MONITORING AND ANALYSES OF THE 2013–2014
SAGAPONACK & BRIDGEHAMPTON—WATER MILL
BEACH EROSION CONTROL DISTRICTS
NOURISHMENT PROJECT

2017 BEACH MONITORING

Prepared for:

Town of Southampton
Long Island New York

COASTAL SCIENCE & ENGINEERING

Monitoring and Analyses of the 2013–2014 Sagaponack & Bridgehampton Beach Erosion Control Districts Nourishment Project
Southampton, Long Island, Suffolk County (NY)

2017

BEACH MONITORING REPORT

Prepared for:

Town of Southampton
Long Island, NY

116 Hampton Road Southampton NY 11968

Prepared by:

High Value Services
Sustainable Solutions
CSE
COASTAL SCIENCE & ENGINEERING

PO Box 8056 Columbia SC 29202-8056

— with —

First Coastal Corporation
4 Arthur Street Westhampton Beach NY 11978

[CSE2434–YR4]
APRIL 2018

COVER PHOTO: Aerial photo taken on 19 July 2017 from west of Mecox Bay looking southwest to the project limit at Water Mill. Ground photo taken at high tide on 3 April 2018 after the series of nor'easters in March. Escarpments were observed, and a section of bulkhead was re-exposed.

— THIS PAGE INTENTIONALLY LEFT BLANK —

EXECUTIVE SUMMARY

Between October 2013 and February 2014, over 2.5 million cubic yards of sand (project volume) were pumped from offshore and spread along 5.6 miles of Sagaponack and Bridgehampton–Water Mill (Southampton, Long Island, NY) (Fig A). The purpose of the project was to widen the beach and provide better storm protection along oceanfront properties. The amount of sand dredged was equivalent to ~170,000 dump-truck loads or about 570 truckloads along a typical property with 100 feet (ft) of oceanfront.

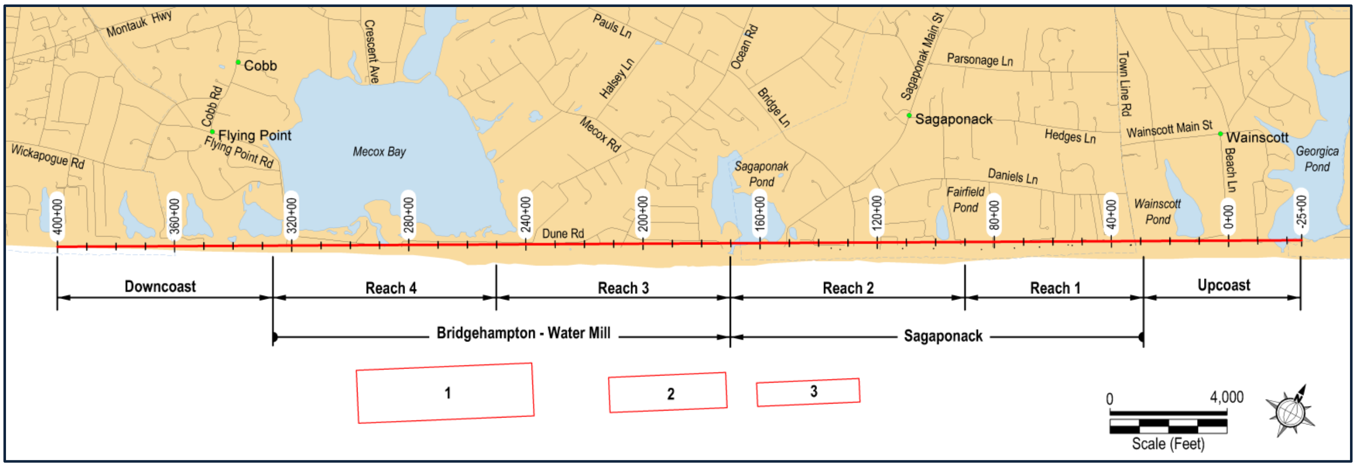


FIGURE A. The project area showing reaches (1–4) and stations (eg: −25+00, 200+00) evaluated by periodic surveys. The boxes offshore are the three dredge areas in water depths of ~40–60 ft which provided the "borrow sand" for the project.

In November 2014, during the first year after project completion, Sagaponack retained 100 percent and Bridgehampton–Water Mill retained 106 percent of the project volume. Since 2015, more sand has been discovered in the project area. Sagaponack was found to contain 108 percent and Bridgehampton–Water Mill 122 percent of the project volume in July 2015, and 124 percent for Sagaponack and 122 percent for Bridgehampton in July 2016. As of July 2017, the trend of increasing sand maintained in Sagaponack. Sagaponack was found to contain 120 percent while Bridgehampton–Water Mill remained at 118 percent. These increases reflect natural gains associated with post-Hurricane *Sandy* added to the nourishment volume. Performance of the project, so far, exceeds the design expectation with no losses to upcoast or downcoast areas.

This report presents detailed measurements of the beach in July 2017 (Year 4 after nourishment) for purposes of evaluating the performance of the project and provides a record for use by FEMA should a major storm impact the area. The shoreline of interest extends from Georgica Pond 1.0 mile east of the Sagaponack project limit at Town Line Road to the Village of Southampton Beach about 1.5 miles west of the Bridgehampton–Water Mill project limit at Flying Point Road.

Nourishment sand shifts across the beach just as natural sand moves from the surf zone to the dry-beach area in summer or back to shallow water in winter. Upon initial placement, more of the nourishment sand is visible, but it quickly "equilibrates" by wave action to take on a natural profile. Some sand shifts to the underwater part of the beach, where it cannot be seen, but where it serves to create a necessary foundation for the visible beach. Other sand pumped onto the visible beach is exposed to winds which move it to the toe of the dune, building height and width over time.

CSE's basic approach for beach monitoring is to track the foredune and the visible and underwater parts of the beach zone as a giant "sand box" within the Sagaponack/Bridgehampton–Water Mill project area. The sand volume of interest slopes gently across the box from the dune line to a reference depth offshore well beyond the outer bar. The total volume in the sand box is measured before nourishment and then compared with each survey after nourishment. The differences in volume provide a measure of sand losses (erosion) or gains (accretion) over time.

CSE calculates sand quantities out to about 1,500 ft offshore, which corresponds to the zone over which the majority of sand movement occurs from year to year. Underwater sand shifts toward shore in summer, producing a widening of the visible beach. Usually, just the opposite occurs in winter with sand moving offshore, leaving a narrower beach. The measurements also allow CSE to subdivide the beach into sections (reaches) along the coast so changes can be reported separately for Sagaponack or Bridgehampton–Water Mill, or the conditions can be determined every 500 ft at "stations" along the coast (Fig B). CSE further considers how much sand is accumulating naturally along the dune line or building up along the outer bar. Volumes are calculated in various layers (lenses) across the sand box. Each layer is a slice of sand volume within particular elevation bands.

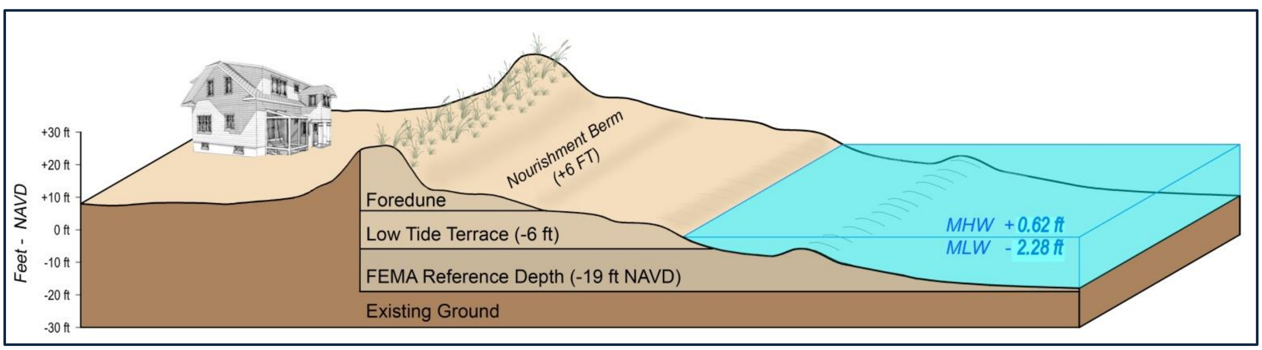


FIGURE B. The beach zone used for calculating sand quantities along Sagaponack and Bridgehampton–Water Mill. The zone of interest extends from the foredune to a specified offshore depth (FEMA reference at −19 feet NAVD), in effect, a large sand box over which waves shape the beach and shift sand around. NAVD–North American Vertical Datum of 1988 which is a fixed elevation used by surveyors. Zero feet NAVD is ~0.5 ft above present mean sea level along Southampton (NY).

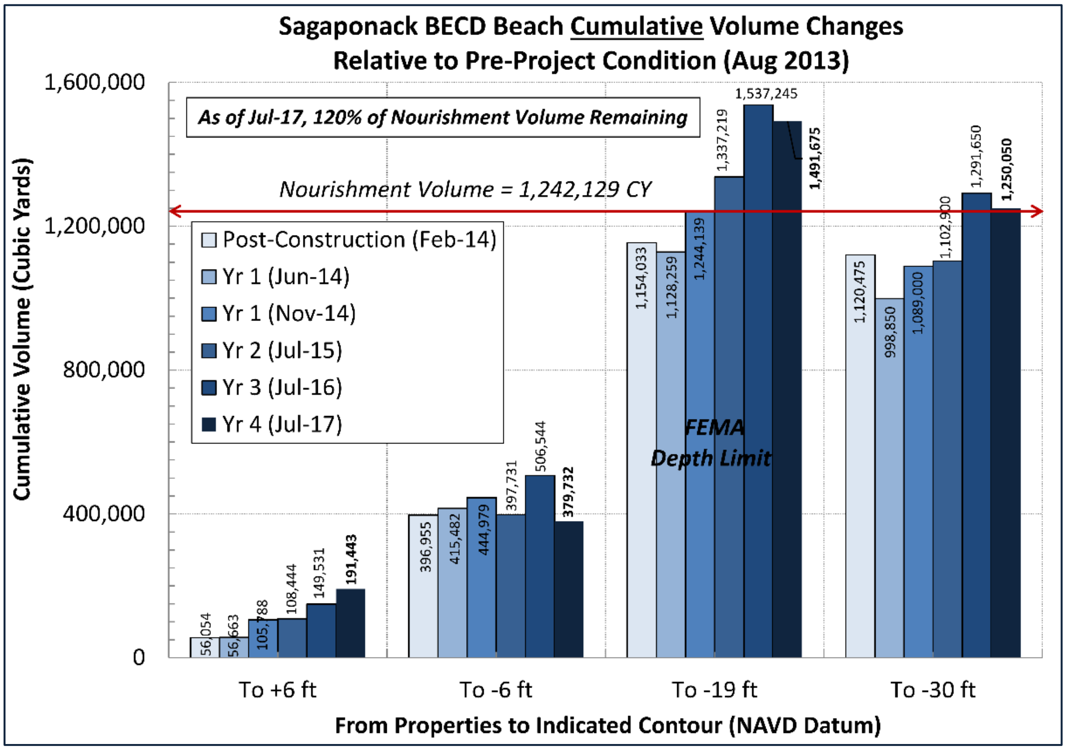
Three lenses of interest are used in this study, representing the foredune, the recreational beach, and the underwater portions of the beach (Fig B). The main text and appendices of this report provide numerous graphs and tables which break down the results in detail. This is useful for future nourishment designs as well as for providing FEMA with documentation of where erosion has occurred within the project area (a requirement for post-disaster restoration funds under community assistance grants).

Many of the report graphs reference "unit volumes" which are a basic measure of how much sand is contained within a particular elevation band (lens) over a 1-ft length of beach (Fig B). Unit volumes (a three-dimensional measure) are used rather than beach width (a one-dimensional measure), because beach nourishment is a volume added to the beach. On a unit shoreline basis, the project added roughly 85 cubic yards (cy) (~5.7 truckloads) along every foot of shoreline. For Sagaponack to Bridgehampton–Water Mill, the project volume is expected to widen the visible beach an average of ~75 ft after natural adjustment. The actual increase in width from place to place will vary with the season (wider in summer than in winter or after storms) and wider at some localities than others due to the natural waviness of the shoreline.

The main findings of the report are graphed in Figures C and D. Figure C shows the additional amount of sand in the project area after nourishment in February, June, and November 2014, July 2015, July 2016, and July 2017 relative to the pre-project condition (August 2013). The left-hand group of bars represents sand volume gained along the foredune. The second group of bars from the left represents sand volume gained between the foredune and visible beach to low-tide wading depth, and the third group of bars from the left represents the total volume gained between the foredune and the FEMA reference depth of −19 ft NAVD.

The results for both BECDs show volume gains over time for all reference depths to the −19-ft contour. These bars, representing the "sand box" that is considered by FEMA for future storm reimbursement purpose, show ~120 percent remains along Sagaponack and ~118 percent remains along Bridgehampton–Water Mill.

The right-hand group of bars was added to this report, and they represent the total volume between the foredune out to deep water of −30 ft NAVD relative to the pre-project condition. Note that the lengths of these bars on the graphs are general shorter than the bars to −19 ft. This means that the offshore zone between −19 ft and −30 ft has given up some sand since the end of construction, accounting for the gain in shallower water. But, significantly, the cumulative volume changes to −30 ft since August 2013 (pre-nourishment) essentially equal the nourishment quantities for each BECD as of July 2017.



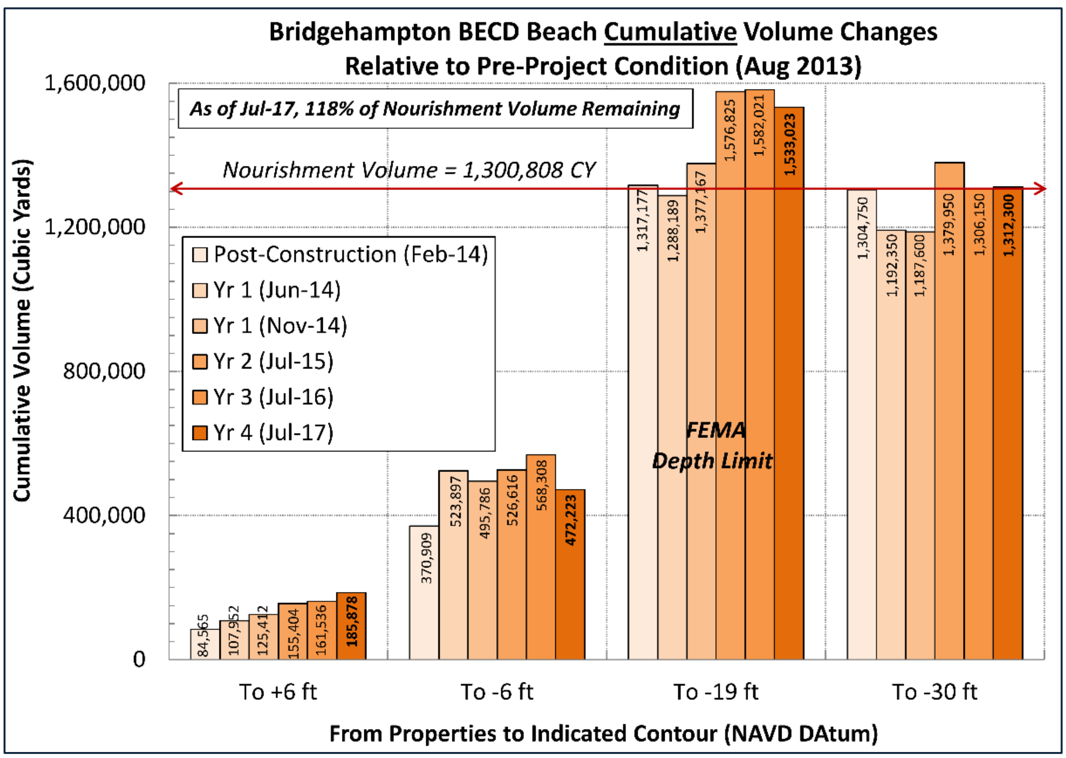
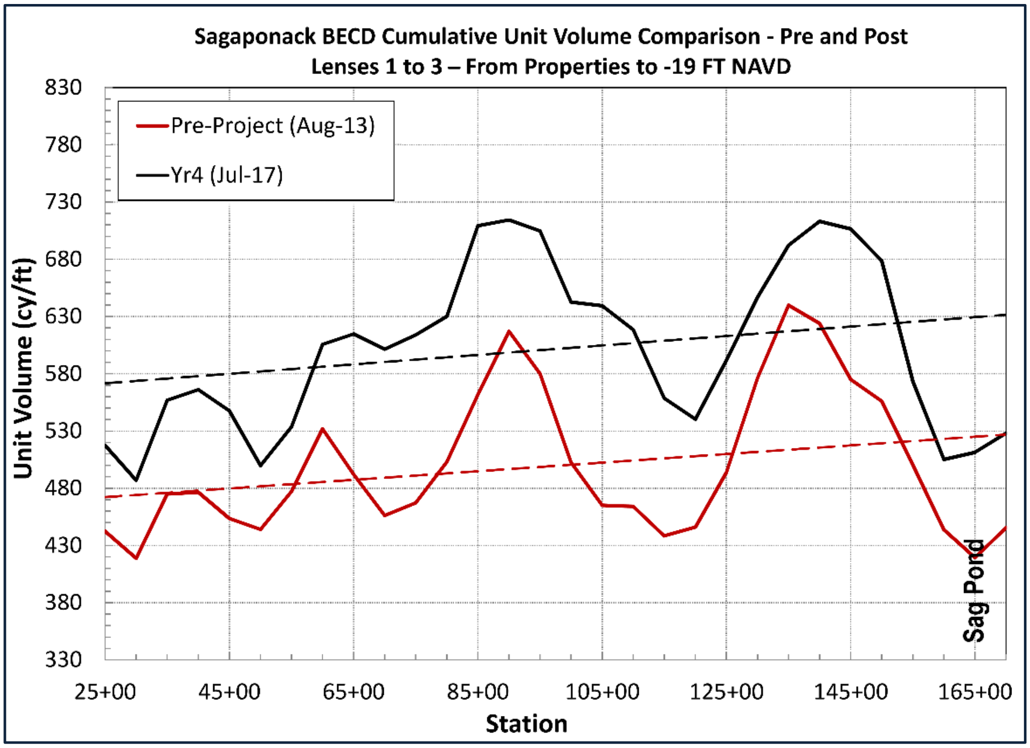


FIGURE C. The volume of nourishment sand within the project boundaries of Sagaponack (upper) and Bridgehampton (lower) relative to the pre-nourishment condition. The left-hand group of bars represents volume gains in the foredune (positive trend). The second group of bars shows the volume from the foredune to low-tide wading depth (mainly positive trend). The third group of bars represents the volume to the FEMA reference depth offshore (positive trend), and the last group of bars tallies the volume from the foredune out to deep water (relatively stable trend). From this, CSE concludes there have been no net losses of sand at each BECD since the project was completed.



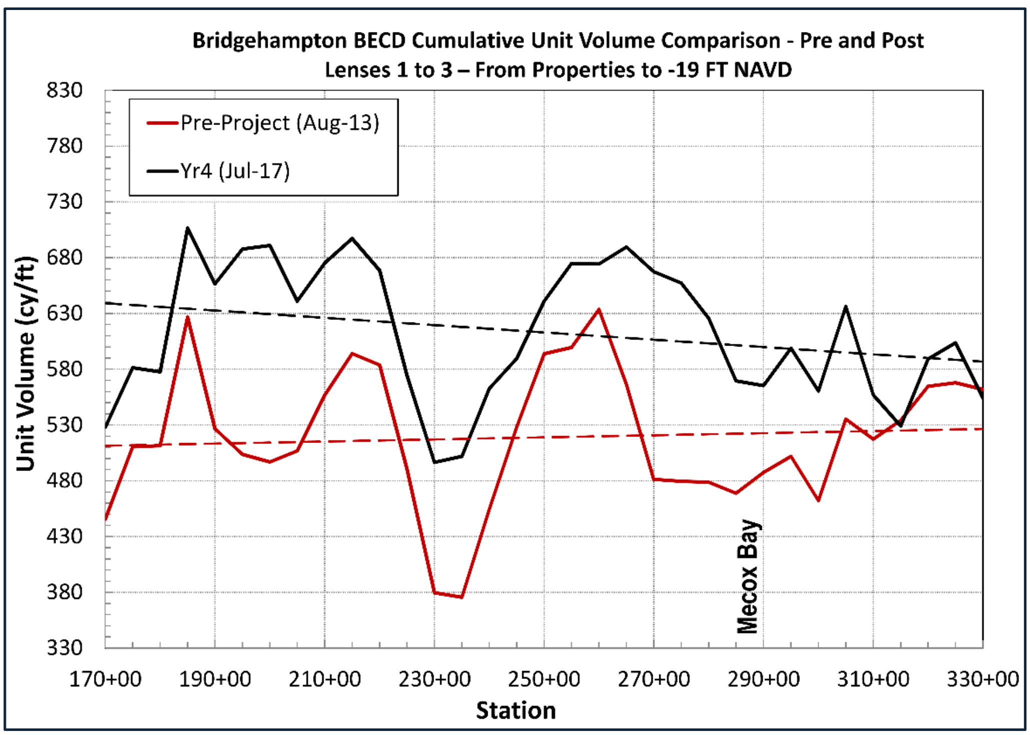


FIGURE D. Variation in sand volumes by stations before and after nourishment for Sagaponack (upper) and Bridgehampton–Water Mill (lower). The average trend is given in the dashed lines. High and low points on each graph reflect the natural waviness of the beach and offshore bar. Waves of sand tend to propagate slowly along the coast, shifting the low points (erosion "hotspots") to the west over time. At most localities, the pattern of high and low points is similar in July 2017 as the pre-project condition in August 2013.

CSE believes this result is related to the timing of the nourishment project approximately one year after Hurricane *Sandy*. That storm likely shifted sand to deep water (−19 ft to −30 ft depths). Some of these post-storm deposits appear to have moved shoreward back into the project "FEMA" boundaries. Results measured to the −30 ft contour show that the extra volumes along Sagaponack and Bridgehampton nearly match the original nourishment volumes, meaning there have been no losses to date beyond deep water of −30 ft NAVD.

Figure D shows the station-to-station increase in unit sand volume due to the project. Conditions before nourishment are shown in red (dashed line is the average trend). Recent conditions (July 2017) are shown in black. The highs and lows from station to station reflect rhythmic variations in the bar and beach topography, a natural phenomenon of surf zones. Some of the differences also correspond to locations of Sagaponack Pond (station ~170+00) and Mecox Inlet (station 285+00 to station 290+00). Over time, the highs and lows of beach volumes tend to propagate slowly downcoast from east to west. CSE will track this movement each year because these undulations in the shoreline sometimes produce erosion "hotspots" where the visible beach narrows and waves reach the foredune at high tide.

CSE and First Coastal Corporation inspect the project area periodically between the regularly scheduled surveys, especially after severe storms or nor'easters. For example, a series of nor'-easters impacted the project area in March 2018, and the team inspected the beach immediately after the events.

Escarpments were observed in a number of localities, particularly along west of Mecox Bay where the beach was narrower. Associated with the escarpments, a portion of the bulkhead that was buried naturally after the 2013–2014 nourishment project became re-exposed after the storms. The beach in front of these areas was barely passable during high tides.

Despite the escarpments and the loss of some steps of the walkovers, overall the dunes remained intact and the beach withstood the storms without any further damage to the oceanfront properties after the March events. It is expected that the beach will naturally recover during the summer season, and at least some of the exposed bulkhead will be re-buried by wind-generated sand over the next few months.

Another important measurement was post-project sand sampling. Nourishment performance depends on quality sand matching the native sediment. The results of CSE's sampling in July 2017 confirmed that the nourishment sand now mixed with native sand closely matches pre-project conditions on the visible beach in terms of color, texture, and size. The mean grain size averaged

0.42 millimeter (mm) before nourishment along Sagaponack and Bridgehampton–Water Mill. In July 2017, four years after nourishment, the mean grain size averages ~0.466 mm, negligibly coarser than the pre-project condition. This helps explain why the nourished beach is indistinguishable from the natural beach (with the exception of beach width). A cursory walk along the beach supports the general observation that the new sand looks and feels similar to the native sand. More importantly, the nourishment sand contained negligible mud and very low percentages of gravel.

This report contains many details that will be of limited interest to the casual reader. However, the purpose of providing details herein is to maintain an objective record of performance. CSE's design anticipated annual losses to average ~120,000 cubic yards per year (cy/yr) or almost 5 percent of the nourishment quantity to erode each year. However, by any measure, the project is performing well so far, and more sand remains within the project boundaries than expected 3.5 years after placement. Residual effects of Hurricane *Sandy* have likely helped the project, with sand from deeper water slowly moving back into the "sand box" CSE uses for the calculations. Upcoast and downcoast areas experienced losses in volume in almost all sections of the profile during the past year, which is consistent with the long-term trend of erosion east of Shinnecock Inlet; however, the losses are of greater magnitude.

Borrow area survey results show that the excavated areas have infilled gradually since project completion. Based on the contractor construction record, ~2.75 million cubic yards of sand were excavated from the borrow areas (yielding an estimated 8 percent loss ratio between excavation volume in the borrow areas and in-place volume on the beach). As of July 2017, there were ~626,000 cy more sand in the borrow areas compared to the after-dredging conditions (February 2014), indicating ~23 percent recovery 3.5 years after dredging.

Perhaps, the most favorable news for individual property owners is the gain along the foredune. During the past four years, the equivalent of over half a dump truck worth of sand has shifted to the dunes for every foot of beach. Windblown sand is accumulating around newly installed sand fencing, building up the foredune and improving the level of protection for all members of the Beach Erosion Control Districts.

CSE's next scheduled survey of the beach is May–June 2018.

— *THIS PAGE INTENTIONALLY LEFT BLANK* —

ACKNOWLEDGMENTS

The Sagaponack–Bridgehampton–Water Mill beach nourishment project was sponsored by two Beach Erosion Control Districts (BECD) administered by the Town of Southampton (NY), and the Year 4 monitoring was funded by the same two BECDs. CSE thanks the leaders of each BECD for their impetus and active participation in project planning and monitoring. We also thank the Town staff for their timely and enthusiastic support including Marty Shea, Kyle Collins, Chris Bean, and Kim Myers.

Coastal Science & Engineering deeply appreciates the support of First Coastal Corporation, including Mr. Aram Terchunian (president), Billy Mack, and Ben Spratford, during the monitoring effort.

Field data collection and analysis were directed by Dr. Haiqing Liu Kaczkowski (PE, NY 090164) with assistance by Drew Giles, Luke Fleniken, and Steven Traynum. The report was written by Dr. Kaczkowski and Dr. Tim Kana (PG, NC 1752) with assistance by Trey Hair, Patrick Barrineau, and Diana Sangster.

— *THIS PAGE INTENTIONALLY LEFT BLANK* —

TABLE OF CONTENTS

— [THIS PAGE INTENTIONALLY LEFT BLANK] —

1.0 INTRODUCTION

This is the fourth annual report on the beach condition along ~5.7 miles of ocean shoreline at Sagaponack and Bridgehampton–Water Mill Beach Erosion Control Districts (BECDs) (Southampton NY) following successful completion of the 2013–2014 beach nourishment project. The nourishment project was conducted between 15 October 2013 and 21 February 2014. Based on the contract between the Town of Southampton and the contractor, Great Lakes Dredge & Dock Company (GLDD), the Sagaponack reach was scheduled to receive 1,242,129 cubic yards (cy) of sand along ~2.7 miles of beach, and the Bridgehampton reach was to receive 1,300,808 cy of sand along ~3.0 miles of beach. The contractor's project record showed 1,244,556 cy of sand were placed along Sagaponack and 1,299,036 cy were placed along Bridgehampton–Water Mill. The actual placed volumes represented ~100 percent of designed volumes for both BECDs. Details of the project design and construction are contained in prior CSE (2014a,b) reports.

Before project commencement, a comprehensive beach condition survey was conducted by CSE in August 2013 to document the pre-project condition. Following project completion, a survey was conducted in February 2014 to confirm in-place nourishment volume. Two semi-annual surveys were completed in June and November 2014 (Year 1); one annual survey was performed in July 2015 (Year 2); one annual survey was performed in July 2016 (Year 3); and one annual survey was performed in July 2017 (Year 4) to document the beach condition after project completion.

The present report summarizes the annual results of the 2017 survey and compares them with the pre-project, post-project, Year 1, Year 2, and Year 3 conditions. CSE submitted preliminary results of the July 2017 condition survey to the Town and each BECD on 18 August 2017. CSE and First Coastal Corporation completed several site visits and provided ongoing liaison with Town officials between July 2017 and March 2018. This year's report present provides additional observations and a detailed summary of the surveys and the physical condition of the beach in Year 4 after nourishment and quantifies sand volume changes relative to pre-project conditions (August 2013). The survey results are used to evaluate the project performance, document volume changes within various calculation limits, and identify erosion hotspots.

This report includes:

- Brief review of the 2013–2014 beach nourishment project.
- Beach monitoring requirement and scope of survey work.
- Data collection methodology and survey control information.
- Beach and inshore surveys and profile comparisons.

- Profile volume analyses for representative contour intervals.
- Net volume changes by profile and reach.
- Calculation of nourishment volumes remaining in the project areas.
- Upcoast and downcoast volume changes.
- Borrow area survey results.
- Monitoring and maintenance recommendations.

Certain information about the nourishment project and previous survey efforts are repeated in this monitoring report to aid the reader. The project planning, design, implementation, and initial performance are detailed in CSE's reports (2012a,b; 2014a,b), and the Year 1, Year 2 and Year 3 surveys are detailed in CSE's monitoring reports (CSE 2015a,b; 2016).

1.1 Project Background, Design and Implementation

Sagaponack beach encompasses ~2.67 miles of ocean shoreline extending from Town Line Road at the eastern end to the mouth of Sagaponack Pond to the west. Bridgehampton–Water Mill beach encompasses ~2.96 miles of ocean shoreline adjacent and west of Sagaponack beach extending from Sagaponack Pond at the eastern end to Flying Point Road at the western end of Mecox Bay to the west. The ~5.63-mile-long Sagaponack–Bridgehampton–Water Mill beach is a segment of the ~30-mile-long mainland bluff shoreline extending from Montauk Point to Shinnecock Bay along the south shore of Long Island (Fig 1.1).

Georgica Pond is 1.0 mile to the east of Sagaponack, and Shinnecock Inlet is ~8 miles to the west of Water Mill. Net sand transport along the coast is east to west (USACE 1958), placing Sagaponack–Bridgehampton–Water Mill "downcoast" of Georgica Pond and its associated groins. Georgica Pond, Sagaponack Pond, and Mecox Bay include intermittent inlets which periodically flush the ponds and provide the primary interruptions to littoral transport along this segment of coast.

Sagaponack–Bridgehampton–Water Mill beach has sustained moderate erosion and loss of sand over the past century through normal processes of storm erosion and bluff recession. In 2012, before Hurricane *Sandy*, portions of the beach were exceedingly narrow and lacked sufficient dune volume for protection of properties during major storms. *Sandy* caused extensive dune recession and undermined foundations of several houses in the project area. CSE and First Coastal Corporation had recommended nourishment and dune enhancement in a feasibility study prior to *Sandy* (CSE 2012a,b).

FIGURE 1.1. Project location map showing the Sagaponack–Bridgehampton–Water Mill beach nourishment project area situated along the mainland bluff shoreline of eastern Long Island. Net sand transport is east to west along the south shore of Long Island.

CSE's previous studies designated the −18-foot (ft) (NGVD*) contour as the standard "FEMA" design limit which is consistent with boundaries used by Fire Island (NY) projects (CPE 2013; CSE 2012a,b; 2014a). This reference depth is applied in the analysis of erosion rates for the area. Based on CSE's beach survey in July 2011 and the best-available historical data, an erosion rate of 4.5 cubic yards per foot per year (cy/ft/yr) was adopted in the beach restoration plan for Sagaponack and 3.5 cy/ft/yr for Bridgehampton. This yielded a total erosion rate of ~120,000 cy/yr for the two BECDs.

Two reaches in each BECD were identified based on the sand deficit in the dune system, and different fill densities (ie – quantity of nourishment per foot of beach) were assigned to each reach. Figure 1.2 shows the project limits along with the locations of the reaches and the three offshore borrow areas.

*[NGVD—*National Geodetic Vertical Datum established in 1929 based on analysis of tide records. It is a fixed elevation which is independent of tidal variations along the coast. A new datum (NAVD), approximately 1.0 ft higher, was established in 1988 for recent use by surveyors (see Section 2.0).*]

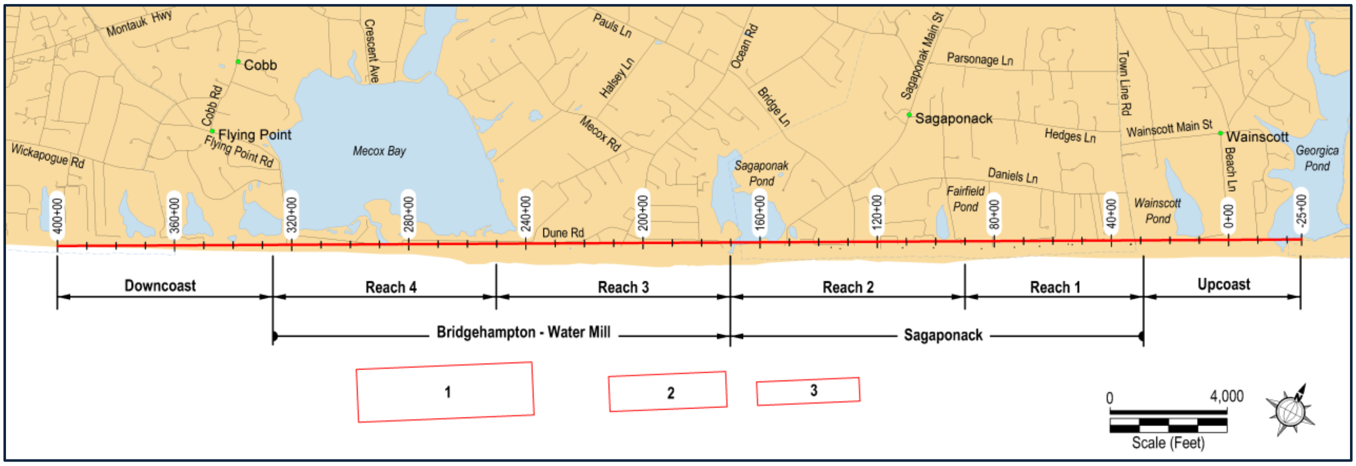


FIGURE 1.2. Project limits and monitoring ranges of the 1-mile upcoast (between stations -25+00 and 25+00) and 1.5-mile downcoast (between stations 330+00 and 400+00) along with offshore borrow areas.

The Town of Southampton with assistance by First Coastal Corporation (FCC) (Westhampton Beach NY) obtained permits from New York State Department of State (NYSDOS), New York State Department of Environmental Conservation (NYSDEC) (Permits 1-4736-07845/00001 & 1-4736-07846/00001 dated 5 March 2013) and US Army Corps of Engineers–New York District (NYACE) (Permits NAN-2012-01092 and NAN-2012-01095 dated 8 August 2013) for Sagaponack–Bridgehampton–Water Mill (respectively) prior to the commencement of construction. The Town also issued Town Trustee Permits (10555 and 10556 dated 17 June 2013) and Town Coastal Erosion Hazard Area Permits (dated 20 June 2013) for Sagaponack–Bridgehampton–Water Mill (respectively) to facilitate the nourishment.

CSE's survey in April 2013 confirmed there was a net loss of sand due to Hurricane *Sandy* (29 October 2012) and the 2013 winter storms in the probable range of 500,000–750,000 cy for the Sagaponack–Bridgehampton project area. Hurricane *Sandy* caused some of the worst dune recession in the past century along the south shore of Long Island, ranking with the Great Hurricane of 1938, the "Ash Wednesday" storm of March 1962, and the great nor'easters of 1991–1992. Figure 1.3 shows some post-storm escarpments and undermined foundations in the project area.

Following Hurricane *Sandy*, the Town requested a permit modification for increased volume which was approved by NYSDEC, NYSDOS, and USACE before project completion. Under the revised permits, the Town was authorized to place an additional 250,000 cy to the originally permitted 1,035,000 cy along the Sagaponack ECD, resulting in an amended total volume of 1,285,000 cy; and additional 247,000 cy to the originally permitted 1,095,500 cy along the Bridgehampton ECD, resulting in an amended total volume of 1,342,500 cy. These changes increased the total permitted volume to ~2.63 million cubic yards of sand from three designated offshore borrow areas (1, 2 and 3) with placement along ~5.63 miles of ocean shoreline.

FIGURE 1.3. Photos taken in the vicinity of 313 Dune Road, Bridgehampton (NY). Aerial image (upper) taken during nourishment construction showing the location of the property in the lower photos: After Superstorm *Sandy* in 2012 (lower left) and 3.5 years after nourishment in 2017 (lower right). [Photos by First Coastal Corporation, Westhampton (NY)]

The purpose of the project was to restore the recreational beach, maintain property values and the local tax base, and provide sufficient sand for ten years of erosion relief under normal circumstances within the boundaries of each BECD. The total project budget for construction, permitting, engineering, administration, and post-project monitoring was (~)$26 million with all funds generated by the BECDs and the Town of Southampton. No state or federal funds were involved. The Town of Southampton served as project owner and administrator.

Great Lakes Dredge & Dock Company (GLDD) submitted a bid below the project engineer's estimate which allowed an increase in the volume of sand by ~20 percent. Based on the Town's available construction budget, the final contracted volume of work was 2,542,938 cy at a bid cost not to exceed $21,943,036 (mobilization and construction). The net unit cost was (~)$8.63/cy. The construction work was completed in one phase under a single contract between the contractor (GLDD) and the Town of Southampton.

The suction cutterhead dredge, *Illinois* (one of the largest such dredges in the U.S.), performed all excavations using three borrow areas offshore of the receiving beach. Beach-quality sand was excavated within the upper 7 ft of substrate in water depths of 40–60 ft and pumped ~1 mile to shore for subsequent spreading by dozers. The nourishment sand was shaped and graded to contours matching the native beach. Pumping operations began on 15 October 2013 and were completed by 21 February 2014 with over 50 days of delays during which wave conditions precluded safe operations. Work was completed without serious incident or injury to contractor personnel despite weather and wave conditions that were stormier than normal for these months. A no-cost time extension of 41 days was granted by the owner (Town of Southampton) for project completion. The project was completed on budget.

Figure 1.4 shows the cumulative changes in volume along each BECD between August 2013 (~2 months pre-construction) and February 2014 (post-construction). Table 1.1 lists the comparison of actual fill volumes and design volumes for each reach. The results show ~29−35 percent of the placed sand settled within the recreational beach zone (foredune to low-tide wading depth at −5-ft), and the remainder was deposited between the −5-ft and −18-ft contours. [Note: These calculations were based on surveys using NGVD datum which is ~1 ft below NAVD datum; hence, −18 ft NGVD is approximately equal to –19 ft NAVD.]

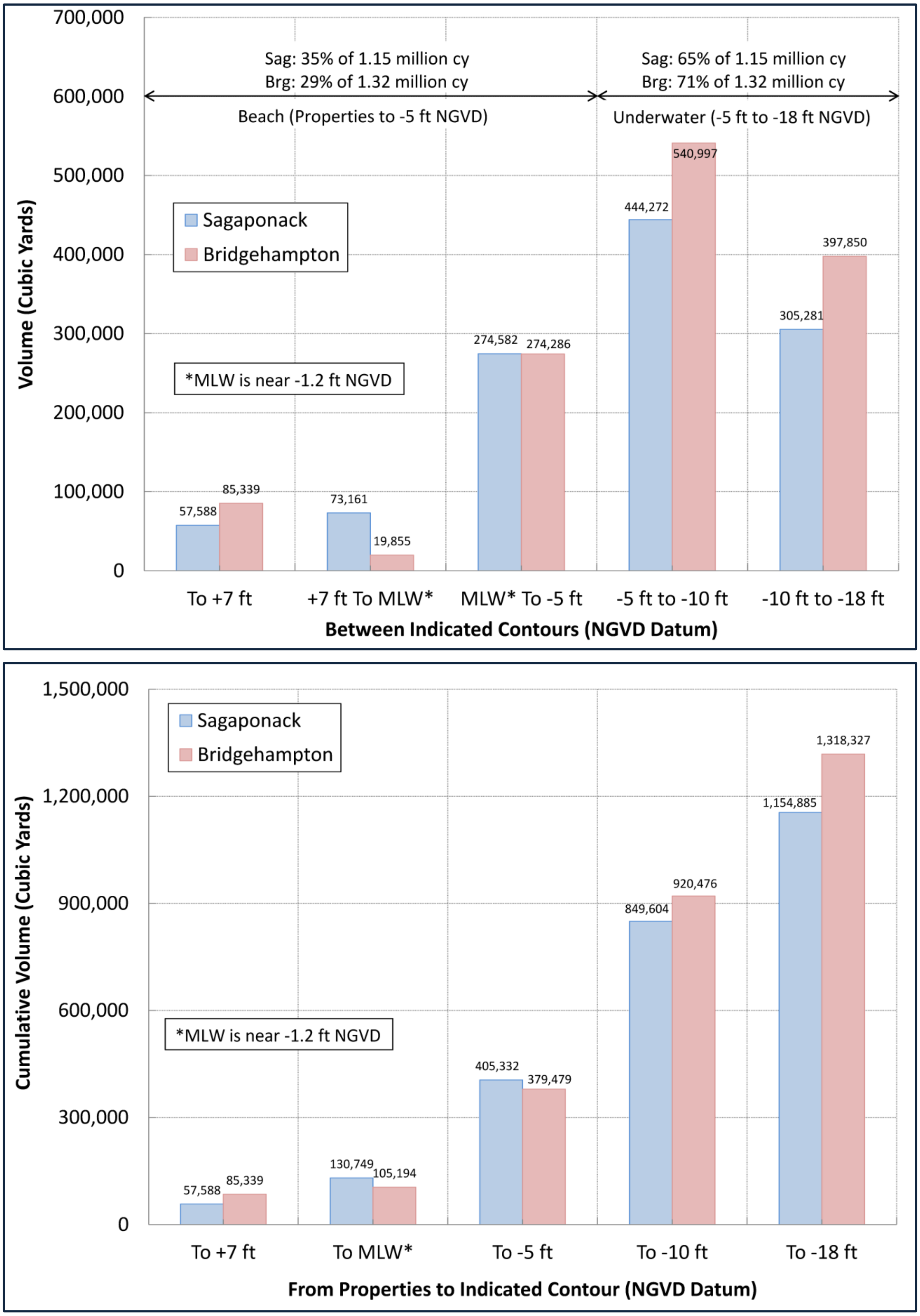


FIGURE 1.4. Beach volume changes between August 2013 and February 2014. **[UPPER]** Sand volume changes between representative contours. **[LOWER]** <u>Cumulative</u> volume changes between properties and the indicated contour. These results reflect the nourishment volumes added between October 2013 and February 2014 plus any natural changes that occurred between August 2013 and February 2014.

TABLE 1.1. Summary of fill volume versus design volume for each reach based on before- and after-dredging surveys on the beach by GLDD. GLDD volume calculations were based on the methodology specified in the project manual (CSE 2013a). CSE volume calculations were from properties to −18 ft NGVD.

ACTUAL FILLED VS DESIGNED QUANTITIES								
DISTRICT	REACH	LIMITS	LINEAR FEET (FT)	PERMIT ALLOWED (CY)	DESIGNED BASED ON BUDGET (CY)	GLDD REPORTED FILLED VOL (CY)	ACTUALVs. DESIGN (%)	CSE CONFIRMED VOL (CY)
SAGAPONACK	1	28+84 TO 90+00	6,116	600,000	579,982	538,448	93%	593,720
	2	90+00 TO 170+09	8,009	685,000	662,147	706,108	107%	561,165
	SUB TOTAL	28+84 TO 170+09	14,125	1,285,000	1,242,129	1,244,556	100%	1,154,885
BRIDGEHAMPTON	3	170+09 TO 250+00	7,991	707,000	685,044	636,547	93%	672,130
	4	250+00 TO 326+35	7,635	635,500	615,764	662,489	108%	646,196
	SUB TOTAL	170+09 TO 326+35	15,626	1,342,500	1,300,808	1,299,036	100%	1,318,327
TOTAL		**28+84 TO 326+35**	**29,751**	**2,627,500**	**2,542,938**	**2,543,592**	**100%**	**2,473,212**

The post-project construction survey indicated the upcoast 1 mile (Town Line Road to Georgica Pond) and the downcoast 1.5 miles along the Village of Southampton eroded along the visible beach between August 2013 and February 2014, but experienced net gains in volume between the low-tide wading depth and the −18-ft depth contour. [Figure 1.2 showed the relative locations of upcoast and downcoast survey areas.] The volume changes after nourishment are shown in Figure 1.5. The gains were small, suggesting only a minimal portion of the nourishment had been transported out of the project area by February 2014.

Prior to the project, a total of 14 beach fills (~2.9 million cubic yards) were placed at various points between Shinnecock Inlet and Montauk Point over an ~60-year period (sources: USACE unpublished records, Suffolk County Department of Public Works, Kana 1999). The present project is nearly as large as all previous nourishments combined east of Shinnecock Inlet. The Sagaponack–Bridgehampton–Water Mill project is also the first project east of Westhampton Dunes to utilize offshore borrow areas. Detailed aspects of project design, sand search, construction procedures, survey methodology, beach volume analysis, upcoast and downcoast changes, and maintenance recommendations, were included in earlier reports (CSE 2014a,b).

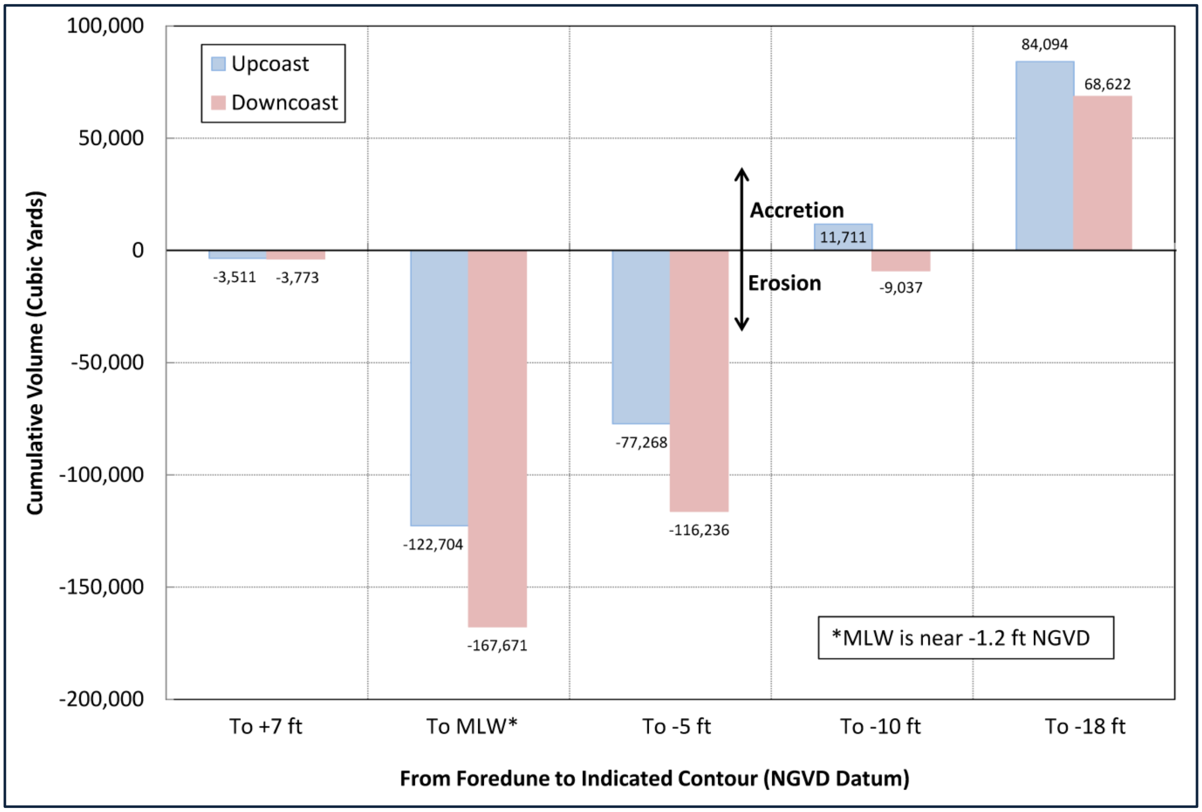


FIGURE 1.5. Cumulative beach volume changes to the indicated contours between August 2013 and February 2014 upcoast (east) and downcoast (west) of the project area. This graph indicates that, on average, the visible beach and inner breaker zone lost sand while the outer surf zone and area seaward of the longshore bar gained sand during the period—a common observation between summer and winter surveys.

— THIS PAGE INTENTIONALLY LEFT BLANK —

2.0 BEACH MONITORING METHODOLOGY AND SCOPE OF WORK

2.1 Purpose of Monitoring

Periodic post-project (physical) monitoring is a prerequisite for post-disaster restoration funds from the Federal Emergency Management Agency (FEMA) under Category G–Community Assistance Grants. If a major storm such as Hurricane *Sandy* (27 October 2012) impacts the project area and there is a presidential declaration of disaster, each BECD and the Town of Southampton may be eligible for funds to restore sand losses due to the storm. Such losses are computed for specified project boundaries (original alongshore length and cross-shore to the −18-ft NGVD or −19-ft NAVD depth contour) using annual monitoring surveys and post-storm surveys after the event.

Therefore, an annual survey is scheduled around June–July to obtain beach conditions and calculate beach volumes within project boundaries before the hurricane season of each year.

2.2 Data Collection Methodology

Hydrographic data collection methodology followed procedures set forth in the USACE Hydrographic Surveying Manual (EM 1110-2-1003; January 2002, updated April 2004). Data collection control was established with connection to the New York Continuously Operating Reference Stations (NYCORS). Geoid Model 12a (GEOID12a) and World Geodetic System of 1984 (WGS'84) were used for the geoid and ellipsoid. Data were collected in the horizontal datum of North American Datum of 1983 (NAD'83) and were measured in US survey feet using State Plane Coordinates in the zone NY-3104 for New York Long Island. The vertical datum was North American Vertical Datum of 1988 (NAVD'88) measured in feet.

Before 2015, data collected in NAVD'88 were converted to National Geodetic Vertical Datum of 1929 (NGVD'29) by an offset of 1.08 ft to meet New York State Department of Environmental Conservation (NYDEC)'s requirement. Since NYDEC has been in transition from using NGVD to NAVD datum, CSE elected to use NAVD datum as of 2015. The previous data sets obtained from the project have been converted from NGVD to NAVD using the 1.08-ft conversion. Key reference datums for a station on the ocean at Shinnecock Inlet (NY), located ~8 miles west of the project area, are shown in Figure 2.1.

CSE's survey was completed using an RTK-GPS (Trimble™ Model R10 GNSS) for data collection. The offshore work was performed using an Applanix™ POSMV inertial motion unit for positioning, which provides centimeter-level precision and corrects for heave, pitch, and roll in real time.

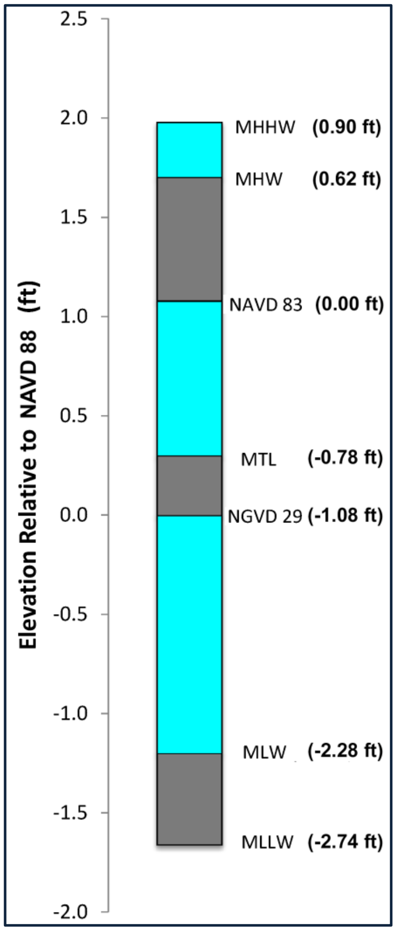


FIGURE 2.1. Key reference datums at Shinnecock Inlet (NY) ~8 miles west of the project area. [MTL = mean tide level]

[Source: NOAA-NOS]

The Applanix™ POSMV is linked to a Teledyne Odom™ CV100 echosounder, which provides soundings at 50 Hz and 0.1-ft precision. With the two systems linked by computer and data processing using Hypack™ 2016, there is no need for wave and tide corrections (which were a basic limitation of historical surveys). Measurements over subaerial portions of Southampton extended from the foredune to low-tide wading depth.

Offshore profiles were collected at 50 Hz (ie – 50 elevation readings per second) at high tide overlapping the wading-depth measurements and then filtered in the office to eliminate spikes and provide a floating-point average. Smoothed inshore data were edited to a manageable size and merged with subaerial data. Survey baseline and control USACE/CSE station coordinates and azimuths are listed in Appendix 1.

Ground photos were taken at representative monitoring stations and compared to pre- and post-project photos of the same areas. This offers a simple visual assessment of dry beach width, dune condition, vegetative growth, escarpments, and general condition of the beach through time. Photos were also taken of any areas or features of particular importance or interest observed during the monitoring event. If a declared storm impacts the project area, pre- and post-storm surveys confirm sand losses within the calculation boundaries, and the Town decides to apply for the post-disaster funds, the photos will provide a convenient visual record for illustrating beach conditions to FEMA officials and the community.

CSE maintains and operates a DJI Phantom 4 Pro (P4P) unmanned aerial system (UAS). A Federal Aviation Administration (FAA)-licensed UAS pilot oversees the safe operation of the UAS at all times as required by federal regulations. The P4P is equipped with a 20 megapixel, 1-inch CMOS image sensor, and a mechanical shutter. This payload results in a powerful camera that eliminates distortion when flying at high speeds and can be used for oblique aerial photography. It is also capable of capturing the greater detail needed for the advanced production of orthomosaics. It can map ~150 acres with a flight time of ~30 minutes on a single battery. Use of multiple batteries allows coverage of larger areas on multiple flights. Photos taken by the device can be processed using Pix4D software to create point clouds, orthomosaics, and digital surface models (DSM).

CSE utilized the P4P system to take oblique aerial photos in the July 2017 survey. These photos provide unique perspectives of the littoral zone up to an above-ground level of 400 ft (FAA ceiling for UAS).

CSE plans to collect an aerial orthophoto of the project area in June–July 2018 (ie – Year 5 after project completion) using the P4P system. Orthophotography provides a spatially rectified image representing the earth's surface in the area of coverage. It can be imported and utilized in the creation of a Geographic Information System (GIS) map and defined coordinate system. The most recent orthophotography for Sagaponack and Bridgehampton–Water Mill BECDs was obtained on 18 April 2013 before construction. An updated aerial orthophoto of the project area was originally scheduled to be taken around the third year (ie – 2016) after project completion. CSE elected to postpone it for two years because the project is performing better than expected. This will allow the new dune vegetation to become established and be more visible on the images.

— *THIS PAGE INTENTIONALLY LEFT BLANK* —

3.0 BEACH AND INSHORE SURVEYS AND PROFILE COMPARISONS

CSE collected beach and inshore profile data following the protocols stated in Section 2. After the data were collected, CSE performed QA/QC on all data by a combination of procedures including measurement of speed of sound, sounding-bar checks, direct soundings in deep water, real-time overlays with historical data using Hypack™ software and cross-check lines for statistical analysis of survey accuracy.

Field data were entered into CSE's beach profile analysis system (BPAS) and combined with historic profile data. Each profile was checked for proper juxtaposition, and datum correction from NGVD to NAVD was conducted with previous profile data (prior to 2015). Consistent with previous reports (CSE 2014a,b & 2015), the pre-nourishment survey in August 2013 was used as the baseline condition to calculate volume changes. Overall volume changes were computed by extrapolating unit volume changes over representative shore lengths.

3.1 Beach Volume Analysis Method

The basic approach for beach monitoring is to track the beach zone within the project area as a sand box filled nearly to the top along one edge (the dune line) and tapering to a thin layer along the opposite edge (ie – in deep water). The total volume in the sand box is measured before nourishment then compared with a survey after nourishment. The differences between the volumes provide a measure of sand losses (erosion) or gains (accretion) over time. This section describes the methodology used by CSE for objective data collection and analyses.

Profile volumes are a convenient way to determine the condition of the beach and compare one area with another. They convert a two-dimensional measure of the beach to a "unit volume" measure. Unit volume, given in cubic yards per linear foot, is a measure of the amount of sand contained in a 1-ft (unit) length of beach. This unit-volume concept is illustrated in Figure 3.1. Specific volumes reflect a quantity in a wedge of sand extending from the dune line or seawall to a particular depth offshore.

Unit volumes for each survey date and unit-volume changes between selected dates were calculated to determine the quantity of sand in 1 linear foot of beach at each station. These unit volumes were used to calculate the station-to-station net volumes, the net volumes of reaches, and finally the net volume for the entire project.

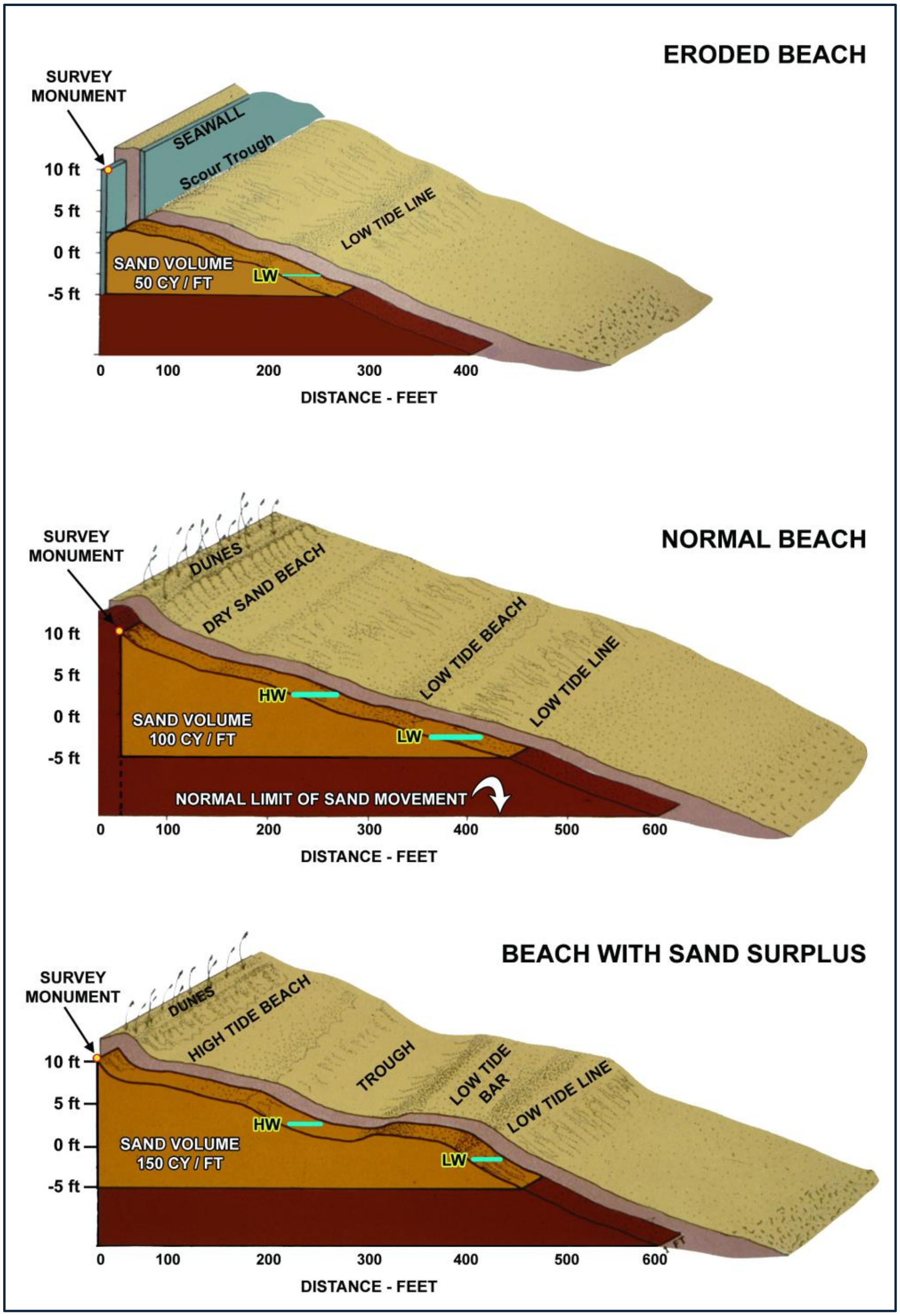


FIGURE 3.1. The concept of unit-width profile volumes for a series of beach profiles showing an eroded beach with a deficit, a normal beach, and a beach with a volume surplus. [After Kana 1990]

Changes in unit volume (or beach width, etc) can be determined by overlaying sequential profiles and computing the differences in cross-sectional area. The change in cross-section (in two dimensions) is extrapolated between adjacent profiles to yield net volume change (in cubic yards) in that section. Using standard statistical techniques (average-end area method), the overall (net) change is computed by summing the changes from profile to profile for subreaches and for total project reach.

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 3.1 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 much lower than the normal beach. Beaches near inlets, by comparison, often incorporate wide low-tide bars resulting in a surplus of sand relative to beaches away from inlets. 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.

Volume changes for the Sagaponack and Bridgehampton "sand box" were estimated using standard methods (average-end-area method) and common cross-shore boundaries and contour datums. Five (5) lenses (ie – volumes between particular reference contours) were used in the planning and designing phases for purposes of evaluating levels of dune protection, dry beach and construction berm adjustments, wet beach condition, inshore surf zone, and the outer surf zone (CSE 2014a,b). Year 1 monitoring report used the same five lenses to be consistent with the previous results (CSE 2015). These five lenses are described as follows.

Lens 1) Volume Above +6 ft NAVD — The 2013–2014 nourishment construction berm was designed at (~)+7 ft NGVD, which is equivalent to (~)+6 ft NAVD. The volume above the +6 ft NAVD elevation is a measure of the sand quantities shifted toward the dunes and upper beach, and therefore a measure of storm and flood protection levels associated with the project or gains in dune volume due to post-project buildup above the contour.

Lens 2) Recreational Beach (+6 ft NAVD to MLW) — This lens includes the dry-sand and wet-sand beach ("berm") from the construction berm elevation to around MLW (−2.3 ft NAVD). This is the primary recreational portion of beach.

Lens 3) Inner Surf Zone (MLW to −6 ft NAVD) — This lens includes the portion of the surf zone where most wave-breaking occurs between MLW and low-tide wading depth at −5 ft NGVD.

Lens 4) Outer Breaker Zone (−6 ft to −11 ft NAVD) — This lens generally encompasses the outer breaker zone and the top of the outer bar, which is a more or less permanent feature of the Long Island south shore in deeper water.

Lens 5) Outer Surf Zone (−11 ft to −19 ft NAVD) — This lens represents the "lower foreshore" extending seaward of the bar to the normal yearly limit of bottom change along Sagaponack–Bridgehampton–Water Mill beach. It is the area beyond which there is relatively little change in the bottom. The outer depth is also consistent with the standard FEMA reference depth for post-storm restoration funds. It includes the "longshore bar," which is a common feature of Long Island profiles and the trough between the bar and the beach.

When sufficient data from multiple survey dates become available, it will be possible to define a site-specific seaward limit of sand movement [ie – *closure depth* where successive profiles tend to converge (or close) over time], suggesting measurable changes in bottom elevation are not occurring beyond that point. RPI (1982, 1985) and Kana (1995) assumed closure depths of ~24–27 ft for the south shore of Long Island using limited data spanning a 24-year period (1955–1979).

Note: To simplify interpretation, after Year 2 (2015), fewer lenses are being used to capture the beach condition without distracting readers by too many details. Their definition and relation to the previous lenses are listed below, and the three simplified lenses are illustrated in Figure 3.2.

- **Lens 1 (Foredune) — Previous Lens 1 representing volumes from properties to the nourishment berm at +6 ft NAVD;**
- **Lens 2 (Beach) — Previous Lens 2 and Lens 3 encompassing the active beach to low-tide wading depth (from +6 to −6 ft NAVD); and**
- **Lens 3 (Underwater) — Previous Lens 4 and Lens 5 representing the surf zone extended to the FEMA reference depth (from −6 ft to −19 ft NAVD).**

In addition to these principal lenses for performance review, CSE will selectively analyze changes into deeper water if there is evidence of sand exchange between the offshore zone and project boundaries.

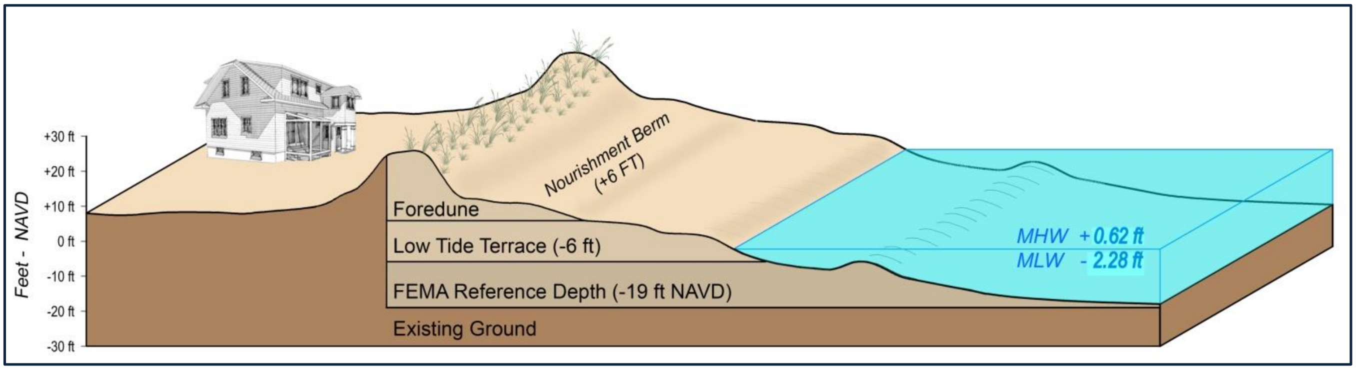


FIGURE 3.2. The beach zone used for calculating sand quantities along Sagaponack and Bridgehampton–Water Mill. The zone of interest extends from the foredune to a specified offshore depth (FEMA reference at −19 feet NAVD), in effect, a large sand box over which waves shape the beach and shift sand around.

Unit volumes for Sagaponack and Bridgehampton profiles were calculated to determine the quantity of sand in one linear foot of beach at each lens at each survey line. These unit volumes were then used to calculate the profile-to-profile net volumes, the reach net volumes, and finally the net volume for the entire project. The profile-to-profile net volumes are proportional to the distance between survey lines and represent the alongshore distribution of sand volume in the project area.

The basic assumption with the methodology is that sand volumes vary regularly in a linear manner from profile to profile. This assumption is generally valid along straight shorelines away from inlets (USACE 2008). The 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 (a common occurrence with older survey data).

Conveniently, the profile stations for Sagaponack and Bridgehampton are evenly spaced at 500 ft. If they are not evenly spaced, the station-to-station net volumes should be proportional to the distance between stations in order to represent the actual alongshore distribution of sand volume. Beach profiles at CSE survey stations are plotted in Appendix 2, and unit volumes and total volumes of the three lenses at each survey line are given in Appendix 3 for comparisons with the pre-project survey (ie – August 2013). Unit volumes of the three lenses and cumulative lenses are discussed in detail in this section, and total volumes will be discussed in Section 4.

3.2 Unit Volume Results

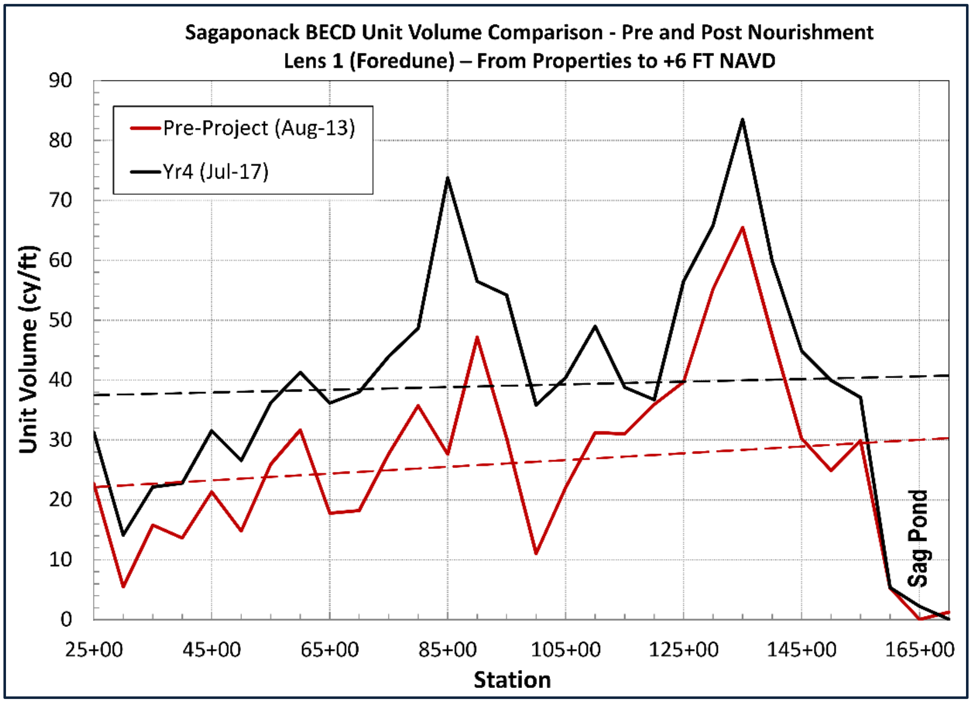
3.2.1 Lens 1 — Foredune (from Properties to +6 ft NAVD)

Lens 1 represents the volume in the backshore and dune area. The nourishment berm elevation was set to +6 ft NAVD in the 2013–2014 project (ie – little nourishment sand was initially placed above the +6-ft contour in this lens). CSE expected the higher dry beach (formed by storm overwash and a landward shift of some sand after nourishment) would remain dry most of the time and would serve as a feeder for dune growth. Unit volumes of Lens 1 from properties* to +6 ft NAVD **by station** along Sagaponack and Bridgehampton are shown in Figure 3.3. For graphic clarity, only unit volumes for July 2017 (black lines in the graphic) are plotted against the pre-construction condition (red line in the graphic).

*[*Landward limit of this lens was originally determined at the properties at the time of project planning and design (CSE 2012a,b). It remains the same for most stations unless there are significant changes landward of a station (eg: structure or fencing) that prevent data collection. If the landward limit of a station is changed, volumes at this station will be re-calculated for all survey dates so volume comparisons will be based on the same portion of beach. Beginning from 2015, all vertical data are corrected to NAVD datum.*]

Before nourishment, west Sagaponack had higher unit volumes than east Sagaponack (red dashed line shows the linear upward trend in the upper graph of Figure 3.3), indicating the overall dune condition of the west was healthier than the east and had more storm protection than the east. The westernmost stations between 160+00 and 170+00 had zero volume above the +6-ft contour because of the existence of Sagaponack Pond where the beach is generally lower. The 2013–2014 nourishment project did not place sand above +6 ft NAVD, but July 2017 survey results showed there was more sand in this lens than pre-project, indicating natural sand accumulation at higher elevations. Black dashed lines representing the linear trend of July 2017 survey show an obvious increase along the project area. As of July 2017, the average unit volume was ~13.2 cy/ft more than the pre-project condition (August 2013), equivalent to an increase of ~3.3 cy/ft/yr.

Average unit volumes at Bridgehampton–Water Mill above the +6-ft contour are fairly uniform from east to west despite large variations from station to station. Stations near Mecox Bay (ie – stations 285+00 and 290+00) contained near-zero volume. The increase of volumes after nourishment is similar to Sagaponack as shown in the dashed, trend-lines comparison in Figure 3.3 (lower), representing an average of ~12.0 cy/ft gain between August 2013 and July 2017, equivalent to an increase of ~3.0 cy/ft/yr. Results for Lens 1 are important because they confirm the foredune along the project area has grown upward and outward by natural processes since nourishment. This has provided increased protection to property within each BECD.



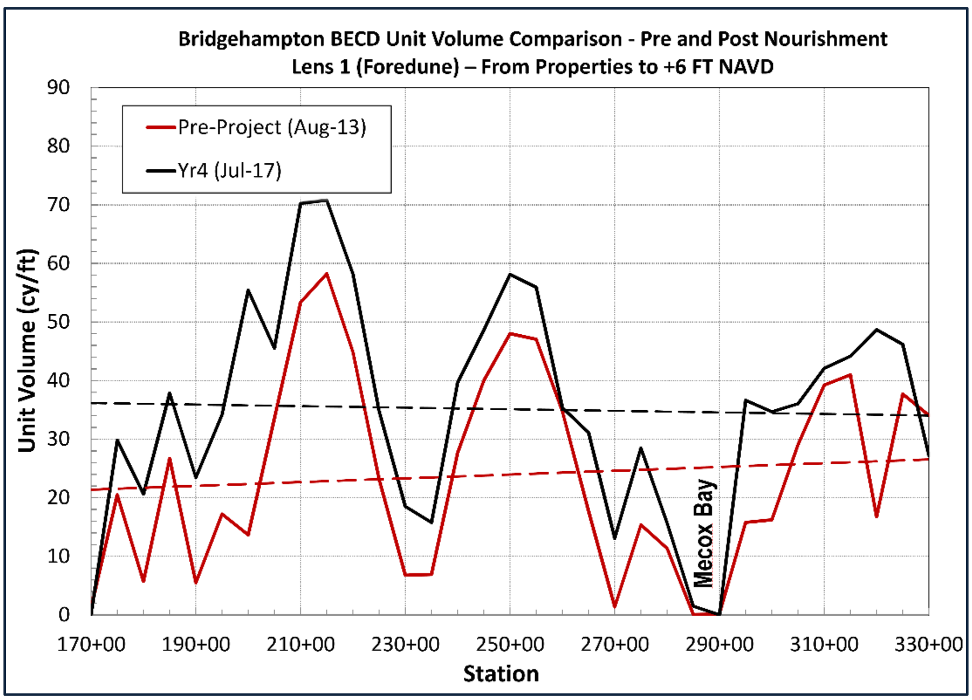
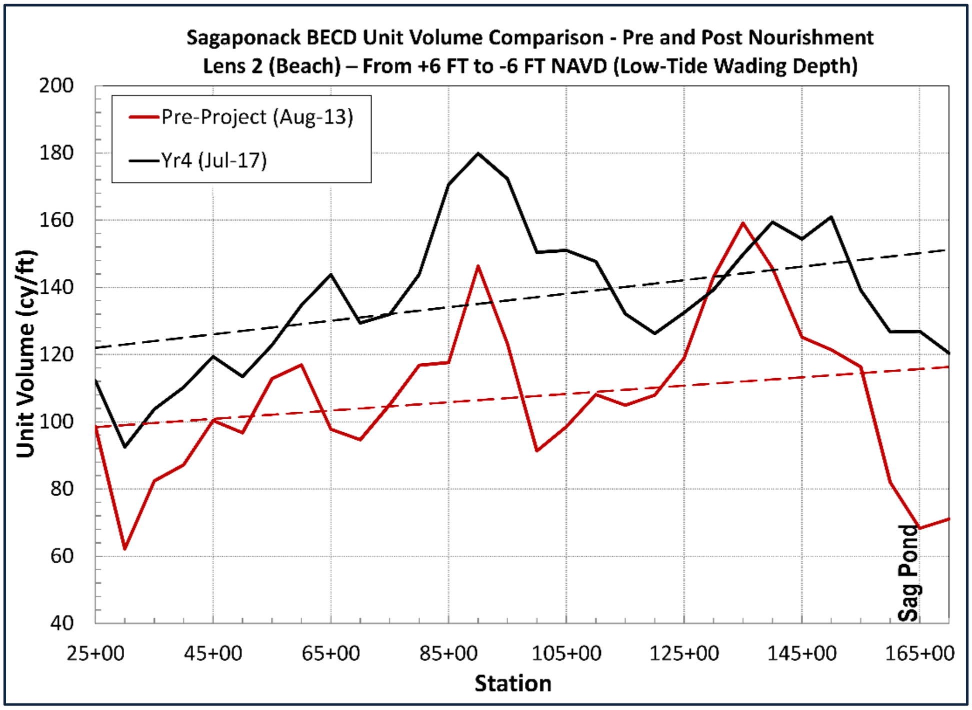


FIGURE 3.3. Comparison of unit volumes along Sagaponack and Bridgehampton–Water Mill from properties to +6 ft NAVD before nourishment (August 2013) and Year 4 survey conditions (July 2017). Dashed lines represent the trend of the lines of the corresponding colors. Unit volumes increased after the project at most stations, indicating the natural sand accumulation in this lens after nourishment.

3.2.2 Lens 2 — Beach (from +6 ft to −6 ft NAVD)

This lens represents the active portion of beach to low-tide wading depth. The majority of wave-breaking, uprush and backrush, and energy dissipation occurs over this zone. Unit volumes of this lens by station along Sagaponack and Bridgehampton–Water Mill are shown in Figure 3.4. It was confirmed by the February 2014 survey that ~30 percent of nourishment sand was initially placed in this lens, equivalent to an average of ~19 cy/ft of gain compared to the August 2013 condition (CSE 2014b). The July 2017 survey showed all stations retained nourishment sand, and unit volumes were higher than the pre-project condition (August 2013). As of July 2017, there were ~13 cy/ft and ~18.5 cy/ft more sand in Sagaponack and Bridgehampton–Water Mill (respectively) than the pre-project condition along the active beach. The higher volume in this lens equates to a wider dry beach for people to use.



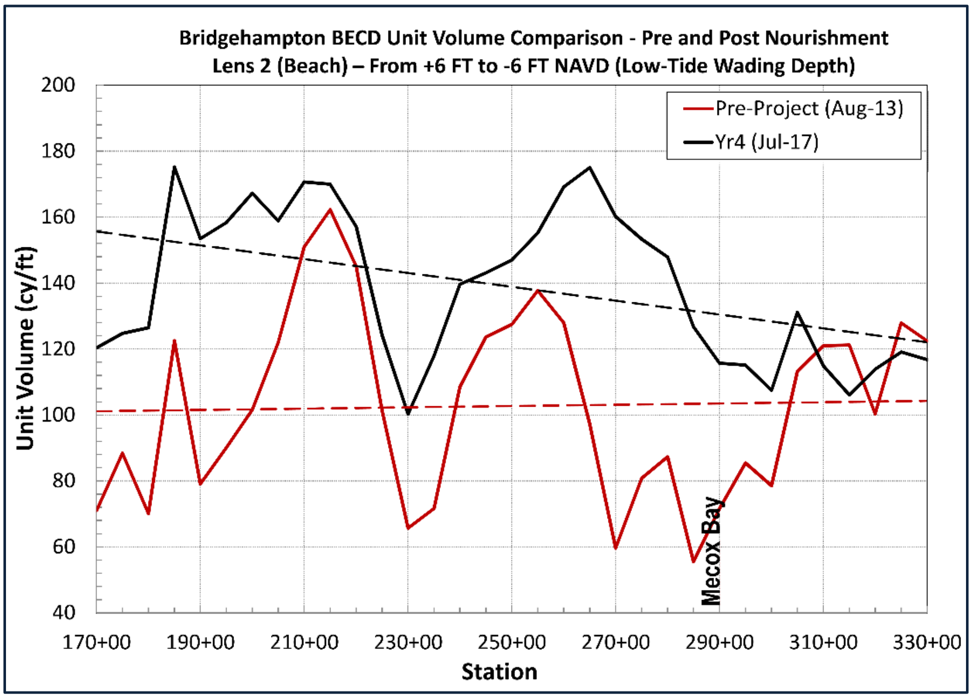
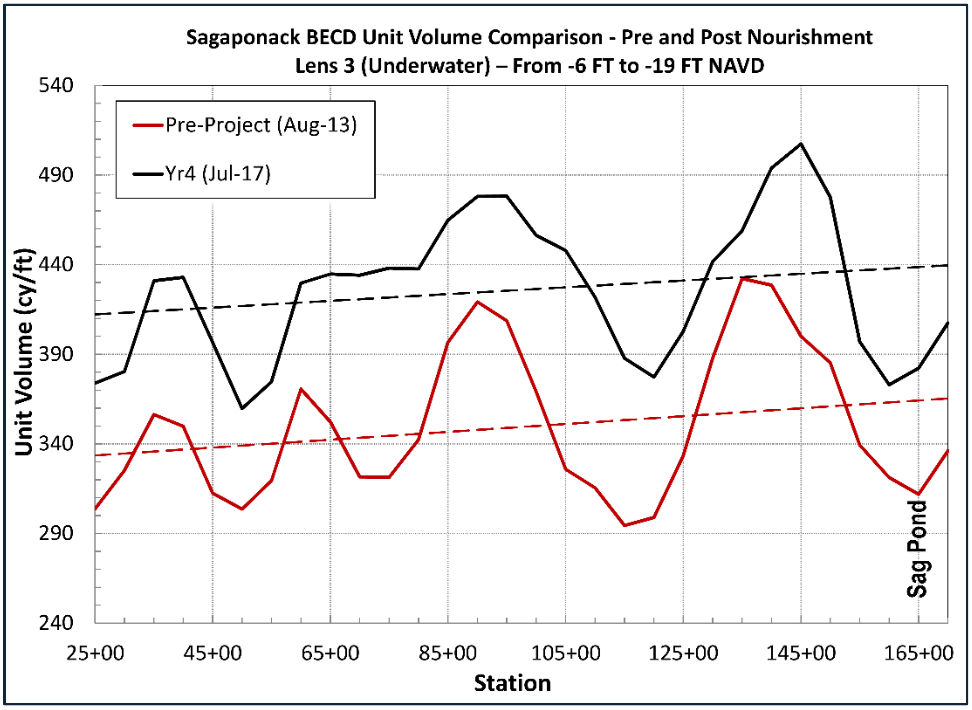


FIGURE 3.4. Comparison of unit volumes along Sagaponack and Bridgehampton–Water Mill from +6 ft to −6 ft NAVD before nourishment (August 2013) and Year 4 survey conditions (July 2017). Dashed lines represent the trend of the lines of the corresponding colors.

3.2.3 Lens 3 — Underwater (From −6 ft to −19 ft NAVD)

Lens 3 represents the underwater portion of the beach extending seaward of the bar to the depth of closure, or normal seaward limit of bottom change at this setting (Rosati et al 1999). 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. Following nourishment construction, CSE confirmed in February 2014 that 65 percent of the nourishment volume was placed in this lens for Sagaponack and 71 percent for Bridgehampton–Water Mill. The July 2017 survey showed that all stations had higher volumes than the pre-project conditon (Fig 3.5). On average, there were ~77 cy/ft more sand in Sagaponack and ~73 cy/ft more sand in Bridgehampton–Water Mill than the pre-project condition in the underwater part of the beach. The total volume remaining in the underwater lenses will be discussed in the next section.



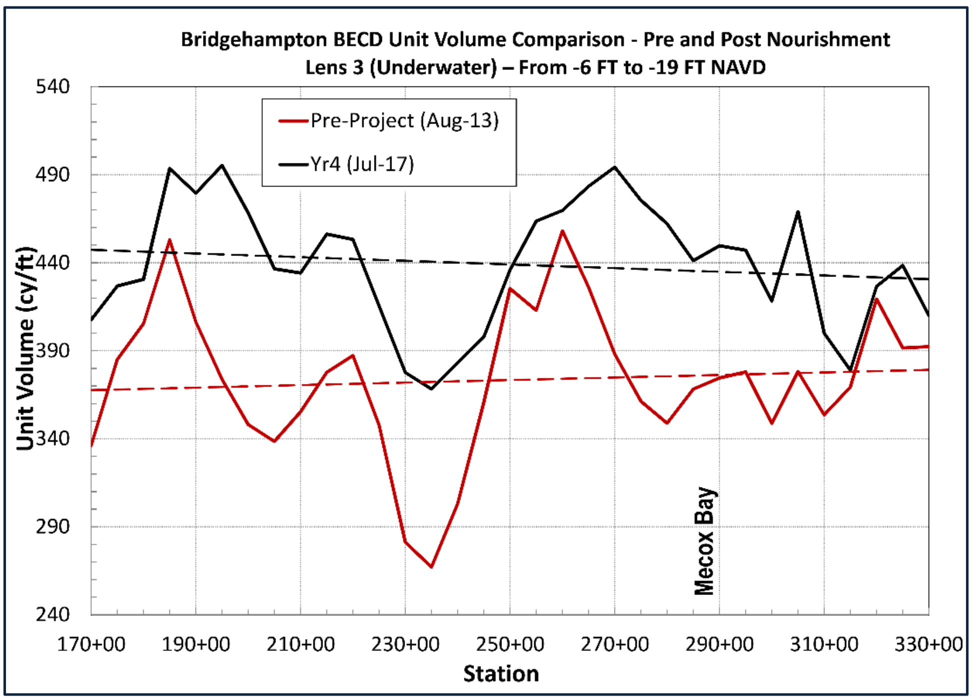


FIGURE 3.5. Comparison of unit volumes along Sagaponack and Bridgehampton–Water Mill from −6 ft to −19 ft NAVD before nourishment (August 2013) and Year 4 survey conditions (July 2017). Dashed lines represent the trend of the lines of the corresponding colors.

3.2.4 Lenses 1–3 — Cumulative Unit Volumes of All Lenses (from Properties to −19 ft NAVD)

Figure 3.6 shows the cumulated unit volumes along the beach from Lens 1 to Lens 3 (ie – from properties to −19 ft NAVD — FEMA reference depth). The overall increase in unit volume is obvious by comparing the two dashed lines in the graphic. The designed average fill density was ~88 cy/ft for Sagaponack and ~83 cy/ft for Bridgehampton. CSE's survey in February 2014 confirmed an average of ~82 cy/ft were gained along the Sagaponack beach during the nourishment project, and ~84 cy/ft were gained for Bridgehampton. As of July 2017, an average of ~103 cy/ft and ~99 cy/ft of sand remained along Sagaponack and Bridgehampton (respectively), indicating both BECDs retained the full amount of nourishment sand plus extra during Year 4 since project completion.

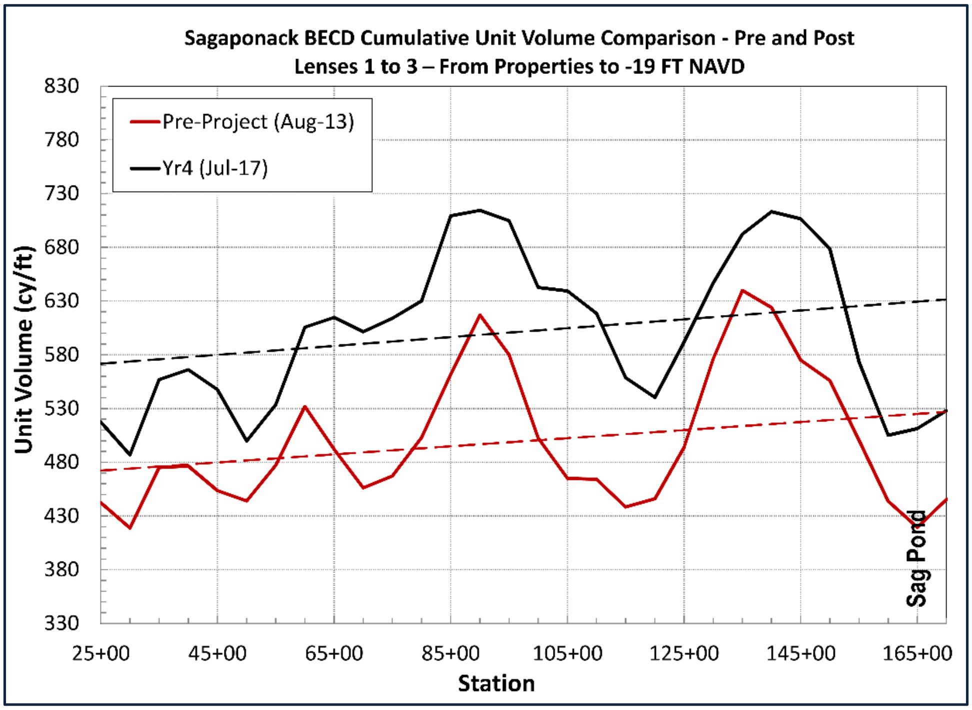
3.2.5 Variations in Unit Volumes

The volume results (eg – Fig 3.6) show systematic variations in sand quantity from station to station before and after nourishment with some localities appearing to contain much more sand than adjacent areas (eg: stations 35+00, 65+00, 85+00 to 95+00, and 135+00 in Sagaponack; and stations 185+00, 200+00, 215+00, 265+00, 300+00, and 325+00 in Bridgehampton–Water Mill). The spacing of these high points is typically ~3,000 to 4,000 ft.

Differences such as this reflect rhythmic variations in the outer bar. While the dune vegetation line often appears straight along the south shore east of Shinnecock Inlet, the visible beach will vary in width, often exhibiting waves of buildup alternating with narrow beach areas. These rhythmic features are often spaced every half-mile or so (Hayes 1972, Thevenot & Kraus 1995) and tend to mirror topography in the nearshore zone.

The longshore bar will contain periodic breaks which serve as underwater channels for return flows. These areas will be deeper and therefore contain less sand in the profile. Where the bar builds up the most (between breaks in the bar), volumes will be greatest. The shape and position of the offshore bar changes over time, shifting high zones and bar breaks down the coast. The visible beach responds with "sand waves" propagating slowly to the west in the project area.

As more surveys are obtained, CSE expects to see shifts of these high and low volume locations as sand propagates to the west. What is most important at this early stage of project evolution is the total quantity of sand retained within the project limits. This is discussed in the next section.



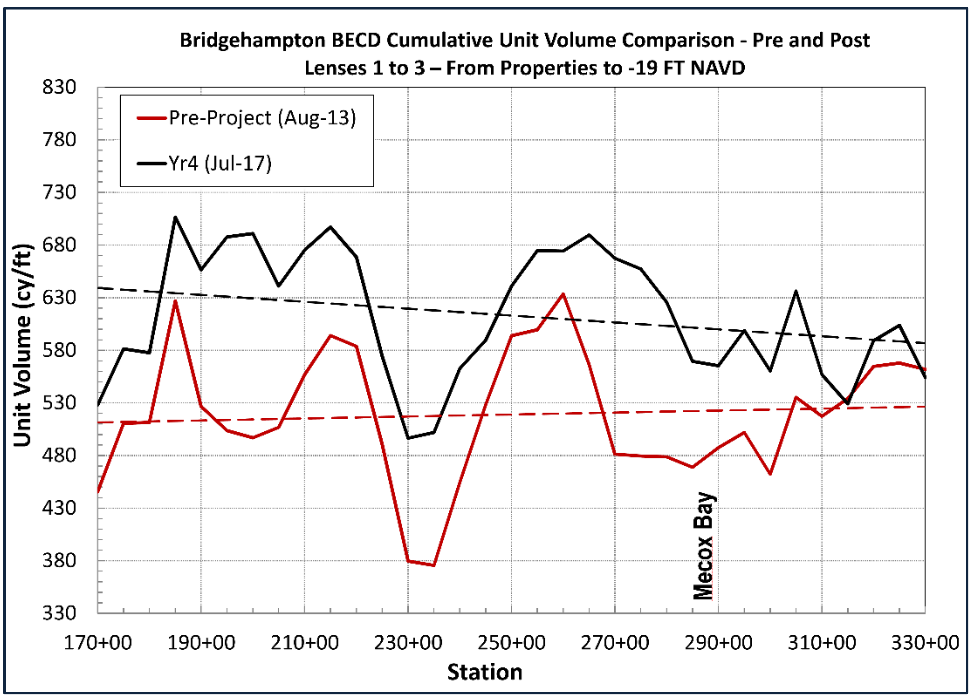


FIGURE 3.6. Comparison of cumulative unit volumes between properties and −19 ft NAVD.

— THIS PAGE INTENTIONALLY LEFT BLANK —

4.0 TOTAL VOLUME CHANGES AND VOLUME REMAINING

The total beach volume was estimated by applying the unit volume calculated at each measured profile over an applicable shoreline distance. The method (known as the average-end-area method) uses the average unit volume of two adjacent profiles multiplied by the distance between the profile stations to estimate the volume of sand between the two profiles. The total volume of sand in the project area is simply the sum of the individual section volumes measured to common vertical datums.

Since Sagaponack and Bridgehampton stations are evenly spaced, the trends in total volume along the project site are similar to results using unit volumes. The same three lenses were used to estimate the total volume, and detailed numbers for each station are listed in Appendix 3.

During the 2013–2014 Sagaponack and Bridgehampton–Water Mill beach nourishment project, the contractor (GLDD) reported 2,543,592 cy of sand were placed along the ~5.63-mile project area based on their before- and after-dredging surveys on the beach. *[The comparison of contractor's reported volumes and CSE's confirmed volumes (based on the post-project survey in February 2014) along with design volume for each reach were listed in Table 1.1 in Section 1 of this report.]* The in-place volume (ie – pay volume to the contractor) represented ~100 percent of the design volume with negligible discrepancy of 655 cy. To facilitate comparisons, the design volume(s) (ie – 1,242,129 cy for Sagaponack and 1,300,808 cy for Bridgehampton) will be used as the "target" in the analysis of nourishment volume remaining in this monitoring report and similar reports thereafter.

CSE conducted a survey in July 2017 (the fourth year after the project) before the 2017 hurricane season. The volume changes relative to August 2013 (before the project) are plotted in Figures 4.1 and 4.2. Results for each BECD are presented in a similar format and discussed separately.

4.1 Sagaponack

Figure 4.1 provides volume changes between reference contours relative to August 2013 (ie – results for individual calculation lenses). Following discussion of each lens, the results are summed to provide measures of the <u>cumulative</u> volumes contained between the foredune and various offshore contours.

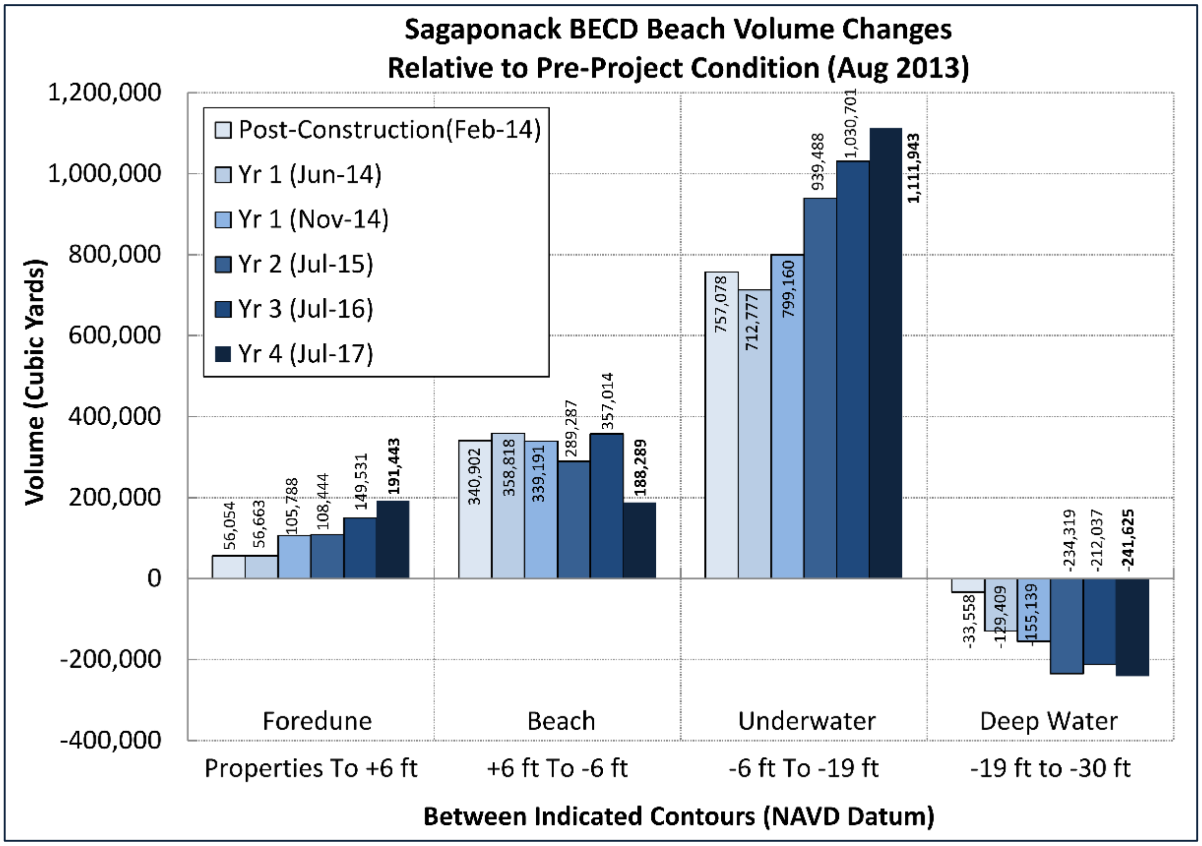


FIGURE 4.1. **Sagaponack** beach volume changes between indicated contours relative to August 2013 survey results.

4.1.1 Foredune

The first set of bars represent net volume changes along the upper beach and foredune between properties and +6 ft NAVD (nourishment berm elevation). Little sand volume was placed along this portion of beach during construction, but a significant amount of sand has accumulated there since project completion. The July 2017 survey results show ~191,500 cy more sand in the foredune area than the condition before nourishment (August 2013). This gain is equivalent to 13.6 cy/ft of shoreline or ~4 cy/ft/yr. The wide dry beach constructed by nourishment provided a new sand source for aeolian transport (ie – wind-generated sand transport) and made natural dune growth possible. In addition, the dune protection measures conducted by individual homeowners (such as installing sand fencing and planting vegetation) have concentrated sand along the back beach and enhanced the foredune.

4.1.2 Beach

The second set of bars in Figure 4.1 represent the total volume changes in the beach between +6 ft (dry-sand beach) and the low-tide wading depth (−6 ft NAVD). The July 2017 survey shows that the sand volume in this portion of the beach remained relatively stable until this past year when ~168,700 cy of sand moved out of this portion of beach.

4.1.3 Underwater

The last two sets of bars in Figure 4.1 show sand volume changes in the underwater zone. One group of bars illustrates the volume in the outer bar between the normal surf zone (−6 ft NAVD) and −19 ft NAVD. The latter depth corresponds to the "FEMA" depth for purposes of calculating volumes lost during major storms and applying for emergency restoration funds. Under normal yearly conditions, nearly all sand movement alongshore or between the visible beach and underwater zone occurs landward of −19 ft. As the third set of bars in Figure 4.1 shows, there have been significant increases of sand volume in this zone since project completion. As of July 2017, there is ~355,000 cy more sand between −6 ft and −19 ft than post-nourishment condition of Feb 2014. The second set of underwater bars show the volume changes between the −19 ft and −30 ft depth contours. This deepwater area has lost ~241,600 cy since nourishment. The loss on the beach and in deep water balances the gain in the upper beach and the −6 ft to −19 ft zones.

4.1.4 Cumulative Volumes

Figure 4.2 shows the cumulative volumes remaining along the project area relative to August 2013. The first set of bars in Figure 4.2 are the same as Figure 4.1. Starting from the second set of bars, volumes in Figure 4.2 represent the cumulative results from properties to the indicated contours. The second set of bars is the summation of the first two sets of bars in Figure 4.1; the third set of bars in Figure 4.2 is the summation of the first three sets of bars in Figure 4.1; and the fourth set of bars total all volumes to a depth of −30 ft NAVD relative to the pre–project condition (August 2013) (ie – cumulation of the four sets of bars in Figure 4.1).

Relative to the FEMA contour (−19 ft), the volume remaining in July 2017 represents 120 percent of the total nourishment volume. In other words, Sagaponack has gained ~337,600 cy (~24 cy/ft) more sand due to natural sand movement since project completion (February 2014). Figure 4.2 shows that the cumulative volume to −30 ft is almost the same as the volume placed in the nourishment project, indicating that the volume changes over the past four years have occurred within the −30 ft depth limit.

Overall, the 1,491,675 cy of sand remaining within the project boundaries out to the FEMA reference depth in July 2017 is equal to ~***<u>120 percent</u>*** of the nourishment volume placed along Sagaponack beach.

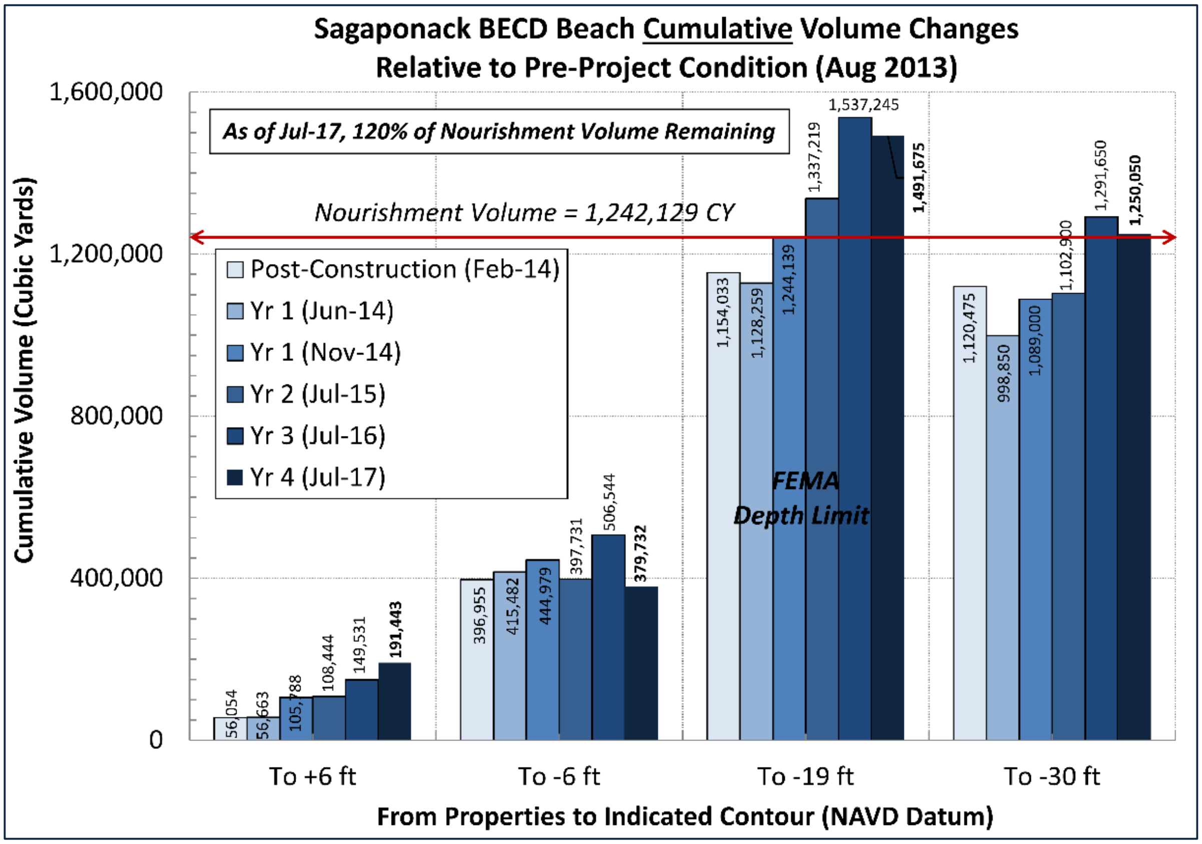


FIGURE 4.2. **Sagaponack** beach cumulative volume changes between properties and indicated contours relative to August 2013 survey results.

4.2 Bridgehampton–Water Mill

Similar to graphs for Sagaponack, Figures 4.3 and 4.4 provide volume changes along the Bridgehampton project area between reference contours relative to August 2013.

4.2.1 Foredune

The first set of bars in Figure 4.3 represent net volume changes along the upper beach and foredune between properties and +6 ft NAVD (nourishment berm elevation). Little sand volume was placed in this portion of beach during construction, but a significant amout of sand has accumulated there since project completion. The July 2017 survey results show ~185,900 cy more sand in the foredune area than the condition before nourishment (August 2013). This gain is equivalent to 11.9 cy/ft of shoreline or ~3.5 cy/ft/yr. The wide dry beach constructed by nourishment provided a new sand source for aeolian transport (ie – wind-generated sand transport) and made natural dune growth possible. In addition, the dune protection measures conducted by individual homeowners (such as installing sand fencing and planting vegetation) have concentrated sand along the back beach and enhanced the foredune.

4.2.2 Beach

The second set of bars in Figure 4.3 represent the total volume changes in the recreational beach zone between +6 ft and the low-tide wading depth (−6 ft NAVD). There has been some sand loss (~120,400 cy) over the past year, but the July 2017 survey shows that there is the same amount of sand in this portion of beach as the volume right after project completion (February 2014). This is reflected in a wide and healthy summer beach in Bridgehampton at the time of CSE's survey.

4.2.3 Underwater

The last two sets of bars in Figure 4.3 show sand volume changes for two underwater zones – inshore including the outer bar and "deep water" between the −19 ft and −30 ft NAVD depth contours. The inshore zone to −19 ft corresponds to the "FEMA" reference depth for purposes of calculating project losses due to major storms. As Graph C shows, there are about 114,500 cy more sand in the inshore zone (July 2017) relative to conditions immediately after nourishment (February 2014). The extra sand has been derived from deeper water as illustrated by the fourth set of bars in Figure 4.3. The deepwater zone seaward of the bar has ~220,700 cy less sand volume compared with the pre- or post-nourishment conditions.

4.2.4 Cumulative Volumes

Similar to Figure 4.2, Figure 4.4 shows the cumulative volumes remaining along the Bridgehampton project area relative to August 2013. The first set of bars in Figure 4.4 are the same as Figure 4.3. Starting from the second set of bars, volumes in Figure 4.4 represent the cumulative results from properties to the indicated contours. The second set of bars are the summation of the first two sets of bars in Figure 4.3; the third set of bars in Figure 4.4 are the summation of the first three sets of bars in Figure 4.3; and the fourth set of bars total all volumes to a depth of −30 ft NAVD relative to the pre–project condition (August 2013).

July 2017 results show that the volume between the properties and −19 ft (FEMA reference depth) represents 118 percent of the total nourishment volume. In other words, Bridgehampton has gained over 215,850 cy (~13.8 cy/ft) of sand due to natural sand movement since project completion. When the results are compared out to the −30 ft contour, the volume off Bridgehampton virtually matches the initial nourishment volume (~1.3 million cubic yards).

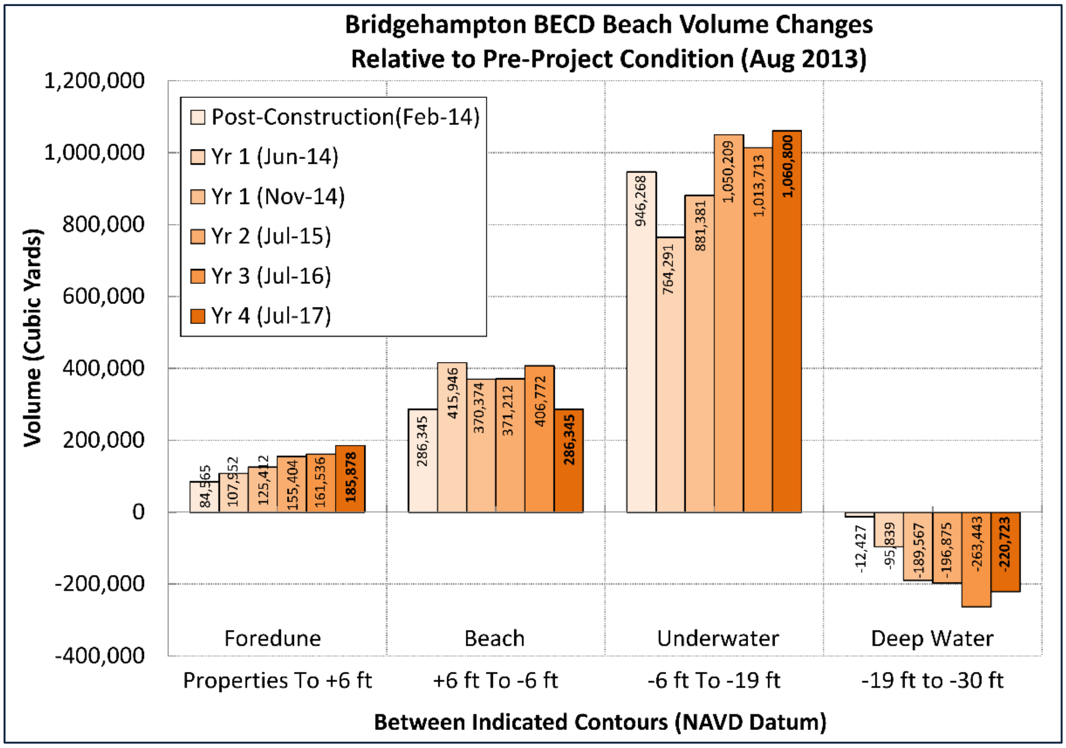


FIGURE 4.3. **Bridgehampton** beach volume changes between indicated contours relative to August 2013 survey results.

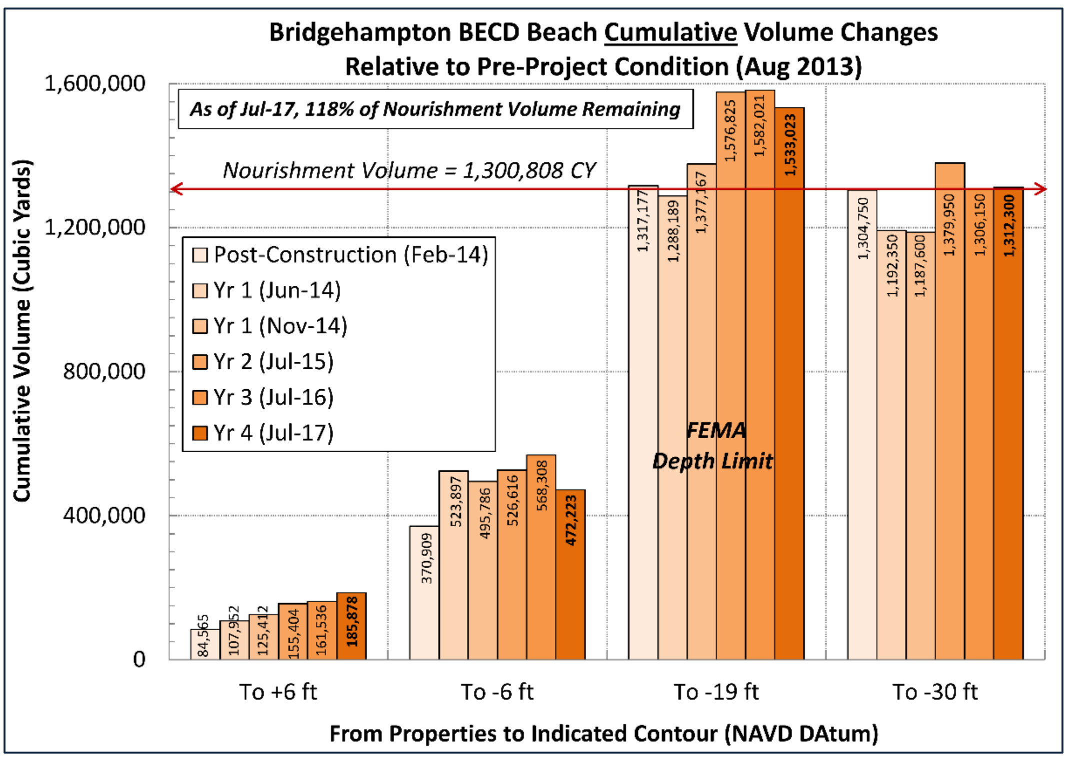


FIGURE 4.4. **Bridgehampton** beach <u>cumulative</u> volume changes between properties and indicated contours relative to August 2013 survey results.

4.3 Discussion and Findings

The July 2017 beach survey shows favorable results for Sagaponack and Bridgehampton with significant volume gains in the dune and underwater zones. Using the FEMA reference depth of −19 ft NAVD (as of July 2017), the Sagaponack BECD retains ~***120 percent*** and the Bridgehampton BECD retains ~***118 percent*** of their original nourishment volumes. The survey indicates that most of the increase is derived from deeper water in the zone between −19 ft and −30 ft NAVD (ie – seaward of the outer bar). When measured to the −30 ft contour, the extra volumes along Sagaponack and Bridgehampton nearly match the original nourishment volumes, meaning there have been no losses to date.

Good performance of the projects, so far, is related to several factors including the project length (nearly 6 miles), relatively low longshore transport rates, and excellent sediment quality. Still, it is generally unusual to observe net gains in a nourishment project. CSE believes this result is related to the timing of the project after Hurricane *Sandy* (October 2012). That storm shifted more sand into deeper water than normal, leaving the underwater zone "sand rich." It is common after storms for the profile to rebuild with "lost" sand migrating back to the visible beach over time. The BECD projects replaced lost sand along the beach zone, and natural post-storm recovery provided a surplus to the inshore area (−6 ft to −19 ft) including the outer bar.

The extra sand residing within the FEMA depth limit along the Sagaponack and Bridgehampton BECDs means greater longevity of the project. CSE's original project design anticipated average annual losses of 63,000 cy/yr for Sagaponack and ~55,000 cy/yr for Bridgehampton. At ~3.5 years after project completion with more sand in the profile, the projects are performing significantly better than expected.

4.4 A Note on Beach Width and Visual Indicators

CSE's annual survey is performed at the beginning of the summer tourist season when the visible beach tends to be wider than average. For most beachgoers, it is difficult to distinguish between a 200-ft wide or a 300-ft wide section of dry-sand beach. Both appear healthy and provide plenty of room for recreation. However, differences become more pronounced if one section is only 50 ft wide from the toe of the dune and the adjacent section is 150 ft wide. Sometimes, especially in fall, the edge of the beach will have sudden 3–5-ft drop-offs at the edge of the surf. These escarpments are visual signs that the "summer" beach is adjusting to higher tides in autumn, or there was a recent storm that cut back the dry beach ("berm") without impacting the foredune. The effect of higher wave events can also be seen in the form of debris lines left close to the base of the dune by waves running up onto the dry beach. These overwash events often deposit sand at slightly higher elevations, positioning it to blow into the foredune after the tides subside.

CSE and First Coastal inspect the beach and periodically monitor these changes between the regularly scheduled surveys, especially after severe storms or nor'easters. In March and April 2018, for example, the team inspected the beach after the series of nor'easters impacted the project area.

It is uncertain yet why the project area west of Mecox Bay was seriously eroded in recent winter storms. Two principal factors that CSE and First Coastal will investigate during Year 5 are the proximity to Mecox Bay and "nourishment end losses." When the Mecox channel is open, sand is drawn into the bay, thus reducing the short-term supply moving across the inlet from east to west. Because the project terminated about 0.5 mile west of Mecox Inlet, this area is likely to erode faster than other sections of beach. Adjacent unnourished areas tend to draw off sand after nourishment from project areas that extend further seaward.

Escarpments were observed in a number of localities, particularly alongshore west of Mecox Bay where the beach was narrower (Fig 4.5, upper). Associated with the escarpments, a portion of the bulkhead that was buried naturally after the 2013–2014 nourishment project became re-exposed after the storms (Fig 4.5, lower). The beach in front of these areas was barely passable during high tides.

Overall, the dunes along Bridgehampton and Sagaponack remained intact and the beach withstood the storms without any damage to the oceanfront properties after the March events. Even at the narrowest sections of the beach, no dune breach occurred and no direct damage to the oceanfront properties was caused by the nor'easters. <u>The important finding of the 2017 survey is that the average width remains better than before nourishment.</u> Wide sections of beach tend to replenish narrow sections along strand shorelines such as Sagaponack-Bridgehampton-Water Mill, filling in the low spots by summer.

If constructed properly, a nourished beach will respond to changing water levels and waves just like the natural beach did before the project. But a principal goal of nourishment is to produce a wider beach so that the seasonal changes in beach width do not encroach on the foredune. A good indicator of success is whether all areas of the project make it through storm and seasonal changes in the beach without adverse impact to the foredune. So far, the project is performing well by that measure. It is expected that the beach will naturally recover during the summer season, and the exposed bulkhead will be re-buried by wind-generated sand.

FIGURE 4.5. [UPPER] Aerial photo taken by First Coastal on 11 March 2018 after a nor'easter. Escarpments were observed alongshore west of Mecox Bay. [LOWER] Ground photo taken west of Mecox Bay by CSE on 3 April 2018 at high tide during the beach inspection. A section of bulkhead was re-exposed after the March nor'easters.

— *THIS PAGE INTENTIONALLY LEFT BLANK* —

5.0 UPCOAST AND DOWNCOAST CHANGES

As part of the annual condition surveys, CSE obtained profiles upcoast and downcoast of the project area to evaluate the impact of the nourishment project along these beach segments. CSE extended the survey limits ~1 mile east and 1.5 miles west of the project boundaries. The upcoast dataset covers station −25+00 (in front of Georgica Pond) to station 25+00 (near the Sagaponack project limit at station 28+84), and the downcoast dataset covers station 330+00 (near the Bridgehampton–Water Mill project limit at station 326+35) to station 400+00 (Village of Southampton).

Changes in the downcoast and upcoast beaches partly reflect spreading of nourishment volume away from the project. Some changes are also associated with onshore and offshore transport (ie – the seasonal shift of sand from the surf zone to the visible beach and back again). Data are available for August 2013 (pre-project), February 2014 (post-project), June and November 2014, July 2015, July 2016, and July 2017. Available profiles are included in Appendix 2. Unit volumes and total volumes at each downcoast or upcoast station to various reference-depth contours are included in Appendix 4.

Figure 5.1 shows the cumulative volume changes since project completion relative to the pre-project condition between the foredune or properties and the indicated depth contour along upcoast and downcoast reaches. There has been accretion or erosion in different portions of the beach over the past four years.

From July 2015 to July 2016, the results suggested upcoast and downcoast areas lost sand in all lenses with the exception that downcoast gained sand in the foredune. The results for the upcoast and downcoast areas differ from the project area (CSE 2016)—the magnitude of the changes is small relative to the project area changes since before nourishment. If measured to the FEMA reference depth (−19 ft NAVD) (ie – the entire "sand box"), there was a net loss of ~50,743 cy along the ~1-mile upcoast area, and a loss of ~82,653 cy along the 1.5-mile downcoast area. The annual loss rate for both areas was ~10 cy/ft between July 2015 and July 2016.

During the past year (July 2016 to July 2017), the results show both upcoast and downcoast areas gained sand if measured to the FEMA reference depth (–19 ft NAVD) or to deep water at –30 ft NAVD. The gained volumes are ~140,650 cy and 47,300 cy (respectively). As discussed in Section 4, both Sagaponack and Bridgehampton areas lost sand over the past year if measured to –19 ft NAVD, and the lost volumes are ~45,570 cy and ~49,000 cy (respectively). The loss in the project area likely contributed to the gain in the upcoast and downcoast areas.

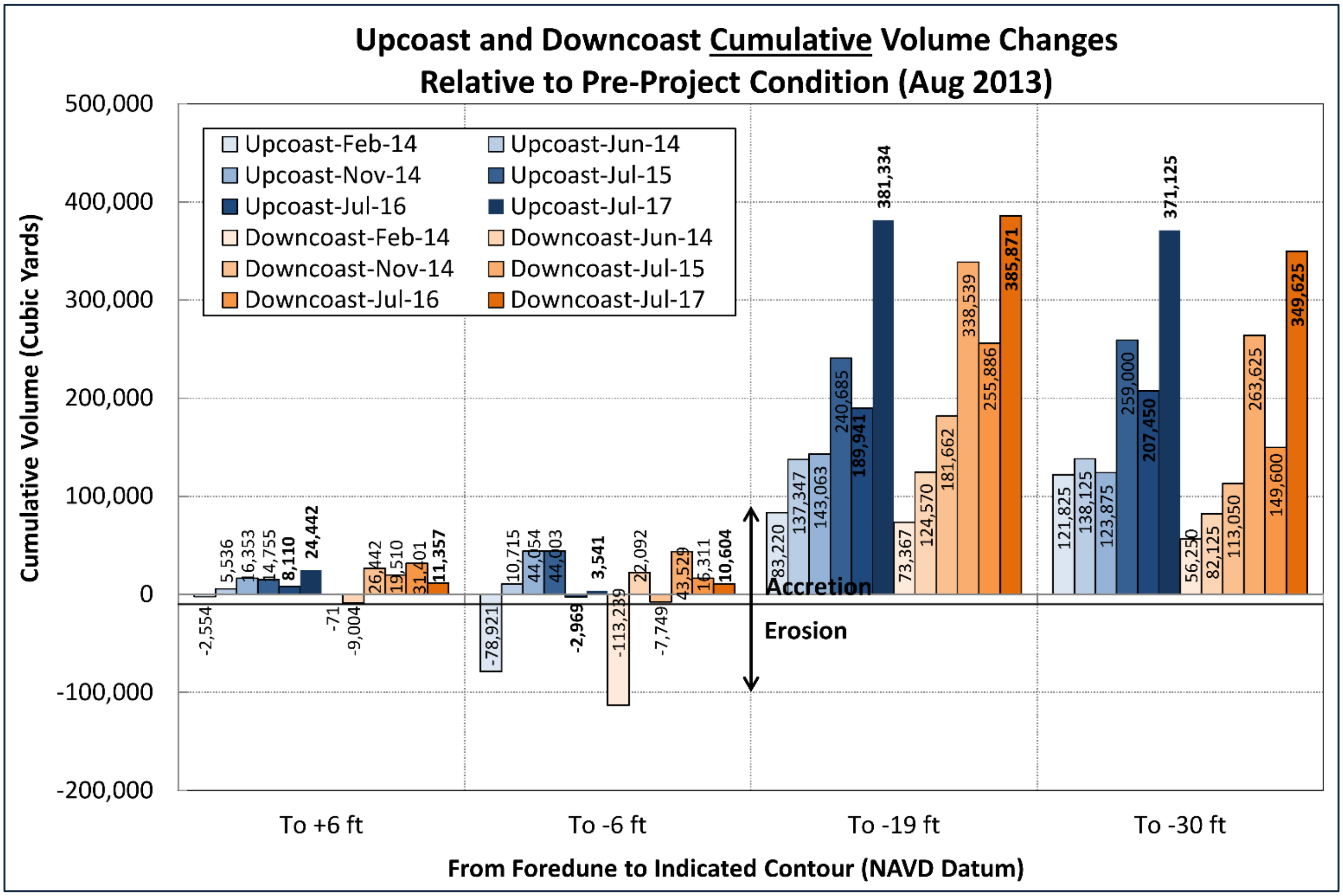


FIGURE 5.1. Cumulative volume changes from the foredune or properties to the indicated contour relative to the August 2013 condition along upcoast and downcoast stations outside the project area.

Following large storms like Hurricane *Sandy* (which occurred before the nourishment project), sand that shifts seaward of the FEMA limit off Long Island (ie — the −19-ft to −30-ft depths) commonly migrates back to shore (USACE 2008) as noted by the natural gains CSE detected in the upcoast and downcoast areas between 2014 and 2017. More sand is expected to shift west over time since the net longshore sediment transport direction is from east to west under normal conditions (USACE 1958, Kana 1995).

6.0 BEACH SEDIMENTS

In accordance with the monitoring plan, before and after the project, CSE collected representative sediment samples from the project area and immediately adjacent unnourished sections east of Sagaponack for purposes of documenting changes in sediment texture.

6.1 Pre-Project Sediment Analyses for Recipient Beach and Borrow Areas

6.1.1 Recipient Beach

Sediment samples of the native beach were collected by CSE at 12 shore-perpendicular transects in July 2011 (CSE 2012a,b). At each transect, five sets of samples (60 total) were obtained include-ing samples from the toe of dune, mid berm, berm crest, beach face (approximate MHW), and low-tide terrace (LTT). The positions of the 12 transects are noted in Figure 6.1, and the five sample positions across each profile are illustrated in Figure 6.2.

The mean grain size of all native beach sand samples (from dune to LTT) ranged from 0.373 millimeters (mm) to 0.488 mm, and averaged 0.42 mm with the average standard deviation of 0.70 mm. The shell content averaged 0.5 percent, and no samples contained sediment in the gravel (2 mm or greater) size class.

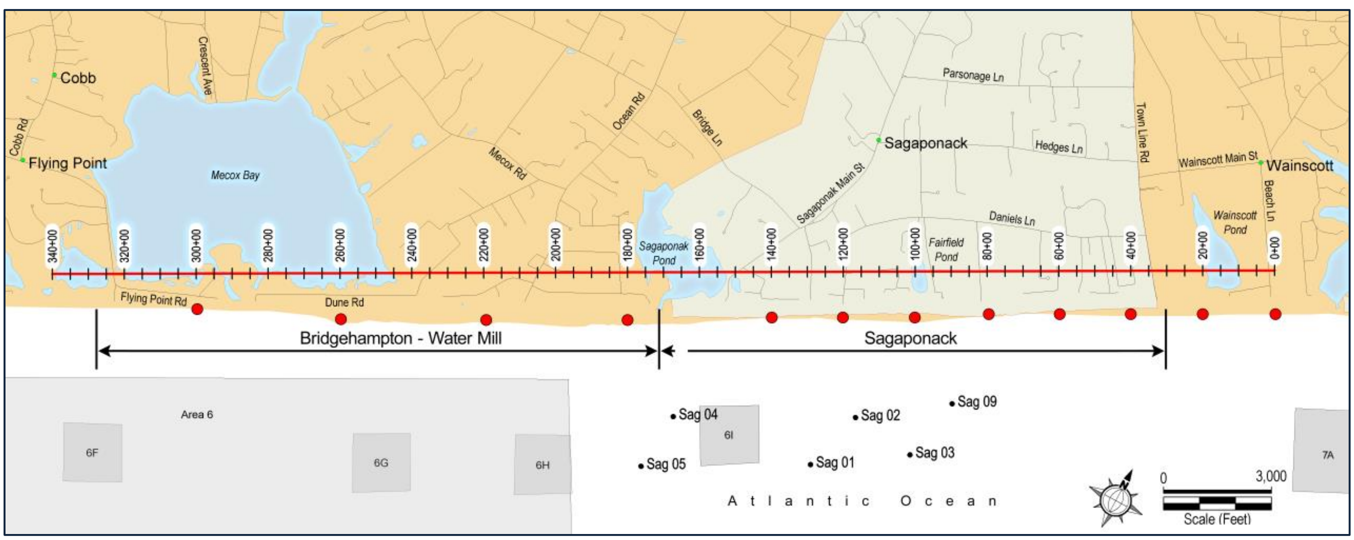


FIGURE 6.1. Location of sediment samples collected at Sagaponack and Bridgehampton marked by red dots.

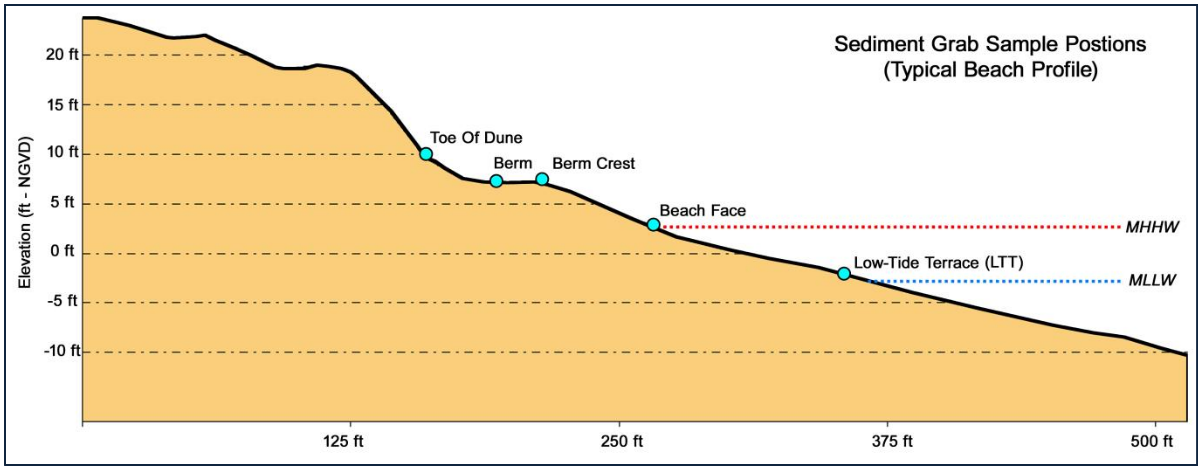


FIGURE 6.2. Sampling locations of the five samples per transect from dune to low-tide terrace (green dots) used to characterize the recipient beach at Sagaponack and Bridgehampton.

6.1.2 Borrow Areas

CSE collected six borings in July 2011 and 50 borings in August 2012 in the potential borrow areas. Mean grain size for the offshore samples was generally uniform with sparse areas of fine and coarse sand occurring (CSE 2012a,b; 2014a). Based on the results of the isopach maps, three borrow areas were delineated for the project. Mean grain size in the borrow areas ranged from 0.424 mm for Area 1, to 0.437 for Area 2, to 0.464 mm for Area 3. The cores within each borrow area were observed to contain very small amounts of fine-grained material. Gravel-sized (or greater) sediment comprised negligible amounts in the offshore samples. Shell content was also relatively minor, generally <2 percent. The similarity of the sand-size classes and shell content in sediment analyses for the recipient beach and the borrow areas suggested the sand would look and perform well once placed on the beach. Minimal turbidity would be expected during construction.

6.2 Sediment Analysis during Construction Phase

During the 2013–2014 nourishment construction, CSE collected a composite-grab sample every 500 ft from the stations completed during construction observations. A composite sample consisted of a series of grab samples at ~10-ft spacing along a transect from the landward limit of fill to the low-tide line mixed together to form one representative sample for the given station. Some additional single-point grab samples in the vicinity of the discharge point were also collected. Selected sand samples were analyzed to determine grain-size characteristics and shell content as a means of monitoring the quality of the material actually placed on the beach.

Nourishment sand placed on the beach was found to be consistent with the borings obtained by CSE. It contained negligible mud, little shell material, and was compatible, clean, and free of debris and clay. The mean grain size of all samples collected during project construction was remarkably consistent for ~90 percent of the samples. It was calculated to be 0.446 mm (ranging from 0.348 mm to 0.824 mm), which is classified as medium to coarse sand (CSE 2014b). For Sagaponack, the mean grain size ranged from 0.348 mm to 0.824 mm and averaged 0.447 mm. For Bridgehampton, the mean grain size ranged from 0.357 mm to 0.714 mm and averaged 0.443 mm.

6.3 Sediment Analysis in Year 4 — July 2017

CSE collected sediment samples in July 2017 (Year 4) at the same 12 transects (~2,000-ft to 4,000-ft spacing) as the pre-project studies. Five samples per transect were collected between the toe of the dune and the low-tide wading zone. *[Positions of the transects and cross-shore sample locations are given in Figures 6.1 and 6.2.]* Samples were split for granulometric and shell analysis, and were tested in the lab using standard ASTM procedures. Grain-size distributions were based on 0.25-phi intervals (21 sieves in the sand-size range). Additional coarse sieves were used for samples which showed significant concentrations of coarse-shell or gravel material. Fines were reported as a percentage of the total based on the quantity passing the #230 sieve (ie – <0.0625 mm diameter).

The results, composited by station, were compared with pre-project and construction data by means of tables and graphs. Results of individual grain-size distributions are reported in Appendix 5 using the Method of Moments as well as traditional graphic methods for calculating mean grain size and related sorting and skewness statistics.

Abbreviations corresponding to morphologic features listed on laboratory data sheets are as follows:

- **Dune Toe** — near base of dune at the primary change in slope.
- **Berm** — on top of the dry beach between the dune and the berm crest.
- **Berm Crest** — near the high-tide swash line and seaward edge of the dry beach.
- **Beach Face** — about midway along the sloping beach face in the swash zone.
- **LTT** — near the low-tide mark, wave plunge point.

As the cross-section in Figure 6.2 showed, the samples collected in July 2017 represent the primary features of the visible beach. Typical grain sizes by position on the beach were produced by averaging the results of the individual samples. The primary size statistics for the dune, berm,

berm crest, beach face, LTT, and all samples combined are listed in Table 6.1. The texture and classification at the beach were determined to be quartz sand, medium in size, and moderately well sorted.***** The average content of shell material ($CaCO_3$) was 0.3 percent, and the average content of gravel (2 mm or greater) was 0.7 percent.

*[*Sorting indicates textural maturity. Well-sorted sediment samples imply the sediments were transported over a great distance or have been in place for a long period of time, causing the grains to become well-rounded and well-sorted. Moderate to poor sorting indicates relatively shorter transport distances, or in the case of a renourished beach, more recent placement of sand.*]

The results indicate the July 2017 samples did not contain significant gravel-sized sediment, and the mean grain size of the nourished beach ranged from 0.319 mm to 1.869 mm, averaging **0.466 mm with standard deviation of 0.666 mm**.

Beach sediments in July 2017 were slightly coarser than the pre-project condition (0.444 mm versus 0.42 mm). Size distributions along the length of the beach in July 2017 were slightly more uniform than before the project (higher standard deviation, 0.603 versus 0.70).

Sediment characteristics along the beach vary moderately in both the alongshore and cross-shore directions as shown in Table 6.2 and Figure 6.3. It is common for surficial grab samples to vary according to the wave and tide conditions that affect the sediment around the time of sampling. The July 2017 mean sediment sizes at different cross-shore positions were relatively uniform, varying from 0.386 mm on the dune to 0.682 mm at low-tide terrace (in comparison to the 2011 samples which varied from 0.372 mm on the dune to 0.478 mm at low-tide terrace). As Figure 6.3 suggests, the results in 2011 were skewed by a few samples (dune at stations 20+00 and 220+00; and LTT at stations 20+00 and 220+00), and the results in July 2017 were more uniform from dune to beach face, but were skewed from low-tide terrace (especially at stations 80+00 and 300+00 which are off the chart and omitted in the figure). The sediment samples at low-tide terrace are apparently influenced by large shell clasts at the sampling locations.

The foregoing results confirm the nourished beach retains essentially the same sediment size distributions, confirming the similarity between native sands on the visible beach and the offshore borrow sands.

TABLE 6.1. Details of sediment characteristics for July 2017 samples at the 12 stations along Sagaponack and Bridgehampton and the adjacent beach. *Note: Samples at Station 80+00 (LTT) and Station 300+00 (LTT) are influenced by large shell clasts on the beach at the sampling locations.

Sagaponack-Bridgehampton-Water Mill Beach Sediment Samples									
		Method of Moments						CaCO3	Gravel
Station-Position		Mean (phi)	STD (phi)	Skew (phi)	Kurt (phi)	Mean (mm)	STD (mm)	percent	percent
0+00	Dune	1.41	0.42	0.23	4.37	**0.377**	**0.749**	0.0	0.0
0+00	Berm	1.11	0.47	-0.45	5.33	**0.464**	**0.724**	0.0	0.3
0+00	Berm Crest	1.15	0.41	0.12	4.27	**0.451**	**0.752**	0.0	0.0
0+00	Beach Face	1.58	0.41	-0.08	3.71	**0.334**	**0.755**	0.0	0.0
0+00	LTT	1.42	0.56	-0.63	3.84	**0.374**	**0.677**	0.0	0.0
20+00	Dune	1.54	0.38	0.18	3.74	**0.343**	**0.769**	0.0	0.0
20+00	Berm	1.19	0.47	-0.36	3.23	**0.438**	**0.721**	0.0	0.0
20+00	Berm Crest	1.21	0.44	-0.26	4.82	**0.434**	**0.738**	0.0	0.1
20+00	Beach Face	1.64	0.37	-0.35	4.04	**0.320**	**0.775**	0.0	0.0
20+00	LTT	0.96	0.68	-0.16	2.73	**0.515**	**0.625**	0.0	0.5
40+00	Dune	1.20	0.44	0.30	4.35	**0.435**	**0.737**	0.0	0.0
40+00	Berm	1.17	0.46	0.04	3.36	**0.444**	**0.727**	0.0	0.0
40+00	Berm Crest	1.24	0.49	0.01	3.66	**0.423**	**0.711**	0.0	0.0
40+00	Beach Face	1.68	0.39	0.09	3.38	**0.311**	**0.765**	0.0	0.0
40+00	LTT	1.45	0.54	-0.67	3.66	**0.366**	**0.686**	0.0	0.0
60+00	Dune	1.26	0.38	0.17	4.13	**0.416**	**0.767**	0.0	0.0
60+00	Berm	0.97	0.40	-0.19	3.57	**0.512**	**0.758**	0.0	0.0
60+00	Berm Crest	0.84	0.54	-0.71	4.20	**0.558**	**0.688**	0.0	0.6
60+00	Beach Face	1.16	0.43	-0.36	4.46	**0.449**	**0.744**	0.0	0.1
60+00	LTT	0.80	0.70	-1.03	4.04	**0.576**	**0.615**	0.0	3.5
80+00	Dune	1.18	0.43	-0.15	4.44	**0.440**	**0.741**	0.0	0.1
80+00	Berm	1.01	0.46	-0.84	5.80	**0.498**	**0.726**	0.0	0.4
80+00	Berm Crest	0.97	0.44	-0.43	5.17	**0.509**	**0.740**	0.0	0.2
80+00	Beach Face	0.71	0.46	0.07	3.52	**0.613**	**0.728**	0.0	0.1
80+00	LTT	-0.96	1.34	-0.47	2.15	**1.940***	**0.394**	0.0	39.4
100+00	Dune	1.27	0.39	0.04	4.69	**0.415**	**0.765**	0.0	0.0
100+00	Berm	0.88	0.52	-0.65	3.95	**0.542**	**0.698**	0.0	0.3
100+00	Berm Crest	1.15	0.39	-0.20	4.07	**0.452**	**0.763**	0.0	0.0
100+00	Beach Face	1.13	0.45	-0.20	3.11	**0.457**	**0.730**	0.0	0.0
100+00	LTT	1.45	0.55	-0.52	3.91	**0.366**	**0.683**	0.0	0.1
120+00	Dune	1.62	0.37	-0.06	4.16	**0.325**	**0.771**	0.0	0.0
120+00	Berm	1.24	0.42	-0.43	5.11	**0.423**	**0.749**	0.0	0.1
120+00	Berm Crest	1.39	0.42	-0.17	3.70	**0.381**	**0.749**	0.0	0.0
120+00	Beach Face	1.49	0.47	-0.55	4.02	**0.355**	**0.722**	0.0	0.0
120+00	LTT	0.61	1.08	-0.89	3.66	**0.654**	**0.472**	0.0	7.0
140+00	Dune	1.47	0.37	0.14	4.27	**0.362**	**0.773**	0.0	0.0
140+00	Berm	1.46	0.47	-1.04	7.51	**0.363**	**0.722**	0.0	0.3
140+00	Berm Crest	1.33	0.44	0.01	3.76	**0.398**	**0.738**	0.0	0.0
140+00	Beach Face	1.40	0.50	-0.55	3.34	**0.378**	**0.706**	0.0	0.0
140+00	LTT	0.88	0.70	-0.19	2.82	**0.545**	**0.618**	0.0	0.6
180+00	Dune	1.64	0.35	0.52	4.33	**0.321**	**0.785**	0.0	0.0
180+00	Berm	1.35	0.51	-0.62	5.68	**0.391**	**0.702**	0.0	0.3
180+00	Berm Crest	1.53	0.37	0.16	3.92	**0.346**	**0.771**	0.0	0.0
180+00	Beach Face	1.62	0.40	-0.30	3.50	**0.324**	**0.759**	0.0	0.0
180+00	LTT	0.49	1.25	-1.15	3.57	**0.714**	**0.420**	0.0	14.3
220+00	Dune	1.21	0.39	0.19	3.80	**0.433**	**0.764**	0.0	0.0
220+00	Berm	1.02	0.54	-0.27	2.94	**0.492**	**0.687**	0.0	0.2
220+00	Berm Crest	0.89	0.55	-0.99	6.30	**0.539**	**0.682**	0.0	1.7
220+00	Beach Face	1.36	0.57	-0.82	4.16	**0.390**	**0.671**	0.0	0.1
220+00	LTT	1.49	0.59	-0.71	3.91	**0.356**	**0.666**	0.0	0.1
260+00	Dune	1.34	0.39	0.24	4.39	**0.396**	**0.763**	0.0	0.0
260+00	Berm	1.19	0.39	-0.18	4.21	**0.440**	**0.765**	0.0	0.0
260+00	Berm Crest	1.42	0.39	0.15	3.71	**0.375**	**0.764**	0.0	0.0
260+00	Beach Face	1.47	0.51	-0.32	3.34	**0.361**	**0.704**	0.0	0.0
260+00	LTT	0.40	0.87	-0.14	3.12	**0.756**	**0.547**	0.0	4.2
300+00	Dune	1.21	0.86	-1.15	4.16	**0.432**	**0.550**	0.0	4.0
300+00	Berm	1.43	0.42	-0.20	3.91	**0.372**	**0.746**	0.0	0.0
300+00	Berm Crest	0.83	0.81	-0.32	2.45	**0.563**	**0.572**	0.0	1.5
300+00	Beach Face	1.31	0.65	-0.94	4.31	**0.403**	**0.635**	0.0	0.6
300+00	LTT	-0.15	1.58	-0.28	1.69	**1.109***	**0.335**	0.0	32.6
320+00	Dune	1.63	0.37	0.18	4.13	**0.323**	**0.776**	0.0	0.0
320+00	Berm	1.15	0.41	-0.08	3.41	**0.450**	**0.753**	0.0	0.0
320+00	Berm Crest	1.30	0.41	-0.03	3.50	**0.407**	**0.751**	0.0	0.0
320+00	Beach Face	1.50	0.51	-0.42	3.87	**0.353**	**0.704**	0.0	0.0
320+00	LTT	0.74	0.99	-1.23	4.83	**0.597**	**0.504**	0.0	6.3
Composite	Dune	1.38	0.48	-0.72	6.71	**0.383**	**0.718**	0.0	0.3
Composite	Berm	1.17	0.49	-0.40	4.28	**0.445**	**0.713**	0.0	0.1
Composite	Berm Crest	1.17	0.53	-0.67	4.93	**0.444**	**0.693**	0.0	0.3
Composite	Beach Face	1.39	0.54	-0.57	3.73	**0.382**	**0.687**	0.0	0.1
Composite	LTT	0.74	1.16	-1.33	4.81	**0.600**	**0.448**	0.0	8.4
Composite	All	1.17	0.73	-1.97	10.62	**0.444**	**0.603**	0.0	1.8

TABLE 6.2. Sediment characterization for 12 recipient beach transects in July 2017 along Sagaponack- Bridgehampton–Water Mill beach. (Grain size in millimeters). [Large shell clasts at Stations 80+00 and 300+00 have been removed from the summary table.]

Station	Dune	Berm	Berm Crest (BC)	Beach Face (BF)	Low-tide Terrace (LTT)	Average
0+00	0.377	0.464	0.451	0.334	0.374	0.400
20+00	0.343	0.438	0.434	0.320	0.515	0.410
40+00	0.435	0.444	0.423	0.311	0.366	0.396
60+00	0.416	0.512	0.558	0.449	0.576	0.502
80+00	0.440	0.498	0.509	0.613	-	0.515
100+00	0.415	0.542	0.452	0.457	0.366	0.446
120+00	0.325	0.423	0.381	0.355	0.654	0.428
140+00	0.362	0.363	0.398	0.378	0.545	0.409
180+00	0.321	0.391	0.346	0.324	0.714	0.419
220+00	0.433	0.492	0.539	0.390	0.356	0.442
260+00	0.396	0.440	0.375	0.361	0.756	0.465
300+00	0.432	0.372	0.563	0.403	-	0.443
320+00	0.323	0.450	0.407	0.353	0.597	0.426
Average	**0.386**	**0.448**	**0.449**	**0.388**	**0.529**	**0.439**

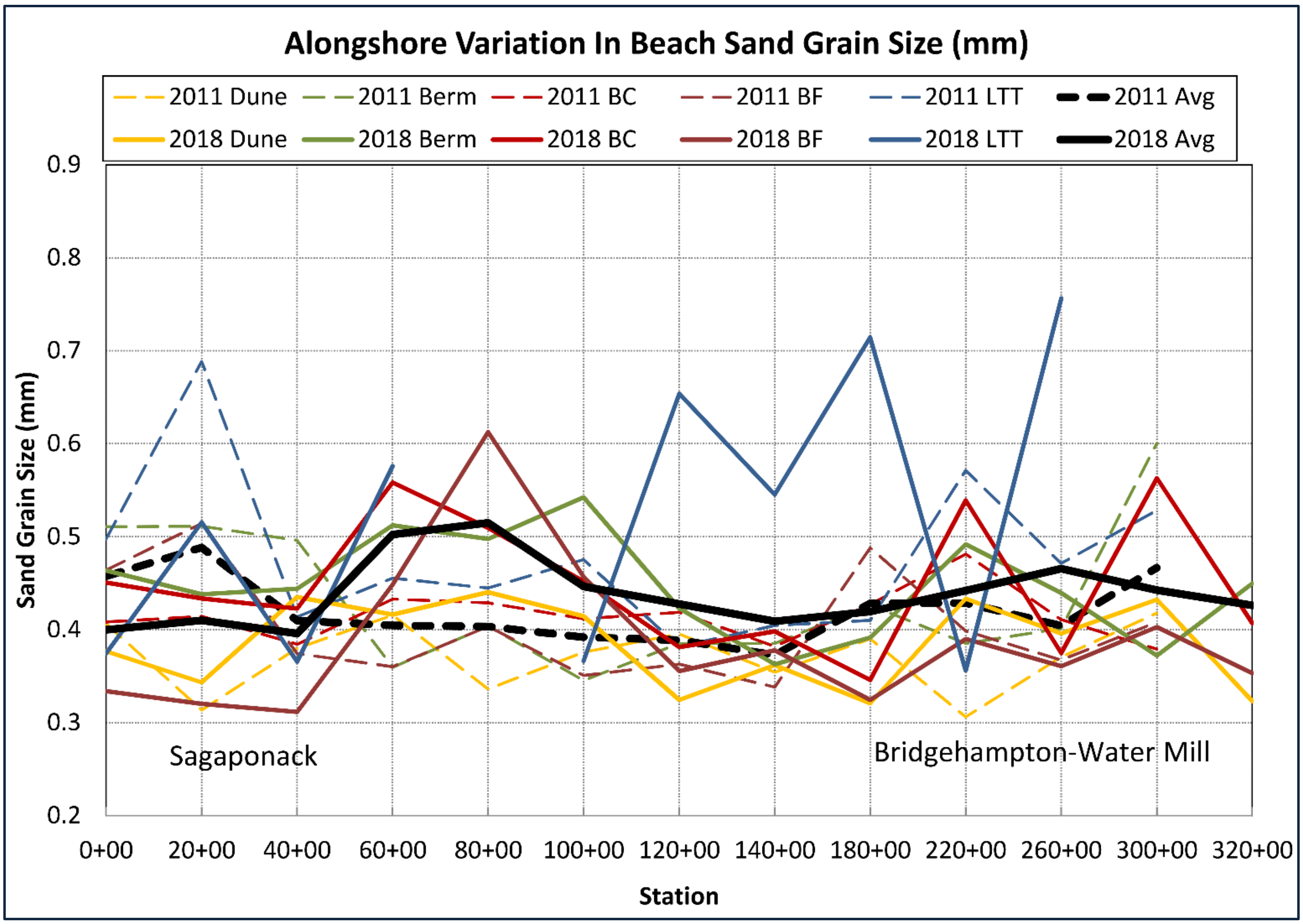


FIGURE 6.3. Alongshore sediment distribution of average grain size at specific cross-shore locations for all transects at Sagaponack and Bridgehampton–Water Mill in July 2017 compared to the pre-project condition in July 2011.

7.0 SUMMARY OF BORROW AREA DREDGING RECOVERY

The 2013–2014 Sagaponack–Bridgehampton–Water Mill beach nourishment project involved excavation and placement of 2,543,592 million cubic yards (final contractor surveys) from three designated offshore borrow areas (Areas 1–3 shown in Fig 1.2). Pre-project bathymetry data were collected by the contractor (GLDD) right before each borrow area was dredged (see the individual dates on Fig 7.1). Post-project bathymetry data were collected by CSE in February 2014 following completion of the construction (CSE 2014). Year 1 bathymetry data were collected in November 2014, Year 2 data were collected in July 2015, Year 3 data were collected in July 2016, and Year 4 data were collected in July 2017. CSE's data collection involved long-axis transect spacing of 200 ft and short-axis spacing of 100 ft over each borrow area.

Figure 7.1 shows overall before-dredging (upper graphic) and after-dredging (lower graphic) conditions by color-coded digital terrain models (DTMs), and Figure 7.2 shows the conditions since project completion using the same color-coded DTMs [ie – Year 1 (November 2014 – upper graphic) and Year 4 (July 2017 – lower graphic); Year 2 (July 2015) and Year 3 (July 2016) results can be found in earlier CSE (2015b, 2016) reports. Figure 7.1 also shows the locations of six representative cross-sections (Sections A–F) through the three borrow areas; the elevation comparisons along these sections are shown in Figure 7.3(A–F). The results illustrate that excavations during construction were within the permitted cut depth of 7 ft, and infilling of the borrow areas has been occurring since project completion.

During construction, all borrow areas were excavated via suction-cutterhead dredge. CSE estimated that an aggregate ~65 percent of the borrow areas was used (ie – ~275 acres out of a total of 423 acres), and each area left significant undisturbed portions from which biological recruitment might occur. The contractor reported that 2,543,592 cy were placed on the beach during the 2013–2014 project. If an excavated and in-place volume ratio of 1.08 is assumed (ie – 8 percent of the excavated material was lost while being pumped onto the beach), the actual excavation volume would be ~2.75 million cubic yards. Nine months after the project (November 2014), ~346,380 cy of sand had returned to the borrow pits, which is equivalent to ~12 percent of the excavation volume. As of July 2015, ~489,350 cy of material had returned to the borrow pits (equivalent to ~18 percent). As of July 2016, ~527,300 cy had returned to the borrow pits (equivalent to ~20 percent). As of July 2017, ~626,000 cy of material had returned to the borrow pits (equivalent to ~23 percent). CSE will continue to monitor the borrow areas via annual bathymetric surveys as more material is expected to gradually infill the excavated areas over the years.

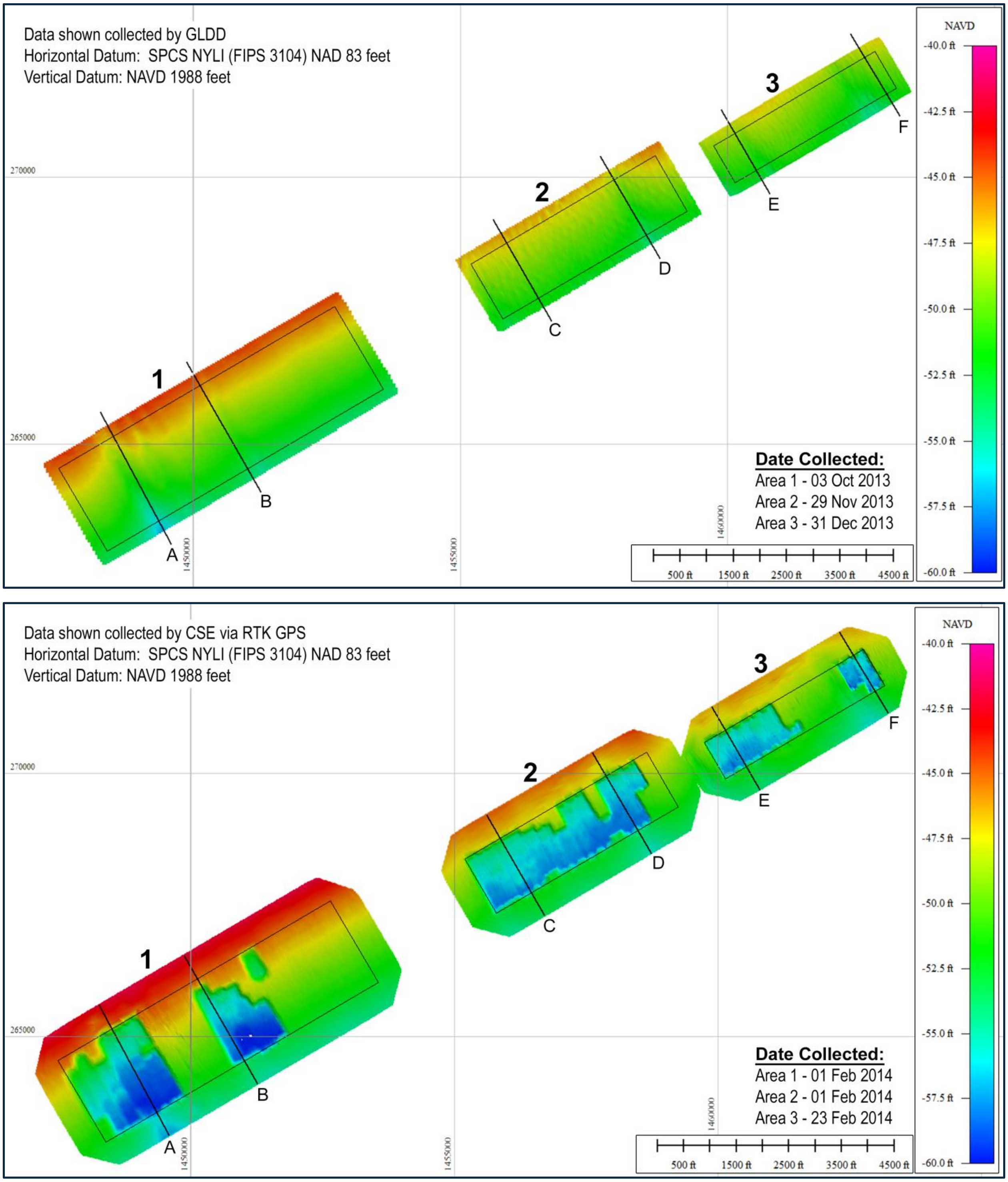
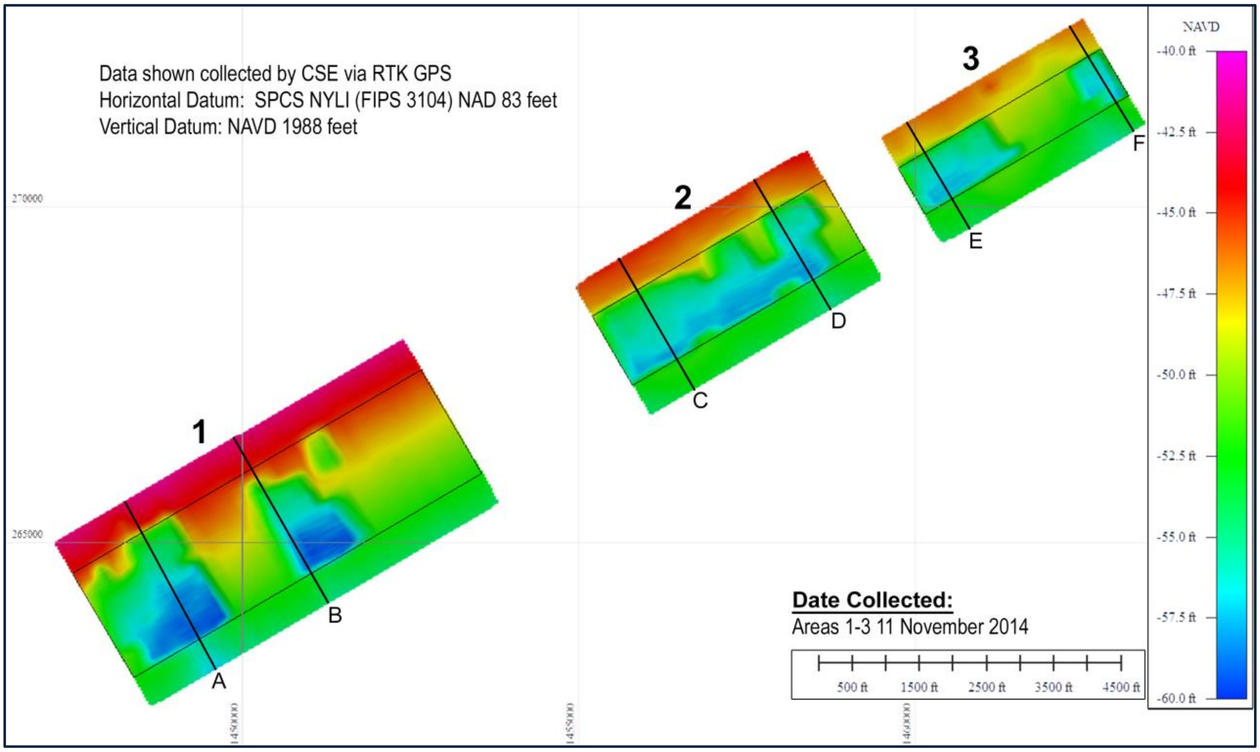


FIGURE 7.1. Borrow areas before-dredging and after-dredging bathymetry DTMs. Before-dredging data were collected by the contractor, and after-dredging data by CSE. The dates of each survey are indicated on the plots.



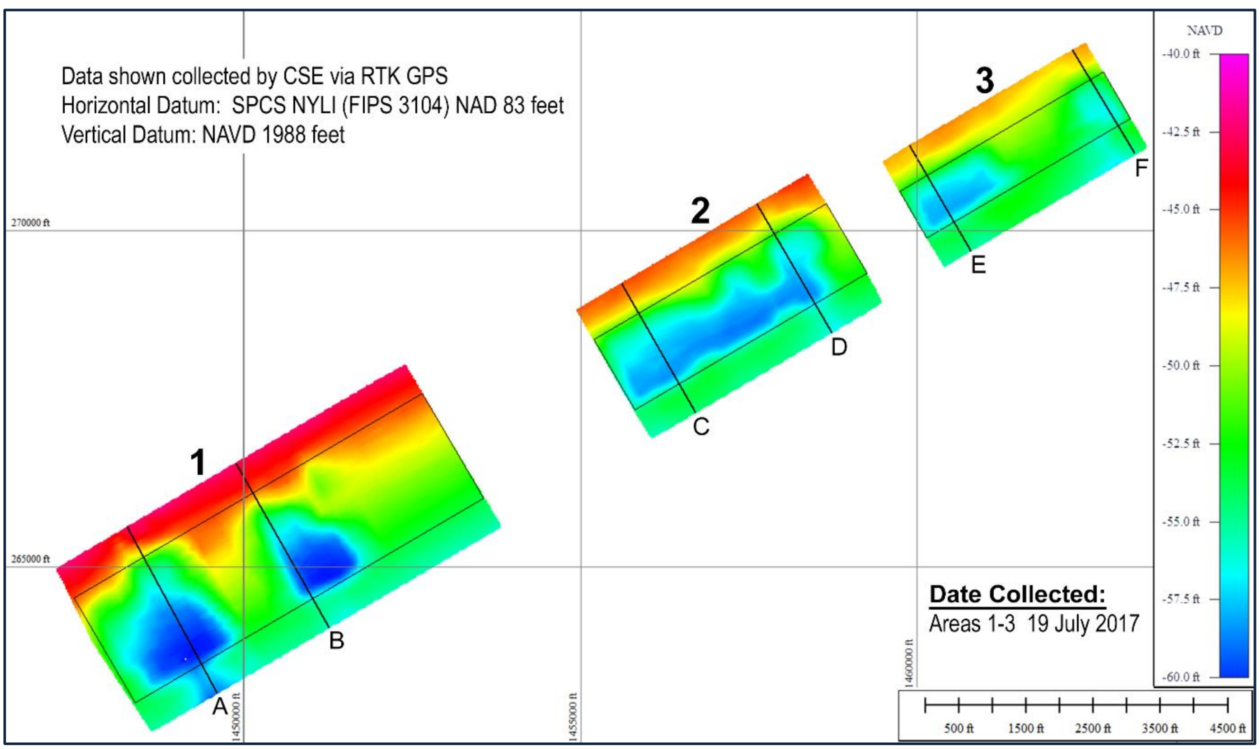
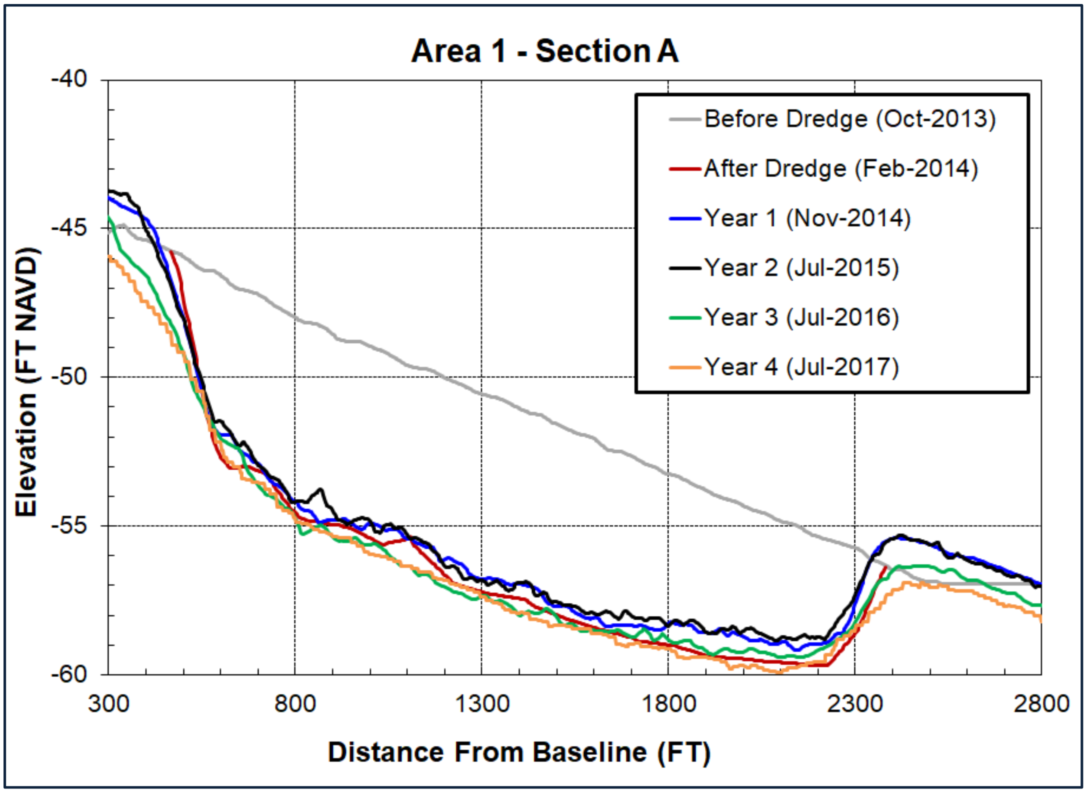


FIGURE 7.2. Borrow areas in November 2014 (Year 1) and July 2017 (Year 4) bathymetry DTMs. Data were collected by CSE. Survey results show there were ~346,380 cy and ~626,000 cy more sand in the borrow areas as of November 2014 and July 2017 (respectively), indicating recovery rates of ~12 percent (Year 1) and 23 percent (Year 4) after project completion.



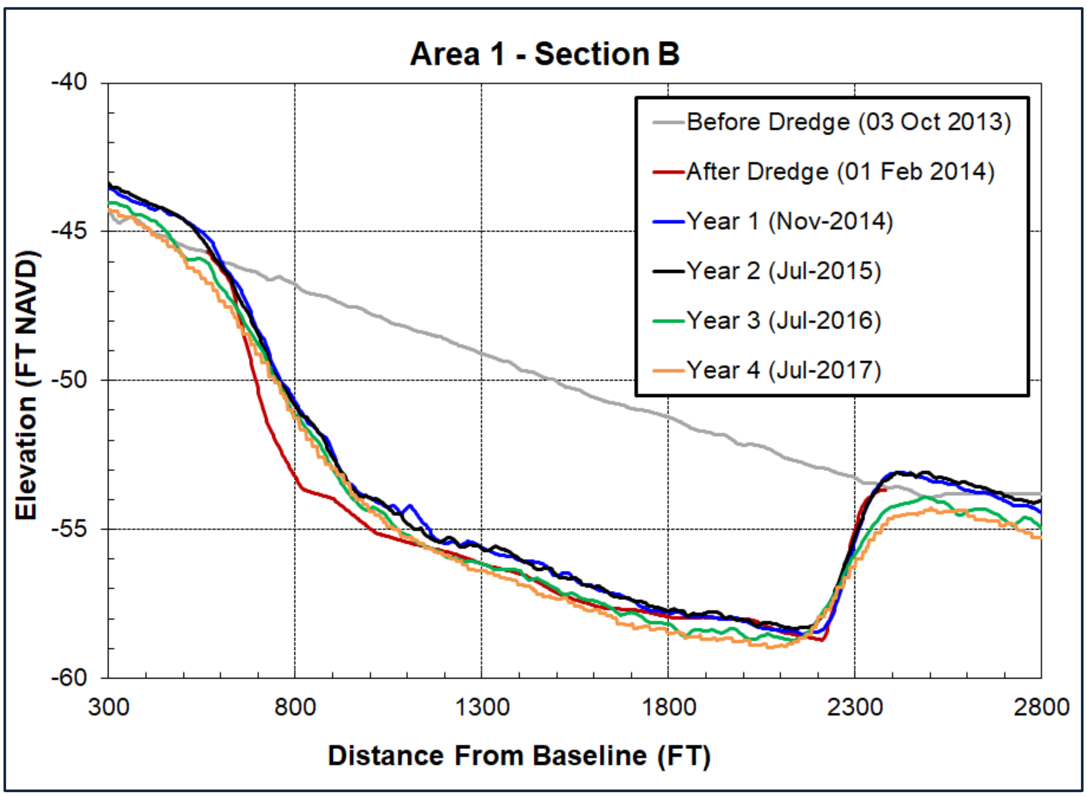
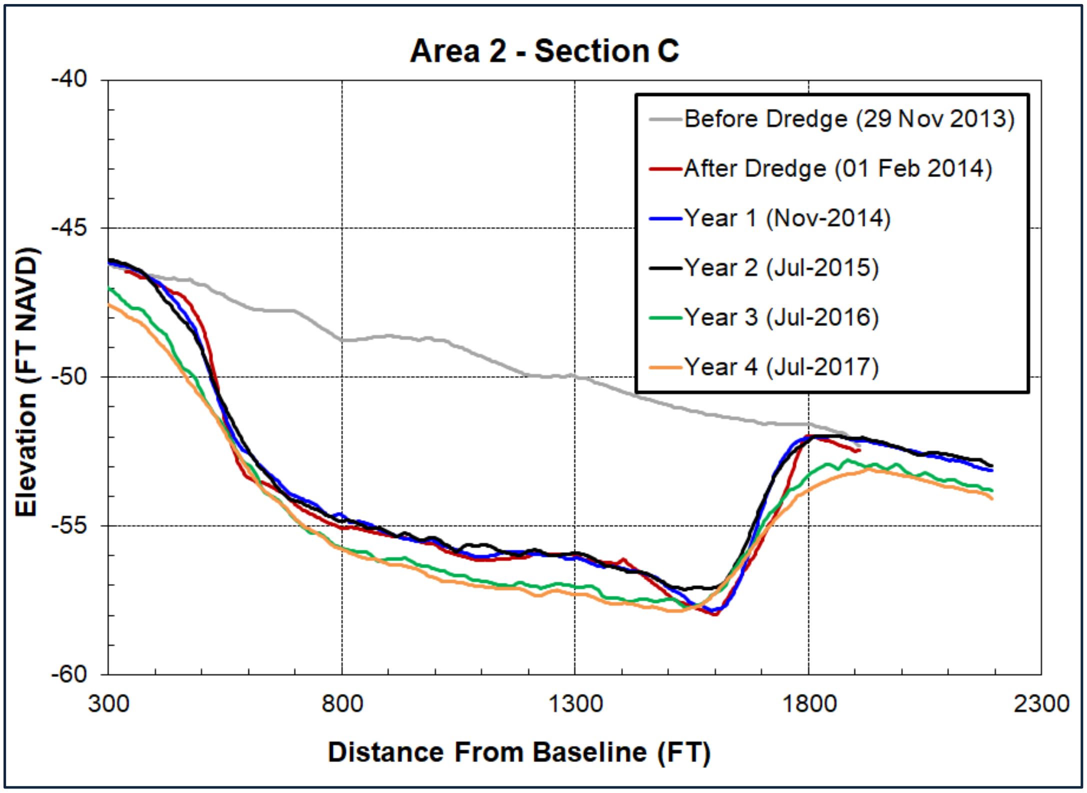


FIGURE 7.3(A–B). Before-dredging, after-dredging, and post-project elevation comparisons along the six representative cross-sections (Sections A to F shown in Fig 7.1) through the borrow areas. Survey data confirmed that excavated depths in the borrow areas were less than 7 ft during construction, and material has been gradually refilling the excavated areas over the past 3.5 years since project completion.



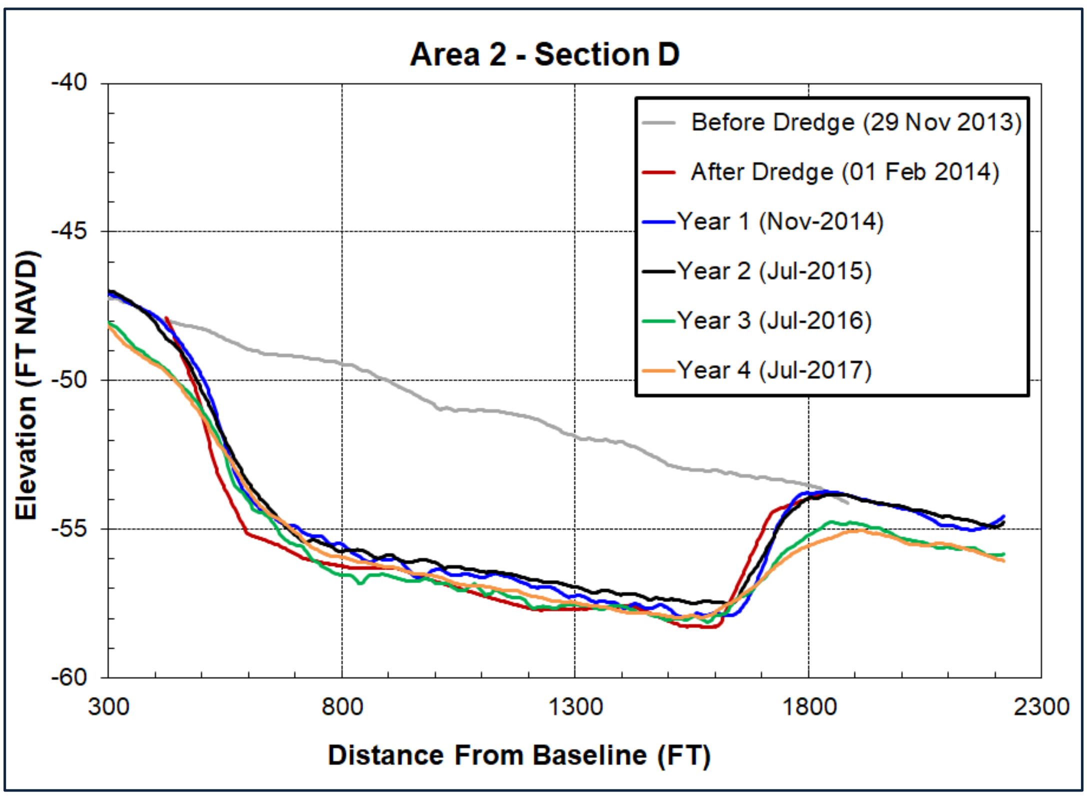
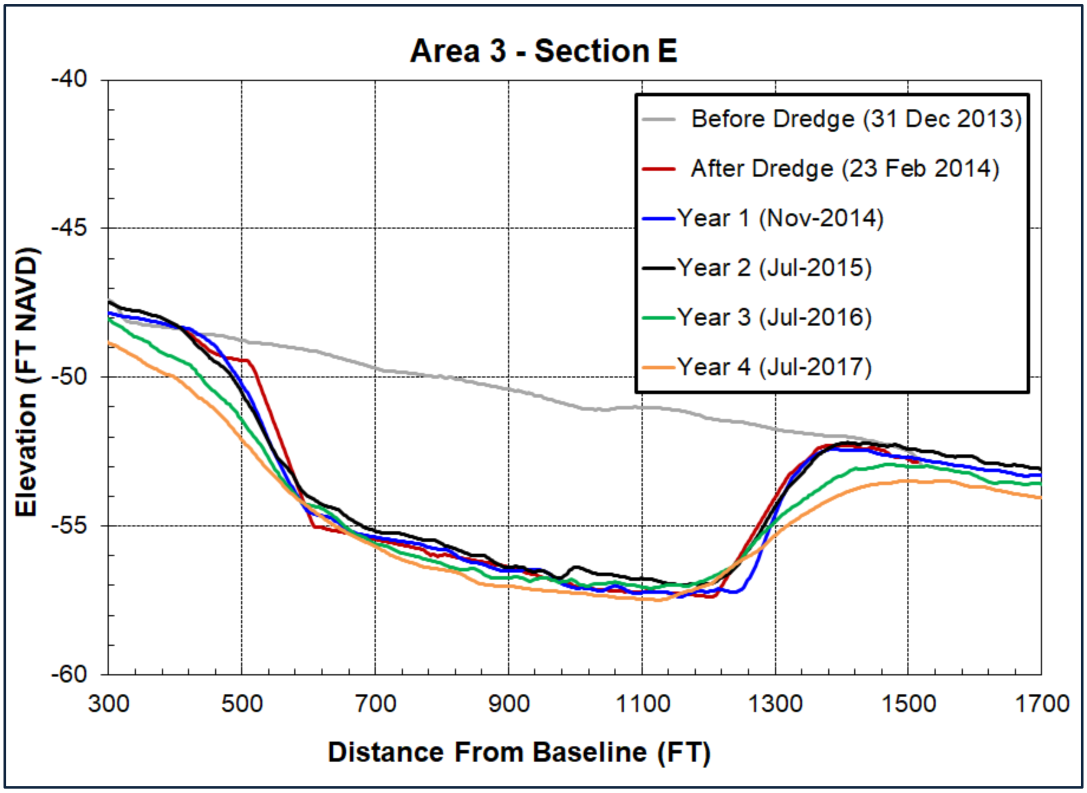


FIGURE 7.3(C–D). Before-dredging, after-dredging, and post-project elevation comparisons along the six representative cross-sections (Sections A to F shown in Fig 7.1) through the borrow areas. Survey data confirmed that excavated depths in the borrow areas were less than 7 ft during construction, and material has been gradually refilling the excavated areas over the past 3.5 years since project completion.



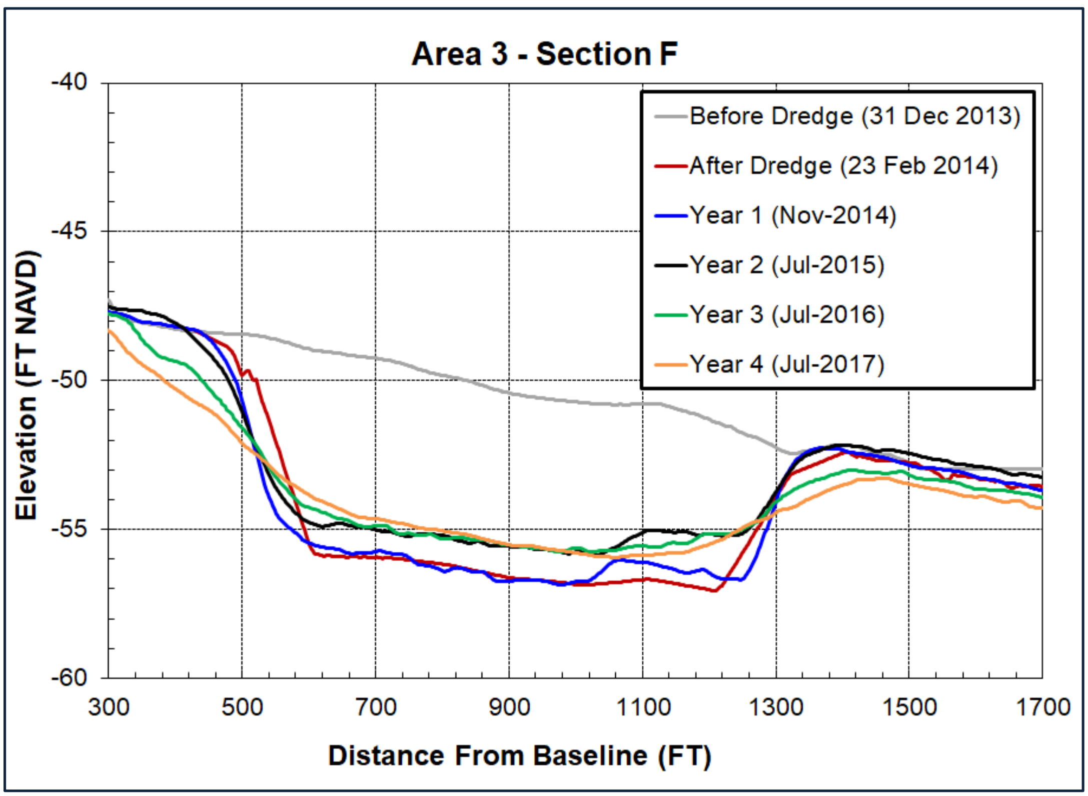


FIGURE 7.3(E–F). Before-dredging, after-dredging, and post-project elevation comparisons along the six representative cross-sections (Sections A to F shown in Fig 7.1) through the borrow areas. Survey data confirmed that excavated depths in the borrow areas were less than 7 ft during construction, and material has been gradually refilling the excavated areas over the past 3.5 years since project completion.

8.0 MONITORING & MAINTENANCE RECOMMENDATIONS

In accordance with FEMA Publication 321 and Code of Federal Regulations 44 CFR 206.226(j), a maintenance program involving periodic renourishment of sand must be established and adhered to by the Town of Southampton to qualify for FEMA post-disaster assistance. The purpose of such a program is to track the physical condition of the beach after nourishment, quantify sand-volume changes, and determine whether the project qualifies for emergency renourishment following declared disasters. It is also intended to identify erosion hotspots and recommend small-scale maintenance renourishment, placement of sand fencing, and/or sand scraping so as to increase the life of the project.

CSE recommends the Town of Southampton continue to conduct an annual assessment of the physical condition of the nourished shoreline. The beach should be surveyed annually using the transect plan established by CSE. Such surveys will give the Town an annual assessment of the beach condition and will reveal problem areas or erosion hotspots that require attention. Annual surveys should be conducted in June or July before the hurricane season. They will serve to document the beach condition prior to the occurrence of a major erosion event, such as a hurricane.

Should a major storm event occur, a post-storm survey should be completed for damage assessment as soon as possible after the storm. Since the project is an engineered beach fill, the annual and post-storm surveys can provide a basis for reimbursement and reconstruction of the beach with federal disaster funds under a community assistance grant (eg — FEMA Category G post-storm restoration funds).

Sand (or snow) fencing and vegetation has been installed along numerous properties by individual owners since project completion, often with the assistance of team partner, First Coastal Corporation (Section 9 figures). Based on New York State Standards and Specifications for Erosion and Sediment Control (by NYDEC dated August 2005), the use of sand (or snow) fencing is effective if a broad area of dry-sand beach is available. Sand (or snow) fencing installed after nourishment has been proven to effectively trap sand and to facilitate dune growth. Artificially sprigged dune grasses will provide a jump-start on native vegetation propagation. CSE encourages the Town to establish a line seaward of which sand fencing is prohibited. This will help to eliminate erosion and washout of fencing materials. In general, the position of sand fencing should be as far landward as practicable.

The construction of such fencing should follow the NYDEC specifications as follows:

"… a minimum of 100 feet (horizontal distance) from the MHT line in two (three or four rows may be used where sufficient land area and sand is available) parallel lines 30 or 40 feet apart. The fences should be roughly parallel to the water line and yet be as nearly as possible at a right angle to the prevailing winds."

"Where this is not possible, erect a single line of fence parallel with the water at least 140 feet from the MHT line and space 30-foot-long perpendicular spurs 40 feet apart along the seaward side to trap lateral drift. As the fences fill with sand, additional sets of fence can be placed over those filled until the barrier dune has reached a protective height. To widen an old dune, the fencing should be set seaward at a distance of 15 feet from the old dune base."

Materials of sand fence or snow fence should:

"Use standard 4-foot sand (snow) fence. The fence should be sound and free of decay, broken wire, and missing or broken slats. Wood posts, for fence support, should be black locust, red cedar, white cedar, or other wood of equal life and strength. They do not need to be treated. They should be a minimum of 6 ft. 6 in. long and a minimum diameter of 3 inches. Standard fence post length is usually 7 ft.–8 ft. and should be used where possible. Four (4) wire ties should be used to fasten the fence to the wood posts. Weave fence between posts so that every other post will have fence on ocean side of posts. Tie wires should be no smaller than 12 gauge galvanized wire. The bottom of the fence should be set about 3 inches into the sand, or a mechanical grader could be used to push some sand against the bottom of fence."

The next physical monitoring activity scheduled between the Town of Southampton and CSE under the present agreement is a full condition survey in 2018 (Year 5) before the hurricane season. CSE plans to conduct the Year 5 monitoring in late May or early June (weather permitting) to avoid the tourist season which normally starts around the July 4th holiday along eastern Long Island.

During the next monitoring year, CSE will provide extra attention to changes west of Mecox Bay. Among the regularly scheduled analyses, CSE will review the recent periods of channel openings at Mecox Bay and prepare an analysis of winds and waves impacting the site during recent nor'easters. Should these additional reviews indicate significant conditions, CSE will recommend limited remedial action or a more comprehensive study of alternatives for managing the western end of the project area.

9.0 SELECTED OBLIQUE AERIAL AND GROUND PHOTOS

Aerial Photos Taken 19 July 2017

Photo 1. Sagaponack - From Peters Pond Lane looking northeast. Town Line Road is the east boundary of the 2013-2014 nourishment project.

Photo 2. Sagaponack - From Gibson Lane looking southwest. Sagaponack Pond is located on the top of the photo.

Photo 3. Sagaponack Pond is located in the middle of the photo. The pond was closed at the time of the photo.

Photo 4. Bridgehampton – From Meadowlark Road looking southwest. Mecox Bay is located on the top of the photo.

Photo 5. Bridgehampton – From Jobs Lane looking southwest.

Photo 6. Mecox Bay was closed at the time of the photo.

Photo 7. From Mecox Bay looking northeast.

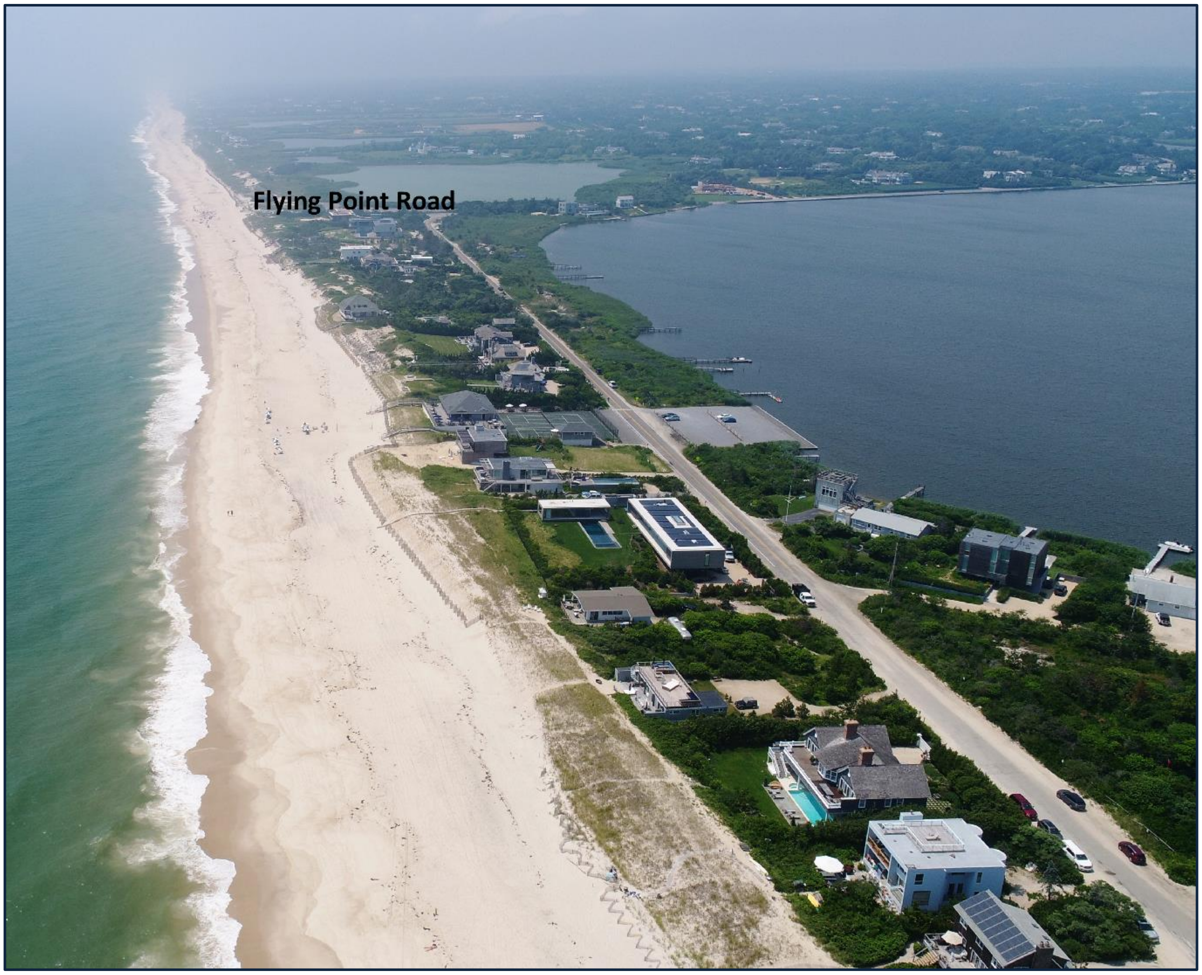


Photo 8. From Mecox Bay looking southwest. Flying Point Road beach access is the western boundary of the 2013–2014 nourishment project.

— *THIS PAGE INTENTIONALLY LEFT BLANK* —

REFERENCES

CPE. 2013. 2009 Fire Island beach renourishment project—post-*Sandy* storm report. Prepared for Sponsoring Communities of Fire Island, New York: Village of Saltaire, Town of Islip, Village of Ocean Beach, Town of Brookhaven. Coastal Planning & Engineering (CPE) of New York PC, 46 pp + appendices.

CSE. 2012a. Shoreline erosion assessment and plan for beach restoration, Bridgehampton–Water Mill Beach, New York. Feasibility Report for Bridgehampton–Water Mill Erosion Control District, Town of Southampton, New York. Coastal Science & Engineering (CSE), Columbia (SC), 112 pp + appendices.

CSE. 2012b. Shoreline erosion assessment and plan for beach restoration, Sagaponack Beach, New York. Feasibility Report for Sagaponack Erosion Control District, Town of Southampton, New York. CSE, Columbia (SC), 110 pp + appendices.

CSE. 2013a. Final Project Manual for Construction for Sagaponack and Bridgehampton Beach Erosion Control District Nourishment Project, Town of Southampton, Suffolk County, New York. (20 June 2013) CSE, Columbia (SC).

CSE. 2013b. Monitoring and Analysis of the 2011 Nags Head Beach Nourishment Project – 2013 Beach Monitoring Report for Town of Nags Head, NC. CSE, Columbia (SC), 89 pp + 8 appendices.

CSE. 2014a. Coastal engineering & geotechnical analyses for beach restoration at Sagaponack & Bridgehampton–Water Mill BECDs, Southampton, New York. CSE, Columbia (SC), 70 pp + appendices.

CSE. 2014b. Final Report – 2013–2014 Sagaponack and Bridgehampton Beach Erosion Control Districts Nourishment Project, Southampton, New York. CSE, Columbia (SC), 82 pp + appendices.

CSE. 2015a. 2013–2014 Sagaponack and Bridgehampton beach erosion control districts nourishment project, Southampton, Long Island, Suffolk County (NY). Year 1 (2014) Monitoring Report for Town of Southampton, New York. CSE, Columbia (SC), 65 pp + appendices.

CSE. 2015b. 2013–2014 Sagaponack and Bridgehampton beach erosion control districts nourishment project, Southampton, Long Island, Suffolk County (NY). Year 2 (2015) Monitoring Report for Town of Southampton, New York. CSE, Columbia (SC), 49 pp + appendices.

CSE. 2016 (December). 2013–2014 Sagaponack and Bridgehampton beach erosion control districts nourishment project, Southampton, Long Island, Suffolk County (NY). Year 3 (2016) Monitoring Report for Town of Southampton, NY. CSE, Columbia (SC), 65 pp + appendices (2434).

Hayes, MO. 1972. Forms of sediment accumulation in the beach zone. In R. Meyer (ed.), *Waves on Beaches and Resulting Forms of Sediment Accumulation*, Academic Press, New York, NY, pp 297-356.

Kana, TW. 1993. The profile volume approach to beach nourishment. In DK Stauble and NC Kraus (eds), Beach Nourishment Engineering and Management Considerations, ASCE, New York, NY, pp 176-190.

Kana, TW. 1995. Signatures of coastal change at mesoscales. Coastal Dynamics '95, Proceedings of the International Conference on Coastal Research in Terms of Large Scale Experiments, ASCE, New York, NY, pp 987-997.

Kana, TW. 1999. Long Island's south shore beaches: a century of dynamic sediment management. In Proc. Coastal Sediments '99, ASCE, New York, NY, pp 1584-1596.

Komar, PD. 1998. Beach Processes and Sedimentation. Second Edition, Prentice-Hall, Inc, Simon & Schuster, Upper Saddle River, NJ, 544 pp.

RPI. 1982. Environmental sensitivity index (ESI) atlas of the lower New York shoreline. Prepared for NOAA. Research Planning Inst, Inc, Columbia, SC, map plates.

RPI. 1985. Fire Island Inlet to Montauk Point, Long Island, New York: sediment budget analysis. Summary Report for New York District, USACE. Research Planning Inst, Inc, Columbia, SC, 85 pp + app.

Rosati, JD, MB Gravens, and WG Smith. 1999. Regional sediment budget for Fire Island to Montauk Point, New York, USA. In Proc. Coastal Sediments '99, ASCE, New York, NY, pp 802-817.

Thevenot, MM, and NC Kraus. 1995. Longshore sand waves at Southampton Beach, New York: observations and numerical simulation of their movement. Marine Geology, Vol 129, pp 249-269.

USACE. 1958. Atlantic Coast of Long Island, New York (Fire Island Inlet to Montauk Point). Cooperative Beach Erosion Control and Interim Hurricane Study. Appendices, U.S. Army Corps of Engineers, New York.

USACE. 2008. *Coastal Engineering Manual: Coastal Project Planning and Design*. EM 1110-2-1100, Part V, Chapter 4, Beach Fill Design. US Army Corps of Engineers, Washington, DC, pp V-4-1 to V-4-109.