Attachment A
Epsilon Memorandum Regarding Retreat and Nourishment Calculations

MEMORANDUM

Date: November 1, 2013

To: Kara Buzanoski, Nantucket DPW

From: Maria Hartnett, Epsilon Associates

Subject: Baxter Road Geotube Project – Coastal Bank Retreat Calculations

The following memo summarizes information about the 'Sconset bluff volume contribution calculation, including (1) a comparison of the current proposed sand mitigation volume with past Sconset Beach Preservation Fund (SBPF) proposals; (2) details on how the bank retreat rate and associated volume were calculated, including data tables; (3) comparison of the calculated bank retreat rates with shoreline change rates; (4) comparison of the calculated bank contribution volume with bank survey data; (5) a discussion of CZM's sand volume mitigation recommendations for the Project area; and (6) a discussion of Coastal Planning & Engineering's littoral budget prepared for the previously-proposed beach nourishment project. The Town of Nantucket requested that I prepare this memo due to my long history of calculating the bank retreat rates and associated volumes.

1.0 Comparison with Bank Retreat Rates and Volumes in Previous Submittals

The following table (Table 1) summarizes the bank retreat rates and volumes provided by SBPF during project filings for the marine mattress and gabion projects, the revetment, and the geotube project. There is significant spatial and temporal variation in coastal bank retreat rates along the 'Sconset bluff. Retreat rates are calculated along multiple transects for each lot; therefore, different project areas will have different retreat rates and associated volumes. The table below shows that each of the SBPF filings has involved a different project area.

Variations in the sand mitigation volume proposed by SBPF are also a result of the varying nature of bluff erosion over time. Erosion of the bluff is an ongoing process and SBPF has periodically undertaken additional LIDAR surveys of the project site; therefore, more recent data (2013 LIDAR survey) were available for use for the geotube and revetment project than for the gabion project (2010 LIDAR survey). Similarly, the geotube and revetment project areas include project areas farther to the north, where bank retreat was occurring as far back as 1994, and therefore a more long-term bank retreat rate could be determined for the geotube and revetment projects (bank retreat rates from 1994-2013 and 2003-2013 could

be determined for the geotube and revetment projects vs. a 2003-2010 bank retreat rate for the gabion project).

For the geotube project, the Town intends to follow the state standard of "Best Available Measure," which has been consistently required by DEP, CZM, and many local Conservation Commissions. The state standard of "Best Available Measure[1]" for sand mitigation is to provide to the littoral system, on an annual basis, the average amount of sand that would have been provided by the eroding bank absent the project. For the marine mattress and gabion project, SBPF offered an additional component of sand mitigation (~7 cy/lf to replicate the amount of sand eroded from the nearshore); this extra component was only associated with that pilot project (which was never implemented) and is not relevant for the current project.

Table I. Summary of Sand Mitigation Volumes in SBPF Proposals

Project	Project Area	Years Used in Calculation	Retreat Rate (ft/yr)	Volume (cy/lf)
Geotube (Current Town Application)	85-107A Baxter	1994-2013 (91-107A Baxter) 2003-2013 (85-91 Baxter)	4.6	14.3
Revetment	63-119 Baxter	1994-2013 (91-119 Baxter) 2003-2013 (71-91 Baxter)	3.8	12.0
Gabion	77-85 Baxter (North) 63-67 Baxter (South)	2003-2010 (North) 2001-2011 (South)	4.96 (North) 3.62 (South)	North 11.6* (Bank) 6.8 (Nearshore) 20** TOTAL South 7.5* (Bank) 7.2 (Nearshore) 16** TOTAL

*Excludes 13% fines

**Includes overfill allowance

2.0 Description of Methodology

The coastal bank retreat calculation was developed using the 2013 LIDAR data and high-resolution georeferenced aerial photographs dating back to 1994 to establish a long-term bank retreat average.

[1] **Best Available Measure**(s) is defined in 310 CMR 10.04 as "… the most up-to-date technology or the best designs, measures or engineering practices that have been developed and that are commercially available.

- **Bank Retreat Rate.** The top of the coastal bank was digitized for 1994, 2003, and 2013 using ESRI ArcGIS software to produce the attached figure (see Figure 1). Top of coastal bank retreat was analyzed along shore-perpendicular transects spaced approximately every 20 feet.

    - For the portions of the geotube project area from 91-107A Baxter Road, the top of coastal bank was actively retreating as early as 1994. For these lots, a long-term (1994-2013) coastal bank retreat rate of **4.0 feet/yr** was calculated. This was calculated by taking the average of the coastal bank retreat along each transect within the area from 91-107A Baxter Road (see Table 1).

    - For the portions of the project area from 85-91 Baxter Road, the top of coastal bank was not actively retreating in 1994 (Figure 1 shows that the 1994 and 2003 top of bank lines are coincident south of the southern half of 91 Baxter Road). For these lots, a 10-year (2003-2013) bank retreat rate of **5.8 feet/yr** was calculated. This was calculated by taking the average of the coastal bank retreat along each transect within the area from 85-91 Baxter Road (see Table 1).

    - For the entire Project area, a single average coastal bank retreat rate was calculated by averaging the above two rates. The average is distance-weighted by transect, which reflects the fact that the majority of the geotube project area has a long-term erosion rate of 4.0 feet/yr, with only the southern 30% exhibiting the higher erosion rate of 5.8 feet/yr. The distance-weighted average is **4.6 ft/yr** (see Table 2).

- **Volume Calculation**: Section views from each of the Project lots from 85-107A Baxter Road were developed from the 2013 LIDAR survey. The volume associated with a bank retreat of 4.6 ft/yr was then determined for each lot using AutoCAD (see typical Figure 2, which shows how the cross-sectional area and associated volume were calculated for each lot). A distance-weighted average volume for all the project lots was then determined (see Table 3), yielding **14.3 cubic yards/linear foot/year (cy/lf/yr).**

3.0 Corroboration of Methodology by Survey Data

The bank retreat volume contribution methodology, based on LIDAR data and aerial photography, was corroborated by independent calculations performed by Woods Hole Group (WHG). WHG has top and toe of bank survey data available at profiles 90 (near 69/71 Baxter Road), 90.5 (near 79/81 Baxter Road), and 91 (near 91 Baxter Road), in years 2006, 2008, and 2013. While these data are too limited to use for the geotube project area since they do not extend far enough northward, they provide a useful check of the above methodology. WHG utilized the top and toe of bluff survey data to calculate a bank contribution volume of **12.4 cy/lf** for the area covered by the profiles (69/71 Baxter Road –

91 Baxter Road); see Tables 4a and 4b. When the above methodology as described in Section 2 was applied to the same project area (71-91 Baxter Road, for years 2003-2013), the volume calculated was **13.2 cy/lf.** The high degree of similarity between these two numbers (they are within 10% of one another) suggests that the methodology used by Epsilon provides an accurate representation of the bank contribution volume, and may even slightly over-estimate the bank contribution volume.

4.0 Corroboration of Methodology by Shoreline Change Data

This calculation was also corroborated by shoreline change data. The WHG shoreline change data for the area from 91-107A Baxter Road were compared to the calculated bank retreat rate for 91-107A Baxter Road. The complete March 2013 WHG Shoreline Monitoring Report is included as Attachment A.

- **Epsilon Methodology**: the 1994-2013 bank retreat rate from 91-107A Baxter Road was calculated as **4.0 ft/yr**.

- **Shoreline Data:** the 1994-2013 distance-weighted shoreline change rate for those profiles located nearest to 91-107A Baxter Road (profiles 91, 91.5, and 92) is **3.9 ft/yr**. (See Table 5.)

The high similarity between these two numbers again supports the accuracy of the calculated bank retreat rate, and suggests that the above methodology may also be slightly conservative.

Comparisons between 1994-2013 shoreline change rates and bank retreat rates were not made for areas farther south of 91 Baxter Road, since the coastal bank was <u>not</u> actively retreating throughout this time period.

5.0 Discussion of CZM Recommendations

Ms. Rebecca Haney of CZM provided a recommended sand volume to the Conservation Commission in a letter dated August 26, 2013 for the revetment project. As noted in SBPF's submission to the Conservation Commission on September 6, 2013, Ms. Haney's suggestion to utilize short-term shoreline change rates from 1978-2009 to estimate the volume of sediment eroded from the coastal bank fails to consider the coastal setting at Sconset and, by doing so, recommends the use of irrelevant data. The Sconset shoreline and beyond (from the Sewer Beds at the south to Wauwinet at the north) have been carefully monitored on a quarterly or semi-annual basis for nearly twenty years, yielding an impressive record of highly-accurate data. This monitoring has consistently shown that shoreline erosion rates in areas where the coastal bank is fronted by dunes are ***significantly higher*** than shoreline rates in areas with an eroding coastal bank. (This observation is as expected, since an eroding dune contributes less to the littoral system than an eroding bank.) In other words, survey data show that the shoreline change rates in areas fronted by

dunes are ***not representative*** of the coastal bank retreat rate. Rather, the shoreline change rate and coastal bank retreat rate may only begin to approximate one another after the coastal dune and any vegetated portion of the coastal bank have completely eroded and sufficient time has passed for an equilibrium to be reached. The coastal dune in the Project area was still present during much of the 1978-2009 time period; therefore, Ms. Haney's suggestion to use a 1978-2009 shoreline change rate to approximate coastal bank retreat is untenable.

Ms. Haney quotes a shoreline change rate of 6 to 10 feet/yr from 1978-2009 in the "project area," but this analysis apparently overlooks the northern section of the revetment project area. The CZM shoreline change data for the Project area (63-119 Baxter Road; CZM transects 285 through 306) indicates somewhat lower shoreline change rates, in the range of 4 to 9.7 feet/yr, and even these rates are in applicable given that they reflect dune erosion, not bank erosion, in the earlier years. Additionally, the CZM data is subject to uncertainty; such uncertainty is inherent to the methodology of identifying a shoreline from aerial photographs used for the broad-reaching CZM shoreline change data project. Although CZM quantifies this uncertainty for each transect; Ms. Haney fails to acknowledge this uncertainty, even though the average uncertainty for the transects in the Project area is almost 3 feet.

Ultimately, Ms. Haney's analysis does not consider the coastal setting at Sconset and therefore in our opinion does not provide an accurate representation for this project.

6.0 Discussion of the 2005 CP&E Sediment Budget

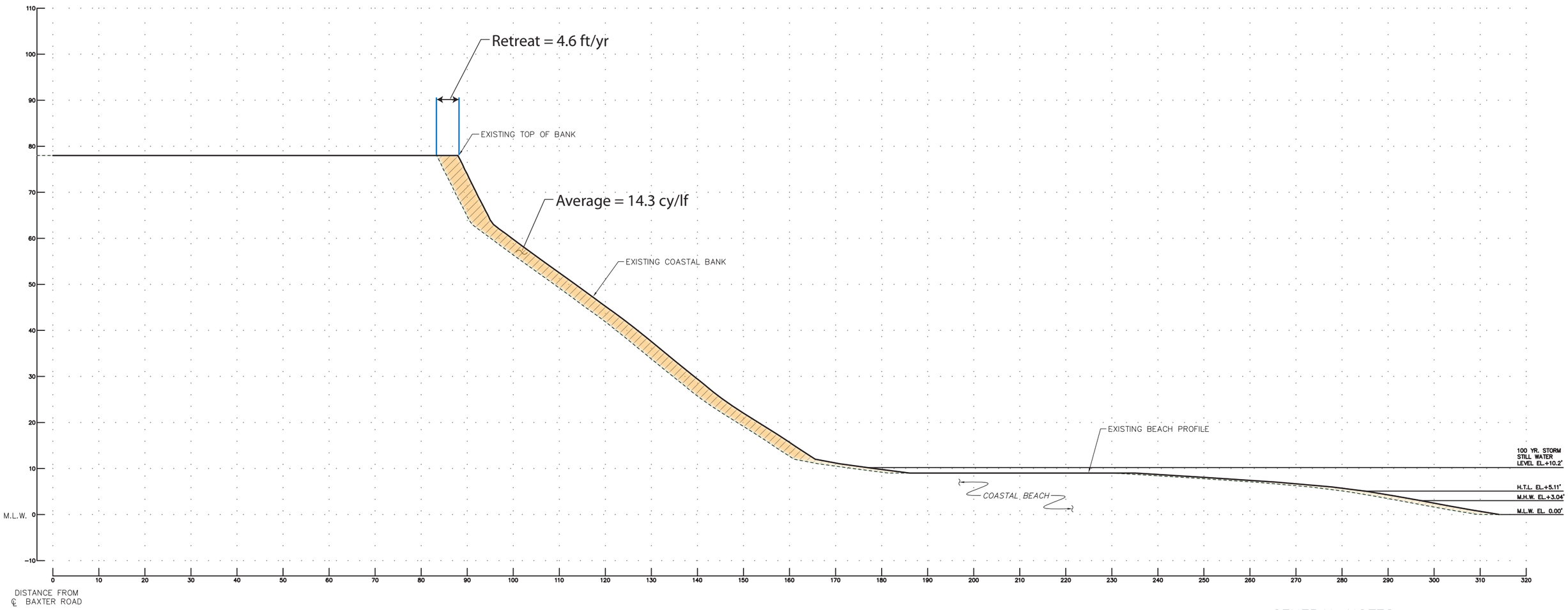
During the permitting effort for the beach nourishment project, Coastal Planning & Engineering (CP&E) prepared a littoral budget based upon data from 1995-2005. (See FEIR, Sconset Beach Nourishment Project, November 30. 2006. Attachment A, Coastal Planning and Engineering (CPE) Engineering Design Report, Sconset Beach Nourishment Project, Nantucket, Massachusetts. Section 8.0, "Littoral Budget" is included as Attachment B to this memo.) This sediment budget relied upon several assumptions (such as locating the nodal point at the area of greatest erosion, applying the shoreline change rate to entire coastal profile [including eroding coastal bank], determining the volume associated with each profile by multiplying the active profile height times the shoreline recession rate and effective distance between profiles) that are appropriate for use in designing a beach nourishment project, but that may not be as appropriate for quantifying the volume and direction of sediment transport in the project area for the purposes of designing a sand mitigation program. While we feel that the CP&E analysis for the beach nourishment project has limitations when applied to the geotube or revetment project, we nonetheless reviewed their analysis to serve as another check of the proposed sediment mitigation volume.

Table 6 presents the CP&E sediment budget values for those profiles within the geotube Project area (profiles 91, 92, and 92.5). The table has been updated from the original CP&E

analysis in three places: (1) the shoreline change rates have been updated to reflect the most current conditions, based on the results of the March 2013 shoreline survey; (2) the active profile height has been changed to reflect the height of the eroding bank, rather than the entire coastal profile out to the depth of closure, to reflect the geotube project's commitment to mitigate the amount of sand eroded from the coastal bank; (3) the discount of the silt percentage applied by CP&E has been removed. This analysis yields an estimated bank contribution volume of **11.4 cy/lf** (see Table 6). This volume is lower than the proposed volume of **14.3 cy/lf**, again indicating that the sand mitigation volume proposed for the geotube project is adequate and possibly conservative (i.e., it may slightly overestimate the bank contribution volume).

G:\Projects\Lighthouse\2013\ConCom\Retreat\Revised\Detailed_Analysis_v2\1994-2003-2013.mxd

Baxter Road Nantucket, MA **Figure 1**



GENERAL NOTES

1. ALL ELEVATIONS ARE BASED ON MEAN LOW WATER DATUM (M.L.W.=0.0').

Baxter Road Nantucket, Massachusetts

Epsilon ASSOCIATES INC.

Figure 2

Coastal Bank Sediment Contribution – Representative Profile (85 Baxter Road)

Table 2. Top of Coastal Bank Retreat Rate Data for 85-107A Baxter Road (1994-2013)

Transect	Lot	1994-2013		2003-2013 (ft)	
		Retreat (ft)	Rate (ft/yr)	Retreat (ft)	Rate (ft/yr)
30	107A	46.2	2.4		
31	107A	43.9	2.3		
32	107A	47.5	2.5		
33	107	51.1	2.7		
34	107	56.2	3.0		
35	107	53.8	2.8		
36	107	57.7	3.0		
37	107	57.3	3.0		
38	105	50.2	2.6		
39	105	50.0	2.6		
40	105	58.5	3.1		
41	105	82.3	4.3		
42	105	84.0	4.4		
43	105	79.8	4.2		
44	105	77.4	4.1		
45	105	75.9	4.0		
46	105	74.7	3.9		
47	101	79.4	4.2		
48	101	76.8	4.0		
49	101	77.3	4.1		
50	101	73.7	3.9		
51	101	75.1	4.0		
52	101	76.3	4.0		
53	101	78.8	4.1		
54	101	77.5	4.1		
55	101	67.8	3.6		
56	Public Access	74.5	3.9		
57	99	70.2	3.7		
58	99	68.1	3.6		
59	99	75.7	4.0		
60	99	80.4	4.2		
61	99	75.1	4.0		
62	99	77.3	4.1		
63	99	84.0	4.4		
64	99	85.5	4.5		
65	99	85.9	4.5		
66	97	81.0	4.3		
67	97	77.2	4.1		
68	97	84.7	4.5		
69	97	91.4	4.8		
70	97	99.2	5.2		
71	97	99.0	5.2		
72	97	100.4	5.3		
73	97	98.1	5.2		
74	93	85.6	4.5		
75	93	95.4	5.0		
76	93	98.8	5.2		
77	93	104.5	5.5		
78	93	108.2	5.7		
79	91	97.7	5.1		
80	91	71.1	3.7		

Transect	Lot	1994-2013		2003-2013 (ft)	
		Retreat (ft)	Rate (ft/yr)	Retreat (ft)	Rate (ft/yr)
81	91			31.9	3.2
82	91			20.5	2.1
83	87			13.2	1.3
84	87			22.8	2.3
85	87			55.1	5.5
86	87			76.8	7.7
87	87			84.5	8.5
88	87			81.1	8.1
89	87			61.6	6.2
90	87			48.3	4.8
91	85			67.7	6.8
92	85			67.4	6.7
93	85			61.0	6.1
94	85			60.6	6.1
95	85			54.9	5.5
96	85			59.1	5.9
97	85			66.8	6.7
98	85			72.3	7.2
99	85			67.3	6.7
100	85			67.2	6.7
101	85			67.9	6.8
102	85			64.3	6.4
103	85			64.5	6.5
Average Bank Retreat Rate by Section			**4.0**		**5.8**
Distance weight (#transects/total transects)			0.7		0.3
Average Bank Retreat Rate 85-107A					**4.6**

Table 3. Coastal Bank Contribution Volume for 85-107A Baxter Road

Lot	Retreat Rate ft/yr	Section Volume cy	Lot Length[1] ft	Weight (Lot Length/Total Project Length)	Volume*Weight cy
107A	4.6	17.2	71	0.05	0.8
107	4.6	16.9	100	0.06	1.1
105	4.6	16.0	175	0.11	1.8
101	4.6	14.7	200	0.13	1.9
99	4.6	13.9	185	0.12	1.6
97	4.6	13.6	180	0.11	1.6
93	4.6	13.3	98	0.06	0.8
91	4.6	13.3	94	0.06	0.8
87	4.6	13.5	177	0.11	1.5
85	4.6	13.3	294	0.19	2.5
Total Project Length[1](ft)			1574		
Average Bank Contribution Volume (cy)					**14.3**

1. Length measured along the +26 MLW contour.

Table 4a. WHG Sconset Bluff and Shoreline Change Data for Profiles 90, 90.6, and 91 (2006, 2008, 2013)

Approximate Location	Year	Shoreline (0-MLW ft)		Top of Bluff		Toe of Bluff	
		D (ft)	Z (ft, MLW)	D (ft)	Z (ft, MLW)	D (ft)	Z (ft, MLW)
Profile 90							
69/71 Baxter Road	2006	34.6	0	-144.19	73.1	-68.59	11.7
	2008	43.3	0	-154.89	72.31	-76.8	12.23
	2013	50.3	0	-161.5	74.04	-75.5	9.41
Profile 90.6							
79/81 Baxter Road	2006	14.1	0	-128.49	81.9	-33.59	9.3
	2008	29.5	0	-135.04	84.4	-27.85	8.93
	2013	36.1	0	-167.04	84.86	-71.68	9.44
Profile 91							
91 Baxter Road	2006	21.8	0	-174.24	76.3	-71.65	8.4
	2008	21.7	0	-174.1	76.3	-77.34	10.6
	2013	26.2	0	-197.52	76.72	-113.61	9.64

D is distance along baseline relative to 0 at benchmark
Z is elevation relative to MLW 1992

Table 4b. WHG Sconset Bluff Volume Change Data for Profiles 90, 90.6, and 91 (2006-2013)

Profile	Distance ft	Distance Weight	2006-2013 Bank Contribution Volume[1] cy
90	425	0.25	4.5
90.6	639	0.38	17.6
91	622	0.37	12.4
Weighted Bluff Retreat Volume			**12.4**

1. Determined by calculating that volume associated with the difference in bluff positions from 2006 to 2013.

Table 5. Shoreline Change Rates from November 1994 to March 2013[1]

Profile	Approximate Location	Effective Distance[2] ft	Weight (Effective Distance / Total Distance)	Shoreline Change Per Profile[1] (Nov 1994-Mar2013) ft	Average Annual Shoreline Change ft (Shoreline Change/ 18.4 years)
91	91 Baxter	622	0.43	-96.5	-5.2
91.5	99/101 Baxter	431	0.30	-58.9	-3.2
92	105 Baxter	404	0.28	-45.4	-2.5
Total Distance (ft)		1457			
Weighted average 85-107A Baxter Road					**-3.9**

1. From Southeast Nantucket Beach Monitoring, March 2013, 60th Survey Report, prepared by Woods Hole Group, August 2013.
2. From FEIR, Sconset Beach Nourishment Project, November 30. 2006. Attachment A, Coastal Planning and Engineering (CP&E) Engineering Design Report, Sconset Beach Nourishment Project, Nantucket, Massachusetts.

Table 6. Update of Coastal Planning & Engineering 1995-2005 Littoral Budget Analysis

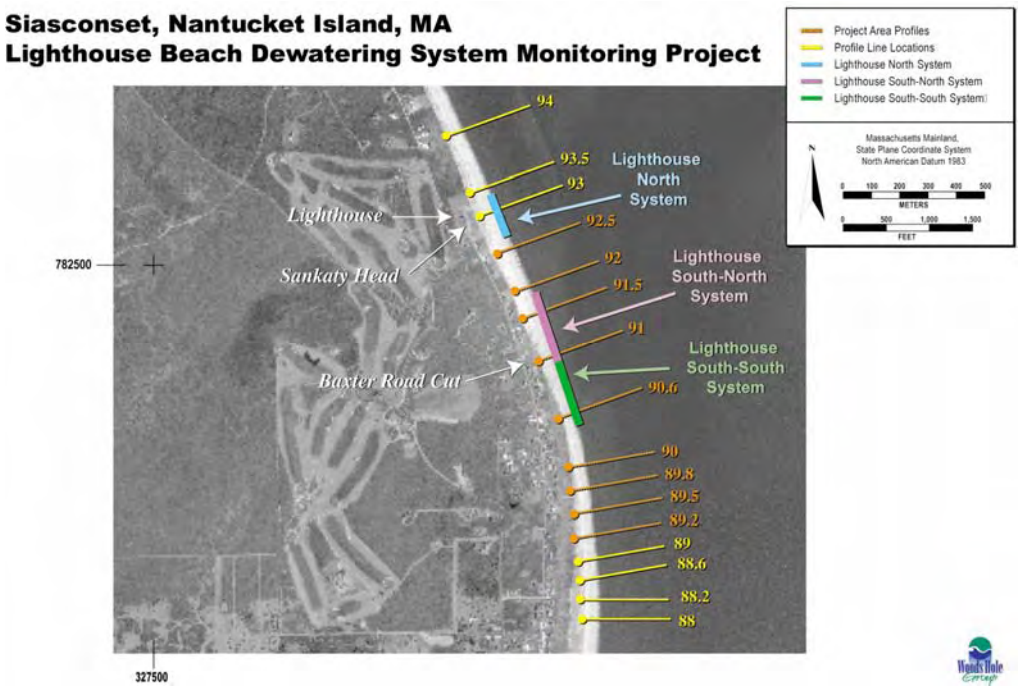
Profile	Approximate Location	Effective Distance[2] ft	Shoreline Change Per Profile[1] (Nov 1994-Mar2013) ft	Average Annual Shoreline Change ft (Shoreline Change/ 18.4 years)	Top of Bank Height[2] ft, MLW	Toe of Bank ft, MLW	Active Profile Height ft	Volume[3] (cy)
91	91 Baxter	622	-96.5	-5.2	82	8	74	-8941
91.5	99/101 Baxter	431	-58.9	-3.2	90	8	82	-4190
92	105 Baxter	404	-45.4	-2.5	102	8	94	-3470
Total Volume Eroded from Project Area (CY)								-16601
Total Volume Eroded from Project Area (CY/LF)								**-11.4**

1. From Southeast Nantucket Beach Monitoring, March 2013, 60th Survey Report, prepared by Woods Hole Group, August 2013.
2. From FEIR, Sconset Beach Nourishment Project, November 30. 2006. Attachment A, Coastal Planning and Engineering (CP&E) Engineering Design Report, Sconset Beach Nourishment Project, Nantucket, Massachusetts.
3. Volume determined by multiplying the effective distance * active profile height * average annual shoreline change, then dividing by 27 to convert to cy (per Section 8.0 of CP&E report referenced above in #2).

SOUTHEAST NANTUCKET BEACH MONITORING

March 2013

60th SURVEY REPORT



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August 2013

Southeast Nantucket Beach Monitoring

March 2013

60th SURVEY REPORT

August 2013

Prepared for:
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1.0 INTRODUCTION

Woods Hole Group, Inc. was contracted by the Siasconset Beach Preservation Fund (SBPF) to collect and analyze beach profile data related to the ongoing shoreline monitoring efforts. This report summarizes the March 2013 topographic survey data, which is the 60th survey conducted at Siasconset since 1994. WHG prepared similar data reports beginning with the 23rd survey. Previously, Coastal Planning & Engineering, Inc. (CP&E) completed more than five-years of monitoring at Siasconset, Nantucket Island, including 22 reports, after the installation of the initial dewatering systems. Coastal Stabilization, Inc. (original license holder in US) installed the original systems in August 1994 in an effort to mitigate beach erosion. One of these systems (Lighthouse South-South) was upgraded during 2001, subject to new permit conditions, as summarized in the SOC (SE 48-1248), U.S. Army Corps of Engineers (USACE) permit, local OOC, Waterways license, and CZM Consistency Statement. SOC SE 48-1248 required quarterly surveys with comparisons against the December 2001 baseline survey. The dewatering systems were shut down in December 2004, and the 3 years of post-upgrade surveys required by the SOC SE 48-1248 were completed. Subsequently, the systems have since been removed. Since this time, the focus of the surveys and reports is not on the performance of the dewatering system. Instead, surveys are intended to document beach profile and shoreline change in the region, and to help plan for and monitor ongoing and future shore protection initiatives.

This report provides comparisons of the recent March 2013 survey to previous data sets back to 1994. This report summarizes the results of volume and shoreline change calculations for three time periods:

- November 1994 survey through December 2001 (pre-operational period prior to the system upgrade);
- December 2001 through September 2012 (post-upgrade); and
- September 2012 through March 2013 (the last survey period).

The survey reports present new beach profile data and compare new beach profiles to previous data. Volume calculations and shoreline change analysis are provided to reveal erosion and accretion trends along the beach. This report does not discuss dewatering system performance or mitigation issues, which are not relevant at this time.

This report is presented in three sections plus one appendix.

- Specific information regarding the March 2013 topographic survey and beach profiles is presented in Section 2.0;
- Section 3.0 presents results of the volume and shoreline change calculations;
- Profile data are plotted in Appendix A.

2.0 MARCH 2013 SURVEY AND PROFILES

2.1 LAND-BASED SURVEY

Woods Hole Group conducted the 60th beach survey to a depth of -5 MLW from March 27-28th, 2013. Profile locations are shown in Figure 1. The horizontal datum for the project is the Massachusetts State Plane Coordinate System, Island Zone (1927), and the vertical datum is MLW, set in 1934 and corrected with 1992 NOAA adjustments by Blackwell and Associates, Inc. (BAI). Profiles were constructed based on RTK GPS data collected along the subaerial beach profile and traditional electronic total station survey data collected in the surfzone. Three geodetic control points were utilized for this survey:

- U.S. Coast and Geodetic Survey disk set in a large boulder located near the intersection of Quidnet and Squam Roads and stamped with the date 1934 and locally known as “Sugarloaf” (N 111,450.63, E 342,409.99, EL.=40.16 MLW92).
- Beach profile Station 84.6, a capped rebar set in a 4” PVC pipe located in the dune at the intersection of Beach Street and Codfish Park Road (N 96,006.53, E 347,614.23, EL.=12.31 MLW92).
- U.S. Coast Guard Disk #1, a brass disk stamped with the date 1961 located across the street from the entrance to the U.S.C.G. family housing near the Loran tower at Low Beach (N 92,601.73, E 344,906.23, EL=13.50 MLW92).

Woods Hole Group conducted the March 2013 survey using a Trimble® R7 GPS, a real-time kinematic global positioning system (RTK GPS). This GPS equipment provides centimeter-level geodetic positioning. The surveyor navigates to previously established (but unmarked) beach monitoring benchmarks, and collects topographic profile data without having to recover and reoccupy beach monuments at each profile. The system operates by establishing a GPS base station over a known geodetic control point. The base station communicates via a radio link with a second GPS receiver in a backpack worn while collecting the survey points on a hand-held data logger. The real-time horizontal positioning data is used to "steer to" the coordinates of the benchmark for each profile, and then walk perpendicular to the bank/bluff to collect the profile data. The RTK GPS equipment limits the surveyor’s ability to wade to -5 MLW due to cabling, and is incapable of collecting wading shots due to excess movement. To remedy this, a Topcon GTS-3B electronic total station was utilized to collect the wading profile data.

Table 1 lists the profiles surveyed by BAI for the November 1994 and December 2001 surveys, and the profiles surveyed by Woods Hole Group for the March 2012 survey. All profiles reached -5 MLW. As explained in Section 3, ongoing erosion in the area afforded surveys of certain profiles extending landward of earlier 1994 and 2001 profiles, providing data for more informative volume calculations farther landward compared to most recent data sets. The “Distance” column in Table 1 represents the landward distance from the original benchmarks for which volume calculations were made between the two most recent surveys. Red numbers represent beach profiles for which volume change was calculated farther landward than in previous reports.

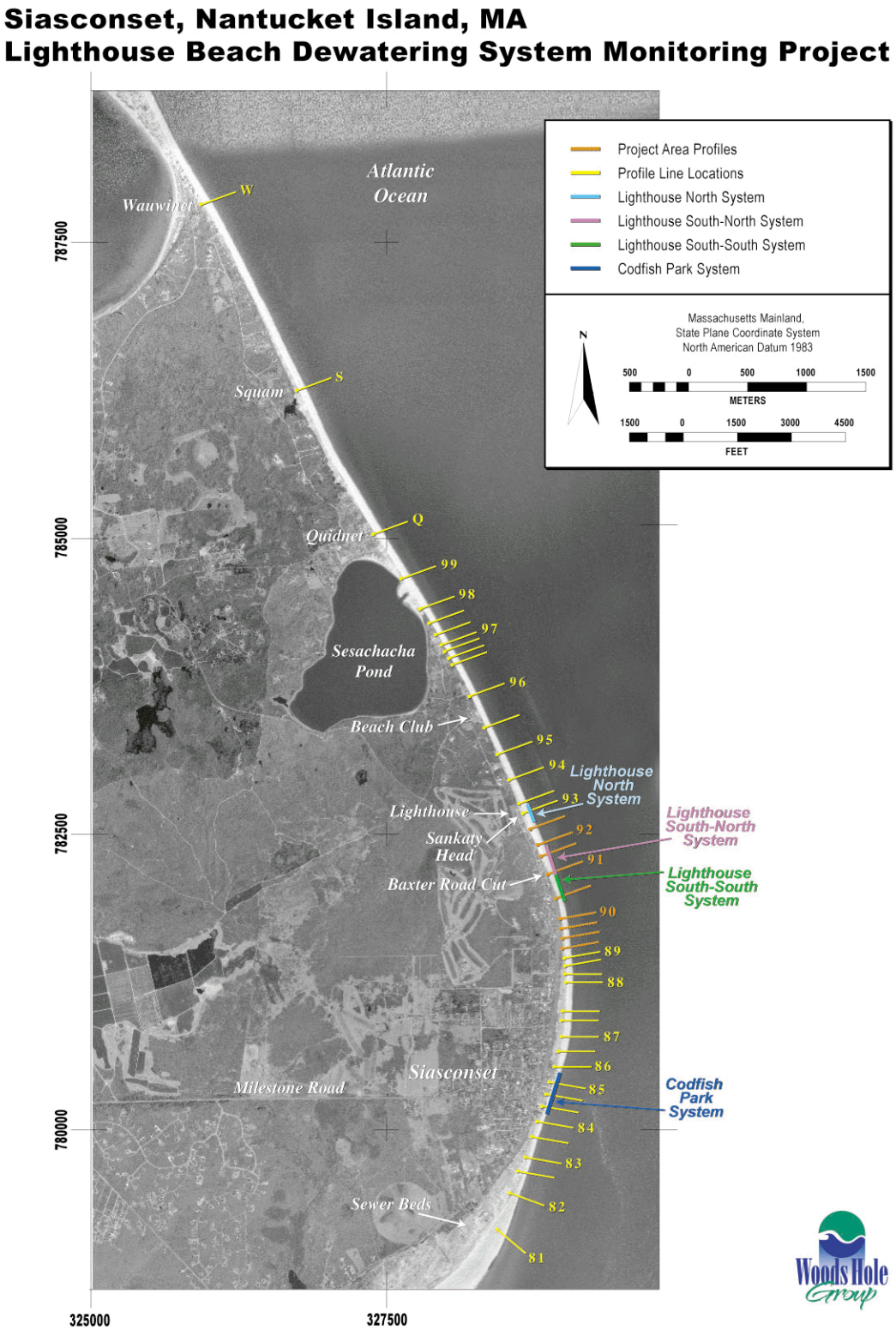

Figure 1. Project Location and Profile Map

Table 1. Profiles Surveyed (Project area shaded)

PROFILE NAME	Distance (ft)	SURVEY DATE			
		Nov-94	Dec-01	Sep-12	Mar-13
81	-200	✓	✓	✓	✓
82	-70	✓	✓	✓	✓
82.6	-50	N/A	✓	✓	✓
83	-20	✓	✓	✓	✓
83.5	-50	✓	✓	✓	✓
84	-20	✓	✓	✓	✓
84.3	0	✓	✓	✓	✓
84.6	0	✓	✓	✓	✓
85	0	✓	✓	✓	✓
86	-30	✓	✓	✓	✓
86.5	-223	✓	✓	✓	✓
87	-75	✓	✓	✓	✓
87.4	-146	N/A	✓	✓	✓
87.5	-155	✓	✓	✓	✓
88	-130	✓	✓	✓	✓
88.3	-110	✓	✓	✓	✓
88.6	-110	✓	✓	✓	✓
89	-167	✓	✓	✓	✓
89.2	-98	✓	✓	✓	✓
89.5	-89	✓	✓	✓	✓
89.8	-72	✓	✓	✓	✓
90	-102	✓	✓	✓	✓
90.6	-59	✓	✓	✓	✓
91	-111	✓	✓	✓	✓
91.5	-72	✓	✓	✓	✓
92	-68	✓	✓	✓	✓
92.5	-53	✓	✓	✓	✓
93	-26	✓	✓	✓	✓
93.5	-50	✓	✓	✓	✓
94	-52	✓	✓	✓	✓
95	-54	✓	✓	✓	✓
95.5	-56	✓	✓	✓	✓
96	-33	✓	✓	✓	✓
96.5	-19	✓	✓	✓	✓
96.7	-18	✓	✓	✓	✓
96.9	-5	✓	✓	✓	✓
97	-11	✓	✓	✓	✓
97.3	-15	✓	✓	✓	✓
97.6	-12	✓	✓	✓	✓
98	0	✓	✓	✓	✓
99	0	✓	✓	✓	✓
Q	-24	✓	✓	✓	✓
S	0	✓	✓	✓	✓
W	-30	✓	✓	✓	✓

N/A Not Available
RED NUMBER = profile using updated volume calculation windows

3.0 RESULTS

3.1 VOLUME CALCULATIONS

Volume calculations were performed using Matlab, and are presented in this report for these time periods:

- November 1994 to December 2001 (the dewatering system pre-operational period);
- December 2001 to September 2012 (the period from dewatering system activation through the last survey);
- September 2012 to March 2013 (the duration since last survey).

These surveys characterize volume change in the profile from the seaward position of the –5 ft isobath, landward to the toe of the dune (Xon). Volume calculations were computed from a landward limit ("baseline distance"), as specified in Table 1, to an offshore depth of –5 ft MLW. This baseline distance location was determined based on the toe of the bank locations for the December 2001 pre-operational survey (where applicable) or as far back as data were available for comparison with other surveys. Specific profiles were also translated horizontally to account for the movement of the benchmarks over time as the beach eroded in certain places (i.e., the 0 point in the field is the stake location, which had changed). Some of these translations are cumulative since December 2001, since five benchmarks were relocated between December 2002 and March 2003 (profiles 81, 87.5, 88.3, 91, and 93) as documented in the 32nd report. A different set of baseline distances was specified for comparisons with November 1994, since surveys at that time did not extend landward of the benchmarks (original baseline). For profiles 91 and 91.5, the baseline distance was modified from 0 ft to -20 ft because the ground survey in December 2001 did not extend landward beyond the toe of dune.

More recently, progressive erosion of the profiles since 2001 has resulted in a scenario where the active portion of certain profiles retreated landward of the baseline distance within which prior volume calculations are made. Figure 2 shows an example for profiles 90.6 and 91; the vertical dashed lines indicate the region within which volume calculations were made in this and prior reports. Prior to 2001, the "Old" area shown in Figure 2 represented the active profile; however, prevailing erosion produced a scenario where recent volume calculations limited to within the Old baseline distance do not represent overall profile change, since a significant portion of the active berm extends landward of the Old baseline. For instance, volume change for several profiles known to have eroded substantially would result in a positive volume change calculation indicating accretion if limited to the Old baseline distance. This trend exists for other profiles, but is not consistent across all profiles. Based upon discussions with SBPF, it was determined that volume calculation will now be extended landward as needed to more accurately represent beach volume change. The seaward limit of -5ft MLW isobath was maintained, while the landward limit of the profile was extended as far landward as practical to compare recent profiles ("New" distance shown by Figure 2). The adjusted profiles are highlighted red in column two of Table 1. The New results are not directly comparable

to calculations made for prior time periods in previous reports, but are more representative of recent dynamic beach response.

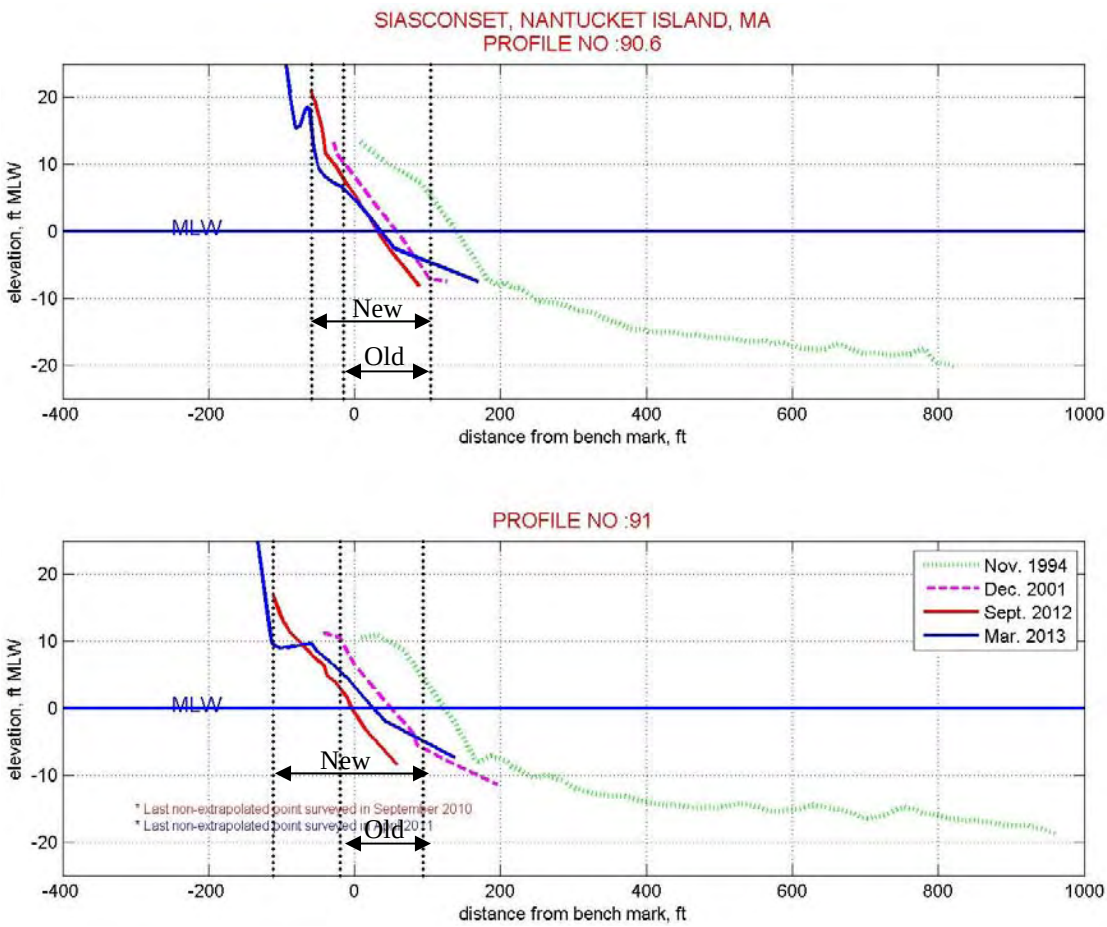

Figure 2. Profile for 90.6 and 91 indicating how the volume calculation region expanded for the March 2013 profiles.

Volume and shoreline change were calculated for the profiles in the entire monitoring area (profiles 81 to W), and the narrower project area as defined in the modified SOC. The project area is defined as the area extending from profile 89.2 through profile 92.5 (Figure 3). The mitigation areas, 1,000 ft to both sides of the previous Lighthouse South-South dewatering system site, are included in the definition of the project area. Profiles 90, 90.6 and 91 are used to calculate the treated area changes, profiles 89.2, 89.5, 89.8, 90 and 90.6 are used to calculate the south mitigation area changes, and profiles 90.6, 91, 91.5, 92, and 92.5 are used to calculate the north mitigation area changes. Although the dewatering system is no longer performing, these "project" and "mitigation" area definitions are maintained for consistency and comparison to past reports.

Table 2 lists the volume change for each profile station from November 1994 to March December 2001, December 2001 to September 2012, and September 2012 to March 2013. Results are summarized below.

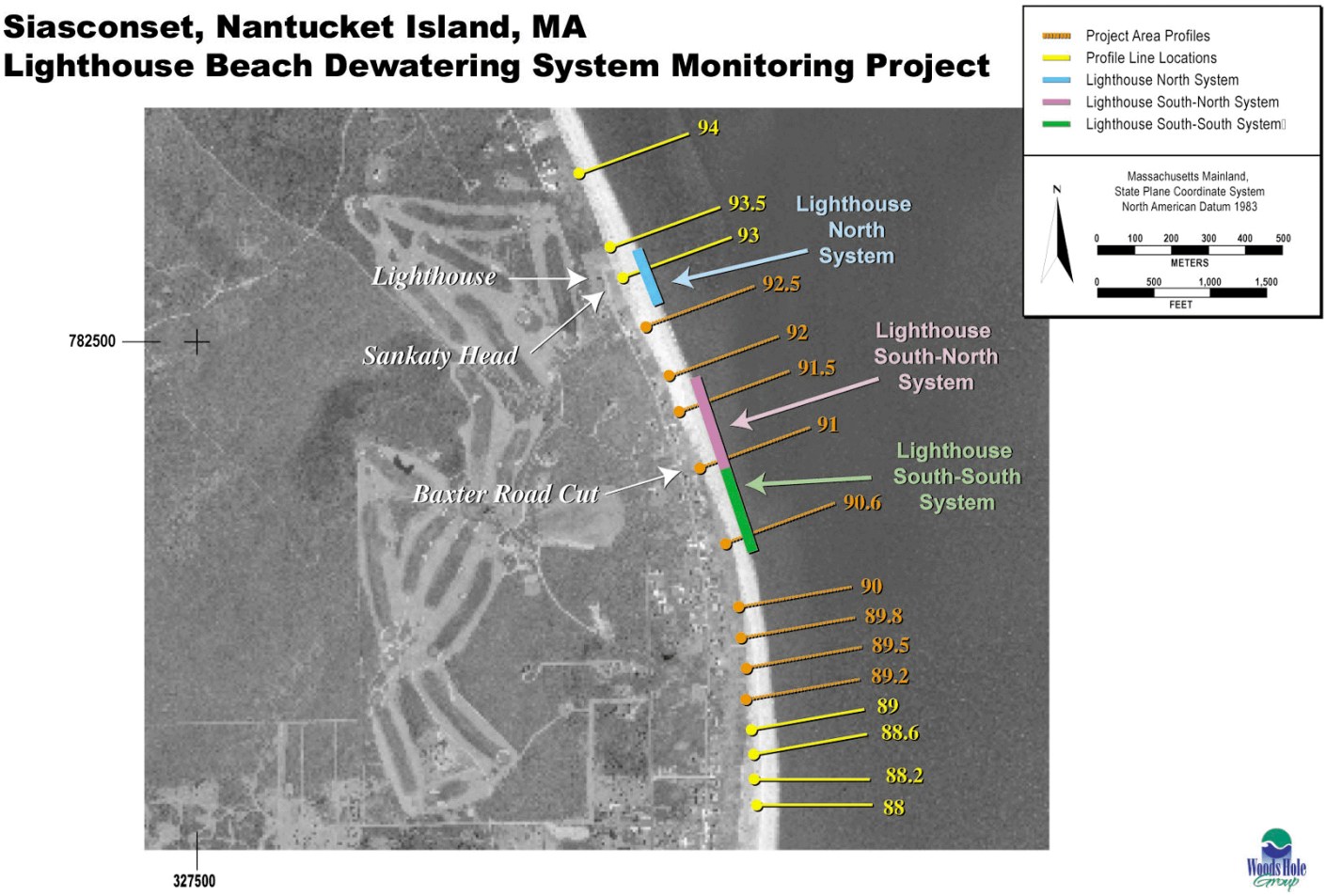

Figure 3. Previous Lighthouse dewatering system sites and project area

Table 2. Volume change per profile from Nov. 1994 to Dec. 2001, Dec. 2001 to Sept. 2012, and Sept. 2012 to Mar. 2013 (+ Accretion, - Erosion)

PROFILE	VOLUME CHANGE PER PROFILE		
	Nov-94 to Dec-01 cy/ft	Dec-01 to Sept-12 cy/ft	Sep-12 to Mar-13 cy/ft
81	-69	5.8	26.8
82	-31.7	12.9	6.2
82.6	N/A	13.3	3.9
83	47.7	22.4	-1.8
83.5	37.6	65.2	-16.5
84	11.8	75.1	-28.9
84.3	14.1	59.4	-31.9
84.6	36.4	0.6	-5.1
85	39.4	-8.1	-25.7
86	4	-16.9	-14.3
86.5	-27.1	-27.8	-20.0
87	-56	-14.5	-22.2
87.4	N/A	-13.4	-25.7
87.5	-50.4	-18.8	-32.5
88	-41.5	-33.9	-29.5
88.3	-48.5	-30.8	-23.9
88.6	-48.8	-24	-23.6
89	-55.5	-18	-19.1
89.2	-60.7	-11.2	-21.1
89.5	-65.2	-14.5	-12.8
89.8	-67.9	-11.3	-11.2
90	-61.5	-9.9	-8.8
90.6	-51.6	-11.9	-6.5
91	-42	-30.1	5.6
91.5	-21.1	-36.6	6.9
92	-12.5	-21.9	6.5
92.5	-21.1	-4.4	-4.7
93	-30.9	1.3	-6.5
93.5	-35.7	2.6	-8.7
94	-25.9	-10	-0.5
95	-25.3	-11.2	-8.2
95.5	-33.2	-23.1	-4.2
96	-6.2	-13.9	-5.4
96.5	-1.9	2.8	-9.7
96.7	-2	3.8	-3.0
96.9	-2.1	14.8	-11.6
97	-7.2	20.9	-5.9
97.3	-3.1	15	-6.0
97.6	3.4	8.5	-2.8
98	-0.3	13.3	-6.6
99	-1.9	25.8	-7.7
Q	6.7	-0.3	-2.4
S	21.4	19.6	-7.9
W	16.5	16.9	1.7

(Project area shaded) (N/A: Not Available)
RED NUMBER = profile using updated volume calculation windows

3.1.1 November 1994 to December 2001

This dewatering system preoperational period extends from the November 1994 (the earliest pre-construction survey) to the December 2001 survey (Table 3).

- Overall, 31 of the 42 profiles eroded since November 1994 (Note profiles 82.6 and 87.4 did not exist in November 1994).
- The central portion of the monitoring area eroded (profile lines from 86.5 through 95.5), from just north of Codfish Park to Sesachacha Pond). Maximum erosion was focused between profiles 87 and 91, where total erosion since 1994 exceeds 40 cy/ft; with a maximum of 68 cy/ft of erosion at profile 89.8.
- The southernmost profiles, characterized by profiles 83 through 86, accreted with the exception of profiles 81 and 82. Maximum accretion was more than 47 cy/ft at profile 83.
- The beach has been relatively stable and even accreting over the long-term from profiles 96 through W.
- In the project area, all profiles from 89.2 to 92.5 eroded between 12 and 67 cy/ft in over 7 years since November 1994.

3.1.2 December 2001 to September 2012

This period extends from the activation of the dewatering system through the last survey in September 2012. Table 3 presents volume change for the monitoring area.

The monitoring area performed as follows:

- Overall 24 transects eroded during the reporting period.
- The southern portion of the monitoring area, profile 81 through profile 84.6, gained sediment over the past 11 years.
- Maximum accretion occurred at profile 84, where more than 75 cy/ft of sediment accumulated in the past 11 years.
- The central portion of the study area, between profiles 85 through 92.5 eroded
- Maximum erosion of more than 36 cy/ft occurred at profile 91.5.
- In the northern reach beach volume changes from profile 96.5 to W were generally positive (0 to 25 cy/ft of accretion).
- In the project area, all profiles from 89.2 to 92.5 eroded between 4 and 36 cy/ft in 11 years since December 2001.

3.1.3 September 2012 to March 2013

This period spans the duration since the last survey in September 2012. Table 3 presents the results. The volume change calculation was adjusted for a number of profiles (highlighted in red in Table 3) as discussed in Section 3.1.

The monitoring area performed as follows:

- Of the 44 profiles surveyed in the monitoring area, 37 profiles eroded, and 7 profiles accreted since September 2012; erosion was the dominate trend for most profiles since the last survey.
- Maximum erosion occurred at profile 87.5, which eroded more than -31 cy/ft and maximum accretion occurred at profile 81, which gained 26 cy/ft.
- Erosion was concentrated between profiles 83.5 and 89.8, where erosion ranged from 5 cy/ft and up to 31 cy/ft.
- In the project area, three profiles accreted and six profiles eroded with a maximum erosion of -21 cy/ft.

3.2 SHORELINE CHANGE ANALYSIS

Woods Hole Group evaluated shoreline change (retreat or advance of the mean low water line) to provide qualitative insight regarding beach response in the project vicinity. This section provides a comparison of shoreline changes since November 1994 for the monitoring area for the three periods under investigation.

Shoreline distances were measured from the baseline horizontally to the 0 ft MLW92 contour level. This elevation was selected for comparison with prior reports. These surveys included comparisons between the earliest survey of November 1994, the pre-operation survey of December 2001, the last survey in September 2012, and the latest March 2013 survey. Table 3 lists shoreline change by profile for the surveys under investigation. Figure 4 illustrates the change in the shoreline positions.

Results can be summarized as follows:

3.2.1 November 1994 to March 2013

- In general, the shoreline advanced in the southern portion of the monitoring area (profiles 82 to 85), retreated substantially in the middle (profiles 86 to 96.7), and was relatively stable or accreting at the northern portion (profiles 96.9 to W).
- Maximum shoreline advance occurred between profiles 83 and 84.6, where the shoreline advanced more than 65 ft, and as much as 150 ft at profile 83.5.
- Maximum shoreline retreat occurred between profiles 86.5 and 91, where the shoreline retreated more than 87 ft and as much as 134 ft at profile 88.3.

3.2.2 December 2001 to March 2013

- Although there has been more variability, the shoreline change trend since December 2001 is similar to the trend since 1994. The southern and northern limits accreted while the middle of the monitoring area eroded.
- An exception to the trend is at the very southern end (profiles 81 and 82) where the overall trend of erosion since 1994 has been accreting since 2001.
- Shoreline advance since December 2001 occurred between profiles 81 and 84.6, with a maximum shoreline advanced of 113 ft at profile 81.

- Shoreline retreat since December 2001 occurred between profiles 85 and 96.5, with a maximum shoreline loss of 63 ft along profile 88.

3.2.3 September 2012 to March 2013

- The shoreline advanced (29 of 44 profiles) between profiles 81 and 83.5 and 89.5 and W since the last survey.
- Maximum shoreline advance in the past seven months occurred at profile 81, accreting 114 ft.
- Erosion was focused between profiles 84 and 89.2 with maximum retreat of 24 ft and 25 ft at profiles 87.5 and 84.3.
  In the project area the shoreline along all profiles, except 89.2, advanced likely due to a portion of sediment eroded from the bluffs remaining on the beach.

Table 3. Shoreline changes from Nov. 1994, Dec. 2001, and Sept 2012 to March 2013 (Distances seaward from benchmark to 0 ft MLW92 contour)

PROFILE	SHORELINE CHANGE PER PROFILE Nov-94 to Mar-13 ft	SHORELINE CHANGE PER PROFILE Dec-01 to Mar-13 ft	SHORELINE CHANGE PER PROFILE Sept-12 to Mar-13 ft
81	-15.7	113.0	114.1
82	8.9	52.7	46.9
82.6	N/A	42.9	37.8
83	129.0	43.9	22.7
83.5	150.2	84.7	0.2
84	119.5	100.5	-19.4
84.3	88.4	64.6	-25.6
84.6	65.8	13.6	17.3
85	32.0	-30.3	-14.8
86	-33.3	-38.6	-4.1
86.5	-87.2	-40.8	-1.1
87	-120.8	-26.5	-0.8
87.4	N/A	-32.7	-16.1
87.5	-133.3	-53.3	-24.3
88	-131.0	-63.0	-13.1
88.3	-134.8	-53.7	-9.1
88.6	-130.6	-44.4	-7.7
89	-129.7	-33.4	-1.9
89.2	-125.9	-27.6	-6.8
89.5	-115.0	-15.6	18.2
89.8	-117.6	-10.5	14.9
90	-121.9	-14.1	8.6
90.6	-103.5	-21.6	5.0
91	-96.5	-6.6	30.2
91.5	-58.9	8.4	37.9
92	-45.4	-27.1	26.2
92.5	-41.3	-0.7	11.8
93	-47.3	-2.8	2.5
93.5	-66.8	-2.0	1.4
94	-50.8	-10.2	13.4
95	-64.7	-22.7	3.2
95.5	-76.1	-40.6	3.1
96	-42.5	-10.5	15.0
96.5	-6.2	-1.1	0.9
96.7	-0.9	6.2	8.1
96.9	4.6	7.9	-3.5
97	13.2	22.9	-0.5
97.3	13.6	18.9	7.2
97.6	14.3	10.2	8.0
98	4.5	5.7	2.5
99	23.7	24.3	1.2
Q	3.7	4.3	11.8
S	33.2	12.9	1.3
W	25.8	22.3	12.0

(N/A : Not Available)

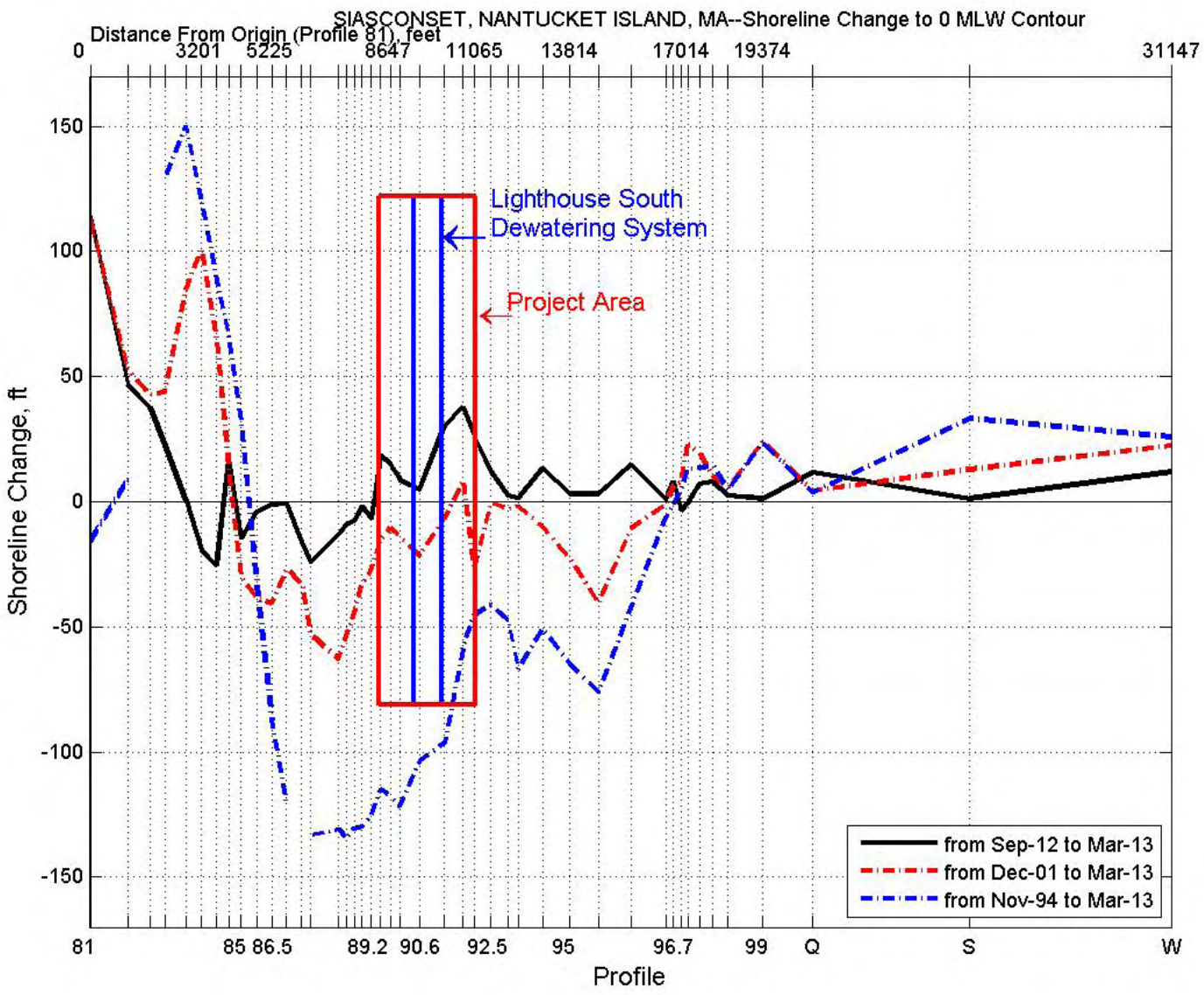

Figure 4. MLW shoreline change from November 1994, December 2001, and September 2012 to March 2013.

3.3 WAVE CONDITIONS

The 60th survey is defined by the time period of September 12, 2012 through March 30, 2013. Wave data for this time period was obtained from the Woods Hole Oceanographic Institution's Martha's Vineyard Coastal Observatory (MVCO), located approximately 1.5 kilometers south of Edgartown Great Pond in 12 meters of water. The MVCO collects wave data every 20 minutes and functioned with a 98% data return for the period. Although the MVCO data is not entirely representative of nearshore conditions at Siasconset (due to partial sheltering of the MVCO from waves arriving from the East to Northeast) the MVCO is the only source for measurements of the directional distribution of waves in the region. At the location of the MVCO, waves arrive primarily from West-Southwest to East-Southeast, with the majority arriving from the South. This is expected since the waves are becoming more shore-normal as they approach the southern-facing shoreline of Martha's Vineyard. Wave data were also obtained from the National Oceanic and Atmospheric Administration's National Data Buoy Center (NDBC) Station 44008. This station recorded data for a 20-minute sampling period every hour and was located 54 nautical miles southeast of Nantucket Island in 62.5 meters of water. NDBC Station 44008 achieved a data return of 99.5% for this sampling period; however, the station went adrift on 2/9/13 and data recorded after this date are not included in Figure 5, nor incorporated elsewhere in this report. Both data sets were processed to evaluate wave characteristics and storm events for the period of interest.

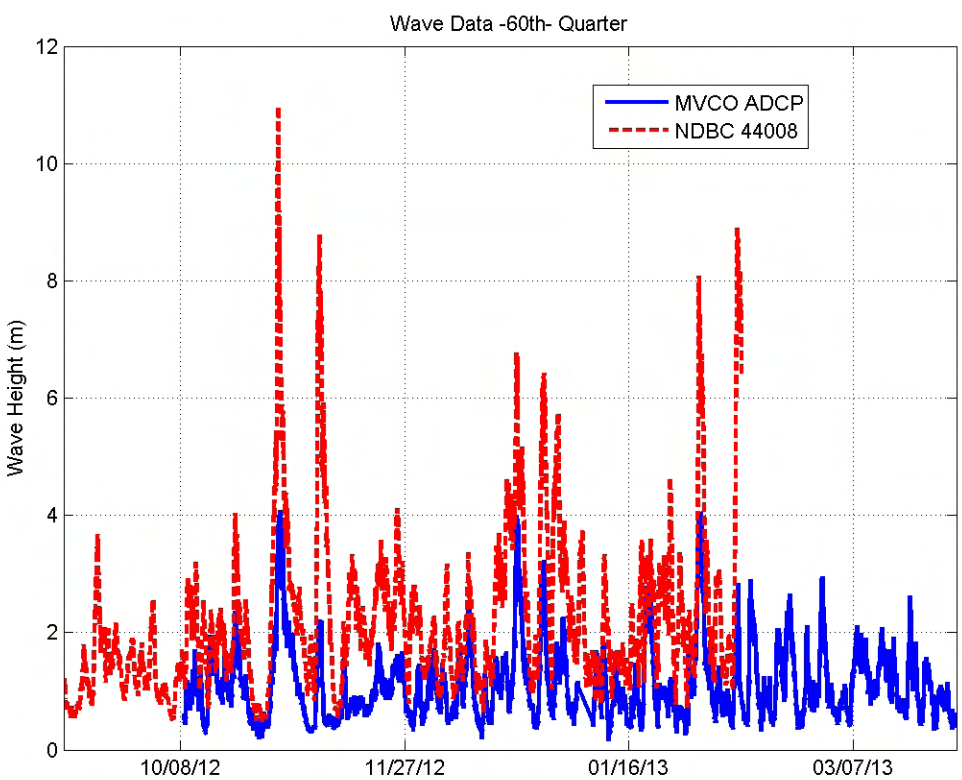

Figure 5. Time series of wave height for 60th survey period

Time series of wave height data for the period show a variety of storms during the 60th survey period. Both the NDBC Station 44008 and MVCO data are shown in Figure 5, indicating which storms observed in the offshore data had an impact on the islands of Nantucket and Martha's Vineyard. There were approximately thirty (30) events when wave heights exceeded 1 meter at the MVCO location for an extended duration. The most significant storm was Hurricane Sandy from October 22-31st that generated waves over 4 m at the MVCO station and 10 m at NDBC Station 44008. The overall energy-weighted average wave height for the time period was 1.3 meters at the MVCO location and 2.67 meters at the offshore NDBC buoy. These heights are indicative of energetic wave conditions for the winter season.

4.0 SUMMARY

From the analysis of the data collected for the 60th survey (March 2013), the following summary can be made

- Significant erosion of the beach, dunes, and bluff was visually observed during the March 2013 survey.

- An analysis of the wave data between the September 2012 and March 2013 indicate this time period was energetic with the overall energy-weighted average wave heights of 1.3 meters at the MVCO location and 2.67 at Station 44008.

- Beach volume change calculations were made between November 1994 and December 2001, December 2001 and September 2012, and September 2012 to March 2013. This is a departure from previous volume change calculations that were made comparing the historical results to the most recent survey. In addition, the region for the volume calculations for the September 2012 to March 2013 was adjusted for a number of profiles. As a result, these volume calculations are not directly comparable to previous reports.

- Between these three monitoring periods, the general trend for volume and shoreline change demonstrated the northern and southern portions of the monitoring area accreted, while the middle portions of the monitoring area eroded.

- The most recent survey shows erosion of more than 10 cy/ft between profiles 83.5 and 88.6 since September 2013 with a maximum of 32 cy/ft at profile 89.8.

- Since September 2012, only six of the nine profiles lost beach volume, and eight profiles exhibited shoreline advance up to 37 ft. This may seem counterintuitive based on the long-term erosional trends for the project area, and given the significant amount of regional erosion observed this winter. However, it appears that a significant portion of sand eroded from the bluffs was deposited in the surf zone between MLW and the -5 ft MLW contour. The profile comparison figures in Appendix A illustrate this trend, and show the amount of material deposited below MLW resulted in shoreline advance, and even an overall gain in beach volume since September 2012 for certain profiles.

8.0 LITTORAL BUDGET

Waves and currents are the forces that transport beach sediment along the coastline, and are the forces of beach erosion in some instances. A "littoral budget" is an assessment of the magnitude and direction of sediment transport in the project area. The Sconset Beach littoral budget is based on annual cumulative sand volume change rates at each profile line. The littoral budget was developed for the time period of December 1995 through December 2005, which also coincides with the period of highest shoreline recession rates.

The average shoreline recession rate was multiplied by the active profile height and effective distance between profiles to develop a volume change rate at each profile line (Table 10). (It would have been preferable to use the measured volumetric change but the lack of profile closure necessitated using shoreline changes). The top of the active profile height varies along the project length, peaking at a height of 110 feet at profile 92.5. (The active profile height (APH) is the distance from the top of the active profile to the depth of closure). Light Detection and Ranging (LIDAR) topographic mapping data was used to determine the top of the active profile height in the highly eroding bluff area (profile 90.6 to 95). The bluff elevation was later confirmed when the August 2006 survey data became available. In the areas where there is a highly vegetated dune landward of the beach, the top of the active profile height was taken at the base of the vegetation. A vegetated dune indicates that it has been stable long enough to vegetate and is therefore not considered part of the 'active' profile height. The depth of closure (Section 5.7) was assumed to be -26 ft MLW along the entire project length.

Once the volume change was established, the percentage of silt at each profile line was removed from the total volume change, in order to account exclusively for the longshore movement of coarse grained material (sand and gravel). It was assumed that the silts were put into suspension by wave activity and swept out of the project area. The percentage of silt was determined by an elevation weighted average of the silt content from 298 cross-shore samples. The cumulative sand volume changes represent the littoral transport rates, as summarized in Table 10.

The total longshore transport could then be estimated by summing the volumetric changes at each line using the sand conservation equation. A starting point for this summation had to be assumed. A typical method of determining this starting point is to identify the point where there is no net sediment transport, which is termed the nodal point. The nodal point is typically located at the location experiencing the highest shoreline recession rates, as there is no sediment being supplied from an updrift source. The largest shoreline recession rate occurs at profile 88.6, which suggests that this is the location of the nodal point. Once the nodal point is located the volumes are then summed going away from this point to provide the littoral transport rate. The sign indicates the direction of transport so positive transport is to the south and west while negative transport is to the north.

Table 10. Littoral Budget between 1995 and 2005

Profile	Effective Distance (ft)	Top of APH (ft)	DOC (ft)	APH (ft)	Shoreline Change (ft/yr)	Volume Change (cy/yr)	Percent Silt (%)	Sand Vol Change (cy/yr)	Littoral Transport (cy/yr)
81	536	11	-26	37	-4.5	-3,300	0.3	-3,300	-20,500
82	865	15	-26	41	7.9	10,300	0.3	10,300	-23,800
82.6*	546	13	-26	39	13.2	10,400	0.2	10,400	-13,500
83	522	15	-26	41	18.6	14,700	0.3	14,700	-3,100
83.5	529	15	-26	41	22.4	18,000	0.3	17,900	11,600
84	444	15	-26	41	18.4	12,400	0.3	12,400	29,500
84.3	396	15	-26	41	12.3	7,400	0.2	7,400	41,900
84.6	351	13	-26	39	8.0	4,000	0.2	4,000	49,300
85	398	13	-26	39	3.9	2,200	0.2	2,200	53,300
86	441	13	-26	39	-0.7	-500	0.2	-500	55,500
86.5	435	14	-26	40	-6.5	-4,200	0.2	-4,200	55,000
87	436	14	-26	40	-13.0	-8,400	0.3	-8,400	50,800
87.4*	351	15	-26	41	-12.0	-6,400	0.2	-6,400	42,400
87.5	533	16	-26	42	-11.0	-9,200	0.2	-9,200	36,000
88	514	18	-26	44	-18.2	-15,200	0.1	-15,200	26,800
88.3	223	18	-26	44	-20.6	-7,500	0.2	-7,500	11,600
88.6	223	18	-26	44	-22.6	-8,200	0.2	-8,200	0
89	248	15	-26	41	-20.7	-7,800	0.2	-7,800	-11,900
89.2	273	15	-26	41	-15.4	-6,400	0.2	-6,400	-18,300
89.5	273	15	-26	41	-16.4	-6,800	0.2	-6,800	-25,100
89.8	276	15	-26	41	-14.3	-6,000	0.6	-6,000	-31,100
90	425	14	-26	40	-12.6	-7,900	0.6	-7,900	-39,000
90.6	639	85	-26	111	-8.0	-21,100	7.6	-19,500	-58,500
91	622	82	-26	108	-7.2	-17,900	15.1	-15,200	-73,700
91.5	431	90	-26	116	-3.8	-7,000	1.7	-6,900	-80,600
92	404	102	-26	128	-4.3	-8,200	1.7	-8,100	-88,700
92.5	483	110	-26	136	-2.0	-4,800	6.2	-4,500	-93,200
93	393	108	-26	134	-8.0	-15,600	3.6	-15,000	-108,200
93.5	500	96	-26	122	-6.1	-13,700	4.6	-13,100	-121,300
94	740	72	-26	98	-6.0	-16,200	3.1	-15,700	-137,000
95	802	57	-26	83	-4.9	-12,200	9.4	-11,100	-148,100
95.5	888	42	-26	68	-4.2	-9,500	4.2	-9,100	-157,200
96	979	26	-26	52	0.9	1,700	1.7	1,700	-155,500
96.5	606	26	-26	52	-1.0	-1,200	1.3	-1,200	-156,700
96.7	208	28	-26	54	0.9	400	0.6	400	-156,300
96.9	210	24	-26	50	1.2	500	0.6	500	-155,800
97	272	25	-26	51	1.0	500	0.6	500	-155,300
97.3	350	24	-26	50	0.3	200	0.4	200	-155,100
97.6	408	24	-26	50	0.1	100	0.4	100	-155,000
98	722	20	-26	46	-0.5	-600	0.4	-600	-155,600
99	1,225	21	-26	47	-0.4	-800	0.4	-800	-156,400
Q	2,985	23	-26	49	-0.3	-1,800	0.4	-1,800	-158,200
S	5,159	18	-26	44	2.5	20,700	0.4	20,600	-137,600
W	2,900	21	-26	47	1.7	8,300	0.4	8,300	-129,300

A plot of the littoral transport curve is shown in Figure 8. This figure shows that from profile 86 through to profile 95.5 that the littoral transport rate is increasing, which is indicative of an erosional area. The graph also shows that north of profile 95.5, the littoral transport rate curve is relatively flat so the volume of material entering the section is similar to the volume leaving this section and the beach is stable. North of profile Q, the sediment transport rate is decreasing, which is indicative of an accretional area.

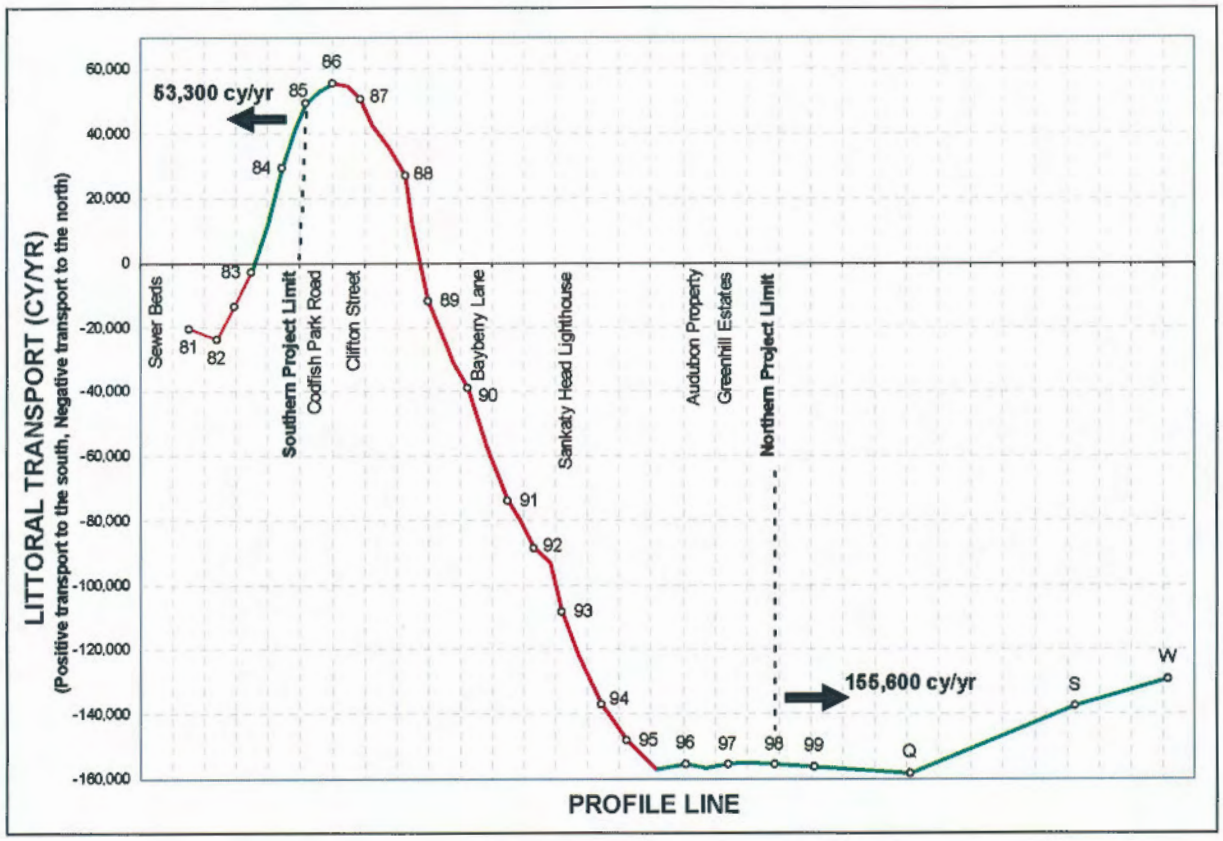

Figure 8. Annual Littoral Transport (Dec 1995 to June 2005)

The southern end of the project is located at profile 85. At this location the sediment transport rate is approximately 53,300 cy/yr being transported to the southwest. The northern end of the project has a sediment transport rate of 155,600 cy/yr being transported to the north. Therefore, the total net loss due to longshore transport is approximately 208,900 cy/yr.

Attachment B
Comparison of Retreat Rates at 79 Baxter Road and Nearby Properties

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Baxter Road Nantucket, MA

Figure 1
Coastal Bank Retreat

Table 1. Top of Coastal Bank Retreat Rate Data for 75-83 Baxter Road

Transect	Lot	2003-2012 (ft)	2012-2013 (ft)
83 Baxter Road			
104	83	48.41	18.60
105	83	46.68	6.14
106	83	39.90	4.50
107	83	38.48	5.42
108	83	40.25	4.83
109	83	43.52	5.54
110	83	38.99	5.91
Avg Rate	**83**	**4.70**	**7.28**
81 Baxter Road			
111	81	45.01	8.99
112	81	39.41	12.23
113	81	33.91	15.30
114	81	27.02	14.71
115	81	23.69	21.08
Avg Rate	**81**	**3.76**	**14.46**
79 Baxter Road			
116	79	5.22	30.65
117	79	NA	20.87
118	79	NA	14.36
119	79	NA	12.22
120	79	1.68	6.29
Avg Rate	**79**	**0.38**	**16.88**
77 Baxter Road			
121	77	10.64	6.31
122	77	3.68	8.93
123	77	6.04	15.44
124	77	11.35	19.33
Avg Rate	**77**	**0.88**	**12.50**
75 Baxter Road			
125	75	21.25	11.07
126	75	25.40	12.19
127	75	18.98	11.57
128	75	22.43	12.20
Avg Rate	**75**	**2.45**	**11.76**