FEASIBILITY REPORT

Shoreline Erosion Assessment and Plan for Beach Restoration Village of Quogue, New York

Prepared for:

Village of Quogue
7 Village Lane Quogue NY 11959

Prepared by:

Coastal Science & Engineering (CSE)
PO Box 8056 Columbia SC 29202-8056

With:

First Coastal Corporation
4 Arthur Street Westhampton Beach NY 11978

[2278-FR]

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SYNOPSIS

The team of First Coastal Corporation and Coastal Science & Engineering Inc (CSE) was retained by The Village of Quogue to evaluate shoreline erosion along the 2.7-mile ocean beach within the village limits and develop alternate plans for beach restoration (Fig A). The goal of the project is to improve the beach-dune system via additions of sand from an external source so that:

- Recreational opportunities are enhanced via a wider beach.
- The community tax base is preserved.
- Normal seasonal processes of erosion and accretion may occur without adverse impact to the dune system.
- The aesthetic quality and ecological values of the beach are maintained.

The target design life for the project is a minimum of ten years* consistent with a majority of locally sponsored beach restoration projects. Beach improvements at 5-year, 10-year, and 60-year levels are also evaluated in the present report.

*[*Design life is defined herein as a significant additional volume of sand remaining within the littoral zone of the project area after 10 years such that the overall condition of the beach dune system is better than preproject conditions.]*

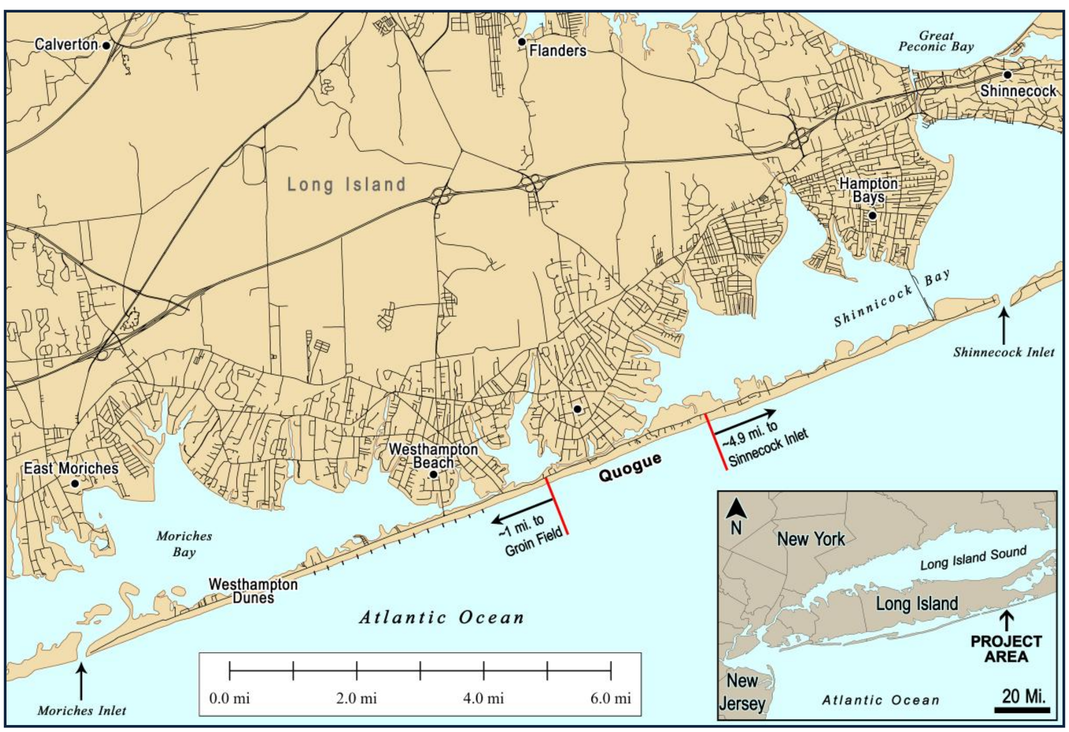


FIGURE A. Vicinity map showing the Quogue Beach project area situated along "Westhampton Beach," a 15-mile-long barrier island between Moriches Inlet and Shinnecock Inlet. Net sand transport is east to west along the south shore of Long Island.

The general approach of the team was to review historical data and related projects along Westhampton Beach, conduct detailed condition surveys of Quogue Beach and determine the sand deficit and average annual erosion rates for three reaches. A recommended project was formulated based on analysis of the existing level of protection seaward of buildings, the relative condition of the beach/dune from one reach to another, and the controlling coastal processes and net sediment transport rates. The team reviewed potential offshore borrow areas designated by the US Army Corps of Engineers (USACE) and approved for other work by New York Department of Environmental Control (NYDEC).

A feasible borrow area which has been evaluated for environmental impacts is situated in 40-60 feet (ft) of water about 1-2 miles offshore of Quogue Beach. Preliminary geotechnical surveys by USACE and others indicate there is likely to be sufficient beach quality sediment in some portions of the offshore area to accomplish a locally sponsored project (pending detailed confirmation of sediment quality and approval for use by the USACE and NYDEC).

KEY FINDINGS

Condition Survey, Sand Deficit, and Annual Erosion Rate

A detailed condition survey involving profiles at ~300-ft spacing from the dune to ~3,500 ft offshore was completed in February 2011 (Fig B). The survey confirms the presence of an offshore bar and systematic variations in the invisible beach in relation to changes in the bar. Profile volume analysis confirmed a sand deficit principally along the eastern and central portion of the project beach. The team subdivided Quogue Beach into three reaches as shown in Figure C. Deficits in the dune (above +10 ft NGVD datum*) were determined by comparing the unit volume of sand seaward of homes and infrastructure against FEMA's standard for dune volume (ie – 20 cubic yards per linear foot above the 100-year still-water surge elevation). Reach 1 at the western (downcoast) end of the project retains a healthy protective dune. Reach 2 in the middle of the project area was found to have about 50 percent less dune volume (with localized exceptions) with respect to Reach 1. Reach 3, the eastern one mile of project shoreline, was found to lack dune protection at the FEMA standard over approximately half the reach and much less protection than Reach 1. In addition, Reach 3 had a major sand deficit compared to the other reaches across the recreational beach out to the outer bar. We determined that Quogue Beach has a sand deficit of ~495,625 cy with respect to an "ideal, healthy beach" for this setting. This quantity represents the minimum initial nourishment volume needed.

*[*NGVD — National Geodetic Vertical Datum of 1929, which is ~0.5 ft below present mean sea level.]*

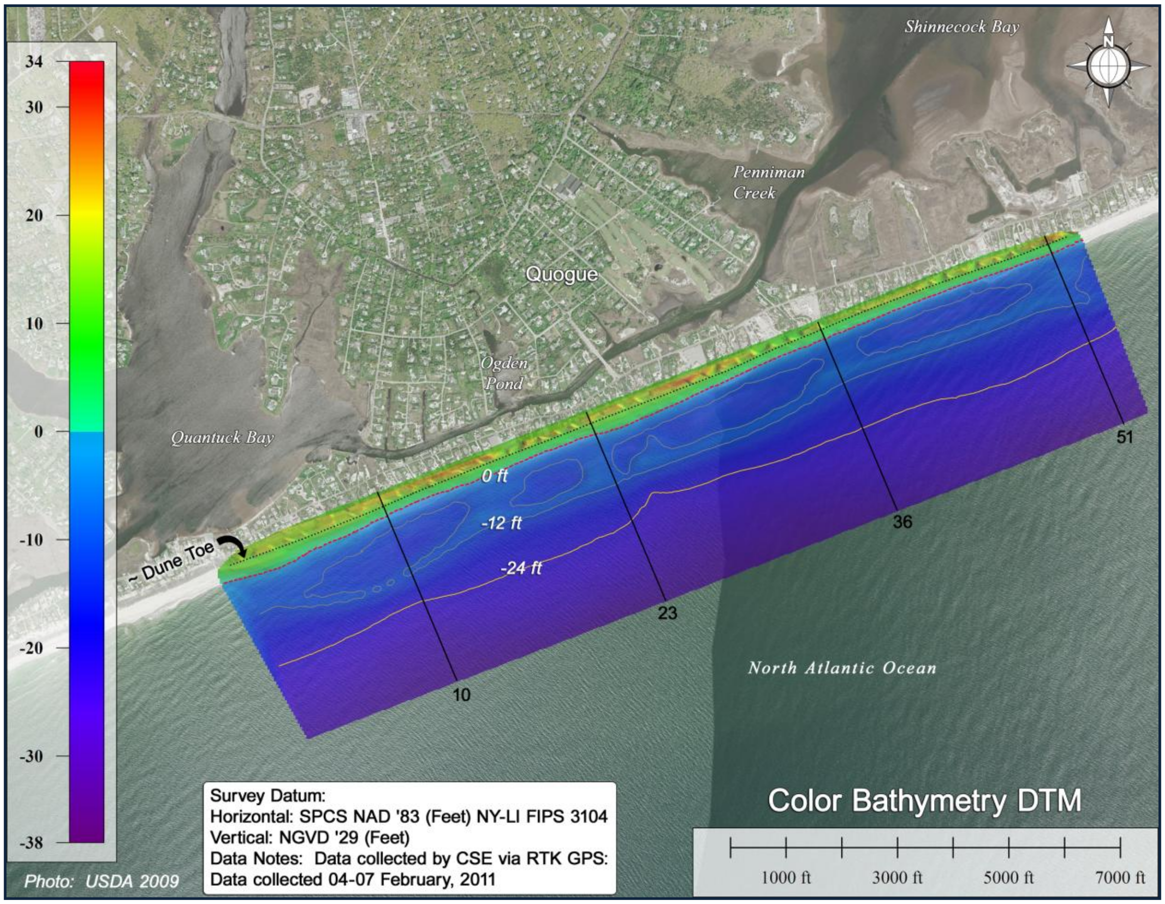


FIGURE B. Results of a condition survey in February 2011. The digital terrain model (DTM) was developed by the team from profiles collected at 300-ft spacing between the baseline and 3500 ft offshore.

The team reviewed historical erosion rates for numerous time periods dating back to the 1950s. Because of various nourishment activities, year-to-year rates of change were found to be highly variable. Best available data indicate the "decadal" average losses have been ~4.2 cubic yards per foot per year (cy/ft/yr) (Fig C). This equates to net losses of ~60,000 cubic yards per year (cy/yr) along the ~14,325-ft village beach. This rate is comparable to the 10-year average volumetric loss in the area from the Westhampton groin field to Moriches Inlet reported by Bocamazo et al (2011).

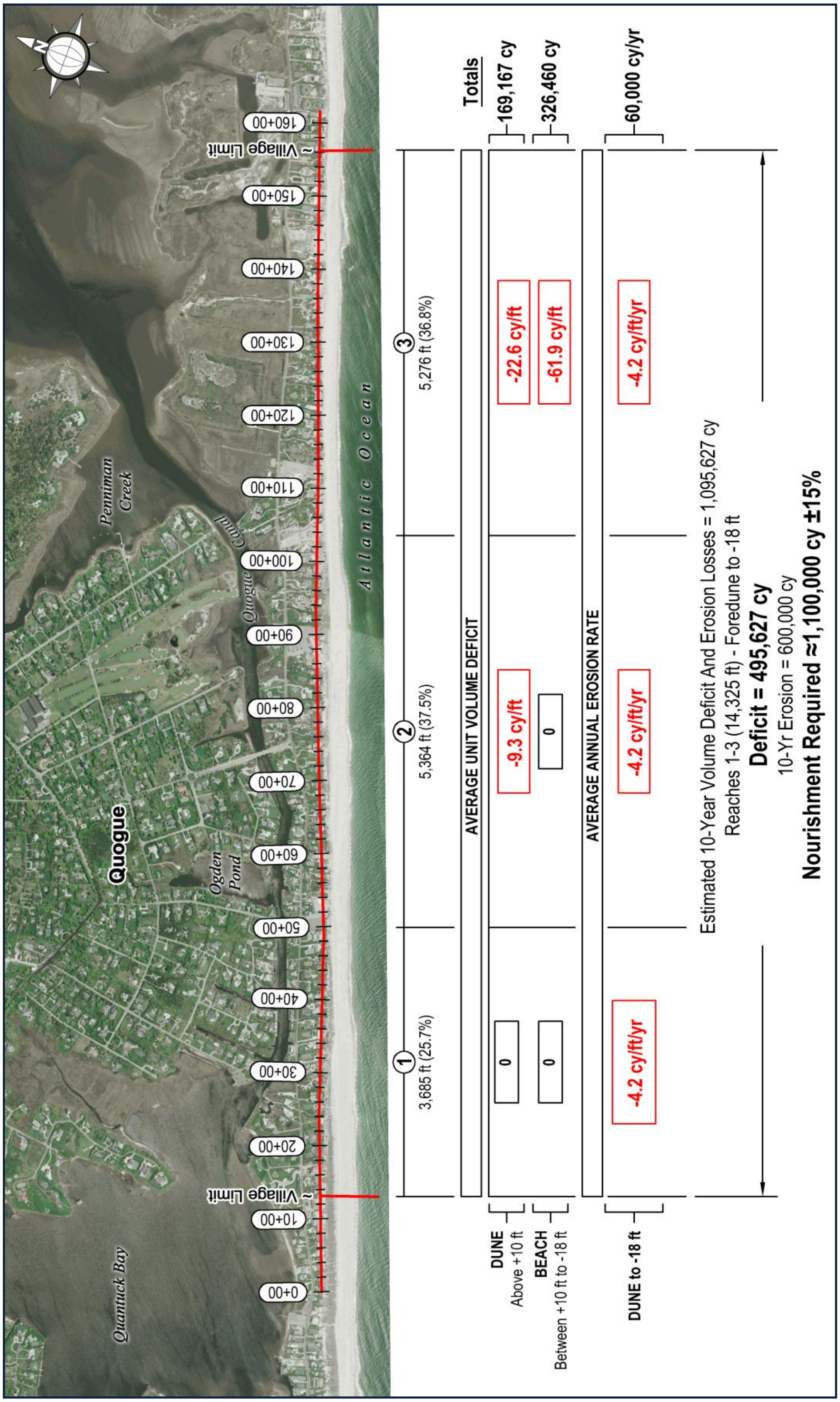


FIGURE C. The estimated profile volume deficit by reach and the average annual erosion rate applicable at decadal time scales for Quogue Beach. The nourishment required assumes replacement of the sand deficit across the littoral profile (including the foredune) and the estimated 10-year erosion losses.

Ten-Year Nourishment Requirement

Combining the initial sand deficit and average annual erosion losses for a 10-year design life yields a recommended project volume of ~1,100,000 cy. This equates to an average addition of ~77 cy/ft within the project area. Because the sand deficit decreases from east to west (the net direction of sand transport), the recommended plan calls for more volume to be placed along Reach 3.

Following placement, the extra sand will tend to feed Reaches 1 and 2 over time, thus extending the life of the project. Based on experience with similar projects and the imprecision of erosion rates and construction cost estimates, nourishment involving 1.1 million cubic yards ±15 percent [ie – 935,000 cy (low scenario) to 1,265,000 cy (high scenario)] is considered an appropriate and viable range for planning.

Sediment Quality and Potential Borrow Sources

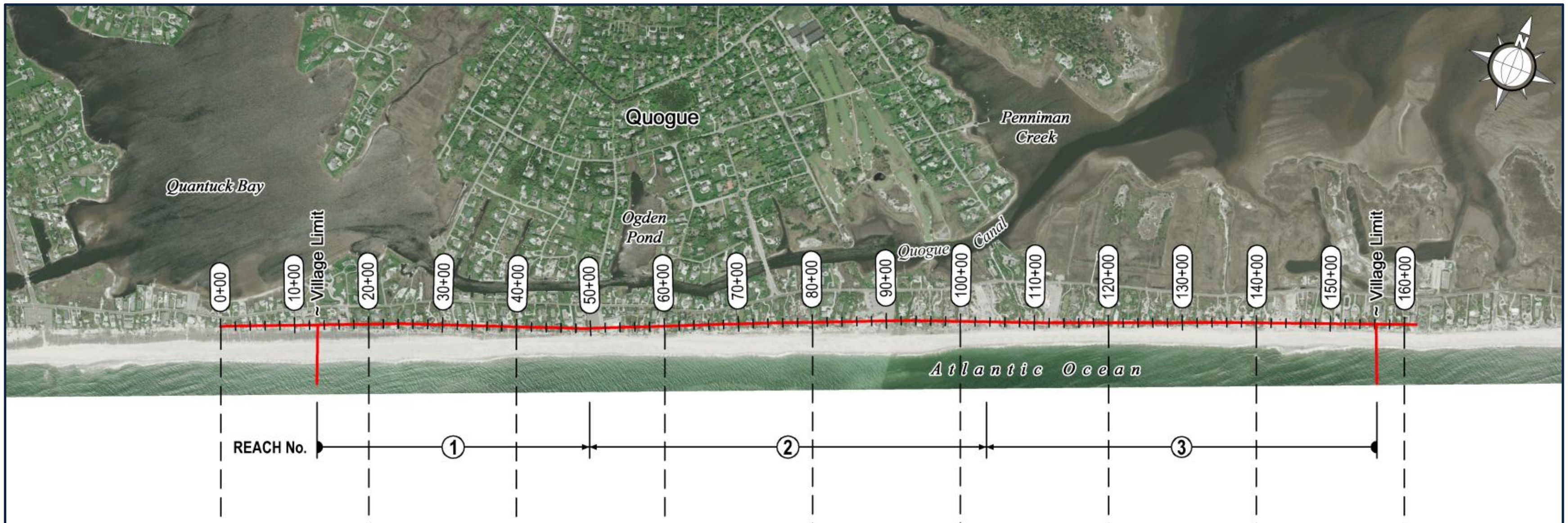
Sediment quality on the beach was determined via sampling. The results (Fig D) confirm that medium-grained sand dominates (composite mean grain size of 45 samples between the toe of dune and low-tide terrace equals 0.45 millimeters). The USACE has identified several borrow areas offshore of Quogue Beach (Fig E). A limited number of borings indicates there is likely to be sufficient beach-quality sediment matching the native beach to accomplish multiple nourishment projects. Areas Q1, Q2 and Q3 (Fig F) are the team's recommended areas for additional sand confirmation surveys. Representatives of the USACE-New York District have identified areas 5A and 5B as reserved for other district work (L Bocamazo, pers comm, May 2011). Assuming areas Q1, Q2, and/or Q3 are available for use by the Village of Quogue, they potentially contain about 8 million cubic yards if excavated to a maximum depth of 7ft below grade. The proximity of the borrow areas to Quogue Beach means that ocean-certified hopper dredgers or suction cutterhead dredges would likely be feasible. Hopper dredging is generally restricted to winter months to minimize environmental impacts.

Environmental Impacts

The primary environmental impacts that apply in the Quogue setting for projects of this type are changes to biota in the borrow area and on the beach, impacts to threatened and endangered species (particularly piping plovers), and impacts to water quality. Sediment quality is the most important variable that can be controlled. Borrow areas containing beach-quality sand with negligible mud, gravel, or cemented limestone fragments tend to reduce turbidity and minimize adverse impacts.

Recommended Plan

Figure G summarizes the recommended nourishment plan for Quoque Beach assuming an offshore borrow area within the previously approved sand search areas (Figs E & F) is permitable. Table A presents a realistic range of cost scenarios based on similar project experience. The recommended plan would provide a range of profile volumes differing by reach. Figure H illustrates the typical nourishment sections and areas of impact across the littoral zone by reach.



Mean Grain Size (mm)	MEAN GRAIN SIZE (mm)									Composite 9 Stations
Toe Of Dune	0.392	0.324	0.272	0.340	0.346	0.514	0.375	0.453	0.426	**0.366**
*Visible Beach	0.427	0.410	0.431	0.436	0.467	0.523	0.433	0.512	0.443	**0.448**
Low Tide Terrace	0.440	0.466	0.560	0.934	0.440	0.592	0.447	0.466	0.698	**0.552**

*Average of Berm, Upper Beach Face (UBF), Lower Beach Face (LBF)

FIGURE D. Mean grain size along Quogue Beach based on sampling in February 2011.

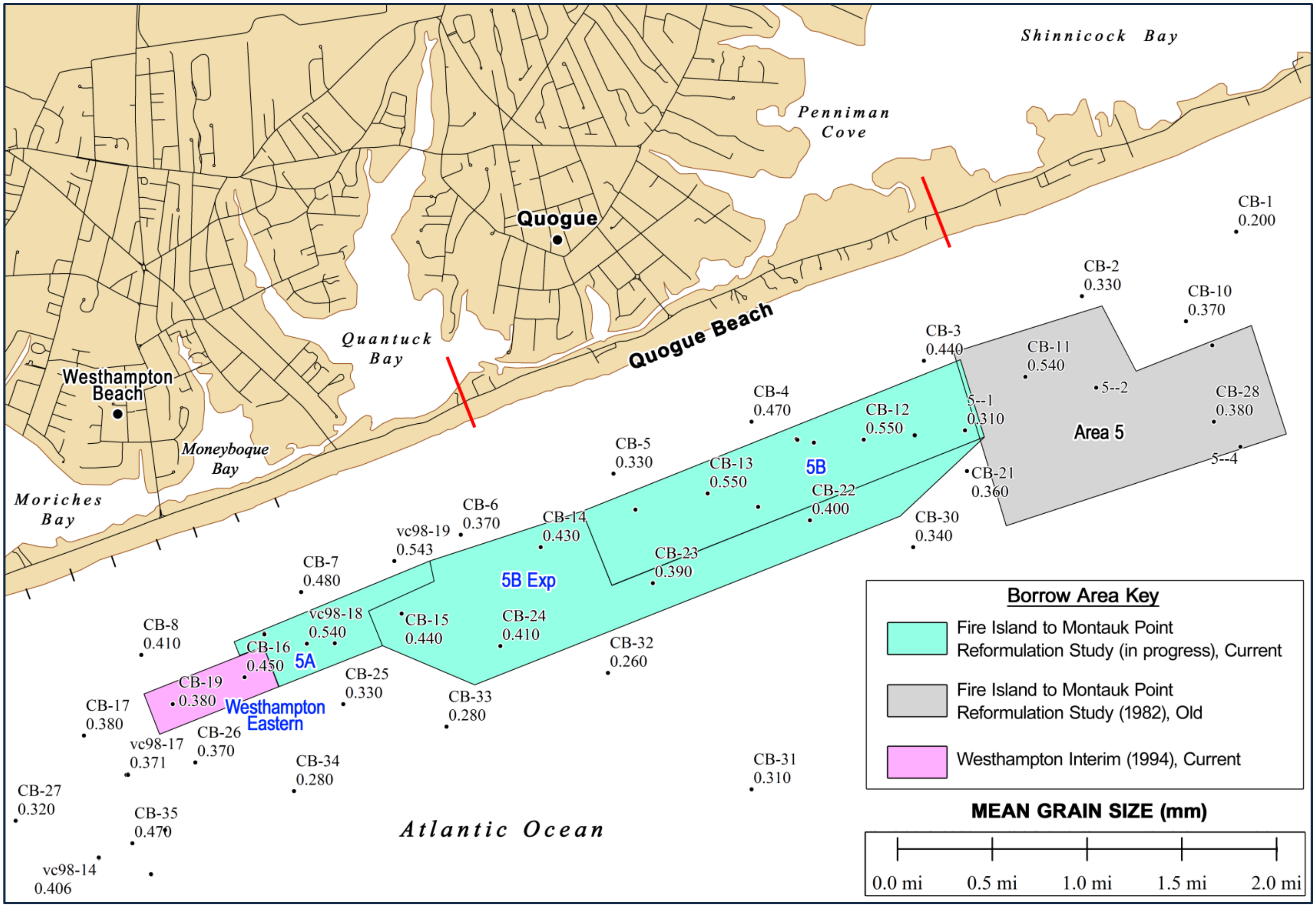


FIGURE E. Previously delineated, potential borrow areas off Westhampton Beach and Quogue Beach as identified by the USACE and reviewed by NYDEC. Core numbers and mean grain size in the upper ~20 ft of substrate are given. [Source: USACE-New York District]

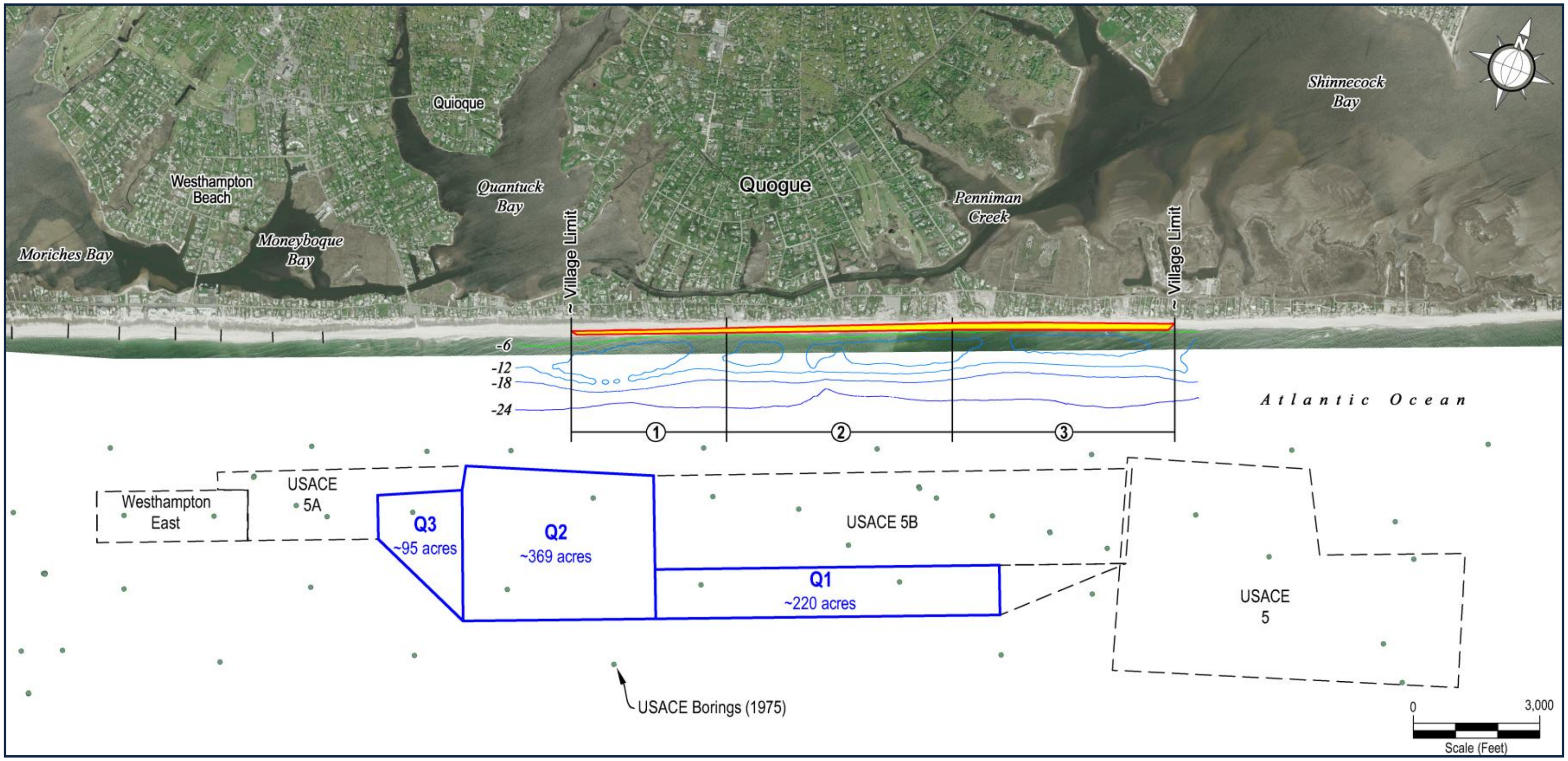


FIGURE F. Potential offshore borrow areas previously identified for the Westhampton Beach area by the US Army Corps of Engineers. Representatives of the New York District have tentatively reserved areas 5A and 5B for other projects. Areas Q1, Q2, and Q3 (USACE areas 5B EXP) may be available for Quogue Beach. These areas potentially contain ~8 million cubic yards of material to a depth of ~7 ft below grade. All areas are considered to be seaward of the active littoral zone at decadal scales.

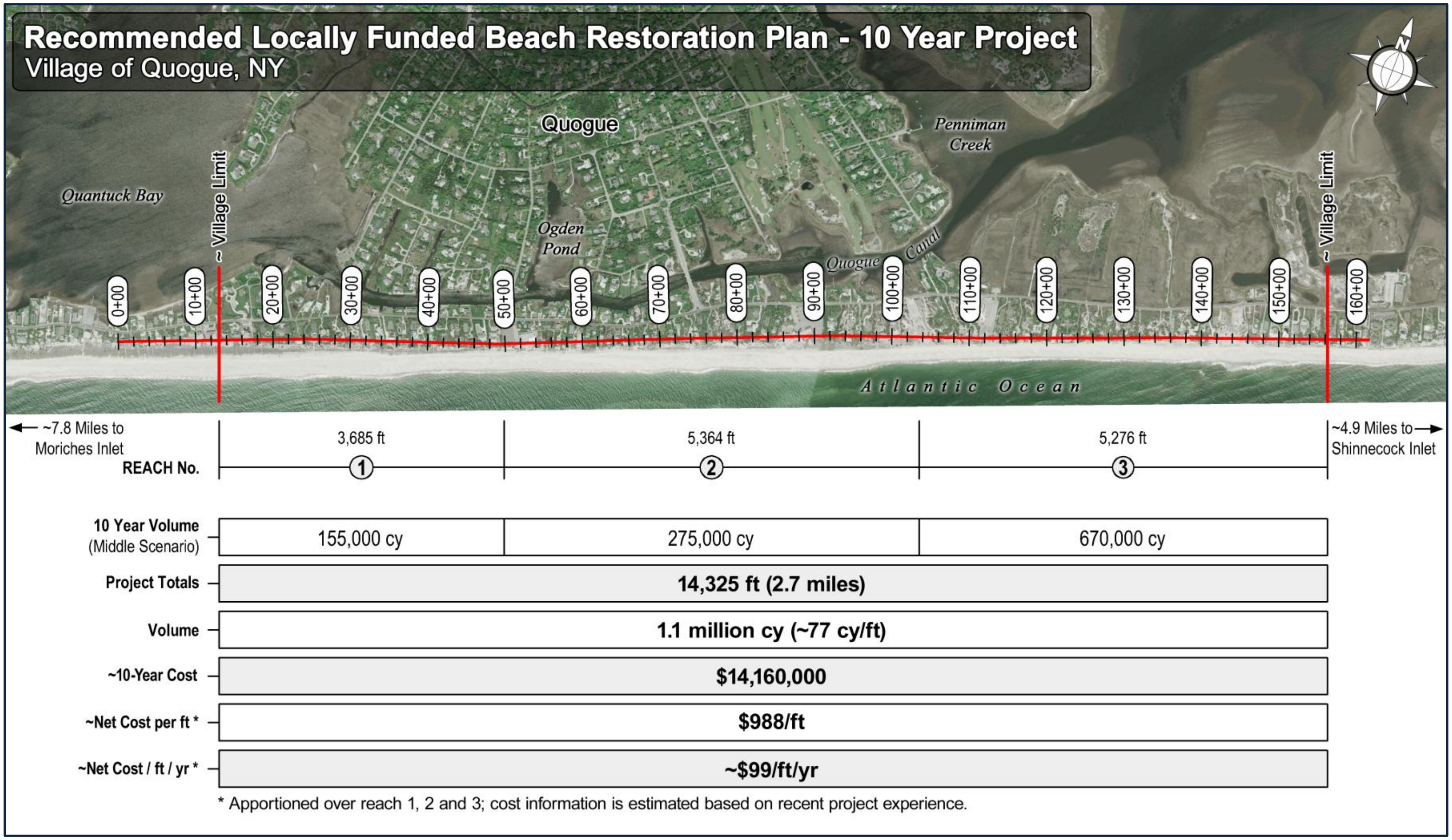


FIGURE G. Recommended locally funded beach restoration plan for the Village of Quogue assuming a nearby offshore borrow area is available and permitable.

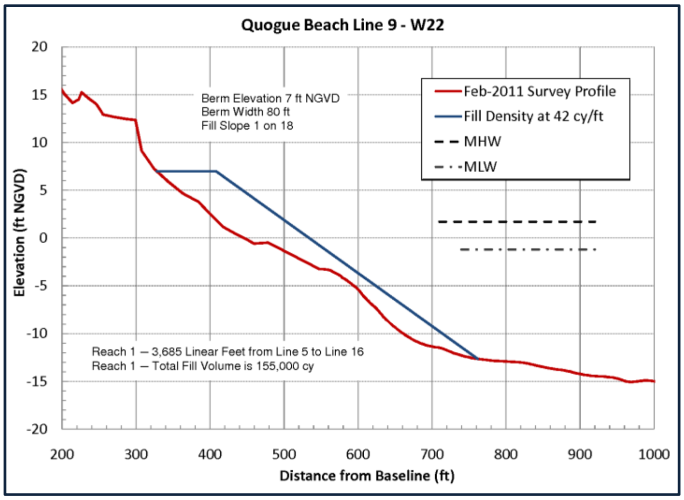
TABLE A. Opinion of probable construction cost and plan for a "ten-year" beach restoration project at Quogue Beach. The scenarios around the recommended plan (middle scenario) are considered viable projects and reflect the uncertainty in erosion rates and construction costs.

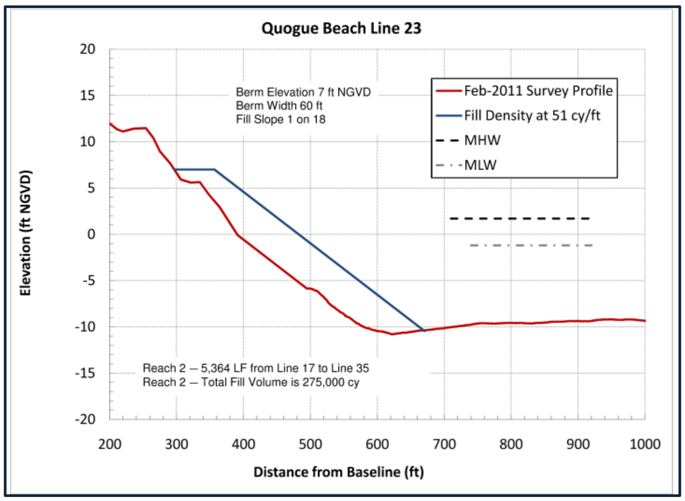
Unit Cost Assumptions:	Dredging @	$ 8.00	per cubic yard
	Mobilization/Demobilization @	$ 3,200,000	
Notes: Unit cost estimate is based on recent project at Smith Point. Mobilization/Demobilization cost is based on recent project at West Hampton.			

CSE Recommended Ten-Year Plan — Middle Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	155,000	42	$ 1,240,000
Reach 2	**L17-L33**	5,364	275,000	51	$ 2,200,000
Reach 3	**L34-L51**	5,276	670,000	127	$ 5,360,000
Totals	**L5-L51**	14,325	1,100,000	77	$ 8,800,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 960,000
				Permitting and Environmental Reports @ 2%	$ 240,000
				Contingency @ 8%	$ 960,000
				Total Project	$ 14,160,000
				Cost per Linear Foot of Beach	$ 988

CSE Recommended Ten-Year Plan — Low Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	131,750	36	$ 1,054,000
Reach 2	**L17-L33**	5,364	233,750	44	$ 1,870,000
Reach 3	**L34-L51**	5,276	569,500	108	$ 4,556,000
Totals	**L5-L51**	14,325	935,000	65	$ 7,480,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 854,400
				Permitting and Environmental Reports @ 2%	$ 213,600
				Contingency @ 8%	$ 854,400
				Total Project	$ 12,602,400
				Cost per Linear Foot of Beach	$ 880

CSE Recommended Ten-Year Plan — Upper Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	178,250	48	$ 1,426,000
Reach 2	**L17-L33**	5,364	316,250	59	$ 2,530,000
Reach 3	**L34-L51**	5,276	770,500	146	$ 6,164,000
Totals	**L5-L51**	14,325	1,265,000	88	$ 10,120,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 1,065,600
				Permitting and Environmental Reports @ 2%	$ 266,400
				Contingency @ 8%	$ 1,065,600
				Total Project	$ 15,717,600
				Cost per Linear Foot of Beach	$ 1,097





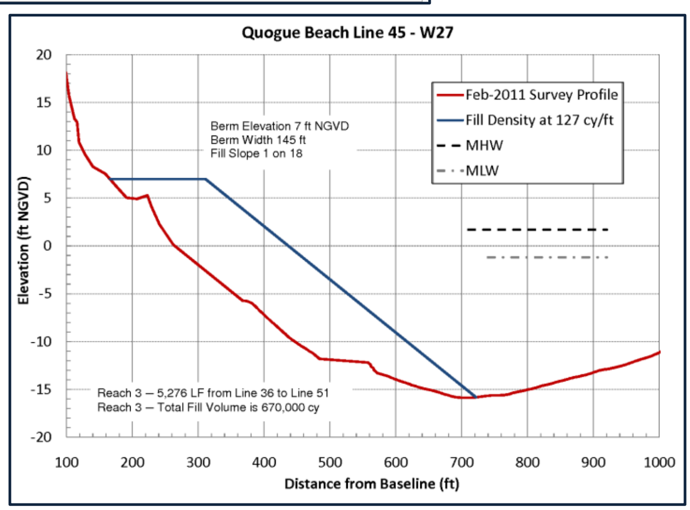


FIGURE H. **[UPPER]** Representative nourishment profiles for Reach 1 showing the initial impact of fill volumes at 42 cy/ft compared with existing conditions (February 2011). **[MIDDLE]** Representative nourishment profiles for Reach 2 showing the initial impact of fill volumes at 51 cy/ft compared with existing conditions (February 2011). **[LOWER]** Representative nourishment profiles for Reach 3 showing the initial impact of fill volumes at 127 cy/ft compared with existing conditions (February 2011).

ACKNOWLEDGMENTS

This report is prepared at the direction of the Village of Quogue (NY) under an agreement between the Village and First Coastal Corporation. It is preliminary to submitting a permit application for beach restoration. First Coastal, as prime consultant, retained the firms of Coastal Science & Engineering Inc (CSE – Columbia SC) and Sea Level Mapping (Wading River NY) to assist with engineering and surveying.

The First Coastal team thanks the Village Board for their support of the project (Mayor Peter Sartorius and trustees Randy Cardo, Ted Necarsulmer, Jeanette Obser and Kimberley Payne). Some of the information herein was obtained through Village archives and from the Quogue Historical Society, as well as First Coastal and CSE archives.

We also thank Save the Dunes & Beaches Foundation (Marjorie Kuhn, director) for their support and helpful suggestions and resident Bob Friedman who provided strong support and recommendations for the project.

Our team drew on previous work by the US Army Corps of Engineers–New York District, and we especially thank Lynn Bocamazo (senior coastal engineer) and Christina Rasmussin (coastal engineer) for providing offshore borrow data. The authors also acknowledge the District and New York Coastal Partnership (Babylon) for support of Dr. Kana under Contract DACW 51-81-C-0030 (FIMP Reformulation Study) and a grant to prepare regional sediment budgets for the area. We also obtained beach survey data from New York State and thank Jay Tanski (NYS Sea Grant Extension Service specialist) for his assistance.

For the project team, Aram Terchunian (First Coastal) is project director assisted by Billy Mack, Mathew Quinn, and Sandra Segelke. Field data collection was performed by Philip McKee (CSE), Dennis Burns (CSE), and Mathew Quinn. Bob Fox (PLS) provided baseline control and QA/QC of the data collection procedures of the team. Data reduction and analysis were directed by Dr. H. Kaczkowski PE (CSE senior coastal engineer) with assistance by CSE staff–Steven Traynum, Philip McKee and Dr. Timothy Kana (PG). Trey Hair and Diana Sangster of CSE prepared the graphics and manuscript. The authors of the report were Tim Kana, Haiqing Kaczkowski, and Aram Terchunian.

TABLE OF CONTENTS

1.0 INTRODUCTION

This feasibility report is prepared at the direction of the Village of Quogue (NY) to develop a plan for beach restoration and shore protection along ~2.7 miles of ocean shoreline. "Quogue Beach" (formerly known as Hampton Beach – US Geological Survey Quadrangle of 1956) is a segment of the 15-mile-long barrier island generally known as Westhampton Beach along the south shore of Long Island (Fig 1.1). Westhampton Beach is bounded by jettied inlets—Shinnecock Inlet to the east and Moriches Inlet to the west. Between Quogue Beach and Moriches Inlet (a distance of ~7.8 miles) is a series of 15 groins built between 1964 and 1970 (USACE 1980), which stabilize a portion of Westhampton Beach. Shinnecock Inlet is about 4.9 miles east of Quogue Beach. Net sand transport along the coast is east to west (USACE 1958), placing Quogue Beach "downcoast" of the Shinnecock Inlet jetties and ~1 mile "upcoast" of the first groin.

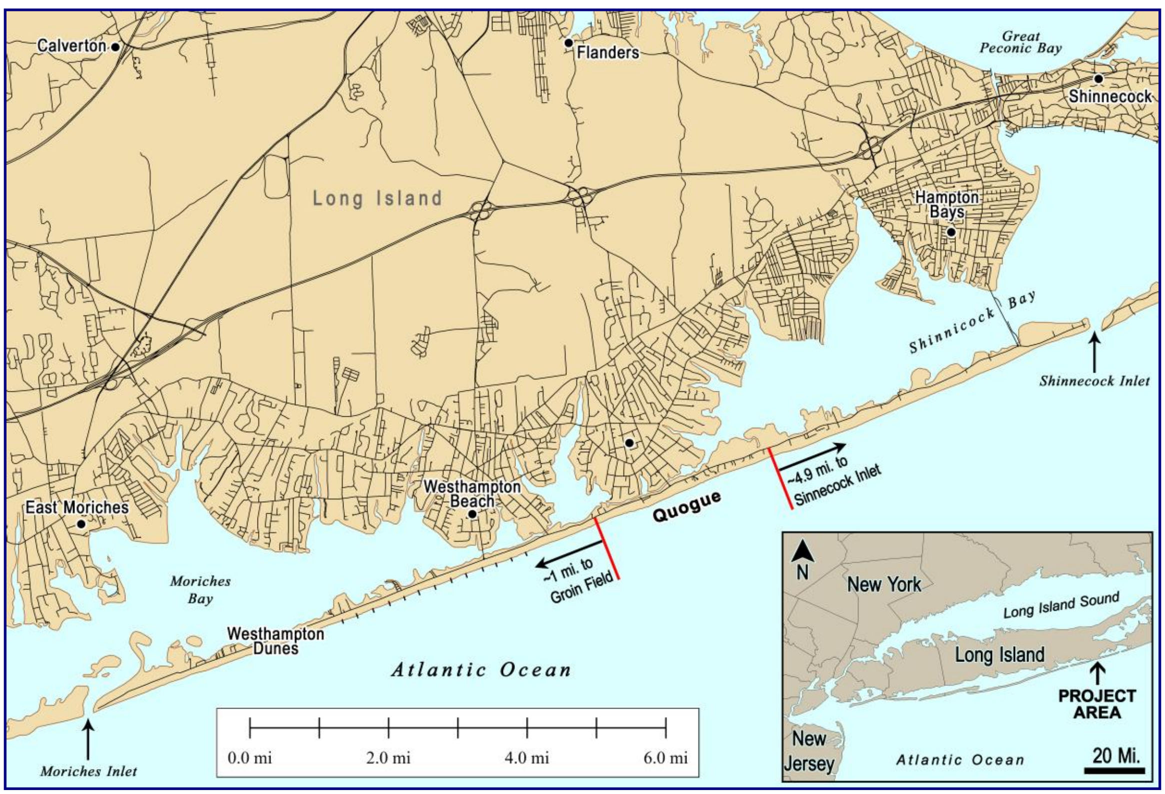


FIGURE 1.1. Vicinity map showing the Quogue Beach project area situated along "Westhampton Beach," a 15-mile-long barrier island between Moriches Inlet and Shinnecock Inlet. Net sand transport is east to west along the south shore of Long Island.

Westhampton Beach has sustained erosion over many years as evidenced by numerous shore-protection and beach-restoration measures implemented since around the 1930s (USACE 1958, 2010). Some erosion is man-induced as proven in court (Westhampton Dunes versus U.S. Government et al), while natural sand losses have also occurred. Quogue Beach has sustained chronic erosion and periodic storm damage to the point where certain properties have little dune protection (Fig 1.2).

FIGURE 1.2. Beach and dune conditions along the eastern half of Quogue Beach in February 2011, showing narrow setback of homes landward of a degraded foredune.

The Village of Quogue retained the team of First Coastal Corporation and Coastal Science & Engineering Inc (CSE) to complete a detailed shoreline erosion assessment and develop plans for beach restoration. The primary goal is to determine the sand deficit and average annual sand-loss rate along Quogue Beach and to develop a plan that provides 5-year, 10-year, or 20-year improvement to the beach/dune system. The assessment and plan covers ~2.7 miles of oceanfront, but also takes into account the adjacent segments of beach.

The plan is preliminary to developing a permit application, final design, and construction of a beach-restoration project. It contains many of the elements found in a US Army Corps of Engineers (USACE) reconnaissance or feasibility study which are mandatory before implementation of federal civil works projects. Given the (~)$2.5 billion backlog of federal beach-restoration projects (USACE 2008) and typical federal expenditures of only (~)$100 million per year (nationwide), there is a long waiting list for subsidized projects. As a result, many beach communities in the U.S. are electing to implement "interim–locally funded" projects until such time as federal assistance may be available [eg – Myrtle Beach (SC), Bogue Banks (NC), Nags Head (NC)].

Our project team completed the following work in connection with the present report.

Literature Review — Searched for and reviewed relevant reports, publications, sediment budgets, and federal project information dating back to the 1930s.

Beach and Inshore Surveys — Established a project baseline in the area of the foredune and surveyed profiles at ~300-feet (ft) spacing from the baseline to ~3,500 ft offshore.

Beach Erosion Analysis and Nourishment Requirement — Merged historical data with present surveys and developed estimates of volumetric losses as well as sand deficits and surpluses for representative beach segments (reaches) along Quogue Beach.

Evaluation of Potential Sand Borrow Sources — Reviewed available data and environmental impact assessments of federally designated offshore borrow areas in the vicinity of Quogue Beach. Compared potential sources with the sediment quality of the native beach.

Plan Formulation — Developed specific beach restoration plans for 5-year, 10-year, and 20-year periods incorporating volumes to replace a particular sand deficit and volumes to replace average annual erosion losses. The recommended plan assumes a “10-year” period of improvement.

Estimate of Probable Construction Costs — The plans for beach restoration include opinions of probable construction costs based on present industry conditions and unit prices for similar projects in the Middle Atlantic Region.

1.1 GENERAL APPROACH

Defense against coastal erosion generally takes two forms—hard solutions (involving shore-protection structures) and soft solutions (involving manipulation of sediment supplies or political controls restricting coastal development). An intermediate defense is also possible whereby sand-retaining structures (eg – groins, breakwaters, or jetties) are placed along the beach to trap and hold sand moving alongshore. The Westhampton Beach groin field is a classic example of the intermediate defense.

In most jurisdictions, soft solutions are favored over hard solutions because they have the potential of preserving the aesthetic character of the beach. Construction of bulkheads, seawalls, and revetments—the common hard structures used for erosion control—have the effect of protecting developed property but do not, by themselves, maintain the beach. If chronic erosion is the predominant trend along any sandy coast, the principal way to maintain the beach, while protecting upland property and infrastructure, is via additions of sand to the beach system. This can be accomplished several ways, including import by trucks from inland sand pits ("borrow areas"), scraping from healthy areas of the beach (such as spits that are growing), or by dredging sand from offshore (or other areas which are not part of the active beach system) and pumping the sand along the beach.

This report will briefly review the advantages and disadvantages as well as costs of each approach. In general, beach nourishment (without sand-retaining structures) is a viable alternative for mitigating erosion if:

1) The local rate of shoreline recession is moderate (ie – <3 feet per year).
2) The value of upland property is high, making it costly to abandon or relocate houses, businesses, and infrastructure.
3) There are good-quality borrow sources in close proximity to the beach.
4) The local jurisdiction prohibits hard erosion-control structures.

As a rule of thumb, locally sponsored nourishment projects are more likely to be funded if the average annual cost to an individual property owner is less than 1-2 percent of the property value. If the annual cost of nourishment is greater than 5 percent of the property value, it obviously becomes an expensive alternative to sustain.

A useful way to view costs of nourishment is on the basis of one foot per year (1 ft/yr). If sand losses average 3 cubic yards per foot of beach per year (equivalent to ~3 ft/yr shoreline recession rate) and the cost of sand delivery is $10 per cubic yard (/cy), it will cost about $30/ft/yr to keep pace with erosion. A typical oceanfront property with 100 ft of shoreline would require expenditures of (~)$3,000/yr under these assumptions. Amounts in this range are realistic for many sites because, as Dolan et al (1990) have shown, most developed shorelines are eroding at less than 3 ft/yr. Further, sand delivery costs are commonly in the $5-10/cy range for medium to large-scale projects.* By comparison, revetments and seawalls along the ocean coast have initial costs in the range $1,000–

$3,000 per linear foot for settings like Quogue Beach (ie – 35-100 times greater than the annual cost of nourishment) (ASCE 1994, Kana 2011).

*[*Note: Small scale projects accomplished by individual property owners often have high unit costs because they lack economies of scale that are possible with community projects.]*

Whether or not nourishment is the best approach for mitigating erosion along a particular segment of shoreline depends on many factors, which are often evaluated during the detailed design stage of a project. Based on the team's experience at other sites, it is apparent that nourishment is likely to be viable for Quogue Beach given the high property values within the community and the lack of undeveloped lots which could absorb relocated houses. The cost of abandonment or relocation is likely to be >$1 million per property based on typical property values which greatly exceed $1 million along the oceanfront (Source: www.zillow.com; USACE 2010).

The team's general approach to analyzing the feasibility of nourishment along Quogue Beach includes the following:

1) Determine the site-specific erosion rates, principal causes of erosion, and sand deficit with respect to some ideal beach/dune condition.

2) Locate the nearest borrow source which may provide beach-quality sand for nourishment.

3) Determine the most cost-effective method of construction.

4) Identify the environmental protection measures necessary to secure project permits and execute construction.

Ideally, the nourished beach should be indistinguishable from a natural beach, provide a healthier profile over which normal beach processes occur (ie – seasonal erosion and accretion), and increase the protection of existing development from storms. If those goals are achieved, community property values, property tax collections, and the aesthetic quality of the community will be maintained or enhanced.

2.0 WORK ACCOMPLISHED AND KEY FINDINGS

2.1 LITERATURE AND HISTORICAL DATA

The team reviewed relevant reports, shoreline data sets from prior work by New York State and the USACE, and related literature (listed in the references). The reports of particular relevance focus on sediment budget analyses at mesoscales (ie – decadal time frames), beach erosion rates, sand sources, and littoral processes. Much of the available data are derived from studies between Fire Island Inlet and Montauk Point (about 82.6 miles), which have been completed by the USACE-New York District. The shoreline of the present project (2.7 miles) represents a small portion of the Fire Island to Montauk Point federal project. Therefore, previous studies provide a less detailed analysis of erosion and sediment transport along Quogue Beach.

The present study is the first comprehensive beach and profile survey conducted in the project area. The survey methods and results will be discussed in Section 2.2. In this section, milestone events in the vicinity of the project area are highlighted. Historical erosion rates (volumetric changes) are summarized from previous data and information sources for a range of time periods, including 1955-1979, 1979-1995, and 1995-2001. The team's surveys allowed updating of historical erosion rates, particularly the period 2001-2011.

2.1.1 Formation of Quogue Beach

Long Island was the southern terminus of the Wisconsin glacier during the last part of the Pleistocene period. Terminal moraines formed the spines of Long Island and what are currently referred to as the North Fork (Harbor Hill moraine) and South Fork (Ronkonkoma moraine) of Long Island. Between about 20,000 and 5,000 years ago, the Wisconsin glacier melted rapidly during a global warming period (Flint 1971). Numerous outwash streams carried huge amounts of sediment onto the continental shelf. This discharge was met by an encroaching shoreline as seas rose nearly 120 meters (m) (~400 ft) (Fig 2.1) and waves reworked stream deposits and deltas of gravel and sand into bars paralleling today's coast. "Interfluve" (ie – high ground) areas between the outwash streams (such as present-day Mastic, Hampton Bays, and the Village of Quogue) became the "headlands" along the south shore. Once sea level approached its approximate present elevation and the glacial melting subsided, littoral sands were shaped into the linear beaches and barrier islands that now protect Long Island's south shore. The drowned stream channels landward of the barrier beaches form the present south-shore bays and ponds.

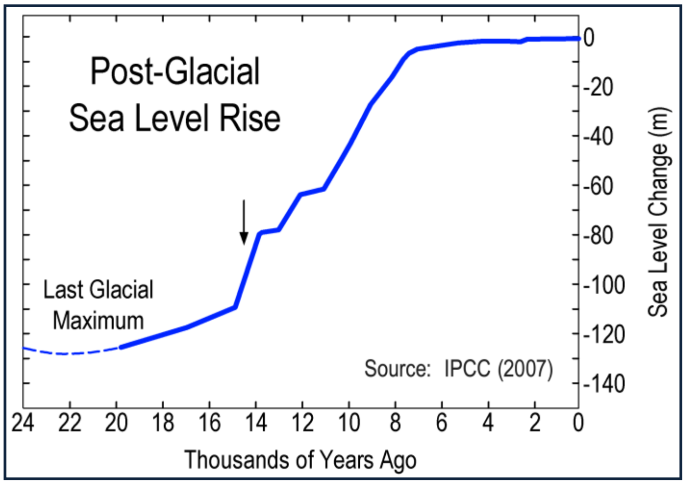


FIGURE 2.1.

Post-glacial sea-level rise curve prepared by the Intergovernmental Panel on Climate Change (IPCC) (2007). Note the present coast formed beginning around 5,000 years ago after sea level approached its present elevation.

1 meter approximately equals 3.3 ft.

[After IPCC 2007]

Tidal inlets have maintained connections with the ocean and have undergone cycles of opening and closing in relation to the passage of storms and supply of littoral sands (Leatherman and Joneja 1980). In settings like Westhampton Beach and Fire Island where the ocean tide range is ~3 ft and mean wave breaker heights are >3 ft (NOAA-NOS 1994), barrier beaches tend to be long with widely spaced tidal inlets (Hayes 1979). Occasional storms produce high waves and tides which breach the barrier beach and create new inlets. But following storms, the inlets tend to close unless there is a sufficient volume of water (ie – "tidal prism") flushing the channel each tide to remove littoral sands entering the inlet (Bruun and Gerritsen 1959).

Around 1755, Quogue Inlet formed ~0.5 miles west of the present west village boundary (8.2 miles east of present Shinnecock Inlet). That inlet flushed Quantuck Bay, but closed in 1829. It reopened in 1848 then closed again in 1886 (Leatherman and Joneja 1980). US Coast & Geodetic Survey maps from 1838 (USCGS T-38, US government archives) show a continuous barrier beach along Quogue (Fig 2.2). Leatherman and Joneja (1980) reported a number of locations for inlets into Shinnecock Bay, east of Quogue, in the 1800s with the closest situated ~0.7 miles east of the village line. By 1893, all inlets flushing Shinnecock Bay were closed, and the outer beach was continuous from Southampton to Fire Island. Quogue Beach, a segment of present-day Westhampton Beach, was effectively attached to the mainland into the 1800s with a narrow tidal wetland separating the mainland from the barrier beach (see Fig. 2.2).

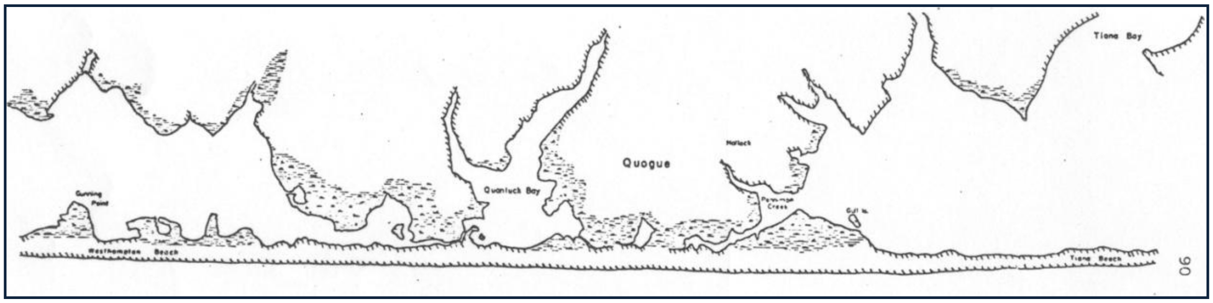


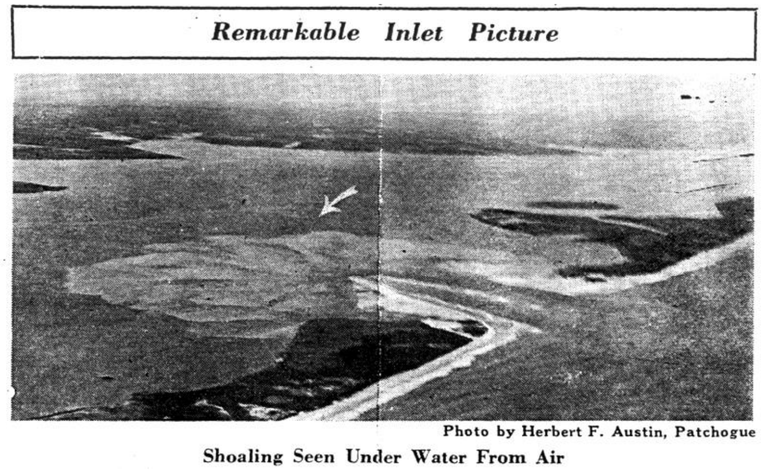
FIGURE 2.2. Portion of 1838 USCGS Map T-58 showing continuous barrier beach and narrow tidal wetland separating the coast from the Village of Quogue (from Leatherman and Joneja 1980, Fig 14).

At some unknown time in the latter half of the 19th century, the Quogue Canal and Quantuck Canal were built to provide a waterway connection from Shinnecock Bay to Quantuck Bay and Moriches Bay (to the west). The canals were improved in 1899 because *"the old channel … was not large enough to permit a free circulation of water…a condition which resulted in the waters becoming stagnant, and which threatened the destruction of the fish and oyster industries, as well as being a menace to health."* (source: www.mikalac.com/tech/tra/shin.html; original author unknown). This followed construction of the Shinnecock Canal in 1892 (source: New York Times 21 July 1892). The purpose of the Shinnecock Canal was to restore tidal flows by way of Peconic Bay to oyster beds in Shinnecock Bay. Efforts were also made (but failed) at the turn of the 20th century to restore an inlet connection between the ocean and Shinnecock Bay.

During the first decades of the 20th century, there was apparently no viable inlet connecting south shore bays between Southampton and Fire Island Inlet (Leatherman and Joneja 1980). This changed when Moriches Inlet reopened during a northeaster on 4 March 1931 (USACE 1958) (Fig. 2.3). The "Great Hurricane of 1938"—the storm of record for eastern Long Island—created present-day Shinnecock Inlet (Fig 2.4) along with 6-7 other breaches of Westhampton Beach (Howard 1939, USACE 1958). The 1938 hurricane also caused numerous washovers and destroyed or displaced many houses (Fig. 2.5). The majority of the breaches closed naturally or artificially. However, Moriches Inlet and Shinnecock Inlet became the focus of efforts to finally stabilize and maintain permanent channels to the bays.

FIGURE 2.3.

Oblique aerial photo of Moriches Inlet in 1931 soon after it formed through Fire Island and Westhampton Beach (source: Island News, NY). The original caption read, “This excellent picture shows exactly what has happened in the new inlet cut across Fire Island by Atlantic storms. The heavy deposits of sand have been dropped just inside the inlet by the swirling incoming tides, the water losing the deposits when it reaches the quieter region of Moriches Bay.” Herbert F. Austin, the photographer, was Dr. Tim Kana’s grandfather.



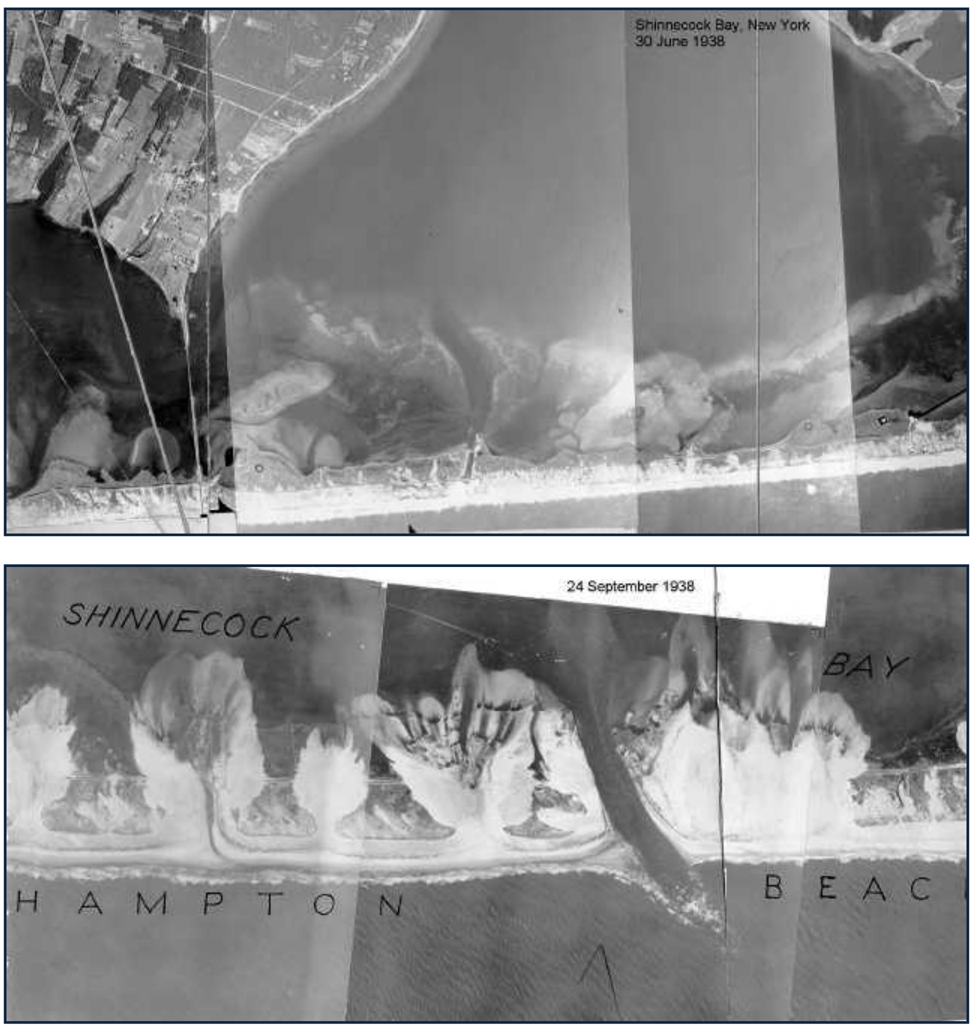


FIGURE 2.4. Shinnecock Bay and the continuous outer beach on 30 June 1938 prior to the Great Hurricane of 1938. The lower image shows the Shinnecock Inlet breach three days after the hurricane on 24 September 1938. Note extensive fans of sediment (“washovers”) across the barrier into the bay. There were no less than seven breaches of Westhampton Beach during the storm with the majority closing naturally after tides and waves returned to normal (USACE 1958). [Images courtesy of Andy Morang. www.lishore.org/photos/ShinHist/index.html]

FIGURE 2.5.

Washover damage across Westhampton Beach after the 1938 hurricane. Ocean is at the top of the image.

[Source: Quogue Historical Society]

Jetties were constructed by the USACE at each inlet in the early 1950s with the Shinnecock jetties finished in 1954 (USACE 1958). These jetties have permanently modified the shoreline and led to local variations in erosion and accretion as well as accumulation of sand in offshore and bay shoals ("ebb-tidal delta and flood-tidal delta" – respectively) (Fig 2.6). The USACE has maintained an active research program to evaluate the stability of Shinnecock Inlet and various mechanisms of sand bypassing from east to west (cf – Williams et al 1998, Morang 1999, Pratt and Stauble 2000, and Militello and Kraus 2001).

FIGURE 2.6.

Oblique aerial photograph looking northeast in August 1981 showing the offset shoreline around the Shinnecock Inlet jetties which were completed in 1954. Chronic erosion occurs immediately west of the inlet in connection with wave sheltering in the lee of the seaward shoals ("ebb-tidal delta").

2.1.2 Sediments and Profile Evolution

As a segment of Long Island's barrier beach system, Quogue Beach is dependent on a sediment supply from more easterly beaches (Fig 2.7). The principal sources of sand are the eroding bluffs and dunes of Montauk, Easthampton and Southampton (Taney 1961). Medium to coarse-grained sand (0.5-1.0 mm diameter) predominates along the ocean coast and can be found as "relict" deposits further offshore (Colony 1932). Around the outer bar (a persistent feature 500-1,500 ft offshore), sediments tend to be finer with sand in the 0.15 to 0.3 mm diameter-size range (Liu and Zarillo 1987).

FIGURE 2.7. Obique aerial photograph in August 1981 looking northeast from the eastern end of the Westhampton groin field to Quogue Beach (upper right corner). Net sand transport along the coast is east to west. Note subtle irregularities in beach width and form which are generally linked to variations in the offshore bar as well as the presence of sand-retaining structures such as groins and jetties. [Photo by TW Kana]

In the past century, sea level has risen at a rate of ~2.5 millimeters per year (mm/yr) (~1 ft per century) (Hicks et al 1983) (Fig 2.8). A rate of this magnitude would account for some recession of the shoreline even if the coast were "stable," simply by inundating the sloping land along the beach.

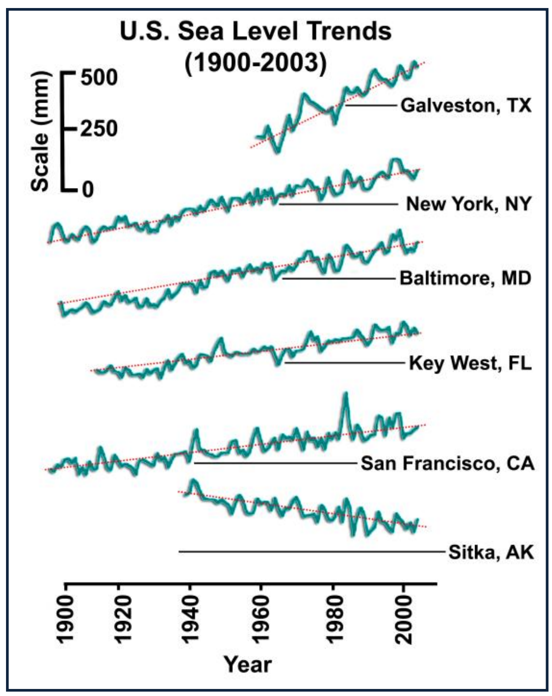


FIGURE 2.8.

Trends in sea level during the 20th century based on tide-gauge records (IPCC 2007). The rates of change vary from place to place because of the combined effect of the global ("eustastic") rise plus local subsidence of the land. The ~2.5 mm/yr trend in New York equates to almost 1 ft of rise during the 20th century.

Barrier islands and strand beaches such as Westhampton Beach, Fire Island, and East-hampton are wave-built features created where the continental shelf has gentle slopes and there is an ample supply of sandy sediments. They are more common in lower tide-range settings (Hayes 1979, Davis 1994). The process of wave-breaking pushes sand shoreward and develops the sloping profile of a beach. The normal limit of wave action is the "dry sand beach" which is pushed up above the normal high tide line. There is a limit to the height and steepness of any beach based on the energy in waves, size of the individual sediment grains, and the restoring force of gravity (Komar 1998). Typical values for Quogue Beach are 1 on 15 to 1 on 25, meaning there is a 1-ft drop in elevation as one walks 15-25 ft toward the ocean in the wave swash zone.

A profile develops at the coast through complex actions of waves, tides, winds and storms (Fig 2.9). During fair-weather conditions and commonly in the summer, the dry beach will build up, leaving a steeper profile at the water's edge. Storms and high-wave periods in winter tend to flatten the profile and shift sand from the dry beach to the low-tide zone. Where the dry beach is narrow or missing, storm events will erode the foredune and backshore areas, redistributing sediments offshore. Erosion of most concern for community planning is the **net** loss of sand each year after the effects of storms and fair-weather buildup are balanced.

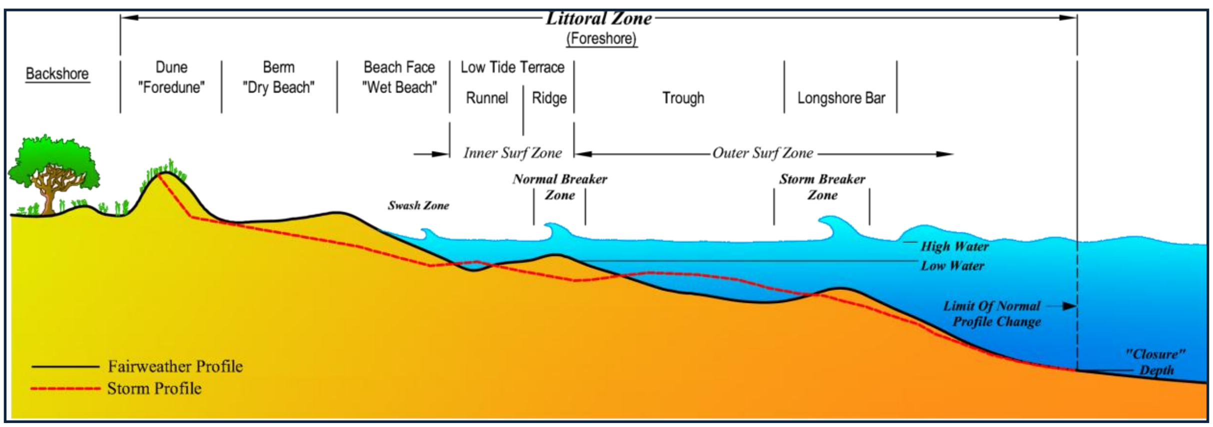


FIGURE 2.9. Representative profile of the littoral zone illustrating the principal features between the dune and offshore. The profile varies with changes in wave energy, the passage of storms, and differences in sediment quality. The present erosion assessment takes into account the cycle of beach profile changes and focuses on the **net** loss of sand each year from the entire littoral zone. [Based on Komar 1998]

A stable beach is a profile that undergoes normal changes without any loss of sand between the dune and some limiting depth offshore. An eroding beach is a profile that loses some volume of sediment each year. The loss may be to deep water or to some other section of the beach, to an inlet, or to a sand spit. Another net loss can occur if sand "washes over" the barrier island and is deposited in the bay (cf – Fig 2.4, lower). Once removed from the active littoral zone, the lost sand can only be returned by artificial means.

Dunes are the portion of the littoral profile well above wave swash levels that are built by winds. Normally, sediments in dunes are slightly finer diameter and more easily moved by winds than those in the active swash zone. The prerequisites for dunes are a healthy dry-sand beach and winds sufficient to entrain and transport sandy material landward. If there is no dry beach, dunes will not form or grow. Highest dunes form where the shoreline is slightly accretional. The dune and its vegetation create a natural barrier that traps sand. If the dune and vegetation are missing, broad expanses of dry beach may extend across the barrier island and provide a conduit for sand losses or breach inlets to the bay. Conversely, if a segment of shoreline is accreting rapidly, dunes may have little time to grow in height before they are stabilized by vegetation and a new dune line forms further seaward. Thus, dune dimensions are one measure of a shoreline's stability (Short 1999).

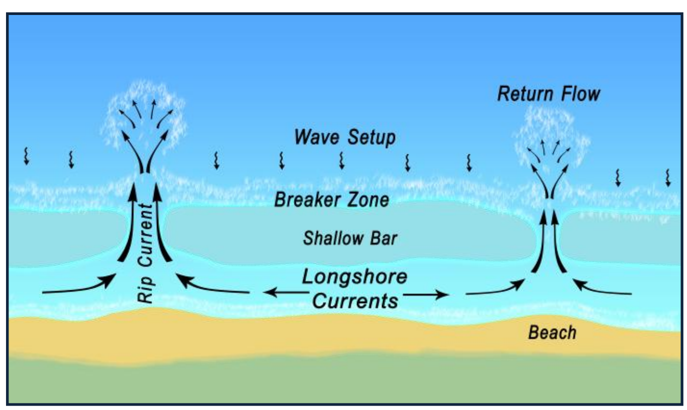
2.1.3 Shoreline Morphology and Sand Transport

The shoreline of barrier beaches tends to be linear in relation to the crests of waves arriving at the beach. The orientation of the foredune, the seaward vegetation line, and the mean high waterline all tend to parallel the average wave crest with many subtle variations. Rhythmic features occur across the littoral profile because of minor variations in wave energy, sediment characteristics, and the influence of inlets and man-made structures. Thus, some sections of dry beach or the adjacent foredune may be wider than nearby sections. Breaks in the outer bar may account for some rhythmic shoreline features, as well as complex circulation of currents in the surf zone (Fig 2.10). In short, the assessment of erosion along any beach requires consideration of the entire littoral profile and its variations alongshore.

FIGURE 2.10.

Complex circulation cells develop in the presence of waves at the shoreline (after Kana 1998).

[Graphic by T Hair]



Quogue Beach depends on a supply of sand from the east to keep pace with losses to the west. While waves arrive at the shore from both westerly and easterly quadrants, on average, waves from the east are larger and tend to produce a “littoral drift” from east to west (Panuzio 1968). This net flow of sand is apparent along the Westhampton groin field where there tends to be a wider beach on the east side of each groin (Nersesian et al 1993; Rosati et al 1999) or at Shinnecock Inlet where the shoreline east of the east jetty is offset seaward of the shoreline west of the west jetty (see Figs 2.6 & 2.7). Interruptions of littoral sand transport by jetties and groins account for many of the erosion problems along the U.S. coast (NRC 1995).

2.1.4 Frame of Reference for Erosion Planning

The formation and evolution of Quogue Beach may be considered at a range of time scales measured in days to thousands of years. For erosion planning purposes, however, the most appropriate time scale is considered to be decades to one century. This is for several reasons. First, storms produce temporary movement of the shoreline but often lead to recovery periods which restore the dry-sand beach. The erosion of interest for community planning is the net sand loss after the cycle of erosion and accretion around a particular storm is complete. Considering erosion rates on an annual basis is a practical benchmark which tends to average out the short-term effects of storms or the seasonal cycle of beach changes.

Secondly, decadal changes are of interest because many of our investments, such as home mortgages or funding of infrastructure, parallel human life spans. The principal littoral conditions presently influencing the supply of sand along Quogue Beach have occurred for barely half a century. Sand transport is influenced by the upcoast inlet and downcoast groins which have been in place only since the 1950s and 1960s (respectively). It is unlikely Shinnecock Inlet will ever be allowed to close and the jetties removed so that Westhampton Beach is once again attached to Southampton Beach. So the shoreline conditions and sand-retaining structures of the past ~50 years are likely to persist into the future.

A final reason to plan at decadal to century time scales is the normal practice of building for “100-year” return period events. The US Federal Emergency Management Administration (FEMA) establishes minimum building elevations at the coast based on the probable maximum storm-tide elevation predicted to occur within 100 years. Certainly, there is a risk of higher surges associated with rarer, more extreme events (as demonstrated by the 2011 Sendai tsunami in Japan). However, the standard for community planning along the US coast is the 100-year storm event. A community may elect to apply more rigorous planning standards, just as the Dutch have, but at higher infrastructure costs.

Differences in opinions regarding the formation, stability and long-term evolution of barrier islands and beaches often stem from different frames of reference (Kana 2011). Barrier islands are geologically young and exceedingly ephemeral (Schubel 1971). The question of how to manage Quogue Beach depends on its likely evolution over a defined time frame. The focus of this assessment is to evaluate the likely sand losses and restoration needs at decadal scales.

2.1.5 Milestone Events in the Vicinity of Project Area

A summary of milestone events over the past century follows.

1938 — The Great Hurricane of 1938 was the most powerful, costly, and deadly hurricane in southern New England's history to date (www.erh.noaa.gov/box/hurricane/hurricane1938.html). It killed upward of 600 people and destroyed thousands of houses. Losses in Westhampton Beach area included 28 deaths and destruction of 150 houses, making it the hardest hit Long Island community (www.sunysuffolk.edu/mandias/38hurricane/damage-caused.html). As previously discussed, the hurricane opened Shinnecock Inlet and other breach channels to Moriches Inlet. These breaches removed large volumes of sand and deposited them in the bays, leaving the remaining properties on the beach exposed and vulnerable to further losses. The eye of the hurricane passed over Bellport (NY) with lowest recorded pressure of 27.94 inches. Later analyses determined the maximum sustained winds were 120-125 miles per hour (mph) (Category 3 on the Saffir-Simpson scale) when the hurricane made landfall. Coinciding with spring high tides, the storm surge reportedly reached 16 ft above sea level in the Westhampton Beach area. Figure 2.11 shows the path of the hurricane and provides snapshots of some of its devastation.

1962 — Ash Wednesday storm (6-8 March) was the northeaster of record along the US Middle Atlantic coast. The duration of the storm, more than its intensity and surge heights, resulted in extreme property damage, loss of dunes, and formation of at least one inlet just west of the present groin field. The new inlet was closed by trucks hauling sand from inland and the adjacent beach within a few weeks of the breach (USACE 1980, Vogel and Kana 1985). A total of 46 houses were destroyed along Dune Road on Westhampton Beach. Following the storm, the USACE pumped over 2.2 million cubic yards from bay deposits to the barrier beaches between Fire Island Inlet and Southampton (USACE 1969).

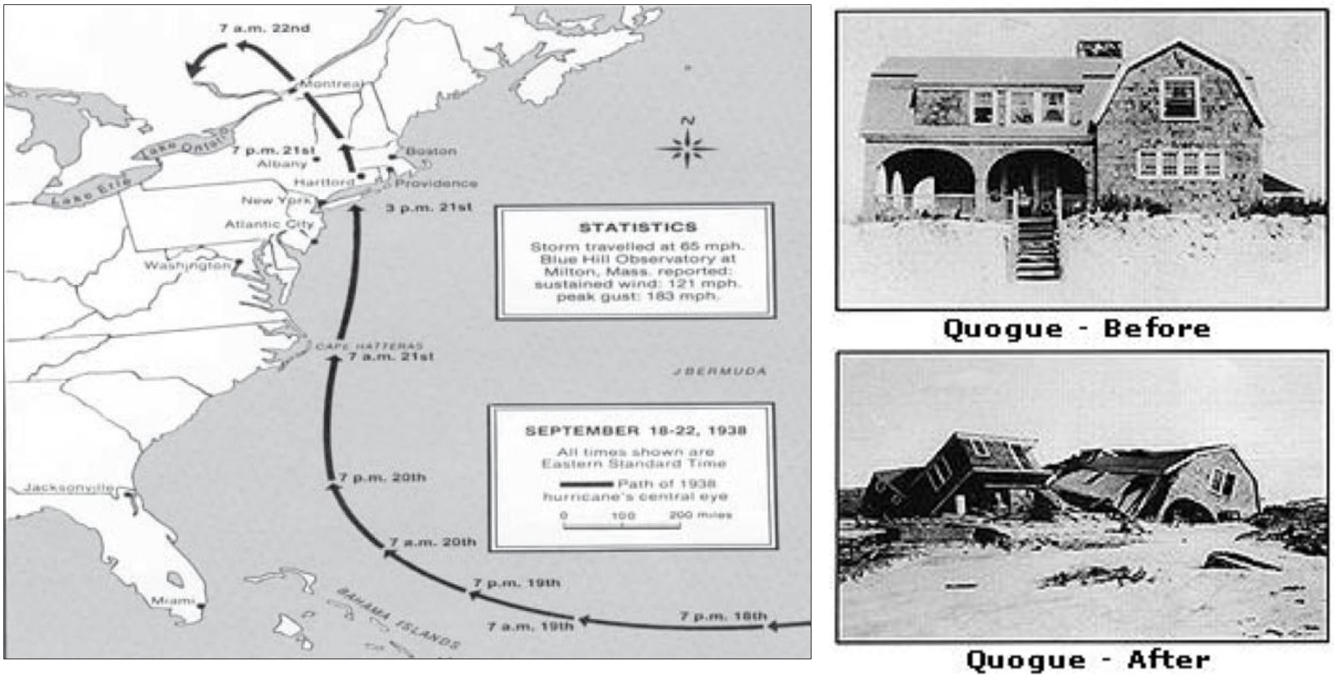


FIGURE 2.11. The Great Hurricane of 1938. Left image: Hurricane path. Right image: House at Quogue before and after the hurricane. [Source: Wikipedia]

1965 to 1970 — To compensate for the loss of sand and the degraded condition of the beach to the west of Shinnecock Inlet, a groin field consisting of 11 quarry-stone groins (USACE 1980) without nourishment was created along Westhampton Beach in an attempt to slow beach erosion. Eleven groins were completed in the Westhampton Beach area around 1965. An additional four groins with beach and dune fill were placed west of the 11-groin field during 1969 and 1970 (see Fig 1.1 for general location). The groin closest to Quogue Beach is ~5,900 ft west of the village limit.

1992 to 1993 — Northeasters caused extensive damage along the oceanfront and breached Westhampton Beach at the western end of the groin field (Bocamazo et al 2011). The first breach occurred in December 1992. Before it could be closed, a second breach opened nearby in early 1993; both were subsequently closed by hydraulic dredge (Terchunian and Merkert 1995).

1996 — The Westhampton groin case was settled which led to the incorporation of the Village of Westhampton Dunes (Dally et al 2000).

1996 to 1997 — The federal Westhampton interim project begins and includes beach nourishment and groin modification along groins 7 to 15 and west to Cupsogue Beach, restoring the beach to buildable conditions and ushering extensive new construction in the areas that had sustained breach inlets in 1992-1993 (Bocamazo et al 2011). Total volume placed using offshore borrow sources was ~3,530,000 cubic yards.

2000 — The first Westhampton interim renourishment project was conducted. Total volume placed was 981,000 cy.

2004 — The second Westhampton interim renourishment project was conducted. Total volume placed was 759,000 cy.

2005 — "West of Shinnecock Inlet—WOSI" interim project begins and includes beach fill west of the Shinnecock navigation channel.

2008 — The third Westhampton interim renourishment project was conducted. Total volume placed was 627,000 cy (Bocamazo et al 2011).

2.1.6 Beach Nourishment and Restoration

The island of Westhampton Beach has been nourished continually since the 1950s with a majority of the fill placed along the western half of the island (groin field to Cupsogue Beach) and immediately west of Shinnecock Inlet. Comparatively little sand has been placed along the Quogue Beach segment based on records from USACE (1958, 1980), Suffolk County Department of Public Works (SCPD 1985), and Bocamazo et al 2011. The majority of early projects were associated with closure of breach inlets west of the groin field (1962, 1980, and 1993). The 1980 breach impacted Cupsogue Beach ~0.5 mile east of the jetties. Encroachment of the bay channel along the back side of the barrier island led to that event (Vogel and Kana 1985). The most recent projects (Bocamazo et al 2011) have been performed in connection with the settlement of the lawsuit at Westhampton Dunes. Projects since 1996 have utilized offshore borrow areas and have placed sand between groin 7 (middle of groin field) and Moriches Inlet.

Table 2.1 provides a summary of estimated beach nourishment volumes by decade along Westhampton Beach derived from various sources as reported by Kana (1999) and Bocamazo et al (2011). Based on available records, ~21 million cubic yards have been placed along Westhampton Beach over six decades. If apportioned over the 15-mile length of the island, this would equate to an average addition of ~260 cy/ft, or 4.3 cy/ft/yr. These amounts will be put in perspective in a later section of the report. Importantly, additions of this magnitude are comparable to the volume losses along a beach eroding at ~3-5 ft/yr.

TABLE 2.1. Estimated beach nourishment volumes placed along Westhampton Beach since the first projects in the 1950s. Compiled from various sources as reported by Kana (1999) and Bocamazo et al (2011). Totals include channel dredging and disposal projects, breach closure projects, and offshore borrow area projects. Unit and average annual volumes are apportioned over the entire length of the island (~81,850 ft).

Decade	Unit Volume (cy/ft)	Volume (cy)	Annual Unit Volume (cy/ft/yr)
1950s	28.8	2,354,000	2.9
1960s	53.4	4,341,000	5.3
1970s	35.5	2,908,000	3.6
1980s	25.3	2,074,000	2.5
1990s	87.2	7,140,000	8.7
2000s	28.9	2,367,000	2.9
TOTALS	**258.8**	**21,184,000**	**4.3**

The effects of nourishment combined with sand trapping in the groin field have allowed portions of Westhampton Beach to build seaward by hundreds of feet. Kana and Mohan (1996) illustrated the change in profiles within the groin field and ~0.5 mile west of the groin field (Fig 2.12). Between 1962 and 1979, the beach between groins 1 and 2 (ie – ~1.2 miles west of Quogue Beach) built 250 ft seaward. A new dune line formed seaward of the original dune. Volumetric accretion measured past the outer bar (to −20 ft mean sea level) was ~345 cy/ft. By comparison, the section of beach downcoast of the groin field (Fig 2.12, lower) sustained dune erosion, ~200 ft of beach recession, and net loss of sand. The accompanying photo in Figure 2.12 shows the narrow beach west of the groin field in 1981. Loss of the foredune set the stage for the breach inlet in 1992.

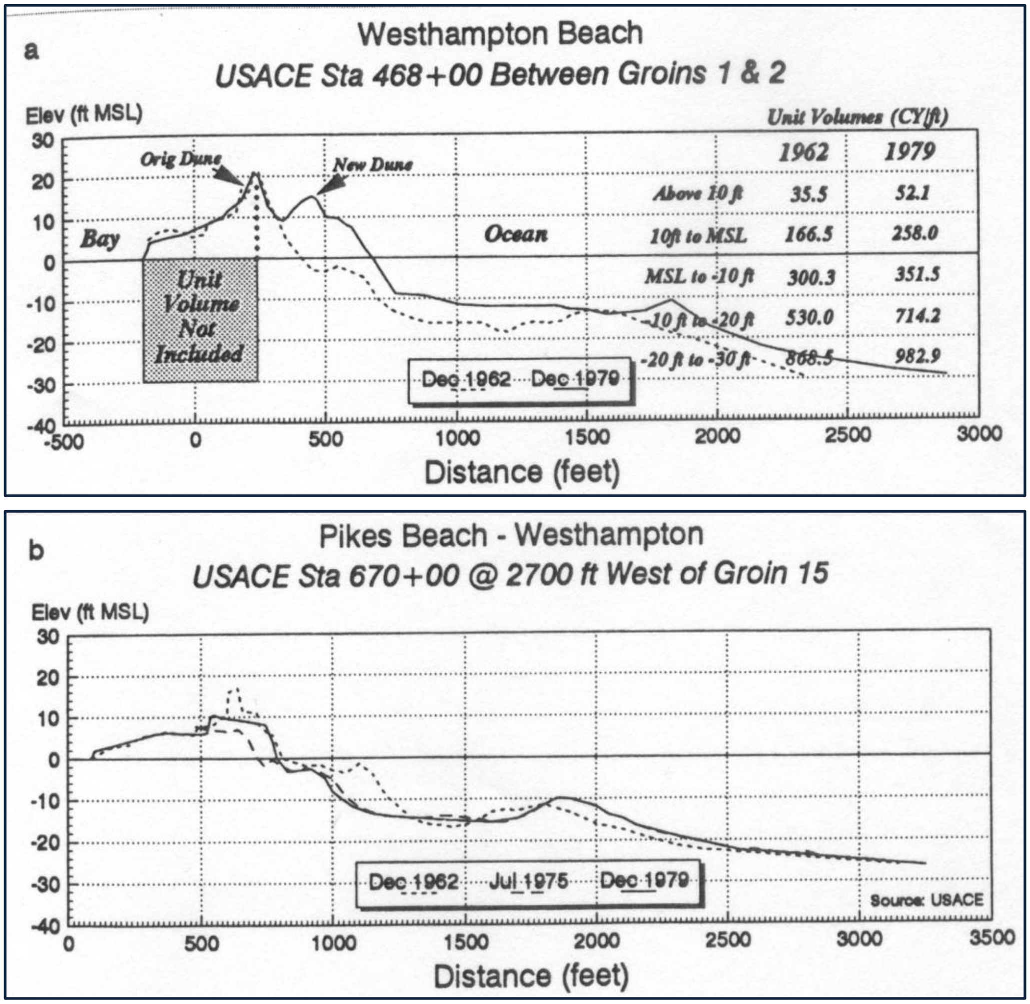


FIGURE 2.12.

Representative, barrier-island cross-sections from the eastern end of Westhampton groin field (a) and from Pike's Beach (b) illustrating opposite trends in shoreline change between 1962 and 1979. Unit volumes refer to the profile areas between the indicated contours.

Photo at left shows Pike's Beach and Westhampton Beach in August 1981, looking east. Groin field is at the top of the photo.

[From Kana and Mohan 1996]

2.1.7 Historic Sediment Budget and Erosion Estimates

The south shore of Long Island has been studied intensely for decades largely through efforts by the New York District–USACE in connection with the Fire Island Inlet to Montauk (FIMP) project. An element of these studies has been formulation of "sediment budgets" for various time periods. Sediment budgets are accountings of the amount of sand moving in the littoral zone over a particular time period.

An easy way to visualize sediment budgets is to think of the littoral zone (foredune to some offshore limiting depth) as a long thin sand box. Sand enters the box at the "upcoast" (east) end and exits the box at the "downcoast" (west) end. This is referred to as "longshore transport." Sand may also enter the box from offshore, particularly near inlets where sand "bypasses" across the channel via inlet shoals, or may be added to the box via artificial nourishment. Sand can similarly leave the box by other ways, including:

- Breach inlets and washovers which tend to shift sand across the barrier beach into the bay.
- Offshore during major storms, perhaps beyond the normal limit of the littoral zone where it cannot return to the beach in a timely manner. **or**
- Artificial excavations of the beach.

Sediment budgets formulated over decades often attempt to factor sea-level rise which has the effect of shifting the seaward boundary landward over time (ie – some sediment is "lost" because it is left offshore beyond the point where it is likely to exchange with the beach).

The principal data available for sediment budget formulation are historical profile surveys. These allow calculations of the volume of sand within the littoral sand box at each survey date. The difference in volumes between dates can then provide a fairly reliable measure of volumetric erosion rates (if the quality of data is good). The other quantities (eg – washover volumes, losses due to sea-level rise, gains due to nourishment) are added to or subtracted from the net volume change as applicable to yield a "true" erosion rate for the time period. Some quantities such as longshore transport often cannot be measured directly and have to be inferred based on the sequential changes from one section of coast to the next.

Despite the complexity and uncertainty with sediment budget formulations, they are one of the most important elements for beach nourishment planning. Several have been prepared for the FIMP project, including RPI (1983, 1985), Kana (1995), Rosati et al (1999), and others. Each sediment budget formulation includes erosion estimates for the Quogue Beach area or particular elements relevant to Quogue such as sand-bypassing rates at Shinnecock Inlet (Nersesian and Bocamazo 1992). The various sediment budgets are summarized in URS (2010).

Figure 2.13 summarizes the Kana (1995) FIMP sediment budget. This budget was formulated for the time period 1955-1979 and, therefore, encompasses the period 10-15 years after construction of the Westhampton Beach groin field (1965-1970). In the budget shown, the "Tiana Beach" compartment includes Quogue Beach. Measured losses between the foredune and a depth of −29.9 ft NGVD averaged 4.7 cubic meters per meter per year (m^3/m/yr) which is equivalent to ~1.9 cy/ft/yr. Beach nourishment added ~1 cy/ft/yr, effectively increasing the net losses (background erosion) to ~2.9 cy/ft/yr.

Rosati et al (1999) analyzed changes between 1979 and 1995. For the Tiana Beach/ Quogue Beach compartment, they determined that average annual losses (dune to −23 ft NGVD) were ~8.3 m^3/m/yr (~3.3 cy/ft/yr). During the 1979-1995 period, there were no beach nourishment projects or breach inlets for this segment of the coast. The Rosati et al (1999) sediment budget is shown in Figure 2.14.

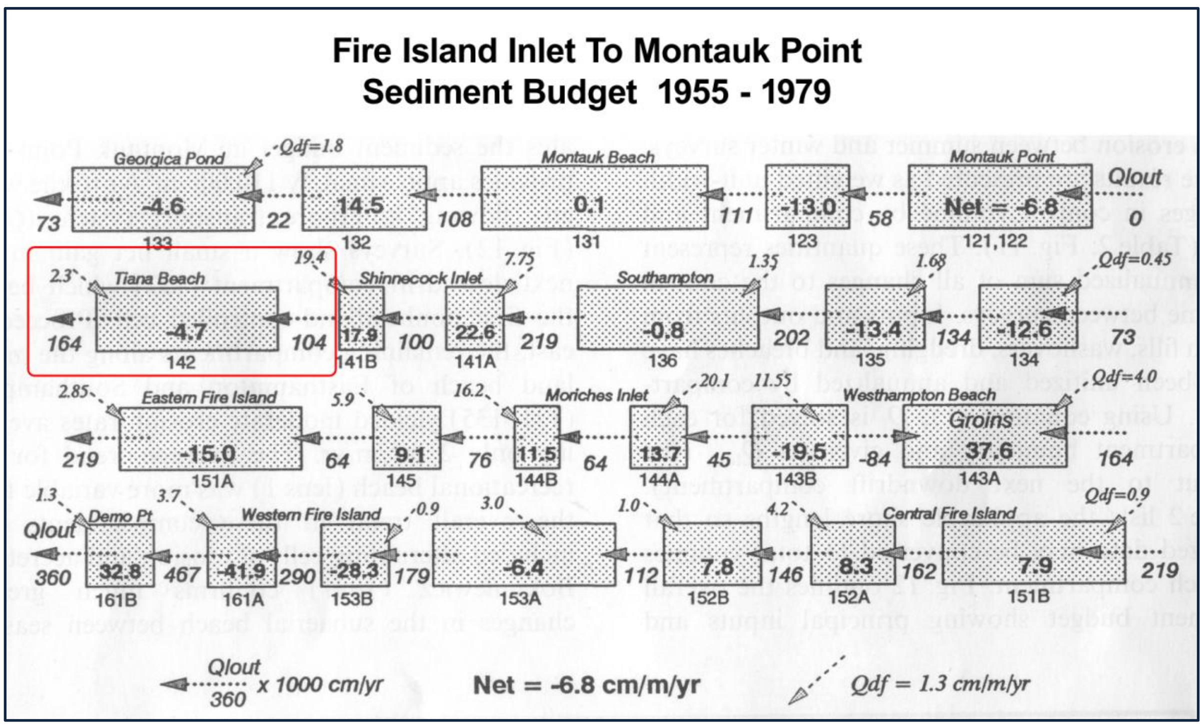


FIGURE 2.13. Summary sediment budget for the FIMP reformulation study (from Kana 1995). The box for "Tiana Beach" includes Quogue. It shows average annual erosion for 1955-1979 at 4.7 m^3/m/yr (1.9 cy/ft/yr) along with beach nourishment inputs of 2.3 m^3/m/yr (~1 cy/ft/yr). [Note: "cm" on the graphic refers to cubic meters.]

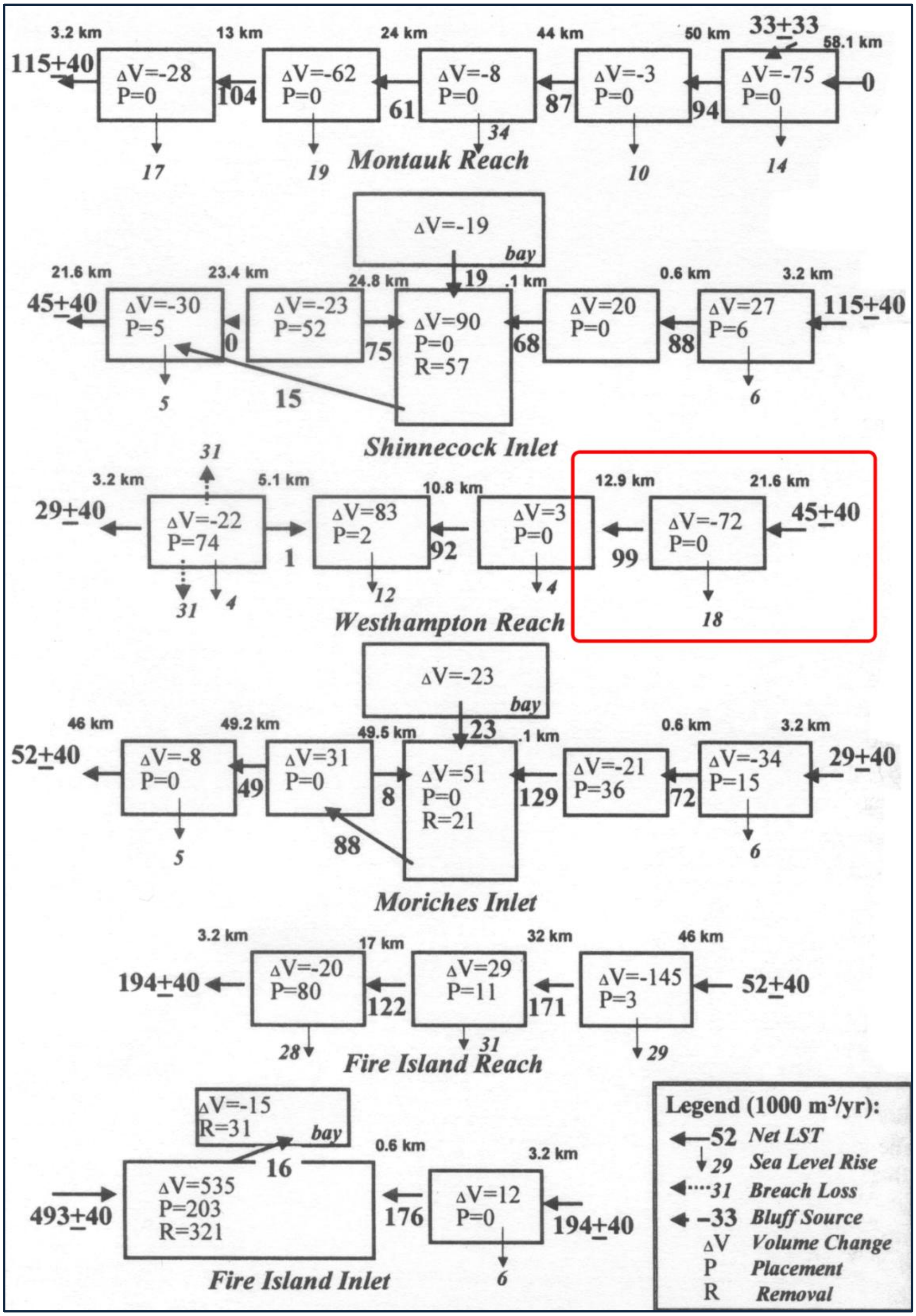


FIGURE 2.14. Regional sediment budget (values for barrier islands based on 1979-1995 and 1983-1995 data) prepared by Rosati et al (1999). The Quogue Beach area (red circled) lost the equivalent of 3.3 cy/ft/yr between 1979 and 1995. There was no nourishment during the period.

An important result of the Kana (1995) and Rosati et al (1999) sediment budgets is the estimated longshore transport rate around Shinnecock Inlet. Kana (1995) estimated that upward of 220,000 m^3/yr entered the updrift compartment (South Hampton) but only ~104,000 m^3/yr bypassed the inlet, the balance being trapped in the ocean and bay shoals. Rosati et al (1999) estimated that ~115,0000 m^3/yr entered the updrift compartment and ~45,000 m^3/yr bypassed the inlet. These estimates yield net trapping rates at the inlet between 70,000 m^3/yr and 115,000 m^3/yr (equivalent to ~91,500-150,000 cy/yr). This reduction in longshore transport helps explain why the Tiana Beach and Quogue Beach segments eroded between 1955 and 1995.

In 1995, a new series of surveys, the Atlantic Coast of New York Monitoring Program (ACNYMP), a cooperative effort of the New York State Department of State, USACE–New York District, and New York Sea Grant was initiated. This program has been collecting information and data on beach changes and coastal processes for the 135-mile stretch of shoreline between Coney Island and Montauk Point. The goal of the ACNYMP is to provide coastal managers, regulators, government officials, and the public with information that will allow them to make better decisions regarding coastal erosion hazard management and resource use. More information can be found at the program's website:
http://dune.seagrant.sunysb.edu/nycoast/.

Data collected under the program include semi-annual beach profile surveys taken at over 348 locations along the shoreline and semi-annual aerial photographs of the entire coast. Among these locations, eight (8) survey lines are within the project area and are coincident with CSE's 2011 survey lines. ACNYMP survey results will be discussed in later sections along with CSE's survey analysis. However, the team discovered certain inconsistencies in this historical data, and there is a high degree of uncertainty in the volume changes.

In 2007, Moffatt & Nichol (as reported in URS 2010) further updated the regional sediment budget under the FIMP project using profiles for 1995-2001 and found continued volumetric losses at −6.6 m^3/m/yr (~2.6 cy/ft/yr) along the Tiana Beach/Quogue Beach compartment. There were no beach nourishment projects in those areas during the period. As part of the Moffatt & Nichol study, estimates of nourishment requirements for various segments along the south shore were prepared. The interim "West of Shinnecock Inlet—WOSI" project was estimated to require 600,000 cy (initial nourishment) to meet the storm damage reduction goals of the USACE (URS 2010).

The U.S. Geological Survey (USGS) conducted an analysis of historical shoreline changes on the New England and Mid-Atlantic coasts (Hapke et al 2010). Shoreline change evaluations are based on a comparison of recent shorelines with historical shoreline positions digitized from maps or aerial photographic data sources. The historical shorelines cover a variety of time periods ranging from the 1800s through the 2000s. Long-term rates and short-term rates were calculated using either all shorelines or historical shorelines for a 25-year to 30-year time period. For the 25-year to 30-year time period, there is a mix of erosion and accretion in the project area, but the overall average is erosional. The erosion rate during this period is about 4 ft/yr at the shoreline segment of the project area. If the dune elevation is assumed to be +7 ft NGVD with the depth of closure at −24 ft NGVD, then the short-term shoreline change rate of 4 ft/yr is equivalent to about 4.6 cy/ft/yr or 65,900 cy/yr of volume loss over the Quogue project site.

The linear erosion rates given by Hapke et al (2010) are imprecise compared with volumetric estimates, but even the best surveys and sediment budgets incorporate inaccuracies which are magnified with distance offshore (cf – Johnston 2003, Kraus and Rosati 1998). Such inaccuracies are unavoidable, but tend to balance out over longer time periods. A key point regarding erosion rates is that volumetric estimates based on overall quantities of sediment contained within a littoral “control volume” tend to be much more reliable than “linear” erosion rates which are derived from movement of a single contour. This is because volumetric measures account for the accretion/erosion cycles each year which bias linear rates. (See Section 2.2 for further discussion.)

2.2 BEACH AND INSHORE SURVEYS

2.2.1 Survey Methods

Condition surveys along Quogue Beach were conducted by CSE 4-8 February 2011 using CSE's 24-ft River King survey vessel along with a RTK-GPS (Trimble® R8 GNSS). Surveyor Bob Fox (NY State licensed) provided major survey control points spaced at ~2,500-ft apart. CSE established eight (8) evenly spaced additional control points in between each of the two monuments and renumbered the survey lines starting from Line 1 and ending at Line 53. Eight of CSE's survey control lines are coincident with the ACNYMP survey lines (discussed in Section 2.1.7). Table 2.2 lists the relationship between these two survey sets. An adjustment of the data referencing ACNYMP's monuments to CSE's baseline allowed direct comparisons between the present survey data and historic survey data collected under the ACNYMP studies.

TABLE 2.2. Relationship between CSE survey lines and ACNYMP monuments

CSE Lines	ACNYMP Monuments	CSE Lines	ACNYMP Monuments
Line 1	W21	Line 31	W25
Line 9	W22	Line 37	W26
Line 17	W23	Line 45	W27
Line 25	W24	Line 53	W28

CSE's survey baseline and profile lines at the project area are presented in Figure 2.15 (upper). The track lines surveyed are illustrated in the lower portion of Figure 2.15. The survey encompassed 16,162 linear feet and control points were ~300-320 ft apart. Profile lines are shore-perpendicular to the baseline. The limits of Quogue Village lie between Lines 5 and 51 with a total length of 14,325 linear feet. CSE survey lines were overlain on the most recent controlled aerial photography (USDA September 2009).

Vertical datum for the survey is NGVD'29 (National Geodetic Vertical Datum of 1929, which is ~0.5 ft below present mean sea level). Figure 2.16 illustrates the various relationships among key reference datums for a station on the ocean at Shinnecock Inlet (NY), ~5 miles east of the project area. At the inlet entrance, the mean ocean tide range is 2.9 ft with an average spring tide range of 3.5 ft (NOAA-NOS 1994). Mean high water (MHW) is 1.7 ft above NGVD; mean tide level (MTL) is 0.3 ft above NGVD; mean low water (MLW) is 1.2 ft below NGVD; and mean lower low water (MLLW) is 1.66 ft below NGVD (USACE 1998, 2008).

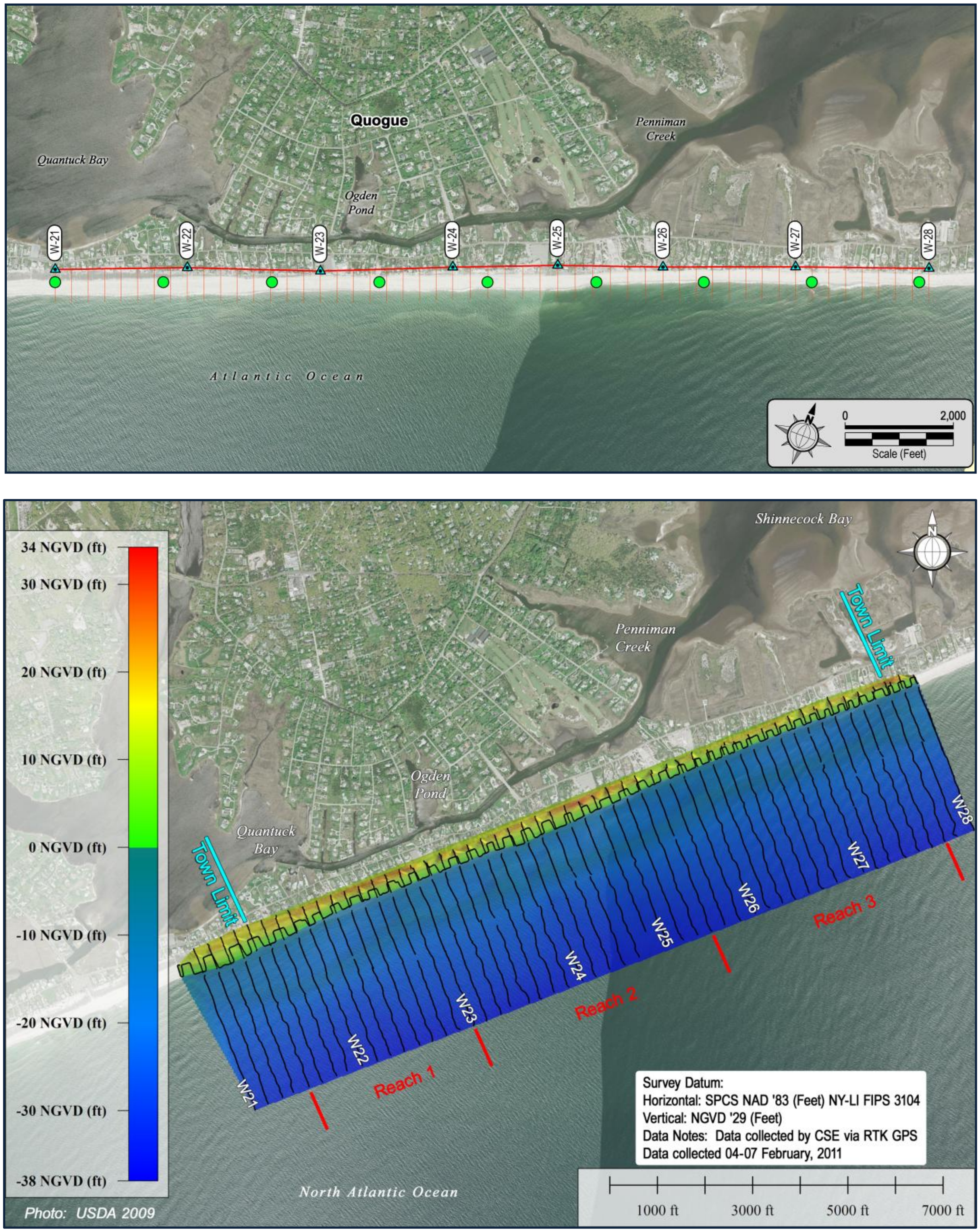


FIGURE 2.14. **[UPPER]** CSE February 2011 survey control lines referencing a baseline and control established by Bob Fox (NYS registered surveyor). The green dots are stations where sediment samples were collected along the beach. **[LOWER]** Track lines showing the specific coverage area during the team's data collection off Quogue Beach.

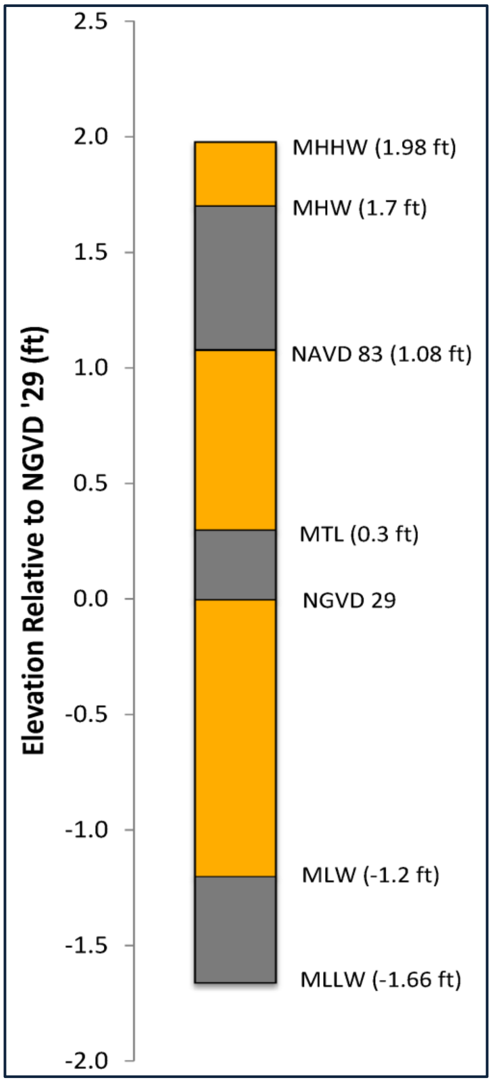


FIGURE 2.16. Key reference datums at Shinnecock Inlet (NY) ~5 miles east of the project area. [Source: NOAA-NOS]

Backshore, beach, and surf zone topography and profile data were collected at low tide using a Trimble® R8 GNSS RTK-GPS. Land-based data collection included sufficient backshore points extended to the front of properties to define the existing dune protection. Inshore profiles were collected using the Trimble® system linked to an ODOM Hydrotrac™ precision fathometer mounted on CSE's survey vessel. Inshore surveys were obtained at higher tide stages to fill in the gap of the land-based data collected around lower tide stages. The survey profiles extended from low-tide wading depth (−5 ft NGVD for this project) into the nearshore area and the outer surf zone (~3,500 ft from the baseline stations). In addition to the cross-shore survey lines, continuous topography of the beach was collected with the aid of CSE's all-terrain vehicle to obtain further details of the beach topography. Representative field data collection photos are shown in Figure 2.17.

The onshore and offshore data sets were merged and filtered to reduce the number of data points. Additionally, offshore points were smoothed using a 7-point floating-point average, and the data were checked for anomalies. Data collected in x-y-z format were used directly for purposes of developing a digital terrain model (DTM), which provides a three-dimensional picture of the beach, the inshore or offshore bars, and the offshore zone.

CSE's survey boat collecting inshore data at high tide

Collecting beach data at low tide

Collecting backshore elevation data extending to existing development

Off-road vehicle used by the team to collect continuous topography of the beach

FIGURE 2.17. Representative photos taken during field data collection in February 2011.

Figure 2.18 illustrates the DTM of the project area by a color-coded smooth contour map using the indicated elevation/depth intervals for each color. Red and yellow are the dune-beach zone; green marks inshore bars; and blue represents water depths >12 ft. The bathymetry DTM shows the crescentic morphology of the offshore bar (light blue band about 1,000 ft offshore). The DTM shows there are several high points along the trough which connect the bar directly to the beach (particularly around Lines ~16, 25, and 36) as well as a split double bar at the eastern end of the project area east of Line 51. The contour plot seems to indicate the dunes are discontinuous rather than continuous because the DTM lacks detail and continuous coverage in the dune field. Obtaining comprehensive topography over the dunes is beyond the present scope of services but can be incorporated in the future.

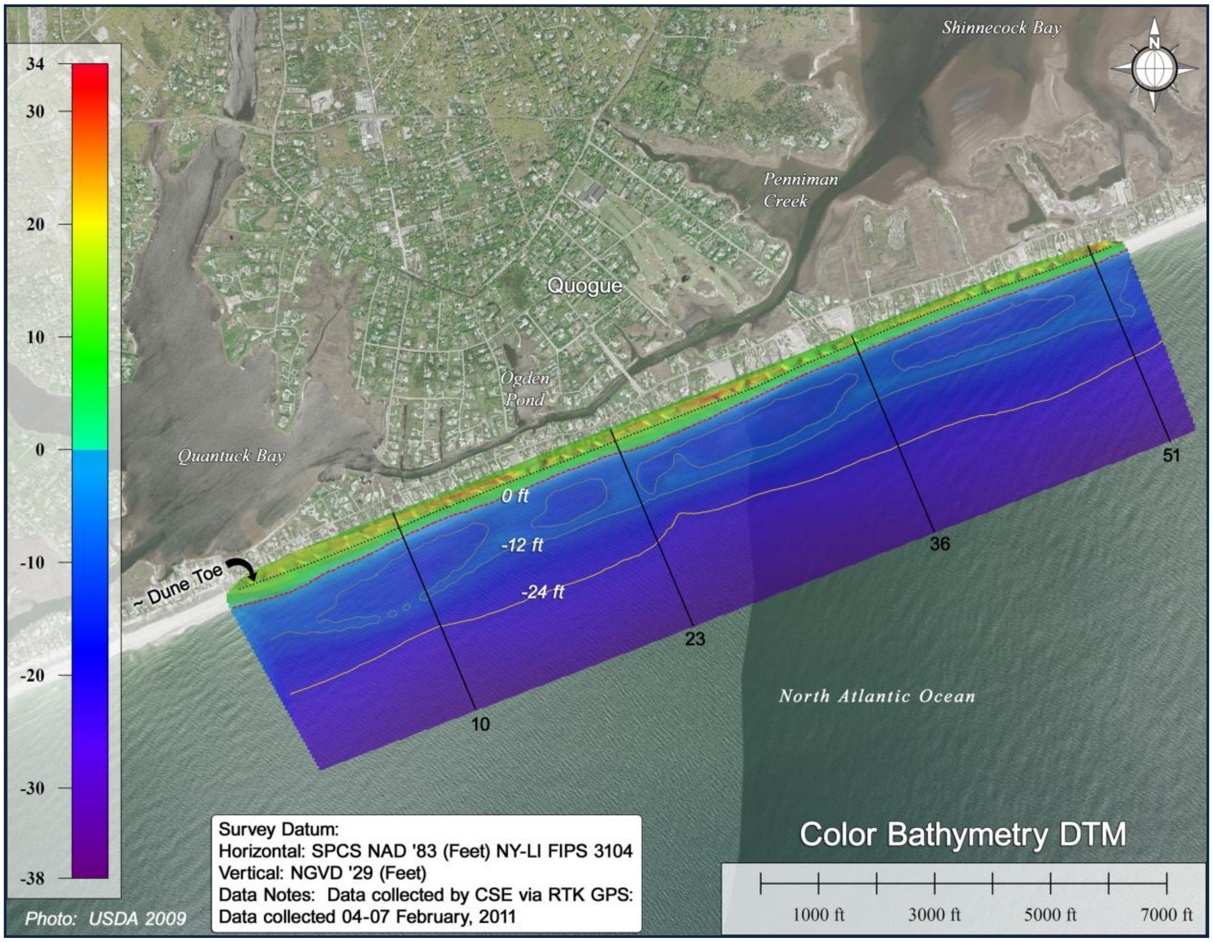


FIGURE 2.18. Color-coded topography and bathymetry DTM interpolated from the February 2011 survey. Quogue Village limits are approximately Lines 5 and 51. Note variations in water depth (and profile geometry) between the outer bar and the beach (discussed in Section 2.2.2)

2.2.2 Beach Profiles

Although sediment transport and morphology changes in the nearshore are three-dimensional, it is customary in beach analysis to separately consider the cross-shore and planform (ie – alongshore) evolution. Survey data (collected in x-y-z format) were converted to x-z (distance-elevation) pairs for purposes of comparing present beach volumes with historical profile data. The present profiles were merged with profiles collected by the ACNYMP studies during the period of 1995 to 2001. ACNYMP data during some years were limited to low-tide wading depth surveys and involved fewer survey lines. Only data for full profile surveys (~3,000 ft offshore) are used in the comparisons.

Representative profiles from the February 2011 survey are shown in Figure 2.19. See Figure 2.18 for general locations. The profile at Line 10 shows the offshore bar situated ~1,500 ft from the baseline, while the profile at Line 36 shows the bar about 900 ft from the baseline. The bar at Line 23 is less distinct because of sand accumulation in the trough between the bar and the beach. High points in the trough can be seen at several places along the shore in Figure 2.18, including midway between Line 10 and Line 23, and at Line 23, Line 36, and Line 51. Line 51 illustrates further complexity in offshore bathymetry with a double bar centered ~600 ft and ~1,200 ft seaward of the baseline. Appendix 1 contains profile data from all survey lines in two-dimensional, cross-shore distance-elevation format for the February 2011 survey and selected historic data.

2.2.3 Profile Volume Approach

Beach/inshore profiles were analyzed using CSE's Beach Profile Analysis System (BPAS) software which facilitates statistical analysis, volume change calculations, and graphing. Profile volumes are a convenient way to determine the condition of the beach and compare one area with another. As Figure 2.9 (in a previous section) illustrated, the active littoral zone encompasses a broad area between the dunes and some limiting offshore depth. Each profile incorporates complex topography which changes continually as the beach adjusts to varying wave energy, sediment supply, and tide range. Figure 2.19 provides an indication of this variability at Quogue in the four profiles collected in February 2011. Profile volumes convert a two-dimensional measure of the beach to a “unit volume” measure as illustrated in Figure 2.20. Using common datums and similar starting points (say, near the dune crest), it is possible to calculate the volume of sand contained in a unit-length of beach.

Profile volumes integrate all the small-scale perturbations across the beach and provide a simple objective measure of beach condition (Kana 1993). They provide quantitative estimates of sand deficits or surpluses when compared against a target or desirable beach condition. The examples of profile volumes in Figure 2.20 show a “normal” beach with a typical unit volume of 100 cy/ft measured to low-tide wading depth. The other profiles in the graphic illustrate values for an eroding beach (in this case, backed by a seawall) and a beach with a sand surplus. The unit volume of the eroded profile is 50 cy/ft, or ~50 percent of the normal beach. The calculation limits can be arbitrary as long as they are consistently applied. Ideally, they should encompass the entire active zone of profile change for the time period(s) of interest.

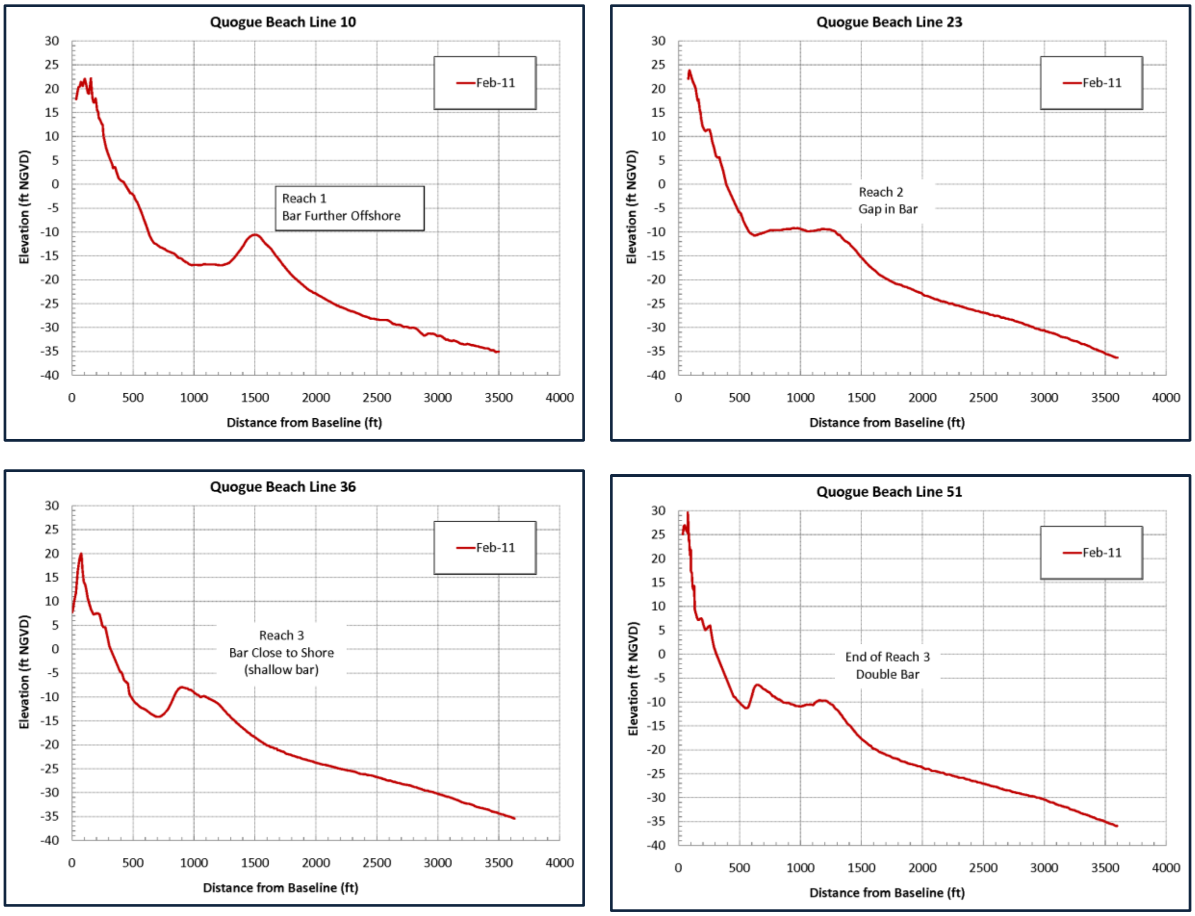


FIGURE 2.19. Representative dune, beach, and offshore profiles for Quogue Beach as obtained by the project team in February 2011. See Figure 2.18 for locations. Note vertical exaggeration is ~40 to 1.

It should be readily apparent that at least 50 cy/ft must be added to the eroded profile in Figure 2.20 to achieve a normal, healthy profile. (In actuality, more sand is required to account for the area between low-tide wading depth and the offshore limit of significant sand movement.) Analyses such as these are necessarily site-specific, but they are practical measures of sand deficits and erosional losses.

Volume change at Quogue Beach was estimated using standard methods (average-end-area method) and common cross-shore boundaries and contour datums. Three lenses (ie – volumes between particular reference contours) were used in the present analysis for purposes of evaluating levels of flood protection, subaerial beach condition, and the outer surf zone. Figure 2.21 illustrates the cross-sectional areas of these three lenses.

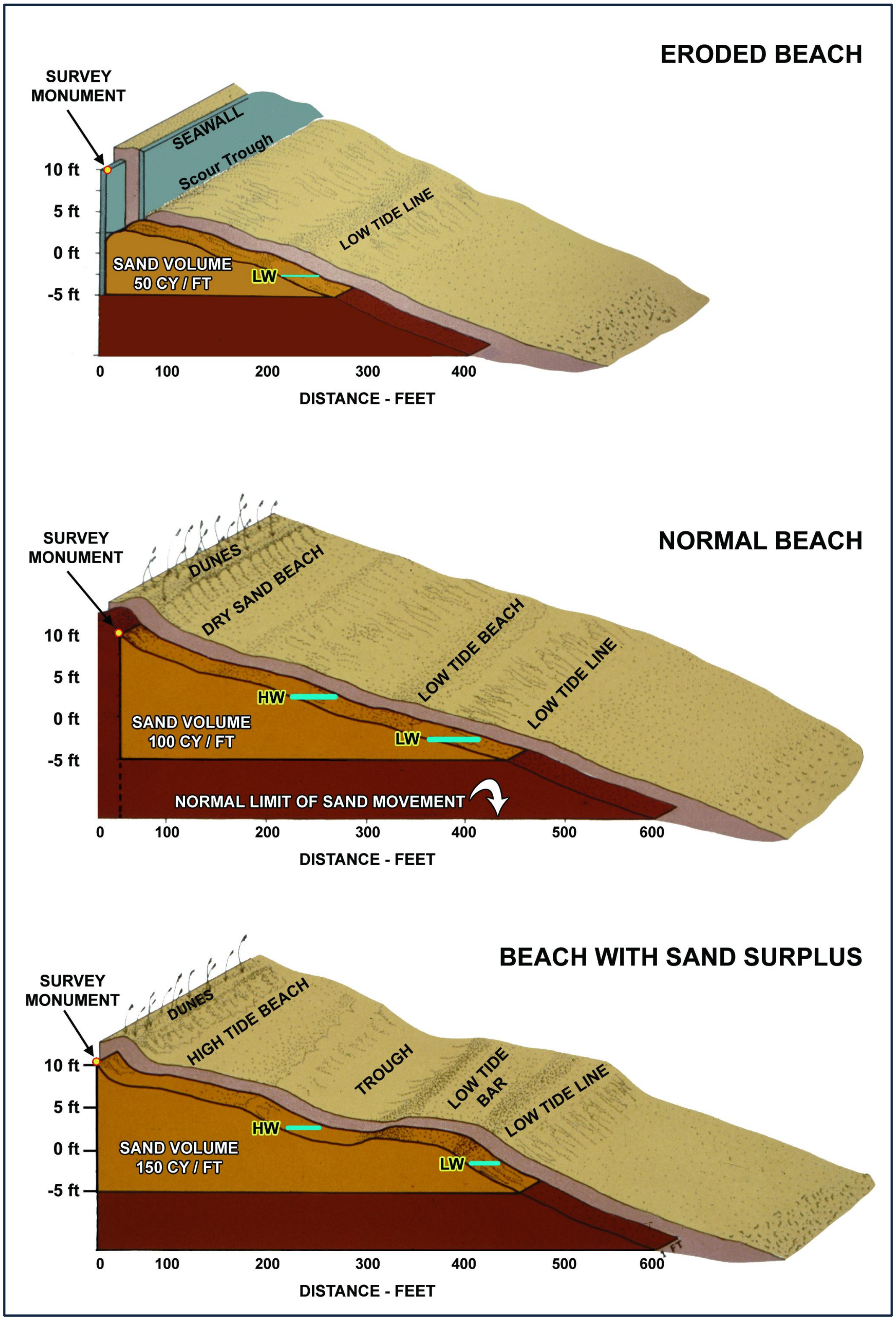


FIGURE 2.20. The concept of unit-width profile volumes for a series of beach profiles showing an eroded beach with a deficit, a normal beach, and a beach with a volume surplus. [After Kana 1990]

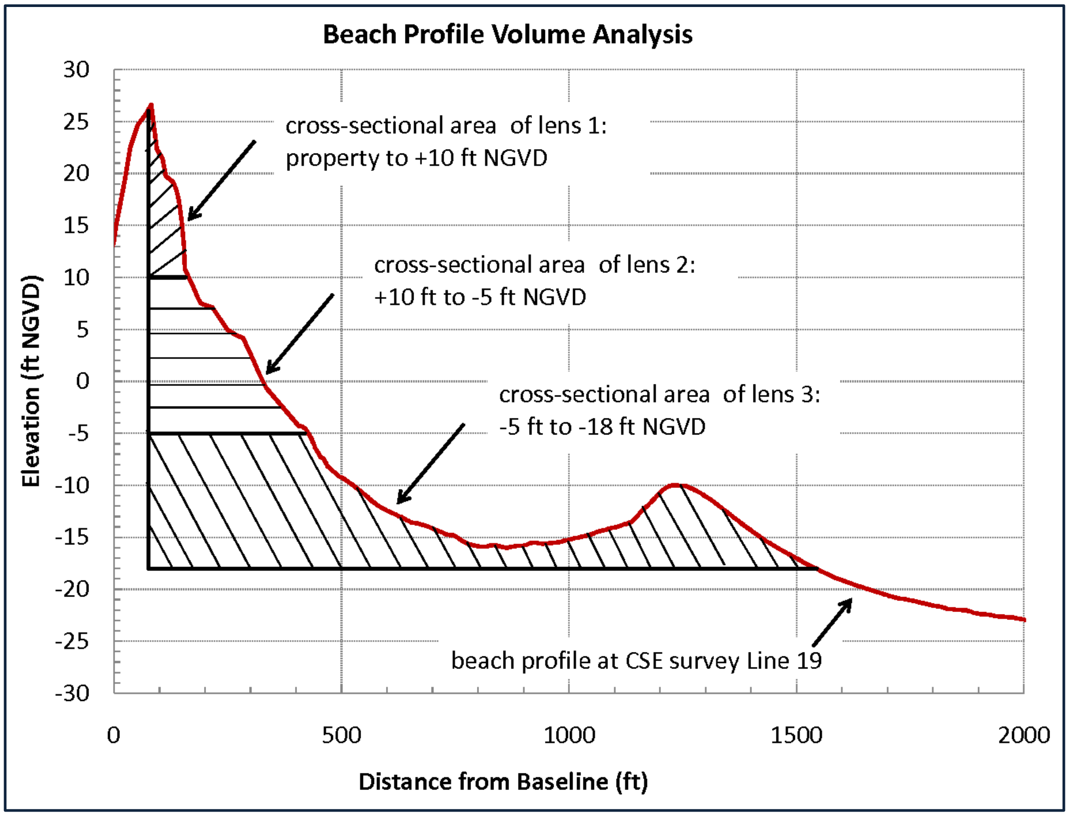


FIGURE 2.21. Illustration of the three lenses used in profile volume analysis.

Lens 1) Volume Above +10 ft NGVD — The volume above +10 ft NGVD is a measure of the sand quantity in the dunes. The +10 ft contour typically marks the seaward vegetation limit or the typical landward limit of waves and tides during **minor** storms.

Lens 2) Subaerial Beach (+10 ft to −5 ft NGVD) — This lens includes the dry-sand beach ("berm") and wet-sand beach (sloping wave swash zone) to low-tide wading depth at −5 ft NGVD. This is the primary recreational portion of beach. The majority of wave-breaking, uprush and backrush, and energy dissipation occurs over this zone.

Lens 3) Outer Surf Zone (−5 ft to −18 ft NGVD) — This lens represents the outer surf zone extending seaward of the bar to the normal seaward limit of bottom change at Quogue. It is the area over which waves of all sizes begin to break and to measurably redistribute sediment. It includes the breakpoint of longshore bars, which trigger wave-breaking in storms, and troughs between bars. When sufficient data from multiple survey dates exist, the seaward limit is chosen to be at ***closure depth*** where successive profiles over time tend to converge (or close), suggesting that measurable changes in bottom elevation are not occurring beyond that point. The −18-ft contour was selected as the outer boundary based on previous analyses by Rosati et al (1999). RPI (1983, 1985) and Kana (1995) assumed closure depths of ~24-27 ft; however, use of deeper limits tends to introduce more survey error, particularly with older data sets (Kraus and Rosati 1998). This is because small errors in data collection (inherent with all surveys over water) become magnified with distance offshore.

The selection of the datum for Lens 1 was also based on federal guidelines for minimum dune protection. FEMA has developed a criterion to determine if a dune is likely to be an effective barrier to storm surges and associated wave action during the base flood event (100-year storm). This criterion is also applied in estimating the landward extent of the base flood event and has come to be known as the "540 Rule." The FEMA 540 Rule definition states:

> *". . . primary frontal dunes will not be considered as effective barriers to base flood storm surges and associated wave action where the cross-sectional area of the primary frontal dune, as measured perpendicular to the shoreline and above the **100**-year still-water flood elevation and seaward of the dune crest, is equal to, or less than, **540** square feet (**20** cubic yards)."*

The 100-year still-water flood level (SWFL) along Quogue Beach is reported to be +10 ft NGVD as determined by FEMA's Flood Insurance Study applicable to the area (FEMA 2008). The average width of the dune system was measured from SWFL (+10 ft NGVD) to the building line (ie – a line approximately the most seaward face of buildings along a given section of beach). Figure 2.22 illustrates application of this criterion using the profile volume analysis. CSE measured the unit volume above the 10-ft NGVD contour between the face of the dune and the adjacent seaward face of buildings. Properties having <20 cy/ft in the dune seaward of the building were considered to have a sand deficit. Those profiles showing a surplus above 20 cy/ft were deemed to have sufficient dune protection (under FEMA guidelines).

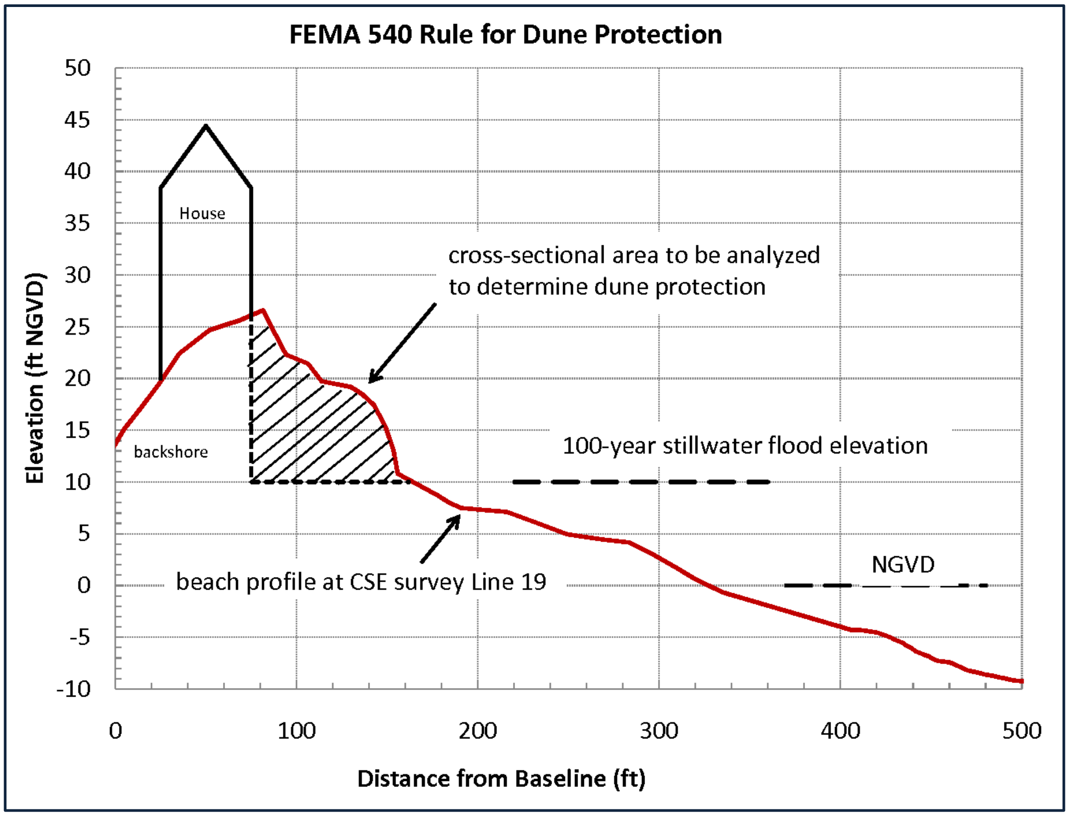


FIGURE 2.22. Profile volume analysis Lens 1 — FEMA "540 Rule."

CSE applied the profile volume concept for Lenses 2 and 3 whereby mean profile volumes were determined for Quogue Beach, then reaches were identified having greater than, less than, or approximately equal unit volumes around the mean for the project area. In this way, it was possible to develop an objective measure of sand deficits or surpluses along the beach and in the foredunes.

Unit volumes for Quogue Beach (February 2011 survey) and ACNYMP profiles were calculated to determine the quantity of sand in one linear foot of beach at each survey line. Unit volumes of the three lenses are given in Table 2.3 for comparison of the 2011 data with previous ACNYMP surveys. Numerical results for all lenses at the CSE and New York State survey lines are listed in Appendix 2 and are plotted in Figures 2.23 and 2.24.

These unit volumes were then used to calculate the line-to-line net volumes and finally the net volume for the entire project area. The line-to-line net volumes are proportional to the distance between lines and represent the alongshore distribution of sand volume in the project area. These net volumes by reach were subsequently divided by the applicable reach lengths to yield weighted average unit volumes, taking into account the variations in applicable shoreline distances from line to line.

TABLE 2.3. Unit volume comparisons for the present condition survey (February 2011) and previous ACNYMP surveys for three reference lenses. [See Figure 2.21 for definition sketch.]

Unit Volume (cubic yard per foot) from property seaward end to +10 ft NGVD								
CSE Line	**Feb-11**	**Apr-01**	**Apr-98**	**Apr-97**	**Oct-96**	**Apr-96**	**Oct-95**	**Apr-95**
1 (W21)	60.11	-	47.26	-	-	-	-	44.09
9 (W22)	70.32	62.98	62.73	-	-	-	-	-
17 (W23)	46.34	-	35.32	-	-	-	60.58	48.59
25 (W24)	61.34	56.33	50.49	59.05	49.26	59.20	-	-
31 (W25)	54.52	-	36.80	-	-	-	-	37.35
37 (W26)	18.50	38.80	38.87	-	-	-	-	-
45 (W27)	31.30	-	29.41	-	-	-	57.74	40.92
53 (W28)	55.67	60.09	53.54	56.64	55.44	-	-	-
Average	49.76	54.55	44.30	57.85	52.35	59.20	59.16	42.74

Unit Volume (cubic yard per foot) from +10 ft to -5 ft NGVD								
CSE Line	**Feb-11**	**Apr-01**	**Apr-98**	**Apr-97**	**Oct-96**	**Apr-96**	**Oct-95**	**Apr-95**
1 (W21)	259.43	-	193.34	-	-	-	-	186.61
9 (W22)	201.43	197.70	218.47	-	-	-	-	-
17 (W23)	155.6	-	112.65	-	-	-	205.13	166.02
25 (W24)	218.29	168.19	129.52	168.03	153.28	183.76	-	-
31 (W25)	146.97	-	215.94	-	-	-		89.97
37 (W26)	116.97	111.18	109.99	-	-	-		-
45 (W27)	126.57	-	125.78	-	-	-	146.04	158.25
53 (W28)	135.49	139.70	134.08	146.13	142.14	-		-
Average	170.09	154.19	154.97	157.08	147.71	183.76	175.59	150.21

Unit Volume (cubic yard per foot) from -5 ft to -18 ft NGVD								
CSE Line	**Feb-11**	**Apr-01**	**Apr-98**	**Apr-97**	**Oct-96**	**Apr-96**	**Oct-95**	**Apr-95**
1 (W21)	510.49	-	461.20	-	-	-	-	379.05
9 (W22)	447.35	490.33	458.03	-	-	-	-	-
17 (W23)	460.28	-	416.42	-	-	-	516.17	423.61
25 (W24)	470.53	458.15	479.28	450.94	417.85	455.01	-	-
31 (W25)	378.62	-	473.67	-	-	-	-	286.88
37 (W26)	426.63	372.53	378.48	-	-	-	-	-
45 (W27)	389.95	-	405.76	-	-	-	436.20	403.20
53 (W28)	375.11	459.84	422.61	428.78	400.83	-	-	-
Average	432.37	445.21	436.93	439.86	409.34	455.01	476.19	373.19

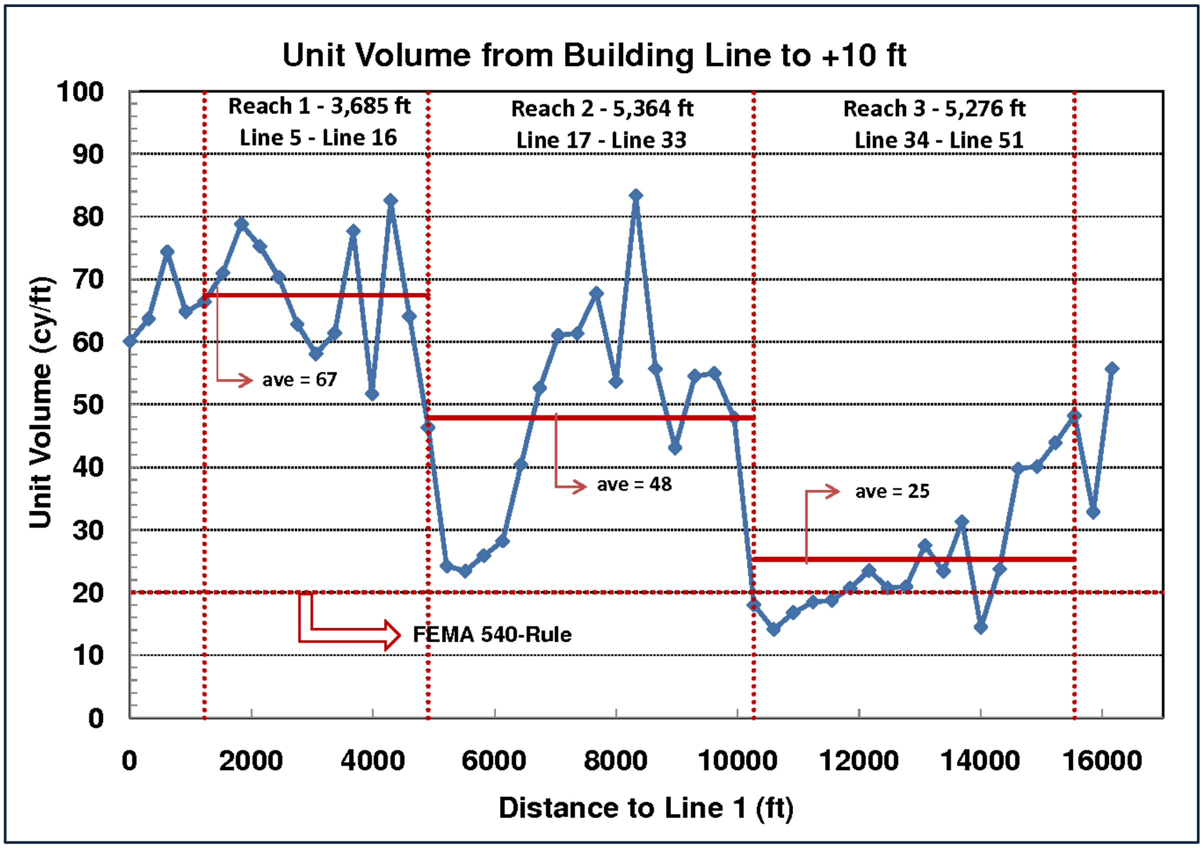


FIGURE 2.23. Unit volumes in the foredunes for the February 2011 survey lines from the approximate seaward property line to the 100-year still-water flood level (+10 ft NGVD).

Based on the unit volume analysis (eg – Fig 2.23), Quogue Beach was divided into three reaches as follows.

Reach 1 — 3,685 linear feet from Line 5 to Line 16. This is the western section of the project area. It is the healthiest reach of the project area with the greatest volume of sand in the foredunes. Properties along this reach have sufficient setbacks and dune volume relative to FEMA's 100-year SWFL and target dune volume. The weighted-average unit volume of this reach is 67 cy/ft, which greatly exceeds the thresholds established by FEMA's "540 Rule."

Reach 2 — 5,364 linear feet from Line 17 to Line 33. This is the middle section of the project area. Properties at the western third of this reach are situated closer to the beach and generally have less dune protection than properties to the east. The unit volume in the dunes (above +10 ft NGVD) is marginal for about 1,200 ft of shoreline with respect to FEMA's "540 Rule." However, the remaining properties along this reach have good setbacks and dune volumes well in excess of the FEMA standard. The weighted-average unit volume for Reach 2 for the dunes is 48 cy/ft, which is nearly 2.5 times the FEMA criteria.

Reach 3 — 5,276 linear feet from Line 34 to Line 51. The eastern mile of project shoreline has the least dune protection. Properties along Reach 3 are situated closer to the beach and many do not achieve FEMA-level protection. More than 2,000 ft of shoreline in Reach 3 fall below FEMA criteria for protective dune volumes. The weighted-average unit volume of this reach is 25 cy/ft.

In summary, the results indicate that weighted-average unit volume in the foredunes (building line to +10 ft NGVD) was 67 cy/ft for Reach 1, 48 cy/ft for Reach 2, and 25 cy/ft for Reach 3. The majority of the Quogue project area retains sufficient dune volume above the 100-year still-water food elevation to satisfy FEMA's "540 Rule" (ie – 20 cy/ft). Approximately 15 percent of the project area (around the eastern end of Reach 3) does not meet the FEMA criteria. Another 15 percent of the project area in the center reach (Reach 2) has only marginal dune protection close to FEMA's 100-year criteria.

Weighted-average unit volumes for other lenses are listed in Table 2.4. The weighted average unit volume from the approximate building line to −18 ft NGVD is 735 cy/ft for Reach 1, 622 cy/ft for Reach 2, and 537 cy/ft for Reach 3. Results are shown in Figure 2.24. These aggregate profile volumes provide an absolute measure of the overall health of the beach from reach to reach. While the calculation is dependent on the particular setbacks of buildings from the beach, it nevertheless provides a standard for comparison. It is apparent that properties along the eastern end of Quogue Beach are closer to the ocean, have less dune protection, and are more vulnerable to damage. Table 2.4 quantifies this difference. If only the recreational part of the beach (+10 ft to −5 ft NGVD) is considered, Reach 1 averages nearly 200 cy/ft, whereas Reach 3 averages 120 cy/ft. The underwater lens (−5 ft to −18 ft NGVD) exhibits somewhat less variation by percentage of the mean for the project area.

TABLE 2.4. Weighted-average unit volume for three lenses.

Unit Volume (cy/ft) to Three Lenses Relative to NGVD							
Reaches	**Length (ft)**	**Property to +10 ft**	**+10 ft to −5 ft**	**−5 ft to −18 ft**	**Property to −5 ft**	**Property to −18 ft**	**+10 ft to −18 ft**
Reach 1	3,685	67	199	469	267	735	668
Reach 2	5,364	48	159	415	207	622	574
Reach 3	5,276	25	120	392	145	537	512
Total/Average	14,325	45	155	420	200	620	575

Total Volume (cy) to Three Lenses Relative to NGVD							
Reaches	**Length (ft)**	**Property to +10 ft**	**+10 ft to −5 ft**	**−5 ft to −18 ft**	**Property to −5 ft**	**Property to −18 ft**	**+10 ft to −18 ft**
Reach 1	3,685	248,643	733,658	1,726,850	982,301	2,709,151	2,460,508
Reach 2	5,364	256,836	854,699	2,224,361	1,111,535	3,335,896	3,079,060
Reach 3	5,276	133,494	631,855	2,070,693	765,349	2,836,042	2,702,548
Total	14,325	638,973	2,220,212	6,021,904	2,859,185	8,881,089	8,242,116

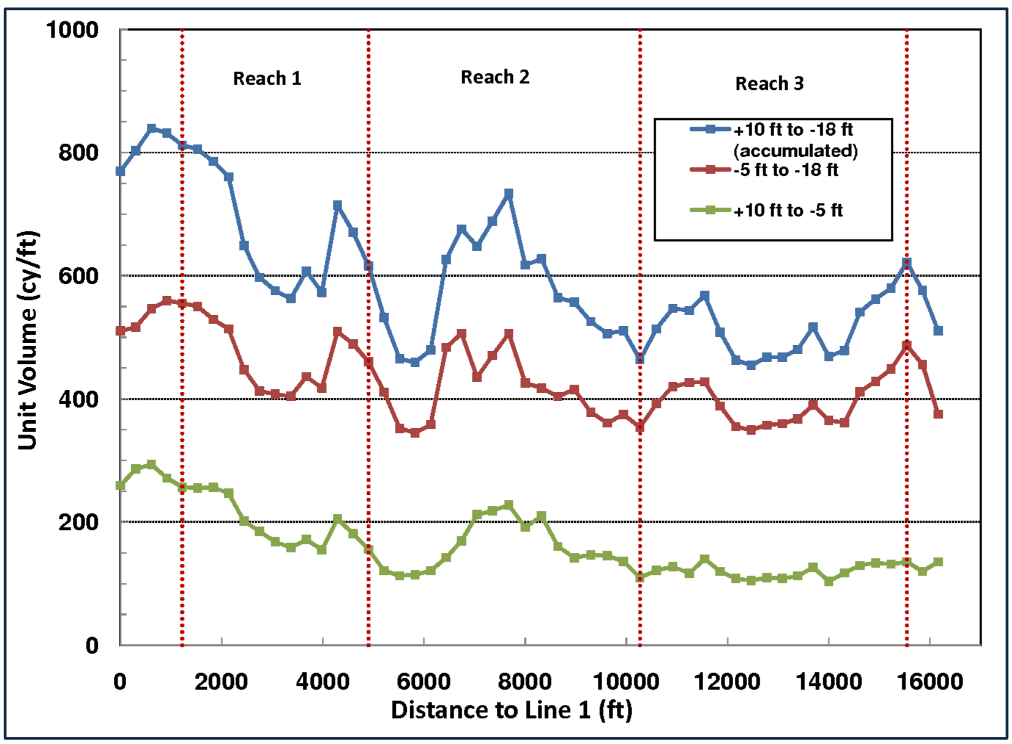


FIGURE 2.24. Unit volumes for the recreational beach (+10 ft to −5 ft NGVD) and the underwater zone (−5 ft to −18 ft NGVD) and their accumulated unit volumes.

2.2.4 Adopted Erosion Rate

A review of Table 2.3 shows there are limited numbers of profiles available for direct comparison with the team's present survey (February 2011). Most dates have two or four comparative profiles. Because of certain inconsistencies in the historical data (eg – profile W25 in the center of the project area appears anomalously low in April 1995 and high in April 1998), there is a high degree of uncertainty in the recent volume changes. For example, if April 1995 and February 2011 are compared, the average volume change is ~5 cy/ft/yr **accretion**. However, if October 1995 and February 2011 are compared, the result is ~3.8 cy/ft/yr **erosion**. There is no practical way of determining which of the data sets may be anomalous. The team has discussed potential inconsistencies in the New York State profiles with Jan Tanski (NY State Sea Grant Extension Service) and has worked with the data on other projects (CSE 2002). It appears there may be some issues with historical benchmarks (J Tanski, pers comm, June 2011). Regardless of potential errors or misinterpretation of historical data by the project team, a realistic erosion rate is required for project formulation along Quogue Beach.

Drawing on the erosion rates reported by Kana (1995), Rosati et al (1999), Moffatt & Nichol (2007) in URS (2010), and Hapke et al (2010) (ie – 2.9 cy/ft/yr, 3.3 cy/ft/yr, 2.6 cy/ft/yr, 4.6 cy/ft/yr – respecttively), there appears to be a consensus that the average annual erosion rate (after nourishment is factored out) has been of the order 3 cy/ft/yr for a majority of periods dating back to 1955. The team recommends an adopted erosion rate for planning purposes related to the long-term average losses. For nourishment along Quogue Beach which is a relatively short segment (2.7 miles) of the Westhampton barrier island, fill losses are expected to be higher than projects involving long reaches. Based on experience, the team recommends an ~40 percent "factor of safety" and an adopted annual loss rate of 4.2 cy/ft/yr. This is equivalent to losses of ~60,000 cy/yr over the length of Quogue Beach. While the team readily acknowledges this rate is an approximation, it is relatively low and therefore somewhat less sensitive than the deficit quantity. For example, if the actual fill losses are 1 cy/ft/yr higher or lower than this recommended rate, the net impact is less than 15,000 cy/yr over the length of Quogue Beach.

2.3 PROJECT FORMULATION — VOLUMES NEEDED TO RESTORE DEFICITS

Normally, beach nourishment requirements are determined based on the following two components (CERC 1984):

1) Initial nourishment to restore an eroded profile to a desired condition.
2) Advance nourishment to anticipate future losses for a designated period.

Along continuous beaches away from inlets, the formulation is fairly straightforward as long as the background erosion rate is known. Sediment quality is also a factor in nourishment planning because of its effect on performance. For example, if a borrow area contained 20 percent mud, this much again would have to be added to the planned dredging (or trucking) volume because of the likelihood that muddy sediments would quickly wash out of the beach and disperse offshore.

CSE estimates that there is a sand deficit in the dunes, the active beach, and the inshore zone. CSE also reviewed average annual erosion rates for numerous periods and recommends an "adopted" average annual loss rate (for planning) at about 60,000 cy/yr. The annual volume changes vary widely and include numerous short periods of accretion. The adopted loss rate is based on long-term (decadal) rates for the project area and factors out the positive effect of prior beach nourishment projects. In simple terms, the true rate of sand loss is higher than the measured changes where nourishment has been applied.

After estimating the sand deficit in the project area and reviewing the annual erosion rates, the team developed the recommended project formulation shown in Table 2.5 under the assumption that the nourishment project will last for at least 5 years, 10 years, or 20 years. This section of the report explains the basis of the nourishment volumes for different life expectancies. The steps in the formulation are as follows:

- Existing profile volumes to seaward limit (−18 ft NGVD) by reach were compared. The average profile volume of Reach 2 (622 cy/ft) was used as the minimum value in this setting.

TABLE 2.5. Estimated nourishment volumes required for 5-year, 10-year or 20-year periods.

Reaches	Reach Lines	Length (ft)	Average Unit Volume to +10 ft (cy/ft)	Average Unit Volume to −18 ft (cy/ft)	Deficit to +10 ft (cy)	Deficit to −18 ft (cy)	Long-Term Erosion Rate (cy/ft/yr)	Estimated Erosion Volume (cy/yr)
Reach 1	**L5-L16**	3,685	67	735	0	0	4.2	15,434
Reach 2	**L17-L35**	5,364	48	622	50,000	50,000	4.2	22,466
Reach 3	**L36-L51**	5,276	25	537	119,167	445,627	4.2	22,101
Total/ Average	**L5-L51**	14,325	45	620	169,167	495,627	4.2	60,000
Minimum Nourishment Plan Recommended								
			Five-Year Plan		**Ten-Year Plan**		**Twenty-Year Plan**	
Reaches	**Reach Lines**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Nourishment Rate (cy/ft)**	**Nourishment Volume (cy)**	**Average Nourishment Rate (cy/ft)**	**Nourishment Volume (cy)**	**Average Nourishment Rate (cy/ft)**
Reach 1	**L5-L16**	3,685	77,168	21	154,335	42	308,671	84
Reach 2	**L17-L35**	5,364	162,329	30	274,658	51	499,317	93
Reach 3	**L36-L51**	5,276	556,130	105	666,633	126	887,639	168
Total/ Average	**L5-L51**	14,325	795,627	56	1,095,627	76	1,695,627	118

- Reach deficits were calculated by applying the average profile deficit over the applicable reach length. The reach with an existing surplus (Reach 1) was not considered to be in need of this initial nourishment quantity. The reach with minimum profile volume (Reach 2) was apportioned 50,000 cy of sand in order to increase the marginal dune protection area (from Line 18 to Line 22) closer to the mean level for remaining sections of beach. The reach with the greatest sand deficit (Reach 3) was apportioned sufficient volume to restore it to the beach condition of an ideal minimum volume (Reach 2). This nourishment volume averages 84 cy/ft of sand along Reach 3. The results show a total deficit (to −18 ft NGVD) of ~495,627 cy, which is equivalent to what federal projects refer to as the "first costs" of a beach nourishment project.

- Advance nourishment requirements were based on the estimated average annual losses over 5-year, 10-year and 20-year periods. The weighted-average erosion rate adopted was ~4.2 cy/ft/yr, which equates to anticipated total losses averaging ~60,000 cy/yr. The adopted erosion rate is based on reported losses of ~2.9 cy/ft/yr (1955-1979, Kana 1995); ~3.3 cy/ft/yr (1979-1995, Rosati et al 1999), 2.6 cy/ft/yr (1995-2001, Moffat & Nichol 2007 in URS 2010), and ~4.6

cy/ft/yr as extrapolated from linear shoreline change reported by USGS (Hapke et al 2010).

- The estimated erosion rate for each reach was applied over different time periods, yielding the advance nourishment requirements, as listed in Table 2.5.
- The initial and advance nourishment volumes were combined to yield the minimum recommended volumes.

The distribution of nourishment volumes is unequal from reach to reach given existing conditions. While the average volumes by reach may have to be adjusted incrementally as conditions change between now and when a project can be constructed, the recommended rates take into account the much greater need at present along Reach 3, as well as the operational requirements of hydraulic fills by dredges. Fill volumes under 25 cy/ft tend to be more difficult to control and execute, thus adding costs to construction.

The recommended nourishment volume in Table 2.5 is considered somewhat conservative provided some additional variation in the volumes along a particular reach can be incorporated in the final plans based on conditions near the time of construction. It will also be advantageous to provide for gradual transitions in fill densities so as to minimize abrupt changes in volume from reach to reach. The following are recommended design considerations:

- Provide a long taper section along Reach 1 to the western project limit in anticipation of natural sand transport out of the project area.
- Divide Reach 2 into two sections in accordance with their sand deficit. The western section of Reach 2 requires a higher nourishment rate than the eastern section.
- Provide a long taper section along Reach 3 in anticipation of the reach supplying sand to western reaches of the project area.
- Provide for adjustments based on differences in underwater profile geometry from reach to reach (eg – where the bar is attached to the beach, less fill is needed to create a stable profile).

The next section identifies sand source(s) to be used for the nourishment and compares their sediment quality to the existing beach.

2.4 BORROW SOURCES ANALYSIS

2.4.1 Natural Beach Analysis

The team collected beach sediments along the project area to determine sand quality and grain-size distribution. Samples were taken at ~2,000-ft intervals with five samples per transect between the face of the foredune and the low-tide terrace. A total of 45 samples was collected along the nine transects. The nine transects are marked in Figure 2.25, and the positions of the five samples on a beach profile are shown in Figure 2.26.

Figure 2.27 shows the sand grabbing tool used to collect sediment samples on the beach. Samples were mechanically sieved at 0.25-phi intervals and were analyzed by standard methods for grain-size distribution.

Figure 2.28 shows the composite grain-size distribution for all 45 samples. **Mean grain size for the composite is 0.452 mm** with less than 1 percent of the material coarser than 2 mm.

Sediment characteristics for each sample at each station along the beach are listed in Table 2.6. Individual sample results are plotted in Appendix 3. The mean sizes of 45 samples of the natural beach are plotted in Figure 2.29. The trends of mean grain size at the nine stations along the beach are also plotted in Figure 2.29 with dotted lines. The trends show that mean sediment size increases slightly from west to east. Overall, the natural beach consists of moderately well-sorted, medium sand.

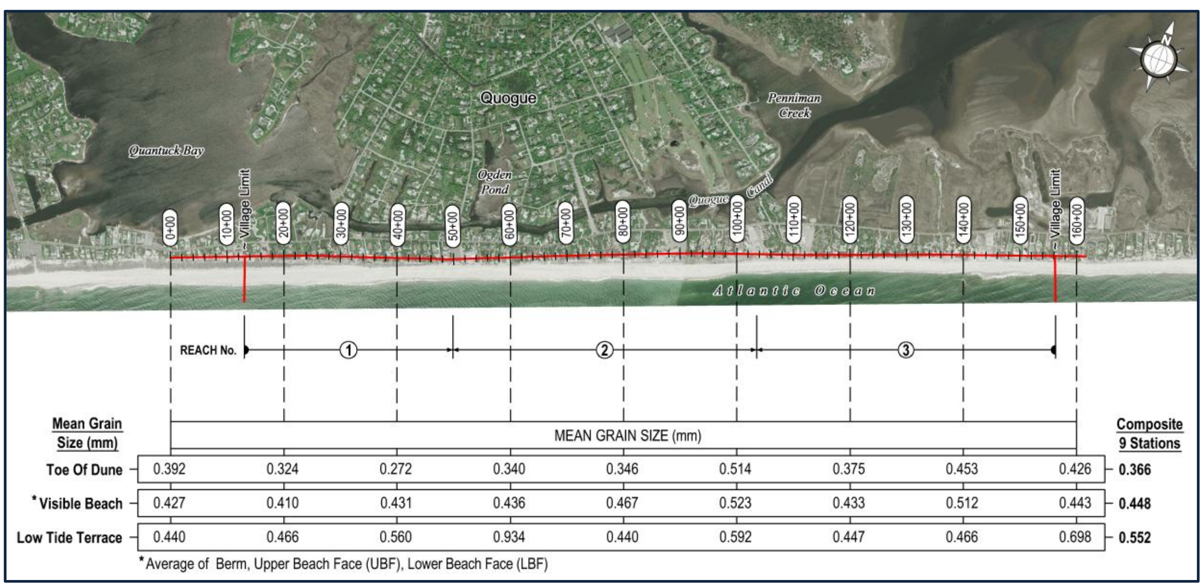


FIGURE 2.25. Mean grain size along Quogue Beach based on sampling in February 2011.

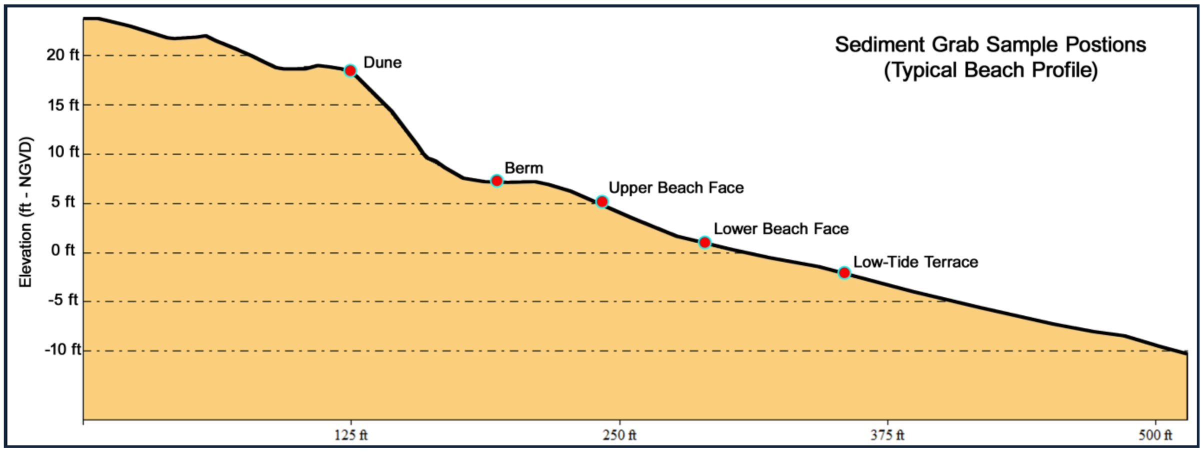
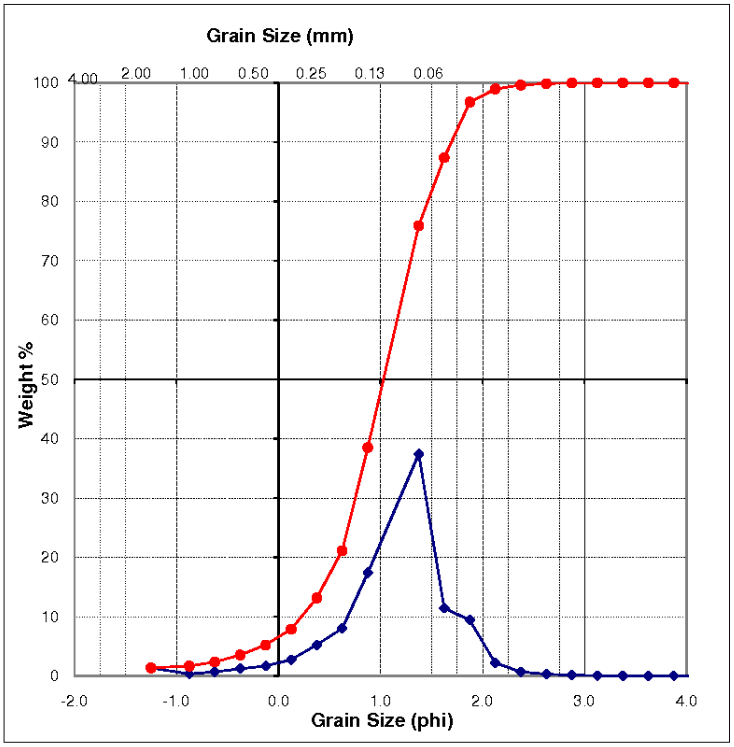


FIGURE 2.26. Positions of the five sediment samples obtained and analyzed across the beach profile at nine transects.

FIGURE 2.27. Sediment samples were collected on the beach.



Project	2278 Quogue, NY Beach
Location	Quogue ,NY
Date	05-Feb-11
Sample #	Comp-All45
Interval	Grab

Mean	0.452 mm
Std. Deviation	0.646 mm
Skewness	-1.137

Sediment Type
MEDIUM SAND
Moderately Well Sorted
Strongly Coarse-Skewed
Leptokurtic

Total weight (gram)	107.62
% finer than 4.00 phi	0.00
% coarser than -1.00 phi	1.35

Class Limits (phi)	Mid Point (phi)	Weight (gram)	Weight %	Cumm. Wt %
-1.000	-1.250	1.448	1.345	1.345
-0.750	-0.875	0.346	0.322	1.667
-0.500	-0.625	0.730	0.678	2.345
-0.250	-0.375	1.268	1.178	3.523
0.000	-0.125	1.789	1.662	5.185
0.250	0.125	2.912	2.705	7.891
0.500	0.375	5.612	5.215	13.105
0.750	0.625	8.624	8.014	21.119
1.000	0.875	18.701	17.377	38.496
1.500	1.375	40.240	37.392	75.888
1.750	1.625	12.312	11.440	87.328
2.000	1.875	10.110	9.395	96.723
2.250	2.125	2.355	2.188	98.911
2.500	2.375	0.713	0.662	99.574
2.750	2.625	0.289	0.268	99.842
3.000	2.875	0.116	0.108	99.950
3.250	3.125	0.030	0.028	99.978
3.500	3.375	0.017	0.016	99.994
3.750	3.625	0.002	0.001	99.995
4.000	3.875	0.001	0.001	99.996
>4.0	4.250	0.004	0.004	100.000

Percentiles

1	*5*	*16*	*25*	*50*
-1.268	-0.028	0.590	0.806	1.327
75	***84***	***95***	***99***	
1.494	1.677	1.954	2.283	

Moment Measures	*(phi)*	*(mm)*
Mean	1.145	0.452
Standard Deviation	0.631	0.646
Skewness	-1.137	
Kurtosis	5.232	
Dispersion	0.254	
Standard Deviation	0.434	0.740
Deviation from Normal	-31.13%	

Graphic phi parameter	Inman *(1952)*	Folk & Ward *(1957)*
Mean	1.134	1.198
Standard Deviation	0.543	0.572
Skewness (1)	-0.355	-0.361
Skewness (2)	-0.669	
Kurtosis	0.823	1.180

FIGURE 2.28. Sediment grain-size distribution for the project beach based on composited results of 45 individual samples (nine transects of five samples each).

TABLE 2.6. Summary of sediment characteristics for samples at nine stations.

Quogue Beach - Sediment Characteristics					
Distance to Line 1 (ft)	Location	mean(mm)	std dev (mm)	skewness	Sediment Description
0	Dune	0.392	0.761	-0.689	MS,ws,ns,m
	Berm	0.454	0.673	-1.215	MS,ws,cs,l
	UBF	0.376	0.746	-0.268	MS,ws,ns,m
	LBF	0.450	0.694	-1.135	MS,ws,cs,m
	LTT	0.440	0.681	-1.385	MS,ws,scs,m
2000	Dune	0.324	0.784	-0.176	MS,vws,ns,m
	Berm	0.368	0.731	-0.196	MS,ws,ns,l
	UBF	0.467	0.657	-0.301	MS,mws,cs,m
	LBF	0.395	0.742	-0.356	MS,ws,cs,m
	LTT	0.466	0.674	-1.025	MS,mws,cs,m
4000	Dune	0.272	0.796	0.154	MS,vws,ns,l
	Berm	0.461	0.754	-1.119	MS,vws,cs,l
	UBF	0.396	0.769	-0.334	MS,ws,cs,m
	LBF	0.435	0.757	-0.139	MS,ws,cs,m
	LTT	0.560	0.671	-0.031	CS,mws,ns,p
6000	Dune	0.340	0.781	0.381	MS,vws,fs,l
	Berm	0.402	0.759	-0.426	MS,ws,cs,m
	UBF	0.406	0.776	-0.267	MS,ws,cs,m
	LBF	0.501	0.702	-0.361	CS,ws,ns,m
	LTT	0.934	0.478	0.005	VC,ps,scs,p
8000	Dune	0.346	0.792	-0.436	MS,vws,ns,m
	Berm	0.381	0.736	-0.127	MS,ws,ns,vl
	UBF	0.481	0.689	-0.837	MS,ws,cs,m
	LBF	0.540	0.636	-0.669	CS,mws,cs,m
	LTT	0.440	0.702	-0.517	MS,mws,cs,m
10000	Dune	0.514	0.650	-0.774	CS,mws,cs,m
	Berm	0.406	0.703	-0.856	MS,ws,cs,m
	UBF	0.673	0.601	-0.178	CS,ms,ns,p
	LBF	0.490	0.655	-0.701	MS,mws,cs,m
	LTT	0.592	0.579	-0.689	CS,ms,cs,m
12000	Dune	0.375	0.755	-0.428	MS,ws,cs,l
	Berm	0.380	0.764	-0.176	MS,ws,cs,l
	UBF	0.465	0.745	0.074	MS,ws,ns,p
	LBF	0.454	0.693	-0.725	MS,mws,scs,m
	LTT	0.447	0.687	-0.709	MS,mws,scs,m
14000	Dune	0.453	0.677	-0.855	MS,mws,scs,m
	Berm	0.406	0.743	-0.330	MS,ws,cs,m
	UBF	0.647	0.566	-0.320	CS,ms,cs,p
	LBF	0.482	0.646	-0.663	MS,mws,scs,l
	LTT	0.466	0.652	-0.480	MS,mws,scs,m
16000	Dune	0.426	0.703	-1.064	MS,ws,cs,m
	Berm	0.416	0.700	-1.046	MS,ws,cs,m
	UBF	0.475	0.693	-0.741	MS,ws,cs,l
	LBF	0.439	0.732	-0.766	MS,ws,scs,m
	LTT	0.698	0.590	-0.573	CS,ms,cs,l
All Samples	Dune	0.377	0.701	-0.933	MS,ws,cs,l
	Berm	0.408	0.721	-0.746	MS,ws,cs,m
	UBF	0.479	0.649	-0.954	MS,mws,scs,l
	LBF	0.464	0.684	-0.797	MS,Mws,scs,m
	LTT	0.551	0.579	-0.948	CS,ms,cs,l
	Composite	0.452	0.646	-1.137	MS,mws,scs,l

Notes: UBF - Upper Beach Face; LBF - Lower Beach Face; LTT - Low Tide Terrace
VS-Very Coarse Sand; CS-Coarse Sand; MS-Medium Sand; FS-Fine Sand.
ps-poorly sorted; ms-moderately sorted;
mws-moderately well sorted; ws-well sorted; vws-very well sorted.
scs-strongly coarse-skewed; cs-coarse-skewed;
fs-fine-skewed; sfs-strongly fine-skewed; ns-Near Symmetrical.
vl-Very Leptokurtic; l-Leptokurtic; m-Mesokurtic; p-Platykurtic

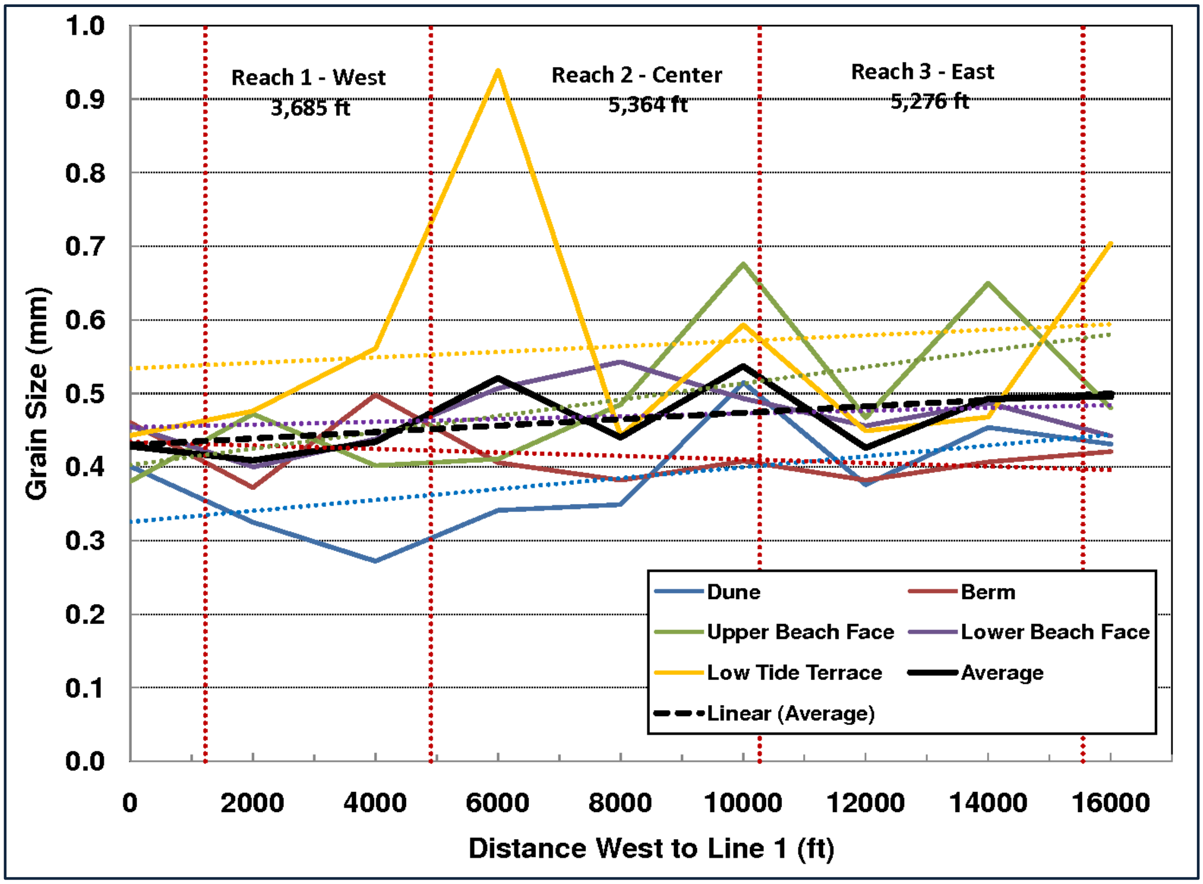


FIGURE 2.29. Sediment mean grain sizes for the nine stations by zone and their trends along the beach. Line 1 is west of the Village limits.

2.4.2 Feasible Borrow Sources

Potential borrow sources for nourishment generally include upland sources (eg – sand pits), lagoon sources (eg – maintenance dredging of bay channels), inlet sources (eg – channel maintenance dredging), and offshore deposits. Of the four types of sources, offshore borrow areas have been generally favored in recent years because they produce fewer environmental impacts than excavations of bay or inlet channels, and they may be situated close to the project site, thus reducing the transportation cost. Dredging (or truck hauling) costs increase with distance between the source and the project beach. Inland sand sources tend to be expensive because of the transportation distance and severe wear and tear on roads.

In general, projects involving >500,000 cy achieve economies of scale that are not possible with truck hauling. If an offshore borrow area can be located within several miles of the project beach, it is possible to achieve lower transfer costs because dredgers can pump directly to the beach. After initial mobilization to the site, an ocean-certified dredge can accomplish 25,000-50,000 cy per day. Recent projects using offshore borrow areas typically involved pumping costs in the range $5-10 per cubic yard (USACE 2010).

Aside from cost of sand delivery, the most important borrow area parameter is sediment quality. Ideally, the sand should provide a reasonable match to the size and color characteristics of the natural beach. In particular, the ideal borrow area should be free of gravel and contain minimal silt and clay content. If the sand is significantly finer than the native beach, larger nourishment volumes will be required to achieve the same performance as coarse-grained sand (Dean 2002).

USACE Designated Borrow Areas

The USACE has conducted detailed studies of potential borrow areas under the *Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York, Storm Damage Reduction Reformulation Study* (FIMP) (USACE 2004a,b). As part of this federally authorized effort, the USACE–New York District has identified (and utilized) offshore borrow areas between Fire Island Inlet and Montauk Point (Fig 2.30).

From 1999 to 2002, seven environmental studies were conducted to develop an understanding of the physical and biological characteristics of these sites (USACE–App B–2008). Sediment samples were collected during the studies at different depth contours and different seasons. The sediment was analyzed using a hydrometer based on ASTM methods D 422 and D 2487 (USACE 2004a). One of the key findings of the studies is that sand (4.75 mm to 75 µm) is the predominant substrate across all borrow areas and depths. In general, sand comprised greater than 90 percent of sediment grain size, with the exception of outlying samples that generally had a lower percent composition of sand and higher percent composition gravel and fines. Sediment grain-size distributions generally remained consistent between seasons at each borrow area.

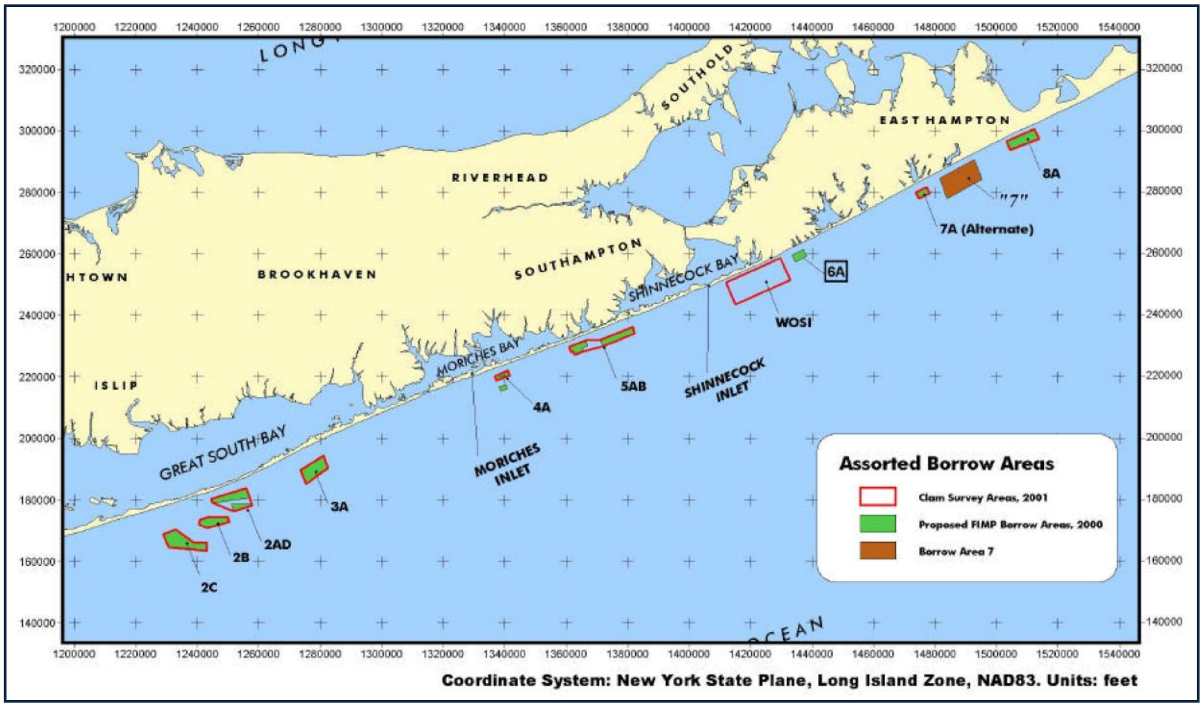


FIGURE 2.30. USACE-designated potential borrow areas, some of which have been used to date for various federal projects. Area 5AB has been evaluated in detail and is strategically positioned for potential use in the Quogue Beach project. [Source: USACE–New York District]

Among the USACE designated borrow areas, 5A and 5B are the closest to the Quogue project area (Fig 2.31). There have been 40 samples collected in these two borrow areas at different seasons (fall and spring) and at different depth contours (30-ft, 40-ft, 50-ft and 60-ft contours) during years 1999, 2000 and 2001. Grain-size distributions are estimated based on the USACE studies [Figures III-12 and III-13 of USACE (2004a) report] and listed in Table 2.6.

TABLE 2.6. Grain-size distributions of sediment samples in potential borrow areas 5A and 5B.

Depth Contours	Gravel	Sand	Fines
30 ft	<3%	~90%	<7%
40 ft	<3%	~95%	<3%
50 ft	<5%	~95%	<3%
60 ft	<1%	~98%	<2%
Notes: gravel (75 mm to 4.75 mm); sand (4.75 mm to 75 µm); fines (<75 µm). No significant difference between fall and spring.			

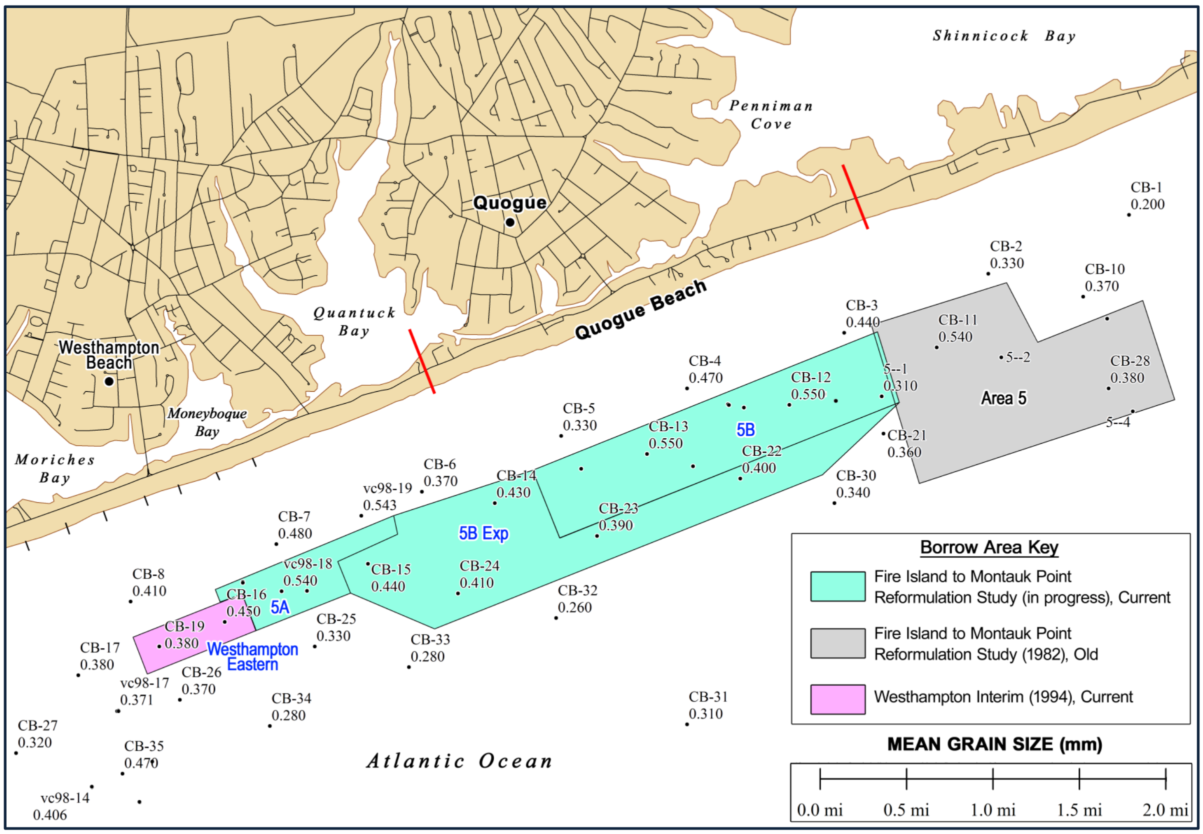


FIGURE 2.31. Previously delineated, potential borrow areas off Westhampton Beach and Quogue Beach as identified by the USACE and reviewed by NYDEC. Core numbers and mean grain size in the upper ~20 ft of substrate are given. [Source: USACE-New York District]

A portion of borrow area 5A was used in the Westhampton interim renourishment project in 2008 (USACE 2008). It is T-shaped with the head section ~5,940 ft long by 430 ft wide and the trunk section ~3,120 ft long by ~1,230 ft wide. Area 5A yields ~237,000 cy of sand for every foot excavated. A sand volume of about 317,000 cy was used in the 2008 project. It is equivalent to about 1.34 ft of excavated depth. The character of material within borrow area 5A is plotted in Figure 2.32. The plot shows that mean grain size in borrow area 5A is about 0.4 millimeters (mm), which is similar to Quogue Beach (mean grain size of 0.45 mm).

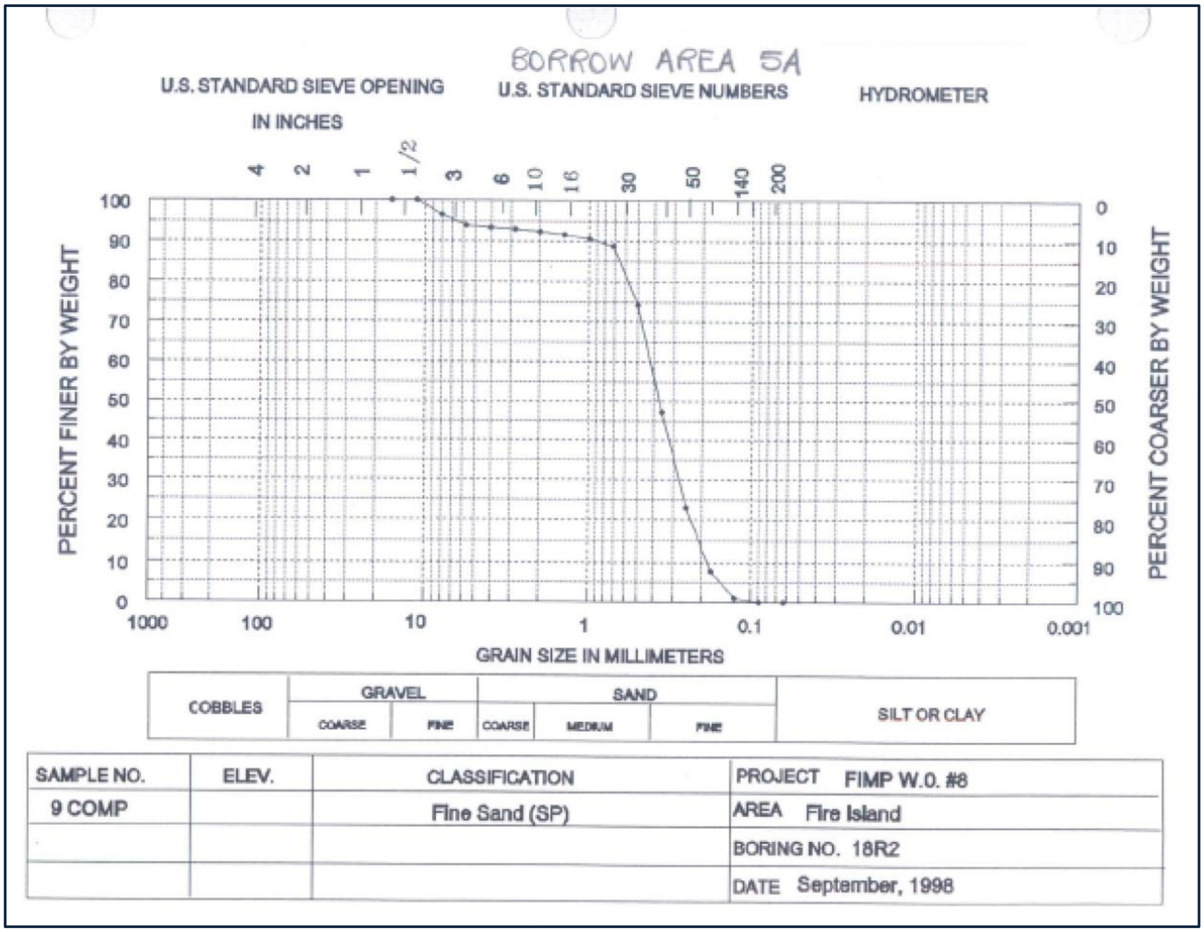
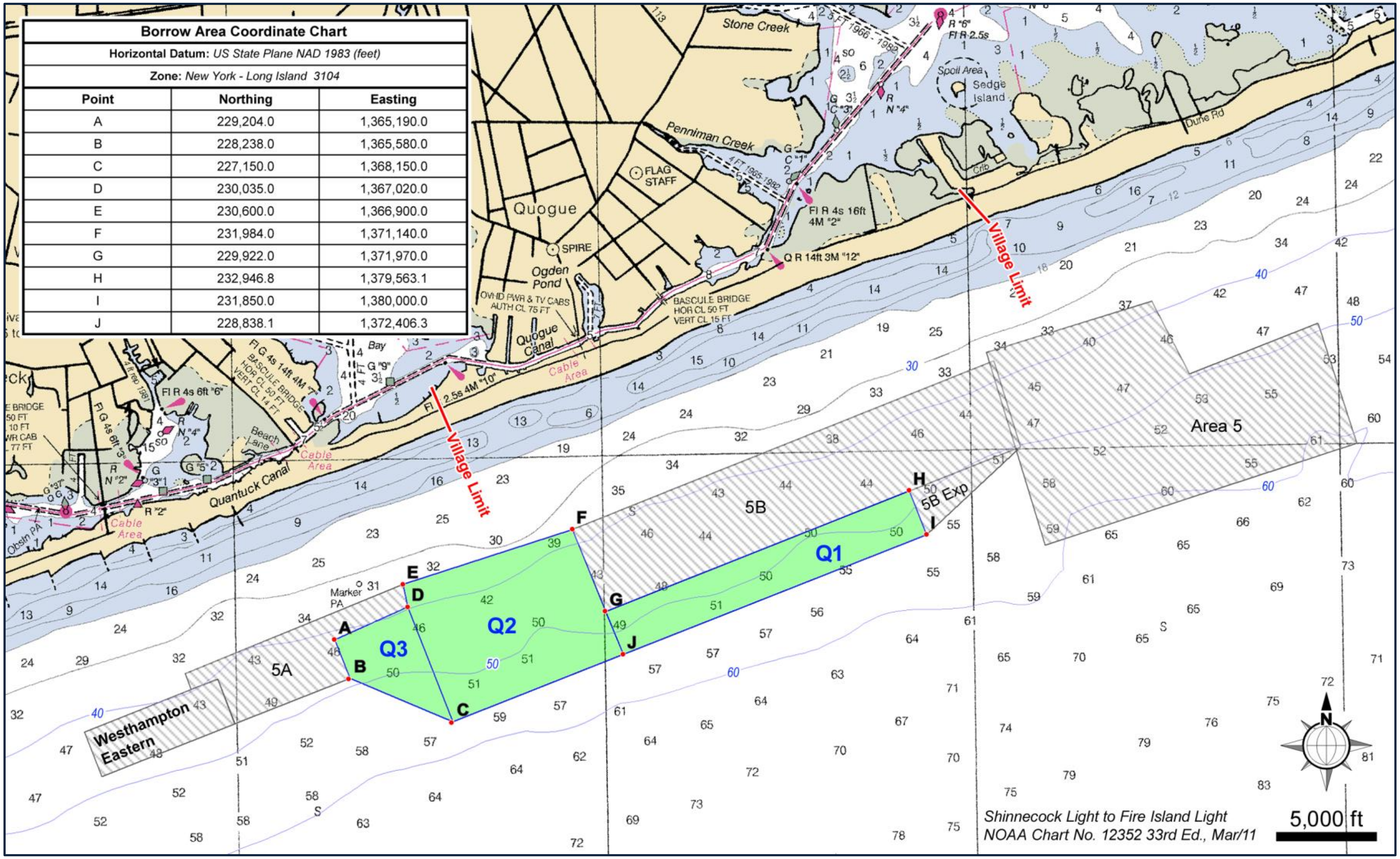


FIGURE 2.32. Sediment character in borrow area 5A based on USACE surveys of the borrow area. [Source: USACE 2004a,b; URS 2010]

Borrow area 5B (Figs 2.31 and 2.33) is located ~3,000 ft directly off the Quogue shore in water depths between ~40-50 ft MLLW. The area has also been identified by USACE as having beach-quality sediments suitable for beach nourishment. It is potentially the most cost-effective offshore borrow area; however, it may not be available to the Village of Quogue because of future potential needs with other federal projects (L Bocamazo, NY District, pers comm, May 2011). The approximate dimensions of area 5B are ~12,000 ft long by 2,500 ft wide, which yields about 1.11 million cubic yards of material for every foot excavated.

Another potential borrow area, "5B Exp" (see Fig 2.31), was designated by the USACE (2004a,b) in the FIMP reformulation study. This is an "expansion" of borrow areas 5A and 5B which encompasses about 700 acres. The project team obtained results of borings (Appendix 4) and sediment quality tests for area "5B Exp" and has identified three recommended areas (Q1, Q2, Q3) for use by the Village of Quogue (Fig 2.33). Area "5B Exp" is included in prior environmental resource studies which have been reviewed and approved by NYDEC (cf – USACE 2004a,b). Areas Q1, Q2, and Q3 (combined) contain ~1.1 million cubic yards for every 1 ft of excavation depth. Existing borings show mean grain size in the size range 0.35-0.5 mm (comparable to Quogue Beach). Depending on the excavation depth, 1.1 million cubic yards (estimated volume requirement for a "ten-year" project) could be obtained in as little as ~100 acres, if the average dredge cut is ~7 ft (a typical minimum cut depth using traditional cutterhead dredges).

Hopper dredges can work shallower cuts, but generally operate more efficiently if the borrow area is elongated. This allows the hopper dredge to accomplish a dredging run and to minimize turns as it sweeps the bottom. Cutterhead dredges work most efficiently using deeper cuts because they are anchored during operation and swing back and forth as they dig over a smaller area. Area Q1 is considered optimal for the Quogue Beach project because it is centered on the project area, likely contains sufficient compatible sediment to as much as 20 ft below the existing substrate (USACE 2004a, URS 2010), and is situated in water depths of at least 40 ft—well beyond the normal limit of sand transport and measurable profile change along the beach. Area Q1 (220 acres) contains nearly 1.1. million cubic yards in the upper 3 ft of substrate. If excavated to 7 ft below the substrate, the area of potential impact would be reduced to ~100 acres.



Borrow Area Coordinate Chart

Horizontal Datum: *US State Plane NAD 1983 (feet)*

Zone: *New York - Long Island 3104*

Point	Northing	Easting
A	229,204.0	1,365,190.0
B	228,238.0	1,365,580.0
C	227,150.0	1,368,150.0
D	230,035.0	1,367,020.0
E	230,600.0	1,366,900.0
F	231,984.0	1,371,140.0
G	229,922.0	1,371,970.0
H	232,946.8	1,379,563.1
I	231,850.0	1,380,000.0
J	228,838.1	1,372,406.3

FIGURE 2.33. Potential borrow areas for Quogue Beach: Q1 (~220 acres), Q2 (~369 acres), and Q3 (~95 acres) within USACE-designated borrow area 5B Exp. Q1 and the outer half of Q2 are in water depths of ~50 ft, well beyond the normal limit of sediment exchange with the beach.

2.5 SUMMARY OF FINDINGS

The project team reviewed historical reports and prior beach surveys, completed a detailed condition survey, and identified feasible borrow areas for a beach restoration project along Quogue Beach. This information serves as a basis for the recommended plan (Section 3).

2.5.1 Setting and Controlling Coastal Processes

Quogue Beach (2.7 miles) receives sand that bypasses Shinnecock Inlet (~5 miles east of Quogue) and moves west to Moriches Inlet (Panuzio 1968, Kraus et al 1995, Rosati et al 1999). Its erosion and accretion is dependent on a continued supply of sand from the east. The USACE has an authorized project ("West of Shinnecock Inlet—WOSI"), which seeks to maintain sand bypassing at the inlet. However, this project terminates several miles east of Quogue Beach. Net transport from east to west is variously estimated in the range of ~60,000 cy/yr to 150,000 cy/yr (rate after sand trapping at Shinnecock Inlet—Kana 1995, Rosati et al 1999). Natural variations in this range, as well as the rate of artificial sand bypassing (ie – inlet dredging and beach disposal), further modify the sand supply to Quogue Beach.

The Westhampton groin field (begins ~1 mile west of Quogue Beach) likely has a favorable impact because of the large supply of sand trapped by the groins. In effect, the groin field provides an anchor to the shoreline, helping to hold it in place. Its effect, though unquantifiable, likely extends "upcoast" toward Quogue Beach. This seems to be reflected in the more favorable condition of the beach along the western 20 percent of Quogue's shoreline.

2.5.2 Sand Deficit and Erosion Rate

The present analysis distinguished three reaches along Quogue Beach having different levels of storm protection (to developed property) and beach condition. From west to east, Reach 1 was found to have a healthy beach and dune volume. The central ~1 mile of shoreline (Reach 2) was found to have an ~50,000-cy deficit in the active beach and underwater portion of the profile. Reach 3 (the easternmost ~1 mile of Quogue Beach) was found to have a deficit of nearly 450,000 cy with one-third of this volume representing lack of dune volume compared with the other reaches. It is apparent that the eastern end of Quogue Beach is narrower with smaller dunes fronting buildings and infrastructure. Many properties in Reach 3 lack dune protection at the recommended FEMA protection level (ie – 20 cy/ft in the foredunes above the 100-year still-water surge elevation, which is ~10 ft NGVD at Quogue).

The average annual erosion rate for Quogue Beach is estimated to be ~3 cy/ft/yr (~2.5 ft/yr) after considering the positive effect of prior beach nourishment projects. Sixty years of beach nourishment at various sections between Shinnecock Inlet and Moriches Inlet have measurably reduced the net shoreline change. When extrapolated over the length of Quogue Beach, the “background” erosion rate equates to ~43,000 cy/yr losses. For purposes of beach nourishment planning, the team recommends a “safety” factor of 40 percent on this estimated erosion rate because sand placement along limited segments of shoreline tends to erode faster compared with long projects (Dean 2002). Thus, the “adopted” rate recommended for planning is 4.2 cy/ft/yr, which equates to ~60,000 cy/yr over the Quogue Beach shoreline. Bocamazo et al (2011) reported the ~5.7-mile section between Groin 7 and Moriches Inlet averages losses of ~180,000 cy/yr. Higher losses are expected west of the groin field. However, this rate places the estimate for Quogue Beach in context. Combining the estimated sand deficit and annual erosion losses at Quogue yields a target “10-year” nourishment volume of ~1.1 million cubic yards.

2.5.3 Beach Sediment and Borrow Area Analysis

Quogue Beach consists of well-sorted, medium sand with a mean diameter of ~0.45 mm. The USACE has identified offshore borrow areas 5A, 5B, and 5B Exp strategically situated 0.7-1.3 miles offshore of Quogue Beach. These areas have been evaluated in detail by the USACE and are approved for nourishment projects by NYDEC. Prior studies of biota and sediment quality indicate these areas would served as feasible sand sources with limited environmental impact if dredging is conducted in winter for projects between Shinnecock Inlet and Moriches Inlet.

Areas 5A and 5B are generally reserved for federal projects. Area 5b Exp (situated adjacent and contiguous to 5A and 5B—see Fig 2.31) is potentially available to the Village of Quogue. Area 5B Exp was subdivided herein into three sections (Q1, Q2, and Q3), totaling ~684 acres. Subarea Q1 (220 acres) could potentially provide 1.1 million cubic yards in the upper ~3 ft of substrate. Alternatively, if excavated ~7 ft below grade, only ~100 acres of Q1 (or the other sections) would be required to accomplish a 1.1 million cubic yard project. Q1 is situated seaward of the 40-ft depth contour, well removed from the active zone of sand transport and sediment exchange along the beach.

Alternate sand sources include inland deposits, Shinnecock Inlet shoal dredging, and bay channel dredging. The project team recommends offshore borrow area 5B Exp for reasons of economics, sediment quality, and environmental impacts. Further, the majority of beach restoration projects now favor use of “external,” non-littoral borrow sources so as to minimize disruption of the sand-sharing system in the littoral zone (water depths approximately <30 ft).

3.0 PRELIMINARY PROJECT PLANS

Based on the foregoing surveys and analyses, the team developed a project plan for three reaches along the Quogue area. The plan takes into account the site-specific profile volume deficit, background erosion rate, nearest borrow area(s), and feasible construction method(s). The plan has been formulated for a ten-year period. Costs are developed for low fill scenario (fill volume minus 15 percent), middle fill scenario (minimum fill volume derived in Table 2.5), and upper fill scenario (fill volume plus 15 percent) based on current market conditions and discussions with qualified contractors.

In brief, the following factors control nourishment costs and affect the success of any project (NRC 1995, Dean 2002).

> **Length** — Nourishment losses decrease and project life increases exponentially with project length. Therefore, longer projects are better. The team's recommended plan encompasses 14,325 ft (2.71 miles) along the Quogue village limit rather than focusing only on the eastern areas of highest sand deficit. Over the next 50 years, it would be advantageous to incorporate adjacent Tiana Beach into a beach maintenance plan, thereby increasing the longevity of future projects along Quogue Beach. This is consistent with plans by the USACE under the “West of Shinnecock Inlet—WOSI” project. The recommended plan applies an erosion safety factor so as to account for end losses which tend to be greater for short project areas.
>
> **Distance to Borrow Area** — Unit costs of construction increase with distance to the borrow area. Short distances to the borrow area of the order 3 miles or less are feasible for ocean-certified pipeline dredges. Longer distances require additional equipment such as booster dredges or use of hopper dredges. The recommended plan meets the criteria for use by the two major types of ocean-certified dredging equipment.
>
> **Sediment Quality** — Coarser sediments produce more stable beach fills and allow use of lower volumes to achieve a particular dry-beach width (Dean 2002). In some cases, however, finer sediments are preferred for aesthetic and other reasons. The USACE-designated offshore borrow areas contain beach-quality sediment based on the available data collected to date (cf – USACE 2008, URS 2010).

The existing information shows a high degree of similarity between sediments in borrow areas 5A, 5B, and 5B Exp, and Quogue Beach.

Size — Larger projects will last longer. However, there are a range of minimum volumes necessary to optimize costs. Pipeline dredges work more efficiently if the nourishment sections involve at least ~25 cy/ft. Lesser section quantities are more labor-intensive, requiring frequent addition of pipe and more careful grading to achieve fine tolerances. The recommended plan meets the minimum size criteria for cost-effective projects.

Clarity of Project Plans and Method of Payment — CSE's design philosophy in over two dozen large nourishment projects has been to produce plans which minimize uncertainties for prospective contractors. The key questions from dredgers are:

What is the sediment quality throughout the borrow area?
How will nourishment pay quantities be measured?
What is the wave climate?

Detailed borrow area surveys are the key to answering the first question. The primary borrow area information needed by dredging contractors is detailed bathymetry of the offshore area and corridor to the beach, and boring logs describing the sediments within the dredging zone.

The second question regarding pay quantity determination depends on the type of nourishment project and equipment used. Normally, the recommended payment method is to base the quantities on pre-project and post-project surveys of the beach. This provides assurance that payment is for material delivered. In some circumstances, it may be advantageous or more practical to pay based on the excavated area.

The third question relates to operation conditions and dredging efficiency. Contractors anticipate losing production time when conditions preclude safe operation. Cutterhead dredges have lower thresholds than hopper dredges for offshore work. Data on wave characteristics during the anticipated dredging season help contractors anticipate downtime. In the absence of such data, contractors tend to use a higher safety factor (with associated higher unit costs for construction).

The potential construction savings generated by clear, detailed project plans, which include comprehensive geotechnical and environmental data, generally far outweigh the costs of additional borings and coastal process data collection.

Background Erosion Rate — To the extent that the nourishment sediment matches the native beach and the project is relatively long, it will erode similarly to the historical rate. CSE has formulated the project plan around the background erosion rate for the project area, recognizing that localized erosion and accretion (associated with storm events) tends to be much great than the average long-term losses.

Project Monitoring — The anticipated outcome and longevity of a nourishment project can never be predicted with absolute certainty. However, careful monitoring and measurement of beach changes improves predictions. The limited historical survey database for this area makes it more critical to immediately establish regular monitoring plans and track the condition of the beach over time before and after project completion.

The recommended plan for beach restoration along Quogue is shown in Figure 3.1. The cornerstone of the plan is nourishment by hydraulic dredge using offshore borrow sediments identified by the USACE (ie – portions of borrow area 5B Exp, or 5B if available). The recommended nourishment volume is 1.1 million cubic yards (±15 percent) to be distributed between the village limits. Fill quantities would be varied from reach to reach according to the condition of the beach near the time of construction. The team prepared the recommended project plan based on the February 2011 beach condition and nourishment volumes needed to restore the deficit and keep pace with yearly losses for at least ten years.

The upper portion of Table 3.1 outlines a nourishment plan using offshore deposits. A majority of the nourishment would go to Reach 3 because of need. However, significant additions of fill are being proposed for each reach with the goal of maintaining the minimum-recommended profile volumes over the ten-year period of the project life while erosion continues.

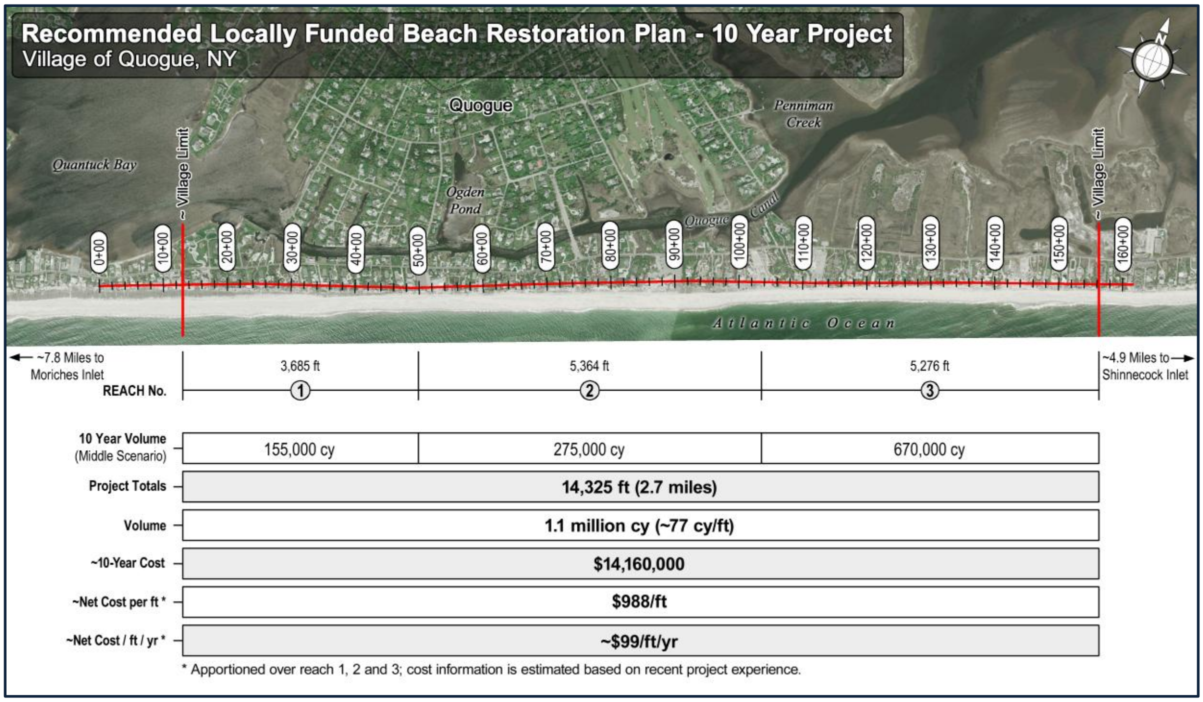


FIGURE 3.1. Recommended "ten-year" beach restoration plan for Quogue involving ~1.1 million cubic yards from the USACE-designated offshore borrow areas. [See Figure 2.33 for recommended borrow areas.]

An ~1.1 million cubic yard project would add an average of about 77 cy/ft over the length of the project. Fill volumes along Reach 3 would be upward of 127 cy/ft under the recommended plan. Figure 3.2 illustrates the expected change in the profile under various additions of sand in each reach. The larger nourishment volume for the eastern end of the project has the advantage of feeding the rest of Quogue Beach over time before the nourishment is lost to the west.

Table 3.1 also provides CSE's preliminary opinion of probable construction cost for the recommended plan. The assumptions for dredge mobilization/demobilization and unit pumping costs are based on recent experience with similar projects. It is important to understand that dredging costs have fluctuated over a considerable range in recent years. Such factors that have affected costs are the frequency of storms, fuel prices, and limited environmental periods for work. With only five companies in the U.S. certified to work offshore, prices rise when there is a shortage of equipment. Conversely, prices fall when there is excess capacity in the industry. For planning and budgeting purposes, the team recommends that the community allow for ±15 percent differences between the estimates and final bids.

A common way that CSE has handled uncertainties in the price of projects is to adjust the fill volume to fit the budget allocated. If bids are favorable, more sand can be added (or money saved). Otherwise, if bids are high, the contracted volume can be reduced. If the project scenario with the team's recommended fill volume (1.1 million cubic yards of sand) is called "middle scenario," a "low scenario" is in accordance with minus 15 percent of the total fill volume (yield 935,000 cy of sand) and an "upper scenario" is in accordance with plus 15 percent of the total volume (yield 1.265 million cubic yards). The cost estimates of the low and upper scenarios are listed in Table 3.1. The team will work closely with community representatives in determining an appropriate budget level and nourishment volume that will result in a viable bid for the work.

The opinion of probable construction cost provides line items for dredge mobilization and demobilization, engineering, surveys, permitting, and contingency. The team recommends additional field data collection during the final design phase of the project for purposes of obtaining more detailed confirmation of borrow area sediment quality. Contractors have repeatedly emphasized to our project team that detailed surveys of borrow areas are a major factor in bids for nourishment projects.

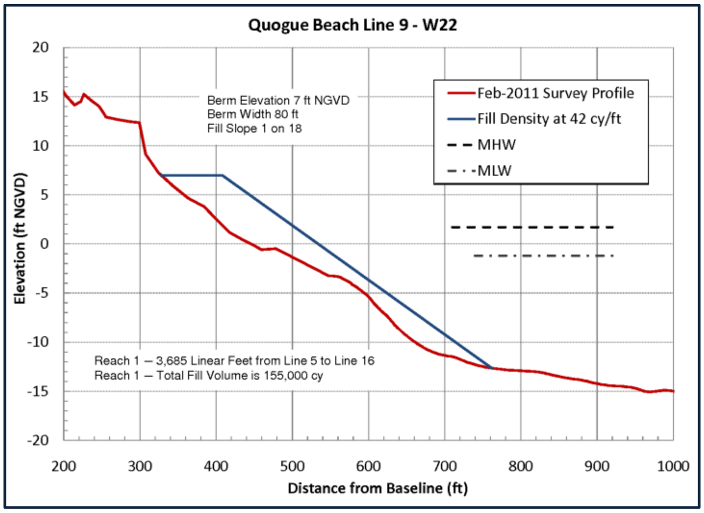
TABLE 3.1. Long-term beach restoration plan at Quogue Beach — "ten-year project." Offshore borrow source 5B Exp (ie – Q1, Q2, and/or Q3) is assumed for construction.

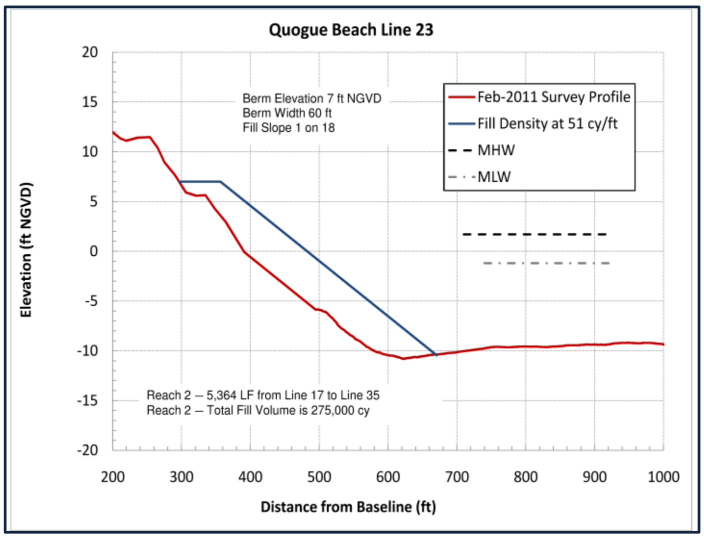
Unit Cost Assumptions:	Dredging @	$ 8.00	per cubic yard
	Mobilization/Demobilization @	$ 3,200,000	
Notes: Unit cost estimate is based on recent project at Smith Point. Mobilization/Demobilization cost is based on recent project at West Hampton.			

CSE Recommended Ten-Year Plan — Middle Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	155,000	42	$ 1,240,000
Reach 2	**L17-L33**	5,364	275,000	51	$ 2,200,000
Reach 3	**L34-L51**	5,276	670,000	127	$ 5,360,000
Totals	**L5-L51**	14,325	1,100,000	77	$ 8,800,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 960,000
				Permitting and Environmental Reports @ 2%	$ 240,000
				Contingency @ 8%	$ 960,000
				Total Project	$ 14,160,000
				Cost per Linear Foot of Beach	$ 988

CSE Recommended Ten-Year Plan — Low Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	131,750	36	$ 1,054,000
Reach 2	**L17-L33**	5,364	233,750	44	$ 1,870,000
Reach 3	**L34-L51**	5,276	569,500	108	$ 4,556,000
Totals	**L5-L51**	14,325	935,000	65	$ 7,480,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 854,400
				Permitting and Environmental Reports @ 2%	$ 213,600
				Contingency @ 8%	$ 854,400
				Total Project	$ 12,602,400
				Cost per Linear Foot of Beach	$ 880

CSE Recommended Ten-Year Plan — Upper Scenario					
Reaches	**Reach Limits**	**Length (ft)**	**Nourishment Volume (cy)**	**Average Unit Volume (cy/ft)**	**Pumping Costs**
Reach 1	**L5-L16**	3,685	178,250	48	$ 1,426,000
Reach 2	**L17-L33**	5,364	316,250	59	$ 2,530,000
Reach 3	**L34-L51**	5,276	770,500	146	$ 6,164,000
Totals	**L5-L51**	14,325	1,265,000	88	$ 10,120,000
				Mobilization/Demobilization	$ 3,200,000
				Final Design, Surveys, Engineering, Construction Admin @ 8%	$ 1,065,600
				Permitting and Environmental Reports @ 2%	$ 266,400
				Contingency @ 8%	$ 1,065,600
				Total Project	$ 15,717,600
				Cost per Linear Foot of Beach	$ 1,097





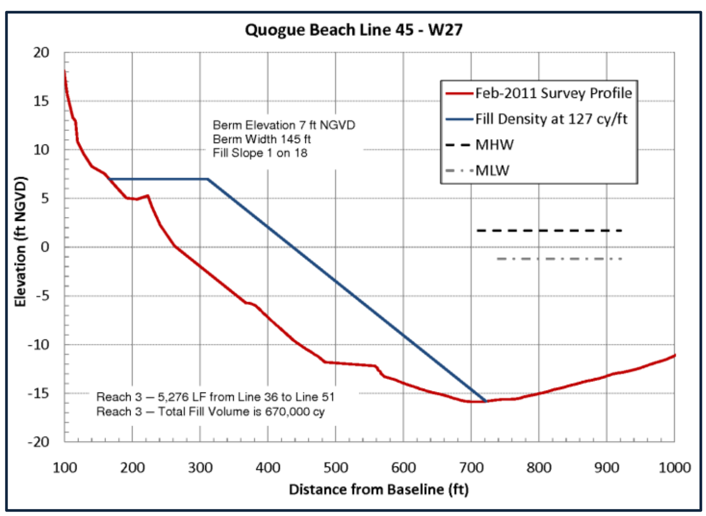


FIGURE 3.2. Representative nourishment profiles compared with existing conditions of February 2011:
[UPPER] Reach 1 showing the initial impact of fill volumes at 42 cy/ft
[MIDDLE] Reach 2 showing the initial impact of fill volumes at 51 cy/ft
[LOWER] Reach 3 showing the initial impact of fill volumes at 127 cy/ft.

4.0 PROJECT IMPLEMENTATION REQUIREMENTS

A relatively large number of tasks are required before construction of a project can proceed. Commonly, permitting and engineering requires 1-2 years for locally funded projects and many times longer for federally sponsored projects. Certain environmental factors also influence construction schedules if recommended protection practices are to be followed.

The primary design tasks remaining before construction are:

- Finalize plan, review with interested parties, initiate permitting.
- Environmental studies and assessments as requested by regulatory and resource agencies.
- Additional offshore surveys and field data collection (eg – borings, cultural resource inventories, waves, tides, etc).
- Coastal engineering analyses.
- Final design, preparation of plans and construction documents.
- Bidding and negotiations with contractors.
- Construction and construction observations.
- Final report.
- Postproject monitoring and maintenance.

In addition to the above-listed tasks, financial analysis, fund raising, and construction easements must be completed or secured in time for project execution. Normally, the owner or governing entity assumes responsibility for these particular items.

Based on experience and discussions with state regulatory agencies in New York, the preferred environmental window for construction is 1 November through 31 March. During warmer months, such factors as bird nesting and migration/recruitment of pelagic species, as well as tourist use, make dredging activities less desirable. Further, the process of applying for and securing permits for beach nourishment can be lengthy and can involve numerous meetings with regulators, public hearings, and agency review. To the extent possible, project designs should seek to minimize adverse environmental impacts, enhance existing habitats, and produce reasonably long-lasting benefits. The preliminary plan outlined herein seeks to achieve these goals in the following ways.

Enhance Existing Habitats

- The proposed plan is a soft solution involving sand and no hard structures.
- Nourishment of the profile lessens the frequency of storm damage to dunes and existing backshore vegetation.
- A wider dry-sand beach will expand the habitat for endangered piping plovers and will provide a source of sand for natural dune growth.

Produce Long-Lasting Benefits

- The proposed project is formulated to provide benefits and an improved beach for at least ten years.
- The recommended plan uses quantifiable surveys as a basis for the design and a means of tracking performance so that the community can monitor the improvements over time.
- Wider beaches allow dunes to grow and provide enhanced storm protection and damage reduction.

The earliest possible time to initiate construction of a ten-year project (using offshore deposits) is November 2013, assuming there are no provisions to allow dredging during warm-season months. The team does not recommend initiation of construction in September or October because of more uncertainties with weather and wave conditions, which impact dredging costs. Also, summer dredging creates more disruption to beach goers and should be avoided wherever possible. The principal exceptions to winter dredging schedules are in areas where such dredging would be unsafe.

The present erosion problem along Quogue Beach is focused along the eastern half of the shoreline. At least 15 percent of the beach lacks FEMA-recommended dune protection. With an infusion of new sand to restore the deficit at the level recommended, there will be an enhanced buffer to accommodate a major storm event. A key element of the recommended plan is yearly surveys and preparation of sand budgets which quantify the volumes of sand moving along Quogue Beach. Ongoing beach and inshore surveys will be important for future planning and developing early protection measures before conditions deteriorate at any point along the beach.

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