Section 3

Project Design

3.0 PROJECT DESIGN

Development of the proposed Project involved analyses of a broad spectrum of alternatives, including various beach nourishment designs, stand-alone beach nourishment, beach nourishment with the creation of a vegetated dune, beach nourishment combined with bank stabilization, and beach nourishment with geotextile tubes and groins. See Section 2.0 for a thorough analysis of all Project alternatives. The preferred design is one that places a substantial volume of beach-compatible sand along the Project shoreline to build a wide, high beach that protects the eroding Coastal Bank and threatened upland properties and structures.

In addition to beach nourishment, which is the primary element of the proposed Project, the following components are also proposed: (1) installation of up to 6,100 feet of geotextile tubes at the toe of Coastal Bank to enhance bank stability in areas of erosion by providing storm protection for the toe of bank; (2) construction of up to 13 groins to slow the loss of sand from erosion hotspots; and (3) bank stabilization through terracing and re-vegetation (see Section 2.8). As demonstrated in Section 2.0, none of these measures taken alone would satisfy the Project's objectives; however, as components of a multi-faceted shoreline management strategy, they provide enhanced protection from storms and help preserve the non-sacrificial portion of the nourished beach while providing more sand to the littoral drift system both north and south of the Project area.

3.1 Site Description

Sconset Beach is located along the eastern shoreline of Nantucket Island, which lies approximately 28 miles south of Cape Cod, Massachusetts. The village of Sconset was first settled three centuries ago as a whaling outpost. In 1850, the Sankaty Head Lighthouse was built at the top of the Coastal Bank overlooking the Atlantic Ocean. This historic lighthouse still stands today, serving as an active aid to navigation. The present-day village almost exclusively consists of private homes, many of which date back to fishing shanties from the 17th and 18th centuries. Much of the village is located along the Sankaty Bluff, which rises nearly 90 feet above the beach and Atlantic Ocean. To the north and south, this Coastal Bank tapers down in elevation until it gives way to Coastal Dune. Coastal Beach fronting the bank and dune resources is relatively narrow, providing little protection from storms. Shoreline change and bank retreat data show that erosion at Sconset Beach has increased significantly in recent years. Over the last 15 years, average annual retreat rates for the bank and dune were 3 feet and 10 feet, respectively, while during the winter of 2005 these resources experienced localized erosion of 5-10 feet and 40-60 feet.

3.1.1 Wetland Resource Areas

The Project is located in a highly-dynamic coastal environment. Wetland resources in the Project area include Coastal Beach, Coastal Bank, Coastal Dune (primarily in the vicinity of Codfish Park), Land Under the Ocean (subtidal), Land Containing Shellfish, and the overlay protected areas of Land Subject to Coastal Storm Flowage and Estimated Habitats for Rare Wildlife (for coastal wetlands) (see Figures 3-1 through 3-3). Coastal Beach is relatively narrow in the northern and central portions of the Project area, and gradually widens southward toward Codfish Park. Coastal Bank has the greatest vertical extent (approximately 90 feet) in the central portion of the Project area and gradually decreases in height to the north and south. This bank is relatively steep along its entire expanse; as a result of undercutting at the toe, some portions of the Coastal Bank are over-steepened to the point where they are nearly vertical, making the bank particularly susceptible to collapse. Wetland resource areas and wetland overlay protected areas are discussed in further detail in Section 6.2.1.

3.1.2 Habitat Areas

Depending on the season, coastal wetland resources in the Project area provide wildlife habitat in a diverse coastal ecosystem populated by upland and marine mammals, shorebirds (including listed species), intertidal and nearshore benthic organisms (e.g., mole crabs and other shellfish and benthic invertebrates), and surfzone finfish and ichthyoplankton (i.e., fish larvae).

The beach and dune areas south of Sankaty Head Lighthouse and the barrier beach fronting Sesachacha Pond are mapped as potential habitat for listed species, specifically the Piping Plover (*Charadrius melodus*) and Least Tern (*Sterna antillarum*) (see Figure 3-3). The Proponent anticipates conducting frequent monitoring for these two species in the Project area commencing one week prior to and extending through the nesting season (April 1 to Labor Day) when work is ongoing. Monitoring performed by the Proponent over the past several years has not identified any nesting of these two species from a point north of Sankaty Head Lighthouse to just north of Codfish Park. Nests have been observed in the northernmost portion of the Project area near Sesachacha Pond and also south of Codfish Park at Low Beach (see Section 4.7).

Similar beach nourishment projects and subsequent monitoring efforts have demonstrated that nourished beaches can provide suitable nesting and rearing habitat for Piping Plovers and Least Terns, and the nourished beach proposed for this Project could similarly be expected to expand and restore nesting habitat (NRC, 1995). The National Research Council (1995) specifically identifies beach nourishment efforts on Cape Cod as successfully improving the quality and availability of Piping Plover habitat by creating higher, wider, and less vegetated beach habitat. While beach nourishment construction activities can be detrimental to Piping Plovers during nesting and before chicks fledge, adhering to a construction schedule between the end of May and November while adopting appropriate construction methodologies and avoiding nesting birds can effectively mitigate this risk while providing feasible construction conditions. Time-of-year restrictions are discussed in greater detail in Sections 4.5.1.1 and 5.1.2, while details regarding the construction schedule are addressed in Section 3.4.

3.2 Preliminary Project Design

3.2.1 Nourishment

Beach nourishment is defined as the introduction of sediment to a beach to compensate for a natural or anthropogenic deficit and is the environmentally-preferred alternative to coastal erosion problems. Beach construction is characterized by the placement of beach-compatible sediment directly on an eroding shoreline to restore its form and subsequently maintain an adequate beach width. Nourishment is often referred to as the soft solution since this technique can mimic the natural process of sediment addition to the beach system. Obtained from sources outside the nearshore coastal system, nourishment material allows some flexibility for beach adjustment during storms and times of elevated sea level. The goal of beach nourishment is a combination berm and dune restoration, which equilibrates over time to design conditions that blend with the natural surroundings.

The Project's proposed nourishment area extends along 3.6 miles of shoreline beginning near Sesachacha Pond and stretching south past the Sankaty Head Lighthouse to 300 feet south of the Town Sewer Beds (south of Codfish Park) (see Figure 1-1). The design calls for 2.9 miles of primary beach nourishment coupled with 0.7 miles (3,500 feet) of dune nourishment. The longer section of primary beach nourishment extends from the pond to a point just south of Gully Road, where the Coastal Dune begins to widen considerably. The dune nourishment portion of the Project spans an area south of Gully Road to protect the area containing the Town Sewer Beds. See Section 3.4 for a comprehensive discussion of construction methodology.

Two primary components comprise the beach nourishment template: the design fill and the advance nourishment. The design storm profile will be built directly against the toe of the Coastal Bank and across the existing beach face, while the advance nourishment profile will be placed seaward. Figure 3-4 illustrates the plan view of the Project design across the entire shoreline, while a series of accompanying cross-sections are provided in Figure 3-5. The design storm profile is intended to provide adequate protection against the combined storm surge and waves from a severe (i.e., 50-year) storm. Meanwhile, the advance nourishment profile is intended to avoid loss of the design beach for the projected design life of the Project. This portion of the nourished beach is considered sacrificial, and will erode over time due to natural ongoing processes; therefore, the advance nourishment portion of beach can be viewed as a direct input to the littoral system. Once erosion begins to impact the design storm profile, the beach will not provide its intended level of protection to landward resources, and renourishment will occur. Efforts proposed to monitor the evolution of the design beach and advance nourishment profile are presented in Section 5.2.

Using these criteria, the storm profile for the Sconset beach nourishment has been designed with a berm width of 100 feet and a berm elevation of 12 feet MLW (see Figures 3-4 and 3-5). The advance nourishment profile will extend seaward an additional 100 feet at the same 12-foot MLW elevation. The seaward face of the beach fill will then slope down at a

1V:10H slope, mimicking the natural slope of the beach face. This beach slope will begin at the 12-foot berm elevation and extend to the existing grade.

A 4-foot-high, 50-foot-wide dune has been added on top of the berm to protect the Coastal Bank during low-frequency storm events (see Figures 3-4 and 3-5). Construction of a storm profile coupled with placement of advance nourishment is proposed along the entire stretch of beach nourishment, while the southernmost portion of the Project includes only dune nourishment. Dune nourishment will create a 125-foot-wide dune extending from 10 feet MLW to an elevation of 16 feet MLW. The dune is designed to reduce overtopping during low-frequency storm events along the length of the Project.

Increasing the elevation of the dune will result in coverage of existing vegetation in some areas of the Project. While the Proponent has sought a design that minimizes impacts to existing vegetation, some coverage is required for two primary reasons. First, the dune should only be impacted during low-frequency (i.e., high intensity) storm events, and so must be set back from the berm crest; the distance between the toe of dune and the berm crest should generally be more than 75 feet. Second, it is not advisable to construct a swale (i.e., a depression) on the landward side of the Coastal Dune; during an intense storm event the dune may be washed into this depression, burying existing vegetation anyway. As stated previously, it is preferable to place the dune as far landward as possible.

The Project requires a total of approximately 2.6 million cubic yards of beach-compatible material to fill the construction template, which has been based on the design section, design life, and economic considerations. A summary of the primary design parameters associated with the nourishment components of the Project are shown in Table 3-1. Section 3.4 presents the proposed construction methodologies and schedules for the various Project components; this section describes specific equipment that may be used by contractors during construction and presents strategies that will be employed to achieve the nourishment design.

Pre- and post-construction surveys will be performed to determine the volume of nourishment material placed within the construction template (see Section 5.2). In addition, daily engineering reviews of the Project's progress will ensure that beach fill is graded to the appropriate design slope and that grain size compatibility is maintained. Daily construction observations will involve measurements of the berm and dune widths to ensure that the permitted Project is constructed to specifications.

Table 3-1 Nourishment design parameters.

Project Component	Length (feet)	Location	Design Width/Elevation	Advance Nourishment Width/Elevation	Volume (cy)
Beach & Dune Nourishment	15,100	Sesachacha Pond to Gully Road	100-foot berm at 12 feet MLW; 50-foot dune at 16 feet MLW	100-foot berm at 12 feet MLW	2.6 million
Dune Nourishment only	3,500	South of Gully Road/Town Sewer Beds	125-foot dune at 16 feet MLW	N/A	

3.2.2 Groins

The current preferred Project design includes up to thirteen (13) groins intended to retain beach nourishment sand along the Project shoreline. These groins are coupled with the placement of a significant volume of nourishment fill, which will markedly increase the sand supply in the longshore transport system. In addition to direct benefits for the Project shoreline, therefore, the Project is expected to benefit beaches to the north and south of the nourishment template. The groins are proposed to enhance the effectiveness and longevity of the nourishment effort. They have been designed to protect the design storm profile as well as a portion of the sacrificial advance nourishment by slowing erosion of sediment from within the Project area. The inclusion of groins will reduce the volume of sand required for the initial nourishment Project and will moderate the frequency of renourishment. As a result, inclusion of the proposed groins as a Project component minimizes the size of the borrow site required to supply the Project and reduces the footprint of the nourishment area.

As presented in Section 2.3.3, increasing the number of groins and decreasing the spacing between the structures decreases the beach fill volume required for a nourishment project while effectively retaining sediment in the presence of strong currents and an energetic wave climate. Constructing a denser groin field also results in a steeper beach face. Though there is little engineering guidance on estimating the steeper beach face caused by a denser groin field, it is well documented that groin spacing is one of the factors governing change in shoreline shape and beach elevation. In the case of this Project, while the preferred design incorporates up to 13 groins, installing a series of up to 40 groins would better retain the nourished beach material by deflecting strong nearshore currents away from the shoreline. In addition to acting as a barrier to longshore transport, the increased number of groins would limit the cross-shore sediment transport associated with equilibration of the fill material. Since less nourishment material would be needed to create the steeper beach profile, a lower volume of fill would be required to achieve the design beach width. In the case of such an alternative, the groins would be shortened to

220 feet and spaced at approximately 300-foot intervals. Since less fill would be placed in the Project area, a longer section of beach would be protected by the groins; the groin field would extend an addition 0.5 miles north and south of the preferred groin field shown on Figure 3-4.

Coastal engineering modeling is underway to integrate the beach nourishment design template with groin characteristics to provide the required storm protection. Modeling results will enable the Proponent to identify the appropriate number, size and location of groins which will optimize the beach nourishment template by minimizing the volume of sand required for an effective Project and maximizing retention of the design profile. The proposed groins will be located completely within the beach nourishment portion of the Project, north of the Coastal Dune, in an area characterized by Coastal Beach directly abutting Coastal Bank (see Figures 3-1 and 3-4). The absence of Coastal Dune in this area, along with wave modeling results, indicates that this stretch of shoreline experiences high wave energy and is consequently a hotspot for sediment transport and shoreline erosion.

The groins will be placed in the vicinity of the nodal point, where longshore transport occurs in both directions, resulting in erosion hotspots. By slowing the loss of beach nourishment material from these hotspots, groins are intended to increase the Project's longevity and decrease the frequency of renourishment. Specific siting design for the groins will be achieved by utilizing results from ongoing efforts to monitor pre-construction conditions and model physical processes; while groins are shown schematically on Figure 3-4, specific groin characteristics will be proposed in the FEIR.

The preliminary preferred design for the groins calls for up to 13 structures constructed in areas of enhanced erosion. The current design proposes to begin the landward portion of the groins at the edge of the Coastal Bank and extend seaward at an elevation of 12 feet MLW. This landward portion will segue into a section sloping down to the storm profile and tapering to the elevation of MLW. Additional groin segments will extend seaward at the elevation of MLW. The groins should extend offshore so that the ends of the structures are located at least within the wave-breaking zone during a typical storm event. Based on this design, the total length of each structure is expected to be 270 feet as measured from the toe of the Coastal Bank. By proposing a groin field consisting of up to 13 structures, the length of each individual groin can be minimized and the width and volume of the beach nourishment envelope can be reduced. Proposed groins will be nearly completely covered by sediment after the initial beach nourishment, and much of the structures will be covered with sand during the design life of the nourished template. By installing the groins to elevation 12 feet MLW, the structures will also initially be covered by sediment within the design storm profile. The groin design is shown in cross-section on Figure 3-5 (Sheet 8 of 9).

The groins will be spaced approximately 500 feet apart. While the proposed groins will be 270 feet long from the landward to seaward ends, there is an effective groin length used from a design standpoint. Standard coastal engineering design is for the distance between groins to be approximately 2-3 times the groin length as measured from the berm crest to the end of the structure; in this case, "groin length" is 180 feet.

The proposed groin design is a pile and panel groin with a rubble-mound head. This design minimizes the footprint of the groin while still retaining sand along the beach. Constructed of wood, the groin stem can be modified or removed as necessary. Due to the energetic wave climate and strong currents within the Project area, a rubble-mound head is proposed at the seaward end of each groin. Without a rubble-mound head, the seaward ends of the structures would experience scour and cause failure of the groin. The rubble-mound head will absorb wave impacts at the most susceptible portion of the structure, and the rubble-mound component also reduces rip currents that can form along the groin stem.

The piles will be 30-foot pressure treated piles spaced at four-foot intervals alternating on either side of the groin. Wooden panels will extend 10 feet down from the top of the structure. These panels will be held between three wales running the length of the groin and will be nailed to the wales using clinched nails. The 6"x6" wales will be bolted to the piles using stainless steel bolts.

The rubble-mound groin head will be constructed of 160 pcf minimum stone weighing from 4-7 tons. The top layer of stone will follow the standard coastal engineering design of a 3 stone crest width and will have 1V:2H side slopes. The crest of the structure will be at Mean Low Water, a design which reduces the size and number of stones required for the structure while still providing protection to the end of the wooden groin stem. The armor stone will be supported on a marine mattress foundation.

A marine mattress foundation is a one-foot-thick compartmentalized geo-grid that is typically about 35 feet long and 5 feet wide. Each cell extends the width of the mattress and is filled with stones between two and six inches in diameter. Geotextile fabric will be attached to the bottom of the mattress to prevent piping or settlement. Each 35-foot-long mattress can be moved easily, so mattresses will be constructed offsite, barged to the Project area, offloaded and placed within the groin footprint. Mattresses will extend five feet beyond the toe of armor stone to provide scour protection. Designed to bend, the mattresses will conform to any scour holes that may be created, which will reduce additional scour.

The tapered profile of the groins has been designed to template the beach nourishment, extend the Project's design life in erosion hotspots, and minimize the nourishment footprint and downdrift impacts. Since the proposed groins are only composed of foundation mattresses and armor stones, their elevation can be altered by removing armor stones, if necessary.

Monitoring of the groins will be achieved in conjunction with the overall physical monitoring of the Project; as such, inspections will extend along the shoreline to the north and south to ensure that the structures do not impede longshore sand transport to such an extent that adjacent shorelines are adversely impacted. By monitoring the entire beach system to determine whether a significant, long-term difference in the beach occurs downdrift of the groins, the Proponent will be able to identify whether any beach losses are related to the groins; if so, the structures will be modified accordingly.

3.2.3 Geotextile Tubes

Geotextile tubes, to be buried in the Coastal Beach along the toe of the Coastal Bank, are included in the Project design to protect the toe of the bank from wave scour and scarping in the event of a severe (i.e. 50-year) storm or a rapid series of smaller storms occurring at a time in the Project cycle when renourishment is required. This is the only scenario in which the tubes are anticipated to be exposed. The geotextile tubes will be located along the Project shoreline at the toe of Coastal Bank where erosion is occurring and landward resources are threatened (see Figures 1-2 and 3-4). Due to the absence of Coastal Dune along this stretch, the Coastal Bank will be vulnerable to erosion during severe coastal storm events without the proposed geotextile tubes.

The geotextile tubes are intended to protect up to 6,100 linear feet of Coastal Bank. Most of the geotextile tubes are proposed seaward of properties containing buildings constructed prior to 1978, and are hence permittable per the state and local wetland regulations (see Section 6.0). Figure 3-6 identifies properties containing pre-1978 buildings.

The performance of the geotextile tubes may be compromised due to flanking, where there is focused erosion at the end of the structures and enhanced localized loss of sediment. Installing long, uniform sections of geotextile tubes will prevent flanking. Therefore, it is proposed to extend the geotextile tubes in front of the occasional property containing only post-1978 structures to maintain the continuity and integrity of the geotextile tube. By avoiding the flanking effect, placing geotextile tubes in front of these properties containing post-1978 structures actually provides protection for the pre-1978 structures as intended.

Installation will occur against the toe of Coastal Bank, where a series of geotextile tubes composed of strong, non-woven geotextile synthetic fabric will be placed end to end. When filled with sand, the geotextile tubes will be approximately six feet high, and toe protection will be provided by a toe anchor tube (see Section 2.4.1 and Figure 3-5 (Sheet 9 of 9)). The tops of the tubes will be buried below the elevation of the design storm profile such that the structures will not be visible after beach nourishment is complete.

Monitoring the geotextile tubes will ensure that they remain sufficiently buried within the design beach profile. Since these structures will be buried at the back of the nourished beach, they will only be exposed and functioning to reflect wave energy in the event of a significant storm event impacting the Project area near the time of required renourishment. If such an event occurs and the structures are exposed, proper maintenance and renourishment efforts will be undertaken as quickly as possible. Monitoring and maintenance measures for the proposed geotextile tubes are discussed in Section 5.2.2.4.

3.2.4 Beach Dewatering

Beach dewatering is included as part of the Project design at the existing Codfish Park and LHS-S beaches because the primary components of the systems are already present in the Project area and can be renovated to become operational (see Section 2.3.4). The potential for the dewatering systems to extend the design life of the nourishment is valuable. While these systems have not been proven conclusively effective, the correlation between beach accretion and erosion with the Codfish Park system upgrade and shutdown supports the argument for continued system operation, particularly since the basic infrastructure for this system already exists in the beach. The Codfish Park system is expected to be operational after a repair to its discharge pipe, and the LHS-S system can be operational with some moderate repairs to the electrical system, discharge pipe, and connection of drainage pipes.

3.2.5 Bank Stabilization through Terracing and Vegetation

As discussed in Section 2.4, bank stabilization is an integral component of this Project. Even with the proposed nourishment, groins, and geotextile tubes, over-steepened portions of Coastal Bank will need to be stabilized using coconut fiber terraces and vegetation to adequately protect landward resources. The Proponent is submitting a Notice of Project Change (NPC)/Phase One Waiver request to MEPA to allow bank terracing and vegetation planting to proceed immediately so that interim protection can be provided to threatened resources until the comprehensive nourishment Project is permitted and constructed. The NPC/Phase One Waiver request is contained in Section 6.1 of this DEIR. As presented in Section 6.1, terraces are proposed at two locations: Mid-Baxter Road and Hoick's Hollow (see Figure 1-2). These two series of terraces are proposed along the stretch of Project shoreline that will receive beach nourishment, and no terraces are proposed seaward of Coastal Dune.

Coastal Bank terraces will consist of two components: lower (toe) terraces and upper (bank face) terraces. The toe terraces are comprised of 6-8 individual 2-foot-high terrace layers which extend approximately 15 feet seaward from the toe of the Coastal Bank. Each terrace layer consists of a single sheet of coconut fiber mat folded over a six-inch layer of beach-compatible sediment. Each subsequent terrace layer is offset approximately 2 feet landward from the one below and is fronted by a layer of coconut fiber bags measuring approximately 3x3x2.5 feet which are filled with beach-compatible sediment.

Bank face terraces are composed of individual terrace layers similar to those in the toe terraces. Each terrace layer extends 3–10 feet seaward from the face of the Coastal Bank, and subsequent terrace layers are offset landward so as to reduce the overall steepness of the bank slope. Once complete, toe and bank face terraces will be covered with 6-18 inches of beach-compatible sediment and will be planted with native vegetation.

In areas where the top of the Coastal Bank is in excess of 30 feet above MLW, a series of eight or nine terraces will be constructed; where the top of Coastal Bank is 20-30 feet above MLW, a series of four or five terraces will be constructed. Once terrace construction is complete, the top surface (including the offset steps) will be planted with American beach grass.

Vegetated toe and bank face terraces will reduce the overall slope of over-steepened portions of the existing Coastal Bank, provide wide areas for planting native bank-compatible vegetation, and protect the toe of bank during large storm events.

3.3 Offshore Borrow Site

Investigations into potential sand sources for the nourishment Project have involved analyses of a range of potential on- and off-Island upland sources and a number of different offshore locations. Sand source alternatives are discussed in detail in Section 2.6. By utilizing data from preliminary investigations and performing detailed monitoring and modeling, the Proponent identified a Primary Study Area within which borrow site investigations and geotechnical surveys were focused in the spring of 2006. This Primary Study Area initially encompassed 2,500 acres of Massachusetts' state waters west of Bass Rip (see Figure 1-4). Investigations were focused in state waters partially with the intent to identify a suitable borrow site close enough to the nourishment area to maintain hydraulic dredging as an operationally-feasible option; this will enable the Proponent to seek competitive bids from both hopper and hydraulic dredging contractors.

To delineate an optimal borrow site within the Primary Study Area, detailed geophysical and geotechnical investigations in the spring of 2006 consisted of seismic-reflection profiling (conducted to map sub-bottom sediment layers), sidescan sonar (performed to acquire a detailed representation of the characteristics of the seafloor), a fathometer survey (to provide updated bathymetric data for interpretation of seabed morphology), and a magnetometer survey (to identify metallic objects that could potentially be cultural resources or obstructions to dredging). Twenty-five (25) vibracores were collected to a maximum depth of 20 feet throughout the Primary Study Area (see Figure 1-5). Vibracores were cut, logged, sampled, and grain size analyses were performed. Results were correlated to the seismic data to confirm the depth to reflectors visible in the geophysical record, and the resulting ground-truthed data were then used to determine the extent and thickness of beach-compatible sediment.

Preliminary analyses of existing and newly-acquired geophysical and geotechnical data were made to identify any potential borrow sites within the Primary Study Area. Based on these analyses, a 345-acre area known as the "Northern Borrow Site" has been delineated in Massachusetts' state waters (see Figure 1-5). Only a portion of this borrow site will be dredged for the Project; assuming an average 10-foot dredge cut thickness, 161 acres of the site would be dredged to supply material for the initial nourishment.

This borrow site stretches along the landward slope of the northern portion of Bass Rip, a large sand ridge. Water depths at the Northern Borrow Site range from 15-60 feet, with depths decreasing in a seaward direction towards the crest of the sand ridge. Seafloor sediment thickness, as determined from core stratigraphy and seismic profiles, increases in a seaward direction towards the crest of the sand ridge. The western slope of the sand ridge is generally characterized by hummocky topography with sediment thickness varying dramatically on a local scale.

A preliminary investigation of the seafloor was made using high resolution sidescan sonar data combined with sedimentological data derived from the sediment cores (see Figure 3-7). This preliminary investigation showed that the seafloor is composed of medium to coarse sand with trace amounts of shells and gravel, consistent with the upper sediment layers found in the vibracores. Sedimentary characteristics of the seafloor sediments are indicative of a high-energy environment with strong currents and high wave energy. See Section 3.3.1 for a more detailed description of grain size at the Northern Borrow Site and corresponding compatibility with the Project's nourishment area.

The central portion of the Northern Borrow Site is comprised of medium-sized sand ripples with elevations of one to two feet and wavelengths of 5-10 feet. The dominant orientation of these features is east-west.

In addition to these medium-sized sand ripples, two sections of the Northern Borrow Site contain significantly larger bedforms (see Figure 3-7). Parabolic or semi-parabolic sand waves with heights of 10-15 feet occur in the northern portion of the Northern Borrow Site. These sand waves generally trend from east to west with their concave (leeward) side facing north, which suggests that the dominant currents flow in a northerly direction. The southern portion of the Northern Borrow Site is comprised of linear sand waves approximately 10-15 feet in height. These sand waves generally trend northwest to southeast with their leeward side facing north.

Summary results indicate that the Northern Borrow Site contains approximately 8.3 million cubic yards of sand with a mean grain size of 0.83 mm (medium sand) (see Section 3.3.1).

In addition to the geophysical and geotechnical investigations described above, wave models were generated for pre-dredge and post-dredge conditions to ascertain potential impacts of dredging on local wave climate (see Sections 2.6.2.3.2 and 4.2.2).

3.3.1 Grain Size Compatibility

One of the primary criteria used in selecting an offshore borrow site is grain size compatibility with the receiving beach. The optimal nourishment material is dependent upon specific site characteristics and environmental conditions in the nourishment area, but nourishment projects often seek borrow material that closely matches or is slightly coarser in grain size than the receiving beach. Borrow site material that is considerably finer than the native beach will be less stable and will erode from the nourished area at an accelerated rate. Due to this Project's dynamic nearshore environment, the ideal borrow material would closely match or be slightly coarser than the native beach sand; if finer material needs to be utilized, the design template will be widened accordingly.

Initial survey efforts of preliminary sand source locations revealed areas where sediments were composed of coarse- to medium-grained sand with some pockets of pebbles and gravel. In some preliminary investigations, the seafloor contained a series of large sand waves reaching a maximum of 10 feet in height. Data collected during coring and sub-bottom surveys indicated that coarse- to medium-grained sediments occurred within the upper 10-12 feet of the seafloor; analyses of sediment cores, sidescan results, and sub-bottom data also identified areas of shallow, finer-grained material. These initial data gathering efforts were used to refine the preliminary sand sources being considered for the Project. Preliminary sand sources once under consideration are discussed in further detail in Section 2.6.2.1.2.

As indicated in Sections 2.6 and 3.3, geophysical investigations conducted within the Primary Study Area in the spring of 2006 have enabled the Proponent to delineate the Northern Borrow Site as the preferred source of nourishment material (see Figure 1-5). Grain size analyses played a large role in the identification of this area as the preferred borrow site.

To constrain the geophysical data, 25 vibracores were collected in the Primary Study Area; ten (10) of these vibracores were collected at nine distinct locations within the Northern Borrow Site (see Figure 1-5). Vibracore and seismic profile data show that the area is characterized by variable stratigraphy with limited lateral continuity of stratigraphic layers. These findings are consistent with the local depositional environment which consists of a drowned proglacial environment comprised of till and outwash (sandur) plains. The thickness of the sandy layer, although highly variable, was readily identified in the seismic record and mapped throughout the study area (see Figure 3-8). Interpretations of seismic data were used to interpolate sand thickness between adjacent vibracore locations and to develop a sediment thickness (isopach) map for the Northern Borrow Site (see Figure 3-9).

Fifty sub-samples were collected from the ten vibracores collected within the Northern Borrow Site; vibracore locations are shown on Figure 3-10. These samples were analyzed using a mechanical sieve. Vibracore results and interpretations of sand layers from seismic records were used to delineate the boundaries of the preferred borrow site. Composite mean grain size, percent silt, and sorting were determined for each vibracore by calculating the weighted average (i.e., the average of each sample weighted by the length of core represented) (see Attachment H for individual vibracore and composite data). Composite mean grain size, percent silt and sorting were calculated by averaging the weighted results for all cores within the limits of the borrow site.

In general, the southern and western portions of the Primary Study Area contained finer-grained sediments (i.e., fine to medium sand from 0.2-0.6 mm in diameter) with some interbedded fine sand and silt. Since the preferred grain size for the Project is medium- to coarse-grained sand, these areas were excluded from the preferred borrow site. Central and northern portions of the area contained beach-compatible sediments with grain sizes generally from 0.5-1.5 mm in the upper layers of the cores. A gravel layer 1.9 feet thick with an average grain size of 4.96 mm was found at the top of vibracore NIVC-06-14 in the Northern Borrow Site (see Figure 3-10). However, this layer has a limited vertical and lateral extent because it is not present in any of the neighboring cores; the neighboring cores (NIVC-06-15, NIVC-06-16, NIVC-06-24 and NIVC-06-25) contained layers of medium to coarse sand 1.0-3.5 mm in diameter at varying levels. The strong reflector associated with the gravel layer in vibracore NIVC-06-14 is readily identifiable within the seismic data, allowing for isolation of this subsurface unit for use or exclusion in the final engineering design plans.

Summary results (composites) indicate that the Northern Borrow Site contains 8.3 million cubic yards of sand with a mean grain size of 0.83 mm (classified as medium sand), a phi sorting of 1.62 (poorly sorted), 0.96% silt content, and 9.29% gravel content.

3.3.1.1 Nourishment Area

Approximately 198 sediment samples were collected from the Coastal Beach, Coastal Bank, and Coastal Dune resources in the Project area for purposes of grain size analyses. These samples were collected along 36 transects located at 500-foot intervals beginning immediately south of Sesachacha Pond and extending just south of the Town Sewer Beds at Low Beach. All sediment samples were collected within 0-4 inches of the surface and were analyzed using a series of 0.25 phi and 0.5 phi increment sieves (-4.25 through 4.0 phi). Silt and clay-sized particles finer than 4.0 phi were collected in the pan and weighed.

3.3.1.1.1 Coastal Beach Samples

Three sediment samples were collected from the dry portion of the Coastal Beach along each of the sampling transects. These samples were taken from: (1) the low beach (LB) area immediately above the swash zone; (2) the upper beach (UB) area, which in the northern portion of the Project area was 3-5 feet seaward of the toe of Coastal Bank and adjacent to Sesachacha Pond and in the southern portion of the Project area was 3-5 feet seaward of the seaward edge of Coastal Dune; and (3) the mid–beach (MB) area, which was located at the mid-point between LB and UB samples. Mean grain size of Coastal Beach samples as calculated for each of the 36 transects ranged from 0.59-0.88 mm and contained 0.17-0.61% silt. In composite (including all transects), the Coastal Beach had a composite mean grain size of 0.73 mm and contained 0.25% silt (see Table 3-2).

3.3.1.1.2 Coastal Bank Samples

Transects L3-L18 were located along a portion of the nourishment area backed by the actively-eroding Coastal Bank. Transects L3-L7 were located where the bank is 25-45 feet high; two sediment samples, one from the upper bank (UBK) and one from the lower bank (LBK) were collected along these transects. Transects L8-L18 were located where the bank is 70-90 feet high; three samples, one UBK, one LBK, and one mid-bank (MBK), were collected along these transects. Transects L19 and L20 were located along a well-vegetated portion of the bank where no sediment was exposed; no Coastal Bank samples were collected along these transects. Average calculations for Coastal Bank samples along each distinct sampling transect revealed mean grain sizes between 0.33-0.52 mm and silt contents between 2.34-29.85%. In composite (including all transects), Coastal Bank samples had a mean grain size of 0.41 mm and contained 12.41% silt (see Table 3-2).

3.3.1.1.3 Coastal Dune Samples

Transects L1, L2, and L21-L36 were located in a portion of the nourishment area backed by a low-lying Coastal Dune of variable width. Transects L21 and L24-L27 are located along a portion of the nourishment area backed by a relatively narrow Coastal Dune; for these transects, dune samples were collected from the upper dune (UD) and lower dune (LD). Transects L22, L23, and L28-L36 were backed by a wide low-lying coastal dune; three dune samples were collected along these transects from UD, LD, and mid-dune (MD) locations. Average calculations for Coastal Dune samples along each distinct transect revealed mean grain sizes between 0.58-0.76 mm and silt contents between 0.11-1.77%. In composite (including all transects), Coastal Dune samples had a mean grain size of 0.69 mm and contained 0.32% silt (see Table 3-2).

Table 3-2 Grain size characteristics of the nourishment area (millimeters).

Sample Transect	Coastal Bank		Coastal Beach		Coastal Dune	
	Mean	% Silt	Mean	% Silt	Mean	% Silt
L1			0.77	0.19	0.60	1.00
L2			0.79	0.24	0.58	1.77
L3	0.48	5.84	0.71	0.23		
L4	0.33	29.85	0.68	0.24		
L5	0.43	18.40	0.65	0.28		
L6	0.38	9.99	0.69	0.25		
L7	0.40	16.76	0.75	0.19		
L8	0.46	16.78	0.83	0.24		
L9	0.37	19.28	0.71	0.29		
L10	0.39	4.94	0.77	0.22		
L11	0.49	6.85	0.67	0.25		
L12	0.38	5.16	0.72	0.24		
L13	0.35	8.54	0.65	0.18		
L14	0.37	2.34	0.65	0.26		
L15	0.36	22.97	0.61	0.30		
L16	0.46	16.60	0.64	0.26		
L17	0.48	11.25	0.70	0.23		
L18	0.52	2.95	0.70	0.18		
L19			0.72	0.21		
L20			0.78	0.17		
L21			0.71	0.24	0.70	0.11
L22			0.81	0.18	0.72	0.26
L23			0.72	0.19	0.71	0.20
L24			0.80	0.25	0.73	0.23
L25			0.81	0.20	0.71	0.26
L26			0.87	0.18	0.72	0.15
L27			0.80	0.61	0.71	0.28
L28			0.88	0.21	0.69	0.14
L29			0.79	0.28	0.76	0.12
L30			0.76	0.28	0.73	0.15
L31			0.76	0.29	0.76	0.12
L32			0.73	0.29	0.67	0.12
L33			0.76	0.20	0.71	0.16
L34			0.73	0.20	0.65	0.26
L35			0.63	0.21	0.70	0.20
L36			0.59	0.42	0.65	0.27
Min	*0.33*	*2.34%*	*0.59*	*0.17%*	*0.58*	*0.11%*
Max	*0.52*	*29.85%*	*0.88*	*0.61%*	*0.76*	*1.77%*
Mean	**0.41**	**12.41%**	**0.73**	**0.25%**	**0.69**	**0.32%**

(Sediment Analysis: CP&E, 2006)

3.3.2 Volume of Sand Available

In addition to containing sediment of a grain size compatible with a project's design, an offshore sand source should ideally have the capacity to supply the quantity of sand necessary to construct the project in its entirety. Not only is it important to identify a borrow site that contains a volume of sediment adequate to satisfy the initial nourishment construction, but the potential availability of sufficient material for a renourishment event(s) is also an important consideration. Once an area with suitable sediment characteristics and grain size can be confirmed, the volume of available material for nourishment can be computed and compared to project requirements.

As discussed above and in Section 2.6.2, results from spring 2006 geophysical investigations in the Primary Study Area were used to delineate a 345-acre Northern Borrow Site on the landward slope of Bass Rip (see Figure 1-5). Sub-bottom profiling results were ground-truthed with vibracores to estimate the quantity of beach-compatible material available for sand mining; sand thickness at the borrow site was determined using geophysical survey results. The distribution of this sandy layer is portrayed on the isopach (sediment thickness) map provided as Figure 3-9. It has been estimated from these data that the Northern Borrow Site contains 8.3 million cubic yards of sand with a mean grain size of 0.83 mm (classified as medium sand) which could be mined for the proposed Project (see Section 3.3.1).

3.4 Construction Methodology and Schedule

Implementation of the Project will require a number of different construction activities along the Project shoreline and at the offshore borrow site. Careful sequencing and timing of these construction activities will avoid and/or minimize adverse environmental impacts while maximizing the likelihood of a successful, efficient and cost-effective Project. Proposed construction methodologies are based on information gained through years of practical experience with coastal and marine construction projects. These methods have been selected based on past success in similar coastal environments.

Construction sequencing on the Project shoreline will begin with placement of nourishment material and will be dependent upon the schedule of simultaneous offshore dredging efforts. After a portion of the nourishment template has been built, groin installation will begin, followed by placement of geotextile tubes. Project construction is proposed to begin at the end of May 2007 and extend through November of that year (see Section 2.5.1.1.1).

A brief description of construction methodologies for each of the Project activities is included below.

3.4.1 Dredging and Nourishment Construction Activities

During dredge and fill operations for the Project, the contractor will be required to conform to standard practices related to offshore dredging of borrow sites. Prior to commencement of dredging, a pre-dredge bathymetric survey will be completed to confirm depths at the proposed borrow site. The contractor will not be allowed to excavate deeper than the permitted cut depths, which will be defined on the final construction plans. The borrow site will be dredged in a manner to achieve specific side slopes with a sloped bottom of uniform grade void of steep holes and mounds. Standard practices will be employed to control turbidity and effluent to the greatest extent practicable. A quality control plan will be required that outlines dredging procedures, tracking, and documentation required.

Two types of dredges are capable of constructing this Project efficiently and cost-effectively: a hydraulic cutterhead dredge and a hopper dredge. The choice of dredge will ultimately depend on the specific location of the borrow site and the wave climate the contractor expects to encounter during construction. Selection of dredging equipment and the accompanying methodology will directly impact the rate at which nourishment material is delivered to the Project shoreline, which will have implications for construction of upland Project components and the duration of Project activities.

3.4.1.1 Cutterhead Dredge

A cutterhead dredge has an actively-rotating auger surrounding the suction line. The rotating cutterhead agitates the sand, which is then pumped up to the dredge as a slurry of sand and water. The slurry is then pumped through a submerged pipeline extending from the borrow site to the shore and then through an exposed pipe along the shore to the nourishment area. The contractor will construct a sand dike at the designed berm break, and the slurry will be discharged landward of the sand dike (see Figure 3-11). As the slurry flows along the beach behind the dike, its flow speed will decrease, causing most of the relatively coarse nourishment material to drop out of suspension before residual flow enters the ocean. By utilizing this diking technique, discharge from beach nourishment is not expected to cause significant adverse impacts related to turbidity (see Section 5.2). Any fine material remaining in suspension in the discharge water is expected to only slightly exceed ambient turbidity levels and will likely be consistent with conditions typically encountered during storms in the Project area.

Cutterhead dredges are capable of near-continuous discharge to the shoreline, which achieves high production rates; when the borrow site is close enough to the nourishment area to utilize this capability, cutterhead dredges may be preferable to hopper dredges so production rates can be maximized. The maximum pumping distance depends on the characteristics of the beach fill, with coarse beach fill (such as is expected for this Project) having shorter feasible pump distances. Booster pumps can be installed in the pipeline to increase the pumping distance, but production decreases with increasing pipeline length. If a nearshore borrow site is delineated and permitted for this Project, production rates using a cutterhead dredge would likely be on the order of 20,000-50,000 cubic yards/day. Cutterhead dredges are generally limited to operating in environments where wave heights are less than five or six feet, and must be towed into safe harbor when waves are expected to exceed eight or nine feet.

3.4.1.2 Hopper Dredge

Trailing-arm hopper dredges are self-propelled ships that pass through the borrow site while dragging trailing arms across the bottom; the dredge slurry is pumped into the hopper through these trailing arms. The hopper dredge then motors to a pumpout station located just offshore from the nourishment area, where beach fill is re-fluidized and pumped onshore through a submerged pipeline and along the beach through an exposed pipe. After each pumpout, the hopper dredge transits back to the borrow site to reload and repeat the process.

For the proposed Project, a hopper dredge would complete three to five trips per day, depending on weather conditions and the distance between the borrow site and pumpout location. The typical hopper dredge has a capacity of approximately 4,000 cubic yards, which, depending on sea conditions and sand density, typically contains about 3,000 cubic yards of sand.

Sea conditions can limit hopper dredge operations at the pumpout location, where a typical maximum wave height for safe operations is limited to approximately six feet, depending on wave period and steepness. Accounting for downtime and some loss of nourishment material from the design template, the daily production rate for this Project would be 9,000-15,000 cubic yards per day. Factoring in likely weather conditions, total Project dredging and delivery using a hopper dredge would likely last approximately 220 days. Depending on construction timing and equipment availability, additional hopper dredges could be added to expedite Project construction.

3.4.1.3 Nourishment Area Construction Activities

Once the sand is deposited on the beach, bulldozers will be used to grade the material and sculpt the construction template (see Figure 3-12). Construction vehicles that can be expected on the beach include bulldozers and graders, among others; the exact equipment used will depend on the contractor’s operating preferences. Equipment is generally stored close to the landward limit of fill within the construction area and in the immediate vicinity of the pipe discharge.

As construction of the nourishment template progresses, the exposed pipe through which the dredge slurry is pumped will be advanced along the beach by adding sections onto its open end. Equipment will be moved down the beach as additional pipe is added to the end of the discharge. Typically, a 500-foot section of beach in the vicinity of the discharge pipe is cordoned off to prevent public access to the active construction zone. The newlyconstructed beach behind the outfall will be open to the public, though the discharge pipe will be laying across the top of the berm. Temporary sand ramps will be constructed every 250 feet or at public access points to allow the public to traverse the discharge pipe. These ramps will be constructed by bulldozers pushing sand from areas immediately adjacent to the pipe; sand ramps are typically about 5 feet wide at the crest.

Proposed dune nourishment is outside the limits of the main beach fill (see Figure 1-2). It is not possible to control fill using hydraulic dredging when placing less than 10 cubic yards/foot or where the template is less than 20 feet wide. Therefore, dune nourishment will best be accomplished by stockpiling sand within the main beach nourishment area and then hauling nourishment material by truck along the beach to the dune nourishment locations.

3.4.2 Groin Construction

The Project is located in a highly-erosive environment where the use of groins will be required to stabilize the proposed fill. Given the exposure of these structures to such a dynamic and energetic wave environment, a rubble-mound T-head with a timber stem is the recommended design (see Section 3.2.2).

Groin construction may be accomplished either prior to or following completion of the nourishment template, which allows flexibility for the Proponent to seek a more competitive cost from contractors. Bidding the groin construction and beach nourishment activities under the same contract will ensure coordination between Project components, allowing timely completion of the comprehensive Project. Furthermore, by making groin construction a sub-contract to the prime nourishment activities, scheduling conflicts can be eliminated. While the Proponent believes it is essential to maintain these options, constructing groins prior to placement of nourishment fill will require less excavation but more water-based construction. Given the dynamic coastal environment and challenging coastal conditions along the Project shoreline, post-nourishment groin construction may be preferable.

Construction materials for the groins will likely be delivered to the Project site via barge and offloaded using a long-arm excavator with a thumb. A pile driver and excavator will be required to construct the groin stems. An experienced contractor may be capable of driving up to 20 piles per day and should be able to drive all the piles required for a groin stem in a single week.

Construction of the marine mattress foundation groins will require 2-3 months of work; however, much of this work will be performed off-site and can occur at any time of year. A crane will be required to place the marine mattress units in their proper locations (see Section 3.2.2). The installation rate of these units will depend on the contractor's familiarity with the product and weather conditions at the site. Placement of armor stones could be accomplished within a single week, but this is also dependent upon the contractor's experience, the type of construction (i.e., in the dry or submerged), and weather conditions. Excavating nourishment fill is often the most time-consuming portion of groin construction. It is estimate that 4-5 months will be required to construct thirteen 270-foot groins.

3.4.3 Geotextile Tube Construction

Geotextile tubes will be installed at the toe of Coastal Bank after the design beach template has been completed. The back beach will be excavated, and the excavated sand will be stockpiled for use when inflating the tubes. Tubes will then be rolled out, anchored within the excavated trench, and inflated using a gravity hopper system where sand is placed in a hopper on legs above portholes in the tubes. Initially filled with water to achieve the required elevation, the tubes will be filled with sand fluidized into a 60% sand/40% water slurry which will then drain via gravity from the hopper. Outflow water will drain across the beach face to the ocean along plastic drains utilized to avoid gully formation or erosion along the beach. Since the silt fraction in the nourishment material will be low, little turbidity is expected to result from this activity (see Section 4.6). As the process of filling each geotextile tube progresses, the gravity hopper system will be moved along the length of the inflated structure to each of the ports, which are located a maximum of 50 feet apart.

An experienced crew can typically construct 100 feet of geotextile tubes in a single day, exclusive of weather delays and mobilization/demobilization activities. Therefore, it is estimated that a single crew will require 2-3 months to construct the proposed 6,100 linear feet of geotextile tubes in the Project area.

The geotextile tubes will be constructed as part of the beach nourishment work and will be installed within the schedule of the overall Project. It is anticipated that installation will closely follow the nourishment work. The details of applicable staging areas and other coordination will be provided in the FEIR.