative to MTL and observation points for all three nourishment project reaches.

All 489 wave direction/period/height conditions from the WIS hindcast analysis were included in the impact analysis. The mean, maximum, and minimum wave height and direction changes were calculated for each observation point and are plotted in Figures A1-A3 in Appendix A. The observation points for all three reaches exhibit the same trends. The mean wave height differences are all virtually null, as are the mean, maximum, and minimum differences in wave direction. In addition, in the instances where the maximum and minimum wave height differences are distinguishable from the mean, the magnitude of the largest reduction in wave height (minimum) is slightly greater than the largest increase in wave height (maximum). In these same instances, the maximum wave height increases can generally be quantified as +0.1 meters (approx. 4 inches).

Some of the more significant modeled wave conditions were selected to have their full-domain wave height difference contours plotted. These color contour plots of changes in wave heights are presented in Figures A4-A13 in Appendix A, where white signifies no change in wave height, yellows and reds signify increases in wave heights and blues signify decreases in wave heights. Figures A4 and A5 provide the wave height change contours for the most common wave condition in the hindcast record (Dir = 112.5-120.0 degrees [ESE to SE by E], T = 6.0-8.0 sec, H = 0.50-1.00 meters) for the Surfside/Cane South and Little River borrow areas respectively. The wave height difference contours in Figures A6-A13 are the results of waves from the SE with varying periods and heights. Easily discernable changes in wave heights are not present until Figures A10-A13 where the wave periods increase to between 12 and 16 seconds and the wave heights increase to between 3 and 4 meters. Even under these extreme wave conditions, the wave height differences never approach severe magnitudes. In fact, by the time the waves reach the nearshore, the change magnitudes (positive or negative) have dampened to the results seen in Figures A1-A3.

Conclusions

After reviewing a significant number of scientific reports on the potential impacts of offshore sand removal, it is clear that the dredging scenarios in the Myrtle Beach borrow areas (Little River, Cane South, and Surfside) are well within reasonable and prudent parameters for dredging activities. All the significant physical qualities of the Myrtle borrow areas are within the ranges of those study areas which were found to exhibit acceptable sand removal plans. The fact that these same borrow sites were used for the initial construction lends additional support to the finding of no significant impact. The initial construction used more material out of the borrow areas than will be needed during multiple re-nourishments and there has been no evidence of significant adverse impact since completion in 1999.

By including all 489 wave conditions in the wave transformation analysis, equal weight was given to the most severe and least likely scenarios as the milder and more likely scenarios. For example a 4 meter high wave with a period of 12 seconds from the ESE at the offshore boundary, which only occurs 2 times in the hindcast record, was (because of the simplistic analysis) given the same weight as a 0.5 meter high wave with a period of 6 seconds from the ESE, which occurs 7,733 times in the hindcast record. A more sophisticated examination and analytical method could be implemented based on percent chance of occurrence or duration of occurrence, but was not warranted due to the minor wave height and direction differences from the model results.

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APPENDIX A: Tables and Figures

Table A1: Modeled wave condition bin definitions.

Bin	Direction (degrees)	Period (sec)	Height (m)
1	60.0 – 75.0	3.0 – 6.0	0.00 – 0.50
2	75.0 – 90.0	6.0 – 8.0	0.50 – 1.00
3	90.0 – 97.5	8.0 – 10.0	1.00 – 1.50
4	97.5 – 105.0	10.0 – 12.0	1.50 – 2.00
5	105.0 – 112.5	12.0 – 14.0	2.00 – 2.50
6	112.5 – 120.0	14.0 – 16.0	2.50 – 3.00
7	120.0 – 127.5		3.00 – 4.00
8	127.5 – 135.0		
9	135.0 – 142.5		
10	142.5 – 150.0		
11	150.0 – 157.5		
12	157.5 – 165.0		
13	165.0 – 172.5		
14	172.5 – 180.0		
15	180.0 – 187.5		
16	187.5 – 202.5		
17	202.5 – 217.5		
18	217.5 – 232.5		

Table A2: Wave probability table for heights between 0.0 and 0.5 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 0.00 - 0.50: 21715 of 175314 EVENTS (12.39 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	1.52	--	--	--	--	--	--	--	--	1.52
30.0 - 45.0:	--	2.11	--	--	--	--	--	--	--	--	2.11
45.0 - 60.0:	--	2.03	--	--	--	--	--	--	--	--	2.03
60.0 - 75.0:	--	3.24	0.01	--	--	--	--	--	--	--	3.25
75.0 - 90.0:	--	2.94	0.24	0.17	0.03	--	--	--	--	--	3.38
90.0 - 97.5:	--	1.21	0.46	1.34	0.76	0.62	0.28	0.02	--	--	4.69
97.5 - 105.0:	--	0.88	0.58	0.51	0.06	0.02	--	--	--	--	2.05
105.0 - 112.5:	--	0.64	1.44	1.20	0.3	0.10	--	--	--	--	3.68
112.5 - 120.0:	--	2.62	16.23	6.87	0.64	0.06	--	--	--	--	26.42
120.0 - 127.5:	--	2.48	8.38	0.95	0.16	0.02	--	--	--	--	11.99
127.5 - 135.0:	--	2.57	6.84	1.59	0.17	0.01	--	0.01	0.02	--	11.22
135.0 - 142.5:	--	0.93	2.11	0.47	0.02	--	0.02	0.05	--	--	3.6
142.5 - 150.0:	--	0.66	0.62	0.10	--	--	--	--	--	--	1.39
150.0 - 157.5:	--	0.61	0.82	0.16	--	--	--	--	--	--	1.59
157.5 - 165.0:	--	0.70	0.23	0.04	--	--	--	--	--	--	0.98
165.0 - 172.5:	--	1.10	0.11	0.04	--	--	--	--	--	--	1.25
172.5 - 180.0:	--	2.14	0.46	0.06	--	--	--	--	--	--	2.65
180.0 - 187.5:	--	1.56	0.23	--	--	--	--	--	--	--	1.79
187.5 - 202.5:	--	3.40	0.12	--	--	--	--	--	--	--	3.53
202.5 - 217.5:	--	3.18	--	--	--	--	--	--	--	--	3.18
217.5 - 232.5:	--	1.17	--	--	--	--	--	--	--	--	1.17
232.5 - 247.5:	--	0.83	--	--	--	--	--	--	--	--	0.83
247.5 - 262.5:	--	0.51	--	--	--	--	--	--	--	--	0.51
262.5 - 277.5:	--	0.48	--	--	--	--	--	--	--	--	0.48
277.5 - 292.5:	--	0.53	--	--	--	--	--	--	--	--	0.53
292.5 - 307.5:	--	0.63	--	--	--	--	--	--	--	--	0.63
307.5 - 322.5:	--	0.50	--	--	--	--	--	--	--	--	0.50
322.5 - 337.5:	--	0.70	--	--	--	--	--	--	--	--	0.70
TOTAL:	--	44.24	38.88	13.51	2.14	0.83	0.29	0.08	0.02	--	100

Table A3: Wave probability table for heights between 0.5 and 1.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 0.50 - 1.00: 80123 of 175314 EVENTS (45.70 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	2.96	--	--	--	--	--	--	--	--	2.96
30.0 - 45.0:	--	2.95	--	--	--	--	--	--	--	--	2.95
45.0 - 60.0:	--	2.63	--	--	--	--	--	--	--	--	2.63
60.0 - 75.0:	--	2.02	--	--	--	--	--	--	--	--	2.02
75.0 - 90.0:	--	2.40	0.04	--	--	--	--	--	--	--	2.44
90.0 - 97.5:	--	2.72	0.54	0.25	0.07	0.23	0.07	0.01	--	--	3.89
97.5 - 105.0:	--	2.66	0.61	0.18	0.02	0.02	--	--	--	--	3.49
105.0 - 112.5:	--	2.06	1.15	0.50	0.12	0.06	0.01	0.01	0.01	--	3.93
112.5 - 120.0:	--	3.89	9.65	2.50	0.25	0.01	0.01	0.00	--	--	16.32
120.0 - 127.5:	--	3.81	4.57	0.54	0.17	0.13	0.02	--	--	--	9.25
127.5 - 135.0:	--	2.78	1.78	0.47	0.20	0.07	0.02	0.00	0.01	--	5.34
135.0 - 142.5:	--	1.88	0.69	0.13	0.10	0.04	0.05	0.01	--	--	2.90
142.5 - 150.0:	--	1.53	0.37	0.03	0.00	0.00	--	--	--	--	1.94
150.0 - 157.5:	--	1.57	0.34	0.07	0.00	0.00	--	--	--	--	1.98
157.5 - 165.0:	--	1.64	0.26	0.06	--	--	--	--	--	--	1.96
165.0 - 172.5:	--	2.16	0.37	0.04	0.00	--	--	--	--	--	2.57
172.5 - 180.0:	--	2.21	0.42	0.07	0.00	--	--	--	--	--	2.71
180.0 - 187.5:	--	2.07	0.17	0.01	--	--	--	--	--	--	2.26
187.5 - 202.5:	--	3.77	0.03	0.00	--	--	--	--	--	--	3.80
202.5 - 217.5:	--	3.89	--	--	--	--	--	--	--	--	3.89
217.5 - 232.5:	--	3.17	--	--	--	--	--	--	--	--	3.17
232.5 - 247.5:	--	3.04	--	--	--	--	--	--	--	--	3.04
247.5 - 262.5:	--	1.75	--	--	--	--	--	--	--	--	1.75
262.5 - 277.5:	--	1.71	--	--	--	--	--	--	--	--	1.71
277.5 - 292.5:	--	1.50	--	--	--	--	--	--	--	--	1.50
292.5 - 307.5:	--	1.42	--	--	--	--	--	--	--	--	1.42
307.5 - 322.5:	--	1.33	--	--	--	--	--	--	--	--	1.33
322.5 - 337.5:	--	1.63	--	--	--	--	--	--	--	--	1.63
TOTAL:	--	72.38	21	4.86	0.95	0.56	0.19	0.04	0.01	--	100

Table A4: Wave probability table for heights between 1.0 and 1.5 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 1.00 - 1.50: 47118 of 175314 EVENTS (26.88 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	4.51	--	--	--	--	--	--	--	--	4.51
30.0 - 45.0:	--	3.01	--	--	--	--	--	--	--	--	3.01
45.0 - 60.0:	--	5.21	--	--	--	--	--	--	--	--	5.21
60.0 - 75.0:	--	6.52	0.00	--	--	--	--	--	--	--	6.52
75.0 - 90.0:	--	3.93	0.06	0.01	--	0.01	--	--	--	--	4.01
90.0 - 97.5:	--	1.63	0.37	0.01	0.02	0.11	0.02	0.00	--	--	2.17
97.5 - 105.0:	--	1.87	1.14	0.12	0.01	0.02	0.01	0.00	--	--	3.18
105.0 - 112.5:	--	1.63	1.05	0.35	0.14	0.14	0.06	0.01	0.01	--	3.40
112.5 - 120.0:	--	1.43	1.74	2.15	0.46	0.19	0.04	0.02	--	--	6.03
120.0 - 127.5:	--	1.19	2.00	0.87	0.26	0.34	0.06	--	--	--	4.72
127.5 - 135.0:	--	1.33	1.08	0.37	0.18	0.07	0.19	0.03	0.00	--	3.24
135.0 - 142.5:	--	1.48	0.95	0.31	0.23	0.19	0.09	0.01	0.01	--	3.26
142.5 - 150.0:	--	1.32	0.80	0.24	0.06	0.02	--	--	--	--	2.43
150.0 - 157.5:	--	1.45	0.73	0.26	0.03	--	--	--	--	--	2.47
157.5 - 165.0:	--	1.94	0.87	0.22	0.01	--	--	--	--	--	3.04
165.0 - 172.5:	--	1.76	0.91	0.25	0.01	--	--	--	--	--	2.94
172.5 - 180.0:	--	1.66	0.71	0.31	0.14	--	--	--	--	--	2.82
180.0 - 187.5:	--	1.48	0.21	0.01	--	--	--	--	--	--	1.71
187.5 - 202.5:	--	3.11	0.05	--	--	--	--	--	--	--	3.16
202.5 - 217.5:	--	3.43	0.02	--	--	--	--	--	--	--	3.45
217.5 - 232.5:	--	3.49	0.01	--	--	--	--	--	--	--	3.50
232.5 - 247.5:	--	2.13	0.01	--	--	--	--	--	--	--	2.14
247.5 - 262.5:	--	2.07	0.00	--	--	--	--	--	--	--	2.08
262.5 - 277.5:	--	2.42	--	--	--	--	--	--	--	--	2.42
277.5 - 292.5:	--	2.14	--	--	--	--	--	--	--	--	2.14
292.5 - 307.5:	--	2.28	--	--	--	--	--	--	--	--	2.28
307.5 - 322.5:	--	2.55	--	--	--	--	--	--	--	--	2.55
322.5 - 337.5:	--	2.89	--	--	--	--	--	--	--	--	2.89
TOTAL:	--	78.59	12.71	5.49	1.54	1.10	0.48	0.08	0.02	--	100

Table A5: Wave probability table for heights between 1.5 and 2.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 1.50 - 2.00: 16826 of 175314 EVENTS (9.60 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	3.82	--	--	--	--	--	--	--	--	3.82
30.0 - 45.0:	--	8.90	--	--	--	--	--	--	--	--	8.90
45.0 - 60.0:	--	9.84	--	--	--	--	--	--	--	--	9.84
60.0 - 75.0:	--	5.30	0.02	--	--	--	--	--	--	--	5.32
75.0 - 90.0:	--	2.19	0.73	0.03	--	--	--	--	--	--	2.95
90.0 - 97.5:	--	0.56	0.56	0.04	0.01	0.03	--	--	--	--	1.20
97.5 - 105.0:	--	0.34	0.54	0.04	--	0.01	--	--	--	--	0.93
105.0 - 112.5:	--	0.42	1.64	0.51	0.11	0.12	0.18	0.12	0.04	--	3.14
112.5 - 120.0:	--	0.46	1.62	1.58	0.18	0.12	0.08	--	--	--	4.04
120.0 - 127.5:	--	0.58	1.97	1.31	0.26	0.80	0.30	--	--	--	5.21
127.5 - 135.0:	--	0.62	1.43	0.59	0.11	0.12	0.20	0.12	--	--	3.20
135.0 - 142.5:	--	0.67	1.72	0.41	0.15	0.41	0.18	0.05	--	--	3.59
142.5 - 150.0:	--	0.49	1.60	0.66	0.11	0.07	--	--	--	--	2.94
150.0 - 157.5:	--	0.78	1.97	0.77	0.17	--	--	--	--	--	3.68
157.5 - 165.0:	--	0.82	1.88	0.68	0.04	--	--	--	--	--	3.42
165.0 - 172.5:	--	1.12	1.32	0.43	0.11	0.01	--	--	--	--	2.98
172.5 - 180.0:	--	0.99	1.16	0.57	0.36	--	--	--	--	--	3.08
180.0 - 187.5:	--	1.14	0.93	0.05	0.01	--	--	--	--	--	2.13
187.5 - 202.5:	--	2.12	1.90	0.03	--	--	--	--	--	--	4.05
202.5 - 217.5:	--	2.45	2.12	0.01	--	--	--	--	--	--	4.57
217.5 - 232.5:	--	2.38	1.11	--	--	--	--	--	--	--	3.49
232.5 - 247.5:	--	1.45	0.43	--	--	--	--	--	--	--	1.88
247.5 - 262.5:	--	1.93	0.13	--	--	--	--	--	--	--	2.06
262.5 - 277.5:	--	2.40	0.09	--	--	--	--	--	--	--	2.49
277.5 - 292.5:	--	1.80	0.07	--	--	--	--	--	--	--	1.87
292.5 - 307.5:	--	1.30	0.02	--	--	--	--	--	--	--	1.31
307.5 - 322.5:	--	1.28	0.01	--	--	--	--	--	--	--	1.29
322.5 - 337.5:	--	1.21	0.02	--	--	--	--	--	--	--	1.23
TOTAL:	--	62.73	25.01	7.69	1.60	1.69	0.94	0.30	0.04	--	100

Table A6: Wave probability table for heights between 2.0 and 2.5 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 2.00 - 2.50: 5978 of 175314 EVENTS (3.41 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	2.43	--	--	--	--	--	--	--	--	2.43
30.0 - 45.0:	--	6.86	0.08	--	--	--	--	--	--	--	6.94
45.0 - 60.0:	--	5.60	0.15	--	--	--	--	--	--	--	5.75
60.0 - 75.0:	--	2.93	0.30	--	--	--	--	--	--	--	3.23
75.0 - 90.0:	--	0.80	3.55	0.79	--	--	--	--	--	--	5.14
90.0 - 97.5:	--	0.03	2.17	0.74	--	--	0.03	--	--	--	2.98
97.5 - 105.0:	--	--	1.35	0.32	--	--	--	--	--	--	1.67
105.0 - 112.5:	--	--	1.05	0.28	0.03	0.03	0.08	--	--	--	1.49
112.5 - 120.0:	--	--	1.30	1.14	0.33	0.13	--	--	--	--	2.91
120.0 - 127.5:	--	--	1.72	0.95	0.08	0.77	0.65	--	--	--	4.18
127.5 - 135.0:	--	0.02	2.06	1.81	0.27	0.82	0.12	0.12	--	--	5.20
135.0 - 142.5:	--	0.03	2.49	1.25	0.37	0.59	0.72	0.38	--	--	5.84
142.5 - 150.0:	--	0.03	2.99	2.69	0.23	0.02	0.02	--	--	--	5.99
150.0 - 157.5:	--	0.02	3.26	1.77	0.32	0.15	--	--	--	--	5.52
157.5 - 165.0:	--	0.02	3.23	1.54	0.22	--	--	--	--	--	5.00
165.0 - 172.5:	--	0.18	2.43	0.60	0.32	0.07	--	--	--	--	3.60
172.5 - 180.0:	--	0.03	3.55	0.65	1.39	--	--	--	--	--	5.62
180.0 - 187.5:	--	0.08	3.41	0.13	--	--	--	--	--	--	3.63
187.5 - 202.5:	--	0.20	5.96	0.23	--	--	--	--	--	--	6.39
202.5 - 217.5:	--	0.15	4.73	0.13	--	--	--	--	--	--	5.02
217.5 - 232.5:	--	0.13	2.69	0.10	--	--	--	--	--	--	2.93
232.5 - 247.5:	--	0.47	0.92	0.02	--	--	--	--	--	--	1.41
247.5 - 262.5:	--	0.69	0.22	0.02	--	--	--	--	--	--	0.92
262.5 - 277.5:	--	0.97	0.18	0.03	--	--	--	--	--	--	1.19
277.5 - 292.5:	--	0.84	0.07	0.02	--	--	--	--	--	--	0.92
292.5 - 307.5:	--	0.79	0.10	--	--	--	--	--	--	--	0.89
307.5 - 322.5:	--	0.55	0.03	0.02	--	--	--	--	--	--	0.60
322.5 - 337.5:	--	0.62	--	--	--	--	--	--	--	--	0.62
TOTAL:	--	26.48	50.02	15.24	3.56	2.58	1.62	0.50	--	--	100

Table A7: Wave probability table for heights between 2.5 and 3.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 2.50 - 3.00: 2243 of 175314 EVENTS (1.28 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	0.45	0.31	--	--	--	--	--	--	--	0.76
30.0 - 45.0:	--	0.18	2.23	--	--	--	--	--	--	--	2.41
45.0 - 60.0:	--	0.45	2.14	--	--	--	--	--	--	--	2.59
60.0 - 75.0:	--	0.04	0.18	--	--	--	--	--	--	--	0.22
75.0 - 90.0:	--	--	2.67	4.32	--	--	--	--	--	--	7.00
90.0 - 97.5:	--	--	1.83	5.08	--	--	0.04	--	--	--	6.95
97.5 - 105.0:	--	--	0.71	1.03	--	--	0.09	--	--	--	1.83
105.0 - 112.5:	--	--	0.67	1.29	--	--	0.09	--	--	--	2.05
112.5 - 120.0:	--	--	0.13	2.14	0.49	0.27	0.09	--	--	--	3.12
120.0 - 127.5:	--	--	0.40	2.59	0.53	1.03	0.58	0.27	--	--	5.39
127.5 - 135.0:	--	--	0.76	3.70	1.11	0.71	0.85	0.4	--	--	7.53
135.0 - 142.5:	--	--	1.07	4.32	0.98	1.11	0.85	0.36	--	--	8.69
142.5 - 150.0:	--	--	1.03	3.83	0.58	0.27	0.09	--	--	--	5.80
150.0 - 157.5:	--	--	1.47	3.74	1.65	0.18	--	--	--	--	7.04
157.5 - 165.0:	--	--	2.50	3.30	0.49	0.18	--	--	--	--	6.46
165.0 - 172.5:	--	--	1.56	2.41	0.45	--	--	--	--	--	4.41
172.5 - 180.0:	--	--	2.36	1.87	0.31	0.13	--	--	--	--	4.68
180.0 - 187.5:	--	--	2.59	2.14	--	--	--	--	--	--	4.73
187.5 - 202.5:	--	--	5.17	3.52	0.04	--	--	--	--	--	8.74
202.5 - 217.5:	--	--	3.92	1.69	--	--	--	--	--	--	5.62
217.5 - 232.5:	--	--	1.47	1.16	--	--	--	--	--	--	2.63
232.5 - 247.5:	--	--	0.13	0.13	--	--	--	--	--	--	0.27
247.5 - 262.5:	--	--	--	0.18	--	--	--	--	--	--	0.18
262.5 - 277.5:	--	--	--	--	--	--	--	--	--	--	0.00
277.5 - 292.5:	--	0.04	--	0.13	--	--	--	--	--	--	0.18
292.5 - 307.5:	--	0.04	--	0.04	--	--	--	--	--	--	0.09
307.5 - 322.5:	--	0.09	--	--	--	--	--	--	--	--	0.09
322.5 - 337.5:	--	0.09	--	--	--	--	--	--	--	--	0.09
TOTAL:	--	1.56	35.58	48.64	6.64	3.88	2.67	1.03	--	--	100

Table A8: Wave probability table for heights between 3.0 and 4.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 3.00 - 4.00: 1053 of 175314 EVENTS (0.60 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	--	0.85	--	--	--	--	--	--	--	0.85
30.0 - 45.0:	--	--	1.04	--	--	--	--	--	--	--	1.04
45.0 - 60.0:	--	--	0.28	--	--	--	--	--	--	--	0.28
60.0 - 75.0:	--	--	--	--	--	--	--	--	--	--	0.00
75.0 - 90.0:	--	--	1.33	1.52	--	--	--	--	--	--	2.85
90.0 - 97.5:	--	--	0.66	5.13	0.28	--	--	--	--	--	6.08
97.5 - 105.0:	--	--	0.47	3.51	--	--	--	--	--	--	3.99
105.0 - 112.5:	--	--	0.09	1.80	--	--	--	--	--	--	1.90
112.5 - 120.0:	--	--	0.09	1.23	0.09	0.19	0.09	--	--	--	1.71
120.0 - 127.5:	--	--	0.09	1.33	0.57	3.80	0.57	0.66	--	--	7.03
127.5 - 135.0:	--	--	0.19	1.71	2.18	1.23	1.42	0.85	--	--	7.60
135.0 - 142.5:	--	--	0.38	3.61	2.66	1.90	2.94	3.04	--	--	14.53
142.5 - 150.0:	--	--	0.47	2.75	4.75	1.23	0.19	--	--	--	9.40
150.0 - 157.5:	--	--	0.28	3.99	2.94	0.66	0.19	--	--	--	8.07
157.5 - 165.0:	--	--	0.47	5.22	1.80	0.19	--	--	--	--	7.69
165.0 - 172.5:	--	--	0.76	4.08	1.23	0.28	0.19	--	--	--	6.55
172.5 - 180.0:	--	--	0.76	3.13	0.28	--	--	--	--	--	4.18
180.0 - 187.5:	--	--	0.38	3.13	0.66	--	--	--	--	--	4.18
187.5 - 202.5:	--	--	1.52	5.60	0.38	--	--	--	--	--	7.50
202.5 - 217.5:	--	--	1.23	1.80	0.19	--	--	--	--	--	3.23
217.5 - 232.5:	--	--	0.19	0.76	--	--	--	--	--	--	0.95
232.5 - 247.5:	--	--	0.09	0.09	--	--	--	--	--	--	0.19
247.5 - 262.5:	--	--	--	0.09	--	--	--	--	--	--	0.09
262.5 - 277.5:	--	--	--	--	--	--	--	--	--	--	0.00
277.5 - 292.5:	--	--	--	--	--	--	--	--	--	--	0.00
292.5 - 307.5:	--	--	--	--	--	--	--	--	--	--	0.00
307.5 - 322.5:	--	--	--	--	--	--	--	--	--	--	0.00
322.5 - 337.5:	--	--	--	--	--	--	--	--	--	--	0.00
TOTAL:	--	--	11.78	50.52	18.04	9.5	5.6	4.56	--	--	100

Table A9: Wave probability table for heights between 4.0 and 5.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 4.00 - 5.00: 120 of 175314 EVENTS (0.07 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	--	--	--	--	--	--	--	--	--	0.00
30.0 - 45.0:	--	--	--	--	--	--	--	--	--	--	0.00
45.0 - 60.0:	--	--	--	--	--	--	--	--	--	--	0.00
60.0 - 75.0:	--	--	--	--	--	--	--	--	--	--	0.00
75.0 - 90.0:	--	--	--	2.50	--	0.83	--	--	--	--	3.33
90.0 - 97.5:	--	--	--	--	0.83	--	--	--	--	--	0.83
97.5 - 105.0:	--	--	--	0.83	--	--	--	--	--	--	0.83
105.0 - 112.5:	--	--	--	--	--	--	--	--	--	--	0.00
112.5 - 120.0:	--	--	--	0.83	0.83	--	--	--	--	--	1.67
120.0 - 127.5:	--	--	--	--	--	3.33	--	--	--	--	3.33
127.5 - 135.0:	--	--	--	1.67	0.83	1.67	--	--	--	--	4.17
135.0 - 142.5:	--	--	--	2.50	5.00	3.33	4.17	4.17	--	--	19.17
142.5 - 150.0:	--	--	--	1.67	9.17	15.00	0.83	--	--	--	26.67
150.0 - 157.5:	--	--	--	0.83	0.83	2.50	1.67	--	--	--	5.83
157.5 - 165.0:	--	--	--	3.33	3.33	0.83	--	--	--	--	7.50
165.0 - 172.5:	--	--	--	3.33	6.67	3.33	0.83	--	--	--	14.17
172.5 - 180.0:	--	--	--	1.67	2.50	--	--	--	--	--	4.17
180.0 - 187.5:	--	--	--	--	1.67	--	--	--	--	--	1.67
187.5 - 202.5:	--	--	--	1.67	4.17	--	--	--	--	--	5.83
202.5 - 217.5:	--	--	--	0.83	--	--	--	--	--	--	0.83
217.5 - 232.5:	--	--	--	--	--	--	--	--	--	--	0.00
232.5 - 247.5:	--	--	--	--	--	--	--	--	--	--	0.00
247.5 - 262.5:	--	--	--	--	--	--	--	--	--	--	0.00
262.5 - 277.5:	--	--	--	--	--	--	--	--	--	--	0.00
277.5 - 292.5:	--	--	--	--	--	--	--	--	--	--	0.00
292.5 - 307.5:	--	--	--	--	--	--	--	--	--	--	0.00
307.5 - 322.5:	--	--	--	--	--	--	--	--	--	--	0.00
322.5 - 337.5:	--	--	--	--	--	--	--	--	--	--	0.00
TOTAL:	--	--	--	21.67	35.83	30.83	7.5	4.17	--	--	100

Table A10: Wave probability table for heights between 5.0 and 20.0 meters.

SUMMARY TABLES BY WAVE HEIGHT BAND

HEIGHT BAND: 5.00 - 20.00: 138 of 175314 EVENTS (0.08 %)
NOTE: "--" ENTRIES MEAN NO DATA IN THIS BIN
EVENT DISTRIBUTION WITHIN HEIGHT BAND (IN PERCENT)

DIR BINS	T= 00-03	03-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-25	TOTAL
15.0 - 30.0:	--	--	--	--	--	--	--	--	--	--	0.00
30.0 - 45.0:	--	--	--	--	--	--	--	--	--	--	0.00
45.0 - 60.0:	--	--	--	--	--	--	--	--	--	--	0.00
60.0 - 75.0:	--	--	--	--	--	--	--	--	--	--	0.00
75.0 - 90.0:	--	--	--	0.72	0.72	0.72	--	--	--	--	2.17
90.0 - 97.5:	--	--	--	--	1.45	0.72	--	--	--	--	2.17
97.5 - 105.0:	--	--	--	--	0.72	--	--	--	--	--	0.72
105.0 - 112.5:	--	--	--	--	0.72	--	--	--	--	--	0.72
112.5 - 120.0:	--	--	--	--	0.72	1.45	--	--	--	--	2.17
120.0 - 127.5:	--	--	--	--	2.17	4.35	--	--	--	--	6.52
127.5 - 135.0:	--	--	--	--	1.45	8.70	5.07	--	--	--	15.22
135.0 - 142.5:	--	--	--	--	0.72	14.49	11.59	3.62	--	--	30.43
142.5 - 150.0:	--	--	--	--	0.72	21.74	5.80	--	--	--	28.26
150.0 - 157.5:	--	--	--	--	0.72	1.45	--	--	--	--	2.17
157.5 - 165.0:	--	--	--	--	0.72	0.72	--	--	--	--	1.45
165.0 - 172.5:	--	--	--	--	0.72	1.45	1.45	--	--	--	3.62
172.5 - 180.0:	--	--	--	--	--	0.72	--	--	--	--	0.72
180.0 - 187.5:	--	--	--	--	0.72	1.45	--	--	--	--	2.17
187.5 - 202.5:	--	--	--	--	--	1.45	--	--	--	--	1.45
202.5 - 217.5:	--	--	--	--	--	--	--	--	--	--	0.00
217.5 - 232.5:	--	--	--	--	--	--	--	--	--	--	0.00
232.5 - 247.5:	--	--	--	--	--	--	--	--	--	--	0.00
247.5 - 262.5:	--	--	--	--	--	--	--	--	--	--	0.00
262.5 - 277.5:	--	--	--	--	--	--	--	--	--	--	0.00
277.5 - 292.5:	--	--	--	--	--	--	--	--	--	--	0.00
292.5 - 307.5:	--	--	--	--	--	--	--	--	--	--	0.00
307.5 - 322.5:	--	--	--	--	--	--	--	--	--	--	0.00
322.5 - 337.5:	--	--	--	--	--	--	--	--	--	--	0.00
TOTAL:	--	--	--	0.72	12.32	59.42	23.91	3.62	--	--	100

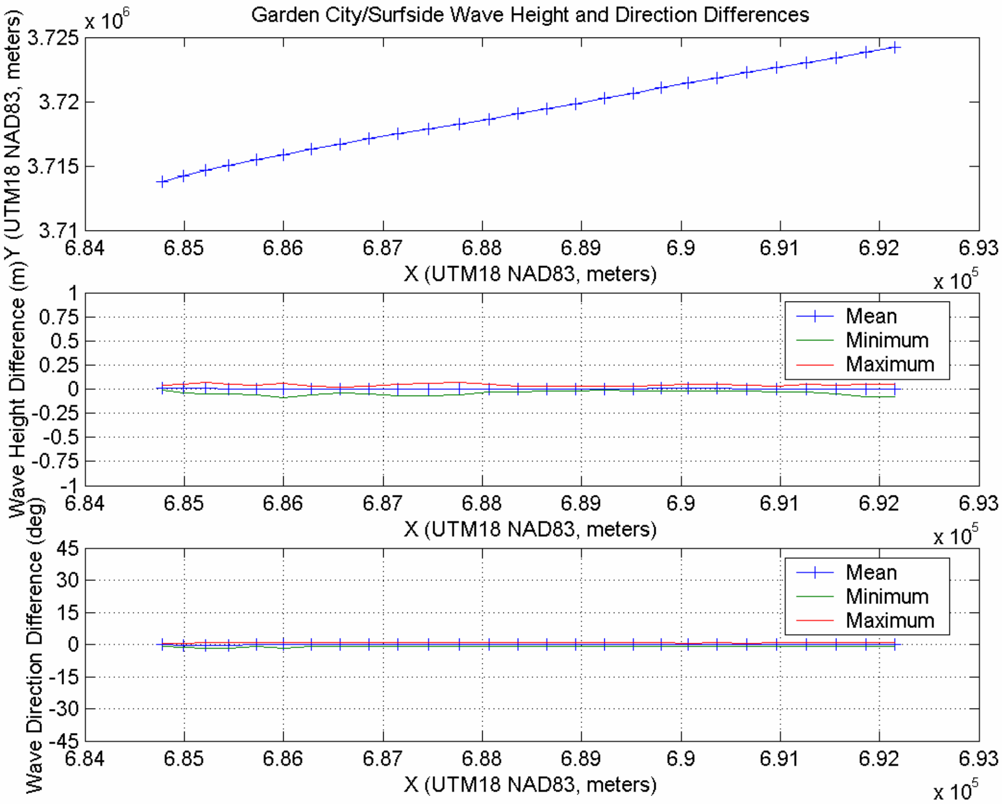

Figure A1: Wave height and direction difference plot for the Garden City/Surfside Reach (all wave condition bins).

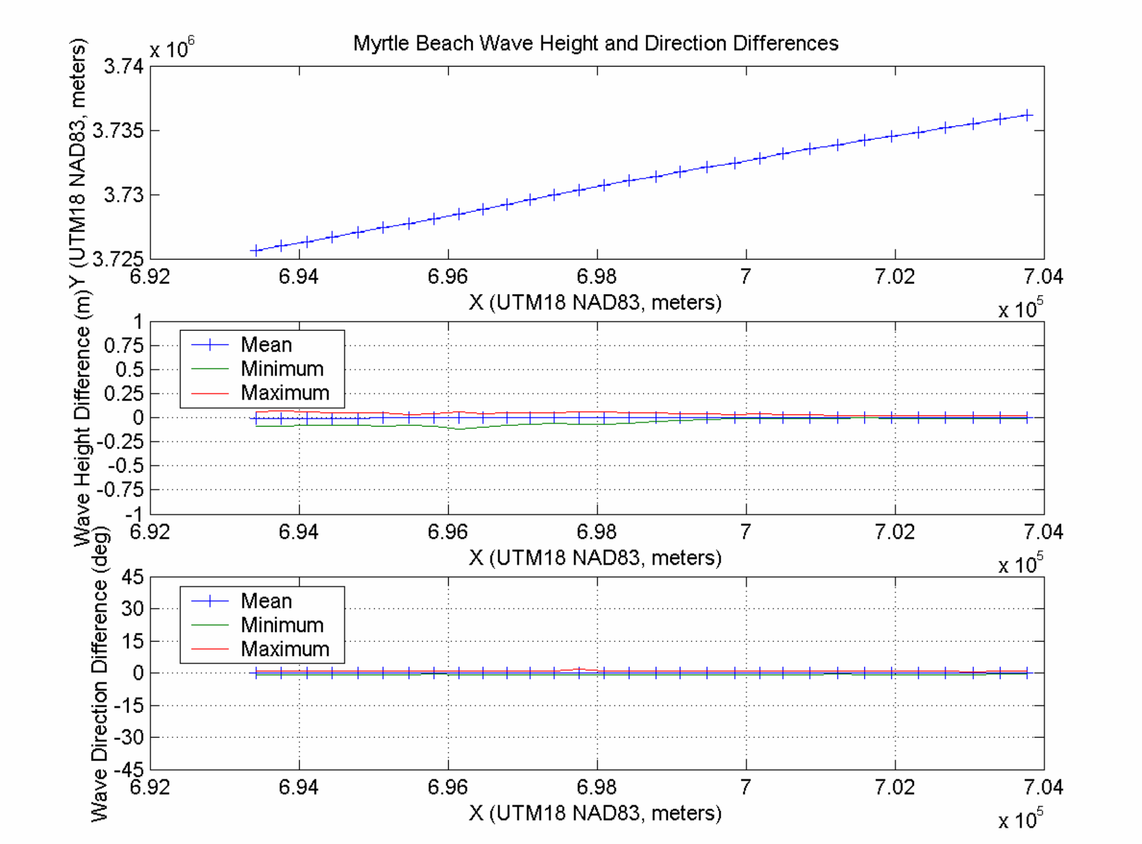

Figure A2: Wave height and direction difference plot for the Myrtle Beach Reach (all wave condition bins).

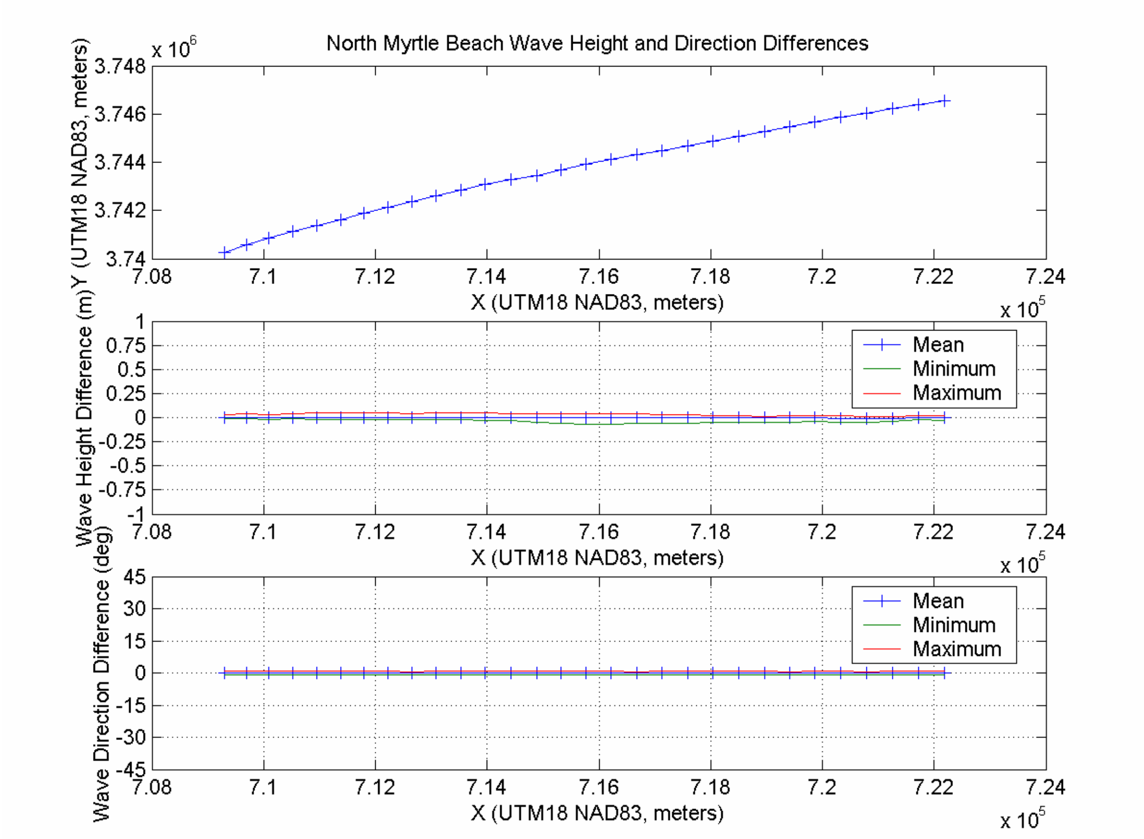

Figure A3: Wave height and direction difference plot for the North Myrtle Beach Reach (all wave condition bins).

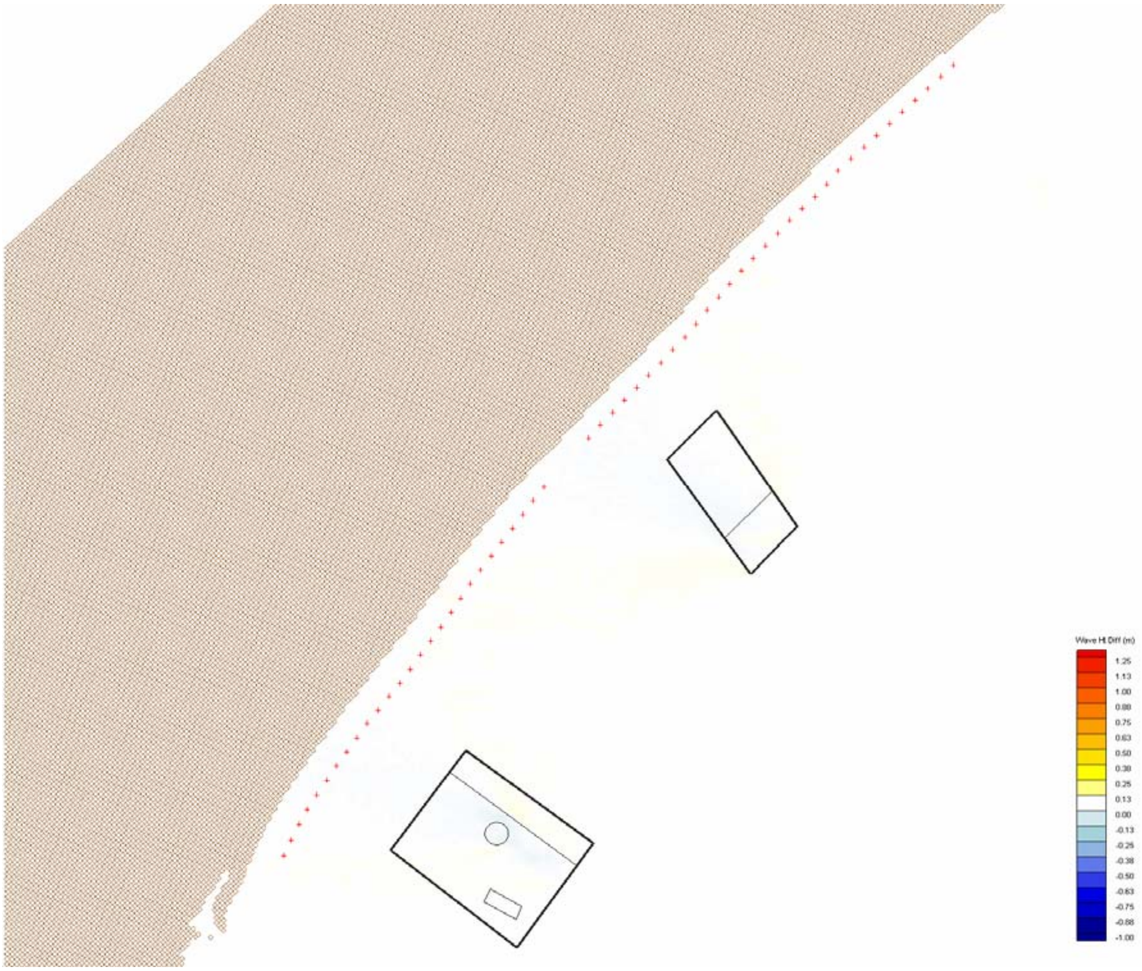

Figure A4: Wave height difference contour plot for the Surfside and Cane South Borrow Areas (Dir = 112.5-120.0 degrees, T = 6.0-8.0 sec, H = 0.50-1.00 meters).

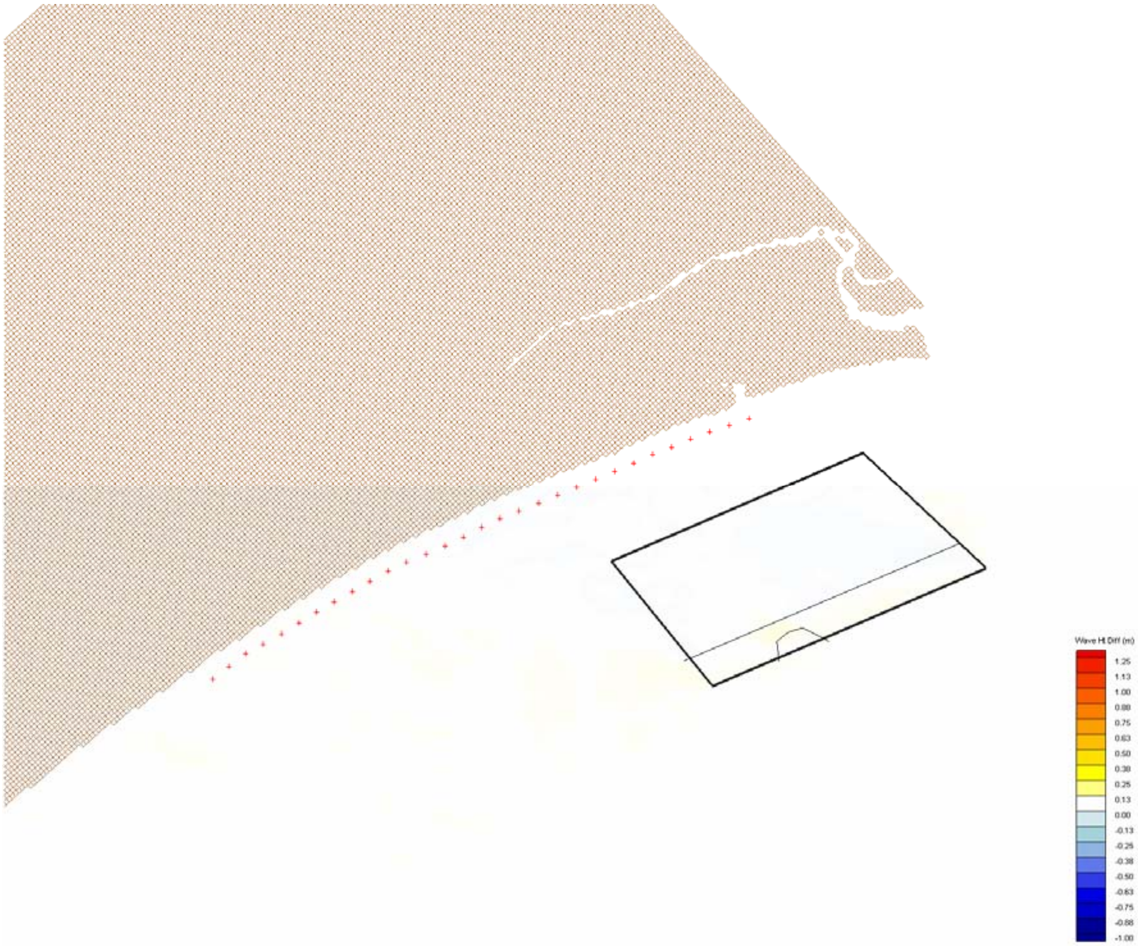

Figure A5: Wave height difference contour plot for the Little River Borrow Area (Dir = 112.5-120.0 degrees, T = 6.0-8.0 sec, H = 0.50-1.00 meters).

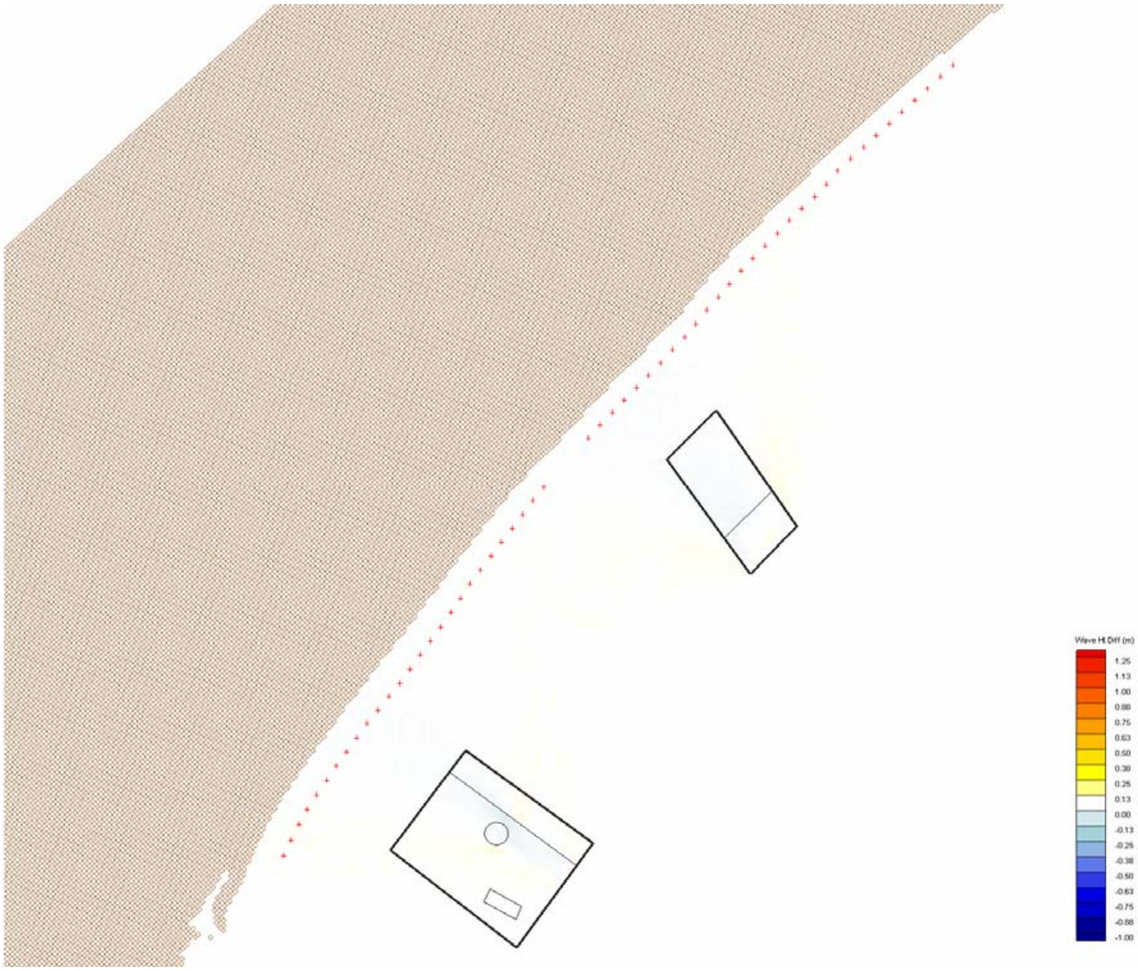

Figure A6: Wave height difference contour plot for the Surfside and Cane South Borrow Areas (Dir = 135.0-142.5 degrees, T = 6.0-8.0 sec, H = 0.50-1.00 meters).

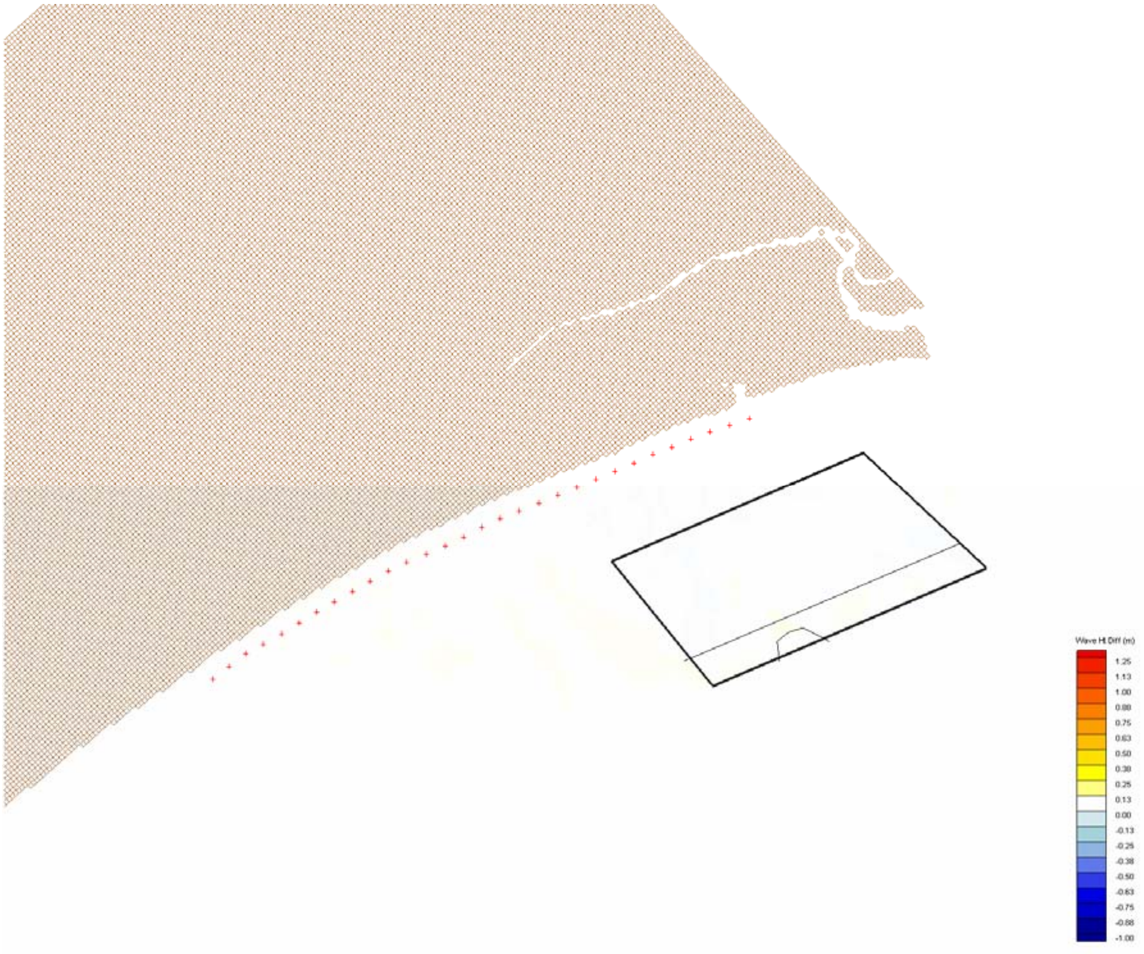

Figure A7: Wave height difference contour plot for the Little River Borrow Area (Dir = 135.0-142.5 degrees, T = 6.0-8.0 sec, H = 0.50-1.00 meters).

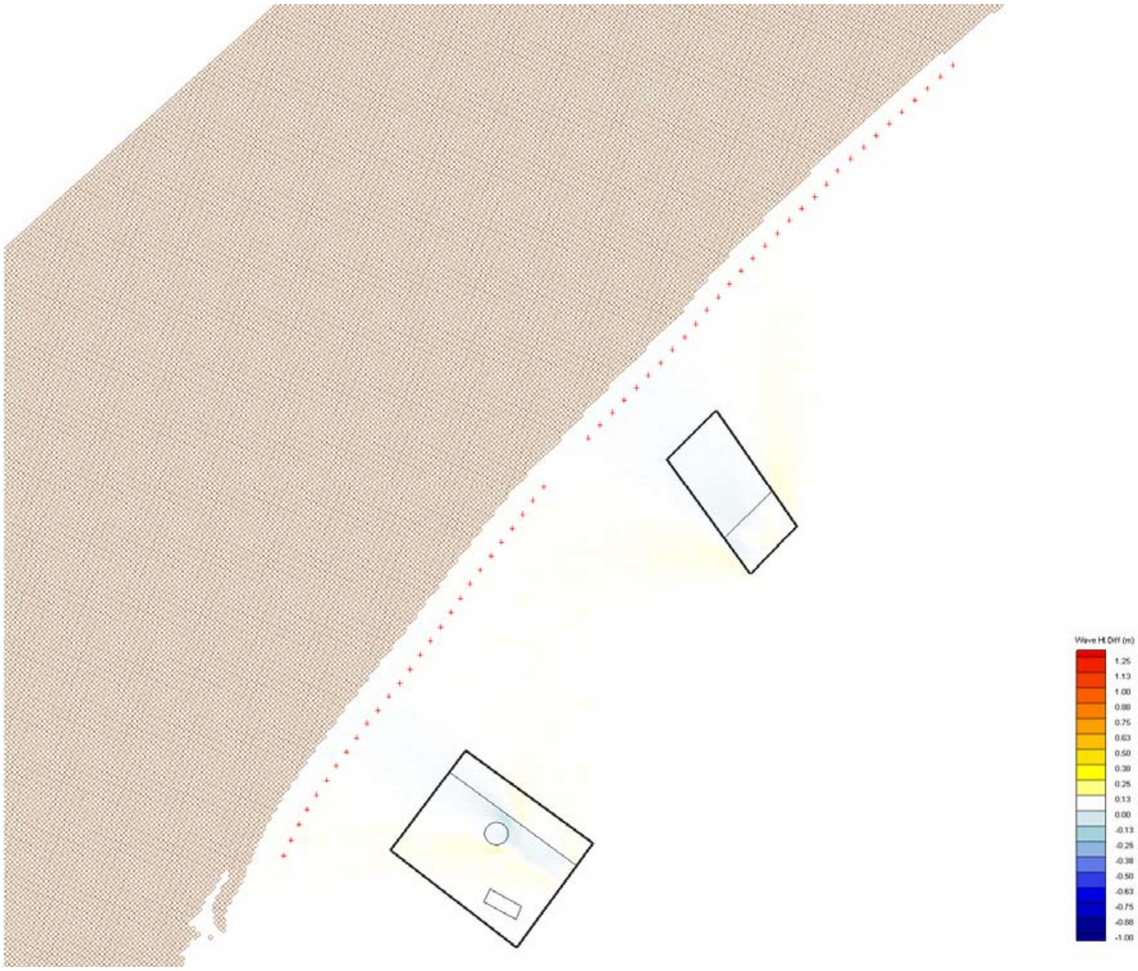

Figure A8: Wave height difference contour plot for the Surfside and Cane South Borrow Areas (Dir = 135.0-142.5 degrees, T = 6.0-8.0 sec, H = 1.00-1.50 meters).

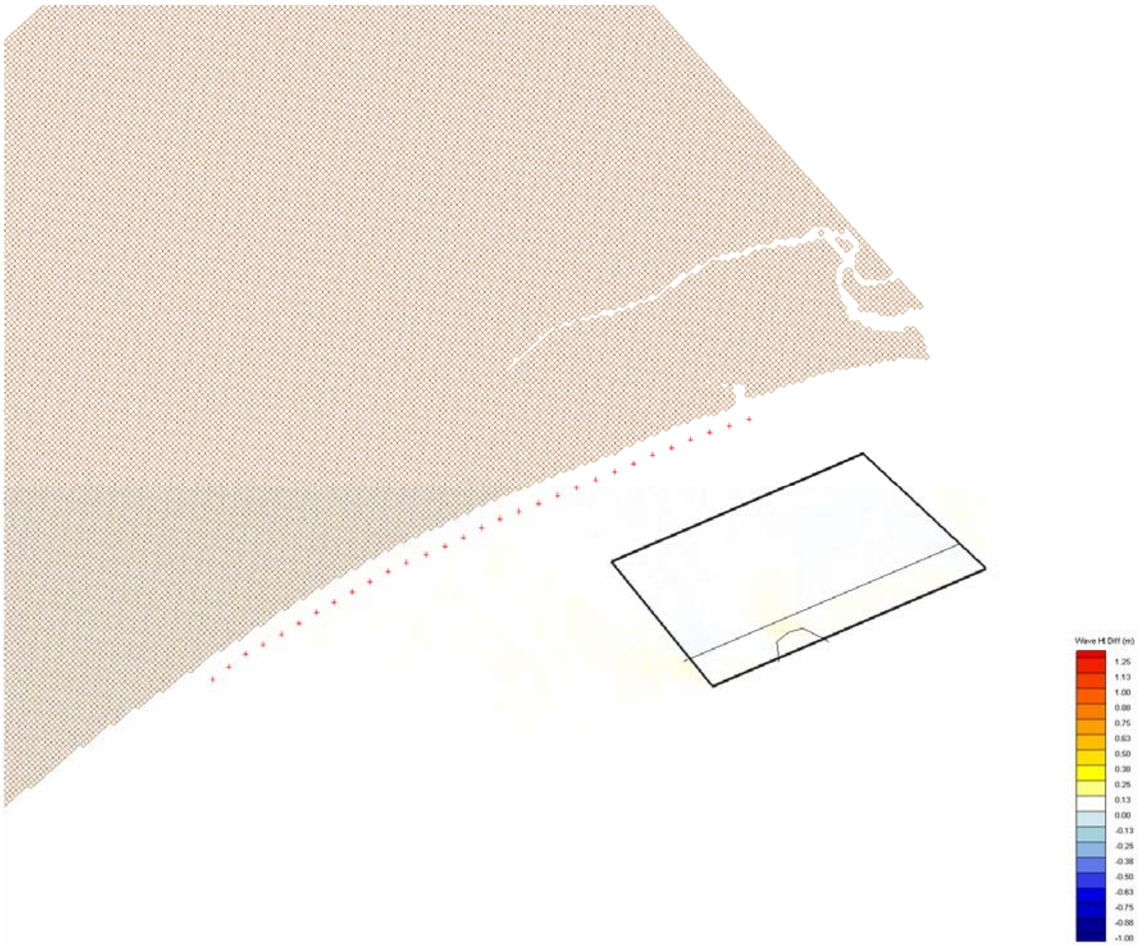

Figure A9: Wave height difference contour plot for the Little River Borrow Area (Dir = 135.0-142.5 degrees, T = 6.0-8.0 sec, H = 1.00-1.50 meters).

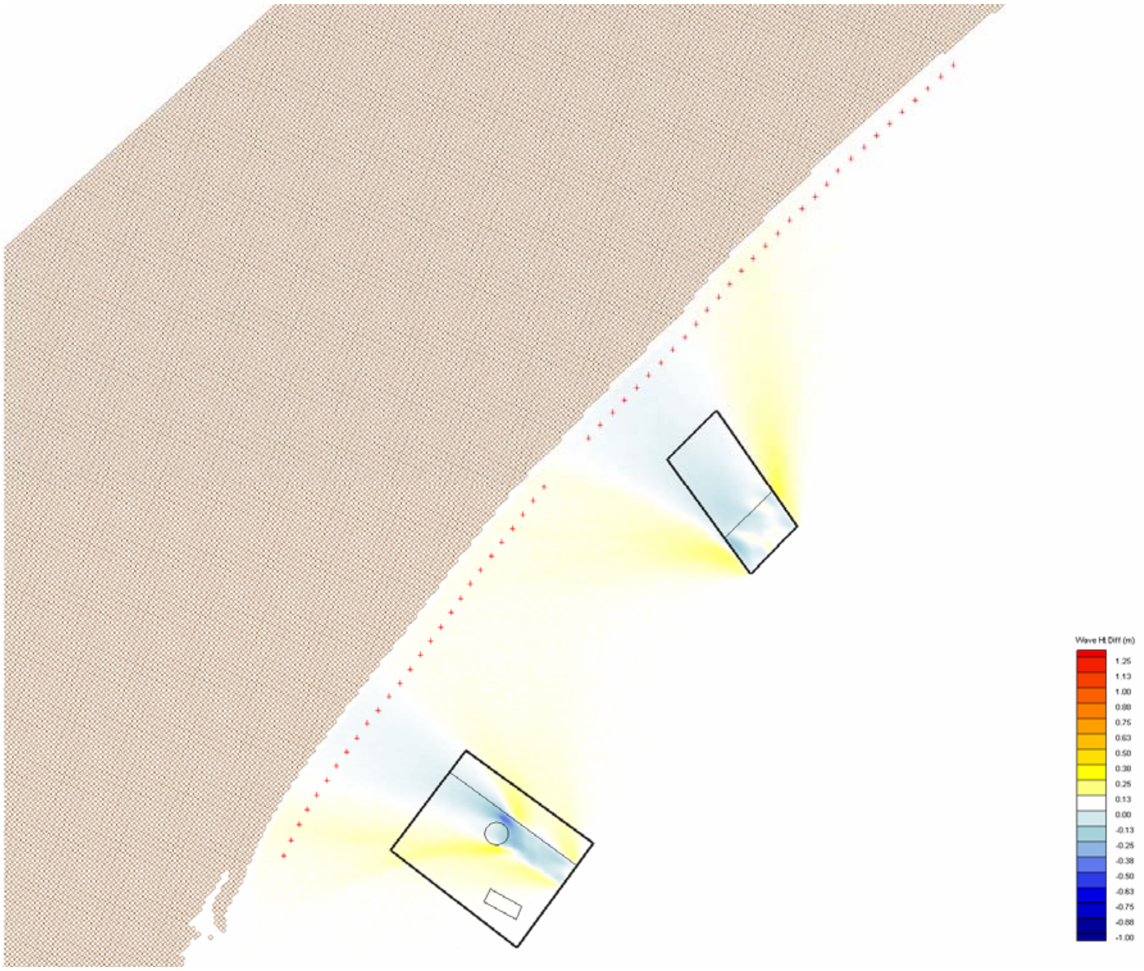

Figure A10: Wave height difference contour plot for the Surfside and Cane South Borrow Areas (Dir = 135.0-142.5 degrees, T = 10.0-12.0 sec, H = 3.00-4.00 meters).

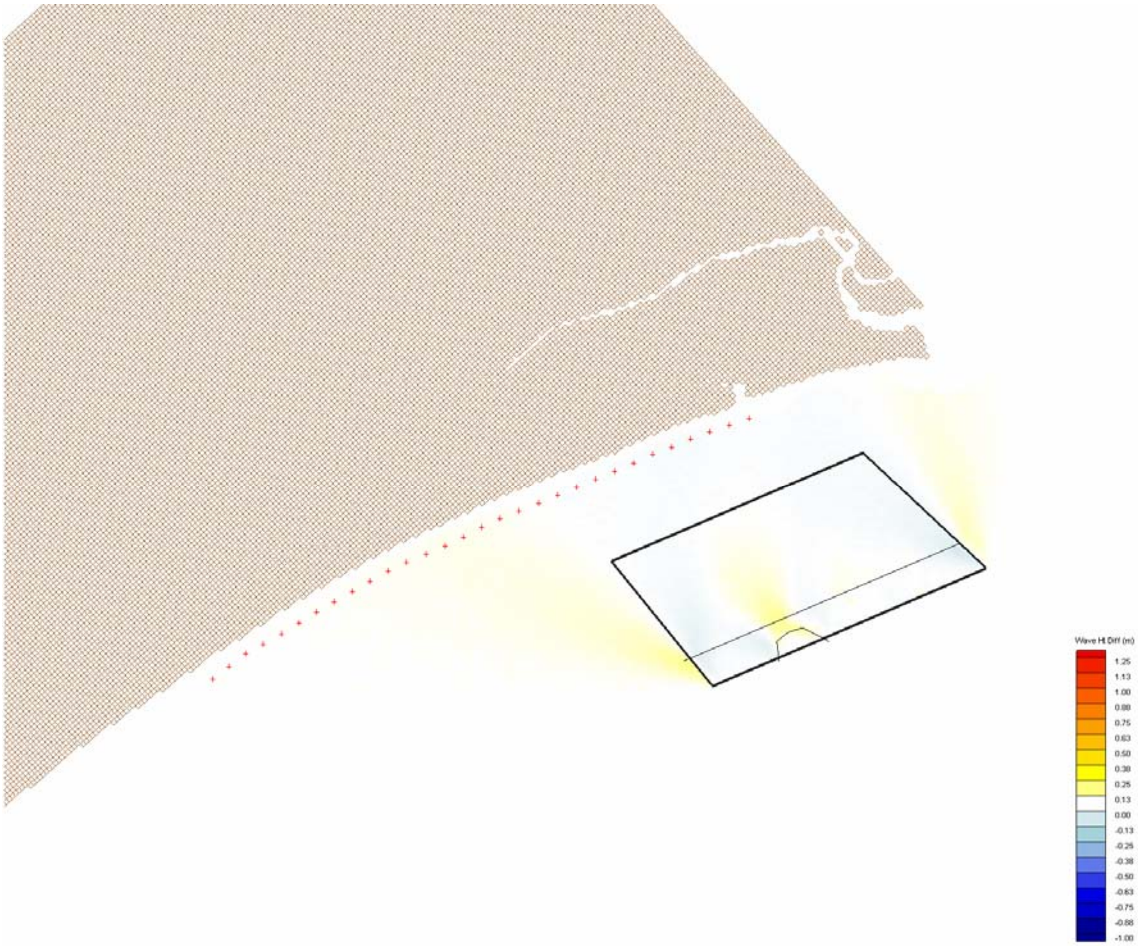

Figure A11: Wave height difference contour plot for the Little River Borrow Area (Dir = 135.0-142.5 degrees, T = 10.0-12.0 sec, H = 3.00-4.00 meters).

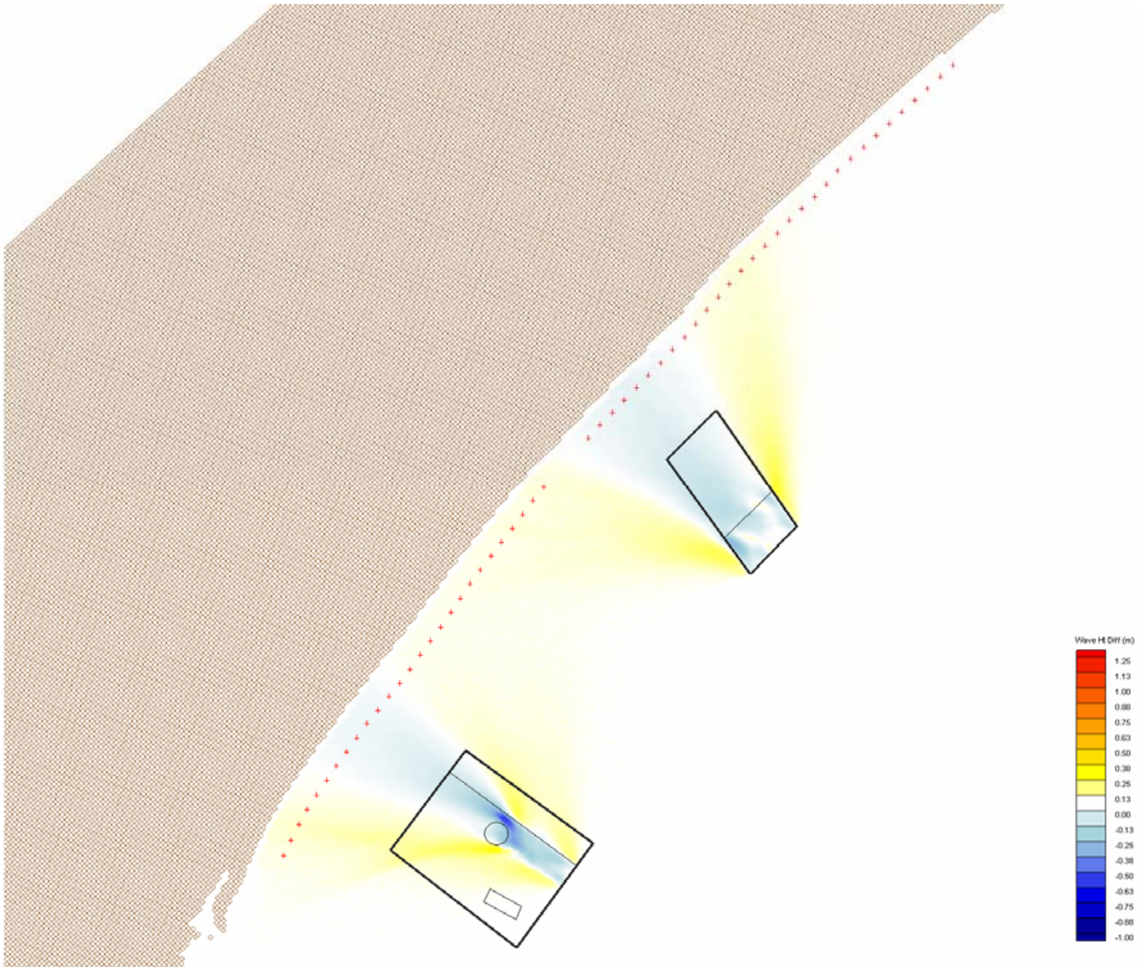

Figure A12: Wave height difference contour plot for the Surfside and Cane South Borrow Areas (Dir = 135.0-142.5 degrees, T = 12.0-14.0 sec, H = 3.00-4.00 meters).

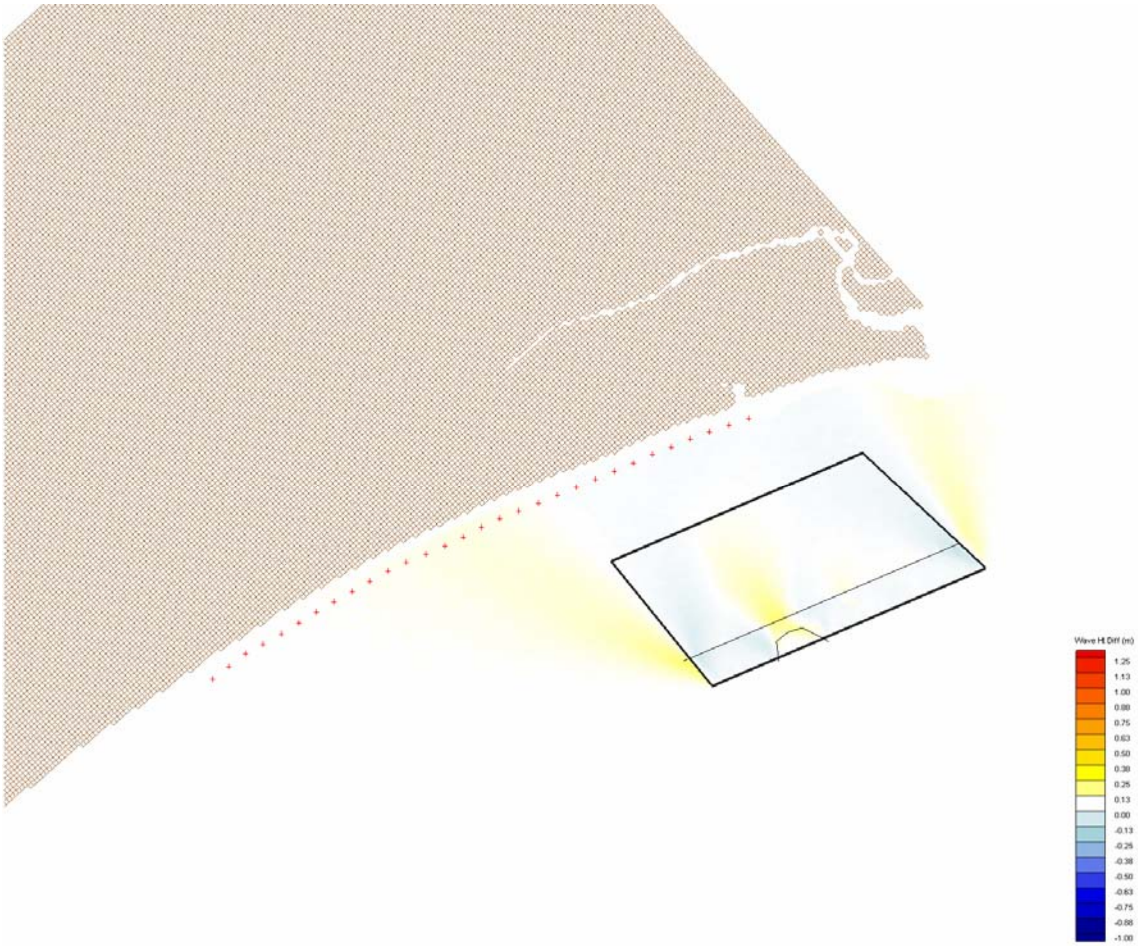

Figure A13: Wave height difference contour plot for the Little River Borrow Area (Dir = 135.0-142.5 degrees, T = 12.0-14.0 sec, H = 3.00-4.00 meters).

Appendix 9

Environmental Monitoring Plan

MRRI CONTROL NO. ____________

MARINE RESOURCES RESEARCH INSTITUTE PROPOSAL SUBMITTAL FORM

TO: R. Boyles

CFDA# (if required): ____________

DATE: 3/22/2007 REQUIRED SUBMITTAL DATE: None

PROJECT TITLE: 2007 Myrtle Beach Renourishment Project: Beach, Nearshore Reef and Borrow Site Monitoring

PRINCIPAL INVESTIGATOR(s): Derk Bergquist, Robert Van Dolah

OTHER PERSONNEL: George Reikerk, Stacie Crowe or TBH, Steve Burns

PROJECT DURATION: 2 years

FUNDING SOURCE: US Army Corps of Engineers

GRANTOR COSTS: $148,981

MATCH COSTS: none

COMMENTS: If Crowe is unable to spearhead project, a new Bio II will be hired

CHECK IF APPROPRIATE:

- ☒ New Personnel to be Hired
- ☒ SCUBA diving required
- ☒ Small boat use
- ☐ Vessel time required
- ☐ Computer Services required
- ☐ Special Equip.

SIGNATURE ____________ DATE: 3/22/2007

PRESUBMITTAL APPROVAL (Section Manager): ____________

SUBMITTAL APPROVAL (Section Director): ____________

BUDGET APPROVAL (Grants Administration): ____________ 3-22-07

COMMENTS: ____________

3-23-07

DIVISION DIRECTOR SIGNATURE/ACTION: ______________________________

☐ APPROVED ☐ DISAPPROVED ☐ MODIFICATION REQUIRED

COMMENTS: ______________________________

____

____

2007 Myrtle Beach Renourishment Project: Beach, Nearshore Reef and Borrow Site Monitoring Scope of Work

Derk C. Bergquist
Robert Van Dolah
South Carolina Department of Natural Resources
Marine Resources Research Institute

Paul T. Gayes
Coastal Carolina University

INTRODUCTION:

The beach nourishment project planned for Myrtle Beach will provide valuable protection for beach properties from storm damage and enhance one of the state's popular tourist destinations. While this project provides many potential benefits, it is essential that the project be completed with minimal environmental damage. As planned, the project will nourish three primary segments of coastline starting at Surfside Beach and moving north to Myrtle Beach and then North Myrtle Beach. Fill for these segments will be dredged from three offshore sand sources: Surfside, Cane North/Cane South, and Cherry Grove. Because of its large scale, this nourishment project has the potential to impact ##km of beach habitat, three offshore sand deposits, and it has the potential to impact a system of nearshore hard-bottom reefs. A series of recent studies, garnering much scientific and mainstream attention, have highlighted the kinds of negative impacts that may occur as a result of beach nourishment activities (Peterson and Bishop 2005). Previous monitoring activities in South Carolina suggest great variability in the response of the environment to beach nourishment and borrow pit dredging, from minimal impact and rapid recovery to severe impacts, much longer-term recovery or recovery to an altered physical and biological condition. Here we propose a series of biological monitoring activities to examine environmental impact and recovery associated with the planned Myrtle Beach renourishment project. Specific objectives of the proposed monitoring efforts will be to:

(1) Document changes in beach profile and determine the ecological impacts on and recovery rates of sediment characteristics and burrowing ghost crabs on nourished beaches.

(2) Determine the impacts on nearshore hard-bottom habitats and biological recruitment to those habitats.

(3) Document the impacts on and recovery of native bathymetry, sediment characteristics, and benthic infaunal communities in sand borrow areas

APPROACH AND RATIONALE:

This scope of work includes several monitoring efforts that have proven very informative in past assessment projects and several components long suspected to respond to nourishment activities but rarely, if ever, explicitly examined. Because of the diverse array of habitats to be found within and adjacent to the planned Grand Strand nourishment activities, this project provides a unique opportunity to perform collaborative and inter-disciplinary monitoring efforts involving ecosystem responses to beach nourishment. This scope of work will include cost estimates to perform Before-After-Control-Impact-Paired-Series (BACIPS) studies of all impact areas. The proposal includes monitoring both pre- and post-nourishment/dredging conditions of 1) the beach profile at all nourished sections, 2) sediment characteristics and ghost crab populations on surfside beach and unnourished control areas to the north and south, 3) changes in the amount and distribution of nearshore hardbottom habitat, 4) recruitment to nearshore hard substrates in the vicinity of the nearshore reefs, 5) finfish populations around the nearshore hard bottom habitat, 6) recovery of natural bathymetry in borrow areas, and 7) sediments and benthic infauna in all three borrow areas and two reference areas (interspersed along the coast). Budget and project timetables assume a pre-nourishment monitoring start date of June-July 2007 for reef and beach and March-April for borrow areas. Post-nourishment sampling schedules tentatively assume 3 mo to complete the Surfside Beach segment, 6 months to complete the Myrtle Beach segment and 3 months to complete the North Myrtle Beach segment.

<u>Objective 1.</u> Document changes in beach profile and determine the ecological impacts on and recovery rates of sediment characteristics and burrowing ghost crabs on nourished beaches.

Beach Profile Monitoring (Gayes)

Monitoring of the physical reworking of the initial beach nourishment was completed by augmenting the statewide BERM Survey program to provide two years of quarterly BERM long beach surveys following construction. At that time, the BERM program was surveying each OCRM benchmark once annually, which reduced the cost of the quarterly surveys. The statewide BERM program has continued to monitor the nourished areas annually subsequent to the completion of the initial Corps funded assessment. BERM now uses an ATV-based RTK-DGPS survey system for areas above water level which is very rapid and cost effective and a more complex RTK-DGPS based single beam fathometer based system for the areas located below the waterline.

The BERM program has evolved since 1997 and is presently supported through a consortium of stakeholders lead by SC OCRM, SC SeaGrant, and The City of North Myrtle Beach and Horry County which are supporting a portion of the statewide program in their jurisdictions, as well as some additional surveys to better serve their specific management needs. Through this cooperative each OCRM benchmark in the Grand Strand is surveyed once annually in support of the State's mandate to monitor coastal erosion and administer the SC Beachfront Management Act. OCRM benchmarks in Surfside/Garden City, North Myrtle Beach and the Arcadian Shores area of Myrtle Beach are surveyed a second time annually following a significant storm event to satisfy the local partner (Horry County and City of North Myrtle Beach) obligation for monitoring the Grand Strand beach nourishment fill over the long term. In addition, the Mean High Water (MHW) contour line is surveyed monthly in Surfside/Garden City and North Myrtle Beach to assist those municipalities identify and better manage local hotspots and high frequency erosional events.

The present proposal seeks to forge a similar partnership with the BERM consortium to assess the physical change and dispersal of the upcoming Grand Strand Renourishment building on the experience and findings of past monitoring efforts as well as results of the much larger SC Coastal Erosion Study. This is expected to provide a much better and user-friendly representation of beach change for engineering, planning and public access to information about the renourishment projects function and behavior. As funding mechanisms become increasingly limited and complex the latter element may be expected to continue to increase in importance as well as aid the Corps engineering-based needs In addition, this system is also structured to make data available to the US Army Corps of Engineers as part of their regional data product managing system developed in concert with another CCU working group.

For the upcoming renourishment project, funds are first requested to cover a second BERM long survey of the Myrtle Beach section not presently funded by the BERM cooperative program. That will result in continuity of historic documentation of long profiles across the project areas and consistent bi-annual data sets for all three phases for very limited new costs. This will provide an assessment of sediment volumes moving across the full active beach system including the shoreface. During the first nourishment project, cross-shore transport and storage of sand on the shoreface was found to be a significant proportion of the total reworking of the beach fill. In addition, the flux of sand through this zone is of concern as the source of potential adverse impacts within the local hardground habitats on the adjacent shelf (focus of associated Index Reef Study).

Very practical interests in the stability and rate of reworking of the upper (subaerial) beach fill would be better served by more frequent sampling. Funding is requested to modify the existing BERM program of bi-monthly survey of the MHW contour along the Surfside/Garden City and North Myrtle Beach areas to include the Myrtle Beach section but to also adjust that effort to be completed every three months (quarterly) at sufficient gridding to generate an accurate 3-D representation of the fill above the MHW contour rather than tracking a single contour on the lower beach. This will would require a very modest amount of funding and would yield a product that would be far more versatile in quantifying volumetric change spatially. Regrettably, the costs and logistical demands of a similar product for the areas below Mean Low Water would be prohibitive using single beam technology. A proposal is presently pending that would establish newer swath bathymetry capabilities within the BERM program which would vastly improve efforts to document beach geometry and volume changes. Should that capability be funded through a different and pending proposal it is intended to be integrated into the effort proposed here.

As a result the proposed physical monitoring of the beach fill would be composed of bi-annual long BERM profiles at the historic series of BERM profiles (OCRM benchmark series) within the areas being nourished as well as for a kilometer on the adjacent unnourished beaches to help quantify cross shore reworking of the fill as has been done in the past. This would be augmented by quarterly surveys of the main body of the fill above Mean Low Water at sufficient resolution to better represent spatial variability in geometry and volume of the upper fill and vastly improve monitoring of the width of the upper permanent beach fill elevation along the coast. The subaerial gridding should begin during July 2007 to ensure two quarters pre-nourishment conditions are documented. The existing BERM program should be able to adequately define the pre-condition for long profiles of the Grand Strand and subaerial beach gridding for the Surfside/Garden City and North Myrtle Beach areas (May/June 2007 time frame). The results and associated data products would allow for valid profiles at any location along the project above MLW and support data transfer, analysis and data products to be GIS based from the resulting DEM's.

It is also recommended that, for at least one key location in each phase of the project, a digital Beachcam system be installed to provided daily snapshot, time averaged and rectified time averaged imagery a 500-1000 meter section of the project. This would build on the system established as part of the Coastal Erosion Study and adopted by Horry County to provide high resolution temporal coverage a specific area of concern (hotspot). It is recommended that these systems be placed in areas of known controversy and conflict associated with the past beach nourishment (at local swash entrances) or where the time averaging technology could aid in identifying bar configurations and prevalence of rip circulation. There is interest from other groups and stakeholders related to issues of rip circulation and use patterns of local beaches that may expand this network. Should any additional camera systems be established for other purposes, the data feed and results would be folded into the nourishment project study products as well.

For a nominal initial cost, such systems can provide a constant (daylight hours) record of conditions and change at critical sites as well as document beach fill endurance at least qualitatively daily over long periods of time for limited costs. To facilitate this function spatially, albeit less frequently, modest funds (cost to lease a small plane for 2 hours ~$200/flight plus a student assistant) are sought to support quarterly collection of oblique digital aerial photographs and oblique digital video as well as immediate before and after any major storm events. This is not envisioned to be expensive orthophotographic imagery but to support web-based dissemination of behavior of the project and at least a qualitative time series across the length of the project. This element should begin during the summer of 2007 so that the system is fully functional and establishes an adequate pre-nourishment baseline.

Impact on Beach Burrowing Macrofauna (Bergquist and Van Dolah)

Several studies assessing the effects of beach nourishment on intertidal communities in South Carolina have found that impacts in the intertidal zone are often short-term with respect to benthic infaunal organisms such as polychaetes and amphipods (Van Dolah *et al.* 1994, Jutte *et al.* 1999b). However, emerging research from along the east coast of the US indicates that nourishment has a significant negative impact on large, burrowing macroinvertebrates. Peterson *et al.* (2000) studied the short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach in North Carolina, and documented dramatic declines in the abundance of several species (mole crabs, bean clams, and ghost crabs) following these physical disturbances. The burrowing organisms inhabiting South Carolina beaches represent a major food source for surf fishes, shorebirds, and predatory crabs and form a significant component of the detritivore and scavenger feeding guilds that ensure proper functioning of the beach ecosystem (Brown and McLachlan 1990; Wolcott 1978, DeLancey 1989).

The potential impacts of the physical disturbance caused by beach nourishment activities on the sizes and recovery rates (greater than one year) of burrowing macroinvertebrate populations remain relatively unstudied in South Carolina and will be investigated in the current study.

The proposed assessment will focus on ghost crabs as they are readily and consistently identifiable. Both the overall abundances of ghost crabs and their population size structure have been shown to respond negatively on short time scales to nourishment activities in South Carolina (SCDNR, unpublished data); however, the time required for ghost crab populations to recover is largely unknown. To investigate recovery of ghost crab populations in the Grand Strand, four survey stations will be selected along the Surfside Beach shoreline including two stations within the nourished segment, one station on the un-nourished segment just north of Surfside Beach and one station on the un-nourished segment just south of Surfside Beach. Each station will represent a 100m wide section of beach parallel to the shoreline and extend from the dunes to the upper intertidal zone. Within this 100m-wide section, four 10m-wide transects will be randomly chosen for examining ghost crabs and sediment characteristics in any one sampling period. Counts of active ghost crab burrows (identified by tracks around the opening of the burrow (Wolcott 1978)) will be made along the four replicate 10 m wide transects. Because burrow diameter is directly proportional to the size of the ghost crab inhabiting it, potential population-level impacts on ghost crabs can be investigated by measuring the burrows to the nearest mm. Along each transect, a composite set of five sediment core samples will be collected for analysis of grain size, sediment composition, and total organic matter.

All surveys of ghost crab population sizes will be performed during summer months as ghost crabs close their burrows during the winter, preventing accurate estimates of population sizes during cooler months. Beach stations will be sampled during the late spring/early summer 2007 to establish pre-nourishment status of the ghost crab population in each of the four segments. Additional surveys will be performed and samples will be collected immediately following nourishment and during the summers of 2008 and 2009 to determine the extent of nourishment impact and the amount of recovery of these populations.

<u>Objective 2:</u> Determine the impacts on nearshore hard-bottom habitats and biological recruitment to those habitats.

Marine hard-bottom habitats provide attachment substrate, predator refugia and foraging grounds for a wide range of invertebrates and fish, including many important fishery species (Grimes et al 1982; Wenner et al 1983; Sedberry and Van Dolah 1984). The Grand Strand hosts the only significant aggregation of nearshore (surfzone) hard-bottom habitats in South Carolina, but their associated communities and importance to local fishery resources remain largely unknown. Renourishment of the Grand Strand is practically guaranteed to impact these reefs as sand placed along the beach migrates offshore and alongshore. The purpose of the proposed monitoring activities is to determine the impact of migrating sediments on 1) the rates of change in the amount of hard-bottom habitat at varying distances from the proposed nourishment project, 2) the community structure and recruitment of habitat-structuring invertebrates to these hard-bottom habitats, and 3) the composition of benthic finfish utilizing the hard-bottom habitats.

Physical Habitat Characterization and Monitoring (Gayes)

A time series of side scan sonar and bottom video characterizations of 13 known nearshore hardbottom areas was completed in 199# to assess potential change in critical reef habitat associated with any potential influx of sand from the initial Grand Strand Beach Nourishment Project (Figure 1; Ojeda et al. 2001). In that study, sites were partitioned with respect to proximity to location of beach fill emplacement both along the beach and in an on-offshore direction. Most areas exhibited only modest change in habitat and that was largely balanced with amount of characterized habitat loss being roughly equivalent to habitat gain (Table 1-modified from Ojeda, Gayes and Sapp, 2001). Two areas (Sites 3 and 4), both located proximal to the constructed beach nourishment in inshore locations, were interpreted to have exhibited modest change in habitat with a small net loss of hardbottom habitat. These results indicate that there is some potential for adversely impacts to the nearshore reef communities in areas immediately adjacent to the nourishment project in this region.

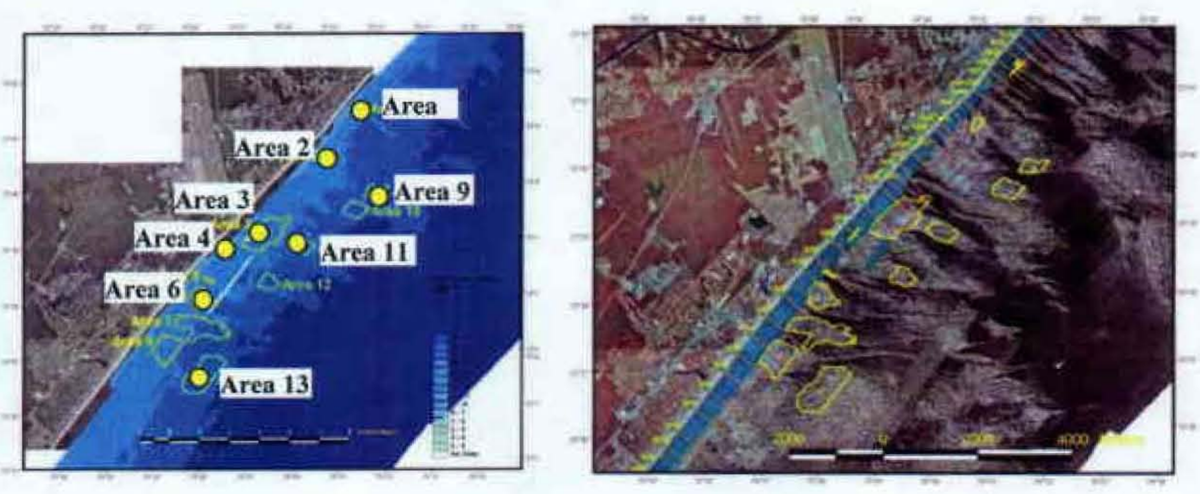

Figure 1. Location of 13 index Reef Sites monitored during the initial Grand Strand Nourishment Project (left). These same locations are shown superimposed on the regional SC Coastal Erosion Study regional side scan sonar mosaic (right).

Table 1 (below) shows the Net Change Analysis for these sites associated with the 1997-2001 study of the initial Grand Strand Nourishment Project (after Ojeda, Gayes and Sapp, 2001). Sites 3 and 4 exhibited modest change with small net habitat loss in the initial study. Sites 1, 2, 11 and 13 exhibited modest change with no net habitat loss in the initial study and site. Sites 5 and 9 exhibited modest change with a small net gain in hardbottom habitat during the initial study.

Table 1. Results of Change Analysis from 1997 to 2001						
Proximity to Phase II	Area	Sand to Sand	Hardbottom to Hardbottom	**Sum of no change**	Hardbottom to Sand	Sand to Hardbottom
Nearshore Proximal	**1**	**32**	**40**	**72**	**14**	**14**
	2	**0**	**91**	**91**	**4**	**5**
	3	5	68	**73**	21	6
	4	5	46	**51**	31	18
Offshore Proximal	9	9	59	**68**	7	25
	10	8	58	**66**	18	16
	11	**18**	**47**	**65**	**17**	**18**
	12	9	65	**74**	10	16
Nearshore Distal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	6	1	86	**87**	7	6
	7	7	58	**65**	20	15
	8	2	80	**82**	10	8
Offshore Distal	**13**	**2**	**74**	**76**	**16**	**8**

Based on these results, it is recommended that monitoring of the upcoming second phase or "*renourishment*" of the Grand Strand Nourishment Project focus attention on the nearshore locations located proximal to the project particularly off Myrtle Beach where the greatest impact was seen during the first nourishment. This should include Sites 1, 2, 3 and 4 which are located inshore and proximal to the Myrtle Beach section of the project. In addition, two sites (Sites 9 and 11) are proposed offshore of the Myrtle Beach section of the project and two sites (one inshore-Site 6 and one offshore-Site 13) are proposed adjacent to the Surfside-Garden City section of the project. These sites will serve to assist with assessment of natural variability in these critical inner shelf habitats as well as document change in an area of extensive hardbottom exposures off Surfside Beach.

Continued monitoring of beach volumes through the BERM program shows that following an initial period of relatively modest loss of constructed beach during the first two years following nourishment, losses of sediment from the construction template increased over time and may have further modified the nearshore system, particularly over the last three years. As a result a pre-construction characterization of the index reef environments is necessary to both serve as the baseline to assess potential impacts of the upcoming project as well as provide the basis to assess longer term changes associated with the initial beach nourishment.

The methods proposed to accomplish this are similar to those utilized during the initial study (Ojeda, Gayes and Sapp, 2001). Side scan sonar surveys will be completed over each of the eight proposed index reefs and the imagery assembled into rectified mosaic images. The same textural analysis and habitat change analysis routines developed for the initial project will be applied and output used to compare with the finding of the 2001 study. In addition, bottom video lines will also be conducted along lines of survey. If visibility allows, additional lines of video survey will be completed to help assess habitat and change following the upcoming renourishment.

The proposed geophysical analysis of habitat change of the index reefs sites will coincide and integrate with SCDNR efforts focused on biological impacts of the projects (below). In reality, due to the nature of data acquisition and operations, broader areas of the inner shelf will be imaged to generate mosaics for textural analysis and change maps.

These areas will provide a larger spatial context for aiding DNR work assessing potential impact on invertebrate recruitment at specific locations on the inner shelf.

Impact of Sand Migration on Invertebrate Communities and Recruitment (Bergquist and Van Dolah)

As beach fill migrates seaward toward the nearshore hard-bottom habitats, substrate burial and sand scour can negatively impact communities of sessile invertebrates that are key to the proper functioning of these reefs. Sedimentation has been shown to decrease the growth rates, densities and recruitment success of many sessile invertebrates such as corals, sponges and ascidians and in more extreme cases completely smother living reef habitats (Hunt and Wittenberg 1992; Miller et al 2002; Golbuu et al 2003; Fabricius 2005; Dikou and Woesik 2006). To examine the potential impact on invertebrate communities of sediment migration resulting from the nourishment, community structure on and recruitment to nearshore reefs will be monitored pre- and post-nourishment.

The proposed biological monitoring will take place at in each of four areas based on their proximity to the Phase II nourishment (nearshore proximal, nearshore distal, offshore proximal and offshore distal) also being monitored for changes in amount of exposed hard bottom habitat (Gayes). Within each area, five randomly chosen stations will be established at which a monitoring array will be deployed (Fig 2). At each station, the surrounding hardbottom communities will be monitored by photographing four 1.0 m^2 quadrats centered at least 1.5 m from the recruitment array. The quadrats will be established on hardbottoms hosting communities at the time of the initial pre-deployment period. The percent cover of various sessile invertebrate taxa will be determined in each quadrat by overlaying a grid of 100 evenly-spaced points on each photo and counting the number of points that fall on each taxon. To reduce costs, no funds are requested to process photos at this time and so should not be considered as a deliverable in the current proposal.

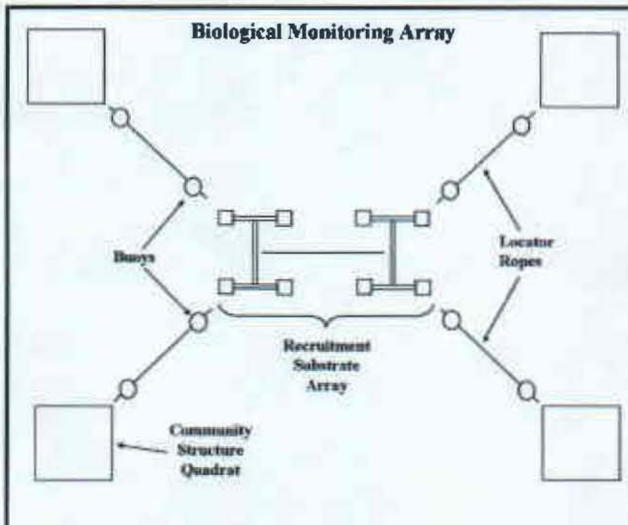

Figure 2. Biological monitoring array to be deployed at each station

Artificial recruitment substrates (12.5cm X 12.5cm unglazed ceramic tiles; as recommended by Harriot and Fisk 1987) will be deployed as part of the biological monitoring array. At each station, a total of eight artificial substrates will be deployed: two replicate tiles for each combination of 2 heights above the bottom (on-bottom and 10cm off-bottom) and two deployment periods (6-month and 12-month). The on-bottom substrates are more likely than off-bottom substrates to be affected by sedimentation at all stations and zones. The off-bottom substrates will allow the detection of spatial and temporal differences in larval supply and other natural factors largely independent of sedimentation, thus allowing a more explicit comparison of the influence of sedimentation on recruitment to the on-bottom substrates. The two deployment periods (6-month and 12-month) will also allow for the assessment of sedimentation impacts on both earlier and later successional benthic species. Work primarily conducted in tropical waters suggests that 5 months is sufficient for accurate measurements of recruitment to artificial substrates (Glassom et al 2006). Six and twelve month deployments will be used here to ensure sufficient recruitment time in the high wave energy and cooler temperate waters of the Grand Strand area. For a period of two years, half of the tiles at each station will be collected and replaced each six months and the other half will be collected and replaced each year (Table 2; based on projected project start date of 7/2007).

All tiles will be photographed prior to collection in order to visually characterize extent of sediment coverage and biotic colonization. All tiles appropriate for a particular deployment will be removed from the bottom, carefully placed in individual containers, and fixed in 10% formalin on the boat. In the lab, the coverage of sessile fauna that recruited to each surface (upper and lower) of each tile will be determined using a point-quadrat technique. A grid with 100 evenly-spaced points will be placed over the central $100cm^2$ portion of each plate. The presence/absence and identity (to the lowest practical taxonomic affinity) of attached organisms will be determined beneath each point, thus providing estimates of percent cover. General linear models will be used to test for differences in recruitment 1) with proximity to the nourishment, 2) between on-bottom and off-bottom substrates, 3) before and after nourishment (6-month periods only) and 4) along gradients of sedimentation as determined by side scan sonar surveys.

Table 2. Timeline for recruitment study. Dep. = deploy substrates; Coll. = collect substrates. The deployment/collection period highlighted in yellow will take place immediately prior to the placement of fill adjacent to the reefs.

Deployment Period	Mar-Apr 2007	Sep-Oct 2007	Mar-Apr 2008	Sep-Oct 2008	Mar-Apr 2009
6-month	Dep.	Coll./Dep.	Coll./Dep.	Coll./Dep.	Coll.
12-month	Dep.	--	Coll./Dep.	--	Coll.

Monitoring reef-associated fish communities (Gayes)

Nearshore areas and hard-bottom reefs provide foraging grounds, prey refugia and nursery habitat for a wide variety of fish species, including many recreationally and commercially important species (Sedberry and Van Dolah 1984; Layman 2000). Very little is known about the fish communities associated with the hard-bottom habitats of the Grand Strand or the impact that modifications to that habitat will have upon local fisheries. In general, as beach fill redistributes, increased suspended sediment loads could physiologically stress resident fishes by reducing the efficiency of visual predation (LaSalle et al 1991), and the burial of hard-bottom as beach fill potentially redistributes could remove habitat structure that is critical to the fish communities in this area. Short-term changes in fish communities and fish diets have been identified in response to turbidity plume associated with beach nourishment activities (Wilber et al 2003). Here we propose to characterize shorter (seasonal) and longer-term (2 years) changes in benthic fish communities associated with nourishment activities adjacent to nearshore hard-bottom areas.

Blackfish traps (Collins 1990) will be deployed at each of the same four reef areas being monitored for changes in overall hard-bottom habitat and benthic invertebrate recruitment (nearshore proximal, nearshore distal, offshore proximal and offshore distal). Cages will be deployed for 2-4 hours during day time. At least 12 traps will be deployed in each area over a period of 2 days during each of March-April, June-July, September-October, and December-January. Prior to deployment, traps will be baited with clupeids. Following retrieval, all fish will be identified to species, enumerated and measured to the nearest mm total length (TL). Otoliths, reproductive tissue, and stomach contents will be removed form 10 fish from each 1 cm size class for each species. Differences in fish abundance, and community structure will be statistically tested 1) with proximity to the nourishment, 2) before and after nourishment (6-month periods only), 3) along gradients of sedimentation as determined by side scan sonar surveys, and 4) among seasons.

<u>Objective 3:</u> Document the impacts on and recovery of native bathymetry, sediment characteristics, and benthic infaunal communities in sand borrow areas.

Bathymetry (Gayes)

Detailed bathymetric surveys of the borrow site areas are proposed to be used to assess the change in seafloor condition associated with dredging at each site. One pre-dredging survey is proposed to establish the condition of the seafloor at the borrow sites planned for use in the upcoming renourishment and also to establish any subsequent infilling of the previously used borrow locations since the last survey of the borrow areas in the late 1990's. This is proposed to be completed in August-September 2007 for the Surfside Garden City area and shortly before initiation of dredging operations in the Myrtle Beach and North Myrtle Beach areas.

Additional surveys are proposed immediately following dredging at each borrow site to document the volumes removed and establish the conditions of the sea floor after dredging. Surveys will also be completed one and two years following dredging to monitor potential infilling and change.

This aspect of the study of the initial nourishment project was hampered by unresolvable problems associated with one pre-dredge survey provided by an outside contractor for the Corps and a relatively coarse survey grid adopted from historical surveys for these purposes. This proposal will modify those methods to better resolve and quantify changes in the dredged areas and utilize one system for pre-post surveys as well as assessing subsequent change.

Bathymetric surveys will be completed using a grid of standard single beam survey grade-fathometer lines (SC BERM program protocols). The BERM system utilizes real-time kinematic DGPS for positioning and establishing vertical control and corrects fathometer output for Heave/Pitch/Roll, sound velocity and water level elevation (tides) during the survey. In addition, a side scan sonar mosaic of the borrow site will be completed during each bathymetric survey to assist efforts to characterize the spatial homogeneity of change in sediment characteristics associated with the dredging and subsequent infilling of the pit.

Survey lines will be completed at 75-meter spacings and extend at least 200 meters beyond the edges of the dredged area to reduce edge effects in the gridding of the

data. In addition, tie lies will be completed on 150 meter spacings and support the side scan sonar surveys to assess the changes in spatial homogeneity of sediment textures infilling the pit over time. These proposed geophysical survey work will coincide and integrate with SC DNR efforts focused on biological impacts of the projects.
The effects of offshore dredging in sand borrow sites is a major environmental concern due to the long-term impacts that have been observed at borrow areas used for previous nourishment projects (Van Dolah *et al*. 1992, Jutte and Van Dolah 1999, 2000), and in several other studies of beach nourishment projects (e.g. Naqvi and Pullen, 1983, Nelson 1985, Jutte *et al.* 2002).

Sediment Characteristics and Infauna (Bergquist and Van Dolah)

Dredging necessarily impacts benthic environments because it removes sediments and their associated communities. As a result, the primary open question associated with beach fill borrow areas is the time required for sediment characteristics and benthic communities to recover from dredging. Monitoring of borrow sites used in previous nourishment projects in South Carolina have suggested that the depth of the dredge pit and the proximity of the borrow area to tidal inlets can have significant consequences for the recovery of benthic ecosystems (Van Dolah et al 1994; Jutte et al 1999; Jutte and Van Dolah. 2000). These same characteristics can also greatly influence the ability of future nourishment projects to re-use a borrow are as deep pits and close proximity to tidal inlets increases the likelihood that dredge pits will re-fill with sediments incompatible with beach sands (Van Dolah et al 1998). SCDNR has been examing benthic recovery in sand borrow areas since the late 80's and has developed one of the strongest databases for this type of disturbance in the southeast US. This database has proven invaluable for improving borrow site selection and management practicies to minimize impact, but the total number of nourishment projects monitored is still too low to allow statistically robust analyses. Here we propose to continue building onto this database by monitoring sediment characteristics and infaunal communities at two of the three borrow sites.

In each of the two borrow areas (Cane North/South and Cherry Grove) and one reference area (located between the borrow areas, ten randomly selected stations will be located using a global positioning system (GPS) and sampled. One benthic grab sample will be collected at each of the ten stations within each borrow area using a 0.04 m^2 Young grab, and each grab sample will be sub-sampled for analysis of sediment characteristics (percent sand, silt, clay, $CaCO_3$, organic matter content, and sand grain size distribution). Benthic organisms will be identified to the lowest possible taxonomic level and enumerated by experienced taxonomists. Previous studies have indicated that ten samples per sampling site and date are sufficient to characterize the dominant benthic taxa (e.g. Van Dolah *et al.* 1994, Jutte *et al.* 1999a).

Samples will be collected at three time points preceeding nourishment (12-month, 6-month and immediately pre-nourishment) to allow the characterization of pre-dredging conditions at the borrow sites relative to the control area. Following the completion of dredging at each borrow site, immediate post-nourishment, and 6-month and 12-month post-dredging samples will also be collected.

Table 3. Timeline for sampling sediment and benthic community monitoring at borrow areas.

Borrow Area	Pre-nourishment 12-month	Pre-nourishment 6-month	Pre-nourishment Immediate	Post Nourishment Immediate	Post Nourishment 6-month	Post Nourishment 12-month
Cane North/South	3-4/2007	8-9/2007	2-3/2008	8-9/2008	3/2009	9/2009
Cherry Grove	8-9/2007	2-3/2008	8-9/2008	12/2008	6/2009	12/2009

Sediment characteristics and infaunal density data at the borrow sites (as a function of those at the control sites) will be analyzed using general linear models. Community-level infauna data will be examined using canonical correspondence analysis (CANOCO software) to test the null hypothesis that borrow and control area communities respond the same over time. By incorporating bathymetric data obtained from the sonar surveys, changes in sediment characteristics and infaunal communities within each borrow area will also be examined as a function of changes in bottom topography.

PROJECT TIMELINE:

TIMELINE

Project Component	Fiscal Year 2007 to 9/07	2008 10/07-9/08	2009 10/08-9/09	2010 10/09-9/10
Beach				
Beach Profile				
MB swash	--	pre	post + 1 yr post	*
MB BERM	--	pre	post + 1 yr post	*
MB Aerials/Beachcam	pre	pre + post	1 yr post	*
SB/GC Biological survey	pre	post	1 yr post	*
Borrow				
Bathymetry				
SB/GC	pre	post	1 yr post	*
MB	--	pre + post	1 yr post	*
NMB	--	pre	post	1 yr post
Sediment and Infauna				
MB	1yr pre + 6mo pre	pre + post	6 mo post + 1 yr post	*
NMB	1 yr pre	6 mo pre + pre	post + 6 mo post	1 yr post
Reef				
Physical Habitat	--	pre	1 yr post	*
Invertebrate Recruitment	pre	post + 6 mo post	1 yr post + 18 mo post	*
Fish Communities	pre	pre + post	post	*
Report				
CCU	--	pre	post + 1 yr post	
SCDNR	--	--	--	Beach + Reef + Borrow

*--further monitoring may be recommended as part of long-term monitoring plan

SB/GC--Surfside Beach/Garden City; MB--Myrtle Beach or Cane North/South;NMB--North Myrtle Beach or Cherry Grove

STUDY PARTICIPANTS:

The proposed monitoring program will be conducted by scientists from the South Carolina Department of Natural Resources Marine Resources Research Institute (MRRI) and Coastal Carolina University (CCU). MRRI and CCU staff have extensive experience in conducting ecological assessments of beach nourishment projects, including monitoring of the previous nourishment project performed at Myrtle Beach (Jutte *et al.* 1999a, b; Jutte *et al.* 2002; Ojeda *et al* 2001).

STUDY COSTS:

This scope of work represents all pre- and post-nourishment monitoring efforts on the beach, around nearshore reefs and in borrow sites. For brevity, we have combined the Scopes of Work for the MRRI (PI's: Bergquist and Van Dolah) and CCU (PI: Gayes), but separate budgets have been included for each participant. The two institutions, if funded, will bill separately. Estimates include partial support for a graduate student to conduct portions of the research (reef fish surveys). Estimated costs include preparation of a final report summarizing all findings.

At the request of the Corps, the budget has been divided into fiscal years 2007-2008 and fiscal years 2009-2010. Only funds for fiscal years 2007 and 2008 are requested here (Current Budget Requests, below). Funds for activities in fiscal years 2009-2010 are not yet available and will be requested during 2008 (Future Funding Requests, below).

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Layman, C.A. 2000. Fish assemblage structure of the shallow ocean surfzone on the eastern shore of Virginia barrier islands. **Estuarine, Coastal and Shelf Science** 51:201-213.

Miller, D.C., C.L. Muir, O.A. Hauser. 2002. Detrimental effects of sedimentation on marine benthos: what can be learned from natural processes and rates? **Ecological Engineering** 19:211-232.

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Nelson, W.G. 1985. Physical and biological guidelines for beach restoration projects. Part I. Biological Guidelines. Report No. 76, Florida Sea Grant College. 65 pp.

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Van Dolah, R.F., R.M. Martore, A.E. Lynch, M.V. Levisen, P.H. Wendt, D.J. Whitaker, and W.D. Anderson. 1994. Environmental Evaluation of the Folly Beach Nourishment Project. Final Report. U.S. Army Corps of Engineers, Charleston District, and the Marine Resources Division, South Carolina Department of Natural Resources. 155 pp.

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Wilber, D.H., D.G. Clark, G.L. Ray, M. Burlas. 2003. Response of surf zone fish to beach nourishment operations on the northern coast of New Jersey, USA. **Marine Ecology Progress Series** 250:231-246.

Wolcott, T.G. 1978. Ecological role of ghost crabs, *Ocypode quadrata*, on an ocean beach: scavengers or predators? **Journal of Experimental Marine Biology and Ecology**. 31, 67-82.

Only funds for activities occurring in fiscal years 2007 and 2008 are being requested at this time. If funded we request that South Carolina Department of Natural Resources and Coastal Carolina University be funded separately as shown below.

SCDNR Current Funding Request

To be funded directly to:
South Carolina Department of Natural Resources

Study Component	FY 2007 *to 9/07*	FY 2008 *10/07-9/08*	TOTALS
Beach	$4,122	$6,143	***$10,265***
Borrow Areas	$32,507	$31,402	***$63,909***
Nearshore Reefs	$26,120	$48,687	***$74,807***
Final Report	$0	$0	***$0***
TOTALS	$62,749	$86,232	***$148,981***

CCU Current Funding Request

To be funded directly to:
Coastal Carolina University

Study Component	FY 2007 *to 9/07*	FY 2008 *10/07-9/08*	TOTALS
Beach	$24,814	$38,303	***$63,117***
Borrow Areas	$10,090	$43,625	***$53,715***
Nearshore Reefs	$0	$40,501	***$40,501***
Final Report	$0	$0	***$0***
TOTALS	***$34,904***	***$122,429***	**$157,333**

Fiscal years 2009 and 2010 funds are not yet available. During 2008, the following expected requests will be made to complete the project described above.

SCDNR Future Funding Request

To be funded directly to:
South Carolina Department of Natural Resources

Study Component	FY 2009 *10/08-9/09*	FY 2010 *10/09-9/10*	TOTALS
Beach	$6,429	$0	***$6,429***
Borrow Areas	$66,654	$13,319	***$79,973***
Nearshore Reefs	$56,308	$0	***$56,308***
Final Report	$0	$34,933	***$34,933***
TOTALS	$129,391	$48,252	***$177,643***

CCU Future Funding Request

To be funded directly to:
Coastal Carolina University

Study Component	FY 2009 *10/08-9/09*	FY 2010 *10/09-9/10*	TOTALS
Beach	$35,000	$0	***$35,000***
Borrow Areas	$30,750	$10,250	***$41,000***
Nearshore Reefs	$40,000	$0	***$40,000***
Final Report	$0	$7,000	***$7,000***
TOTALS	$105,750	$17,250	***$123,000***

State And Local Department/Agency
Indirect Cost Negotiation Agreement

EINs: 57-0882454 (Marine Division)
57-6000286 (Other DNR)

Organization:

State of South Carolina
Department of Natural Resources
c/o State Budget and Control Board
Office of State Budget
1201 Main Street, Suite 870
Columbia, South Carolina 29201

Date: February 5, 2007

Report No(s).: 07-A-254

Filing Ref.:
Last Negotiation Agreement
dated June 20, 2005

The indirect cost rates contained herein are for use on grants, contracts, and other agreements with the Federal Government to which Office of Management and Budget Circular A-87 applies, subject to the limitations in Section II.A. of this agreement. The rates were negotiated by the U.S. Department of the Interior, National Business Center, and the subject organization in accordance with the authority contained in the Circular.

Section I: Rates

	Effective Period				Applicable
Type	From	To	Rate*	Locations	To
Fixed Carryforward	07/01/06	06/30/07	22.68%	All	PR/DJ
Fixed Carryforward	07/01/06	06/30/07	22.60%	All	All Other

*Base: Total direct salaries and wages, excluding fringe benefits.

Treatment of fringe benefits: Fringe benefits applicable to direct salaries and wages are treated as direct costs; fringe benefits applicable to indirect salaries and wages are treated as indirect costs.

Section II: General

A. **Limitations:** Use of the rates contained in this agreement is subject to any applicable statutory limitations. Acceptance of the rates agreed to herein is predicated upon these conditions: (1) no costs other than those incurred by the subject organization were included in its indirect cost rate proposal, (2) all such costs are the legal obligations of the grantee/contractor, (3) similar types of costs have been accorded consistent treatment, and (4) the same costs that have been treated as indirect costs have not been claimed as direct costs (for example, supplies can be charged directly to a program or activity as long as these costs are not part of the supply costs included in the indirect cost pool for central administration).

B. **Audit:** All costs (direct and indirect, federal and non-federal) are subject to audit. Adjustments to amounts resulting from audit of the cost allocation plan or indirect cost rate proposal upon which the negotiation of this agreement was based will be compensated for in a subsequent negotiation.

C. **Changes:** The rates contained in this agreement are based on the organizational structure and the accounting system in effect at the time the proposal was submitted. Changes in organizational structure, or changes in the method of accounting for costs which affect the amount of reimbursement resulting from use of the rates in this agreement, require the prior approval of the responsible negotiation agency. Failure to obtain such approval may result in subsequent audit disallowance.

D. **Fixed Carryforward Rate:** The fixed carryforward rate is based on an estimate of the costs that will be incurred during the period for which the rate applies. When the actual costs for such period have been determined, an adjustment will be made to the rate for a future period, if necessary, to compensate for the difference between the costs used to establish the fixed rate and the actual costs.

E. **Agency Notification:** Copies of this document may be provided to other federal offices as a means of notifying them of the agreement contained herein.

F. **Record Keeping:** Organizations must maintain accounting records that demonstrate that each type of cost has been treated consistently either as a direct cost or an indirect cost. Records pertaining to the costs of program administration, such as salaries, travel, and related costs, should be kept on an annual basis.

G. **Reimbursement Ceilings:** Grantee/contractor program agreements providing for ceilings on indirect cost rates or reimbursement amounts are subject to the ceilings stipulated in the contract or grant agreements. If the ceiling rate is higher than the negotiated rate in Section I of this agreement, the negotiated rate will be used to determine the maximum allowable indirect cost.

H. **Use of Other Rates:** If any federal programs are reimbursing indirect costs to this grantee/contractor by a measure other than the approved rates in this agreement, the grantee/contractor should credit such costs to the affected programs and the approved rates should be used to identify the maximum amount of indirect cost allocable to these programs.

I. **Central Service Costs:** Where central service costs are estimated for the calculation of indirect cost rates, adjustments will be made to reflect the difference between provisional and final amounts.

J. **Other:**

1. The purpose of an indirect cost rate is to facilitate the allocation and billing of indirect costs. Approval of the indirect cost rates does not mean that an organization can recover more than the actual costs of a particular program or activity.

2. Programs received or initiated by the organization subsequent to the negotiation of this agreement are subject to the approved indirect cost rate if the programs receive administrative support from the indirect cost pool. It should be noted that this could result in an adjustment to a future rate.

3. New indirect cost proposals are necessary to obtain approved indirect cost rates for future fiscal or calendar years. The proposals are due in our office 6 months prior to the beginning of the year to which the proposed rates will apply.

Section III: Acceptance

Listed below are the signatures of acceptance for this agreement:

By the State Department/Agency:

Carole Collins /s/

CAROLE COLLINS
Name (Type or Print)

DEPUTY DIRECTOR
Title

29 JAN 07
Date

By the Cognizant Federal Government Agency:

Deborah A. Moberly /s/

Deborah A. Moberly
Name

Indirect Cost Coordinator
Indirect Cost Services
Title

U.S. Department of the Interior
National Business Center
Agency

Date February 5, 2007

Negotiated by Steve Dallosta
Telephone (916) 566-7111

FINANCIAL AUDIT INFORMATION

Please complete and return with your application:

Date of your organization's financial audit: March 2006

Period covered by audit: July 2004 – June 2005

Findings

No Material Findings: XX

If there were negative findings, explain how they have been resolved (if additional space is needed, please attach pages):

Next scheduled audit: March 2007

Period to be covered by scheduled audit: July 2005 – June 2006

DO NOT SEND A COPY OF YOUR FINANCIAL STATEMENT!

Charles Myers, Jr., South Carolina Department of Natural Resources
Fiscal Officer's Name and Signature
Charles Myers Jr
Fiscal Officer's Phone Number: (803) 734-6191
Internet Address: myersc@dnr.sc.gov

STUDY COSTS:

This scope of work represents all pre- and post-nourishment monitoring efforts on the beach, around nearshore reefs and in borrow sites. For brevity, we have combined the Scopes of Work for the MRRI (PI's: Bergquist and Van Dolah) and CCU (PI: Gayes), but separate budgets have been included for each participant. The two institutions, if funded, will bill separately. Estimates include partial support for a graduate student to conduct portions of the research (reef fish surveys). Estimated costs include preparation of a final report summarizing all findings.

At the request of the Corps, the budget has been divided into fiscal years 2007-2008 and fiscal years 2009-2010. Funds for activities in fiscal years 2009-2010 are not yet available.

References Cited:

Brown, A.C., and A. McLachlan. 1990. *Ecology of Sandy Shores*. Amsterdam: Elsevier, 328 pp.

DeLancey, L.B. 1989. Trophic relationships in the surf zone during the summer at Folly Beach, South Carolina. **Journal of Coastal** Research.5, 477-488.

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Grimes, C.B., C.S. Mannoch, G.R. Huntsman. 1982. Reef and outcropping fishes of the outer continental shelf of North Carolina and South Carolina, and ecological notes on the red porgy and vermillion snapper. **Bulletin of Marine Science** 32:277-289.

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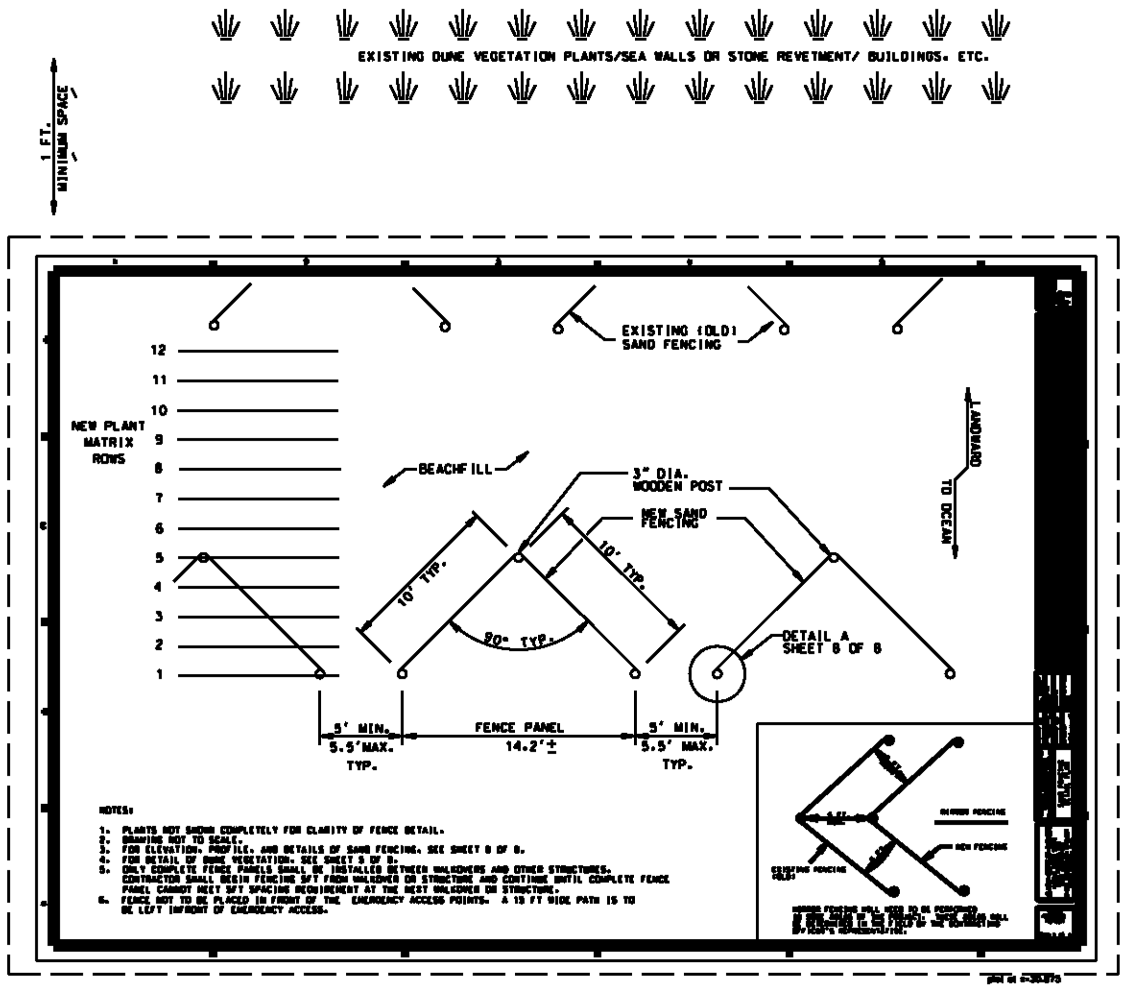
Wolcott, T.G. 1978. Ecological role of ghost crabs, *Ocypode quadrata*, on an ocean beach: scavengers or predators? **Journal of Experimental Marine Biology and Ecology**. 31, 67-82.

Appendix 10

Sand Fencing Design Drawings

NOTES:
1. DRAWING NOT TO SCALE.
2. FOR ELEVATION, PROFILE, AND DETAILS OF SAND FENCING, SEE SHEET 8.
3. FOR DETAIL OF DUNE VEGETATION, SEE SHEET 5.
4. OCEAN SIDE POST SHALL NOT BE PLACED FENCE WITHIN 5 FT OF PUBLIC OR PRIVATE WALKOVER OR STRUCTURES WHERE TURTLES COULD BE TRAPPED BY FENCING TRYING TO RETURN TO THE OCEAN.
5. ONLY COMPLETE FENCE PANELS ARE TO BE USED. WHERE FENCING IS TO BE PLACED BETWEEN WALKOVERS OR STRUCTURES, CONTRACTOR SHALL START FENCING 5.5 FT FROM WALKOVER OR STRUCTURE AND CONTINUE UNTIL COMPLETE FENCE PANEL CANNOT MEET 5.5' SPACING FROM WALKOVE

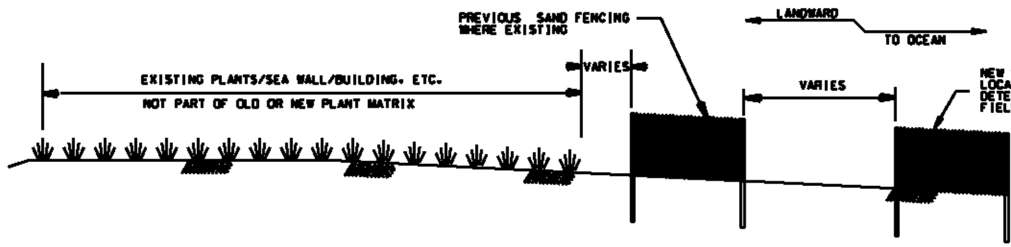
3



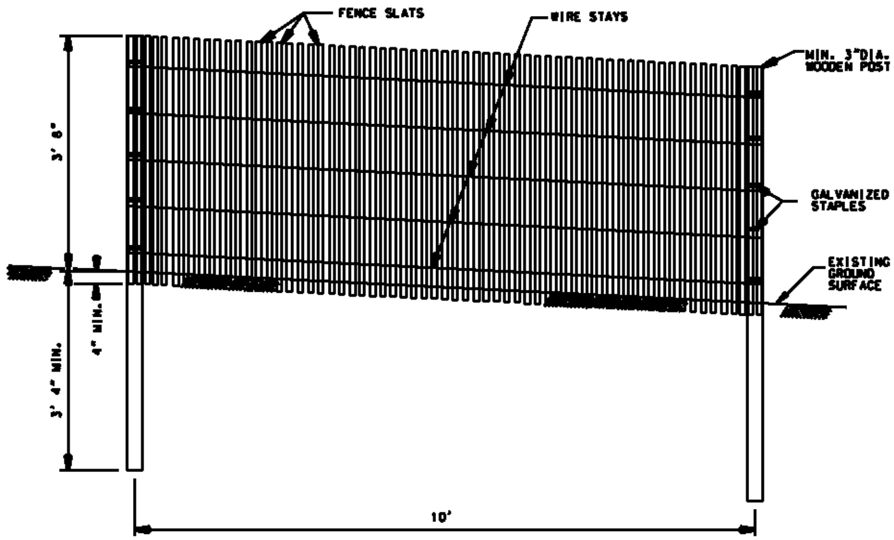
NOTES:

1. PLANTS NOT SHOWN COMPLETELY FOR CLARITY OF FENCE DETAIL.
2. DRAWING NOT TO SCALE.
3. FOR ELEVATION, PROFILE, AND DETAILS OF SAND FENCING, SEE SHEET 4.
4. FOR DETAIL OF DUNE VEGETATION, SEE SHEET 2.
5. ONLY COMPLETE FENCE PANELS SHALL BE INSTALLED BETWEEN WALKOVERS AND OTHER STRUCTURES. CONTRACTOR SHALL BEGIN FENCING 5FT FROM WALKOVER OR STRUCTURE AND CONTINUE UNTIL COMPLETE FENCE PANEL CANNOT MEET 5FT SPACING REQUIREMENT AT THE NEXT WALKOVER OR STRUCTURE.

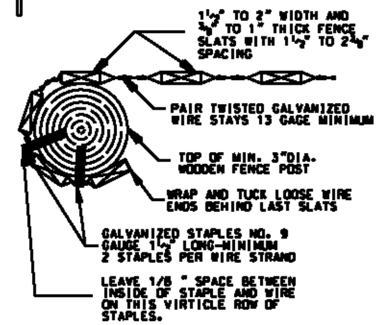
NOTE: SPACING BETWEEN FENCE PANELS CHANGED FROM 5.5FT TO 7.5FT.



FENCING AND BEACH GRASS
NO SCALE



ELEVATION -- FENCE PANEL
NO SCALE



DETAIL A
FENCE POST (TYP.)
NO SCALE

NOTE:

1. NEW PLANT MATRIX NOT SHOWN FOR CLARITY.
2. A MINIMUM OF 5 PAIRS OF GALVANIZED WIRES SHALL BE PROVIDED.
3. SAND FENCE SHALL BE PLACED IN 4" DEEP TRENCH. SAND SHALL BE PLACED BACK IN TRENCH AND COMPACTED TO EXISTING GROUND SURFACE.
4. USE 1 STAPLE PER WIRE STRAND ON MIDDLE POST.
5. ANY FENCE MATERIAL IN THE ESTIMATED QUANITY THAT IS NOT INSTALLED WILL BE TURNED OVER TO THE SPONSOR. FENCE MATERIAL WILL BE DELIVERED TO STORAGE AREA LOCATED BY THE SPONSOR.
6. DO NOT HAMMER STAPLES HARD AGAINST WIRE.
7. PROPERTY EASEMENT, CONSTRUCTION LIMITS, EXISTING FENCE POST, SWASHES, DRAIN PIPES, EMERGENCY LANE IN (REACH 2) OR EXISTING DUNE WILL DETERMINED NEW FENCE LOCATION WHICH WILL BE DETERMINED IN THE FIELD.

SAND FENCING DETAILS

07 MB fendetail-8.dgn
plot at x-30.875

Appendix 11

Scoping Letters and Other Public Comment

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
69A HAGOOD AVENUE
CHARLESTON, SOUTH CAROLINA 29403-5107

REPLY TO
ATTENTION OF

April 4, 2006

Planning Branch

Dear Ms.

The purpose of this letter is to inform you that the U.S. Army Corps of Engineers, Charleston District is planning a renourishment of an existing storm protection project along the “Grand Strand” in the vicinity of Myrtle Beach, South Carolina. This planning effort, as well as the potential, subsequent renourishment is being performed under the authority of Public Law 84-99, which allows the Corps of Engineers to perform repairs to Federally-authorized shore protection works that have been damaged by coastal storms. In addition, due to the cycle of nourishment originally calculated during authorization of this project, there is a potential that the volume of sand placed will be greater than what is authorized strictly under P.L. 84-99.

The 2005 hurricane season was unusually intense and destructive. Analysis is currently being conducted to determine whether Hurricane Ophelia caused significant erosion along the length of the federal project. If the analysis finds that significant erosion has occurred and the project meets all of the requirements of P.L. 84-99, the beach profile will be returned to the pre-storm condition. If approved for construction, it is expected that this work will be performed around September 2006.

The Charleston District prepared an Environmental Impact Statement (EIS) which was finalized in January 1993 and issued a Record of Decision in October of 1993. The planned PL 84-99 effort is the same project and should result in the same impacts to human health and the environment. The original EIS can be viewed or obtained by download from the internet at “http://www.sac.usace.army.mil/ea/”, or you can request a copy by contacting Mr. Shawn Boone by phone ((843) 329-8158), or email (shawn.a.boone@usace.army.mil). It is assumed that previous coordination regarding this project is still valid unless otherwise notified.

We want to give you the opportunity to comment on the proposed P.L. 84-99 renourishment and to provide any data that you think should be considered and incorporated. If you have any questions or require additional information, please contact Mr. Shawn Boone, as noted above. Please provide any comments by April 21, 2006.

Respectfully,

Joseph A. Jones
Chief, Planning Branch

Ms. Carolyn Boltin
Office of Ocean and Coastal Resource Management
SC Dept. of Health and Env. Control
1362 McMIllan Avenue Suite 400
Charleston, SC 29405

Dr. Rodger Stroup, Director
SHPO, SC Department of Archives
8301 Parklane Road
Columbia, SC 29223

Mr. Pace Wilber
National Marine Fisheries Services
219 Fort Johnson Road
Charleston, SC 29412-9110

Dr. Gerald Miller
EPA - Region IV
61 Forsyth Street
Atlanta, GA 30303

Mr. Tim Hall-Field Supervisor
US Fish and Wildlife Service
176 Croghan Spur Road, Suite 200
Charleston, SC 29407

Ms. Sally Murphy
SC Dept. of Natural Resources
PO Box 12559
Charleston, SC 29422

Mr. Quinton Epps, Manager
Water Qual. Cert. & Wetlands Plan. Sec.
SC Dept of Health and Env. Control
2600 Bull Street
Columbia, SC 29201

Mr. Ed Duncan
Environmental Programs Director
SC Dept. of Natural Resources
PO Box 12559
Charleston, SC 29422-2559

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
69A HAGOOD AVENUE
CHARLESTON, SOUTH CAROLINA 29403-5107

REPLY TO
ATTENTION OF

April 5, 2006

Planning Branch

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Respectfully,

Joseph A. Jones
Chief, Planning Branch

Mr. Nick Smith
Section 106 Coordinator
Shawnee Tribe
P.O. Box 189
Miami, OK 74355

Ms. Rebecca Hawkins
Section 106 Coordinator
Shawnee Tribe
P.O. Box 189
Miami, OK 74355

Mr. Willard Steele, THPO
Ah-Tah-Thi-Ki Museum
Seminole Tribe of Florida
HC-62, Box 21-A
Clewiston, FL 33440

Mr. Russell Townsend
Tribal Historic Preservation Office
The Eastern Band of the Cherokee Nation
P.O. Box 455
Cherokee, NC 28719

Mr. Tyler Howe
Tribal Historic Preservation Specialist
The Eastern Band of the Cherokee Nation
P.O. Box 455
Cherokee, NC 28719

Mr. Charles Enyart, Chief
Eastern Shawnee Tribe
P.O. Box 350
Seneca, MO 64865

Ms. Delores Herrod
Environmental Director
Kialegee Tribal Town
P.O. Box 332
Wetumka, OK 74883

Mr. Robert Thrower
Tribal Historic Preservation Officer
Poarch Band of Creek Indians
5811 Jack Springs Road
Atmore, AL 36502

Ms. Lisa Stopp
Tribal Historic Preservation Officer
United Keetoowah Band of Cherokee Indians
P.O. Box 746
Tahlequah, OK 74465

Mr. Leo Henry, Chief
Tuscarora Nation
2235 Mount Hope Road
Sanborn, NY 14132

Mr. Richard Hill, Chairperson
Haudenosaunee Standing Committee on Burial Rules and Regulations
Tuscarora Nation
2235 Mt. Hope Road
Sanborn, NY 14132

Mr. Charles Coleman
Tribal Historic Preservation Officer
Thlopthlocco Tribal Town
Rt. 1, Box 190-A
Weleetka, OK 74880

Mr.Louis McGertt, Mekko
Thlopthlocco Tribal Town
P.O. Box 188
Okemah, OK 74859

Ms. Lillie Strange
Environmental Director
Jena Band of Choctaw Indians
P.O. Box 14
Jena, LA 71342-0014

Ms. Joyce Bear
Tribal Historic Preservation Officer
Muscogee (Creek) Nation
P.O. Box 580
Okmulgee, OK 74447

Mr. Scott Miller
Section 106 Coordinator
Absentee-Shawnee Tribe of Indians of Oklahoma
2025 South Gordon Cooper Drive
Shawnee, OK 74801-9381

Ms. Josephine Yargee
Section 106 Coordinator
Alabama-Quassarte Tribe
P.O. Box 187
Wetumka, OK 74883

Dr. Wenonah G. Haire
Tribal Historic Preservation Officer
Catawba Indian Nation
P.O. Box 750
Rock Hill, SC 29731

Dr. Richard Allen
Section 106 and NAGPRA Consultant
Cherokee Nation
P.O. 948
Tahlequah, OK 74465-0948

Ms. Virginia Nail, Chickasaw Nation Historic Preservation Officer
Chickasaw Nation
Arlington at Mississippi
P.O. Box 1548
Ada, OK 74821

Mr. Terry D. Cole
Tribal Historic Preservation Officer
Choctaw Nation of Oklahoma
P.O. Drawer 1210, 16th & Locust Street
Durant, OK 74702-1201

South Carolina Department of
Natural Resources

John E. Frampton
Director

D. Breck Carmichael, Jr.
Deputy Director for
Wildlife and Freshwater Fisheries

February 7, 2007

Mr. Joseph A. Jones
Planning Branch
U.S. Army Corps of Engineers
69 Hagood Avenue
Charleston, SC 29403-5107

Attn: Shawn Boone

Re: Myrtle Beach Storm Damage Reduction Project
Georgetown and Horry Counties
FWS Log No. 2007-F0041

Dear Mr. Jones,

This letter is to provide recommendations for the scheduled Myrtle Beach Storm Damage Reduction project as it relates to sea turtle mortality in coastal waters off the counties of Horry and Georgetown. This project is proposing the use of a hopper dredge in the three borrow sites for the entire duration of the project (15 months from onset of project). Sea turtles, especially loggerheads (threatened) and leatherbacks (endangered) are abundant in waters off of Horry and Georgetown counties April through November.

While the USFWS Biological Opinion (BO) adequately addresses concerns for sea turtles while they are on the beach, the Biological Assessment (BA) provided by the USACE (2006) and the BO provided by the NMFS (1997) do not adequately address concerns for sea turtles in the water. Also, SCDHEC/OCRM Critical Area Permit regulations state that "dredging in borrow areas shall not be in conflict with spawning seasons or migratory movements of significant estuarine or **marine species** [Section 30-13. N. 2 (c)]. In addition, SCDNR and USACE have a written agreement that hopper dredges will only be used December through March in South Carolina waters (see enclosure).

According to the Endangered Species Act of 1973, Sec. 4.(a), there are five factors (A-E) that are probable cause for a species to become endangered or threatened. They are as follows:

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;
(B) over utilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms;
(E) other natural or manmade factors affecting its continued existence.

By adhering to the seasonal hopper dredge window previously agreed upon between the SCDNR and USACE, three (A, D, E) of these five factors can be avoided.

A hopper dredge should only be used from December 1 – March 31 because:

1. Loggerheads and leatherbacks are abundant in waters off Georgetown and Horry Counties from April through November.
2. The USACE BA and NMFS BO do not contain recent, available data on the spatial/temporal abundance and distribution of loggerheads and leatherbacks in South Carolina offshore waters. These data support the fact that waters in the action area are high-risk areas and dredging should only be scheduled from December through March ("cold water periods") as stated in the NMFS BO (1997).
3. Contrary to the NMFS BO, leatherback sea turtles are likely to be adversely affected by hopper dredge activities.
4. A hopper dredge was used for the initial Myrtle Beach Storm Reduction project and five loggerheads were killed while using deflecting dragheads.
5. Using a hopper dredge is in violation of SCDHEC/OCRM Section 30-13.N.2(c) because it interferes with the reproductive migration of loggerheads and the seasonal migration of leatherbacks.

The SCDNR and USACE spent a considerable amount of time in 1991 to come to an agreement concerning the temporal window within which hopper dredges are allowed in South Carolina waters. It would be in our best interests, and that of sea turtle recovery, if we would continue to abide by this agreement. This should be of interest especially to the USACE since the Hopper Dredge Protocol for the Atlantic Coast states that three "takes" ceases operations and five "takes" terminates the project. Additionally, two "takes" of an endangered species will also suspend the project, resulting in considerable lost time and expense, not to mention the loss of sea turtles to the species.

We thank you for your consideration of our recommendations and look forward to working with you on future projects. Your interest in protecting threatened and endangered species is appreciated.

Sincerely,

DuBose B. Griffin

DuBose B. Griffin, Biologist
SC Sea Turtle Program Coordinator

Cc: Melissa Bimbi
Derrell Shipes
Susan Davis
Ed Duncan
Charlotte Hope
Breck Carmichael
Robert Chappel
Alan Shirey
Robert Boyles
David Whitaker
Robert Van Dolah
Sandy MacPherson
Barbara Schroeder
David Bernhardt
Barbara Neale

Enclosures:

Letter from Lt. Colonel Mark E. Vincent to Dr. James A. Timmerman, Jr. dated September 16, 1991.

Loggerhead aerial observations (n = 286) from 2001 through 2006 during April, May and June in the action area (SCDNR, unpublished data).

Leatherback aerial observations (n = 208) from 1993 through 2006 during April, May and June in the action area (SCDNR, unpublished data).

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 919
CHARLESTON, S.C. 29402-0919

REPLY TO
ATTENTION OF

9/16/91
Copy:
Paul Sandifer
Ed Duncan
Buford Mabry
Jim Quinn
Tom Kohlsaat

September 16, 1991

Programs and Project Management
Division

Dr. James A. Timmerman, Jr.
Executive Director
S.C. Wildlife and Marine Resources
Department
Post Office Box 167
Columbia, South Carolina 29202

Dear Dr. Timmerman:

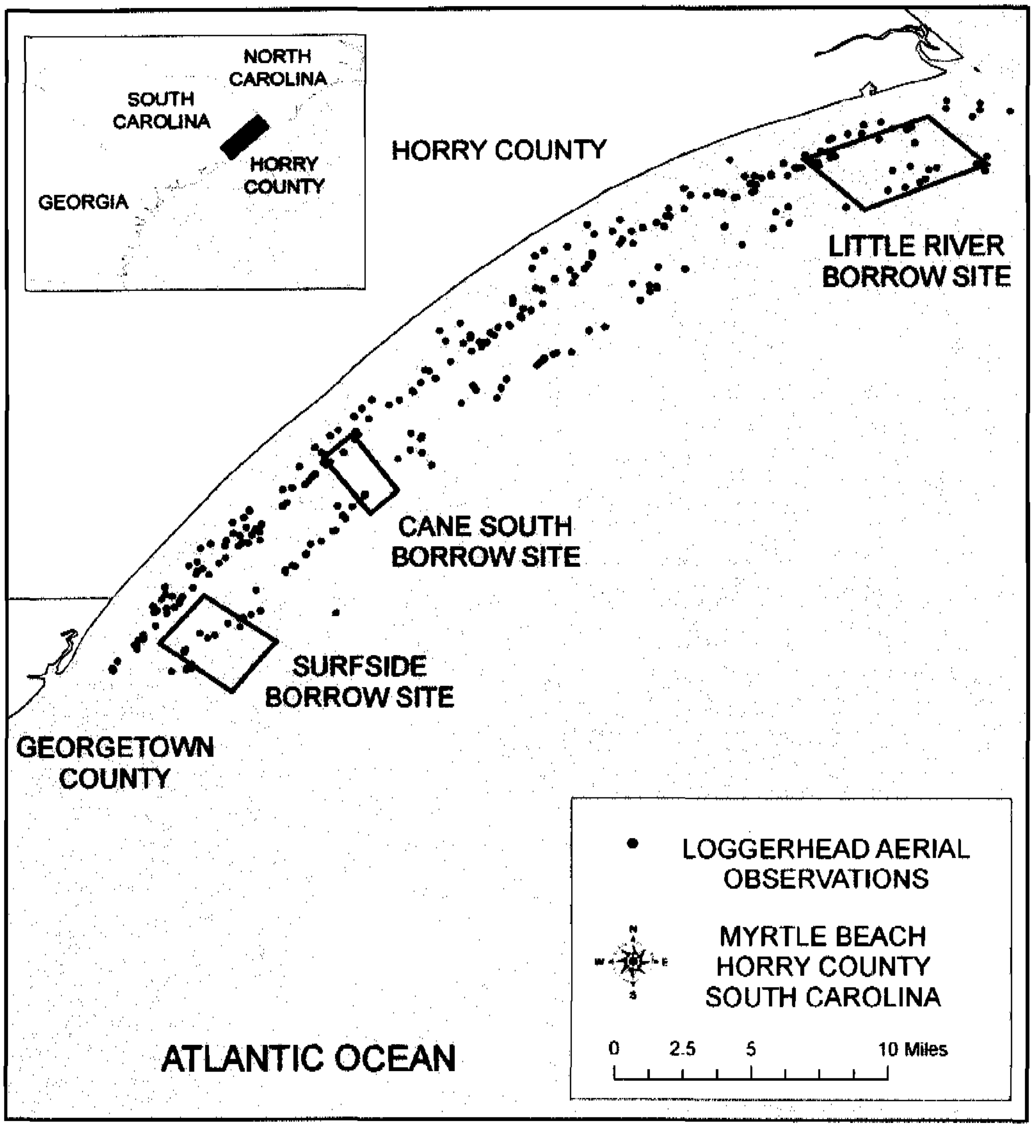
This is to inform you that the Corps of Engineers, in consultation with the South Carolina State Ports Authority, has decided not to proceed with hopper dredging in South Carolina waters until December 1, 1991. This decision should resolve the issues raised in your recent letters regarding the Charleston Harbor project.

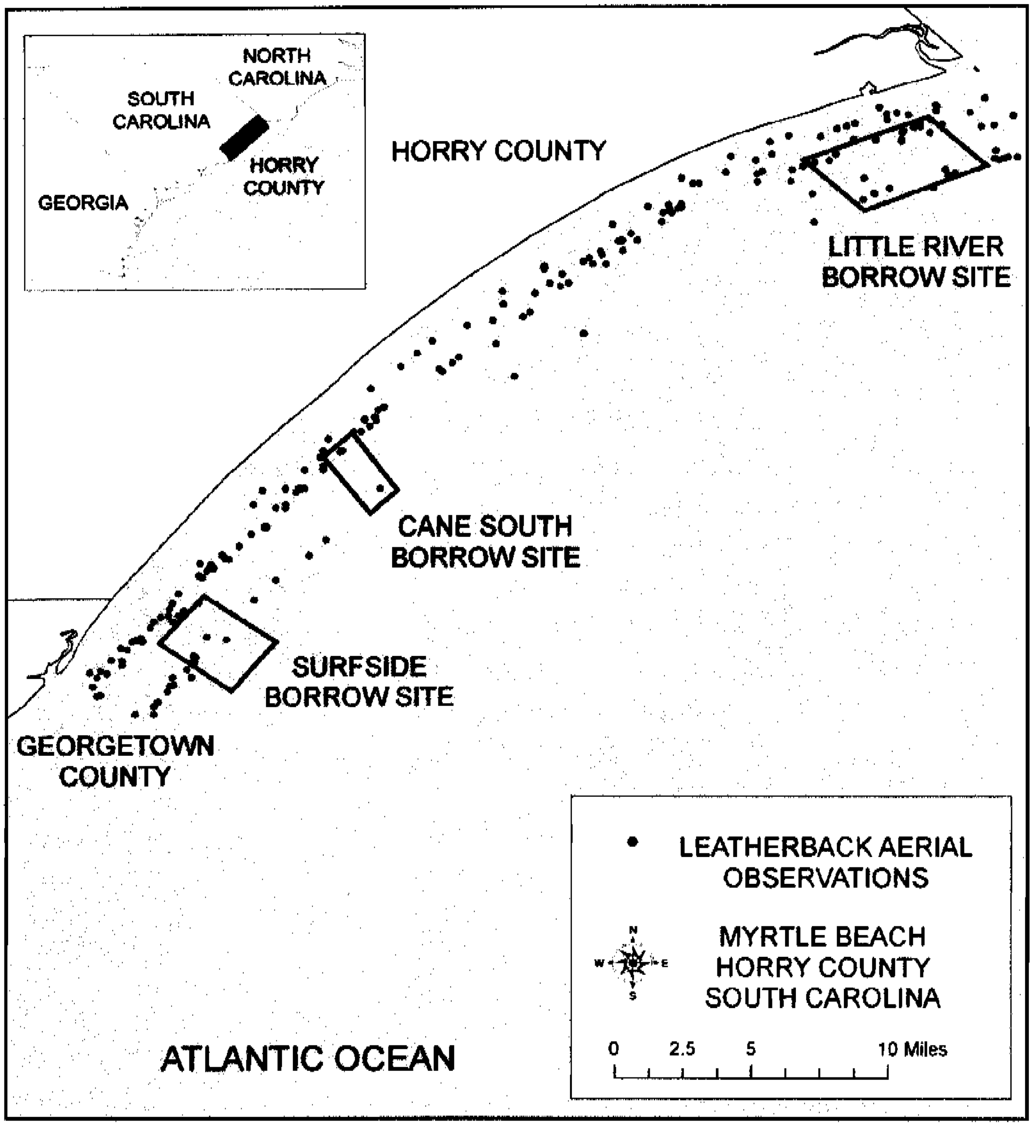
We have concluded that the overall public interest is best served by voluntarily restricting the use of hopper dredges in state waters to the 1 December to 31 March time frame as you and your staff have recommended. Unfortunately, this suspension of hopper dredging will add significant cost and time for completing the work. However, our actions afford threatened and endangered sea turtles an added measure of protection that is warranted under the circumstances.

All of us at the Charleston District office appreciate the very professional manner in which you and your staff have dealt with this complex and sensitive matter. We look forward to working closely with you in the future to bring this vital project to a successful conclusion.

Sincerely,

for Donald W. Alexander
MARK E. VINCENT
LTC, Corps of Engineers
District Engineer


NORTH CAROLINA
SOUTH CAROLINA
HORRY COUNTY
GEORGIA
HORRY COUNTY
LITTLE RIVER BORROW SITE
CANE SOUTH BORROW SITE
SURFSIDE BORROW SITE
GEORGETOWN COUNTY
ATLANTIC OCEAN
LOGGERHEAD AERIAL OBSERVATIONS
MYRTLE BEACH
HORRY COUNTY
SOUTH CAROLINA
0 2.5 5 10 Miles


NORTH CAROLINA
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HORRY COUNTY
LITTLE RIVER BORROW SITE
CANE SOUTH BORROW SITE
SURFSIDE BORROW SITE
GEORGETOWN COUNTY
ATLANTIC OCEAN
LEATHERBACK AERIAL OBSERVATIONS
MYRTLE BEACH
HORRY COUNTY
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DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
69A HAGOOD AVENUE
CHARLESTON, SOUTH CAROLINA 29403-5107

REPLY TO
ATTENTION OF

June 14, 2007

Planning Branch

Ms. DuBose B. Griffin
Sea Turtle Program Coordinator
SC Department of Natural Resources
Post Office Box 12559
Charleston, SC 29422

Dear Ms. Griffin:

The purpose of this communication is to respond to your letter dated February 7, 2007 regarding the Myrtle Beach Storm Damage Reduction Project. It is understood that the potential use of a hopper dredge, between and including the months of April and November, to perform the upcoming nourishment of the project is not preferred by the South Carolina Department of Natural Resources (SCDNR). This letter will state the reasons for considering the hopper method of dredging and address other concerns stated in the referenced letter.

The U.S. Army Corps of Engineers (USACE) makes every effort to comply with any and all legal requirements. While some may find existing Biological Opinions unsupported, outdated or otherwise wanting, they are the documents used to guide the use of specific construction devices. This policy is in accordance with the Endangered Species Act. In addition, guidelines for the granting of state permits relevant to erosion control and areas of consideration to be taken into account by the permit grantors are of concern to the Charleston District. However, the final determination in South Carolina is made by the Office of Coastal Resource Management (OCRM). OCRM has granted and reaffirmed for the pending nourishment a statement of coastal consistency.

With regard to the September 1991 letter referenced in your correspondence, there are some critical differences in the situations surrounding the operations taking place fifteen years ago and the current effort. First and foremost, the agreement pertained to dredging operations taking place in the harbor while the Grand Strand project will be nourished using an offshore borrow source. Prohibitions against hopper dredge use in the harbor, outside of the time between December 1 and March 31 continues to be enforced. Secondly, the geologic environment within the harbor is significantly different from the offshore borrow areas. Borrow sites for the Grand Strand's protection are relatively shallow sand lenses and difficult to mine by other means than a hopper dredge.

With regard to hopper dredging, there have been a number of improvements in data collection, equipment configuration and awareness education since the initial construction of the Horry and Georgetown County protective beaches. A few of these improvements are:

- Silent Inspector – allows real time monitoring and storage of drag-head movements resulting in increased accountability.
- Deflector Plate Modification
- Training and Documentation Requirements

USACE, Charleston District is very aware that "takes" of endangered and threatened species result in lost time and consequently money. Viewed in isolation, the potential of a take would be enough to deter a prudent person from pursuing the use of a hopper dredge. However, given the lengthy estimated time of construction for this project (16 months), working only within the specified window of time would result in no fewer than four starts and stops. One of the major cost elements associated with dredging operations is the mobilization and de-mobilization of equipment and crew. For this effort, the estimated costs for this element are $2.5 million. Delaying construction operations also has the effect of complicating the planning of future nourishments and impairing the function of the protective berm which could result in loss of structures.

Preservation of the environment and of endangered species is a serious concern of the Corps of Engineers. It is recognized that endeavors undertaken within the authority of the Corps of Engineers' purview have an effect on natural resources. However, the complexities of the stakeholder's interests in the project area, the State of South Carolina and the United States as they pertain to the Grand Strand Storm Damage Reduction Project are significant. The Corps prides itself on being a learning organization and is willing to listen to arguments, discuss findings and work towards solutions to complex problems.

Respectfully,

Joseph A. Jones
Chief, Planning Branch

Appendix 12

Coordination Between the Minerals Management Service and the Charleston District, Army Corps of Engineers

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
69A HAGOOD AVENUE
CHARLESTON, SOUTH CAROLINA 29403-5107

REPLY TO
ATTENTION OF

June 29, 2006

Planning Branch

Ms. Renee Orr
Minerals Management Service
381 Elden Street
Mail Stop 4010
Herndon, VA 20170

Dear Ms. Orr:

The U.S. Army Corps of Engineers, Charleston District is currently involved in the planning phase of a beach re-nourishment effort in the Grand Strand (Myrtle Beach) of Horry County, South Carolina. This endeavor is under the auspices of a congressional appropriation for the Emergency Flood Control Funds Act (Public Law 84-99) to repair damage done to Federal projects by Hurricane Ophelia during the 2005 hurricane season.

It is requested that this letter represent a formal request to initiate coordination for the purpose of entering into a Memorandum of Agreement (MOA) for the use of outer continental shelf resources, pursuant to the provisions of Section 8(k)(2)(D) of the Outer Continental Shelf Lands Act (OCSLA) (43 U.S.C. 1337(k)(2)(D), as amended by P.L. 103-4261. The estimated volume of material needed is a total of 1.5 million cubic yards of beach compatible sand.

Enclosed is a copy of the previous MOA entered into for the initial construction of the project and a map indicating the project location as well as the proposed borrow areas.

It is the goal of the Charleston District to start construction as soon as possible and anticipate an October 2006 commencement. However, this timeframe is an estimate and is subject to a number of variables including contractor availability, weather and environmental factors.

For specific information regarding this project, please contact Shawn Boone, of my staff, by phone at (843) 329-8158 or by email at shawn.a.boone@usace.army.mil .

Respectfully,

Lt Col Edward R. Fleming
Commander, Charleston District

Enclosures

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Washington, DC 20240

Mr. Thomas E. Leath
City Manager
City of Myrtle Beach
P.O. Box 2468
Myrtle Beach, South Carolina 29578

NOV 22 2006

Re: Storm Damage Reduction Project, Myrtle Beach, South Carolina

Dear Mr. Leath:

The Minerals Management Service (MMS) received your October 4, 2006, request for a negotiated lease for approximately 1,442,500 cubic yards of beach compatible sand from the Cane South Borrow Area which lies partially in Federal waters. The sand will be used to restore Reach Two of the Myrtle Beach-Horry County Storm Damage Reduction Project scheduled to begin in the spring or summer of 2007.

After review of the information you and the U.S. Army Corps of Engineers provided, we have determined that the City of Myrtle Beach qualifies for a negotiated lease agreement for the identified sand sources for the proposed project. This determination is based on the public accessibility of the project and that it will be funded from local, State, and Federal monies.

There are certain requirements that will need to be completed prior to the issuance of a negotiated lease to fulfill our National Environmental Policy Act (NEPA) responsibilities. We are presently cooperating with the U.S. Army Corps of Engineers (Corps) in the preparation of an Environmental Analysis (EA) for the project which includes use of the sand from the borrow areas under our jurisdiction. As part of the NEPA process the Corps is conducting the required Essential Fish Habitat consultation, with NOAA Fisheries as well as the Section 7 endangered species consultations with the Fish and Wildlife Service and NOAA Fisheries; some of the information from these consultations will likely become terms and conditions attached to the lease document. Once the draft EA is prepared, we will provide you and the Corps with a copy for review. A schedule for review and approval of the requested negotiated agreement is attached.

In addition to the above, we also have to consider seabed hazards and protection of any archaeological resources that might lie within the boundary of the borrow areas. It is our understanding, from talking to the Corps representative, that these surveys are now underway and that a report with the data and findings will be available for review by our staff archaeologist prior to issuance of the lease.

TAKE PRIDE IN AMERICA

RECEIVED
NOV 27 2006
CITY MANAGER'S OFFICE

We look forward to working with you on this project. If you have any questions, please do not hesitate to call me at (703) 787-1215, or Roger Amato of my staff at (703) 787-1282.

Sincerely,

L. Renee Orr
Chief, Leasing Division

Attachment

Tentative Schedule for Completion of an MOA and Negotiated Lease Agreement with Horry County and the Cities of Myrtle Beach and North Myrtle Beach, South Carolina

MILESTONE	TARGET DATE
Requests for OCS sand received from Horry County And Cities of Myrtle Beach and North Myrtle Beach	October 9, 2006
Initiate Informal EFH and Section 7 Consultations with NOAA Fisheries and the Fish and Wildlife Service (USACE)	underway
Complete MOA with USACE	December 4, 2006
Conduct Air Quality Conformity Determination	December 29, 2006
Receive Biological Opinions and Conservation Recommendations from NOAA and the F&WS	January 15, 2007
MMS Completes Archaeological Review	January 21, 2007
Complete Draft EA (USACE)	January 30, 2007
MMS completes review of EA	February 15, 2007
MMS Incorporates Opinions and Recommendations As terms and Conditions of the Lease	February 15, 2007
MMS Sends Draft Lease to USACE, Horry County, and Cities of Myrtle Beach and North Myrtle Beach	February 21, 2007
MMS receives Comments on Draft Lease	March 7, 2007
MMS Sends Final Lease Agreements to Horry County and Cities of Myrtle Beach and North Myrtle Beach	March 15, 2007
MMS Sends Letter to Congressional Committees	March 31, 2007
USACE Begins Sand dredging Operations	June 2007
MMS Receives Post-Dredging Surveys from USACE	30 days after completion of project

**MEMORANDUM OF AGREEMENT
BETWEEN
THE MINERALS MANAGEMENT SERVICE
OF THE DEPARTMENT OF THE INTERIOR
AND THE CORPS OF ENGINEERS
OF THE DEPARTMENT OF THE ARMY**

Title I. <u>Purpose and Authority</u>

A. Under the authority of Section 8(k)(2)(A)(i) of the Outer Continental Shelf Lands Act (OCSLA) (43 U.S.C. §§ 1331–1356a, Pub.L. No. 95-372, as amended by Pub.L. No. 103-426), the Department of the Interior's (DOI) Minerals Management Service (MMS) and the Department of the Army's Corps of Engineers (USACE), enter into this Memorandum of Agreement (MOA) for the use of Federal sand resources on the Outer Continental Shelf (OCS) for the Myrtle Beach Storm Damage Reduction Project, herein referred to as the "Project," for Horry County and the cities of Myrtle Beach and North Myrtle Beach, South Carolina.

B. The purpose of this MOA is to establish procedures to ensure timely coordination and cooperation between MMS and the USACE as each carries out its specific responsibilities related to the use of Federal OCS sand resources for the Project.

C. The MMS, under the authority delegated by the Secretary of the Interior, is authorized, pursuant to Section 8(k)(2)(D) of the OCSLA (43 U.S.C. § 1337 (k) (2)(D)) to enter into an MOA with any Federal agency that proposes to make use of certain specified minerals (including sand), subject to the provisions of the OCSLA.

The MMS has determined that the Project meets the requirements of Section 8(k) (2) (A) (i) of the OCSLA. Therefore, in accordance with Section 8(k)(2)(D), the MMS authorizes the use, and establishes the terms and conditions for any use, of Federal OCS sand resources identified for the construction of the Project.

Nothing in this MOA is intended to abrogate or diminish the Secretary of the Interior's authority under the OCSLA to oversee and regulate the removal of Federal sand resources from the OCS.

Title II. <u>Project Description</u>

A. The USACE is undertaking this project under Section 101 of the Water Resources Development Act of 1990 (Pub. L. No. 101-640) and Emergency Flood Control Funds Act (Pub. L. No. 84-99) appropriations to repair damage done to Federal projects by Hurricane Ophelia during the 2005 hurricane season.

B. The USACE Charleston District anticipates placing approximately 3 million cubic yards of sand along 3 reaches of the beach to restore them to the Project design specifications. The sand for the Project will come from 3 borrow areas that straddle the 3-nautical mile line from the shore. These are the Surfside, Cane South, and Little River borrow areas (see chart below).

Northing	Easting	Lat. (Degrees)	Long. 83 (Degrees)	Lat. (Decimal)	Long. (Decimal)	Borrow Area
639.246	2623.249	33 34 24.0708	78 57 12.0636	33.573353	78.953351	Surfside
630.581	2635.071	33 32 56.0076	78 54 54.5076	33.548891	78.915141	Surfside
620.845	2628.043	33 31 21.0828	78 56 19.7448	33.522523	78.938818	Surfside
629.232	2616.232	33 32 53.3796	78 58 37.1496	33.548161	78.976986	Surfside
670.935	2646.540	33 39 32.9173	78 52 29.0976	33.659144	78.874749	Cane South
660.021	2654.062	33 37 43.0477	78 51 02.7967	33.628624	78.850777	Cane South
655.536	2649.791	33 36 59.9141	78 51 54.4014	33.616643	78.865112	Cane South
666.291	2641.959	33 38 47.9036	78 53 24.4137	33.646640	78.890115	Cane South
734.282	2738.026	33 49 39.6189	78 34 09.2403	33.827672	78.569233	Little River
725.110	2747.711	33 48 06.6224	78 32 17.0394	33.801840	78.538067	Little River
715.809	2726.152	33 46 39.6245	78 36 35.0437	33.777673	78.609734	Little River
725.633	2718.229	33 48 18.6076	78 38 06.2349	33.805169	78.635065	Little River

Title III. Provisions

A. This MOA applies only to the initial construction of the Project described above. It is acknowledged that there is a potential need for future Federal OCS sand for periodic nourishment. It is intended that USACE and the MMS enter into subsequent MOAs, as required in the future, and consistent with the responsibilities of the Secretary of the Interior under the OCSLA and other Federal laws, for the continued use of Federal OCS sand for such periodic nourishment.

B. The MMS and USACE recognize that planning and coordination between the two agencies will ensure that responsibilities under the OCSLA, other Federal laws, and this Congressionally-authorized Project are carried out and accommodated in an efficient and timely manner so that the project schedule will not be unnecessarily delayed or compromised. Both parties also recognize that the MMS, as a bureau in the DOI, has certain stewardship responsibilities for the orderly, timely, and efficient recovery of OCS minerals using the best available technology while ensuring environmental compliance. To that end, with respect to the Project, USACE and the MMS agree to the following:

1. Notification of OCS Activity near the Borrow Areas

The MMS will notify the USACE in a timely manner of any OCS activity within the jurisdiction of the DOI that may adversely affect the USACE's ability to use the Federal OCS sand resources for the Project.

2. Environmental Compliance and Studies

The USACE will provide the MMS with all non-privileged documents which contain environmental information and analyses with respect to the Project.

All the requirements of the National Environmental Policy Act (NEPA) will be met relative to DOI's stewardship responsibilities for mineral resources under its jurisdiction and its specific responsibilities under Section 20 of the OCSLA (43 U.S.C. § 1346). This will include a National Oil and Hazardous Substances Pollution Contingency Plan, completion of an archeological survey and report, and all consultations for endangered and threatened species and essential fish habitat. All environmental studies for the commencement of this Project will have been completed within the required time.

3. Pre- and Post-Bathymetry Surveys

The USACE will provide the MMS with pre- and post-bathymetric surveys of the designated borrow areas. This data will be submitted to the MMS within thirty (30) days after the post-project survey is completed. The recommended delivery format for submission is ArcGIS geodatabase. All geospatial data should be submitted in North American Datum 1983 Geographic and Universal Transverse Mercator grid. The data are to be accompanied by complete metadata documentation in the Federal Geospatial Data Committee Content Standard for Digital Geospatial Metadata format, which can be found on the Internet at http://fgdc.er.usgs.gov/. The data shall be collected in such a manner that the post-dredging bathymetry survey is compatible with the pre-dredging bathymetric survey data to enable the latter to be subtracted from the former to calculate the volume of sand removed and the shape of the excavation.

4. Electronic Positioning System

In order to ensure the accuracy of the dredge relative to the borrow area specified in the lease agreement, the USACE will ensure that the dredge is equipped with an onboard differential global positioning system (DGPS) capable of maintaining and recording the location of the dredge within an accuracy range of no more than plus or minus 3 meters during all phases of the project. The DGPS will be approved by the MMS prior to the conduct of any dredging within the borrow area.

5. Ordinance Reporting Requirement Plan

If any ordinance is encountered while conducting sand dredging activities within the Project area, the USACE will report the discovery in a timely manner to Ms. Renee Orr, Chief, MMS Leasing Division, at (703) 787-1300.

6. Submittal of Production and Volume Information

Following completion of all activities authorized under this MOA, the USACE, in cooperation with the dredge operator, shall submit to MMS a certified copy of the complete operational data set (dredge head tracklines, cut slope angles, cut depth, etc.), outlining any deviations from the original operational design plan. This report should be sent to Ms. Renee Orr, Chief, MMS Leasing Division, 381 Elden Street, MS 4010, Herndon, Virginia 20170. The report shall be submitted within 120 days following completion of the activities authorized under this MOA.

7. Project Completion Report to the MMS

Upon final completion of the activities authorized under this MOA, the USACE will submit to the Minerals Management Service, Chief, Marine Minerals Branch, 381 Elden Street, MS 4010, Herndon, Virginia 20170, 1 paper copy and 1 electronic copy of a project completion report. The report shall contain, at a minimum, the following information:

- the names and titles of the project managers overseeing the effort (both for USACE and the dredging/engineering firm), including contact information (phone numbers, mailing addresses, and email addresses);
- the location and description of the Project, including the final total volume of material extracted from the borrow areas and the volume of material actually placed on the beach or shoreline (including a description of the volume calculation method used to determine these volumes);
- a narrative describing the final, as-built features, boundaries, and acreage, including the restored beach width and length;
- a table, an example of which is illustrated below, showing the various key project cost elements;

	Project Cost Estimate ($)	Cost Incurred as of Construction Completion ($)
Construction		
Engineering and Design		
Inspections/Contract Administration		
Total		

- a table, an example of which is illustrated below, showing the various items of work construction, final quantities, and monetary amounts;

Item No.	Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Final Quantity	Bid Unit Price	Final Amount	% Over/ Under
1	Mobilization and Demobilization								
2	Beach Fill								
3	Any beach or offshore hard structure placed or removed								

- a listing of construction and construction oversight information, including the prime and subcontractors, contract costs, etc.;
- a list of all major equipment used to construct the Project;
- a narrative discussing the construction sequences and activities, and, if applicable, any problems encountered and solutions;
- a list and description of any construction change orders issued, if applicable;
- a list of any pipelines or other oil/gas-related infrastructure in the Project area, the owners, and any contacts made;
- a list and description of any safety-related issues or accidents reported during the life of the Project;
- a narrative and any appropriate tables describing any environmental surveys or efforts associated with the Project and costs associated with these surveys or efforts;
- a table listing significant construction dates beginning with bid opening and ending with final acceptance of the Project by Horry County and the cities of Myrtle Beach and North Myrtle Beach;
- an appendix containing the as-built drawings, beach-fill cross-sections, and survey data;
- any additional pertinent comments.

The report shall be submitted within 120 days after completion of the activities authorized under this MOA.

8. Sharing of Information

Consistent with the purpose stipulated by both agencies in Title I, Part B., the USACE and the MMS agree to: (1) share all information needed for or generated from the Project, including the sharing of implementation and other applicable schedules; (2) provide such information to the requesting agency as expeditiously as possible; and (3) work collaboratively to ensure that all required completion report information is received.

9. Resolution of Disputes

In the case of a substantial disagreement between USACE and the MMS with respect to any aspect of or decision to implement the Project, the undersigned will designate a senior management official in their respective agencies to determine an appropriate course of action, including a firm and expeditious schedule, to resolve such disagreement.

10. Effective Date

This MOA will become effective when signed by the Chief, Leasing Division of the MMS and the Assistant Secretary of the Army (Civil Works). This MOA my be amended or revoked at any time by mutual agreement between the agencies, and expires upon completion of the project.

L. Renee Orr
Chief, Leasing Division
Minerals Management Service
Department of the Interior

Date: 1/30/07

Edward R. Fleming
Lieutenant Colonel, U.S. Army
District Commander
Corps of Engineers

Date: 19 January 2007