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May 2, 2017

Nantucket Conservation Commission
2 Bathing Beach Road
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Subject: Response to Comments on Annual Report
SE48-2824, Sconset Bluff Geotextile Tube Project

Dear Commissioners:

The following document presents responses from the Sconset Beach Preservation Fund to the memo to Jeff Carlson from Greg Berman dated April 7, 2017. Following these responses, we have also provided a response to the comments provided by Applied Coastal on behalf of the Nantucket Land Council in a memo dated April 12, 2017.

We look forward to discussing the Annual Report with the Commission at the May 22, 2017 meeting.

Sincerely,
EPSILON ASSOCIATES, INC.

Maria B. Hartnett

Maria B. Hartnett
Associate

RESPONSE TO THIRD PARTY REVIEW

This report presents responses from the Sconset Beach Preservation Fund to the memo to Jeff Carlson from Greg Berman dated April 7, 2017. This report is organized to follow the order of Mr. Berman's letter. Comments excerpted from his letter are presented in italicized text followed by responses in plain text.

This document includes the following attachments that are referenced in our responses and that were previously provided to the Conservation Commission (Attachments A-D), as well as a supplemental analysis included as Attachment E:

- Attachment A: November 1, 2013 Epsilon Memo "Baxter Road Geotube Project – Coastal Bank Retreat Calculations"
- Attachment B: Explanation of Tidal Datum Used for Siasconset Beach Dewatering Project Per Leo Asadoorian, PLS, Blackwell & Associates, Inc.; March 23, 2004
- Attachment C: Southeast Nantucket Beach Monitoring 71st Survey Report, prepared by Woods Hole Group, March 2017
- Attachment D: 2001-2007 Wetland Well Monitoring Data
- Attachment E: Bank Retreat Calculations for North and South Control Areas

2.1 Sand Delivery - Response to Comments

"Additionally, some bluff erosion (6,000 cy in 4/1/14-3/31/15 and 1,920 cy in 4/1/15-3/31/16) was added into the mitigation volume. Unless this volume was entirely replaced on the bluff it should not be counted as mitigation, and it is difficult to determine if/when it was replaced…If these volumes do not qualify as mitigation the summary mitigation volumes would look like the table below [which shows a deficit of sand]."

We believe some clarification will assist with this comment. The Sand Report tracks all sand delivered for the Project, including sand for mitigation, sand for construction, and sand that was placed on the bluff face to smooth out deep rills and gullies prior to the planting of vegetation. The Sand Report indicated that sand placed on the bluff face was not counted as mitigation if it remained on the bluff face and was not available to the littoral system. During the construction of the fourth tier, however, when the third tier of geotextile tubes had to be exposed to allow placement of the fourth tier, much of the previously-placed sand slumped down off the bluff and was available to the littoral system. This component of the sand was then counted as part of the mitigation. As noted in the June 2016 Sand Delivery Report, "Since the purpose of the mitigation volume is to replicate that amount of sand that would have eroded from the bluff on an annual basis without the Project, it is appropriate to account for that volume of the bluff that eroded and to subtract this volume from the mitigation requirement." Therefore, we continue to refer to the sand amounts listed in Table 1 in the Sand Delivery and Contribution Report, which shows a surplus of sand.

"Additionally, the sand delivery data for the most recent year was not provided."

The Annual Report on which Mr. Berman is commenting was submitted in December 2016, prior to the end of the most recent sand year on March 31, 2017. A new Sand Delivery Report that details sand deliveries and volumes will be submitted later this spring as required.

Response to Comments on Section 3.1

"2.1 Sand Delivery – It is important to continue to monitor and report the sand volume delivery activities associated with this project."

We agree; sand deliveries will continue to be monitored and reported on an annual basis as required.

2.2 Bluff Monitoring - Response to Comments

"...no information (aka metadata) has been provided on the horizontal/vertical accuracy of the survey, grid cell resolution of the DEM, on-the-ground horizontal/vertical control points, or even the method of topographic survey (i.e., LiDAR vs Photogrammetry)."

The survey in April 2016 was a photogrammetry survey. The July 2013 survey, as reported to the Commission at the time of the survey, was a traditional LiDAR survey flown by airplane.

For the April 2016 photogrammetry survey:

- 105.593 acres were covered in aerial survey

- Horizontal/vertical accuracy of the survey
  - Ground Sample Distance -2.77 cm/pixel
  - Absolute accuracy: 5.54 cm horizontal, 8.31 cm vertical

- 11 Ground control points used (coordinates in meters)
  - GCP 1 - (419344.026,4570424.093)
  - GCP 2 - (419519.090,4569638.567)
  - GCP 3 - (419524.259,4569696.553)
  - GCP 4 - (419525.654,4569758.021)
  - GCP 5 - (419511.988,4569825.901)
  - GCP 6 - (419426.446,4569840.356)

- GCP 7 - (419379.226,4570115.801)
- GCP 8 - (419438.282,4570138.555)
- GCP 9 - (419334.684,4570268.833)
- GCP 10 - (419395.732,4570291.118)
- GCP 11 - (419283.827,4570427.461)

- Root Mean Square Error ("RMSE") (As a percentage)
  - X- 0.899748
  - Y- 2.862256
  - Z- 3.069953

- -Projection of Aerial and DEM - UTM19
  - Grid cell resolution of the DEM: 0.0271 x 0.0271 Meters

In addition to the aerial topography obtained by UAV in 2013 and 2016, there is also freely available LiDAR data from 2000, 2007, 2010, 2012, and 2014. All of this data can be downloaded with full metadata (i.e. error analysis) from https://coast.noaa.gov/dataviewer . If nothing else these data could be used to quality check the method of using LiDAR for determining volume, as all of these dates overlap with the profiles that were collected for this project and used to determine annual nourishment requirements.

The SBPF appreciates the note on additional data available. It is noted that the bluff contribution volume was calculated using long-term data sources from 1994-2013, and so incorporates data sources prior to the LiDAR data from 2000. The bluff contribution rates (as detailed in our memo dated November 1, 2013 that was previously submitted to the Conservation Commission and is included here as Attachment A) were previously checked against and corroborated by both (1) bluff survey data and (2) shoreline change rates. Therefore, some of the quality checks recommended here have already been provided. In fact, the data available for Sconset Beach includes shoreline surveys back to 1994 and represents a much more robust data set than is typically available for coastal projects.

Response to Comments on Section 3.1 Monitoring Program Adjustments

"2.2 Bluff Monitoring – Depending on the quality of the data, annual aerial bluff monitoring is an efficient method of estimating the volume eroded each year. In addition, I would recommend that a visual survey is performed at least once a month (and right after every storm) in order to determine if any part of the geotube has less than adequate cover (2-3'), or much worse, that it be exposed, and for it to be covered again ASAP."

We agree that aerial bluff monitoring is a useful tool for evaluating the volume eroded from the bluff each year and intend to continue an annual aerial survey. As required by the Project's Order of Conditions, the geotextile tubes are monitored after every storm (minor or major) and are re-covered as needed, generally in a week or less, depending on safety, weather and other practical considerations. Work logs documenting each time the geotextile tubes are uncovered and subsequently re-covered are submitted quarterly to the Commission.

2.3 Shoreline Monitoring - Response to Comments

"The WHG Report utilizes mean low water (MLW) for the vertical datum for their shoreline change report due to previous reporting requirements. The CZM Shoreline Change Project uses mean high water (MHW) shoreline derived from LiDAR or local high water line (HWL) from color orthophotographs as a proxy for MHW. Most shoreline change projects use MHW as that is the vertical datum that will first intersect infrastructure when looking at an eroding shoreline. While MHW and MLW often correlate, they may not be directly tied. For example, after a coastal bank erodes it may cover much of the intertidal zone which would push MLW further seaward, but perhaps not move MHW as far. It might be of use to the Conservation Commission to see how these two datum points on the profiles correlate, and if reasonable WHG may want to switch to using MHW for reporting as this datum is closer to the project array than MLW."

We appreciate the comment and agree there can be certain conventional advantages to using a MHW reference. For instance, CZM recommends the use of MHW as a reference datum for LIDAR and Photogrammetry data because these are remote sensing methods that have difficultly capturing data below MHW even at lower stages of the tide. Even when these data are taken at low tide, wave action can obscure the MLW line making it difficult to detect by either photogrammetry or LIDAR. Therefore, MHW is the better reference datum for those remote sensing technologies. At Siasconset, however, we have the actual survey data that captures data well below MLW. Thus we are not limited by the typical remote sensing based challenges associated with delineating MLW.

The selection of MLW also has a historical context at Siasconset. From the first surveys and studies of the beach in 1994, MLW was used as the reference point. We understand one reason is the MLW datum serves as the established vertical datum for the entire project coordinate system dating all the way back to the first survey in 1994. The MLW datum is actually based on tidal benchmarks established in 1992, and is referenced as MLW92. Reference materials are attached (see Attachment B - Explanation of Tidal Datum Used for Siasconset Beach Dewatering Project Per Leo Asadoorian, PLS, Blackwell & Associates, Inc.; March 23, 2004) that document the establishment of the MLW92 vertical project datum. To report the shoreline changes in reference to MHW instead of MLW would cause a disconnect between the recent survey with the prior seventy (70) surveys that have been conducted. While MLW92 was established as a tidal benchmark, we do not have a historic record of MHW locations. There also is the advantage of being able to directly compare current surveys and positions to those surveyed from the beginning. Selection of a datum at this site also is complex, because the tides along Siasconset are different from the established NOAA tidal station in Nantucket Harbor. In fact, local tide measurements we collected showed that high tide elevation varies along the beach.

What also is unique to this site is the foreshore slope of the beach profiles is typically very steep along the Siasconset shoreline. There is not a typical equilibrium beach profile with a berm/bar configuration. Rather, the beach foreshore slope tends to be quite steep and linear. When conducting the surveys, the distance between MHW and MLW often comes with a few short paces down the beach slope by the surveyor. Whereas some beaches have different dynamics associated with the location and movement of MHW and MLW, this has not been the case at Siasconset. Shifting the datum from MLW to MHW will not change the shoreline change trends. For all of these reasons, we are comfortable using MLW at this site for technical reasons, and with the added benefit of comparing to a long history of surveys.

"Additionally, project shorelines were delineated at the MLW line and not at the toe or top of Bank. While the erosion rates at these locations are certainly linked there is a typically convoluted correlation between them (e.g., 2′ of erosion at MLW does not immediately equal 2′ of loss at the top of the bank). Erosion of the coastal bank can build the adjacent beach, which may indicate accretion when looking at the wet/dry line. The WHG report shows a strong linear relationship between MLW and beach volume. This indicates that MLW might be used as a proxy for beach volume in the future, however MHW should also be graphed in a similar way to determine if the trend is valid for this higher datum as well."

Based on the discussion about MLW and MHW datums above and the steep, linear characteristic of the beach profile, we do not think adding a correlation analysis between MHW and beach volume will produce a meaningfully different result. Since the long-term position of MHW is not readily available from the profiles, there also will be less data to analyze. Thus, we believe the analysis based on MLW is sufficient.

"Overall, the major changes in this dynamic area completely overshadow any signal that might be from the geotube project. No additional shoreline change can be attributed to the project at this time."

We agree with this assessment – there is no evidence of increased erosion from the project.

Response to Comments on Section 3.1 Monitoring Program Adjustments

"2.3 Shoreline Monitoring – The requested reduction to 2 profiles per year is reasonable based on the collected data so far as well as more consistent with MassDEP guidance."

We agree with this assessment.

"One of the main reasons to include wading shots in a beach profile (besides to tie into the bathymetry) is to include the potential sand bars, which can hold a significant volume of sediment (especially in winter and post bluff erosion). Without examining individual beach profiles (not included in WHG report) one cannot determine the value of profiling below MLW. While profiling to -5' MLW can be logistically quite difficult, the request to completely eliminate wading shots might not be necessary. Instead of taking the profile to -5'MLW the profile could be taken to -2 to -3'MLW, which would be easily accessible on most calm days. While the data shows only an improvement of 1.1cy/ft (1.4%) over extrapolation below MLW, this is based on trying to track 22cy/lf/yr of nourishment (1.1 cy/ft out of 22 cy/lf is 5%). If the volume is changed to 14.3 cy/lf/yr (as requested by the applicant in Section 3.2) this would make the 5% now 8% of the nourishment volume."

We are not certain if any of the monitoring reports were provided to Mr. Berman. We recommend reviewing the latest survey report (see Attachment C), which includes the beach profile plots in an appendix. The beach profile at Siasconset does not follow a typical equilibrium beach profile with a sandbar offshore. Due to the dynamic and erosive nature of the wave climate at Siasconset, the beach has a very steep foreshore slope offshore typically to about -7 to -10 feet MLW before becoming more gradual, particularly in the Project area. The beach profile also typically lacks a definitive sandbar even during different seasons. And, given the nature of the profile, there would not be a sand bar supported on the steep beach face at these relatively shallow locations. Changing the depth of the wading shots from -2 to -3 feet MLW instead of -5 ft-MLW also does not, unfortunately, change the data collection method as the total station and survey rod would still be needed since the profile drops off steeply. After reviewing the RTK GPS data, the topo survey can only wade down to 0-ft MLW before there is a steep slope break. Thus, the wading shots do not record potential sand bars and associated volumes. Therefore, we continue to recommend that extrapolation from 0 MLW to -5 feet MLW would result in important survey efficiencies and decrease risk to the survey crew without a degradation in the quality of the data.

Additionally, the mitigation volume of 22 cy/lf/yr is a based on the amount of material contributed by the bluff annually to the beach, 14.3 cy/lf/yr, along with a conservative safety factor of nearly 8 cy/lf/yr. This difference in the calculated beach volume of 1.1 cy/ft between extrapolation method and the surveyed profile data only exists on the submerged portion of the profile between 0-ft MLW and -5ft-MLW, where only 6% of the beach profile volume is contained. Assuming that there would be 8% error (1.1 cy/ft / 14.3 cy/lf/yr) in tracking the mitigation volumes assumes that the entirety of the 14 cy/lf/yr of material is located between 0 and -5 ft-MLW all at one time, when in fact this material is likely spread over different portions of the beach at any given time. Furthermore, spreading this beach volume difference of 1.1 cy/ft over this distance between 0-MLW and -5-MLW, typically 60 to 100-ft, equates to a vertical difference of about a 1/10th of a foot over this distance, which is well within the survey error for the wading shots.

2.4 Wetland Well Monitoring - Response to Comments

"It is highly likely that the catch basin (on the east side of the road) has no effect on wetland water levels on the west side of the road…"

We agree with this assessment.

"There is also a reference to "50 previous well readings…from 2001-2007" helping define the expected variation (2-5' over 6 years), however no mention of what wells or the sampling parameters/timing are explained. Additionally, it is not only the range that is important for wetlands. If the annual low gets lower than historic levels then there may not be as much water as there used to be during dry times. It's unlikely this has changed significantly, but it cannot be determined from the information provided."

As noted in the report, over 50 well monitoring events occurred in the period of 2001-2007, which is 10-15 years before the most recent data collected in 2016 and included in the Annual Report. These past readings were previously provided to the Commission and are attached here for ease of reference (see Attachment D). These historic readings can provide a general context for the 2016 readings, but the significant time period (9-15 years) between the datasets provides limitations on the conclusions that can be drawn.

- There are six wells (E-1 through E-6, referred to as the "historic wells") monitored in the period from 2001-2007 that are located on the seaward side of lots 84-96 Baxter Road (i.e., the same area as current wells E-2, E-4, and E-6R). (Note: new wells E-2 and E-4 are in slightly different locations than historic wells E-2 and E-4).

- In five of these six historic wells, the previous historic low water levels ranged from 7.1 to 8.3 feet below the surface, with the 6th historic well (E-4) having notably higher groundwater with a lowest reading of 4.2 feet.

- The historic well readings were taken from the ground surface whereas the 2016 well readings, as indicated in the Annual Report, were recorded from the top of the well, which is about 8-inches above the ground surface. To allow a direct comparison, the 2016 low readings (9.2-10.8) are adjusted by 8 inches to record a depth from the ground surface of approximately 8.5-10 feet.

- The historic well low readings (7-8 feet) are in the same ballpark as the 2016 adjusted low readings (8.5-10 feet), though the 2016 readings are somewhat lower.

No further conclusions can be drawn from the data given the 9-15 year period between well readings. We reiterate both our comment and Mr. Berman's comment that it is unlikely that the catch basin would have impacted the wetland water levels. We note that water levels in the wells appear to correlate well with precipitation and that a visual assessment of the wetland suggests it is not being impacted by the Project.

Response to Comments on Section 3.1 Monitoring Program Adjustments

"2.4 Wetland Well Monitoring – If the data from 2001-2007 shows similar dry levels as this project the well monitoring could be discontinued."

The historic well data from 2001-2007 shows generally similar dry levels as the 2016 data. Additionally, the well data from 2016 appears to correlate well with precipitation, and the range of water levels observed is similar in the 2016 data as in the historic data from 2001-2007. These findings support the recommendation that the monitoring be discontinued.

2.5 Beach Invertebrate Monitoring - Response to Comments

"The low abundance of invertebrates in the area likely do not warrant further sampling….2.5 Beach Invertebrate Monitoring – The invertebrate monitoring could be discontinued as no impacts to the few species have been observed."

We agree with this assessment.

2.6 Underwater Video Monitoring - Response to Comments

"The survey dates of 2007 and 2016 are too far apart for a coherent analysis in such a dynamic area… Additionally, the geotubes were installed in 2013/2014 and so seven years have passed between the "baseline" study and the installation."

We agree with this statement and stated similar reservations or caveats in our report. We attempted to make a comparison since the 2007 data represented the most recent video data available, but we are in agreement that the significant time passing between events limits the ability to make a definitive comparison. Nonetheless, we believe the data show that a productive cobble habitat was present offshore of Sconset in both 2007 and in 2016 and that there is no evidence that this cobble habitat is being covered, nor is there an expectation that this would occur based on the volume of mitigation material.

"2.6 Underwater Video Monitoring – Video monitoring likely is not needed yearly. Sidescan sonar or backscatter might be more efficient at classifying bottom type than underwater video, although it would miss the species of flora and fauna provided by video. Sidescan would give seamless bottom coverage, but would need a few ground truth points (video/planview/SPI). Even a high-resolution (aka chirp) seismic profiling system would be unlikely to distinguish any fine layering of nourishment sand on the near coastal system. Another method that has been used to determine sediment coverage and depth is Sediment Profile Imagery (SPI). This technology uses a camera housing and penetrates the sediment/water interface. The resulting image shows the shallow stratigraphy below the

interface, and might be of use in this project if the nourishment sand can be distinguished from native sand. In areas of high cobble this system doesn't work well."

We agree with this assessment that video monitoring is not needed yearly and suggest it only occur once every three years or in the event that the mitigation template contributes 3-5 times more sand than the unprotected bluff.

We agree with the statement that the SPI camera doesn't work well in areas of high cobble like Sconset and do not believe this tool would be a good fit for the Sconset project, due to both the high presence of cobble and other hardbottom and due to the difficulty of distinguishing the nourishment sand from native sand.

SBPF will evaluate if sidescan sonar is a potential means of completing the survey. As noted by Mr. Berman, sidescan will not provide information on flora and fauna but will provide information on bottom coverage type (sand vs. cobble).

2.7 Annual Drainage System Report - Response to Comments

"If the accumulated sediment is below the threshold for cleaning (as indicated in the Epsilon Report) then the system is likely performing as designed…If the town is willing to take this monitoring program over after one more year it would likely be minimal effort."

We agree with this assessment.

3.2 Mitigation System Adjustments - Response to Comments

"Standard compensatory nourishment can be calculated by multiplying the erosion rate, by the existing landform height and length to get a volume…"

We agree that standard compensatory nourishment can be calculated by multiplying the erosion rate by the landform height and length. However, as described below, we took a more conservative approach when calculating the Sconset nourishment volume.

Standard Compensatory Nourishment Volume

Below is how the standard compensatory nourishment would be calculated by multiplying bank erosion rate * length of landform * height of landform:

First we calculate the bank height in the Project area:

Bank Height 87-105 Baxter Road			
Location	Top of Bank (ft MLW)	Toe of Bank (ft MLW)	Bank Height above Toe (ft)
105 Baxter	93	10	83
101 Baxter	85	10	75
99 Baxter	80	10	70
97 Baxter	78	10	68
93 Baxter	78	10	68
91 Baxter	74	10	64
87 Baxter	77	10	67
Average height (ft)			**71**

Next we calculate the nourishment volume using the standard methodology:

Standard Calculation of Compensatory Mitigation				
Bank Retreat (ft/yr)	Length of Landform (ft)	Bank Height (ft)	**Mitigation Volume**	
4.6	947	71	308046	cf
			11409	cy
			12.0	**cy/lf**

This standard calculation results in a mitigation volume of 12.0 cy/lf/yr.

Sconset Calculation of Nourishment Volume

As discussed in detail in the November 1, 2013 memo provided to the Commission during its review of the NOI (and included here as Attachment A), a more conservative approach was taken for Sconset. We felt that taking a vertical slice of the bluff (by multiplying the retreat rate by the landform height) may not fully account for how much the material the bluff contributes since it has a tall, sloping face. We therefore applied the retreat rate to actual cross-sections of each of the lots and calculated the volume contributed from each profile of the bluff. This more conservative approach yielded **14.3 cy/lf/yr**, which is nearly 20% higher (19% higher) than the standard calculation. Therefore, there is already some conservatism incorporated into the calculation.

"The Epsilon report requests that, at a minimum, the average volume (14,000 cy) be placed as mitigation without the extra 50% safety factor. Instead the safety factor would be the requirement to keep the geotube covered with sand at all times. If the Conservation Commission approves this adjustment they may want to consider that ANY exposed section of geotube would require sand placement such that the geotube is then covered by at least

2-3' of sand again, within a very short time period. The Conservation Commission could also reduce the safety factor over time to see if there are negative effects occurring (ie. Dropping the safety factor by 10% each year, so from 50% it would be 0% in 5 years). If it is the intention of the applicant to attempt to hold the shoreline in its current position, the nourishment required would be needed in perpetuity at an increasing level of cost and effort as sea level rises and the rest of the shoreline changes."

We continue to identify the need for a more adaptive mitigation program. We suggest that a minimum volume of 14.3 cy/lf/yr be placed each year, with an ongoing requirement to keep the geotextile tubes covered. In a more energetic year, more sand would be needed to keep the geotextile tubes covered than the required 14.3 cy/lf/yr. As noted above, this 14.3 cy/lf/yr is more conservatively calculated than at any other known project in Massachusetts. Additionally, the Project has been installed for four winters, so we believe now is an appropriate time to consider a more adaptive mitigation program.

As an additional idea of an adaptive mitigation program, DEP suggested a process whereby the required volume of 22 cy/lf/yr is available on the sand template at the start of each sand year (April 1) and that new sand is delivered to "re-fill" the template to that level at the end of each sand year (March 31), such that however much sand is eroded during storms is replaced each year. In the event more than 22 cy/lf/yr erodes in an energetic year, additional sand would be provided on an as-needed basis throughout the winter to keep the geotextile tubes covered with sand. Such an adaptive approach allows the mitigation sand to more closely match the natural system in which the amount that actually erodes varies from year to year.

SBPF has always acknowledged that mitigation sand will be needed in perpetuity and accepts this requirement.

Additional Considerations – Response to Comments

"The project site has not experienced a significant storm event since the installation of the geotube array. Until data is available from the geotube array experiencing a larger storm (for example with Stillwater elevations intersecting the geotube array), the Conservation Commission may want to carefully deliberate before removing conservative controls on the project (ex. high volume of nourishment and monitoring)."

We are not certain which criteria are being used to state that the Project has not experienced a significant storm. The Project has experienced the following large, named storms during the nearly 3.5 years since its construction. The storm marked with an asterisk meets the

Commission's definition of a significant[1] storm (sustained windspeeds of 40 mph for 6 hours or more):

Date of Storm	Major Storms
January 26-27, 2015	Juno*
January 23-24, 2016	Jonas
February 8-9, 2016	Mars
September 5, 2016	Tropical Storm Hermine

* Meets definition of "significant" storm

As the geotextile tubes have been in place for four winters, we believe it is an appropriate time to consider a more adaptive sand mitigation program.

Due to the scale of this project (947' length) there is a high potential for current to set up parallel to the smooth exposed geotube during storm conditions with oblique waves. This type of current can rapidly scour the end of the array, even with a well-built return.

While we acknowledged during the NOI review process that end scour can occur, there is no evidence of this occurring. The geotextile tubes are checked after every storm and we have not observed signs of end scour. The visual inspections suggest that the returns and the large volume of mitigation sand covering them are functioning as designed to prevent flanking from occurring.

"One of the dangers of "holding the line" with either a CES or softer alternatives (i.e. coir envelopes/fencing) is that the stabilization array will eventually, artificially protrude further seaward than the rest of the shoreline. Flanking may occur if adjacent properties continue to erode naturally, while the project site maintains a shoreline position further seaward than necessary to protect the house. Flanking could require returns to be extended landward over time in order to protect the house, which would allow the property to protrude further

[1] We do not believe the reference to a "larger storm" being defined by stillwater elevations reaching the base of the geotubes is accurate. The elevation near the toe of the geotextile tubes is typically ~10 feet MLW. Based on the 2014 FEMA FIS, the 100-year FEMA floodwater elevation for the area near the Sconset geotube project (Transect 13) is 5.8 feet NAVD88. This elevation is converted to the project datum of MLW using a conversion of 1.52 feet, resulting in a 100 year stillwater elevation of 7.32 feet (MLW). Thus, the 100-year flood stillwater elevation (7.32 feet MLW) is well below the toe of the geotextile tubes (~10 feet MLW). We do not think it was the intent of this comment to require something greater than a 100-year storm to meet the definition of a "larger storm."

seaward than the rest of the shoreline and affect the coastal processes (erosion and sediment transport)....

"Erosion doesn't stop in areas adjacent to a shoreline stabilization project and "holding the line" can become more and more difficult over time. Eventually there will be a time when the landward retreat of the array, to be more compatible with the surrounding shoreline, will be the preferred course of action....A section in the Work Protocol on the eventual retreat (or abandonment) of the array might be helpful and inform monitoring activities to support the long-term longevity of stabilization methods being utilized at this site."

Many of these general comments were discussed extensively during the NOI review process. While we provide brief responses to these general comments below, we note that the purpose of the annual review, as listed in the Project's Order of Conditions, is to review monitoring data and "recommend any necessary changes to the beach nourishment program for the Conservation Commission's review and approval," for the existing, approved geotextile tube project.

Regarding the comments about flanking, Project representatives acknowledged during the public hearing process on the NOI that returns may have to be lengthened over time. Additionally, the SBPF intends to pursue permits for an expanded system in the future. Such an expansion would result in a long, contiguous portion of the bluff that is protected (approximately 3,400 linear feet). This type of project where nearly 2/3 of a mile of bluff will be protected is different than the typical segmented project where only one or two lots are protected and where flanking is a significant consideration, especially if such shorter projects do not have sand mitigation or well-designed returns. For this longer project with its substantial sand mitigation program, it is anticipated that the protected section of bluff and associated beach, while it may eventually protrude farther seaward than the immediately adjacent shorelines, will continue to have a beach in front of it and will continue to allow littoral processes to continue. As was discussed during the NOI review process, we expect a similar response from the geotextile tubes as we have seen with >10 years of bluff protection via the biodegradable terraces at 79 Baxter Road and other locations, where there is some shoreward protrusion of the bluff yet there is still a dry beach present in front of the terraces. While we anticipate that the sand mitigation program will assist in maintaining a beach in front of the geotextile tubes, if there is some future effect on sediment transport processes, the placement of the mitigation sand could be adjusted to provide a higher proportion of sand at the ends of the geotextile tubes than in the front of the geotextile tubes.

We disagree with the statement that the eventual retreat or abandonment of the Project will be required. With a commitment to ongoing sand mitigation, the homeowners of the SBPF are dedicated to long-term preservation of the bluff and this historic neighborhood.

RESPONSE TO COMMENTS FROM THE NANTUCKET LAND COUNCIL/ APPLIED COASTAL RESEARCH AND ENGINEERING

This document presents responses to the three main comments provided by Applied Coastal in a memo dated April 12, 2017. Comments excerpted from the memo are presented in italicized text followed by responses in plain text.

> *"A great deal of emphasis has been placed on the variability of the measurements contained in the beach monitoring datasets and how the variability limits the value of data as a useful tool to evaluate the performance of the geotube project….At the six profiles examined by Epsilon, the erosion rate post geotube construction is higher than the historical long-term erosion rate."*

We agree with the ACRE statement regarding differences between short- and long-term changes. This is exactly why we've introduced the long-term data into the annual and quarterly reports. We also explored various statistical comparisons and trends, and concluded there is not yet a statistically defensible result. As ACRE stated in their analysis, short-term data can be inconclusive when viewed over long periods. Thus, it is not yet meaningful to compare the relatively short-term beach responses since the geotubes were installed against the long-term record. In fact, what we found is similar short-term shoreline changes previously occurred several times over the long-term record. This is apparent visually from the plots in the ACRE memo. We also recognized the period of beach accretion preceding the geotube installation, which as ACRE stated was anticipated to be followed by a period of erosion independent of the geotubes. These natural dynamics, combined with movement of the added sand volume placed in the project area for mitigation, may also skew or mask the response of the beach subsequent to the geotube installation. We plan to continue using regular comparisons against the long-term data record to help ascertain potential project influences, appropriate mitigation, and overall project management.

> *"The bluff monitoring program was utilized to compute the volume of material contributed from the unprotected bluff to the littoral system….It is to be expected that the areas to the north and south of the project area would contribute lower volumes of sediment as they are located outside the initial project area."*

We agree that it is worthwhile to compare the volume of material eroded from the geotextile tube area to the unprotected areas to the north and south that were used as "control" areas during the bluff monitoring survey. As shown on the attached (see Attachment E), we reviewed the bluff erosion rate for the geotextile tube area, the north control area, and the south control area. The time period reviewed was from 1994-2013 for those areas that had begun eroding in 1994 (91 Baxter northward) and 2003-2013 for those areas that began eroding later (91 Baxter southward). We first looked at bluff retreat rates for the geotube area and the control areas using the same methodology used to determine the bluff contribution rate in the geotube area (see Attachment E), and then we performed a simple volume calculation using bluff retreat rate * height. As noted in the response to Mr. Berman, we do not recommend using this simple calculation for determining the bank contribution rate for mitigation purposes, but it is useful here for comparing relative volume contribution from different bluff segments. This comparison indicates that the volume eroded from the north and south control areas is about 80% of the volume eroded from the geotextile tube area. We note that there is significant temporal and spatial variability in the amount of bluff erosion, with erosion hotspots developing in one location for a few years and then moving on to another location. Thus, the relationship between the volume eroded from the unprotected control areas and the volume eroded from the geotube area will vary through time. However, the availability of 25+ years of data on erosion volumes provides a high degree of assurance that mitigation volumes can be compared to historic rates or erosion over time. Nevertheless, we will add a note to all future comparisons of control area erosion to geotube area erosion that the control areas may slightly underestimate the volume of sand that would have eroded from the geotextile tube area. However, this does not change our overall conclusion that the mitigation template is contributing more sand than the unprotected bluff: if we adjust the measured control area erosion of 12.9 cy/lf/yr upwards to account for the 80% proportion, we get ~16 cy/lf/yr, which is still less than the mitigation template contribution of 18.1 cy/lf/yr.

Overall, the current bluff contribution amount is just one of several tools we use when evaluating the geotextile tube project: we also compare the mitigation volume to the historic bluff contribution rate, we review the post-geotube shoreline change data compared to the long-term trend, and we monitor the geotubes after every storm. When all the data are considered together, we do not see any evidence of increased erosion of adjacent beaches.

"SBPF claims that the mitigation volume required for the geotube project is 1.5 times the average annual bluff contribution rate, which is not supported by the data or their analysis. The required mitigation rate of 22 cy/lf/yr was arrived at through scientific and engineering studies and analysis conducted by SBPF consultants on previous Sconset Beach projects."

A detailed response to this comment has been provided on numerous occasions over the past nearly four years during other Conservation Commission hearings, most recently during the NOI hearing process for the geotube project. We are attaching our November 1, 2013 memo (Attachment A), which addressed this comment in detail and provided the means used to calculate the bluff mitigation volume. The below table from the November 2013 memo includes previous mitigation volume calculations for other projects proposed by SBPF and describes that the 14.3 cy/lf/yr is the most conservative calculation of bluff contribution volume performed to date. We also note that the source of confusion appears to be that the marine mattress and gabion pilot project included a nearshore component of

~7 cy/lf that represents the volume of sand out to the depth of closure at -26 feet MLW (about 1500 feet offshore). This nearshore component is not included in the bluff contribution calculations for the geotextile tube project since, as noted both in the Epsilon memo and in the third party review by Mr. Berman, the state standard for mitigation is to provide the average amount contributed from the eroding landform (the bluff).

The attached Epsilon memo (Attachment A) also explains how the calculation used to determine the bluff contribution volume was corroborated by both (1) bluff survey data and (2) shoreline change data. The attached memo provides ample support for the mitigation calculation.

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

"We agree with Epsilon that the aerial bluff monitoring should continue on an annual basis. The program could be expanded to monitor changes in the aerial beach profile, which could provide important information regarding the position of the geotube toe relative to the highwater line. At the conclusion of the 3-Year Special Conditions window required as part of the permit for the geotube project, the shoreline monitoring could be shifted from a quarterly basis to spring and fall surveys without jeopardizing the dataset. However, we disagree that the profile surveys should be truncated at the waterline and not include the nearshore bathymetry. The shape of the aerial and subaerial beach profile is important for understanding and monitoring the dynamics of the littoral system."

We will continue the annual bluff monitoring and believe that now is an appropriate time to switch to semi-annual beach surveys, a position also supported by Mr. Berman. We also believe our analysis of extrapolation and the associated small errors (1.4%) demonstrate that extrapolation is a reasonable technique that can drastically improve survey efficiency and reduce risks to the survey crew.

"Reducing the number of survey profiles was discussed. Prior to any reduction in the number of profiles, it is important to understand which profiles would be eliminated. It is important to ensure that long-term monitoring stations are not eliminated, nor monitoring stations that will provide the first evidence of potential adverse impacts associated with the geotube project, as well as future projects which SBPF are preparing."

As clarification, our suggestion for reducing the number of survey profiles was only for the bathymetry surveys, so that the survey can be completed within one day. We suggested we retain all historic whole number profiles plus Q, S and W. As noted in the analysis by Woods Hole Group attached to the Annual Report, the bathymetry offshore Siasconset features a generally stable profile, particularly in the northern and central portions of the monitoring area (which includes the geotextile tubes). Bathymetry data are helpful for general scientific purposes to understand regional coastal processes (e.g., offshore shoal movements and evolutions), but are not conclusive for determining whether the geotextile tubes are having an adverse impact upon adjacent beaches. Shoreline position data are most useful for that purpose. Bathymetry surveys conducted a maximum of once per year are sufficient to characterize regional morphology.

Attachment A

November 1, 2013 Epsilon Memo "Baxter Road Geotube Project – Coastal Bank Retreat 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

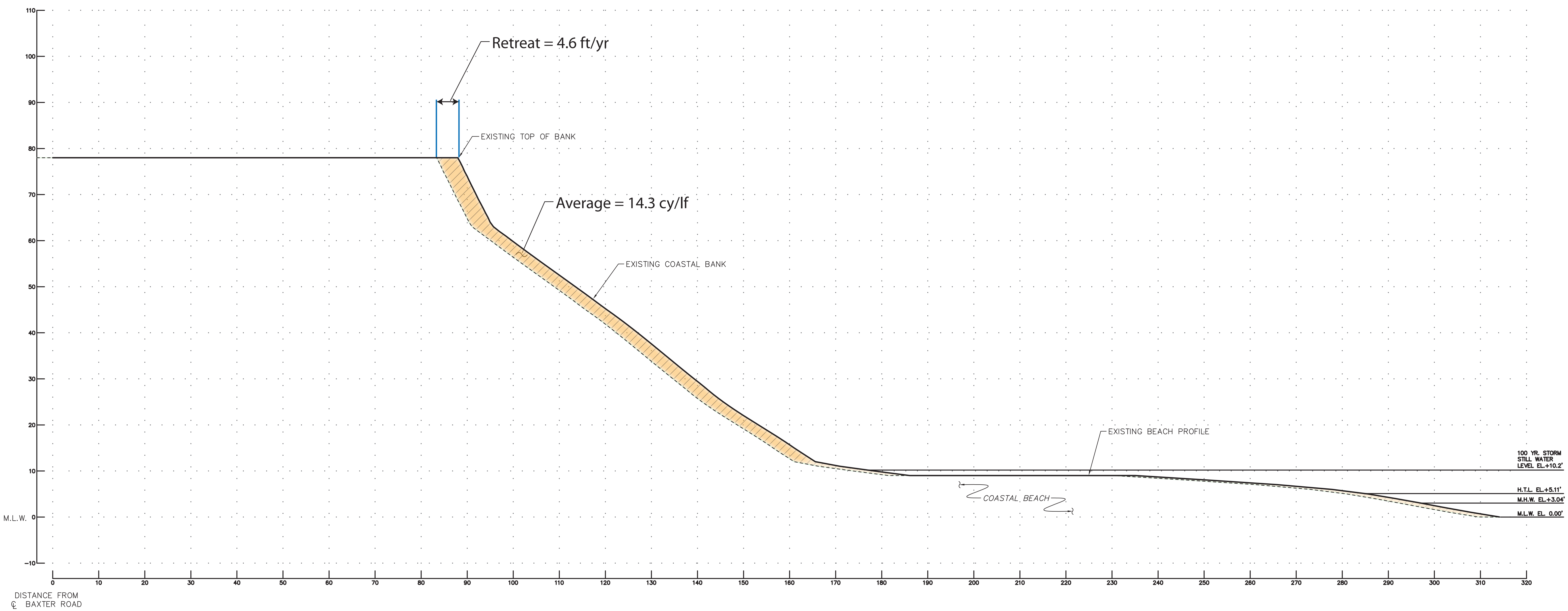
During the permitting effort for the beach nourishment project, Coastal Planning & Engineering (CP&E) prepared a littoral budget based upon data from 1995-2005. (See FEIR, Sconset Beach Nourishment Project, November 30. 2006. Attachment A, Coastal Planning and Engineering (CPE) Engineering Design Report, 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)

Transcect	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).

Attachment B

Explanation of Tidal Datum Used for Siasconset Beach Dewatering Project Per Leo Asadoorian, PLS, Blackwell & Associates, Inc.; March 23, 2004

Explanation of Tidal Datum Used for Siasconset Beach Dewatering Project Per Leo Asadoorian, PLS, Blackwell & Associates, Inc.

March 23, 2004

In 1994, when the beach dewatering project began, Blackwell & Associates, Inc. was contacted by Fugro East (now ENSR International) to provide elevations at monitoring wells placed in Sconset as part of preliminary investigations for a dewatering system to be placed seaward of Codfish Park.

Discussions at that time with Coastal Geologist Stan Humphries, dealt with a datum that was indicative of sea level and not in the 1934 Half-Tide-Datum, which had been in use on Nantucket for 62 years. The 34 HTL datum was based on three (3) months of tide gauge readings, August – October 1934 and reduced to mean values. This datum was found not to represent actual mean sea levels due to the short duration of gauge readings.

A tidal datum is usually considered to be the "average of all occurrences of a certain tidal extreme for a period of 19 years – actually 18.6 years rounded to the nearest whole year." Obviously using the 19 - year tidal epoch would be more representative of the current sea level as opposed to the '34-datum. On May 23, 1994 this office received a publication dated June 5, 1992 from the National Oceanic and Atmospheric Administration (NOAA) for Nantucket Island. It correlated twelve (12) tidal benchmarks, two (2) of which also had 1934 benchmark elevations established on them, within a 16-year tidal time period. These two 1934 benchmarks, known as Tidal Benchmark No.'s 22 & 23 still exist and are in good condition.

Since benchmarks 22 & 23 are within the island wide control loop established by the U.S. Coast and Geodetic Survey in 1934, it was possible to correlate any U.S.C. & G.S. benchmark on Nantucket to the 1992 adjustment provided by NOAA. All forty-four (44) monitoring stations had a 1992 tidal benchmark elevation established on them for beach profiles at each location.

We have always referred to this datum as the 1992 MLW Datum, since this was the date of the NOAA publication, but the actual time period used to establish this adjustment was from 1969 through 1984. NOAA has since issued an updated publication dated April 21, 2003, which encompasses a complete tidal epoch of 19 years (Jan.1983 – December 2001). I have compared elevations of tidal data for each publication (1992 & 2001) and found them to vary by only 0.01' to 0.03'.

In summary, a local tidal benchmark system (Nantucket/Station ID 8449130) was used for this project. The NOAA tidal benchmark elevations have not been adjusted to the North American Vertical Datum of 1988 (NAVD88). The elevations established on the beach monitoring control stations are relative to Mean Low Water (MLW) and correlate with elevations for tidal benchmark No.'s 22 and 23 as published by NOAA on June 5, 1992.

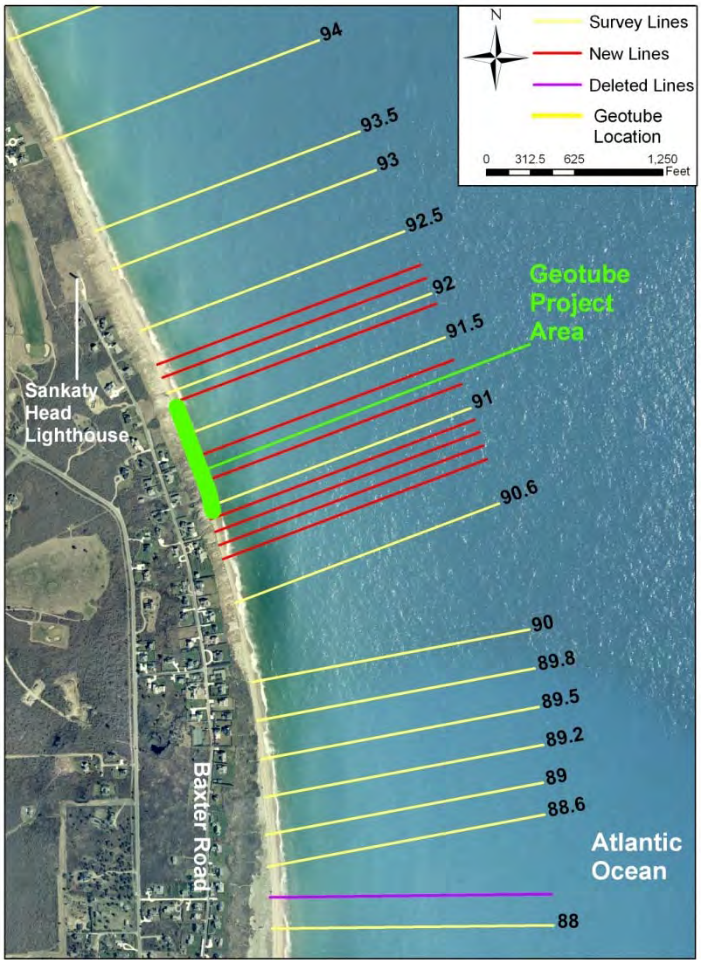
Attachment C

Southeast Nantucket Beach Monitoring 71st Survey Report, prepared by Woods Hole Group, March 2017

SOUTHEAST NANTUCKET BEACH MONITORING

March 2017

71st SURVEY REPORT



WOODS HOLE GROUP

81 Technology Park Drive
East Falmouth MA 02536

March 2017

Southeast Nantucket Beach Monitoring

March 2017

71st SURVEY REPORT

March 2017

Prepared for:
Siasconset Beach Preservation Fund
P.O. Box 2279
Nantucket, MA 02584

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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 supporting ongoing shoreline protection and monitoring efforts. This report summarizes the February 2017 topographic survey, the 71st survey conducted at Siasconset since 1994, which represents the first quarter of 2017 by current permit requirement. Woods Hole Group 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 surveys, after Coastal Stabilization, Inc. (original license holder in US) installed the original beach dewatering systems in August 1994 to mitigate beach erosion.

Surveys are intended to monitor beach profile and shoreline change in the region, and to plan shore protection initiatives. One of the recent initiatives includes an 852 foot long geotube system constructed between December 2013 and January 2014 to stabilize the bluff between profiles 90.9 and 91.9. The original geotube system consisted of three tiers of geotubes, and a fourth tier was added between November and December 2015 extending the northern and southern ends of the project by 21 feet and 74 feet, respectively. The monitoring program was modified to include additional profiles to monitor the shoreline fronting and adjacent to the geotubes. Quarterly shoreline monitoring is required by the geotube project's Order of Conditions (SE 48-2824). Quarterly monitoring extends from the toe of the dune or bank seaward to the -5 ft MLW contour. Additionally, the quarterly monitoring program includes top of bank monitoring within the geotube project area and adjacent profiles 90-93. Bathymetric monitoring is required twice annually in the spring and fall quarters. Discussions are ongoing with the Nantucket Conservation Commission to optimize the monitoring program, including extent and frequency of beach profile and bathymetric surveys. Electronic copies of the raw profile data are provided on the attached CD.

This report compares the recent February 2017 survey to previous data sets dating to 1994, and summarizes volume and shoreline change calculations for five time periods:

- November 1994 survey through December 2001 (pre-operational period prior to the dewatering system upgrade);
- December 2001 through September 2013 (post-dewatering system upgrade and pre-geotube installation period);
- September 2013 through February 2017 (post-geotube installation period);
- March 2016 through February 2017 (the last year); and
- October 2016 through February 2017 (since last survey).

September 2013 is a baseline for comparisons of pre- and post-geotube installation periods. The survey reports present new beach profile data, and compare new beach profiles to previous data. Volume calculations and shoreline change analyses lend insight to erosion and accretion trends along the beach.

This report is presented in three sections plus two appendices.

- Section 2.0 provides specific information regarding the current February 2017 topographic and bathymetric surveys as well as the corresponding beach profiles;
- Section 3.0 presents results of the volume and shoreline change calculations and wave conditions, including a subsection on long-term trends;
- Appendix A presents the plots of the profile data; and
- Appendix B includes the electronic copy of raw profile data.

2.0 FEBRUARY 2017 SURVEY AND PROFILES

2.1 LAND-BASED SURVEY

Woods Hole Group conducted the 71st beach survey to a depth of -5 MLW from February 2nd to 3rd, 2017. Profile locations are shown on Figure 1. The horizontal datum for the project is the Massachusetts State Plane Coordinate System, Island Zone (1927) and units of feet. The vertical datum is mean low water (MLW) originally set in 1934 and corrected with 1992 NOAA adjustments by Blackwell and Associates, Inc. (BAI) (referred to hereafter as MLW92). The conversion from MLW92 to NAVD88 is -1.4 feet. Woods Hole Group conducted the February 2017 survey using a Trimble® R8 GPS receiver, a real-time kinematic global positioning system (RTK GPS) providing centimeter-level geodetic positioning. The system operates by receiving position corrections in real time from the Leica SmartNet Virtual Reference Station (VRS) network over the cellular data network. This system replaces the need for setting up a second GPS receiver as a base station on a benchmark. The system is site-calibrated to the MLW92 vertical datum using the following three (3) geodetic control points:

- Station #277, a capped rebar set inside the fence by Sankaty Lighthouse at the end of Baxter Rd (N 103,724.7035, E 346,893.4132, El=109.40 MLW92).
- Station #278, a capped rebar set outside the fence by Sankaty Lighthouse at the end of Baxter Rd (N 103,959.4018, E 346,817.3680, El=100.58 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 former Loran tower at Low Beach (N 92,601.73, E 344,906.23, El=13.50 MLW92).

Profiles were surveyed based on RTK GPS data collected along the subaerial beach profile and traditional electronic total station survey data collected in the surf-zone. At each profile, the surveyor uses the RTK GPS to navigate 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 real-time horizontal positioning data is used to "steer to" the coordinates of the benchmark for each profile, and then the surveyor walks 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 Leica TS-02 electronic total station is utilized to survey a swimmer with a survey rod to collect the wading profile data.

Table 1 lists the profiles in the monitoring program surveyed for the November 1994, December 2001, September 2013, March 2016, October 2016, and February 2017 surveys. All surveyed profiles reached the target depth of -5 MLW except profiles Q1 and Q2 due to an unrecoverable instrument malfunction. Profiles not reaching the target depth are extrapolated using the average offshore slope presented in the baseline erosion rates report. A visual assessment of the profiles reveals the extrapolated profile sections compare well in shape with previous profiles, and indicates volume calculations effectively characterize the beach changes. Previous surveys showed the extrapolation method adequately characterizes the beach profile, which is relatively consistent, steep, and linear on this section of coast.

As further explained in Section 3, ongoing erosion afforded surveys of certain profiles extending landward of earlier 1994 and 2001 profile baselines, providing data for more informative volume calculations farther landward when comparing the most recent data sets. The "Distance" column in Table 1 represents the landward distance from the original benchmarks where volume calculations were possible between the two most recent surveys. The September 2012 survey (not shown) established a new landward baseline for comparison at certain profiles. Red numbers represent beach profiles where volume change was calculated farther landward than in previous reports.

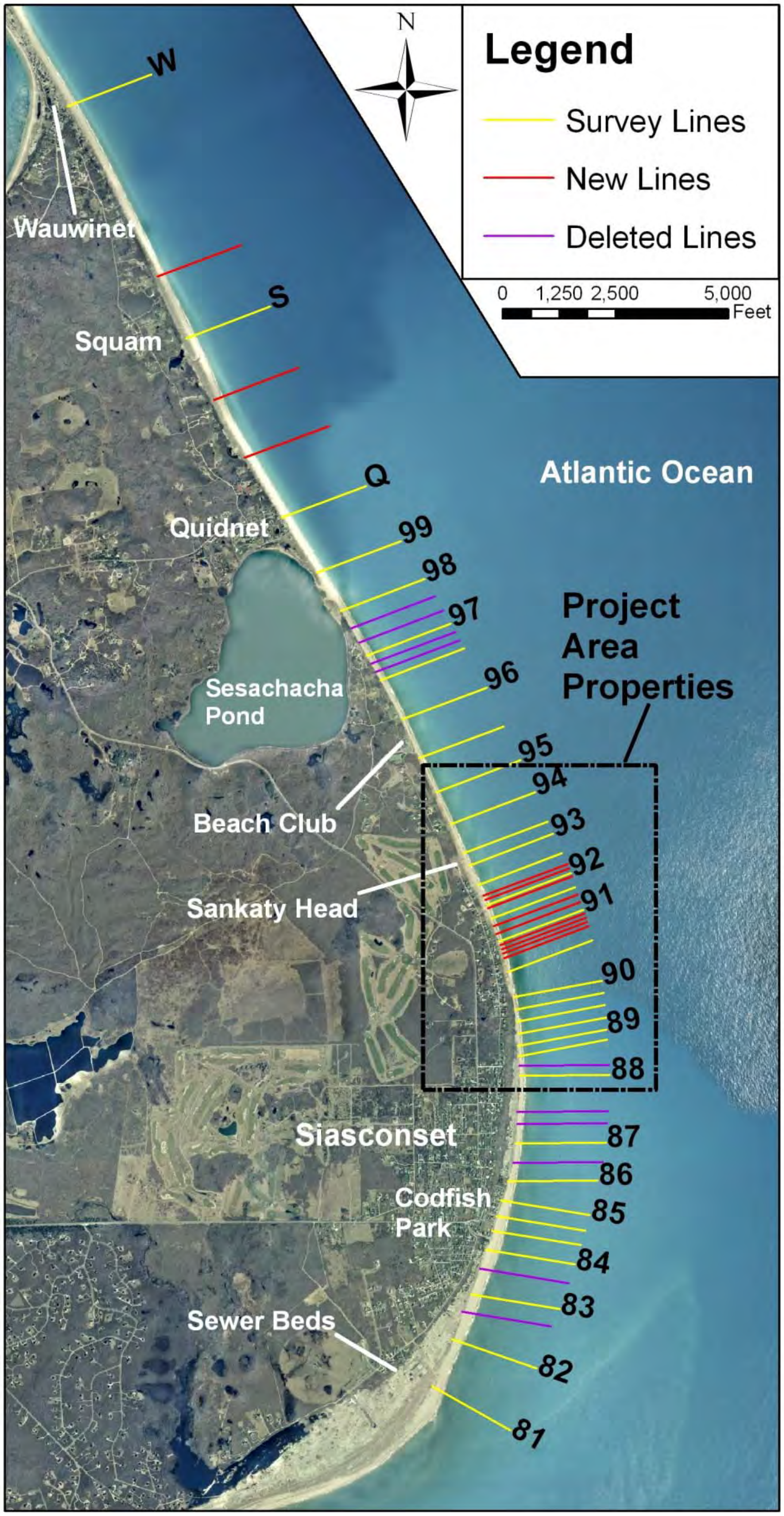


Figure 1. Project Location and Profile Map

Table 1. Profiles surveyed by date.

PROFILE NAME	Baseline Distance[2] (ft)	SURVEY DATE					
		Nov-94	Dec-01	Sep-13	Mar-16	Oct-16	Feb-17
81	-200	✓	✓	✓	✓	✓	✓
82	-70	✓	✓	✓	✓	✓	✓
83	-20	✓	✓	✓	✓	✓	✓
84	-20	✓	✓	✓	✓	✓	✓
84.3	0	✓	✓	✓	✓	✓	✓
84.6	0	✓	✓	✓	✓	✓	✓
85	0	✓	✓	✓	✓	✓	✓
86	-30	✓	✓	✓	✓	✓	✓
87	-75	✓	✓	✓	✓	✓	✓
88	-130	✓	✓	✓	✓	✓	✓
88.6	-110	✓	✓	✓	✓	✓	✓
89	-167	✓	✓	✓	✓	✓	✓
89.2	-98	✓	✓	✓	✓	✓	✓
89.5	-89	✓	✓	✓	✓	✓	✓
89.8	-72	✓	✓	✓	✓	✓	✓
90	-102	✓	✓	✓	✓	✓	✓
90.6	-59	✓	✓	✓	✓	✓	✓
90.8[1]	NS	NS	NS	NS	✓	✓	✓
90.85[1]	NS	NS	NS	NS	✓	✓	✓
90.9[1]	NS	NS	NS	NS	✓	✓	✓
90.95[1]	NS	NS	NS	NS	✓	✓	✓
91	-111	✓	✓	✓	✓	✓	✓
91.2[1]	NS	NS	NS	NS	✓	✓	✓
91.35[1]	NS	NS	NS	NS	✓	✓	✓
91.5	-72	✓	✓	✓	✓	✓	✓
91.9[1]	NS	NS	NS	NS	✓	✓	✓
92	-68	✓	✓	✓	✓	✓	✓
92.1[1]	NS	NS	NS	NS	✓	✓	✓
92.2[1]	NS	NS	NS	NS	✓	✓	✓
92.5	-53	✓	✓	✓	✓	✓	✓
93	-26	✓	✓	✓	✓	✓	✓
93.5	-50	✓	✓	✓	✓	✓	✓
94	-52	✓	✓	✓	✓	✓	✓
95	-54	✓	✓	✓	✓	✓	✓
95.5	-56	✓	✓	✓	✓	✓	✓
96	-33	✓	✓	✓	✓	✓	✓
96.5	-19	✓	✓	✓	✓	✓	✓
97	-11	✓	✓	✓	✓	✓	✓
98	0	✓	✓	✓	✓	✓	✓
99	0	✓	✓	✓	✓	✓	✓
Q	-24	✓	✓	✓	✓	✓	✓
Q1[1]	NS	NS	NS	NS	✓	✓	✓
Q2[1]	NS	NS	NS	NS	✓	✓	✓
S	0	✓	✓	✓	✓	✓	✓
S1[1]	NS	NS	NS	NS	✓	✓	✓
W	-30	✓	✓	✓	✓	✓	✓

SHADING indicates the geotube project area

Note that historical profiles 82.6, 83.5, 86.5, 87.4, 87.5, 88.3, 96.7, 96.9, 97.6, and 97.3 and the September 2013 profiles 89.3, 89.4, 89.6, 92.8, 92.9, 93.2, and 93.8 were removed in April 2014 from the monitoring program and therefore were not surveyed.

NS = Not Surveyed; RED NUMBER = profile using updated volume calculation windows;

1 = Profile added in April 2014.

2 = Distance is landward extent of the profile used for volume calculations.

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 2013 (the pre-geotube installation period);
- September 2013 to February 2017 (the post-geotube installation period);
- March 2016 to February 2017 (the last year); and
- October 2016 to February 2017 (the duration since the 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 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 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, as five benchmarks were relocated between December 2002 and March 2003 (profiles 81, 87.5, 88.3, 91, and 93), 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.

Progressive erosion of the profiles since 2001 resulted in a scenario where the active portion of certain profiles retreated landward of the baseline distance within which original volume calculations were made. Figure 2 shows an example for profiles 90.6 and 91; the vertical dashed lines indicate the region where volume calculations were made in 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 incorrectly indicating accretion if limited within the Old baseline distance. This trend exists for other profiles, but is not consistent across all profiles. To better characterize beach change, a new method was established in 2013 whereby volume calculations were extended landward as needed to more accurately represent beach volume change starting in March 2013 (using the September 2013 as the new baseline). 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 more accurately represent recent dynamic beach response.

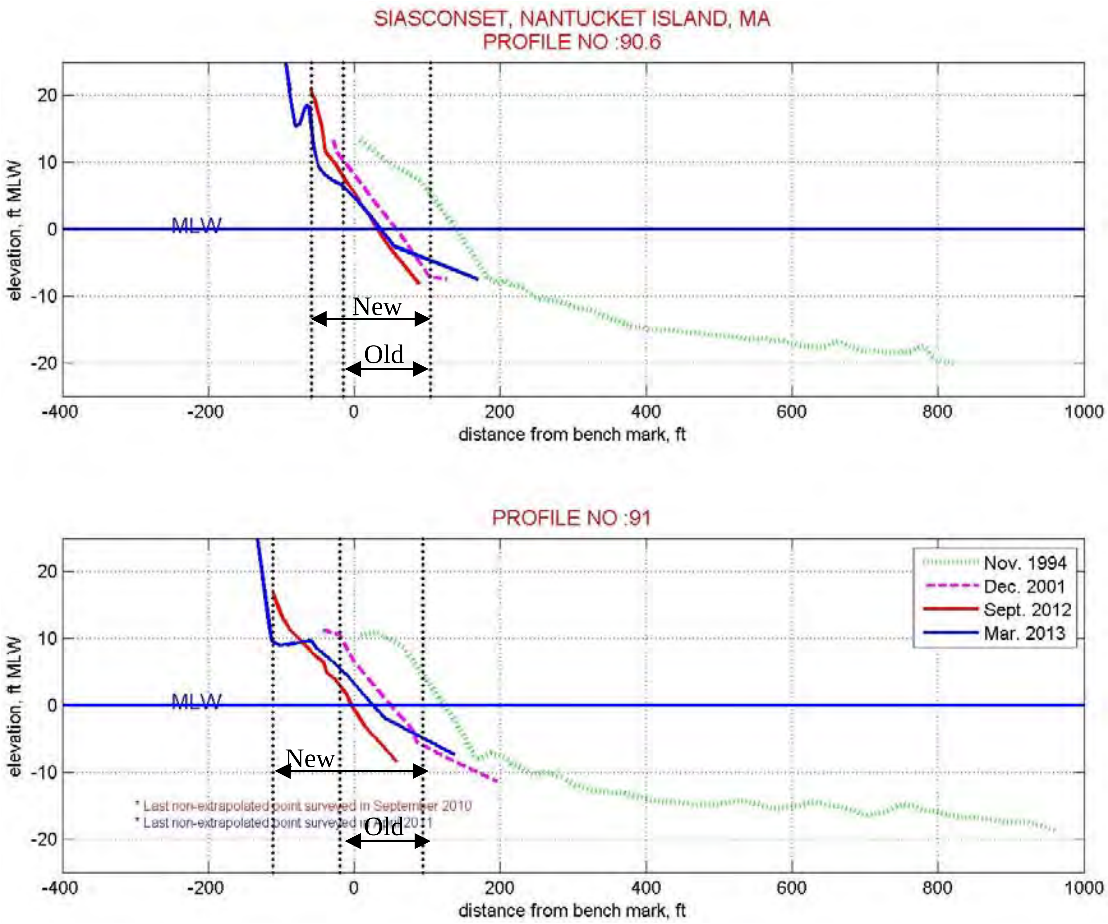


Figure 2. **Profile for 90.6 and 91 indicating how the volume calculation region expanded for the March 2013 profiles.**

Volume and shoreline change were calculated for the profiles in the entire monitoring area (profiles 81 to W). The historical project area was defined as the area extending from profile 89.2 through profile 92.5 (Figure 3) with two mitigation areas, 1,000 ft to both sides of the previous Lighthouse Beach dewatering system site, included in the definition of the project area. Historically, profiles 90, 90.6 and 91 were used to calculate the treated area changes, profiles 89.2, 89.5, 89.8, 90 and 90.6 were used to calculate the south mitigation area changes, and profiles 90.6, 91, 91.5, 92, and 92.5 were used to calculate the north mitigation area changes. Since the dewatering system is no longer performing, the definition of the project area has been modified to indicate the boundaries of the geotube monitoring area between profiles 88 and 94 and the actual geotube project area with a footprint between profiles 90.9 and 91.9.

Table 2 lists the volume change for each profile for each time period. Volume calculations for the twelve (12) new profiles were only calculated for the most recent periods since the profiles were added in April 2014. Results are summarized below.

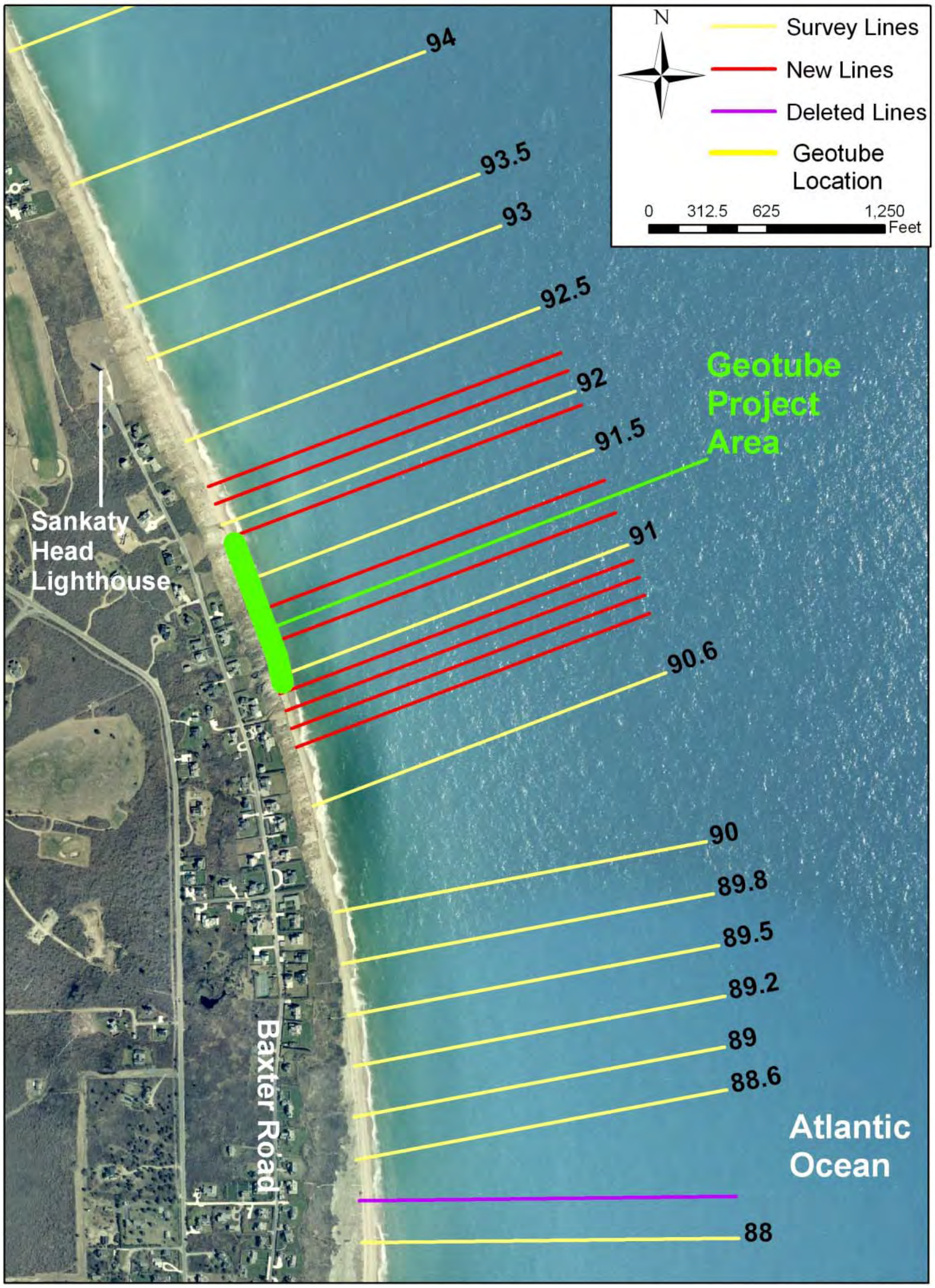


Figure 3. Siasconset Project Area

Table 2. Volume change per profile from Nov. 1994 - Dec. 2001, Dec. 2001 - Sept. 2013, and Sept. 2013 - , Mar. 2016 -, and Oct. 2016 – Feb. 2017.

PROFILE	VOLUME CHANGE PER PROFILE				
	Nov-94 to Dec-01 (cy/ft)	Dec-01 to Sept-13 (cy/ft)	Sep-13 to Feb-17 (cy/ft)	Mar-16 to Feb-17 (cy/ft)	Oct-16 to Feb-17(cy/ft)
81	-69	13.6	-17.4	-11.4	16.6
82	-31.7	31.6	-11.4	11.9	-1.6
83	47.7	25.5	-16.0	-16.3	-12.7
84	11.8	54.4	7.3	-3.2	-3.3
84.3	14.1	36.6	12.1	0.3	3.2
84.6	36.4	4.5	11.1	6.8	6.0
85	39.4	-23.5	6.9	7.3	5.6
86	4	-20.5	-9.3	1.3	3.9
87	-56	-22.3	-19.3	-3.9	1.6
88	-41.5	-50	4.3	1.3	5.4
88.6	-48.8	-33.5	0.9	1.4	6.0
89	-55.5	-18.9	-0.5	1.2	7.7
89.2	-60.7	-17.8	-2.9	-4.2	1.0
89.5	-65.2	-13.7	-4.6	-7.5	-0.8
89.8	-67.9	-9.5	-10.4	-11.5	-5.8
90	-61.5	-7.3	-7.0	-9.6	-6.1
90.6	-51.6	-8.7	-11.1	-7.6	-3.5
90.8	N/A	N/A	N/A	-6.7	-1.5
90.85	N/A	N/A	N/A	-5.6	-0.6
90.9	N/A	N/A	N/A	-5.1	-0.8
90.95	N/A	N/A	N/A	-3.1	1.2
91	-42	-14.1	-6.6	-5.3	-1.4
91.2	N/A	N/A	N/A	-0.6	2.0
91.35	N/A	N/A	N/A	-1.9	1.0
91.5	-21.1	-24.6	-5.1	-2.5	-0.5
91.9	N/A	N/A	N/A	-2.2	-2.2
92	-12.5	-13.7	-6.1	1.4	2.4
92.1	N/A	N/A	N/A	-0.8	1.3
92.2	N/A	N/A	N/A	-2.3	-1.6
92.5	-21.1	-0.8	-5.3	7.1	5.7
93	-30.9	2.4	-8.1	-0.6	4.6
93.5	-35.7	5.5	-7.1	-1.8	1.2
94	-25.9	-4.5	-10.5	-5.9	-1.5
95	-25.3	-12.9	-17.3	-6.2	-0.8
95.5	-33.2	-22.3	-15.6	-4.1	0.5
96	-6.2	-16.9	-18.9	-7.1	-0.9
96.5	-1.9	-2.4	-14.9	-6.6	-2.4
97	-7.2	18.3	-6.7	-4.2	0.9
98	-0.3	12.7	-4.2	-0.4	-4.1
99	-1.9	19.7	-0.6	-0.6	-0.2
Q	6.7	-5	-5.4	1.8	3.0
Q1	N/A	N/A	N/A	3.3	3.8
Q2	N/A	N/A	N/A	7.0	6.8
S	21.4	14.9	2.8	6.6	8.9
S1	N/A	N/A	N/A	6.6	6.0
W	16.5	13	10.7	8.6	13.2

(+ Accretion, - Erosion) (N/A: Not Available)
SHADING indicates the geotube project area

3.1.1 November 1994 to December 2001

This period, traditionally known as the dewatering system pre-operational period, is included for historical consistency, and extends from the earliest dewatering system pre-construction survey to the December 2001 survey before the (now not operating) dewatering system upgrade.

- The central portion of the monitoring area eroded (profile lines from 87 through 99), from just north of Codfish Park to Sesachacha Pond. Maximum erosion was focused between profiles 87 and 91, where total erosion since 1994 exceeded -40 cy/ft; with a maximum of -68 cy/ft of erosion at profile 89.8.
- The southern profiles, characterized by profiles 83 through 86, accreted with the exception of the southern-most profiles 81 and 82. Maximum accretion exceeded 47 cy/ft at profile 83.
- The beach was relatively stable and accreting from profiles Q through W.

3.1.2 December 2001 to September 2013

This period, also reported for historical context and consistency, extends from the activation of the upgraded dewatering system through the last survey prior to geotube installation (September 2013). Table 2 presents volume change for the monitoring area.

The monitoring area performed as follows:

- The southern portion of the monitoring area, from profile 81 through profile 84.6, gained sediment over the 12 years.
- Maximum accretion occurred at profile 84, where more than 54 cy/ft of sediment accumulated in the 12 years.
- The central portion of the study area, between profiles 85 through 92.5 eroded.
- Maximum erosion of -50 cy/ft occurred at profile 88.
- In the northern reach, beach volume was stable or accreted from profile 97 to W except profile Q (between ~12 to 19 cy/ft of accretion).

3.1.3 September 2013 to February 2017

This period spans the period since the installation of the geotubes; September 2013 has been established as a baseline survey. Table 2 presents the results.

The monitoring area performed as follows:

- Of the 34 profiles surveyed in the monitoring area, erosion was the dominant trend with 26 profiles eroding and 8 profiles accreting since the geotubes were installed. Note that in September 2013 only 34 of the current 46 profiles were included in the monitoring program and can be used for comparison.
- Maximum erosion occurred at profile 87, which eroded more than -19 cy/ft.
- Accretion ranging from 1 to 12 cy/ft was focused between profiles 84 to 88.6, excepting 86 and 87, in Codfish Park.

- Profiles 91 and 91.5 in the geotube project area eroded between -5.1 to -6.6 cy/ft since the geotubes were installed.

3.1.4 March 2016 to February 2017

This period spans the duration since the last annual survey in March 2016. Table 2 presents the results.

The monitoring area performed as follows:

- Of the 46 profiles surveyed in the monitoring area, erosion was the dominant trend with 30 profiles eroding and 16 profiles accreting since the last annual survey.
- Erosion occurred along most of the project area, with a maximum erosion of nearly -16.3 cy/ft at profile 83.
- All 6 profiles in the geotube project area eroded since the last year, with a maximum erosion of -5.3 cy/ft at profile 91.

3.1.5 October 2016 to February 2017

This period spans the duration since the last survey in October 2016. Table 2 presents the results.

The monitoring area performed as follows:

- Of the 46 profiles surveyed in the monitoring area, 20 profiles eroded and 26 profiles accreted since the last survey.
- Erosion occurred primarily in the central part of the project area, but with maximum erosion of nearly -13 cy/ft at profile 83.
- Accretion occurred in both the north and south of the project area, with maximum accretion of 16.6 cy/ft at profile 81.
- Of the six profiles in the geotube project area, three accreted and three eroded.

3.2 SHORELINE CHANGE ANALYSIS

Woods Hole Group evaluated shoreline change (retreat or advance of the mean low water line) to provide insight regarding beach response in the project vicinity. This section provides a comparison of shoreline changes in the monitoring area since November 1994 for the five (5) periods under investigation. Shoreline distances were measured from the baseline horizontally to the 0 ft MLW92 contour level for consistent comparison with prior reports. Table 3 lists shoreline change by profile for the surveys under investigation. Figure 4 illustrates shoreline change.

Results can be summarized as follows:

3.2.1 November 1994 to February 2017

- Except for the extreme southern limit of the monitoring area, the shoreline advanced in the southern portion of the monitoring area (profiles 83 to 85), retreated in the middle (profiles 86 to 96.5), and accreted at the northern portion (profiles 97 to W, except Profile Q) since the surveys began in 1994.

- Maximum shoreline advance occurred between profiles 83 and 85, where the shoreline advanced more than 125 ft at profile 84.
- Maximum shoreline retreat occurred between profiles 87 and 91, where the shoreline retreated more than -113 ft.

3.2.2 December 2001 to February 2017

- Except the extreme southern limit of the survey area, 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 retreated.
- Shoreline advance since December 2001 occurred between profiles 81 and 84.6, except profile 83, with a maximum shoreline advance of nearly 106 ft at profile 84.
- Shoreline retreat since December 2001 occurred between profiles 85 and 96.5, except profile 93.5, with a maximum shoreline loss of more than -64 ft at profile 87.

3.2.3 September 2013 to February 2017

- Shoreline recession has been the dominant trend since the geotubes were installed with 26 profiles retreating and 8 profiles accreting since the September 2013 survey. Note that in September 2013 only 34 of the current 46 profiles were included in the monitoring program and can be used for comparison.
- The maximum shoreline advance was 23.3 ft at profiles 84.3.
- The maximum shoreline retreat was -42.9 ft at profile 87.

3.2.4 March 2016 to February 2017

- Overall, shoreline recession was the dominant trend with 36 profiles retreating and 10 profiles accreting over the past year since March 2016.
- Accretion occurred between 82 and 89 (excepting 83, 84, and 8), 92.5, and Q2, with a maximum accretion of 30.0 ft at profile 82.
- Maximum shoreline retreat in the past year was -36.2 ft at profile 83.
- All six (6) profiles in the geotube project area eroded during the last year.

3.2.5 October 2016 to February 2017

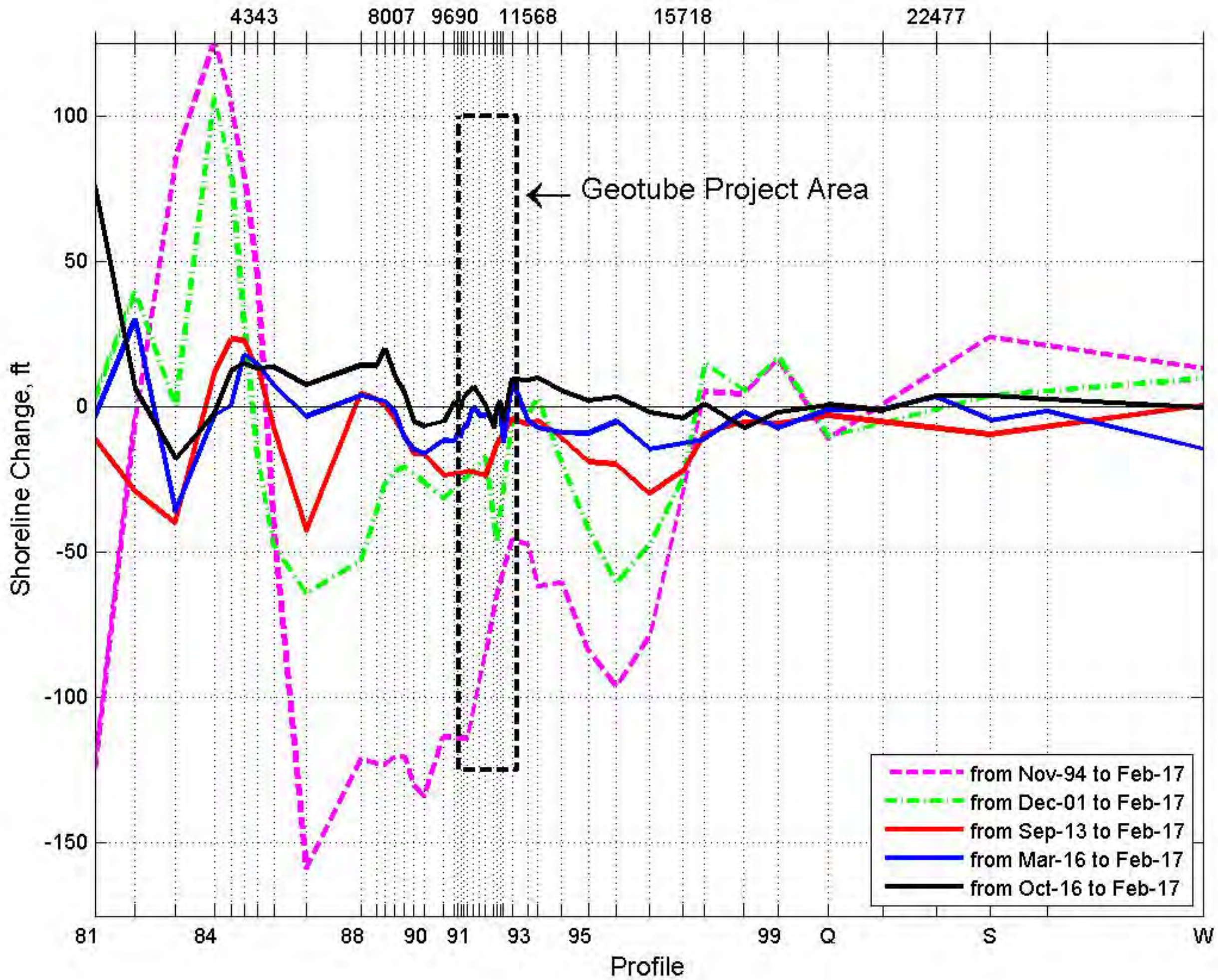
- Shoreline accretion was the dominant recent trend since the last survey with 31 profiles advancing and 15 profiles retreating.
- Maximum shoreline advance in the past three months occurred at profile 81, advancing 76.0 ft.
- Maximum shoreline retreat in the past three months occurred at profile 83, retreating -18.0 ft.
- Of the six (6) profiles in the geotube project area, only profile 91.9 retreated at -7.3 ft, while the other profiles advanced 0.4 to 6.9 ft.

Table 3. Shoreline changes from Nov. 1994, Dec. 2001, Sep. 2013, Mar. 2016, and Oct. 2016 to Feb. 2017 (Distances seaward from benchmark to 0 ft MLW92 contour).

PROFILE	SHORELINE CHANGE PER PROFILE				
	Nov-94 to Feb-17 (ft)	Dec-01 to Feb-17 (ft)	Sep-13 to Feb-17 (ft)	Mar-16 to Feb-17 (ft)	Oct-16 to Feb-17(ft)
81	-125.6	3.1	-11.2	-3.3	76.0
82	-4.2	39.6	-29.0	30.0	6.1
83	84.9	-0.2	-40.1	-36.2	-18.0
84	125.4	106.4	11.3	-2.9	-2.4
84.3	104.3	80.5	23.3	0.4	12.2
84.6	79.8	27.6	22.8	17.9	14.9
85	45.2	-17.1	13.2	14.5	13.2
86	-42.9	-48.2	-8.4	7.3	13.5
87	-158.7	-64.4	-42.9	-3.4	7.4
88	-121.1	-53.1	4.6	3.7	14.2
88.6	-122.6	-36.4	2.5	2.5	14.2
89	-122.9	-26.6	0.3	1.9	20.0
89.2	-120.5	-22.2	-4.3	-1.9	10.3
89.5	-120.0	-20.6	-10.2	-10.8	4.8
89.8	-130.3	-23.2	-16.2	-14.7	-5.3
90	-133.9	-26.1	-16.3	-16.2	-6.7
90.6	-113.5	-31.6	-23.4	-11.7	-5.0
90.8	N/A	N/A	N/A	-11.7	1.5
90.85	N/A	N/A	N/A	-9.3	0.2
90.9	N/A	N/A	N/A	-10.3	-0.6
90.95	N/A	N/A	N/A	-6.7	3.2
91	-113.9	-24.0	-22.2	-6.7	4.6
91.2	N/A	N/A	N/A	-0.2	6.9
91.35	N/A	N/A	N/A	-3.0	3.8
91.5	-84.6	-17.3	-23.8	-3.1	0.4
91.9	N/A	N/A	N/A	-3.9	-7.3
92	-65.1	-46.8	-13.2	-2.3	-0.7
92.1	N/A	N/A	N/A	-1.3	2.0
92.2	N/A	N/A	N/A	-12.4	-4.9
92.5	-45.8	-5.2	-4.2	8.8	9.6
93	-47.5	-3.0	-6.2	-5.0	9.1
93.5	-61.6	3.2	-4.9	-7.3	10.0
94	-60.3	-19.7	-10.8	-8.9	5.3
95	-83.8	-41.8	-18.9	-9.2	2.2
95.5	-96.3	-60.8	-19.8	-5.0	3.4
96	-79.2	-47.2	-29.9	-14.4	-1.9
96.5	-29.3	-24.2	-22.0	-12.5	-4.0
97	5.1	14.8	-9.2	-11.1	0.8
98	4.3	5.5	-5.2	-2.0	-7.2
99	16.4	17.0	-5.6	-7.2	-2.1
Q	-11.1	-10.5	-3.0	-1.0	0.7
Q1	N/A	N/A	N/A	-0.8	-1.3
Q2	N/A	N/A	N/A	3.4	3.7
S	24.0	3.7	-9.5	-4.6	3.8
S1	N/A	N/A	N/A	-1.6	2.5
W	13.1	9.6	0.4	-14.5	-0.3

(N/A: Not Available)

SHADING indicates geotube project area



Note: Shoreline change is interpolated for transects where data are unavailable

Figure 4. **MLW shoreline change from November 1994, December 2001, September 2013, March 2016, and October 2016 to February 2017.**

3.3 LONG-TERM TRENDS

To help visualize long-term trends at select profiles along the monitoring area, the Woods Hole Group put together a series of figures showing the cumulative shoreline change (feet) in shoreline position relative to a 1994 baseline position (zero on the vertical axis) over time on the horizontal axis for a representative subset of beach profiles. The figure captions include profile-specific observations. The nine (9) beach profiles shown in Figure 5 through 12 represent the stretch of beach subject to monitoring including:

- Near the south of the monitoring area (Profile 84)
- Approximately 1,000 ft and 500 ft south of the geotubes (Profiles 90 and 90.6)
- Within the geotube area (Profiles 91, 91.5 and 92)
- Approximately 500 ft and 1000 ft north of the geotubes (Profiles 92.5 and 93)
- Near the north end of the monitoring area (Profile S)

Individual data points on each plot represent the change in shoreline position at mean low water (MLW), based on the surveyed beach profile at that time. Positive numbers indicate shoreline advance and negative numbers indicate shoreline retreat relative to the 1994 baseline (assumed zero). On the figures, blue dots represent data obtained from surveys before the installation of geotubes. Red dots represent data obtained from surveys obtained after the installation of geotubes. Based on the data presented below, the shoreline response since the geotubes were installed is not materially different from other shoreline responses measured in the past. However, the project installation year provides a known geographic and temporal reference point, is subject to the current regulatory requirements, and is expected to be subject to future monitoring.

The plots demonstrate the temporal variability and show:

- Periods of stability when there is little cumulative change in shoreline position as seen in Figure 5 from December of 1996 to May of 2002;
- Periods of shoreline advance as seen in Figure 5 from May 2002 to February 2005; and
- Periods of shoreline retreat as seen in Figure 6 from December 1996 to February 2005.

General observations derived from the data plotted on Figures 5 through 13 are summarized below. This collection of long-term observations accentuates the high degree of variability at this site, and indicates that recent shoreline changes are similar to changes that occurred in the past:

- Each profile includes times of shoreline advance and shoreline retreat, demonstrating a high degree of variability on short and long time scales. This high degree of variability, with observed short-term periods of erosion or accretion, suggests that adverse effects from the geotextile tubes could only be reliably determined through the prevalence of sustained periods (2 years or more) of shoreline erosion exceeding historic observations.

- Each profile responds differently on variable time scales.
- This variability does not lend itself to fitting a long-term trend line with a high degree of statistical accuracy.
- The current (February, 2017) shoreline position is generally similar (within about 20 feet) to the shoreline position in the ~2005-2008 timeframe, although there is substantial variability (up to 50 feet of cumulative difference) between these dates (which may be a result of short-term storm events, such as Hurricane Irene in August 2011 and Superstorm Nemo in February 2013).
- The short-term variability shown by surveys since geotube installation in January 2014 is similar to short-term variability (~2-3 year periods) observed over many years of surveys before the geotubes were installed. Surveyed post-geotube shoreline changes are not materially different from previous observations as related to rates and duration of shoreline change. No accelerated erosion in excess of historical observations is evident.

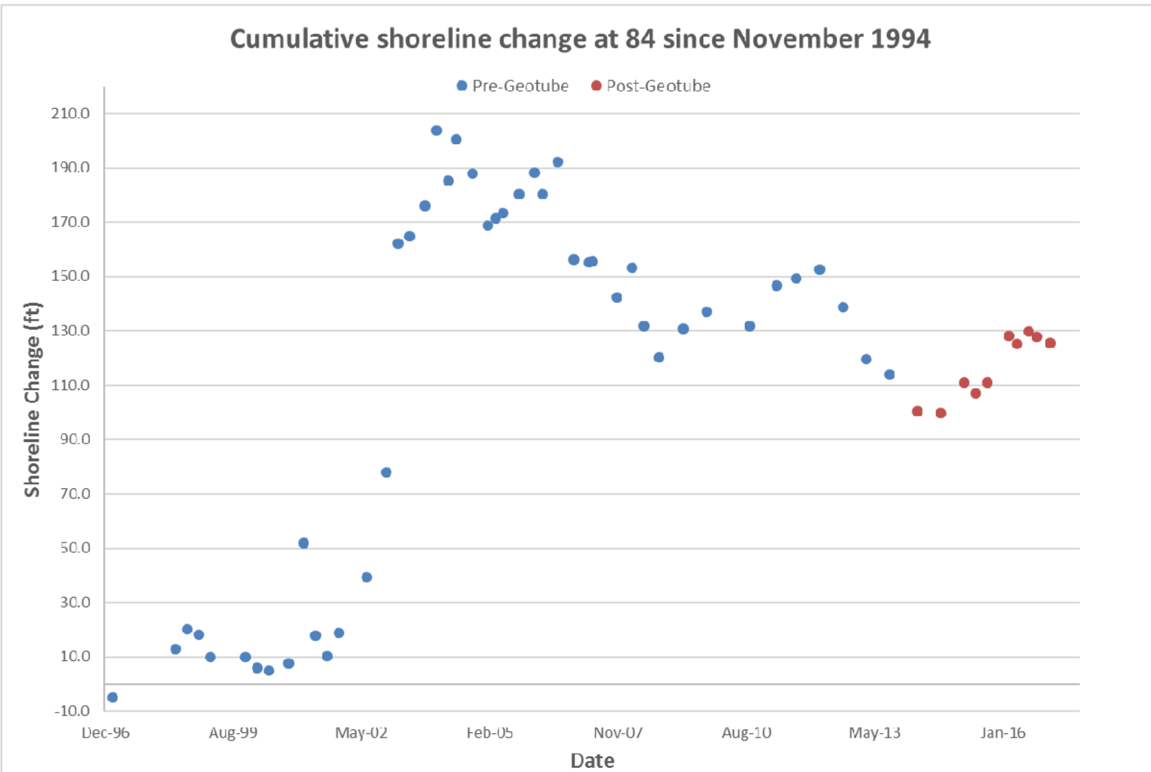


Figure 5. Cumulative Shoreline Change (ft) at Profile 84 since November 1994.

- Overall shoreline advance of ~130 ft since 1994
- Relatively stable shoreline position from 1996 to late 2001
- 200 ft of shoreline advance from September 2001 to January 2004
- Variable alternating periods of relative stability with modest shoreline advance and retreat spanning multiple years since 2004
- Current shoreline position similar to 2008; an observation also noted for other profiles

- Recent trend of shoreline advance since October 2014; similar periods of shoreline advance on the order of 30 ft also experienced from October 2008 to March 2012 and from February 2005 to August 2006

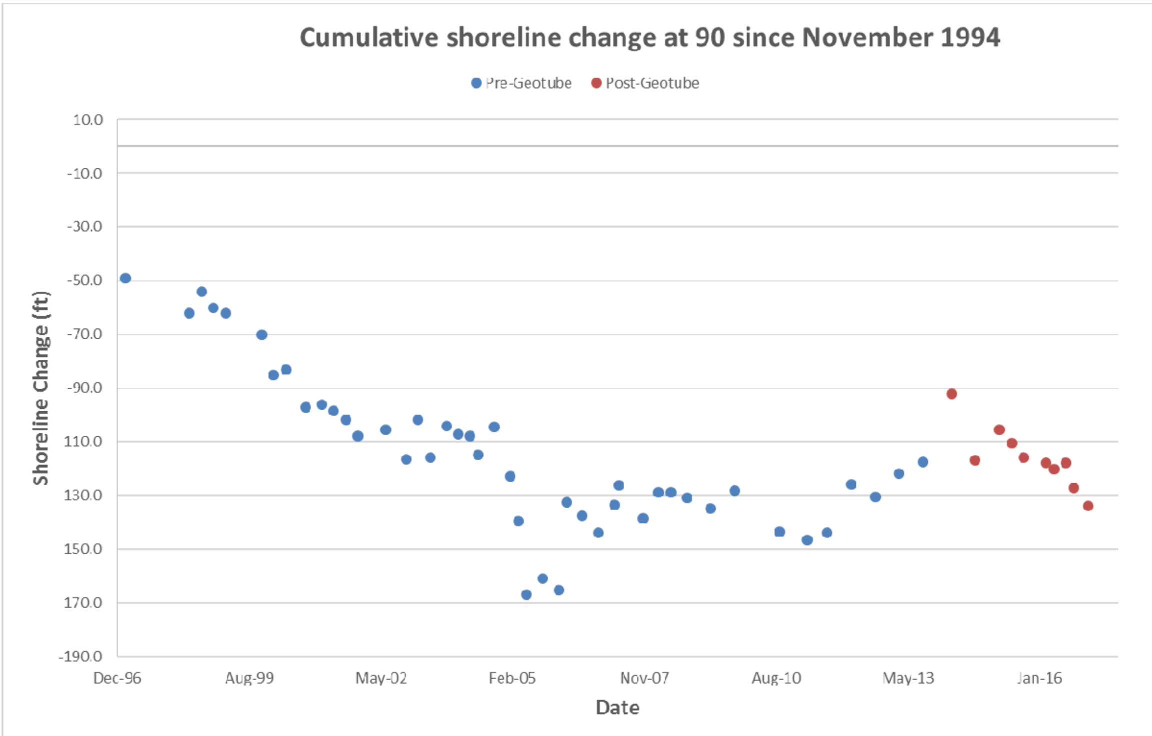


Figure 6. Cumulative Shoreline Change (ft) at Profile 90 since November 1994.

- Variable periods of shoreline retreat, stability, and advancement
- Net shoreline erosion on the order of -120 ft since 1994
- Relatively consistent erosion from 1996 through April 2001;
- Sharper short-term shoreline retreat between June 2005 and February 2006
- Shoreline advance from February 2006 to November, 2007
- Substantial reversing trend of beach accretion from April 2011 to April 2014
- Current shoreline position similar to 2007; an observation common to other profiles
- Recent trend of shoreline retreat since April 2014; similar to the rate experienced from September 1998 to December 2001

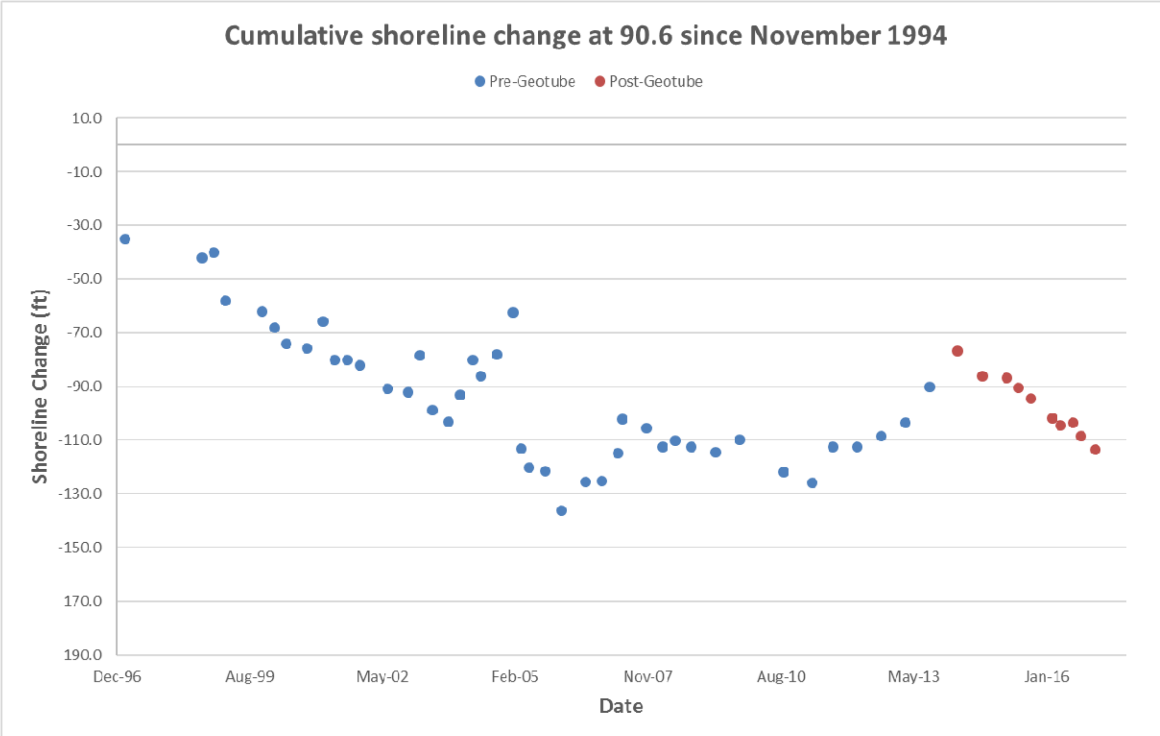


Figure 7. Cumulative Shoreline Change (ft) at Profile 90.6 since November 1994.

- Variable periods of shoreline erosion, stability, and accretion
- General trend of shoreline erosion between 1996 and 2003
- Substantial advance from October 2003 to February 2005
- Sharp retreat from 2005 to 2006
- Net shoreline retreat on the order of -100 ft since 1994
- Recent trend of shoreline erosion since April 2014; similar periods experienced previously in 1998-2000 and 2005-2006
- Current shoreline position similar to 2007; an observation common to other profiles

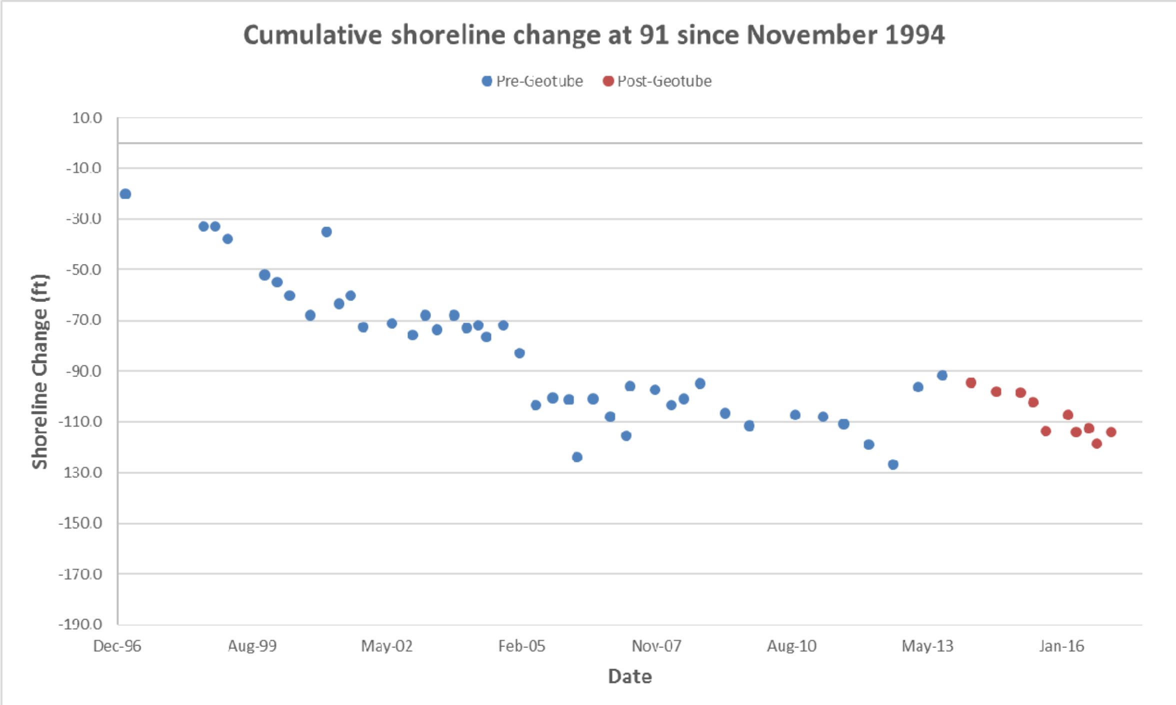


Figure 8. Cumulative Shoreline Change (ft) at Profile 91 since November 1994.

- Net shoreline loss since 1994 on the order of -110 ft
- Substantial trend of beach erosion at variable rates through 2007
- Variable shoreline position since 2005 with reversing trends of beach accretion and erosion
- Substantial shoreline advance from September 2012 to March 2013
- Little net change in the shoreline position since April 2007; similar to other profiles
- Current trend of beach retreat since September 2013
- Similar shoreline erosion measured also in September 2010 to September 2012, October 2003 to June 2005, and December 1998 to June 2000

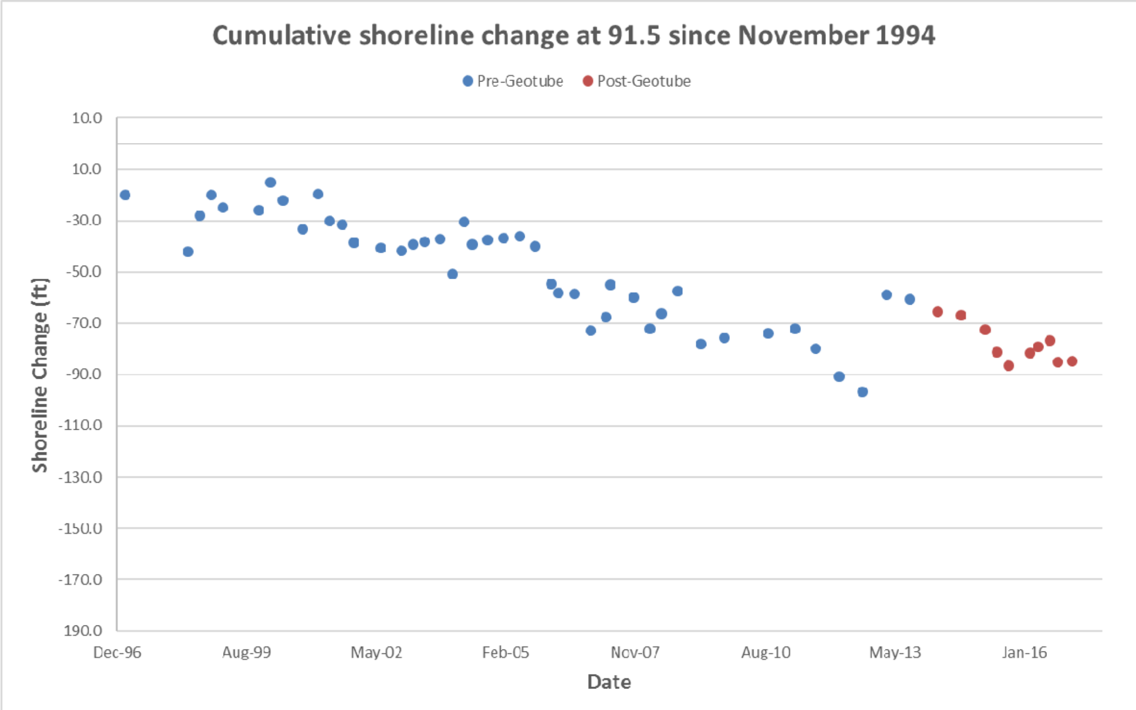


Figure 9. Cumulative Shoreline Change (ft) at Profile 91.5 since November 1994.

- Net shoreline retreat on the order of -75 ft since 1994
- Relatively consistent long-term shoreline erosion from 1996 through September 2012; with short-term variability
- Substantial beach accretion occurred from September 2012 to March 2013
- Current shoreline position similar to December 2006; the observation that the current shoreline position is similar to the condition 8-10 years ago is common to other profiles
- Recent trend of beach stability since October 2015

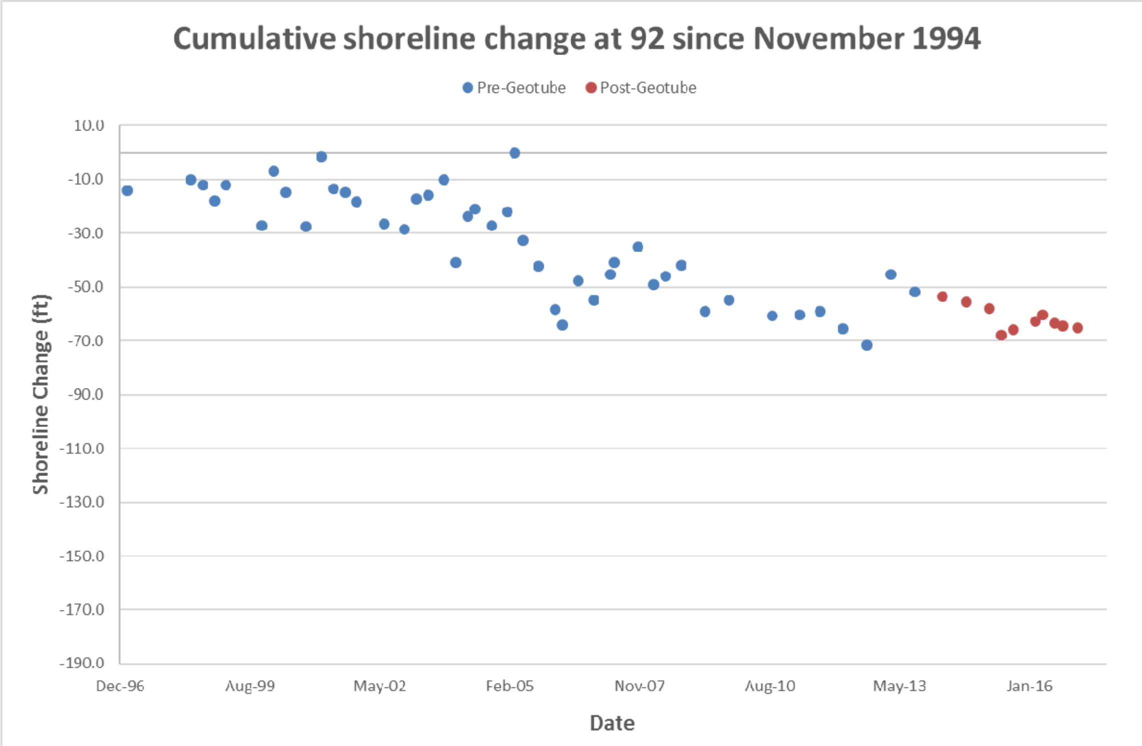


Figure 10. Cumulative Shoreline Change (ft) at Profile 92 since November 1994.

- Highly variable shoreline position
- Net erosion on the order of -60 ft since 1994
- Current shoreline position similar to observations since 2005; similar to other profiles
- Recent trend of beach stability since October 2015

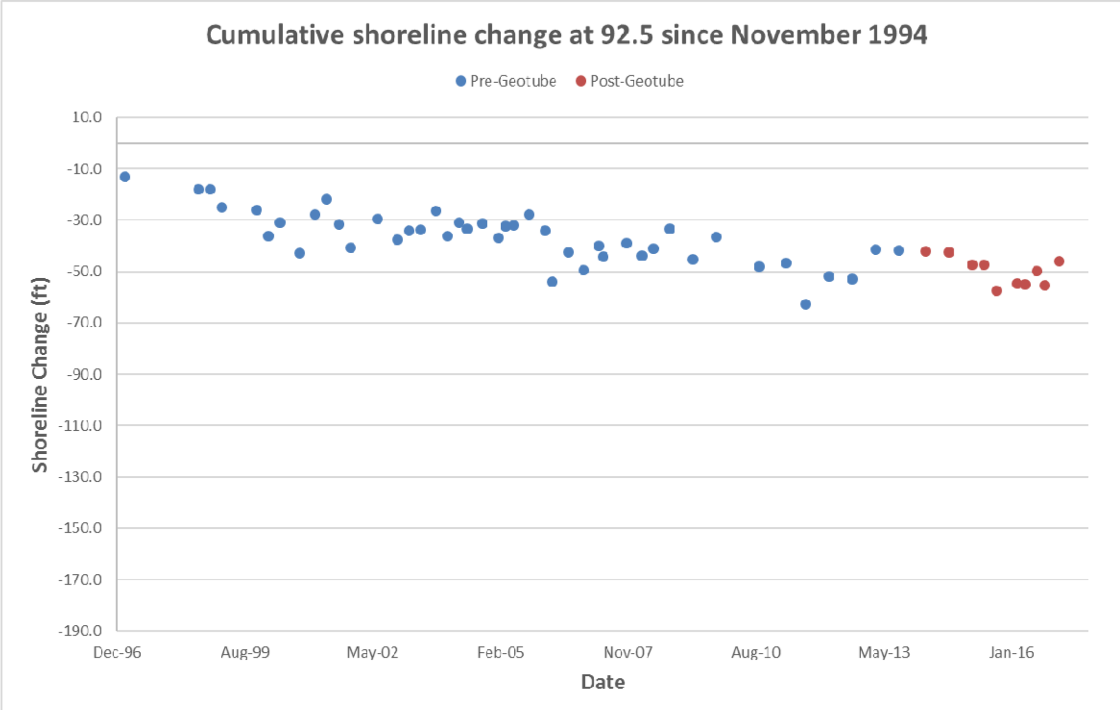


Figure 11. **Cumulative Shoreline Change (ft) at Profile 92.5 since November 1994.**

- Highly variable shoreline position
- Net erosion on the order of -50 ft since 1994
- Current shoreline position similar to observations since 2005; similar to other profiles
- Recent trend of beach stability since October 2015

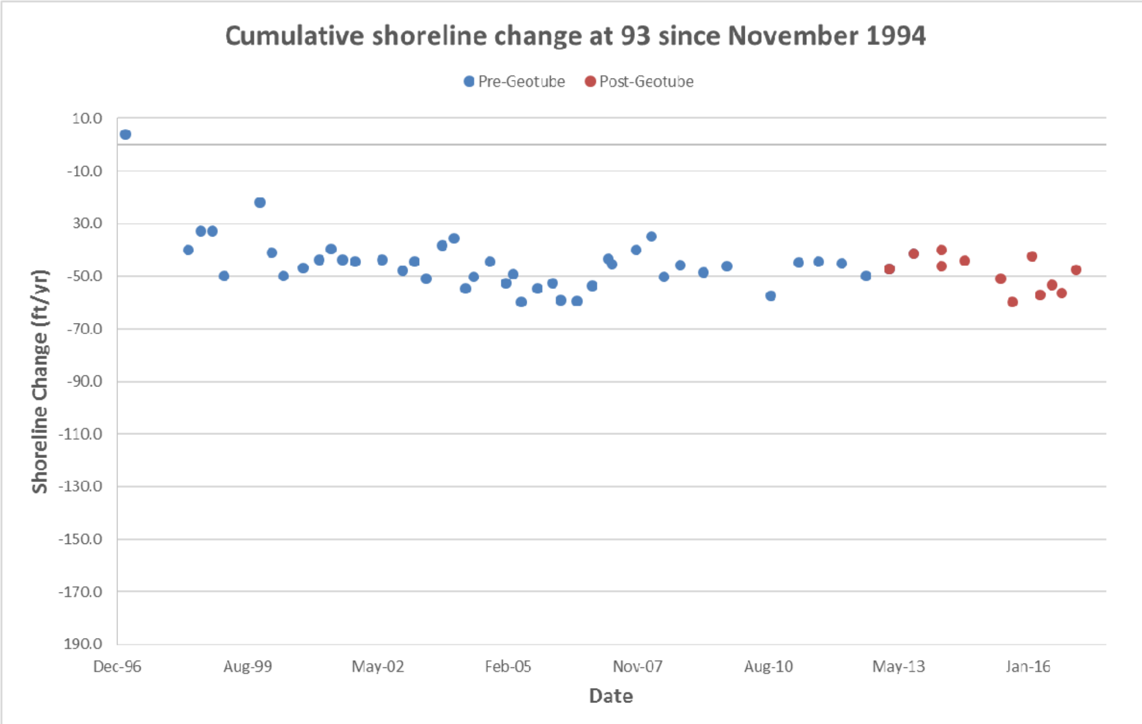


Figure 12. Cumulative Shoreline Change (ft) at Profile 93 since November 1994.

- Relatively stable shoreline position since 1998
- Majority of net losses occurred between 1994 and 1998
- Current shoreline position similar to the envelope since 2005
- Recent short-term variability in the shoreline position similar to past short-term variations

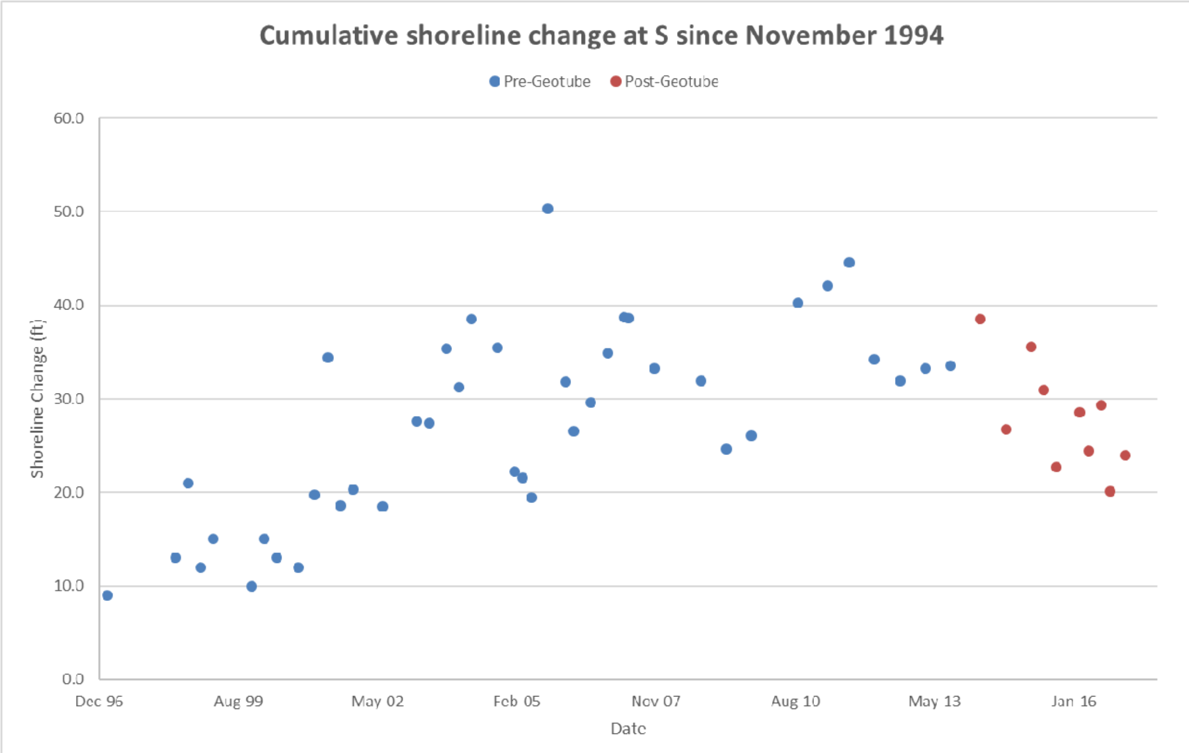


Figure 13. Cumulative Shoreline Change (ft) at Profile S since November 1994.

- Net shoreline advance on the order of 25 ft since 1994
- Majority of accretion occurred up to 2010
- Relatively stable but variable shoreline position since 2005; as with other profiles, the current shoreline position is almost identical to 2006

3.4 WAVE CONDITIONS

The 71st survey is defined by the time period of October 29, 2016 through February 1, 2017. Nearshore wave data for this time period was obtained from the Woods Hole Oceanographic Institution's (WHOI) 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 the data are freely available from their website (http://www.whoi.edu/mvco/). 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 refract toward a shore-normal approach to the southern-facing shoreline of Martha's Vineyard. The MVCO station was shut down for maintenance on July 17, 2016 and service was restored on September 22nd. The wave sensor went offline shortly thereafter and has since not been repaired. WHOI indicated that the wave sensor is scheduled to be repaired in the spring 2017.

Offshore wave data is typically obtained from the National Oceanic and Atmospheric Administration's (NOAA's) National Data Buoy Center (NDBC) Station 44008, located 54 nautical miles southeast of Nantucket Island in 62.5 meters of water. NDBC Station 44008 records data for a 20-minute sampling period every hour. However, this station ceased transmissions after October 10th as the remnants of Hurricane Mathew passed through the area and a later reconnaissance determined that no buoy was on station. NOAA indicated this station is on the future maintenance schedule for replacement; therefore, wave data from station 44008 is not available during this period.

As there was little data to no available for either station, wave data was not assessed during this time period. Wave data should be available for the next scheduled quarterly survey during spring 2017.

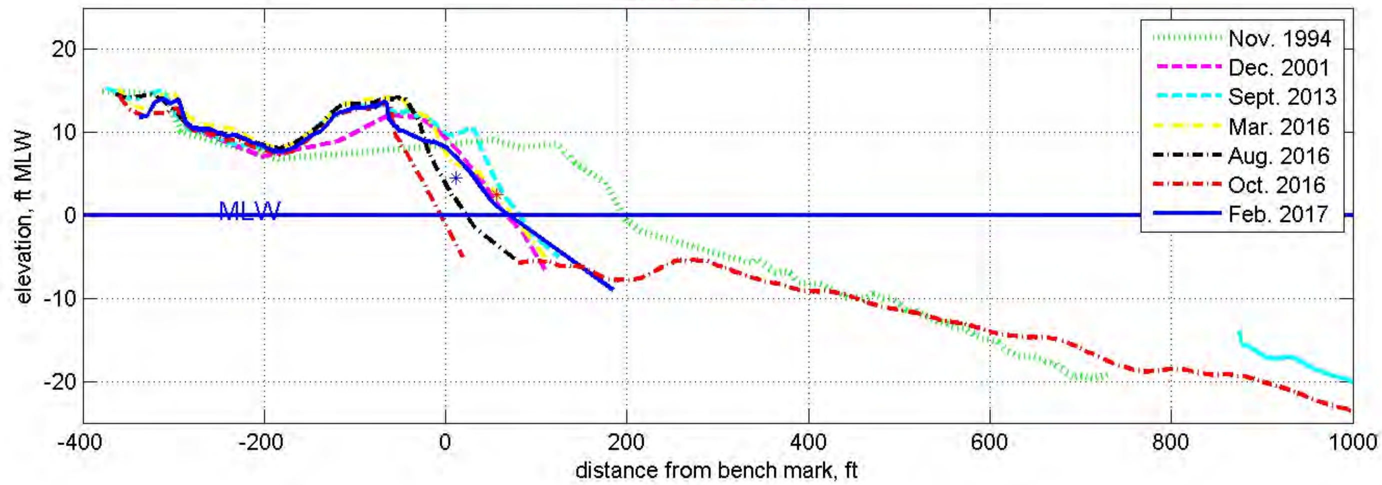
4.0 SUMMARY

The Winter 2017 quarterly survey included collection of topographic and bathymetric survey data, and the resulting transect profiles are plotted in Appendix A. From the analysis of the data collected for the 71st survey (February 2017), the following summary can be made:

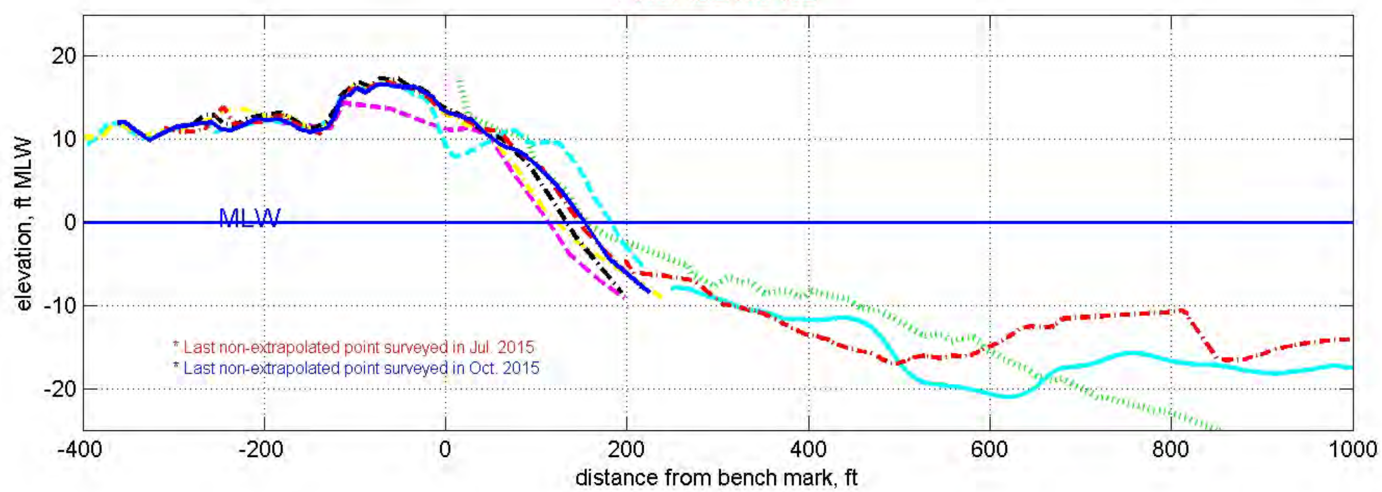
- Wave data was not available for either the offshore NOAA station 44008 or the nearshore MVCO station because both sensors were either inoperable or missing. According to the parent organizations, both stations should be restored by the next quarterly survey (spring 2017).
- Low Beach at profiles 81 and 82 continues to exhibit extremely variable shoreline change.
- Since the geotubes were installed in September 2013, 26 of the 34 profiles have eroded throughout the monitoring area. Within the geotube project area, profiles 90.9 to 91.9, volume loss and shoreline retreat have been the dominant trend which is consistent with the rest of the monitoring area.
- In the past year, erosion has been the dominant trend as 30 of the 46 profiles in the entire monitoring area lost beach volume and 36 profiles lost beach width.
- Since the last survey in October 2016, the dominant regional trend for beach volume change was accretion (31 accreting and 15 eroding) and shoreline advance. This is not typical for a winter profile, but the shoreline of Siasconset was significantly impacted by two hurricanes, Hermine and Matthew, in the fall of 2016 as reported during the last 70th Quarterly October 2016 report. It was documented that the storms had caused erosion along 43 of the 46 profiles, which was unexpected for post-summer beach profiles. It is possible that the beaches have been recovering from the storm impacts as the sand eroded by the storms is distributed along the beaches. Substantial natural variability is characteristic of the region depending upon prevailing conditions.

APPENDIX A – PROFILE PLOTS

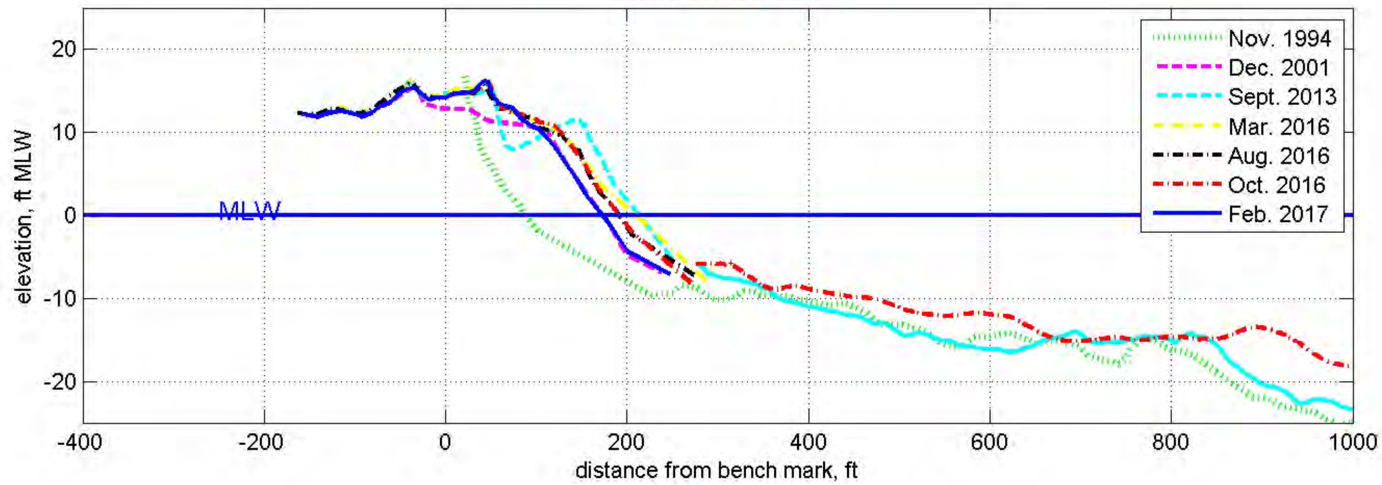
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :81



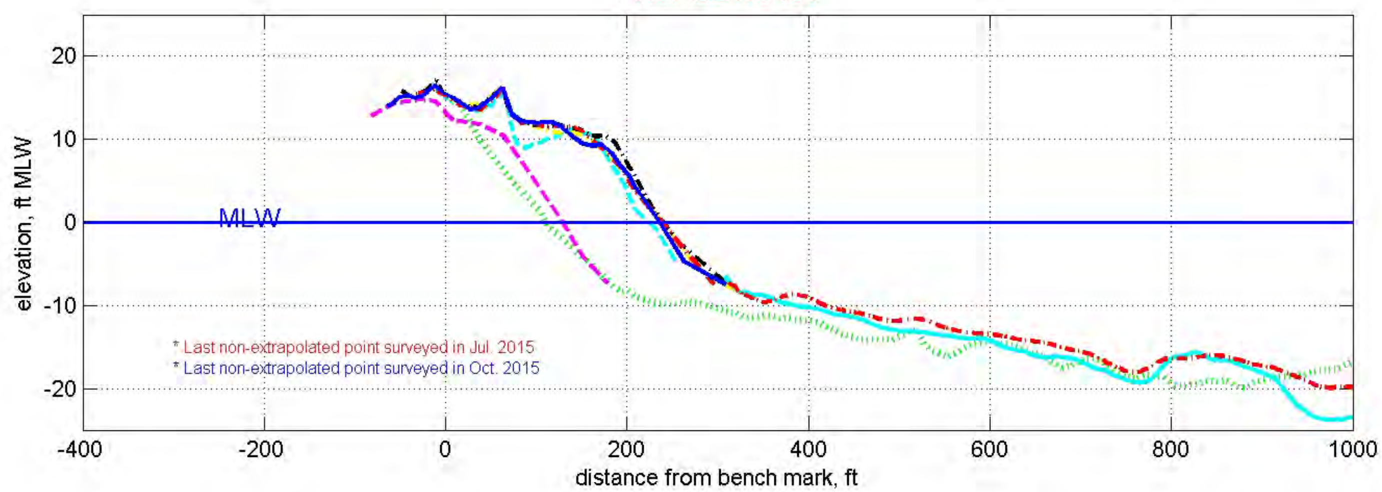
PROFILE NO :82



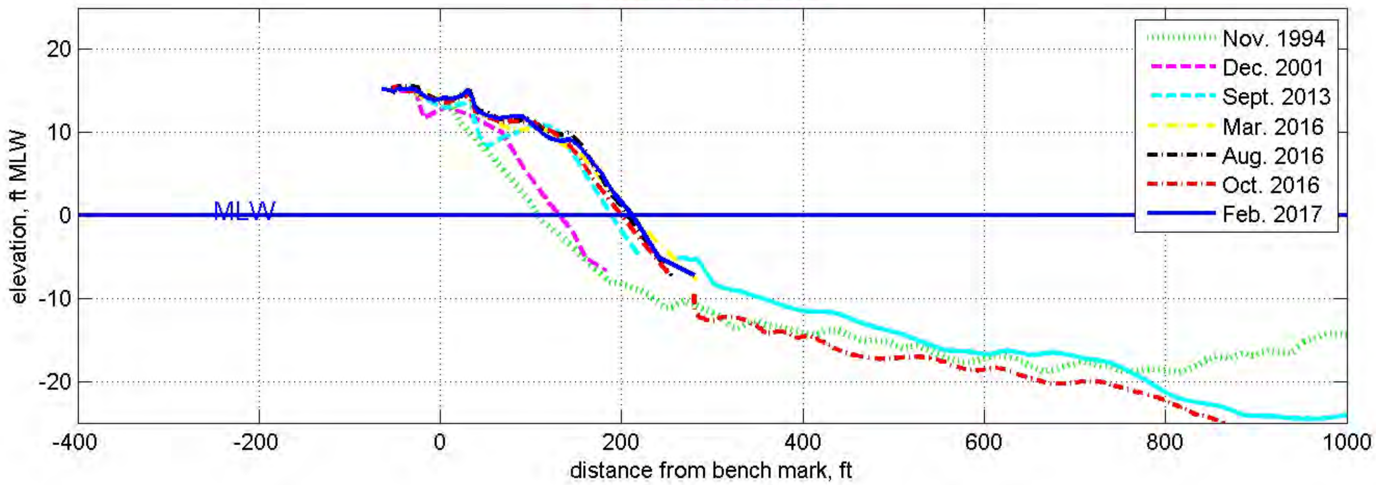
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :83



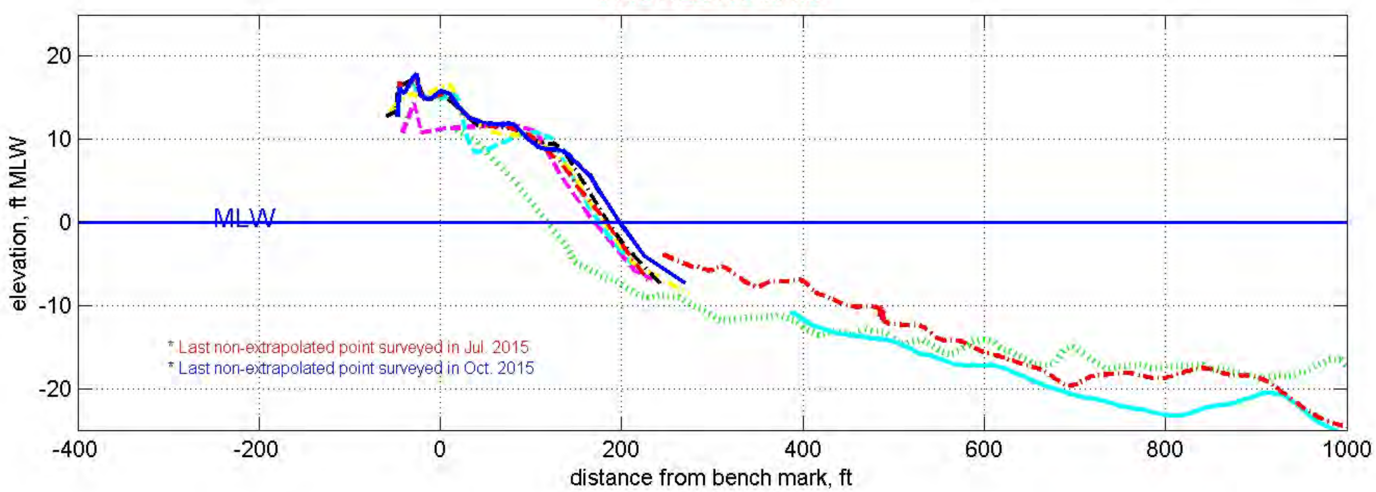
PROFILE NO :84



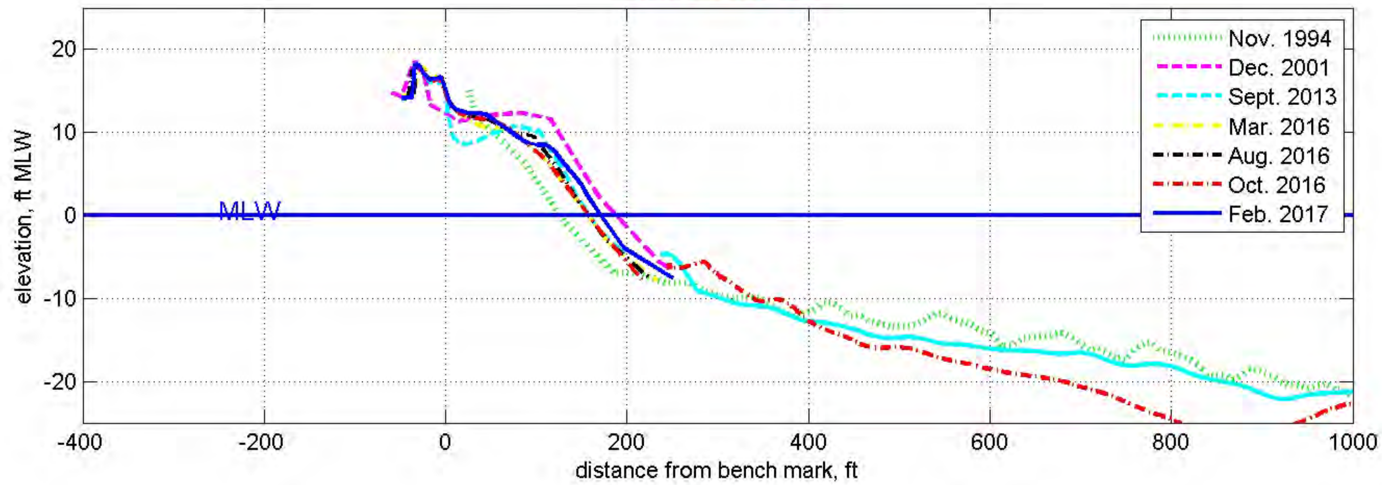
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :84.3



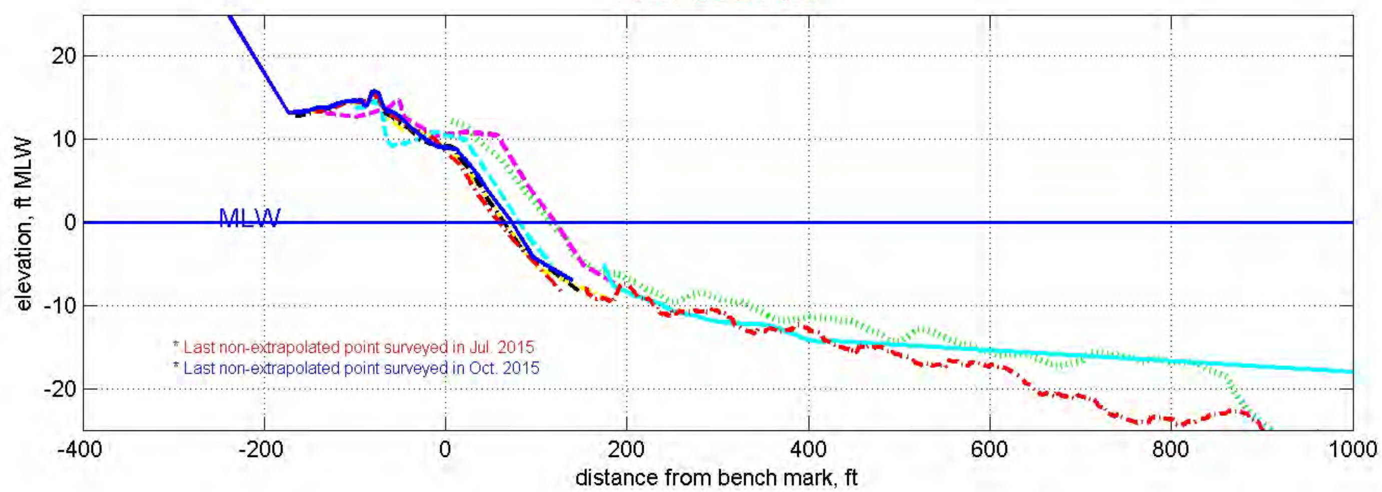
PROFILE NO :84.6



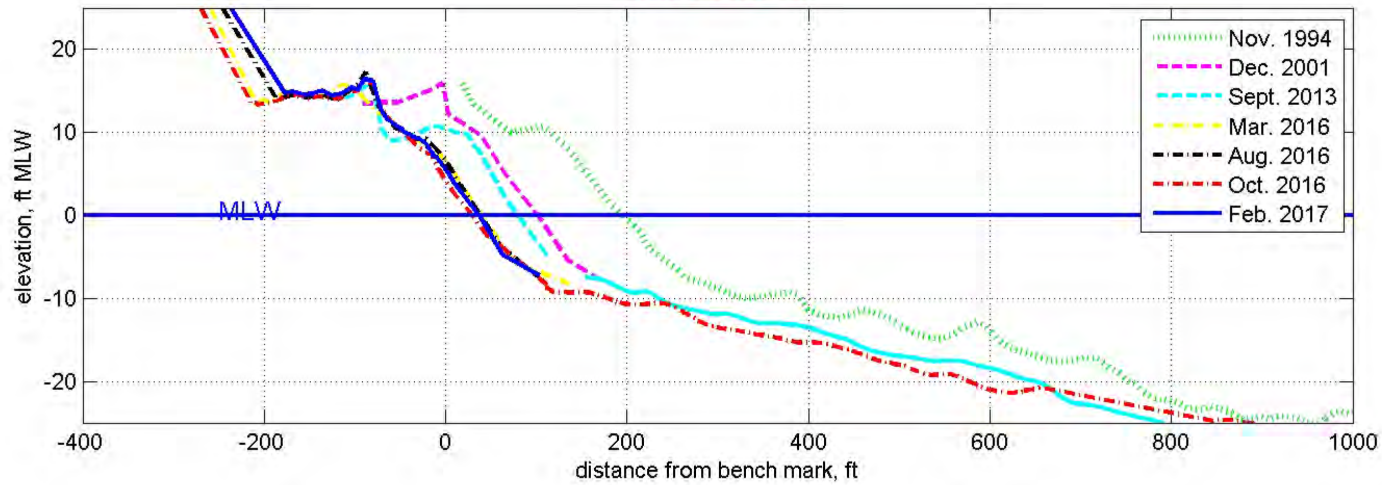
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :85



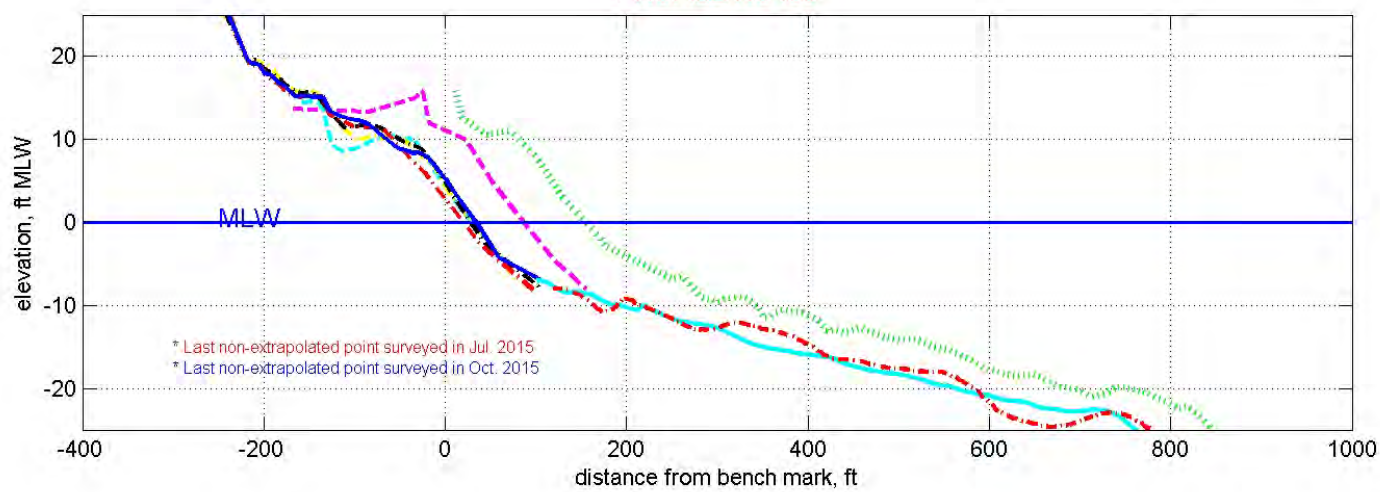
PROFILE NO :86



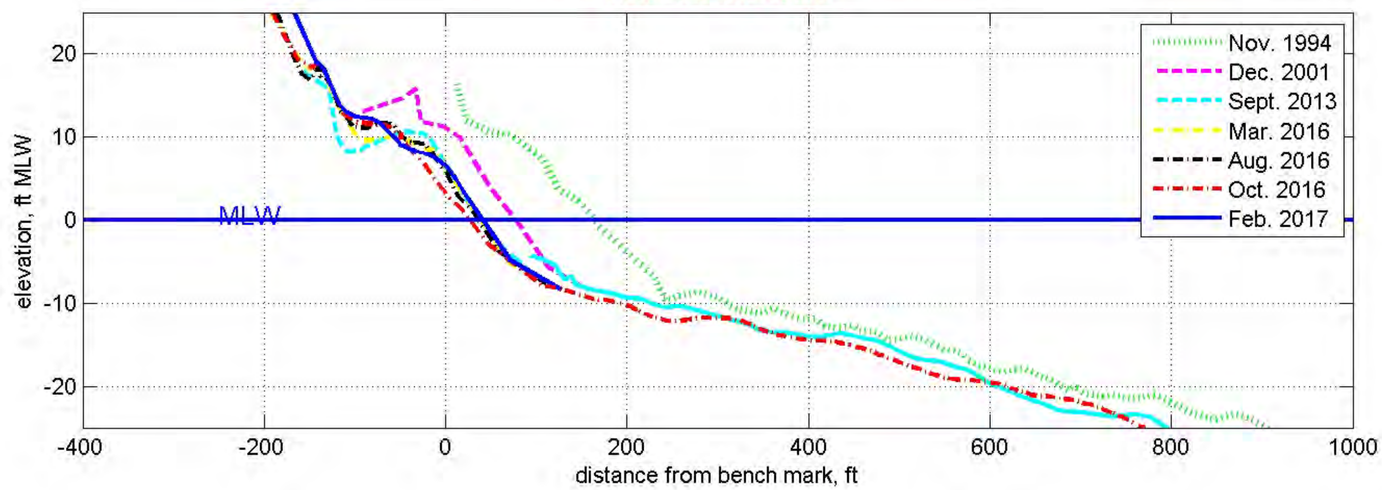
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :87



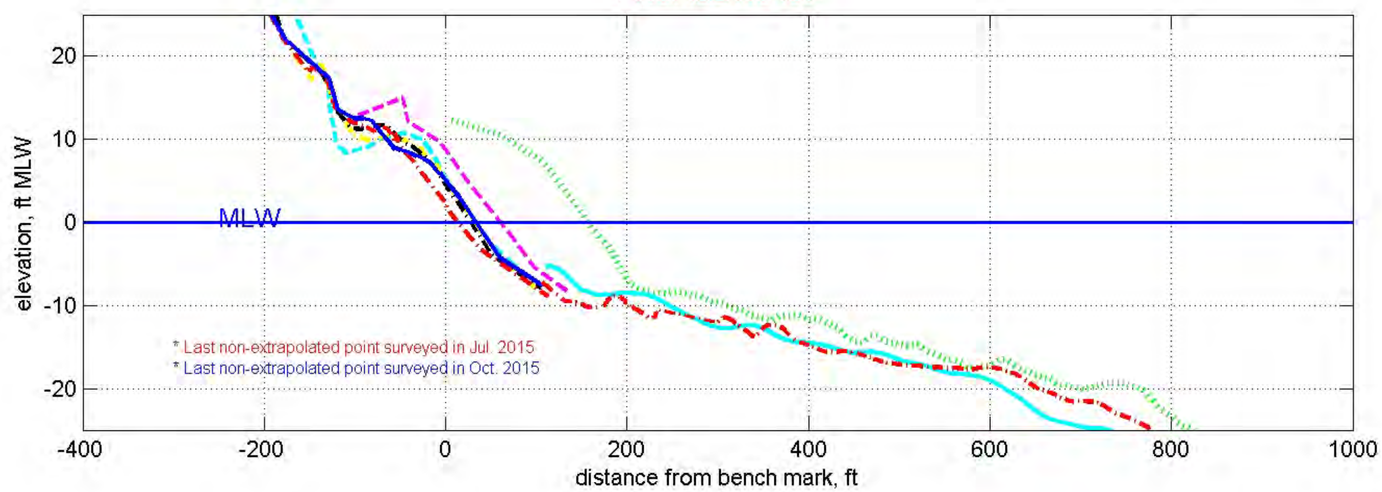
PROFILE NO :88



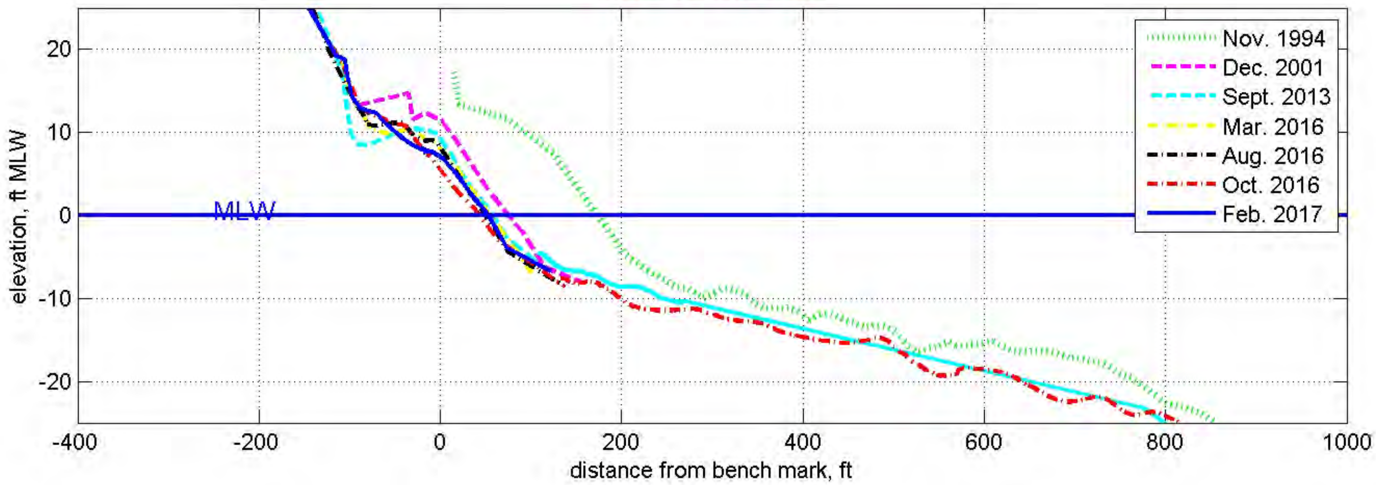
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :88.6



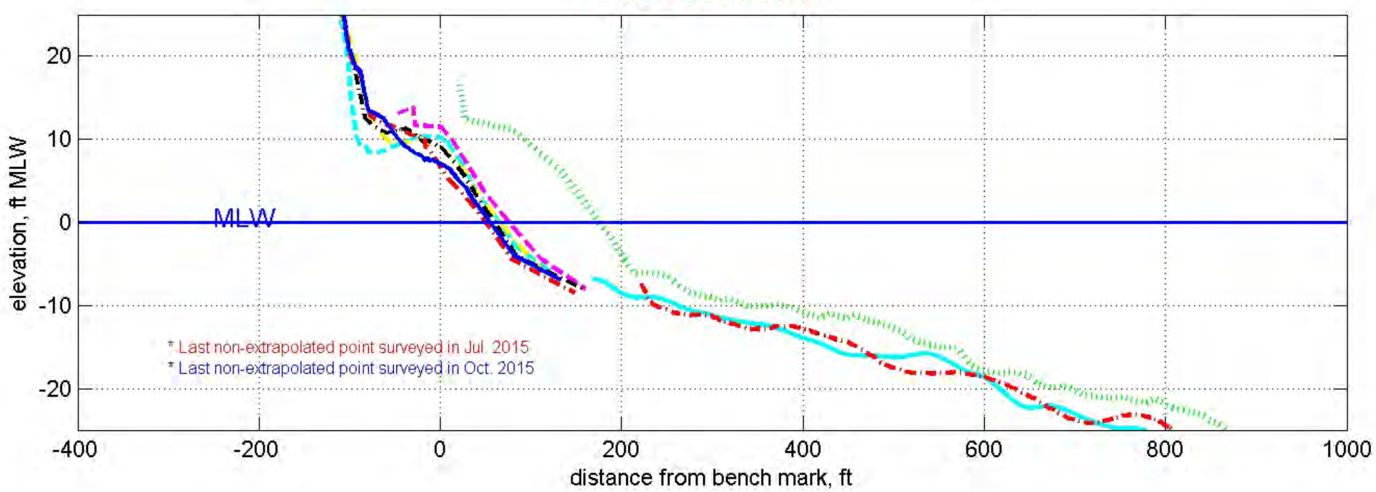
PROFILE NO :89



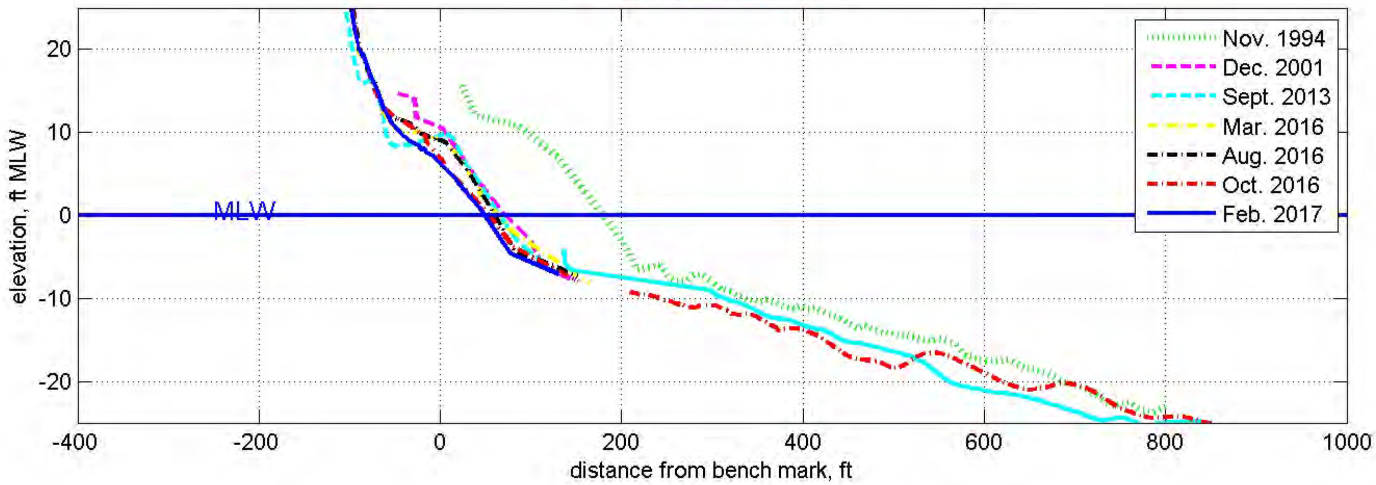
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :89.2



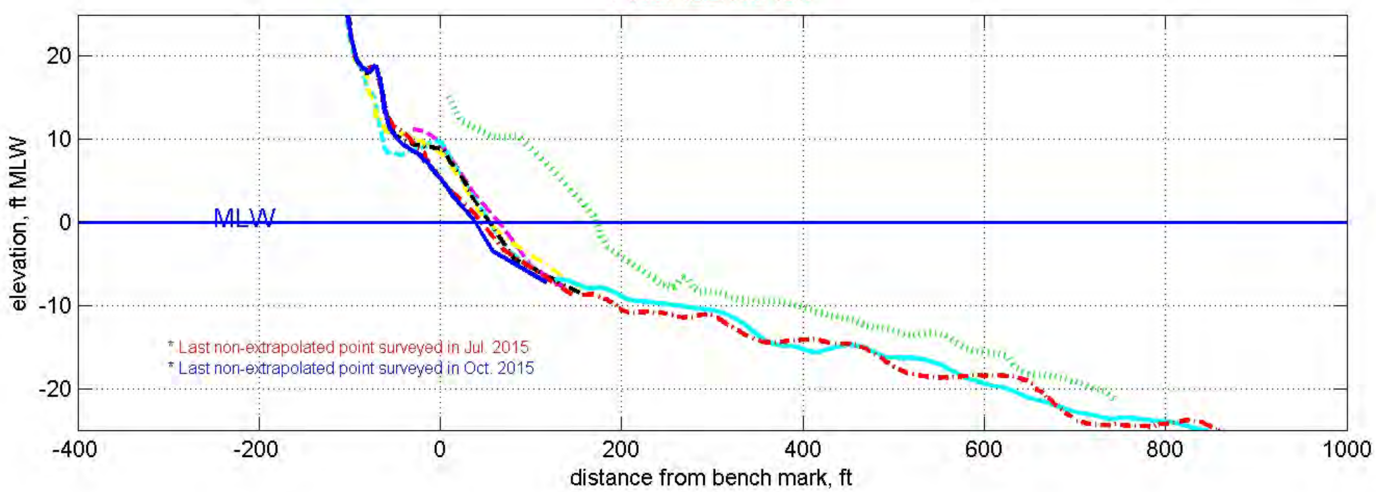
PROFILE NO :89.5

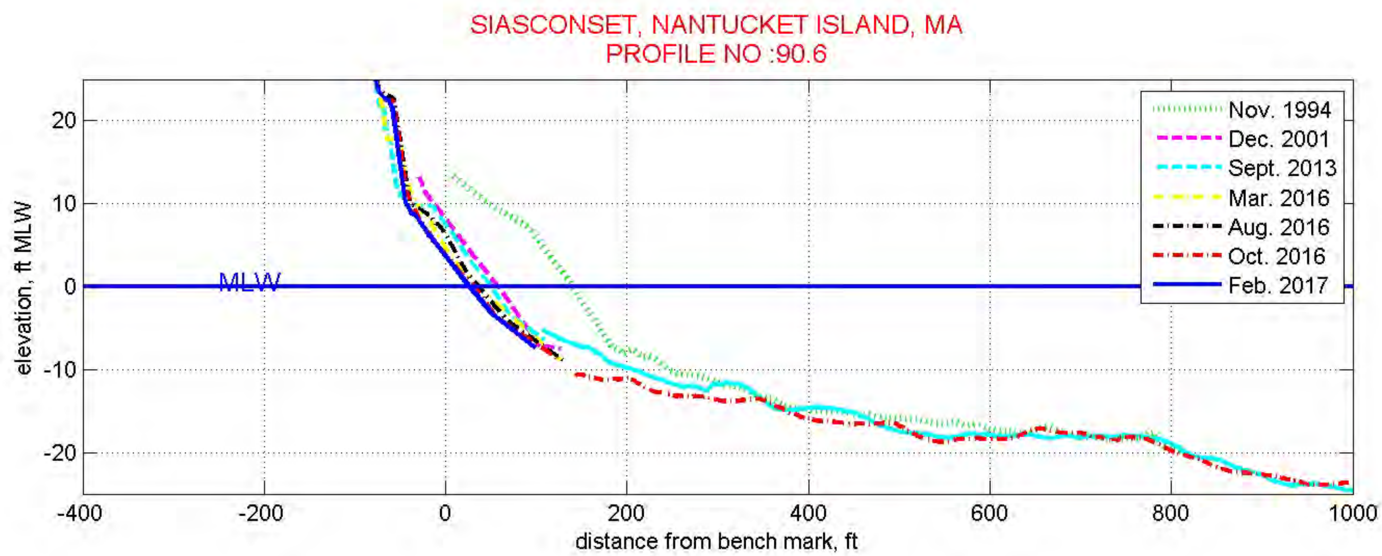


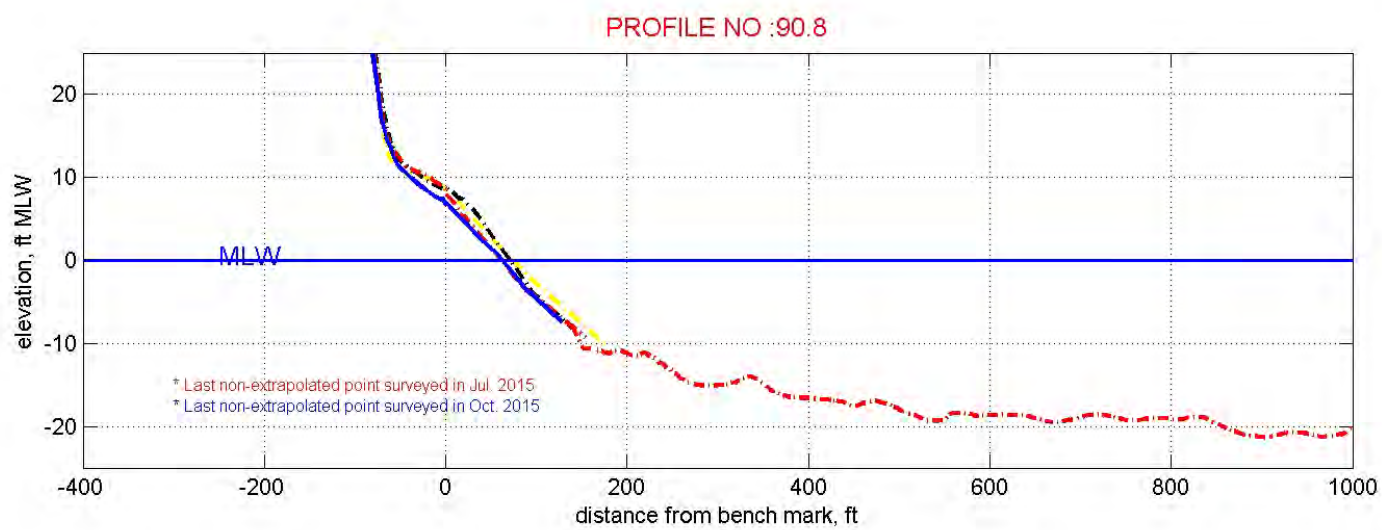
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :89.8



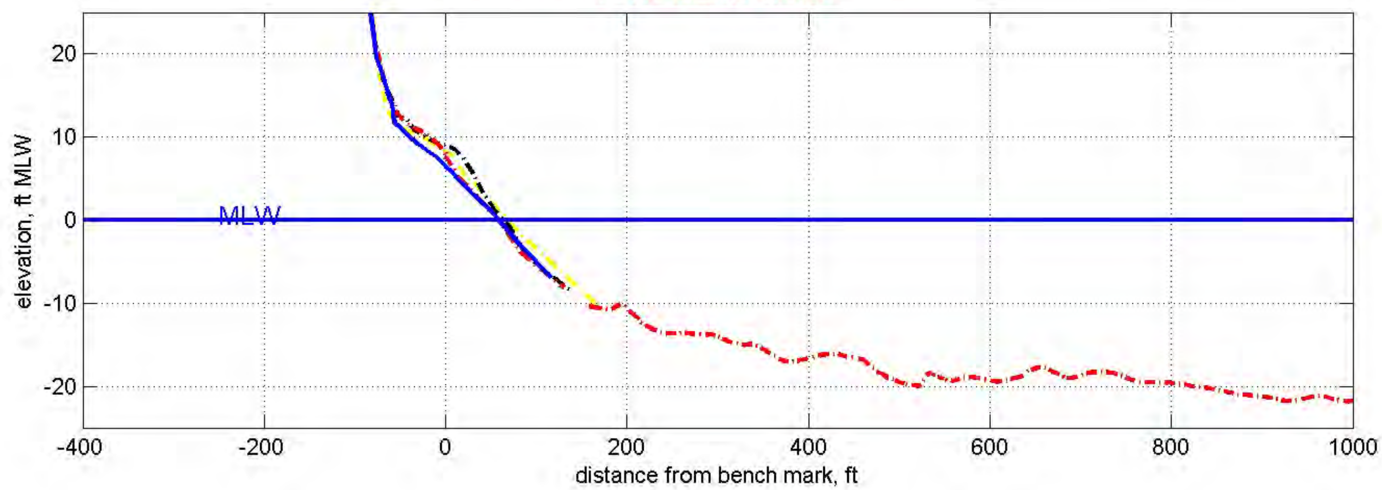
PROFILE NO :90



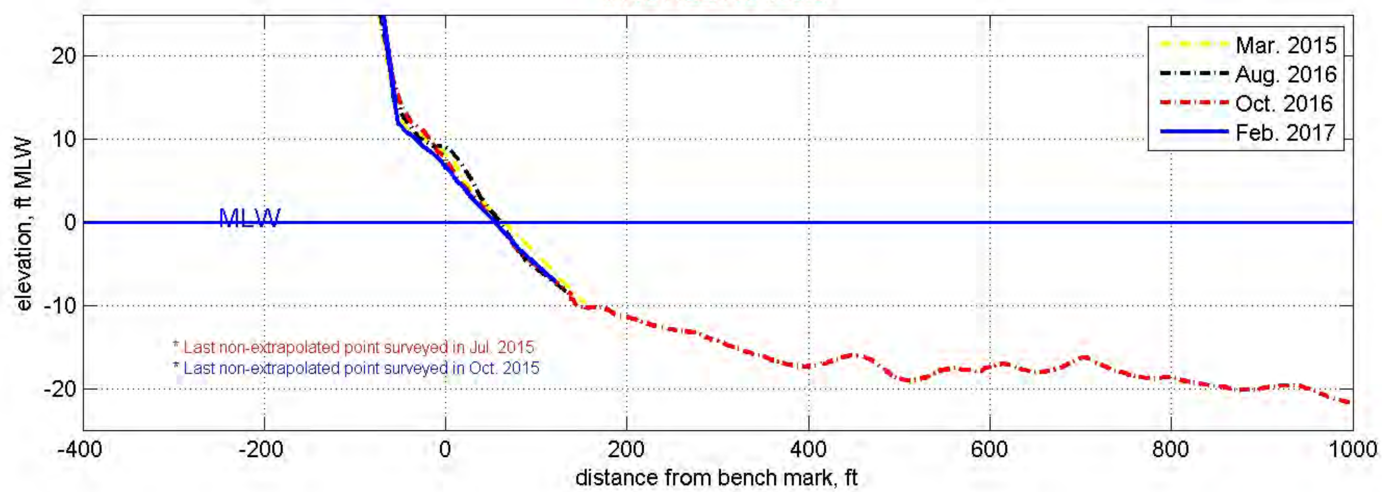

SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :90.6
elevation, ft MLW
distance from bench mark, ft
MLW
Nov. 1994
Dec. 2001
Sept. 2013
Mar. 2016
Aug. 2016
Oct. 2016
Feb. 2017
20
10
0
-10
-20
-400
-200
0
200
400
600
800
1000


PROFILE NO :90.8
elevation, ft MLW
distance from bench mark, ft
MLW
* Last non-extrapolated point surveyed in Jul. 2015
* Last non-extrapolated point surveyed in Oct. 2015
20
10
0
-10
-20
-400
-200
0
200
400
600
800
1000

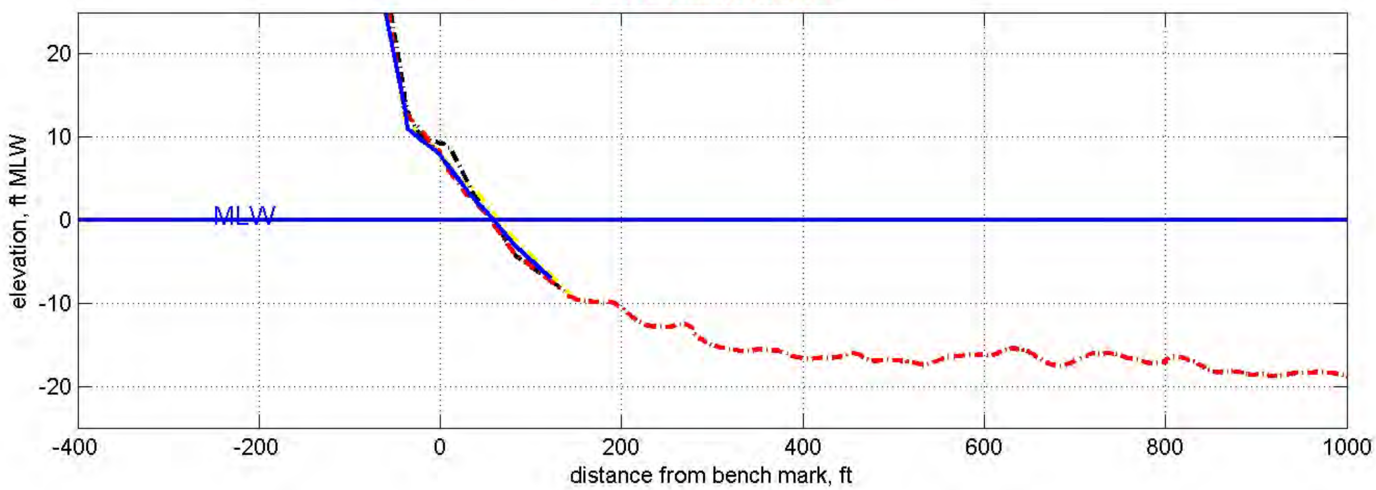
SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :90.85



PROFILE NO :90.9



SIASCONSET, NANTUCKET ISLAND, MA
PROFILE NO :90.95



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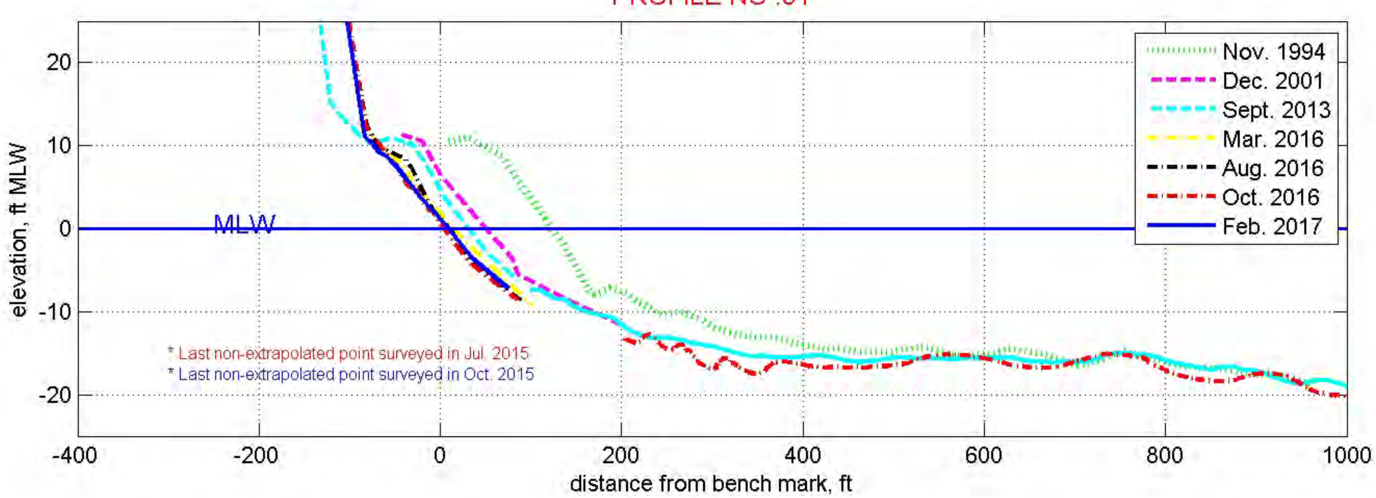

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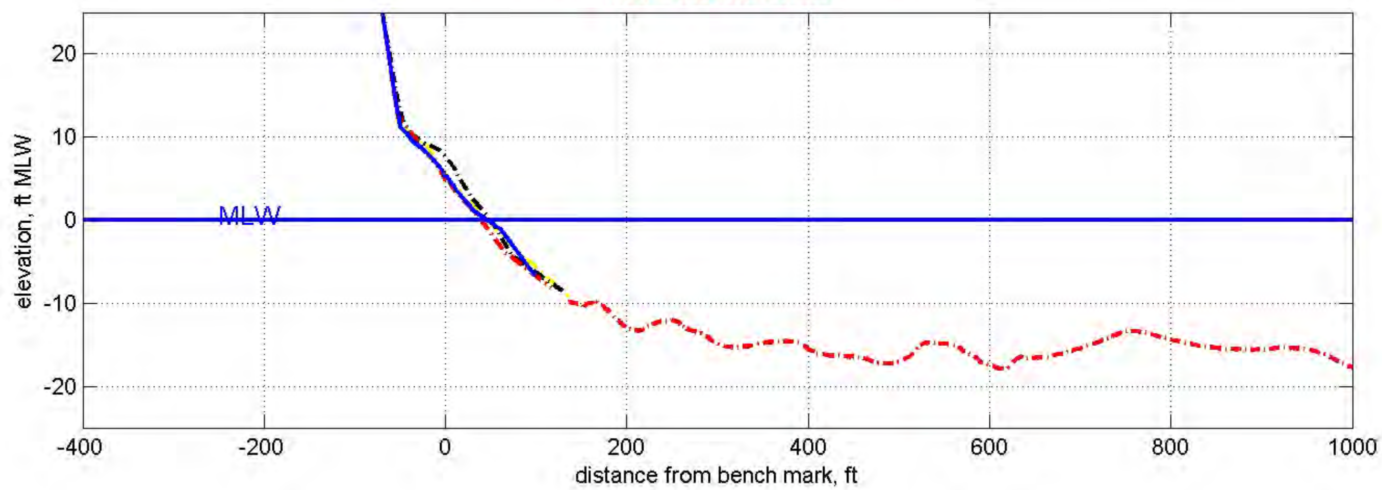

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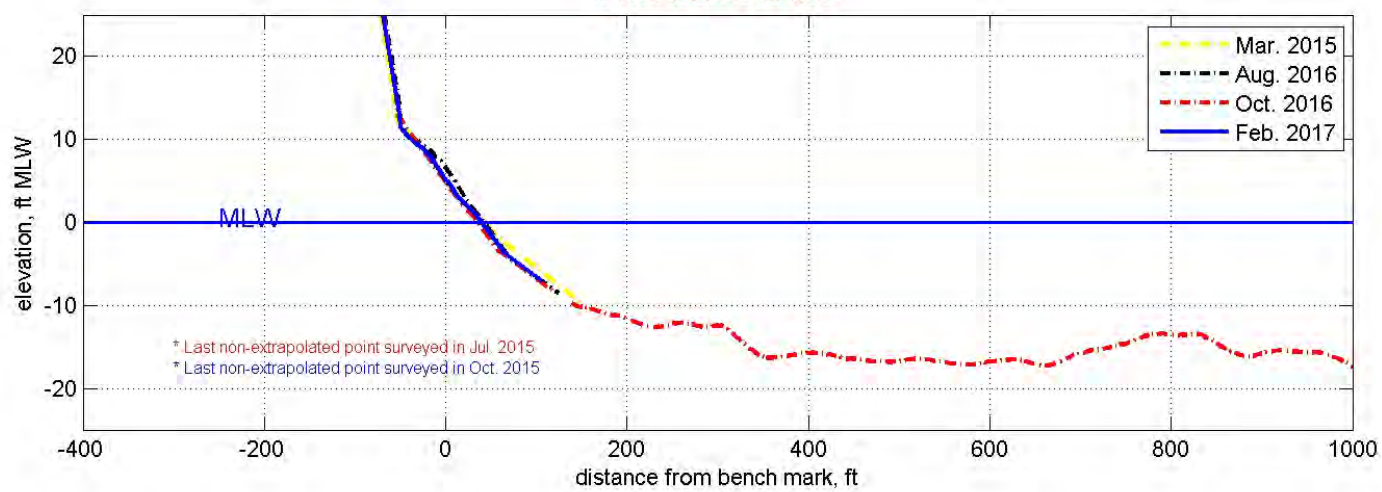

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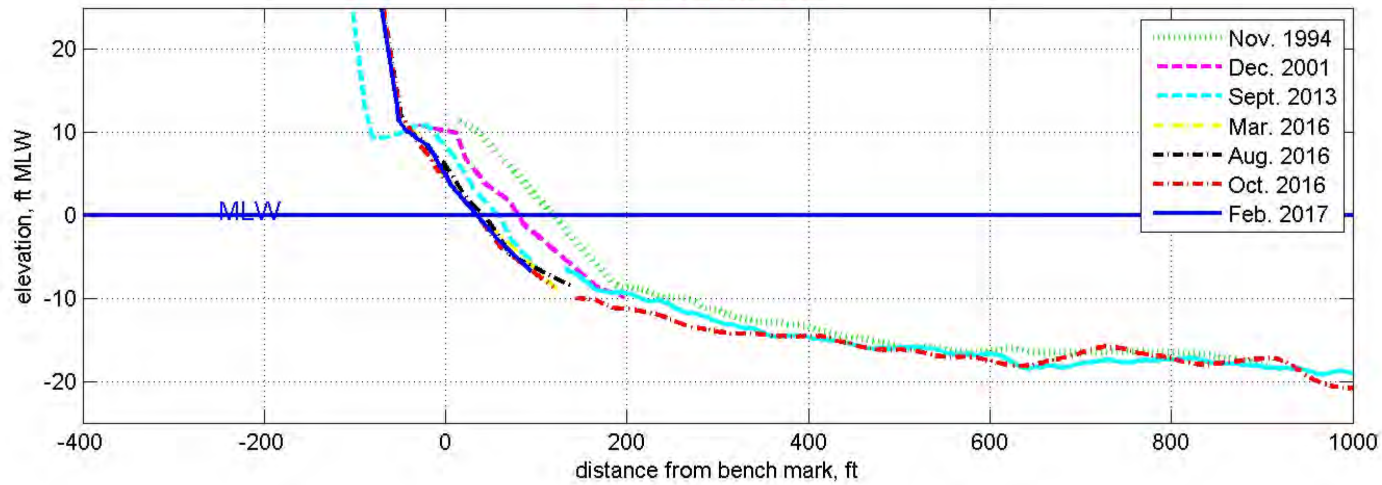

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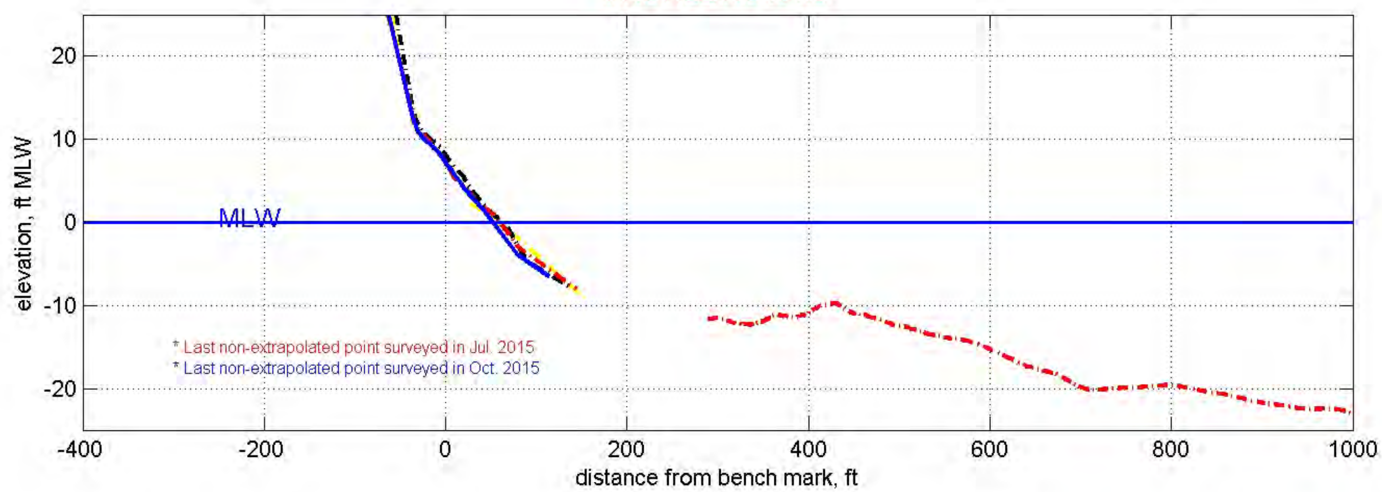

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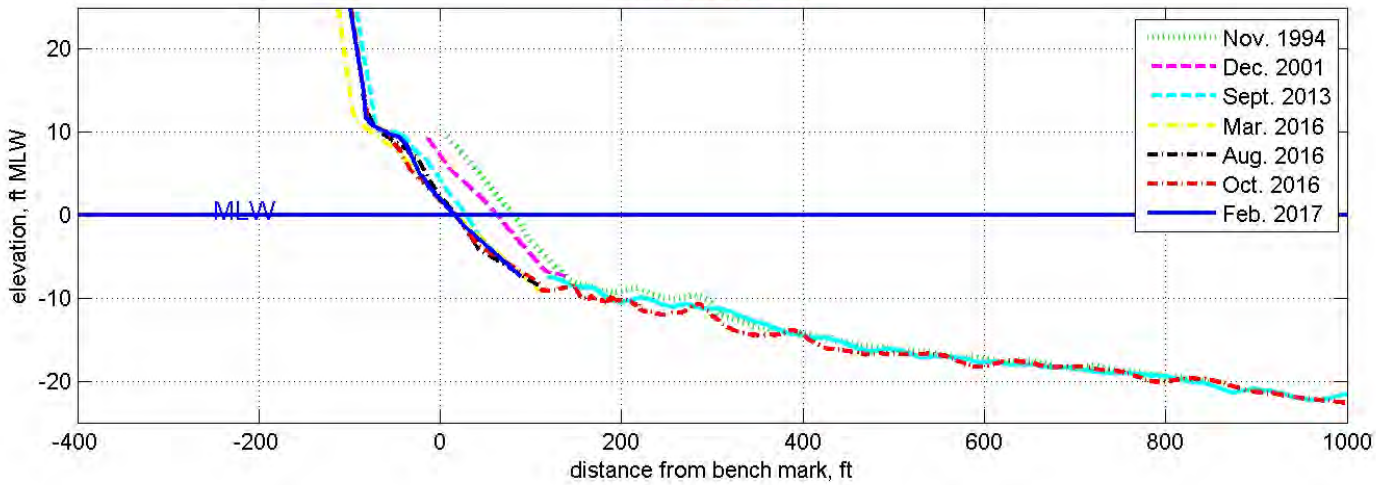

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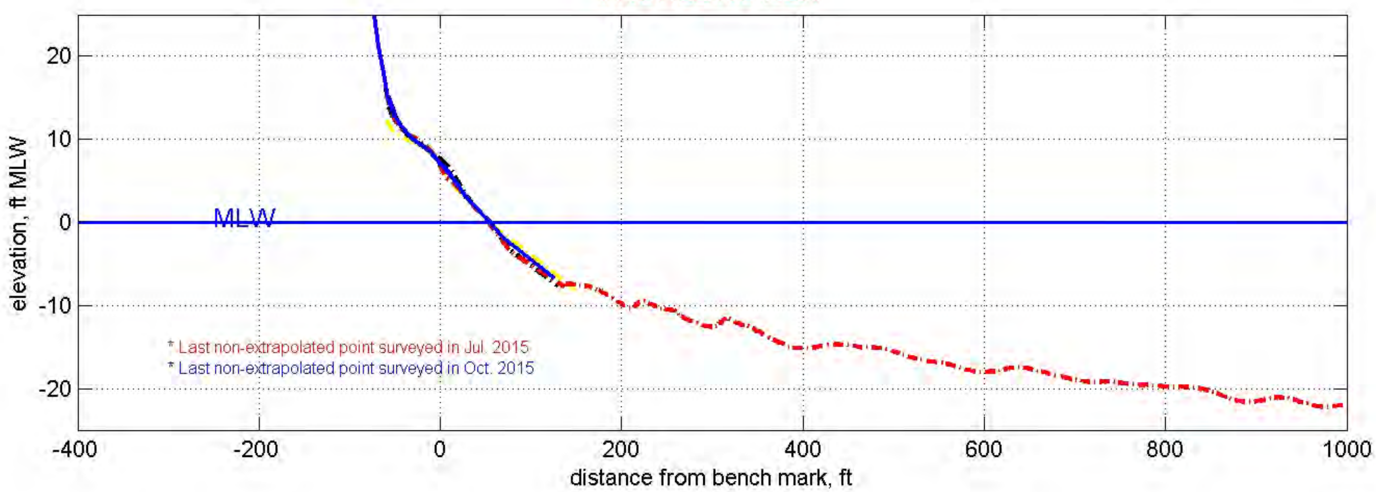

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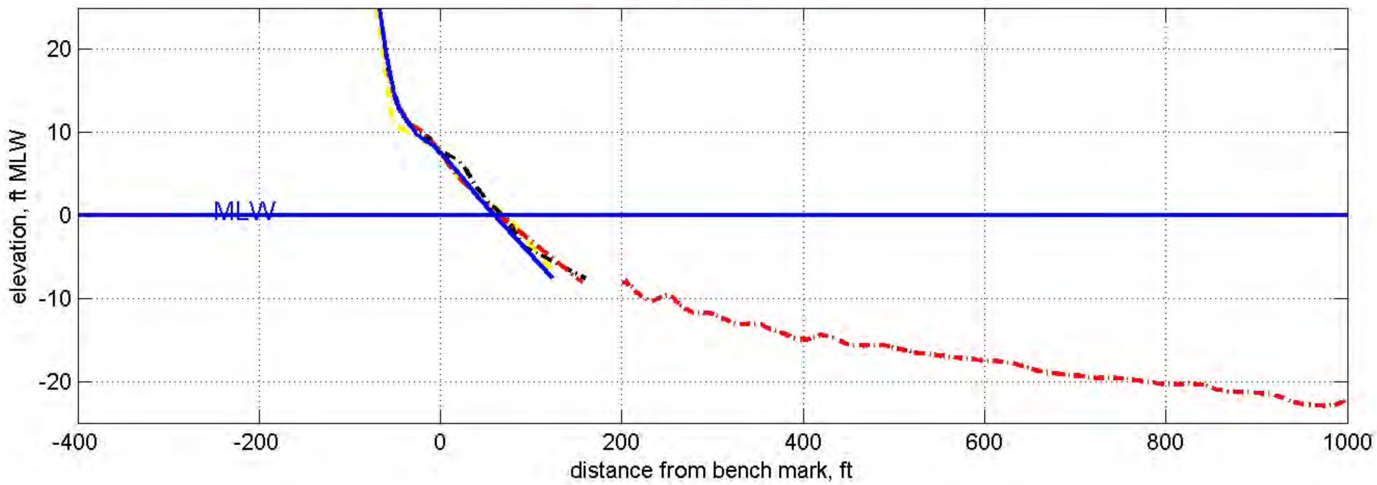

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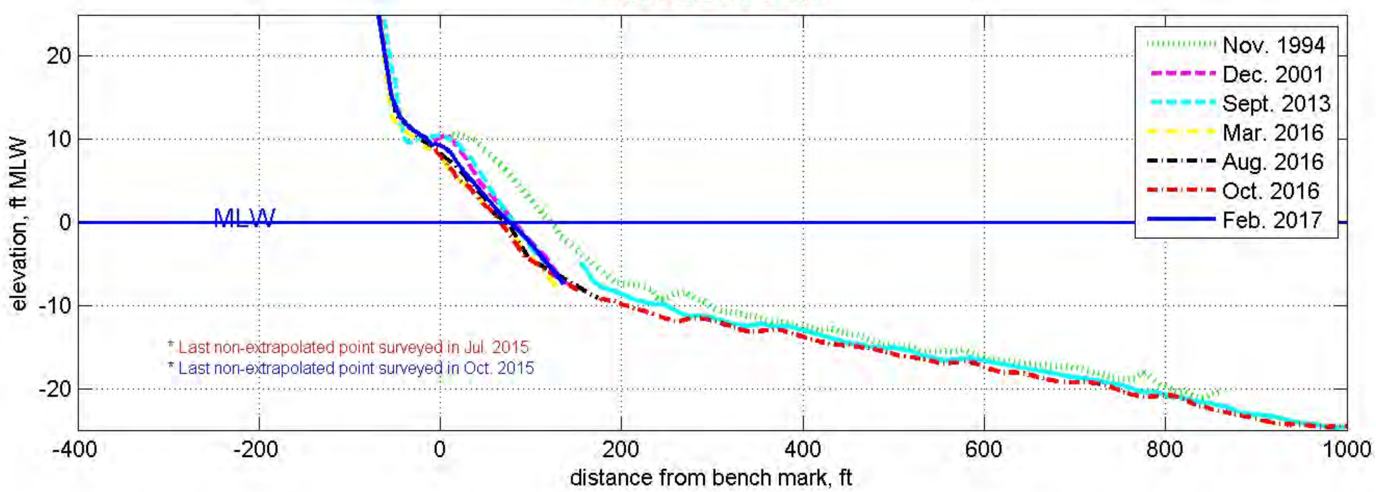

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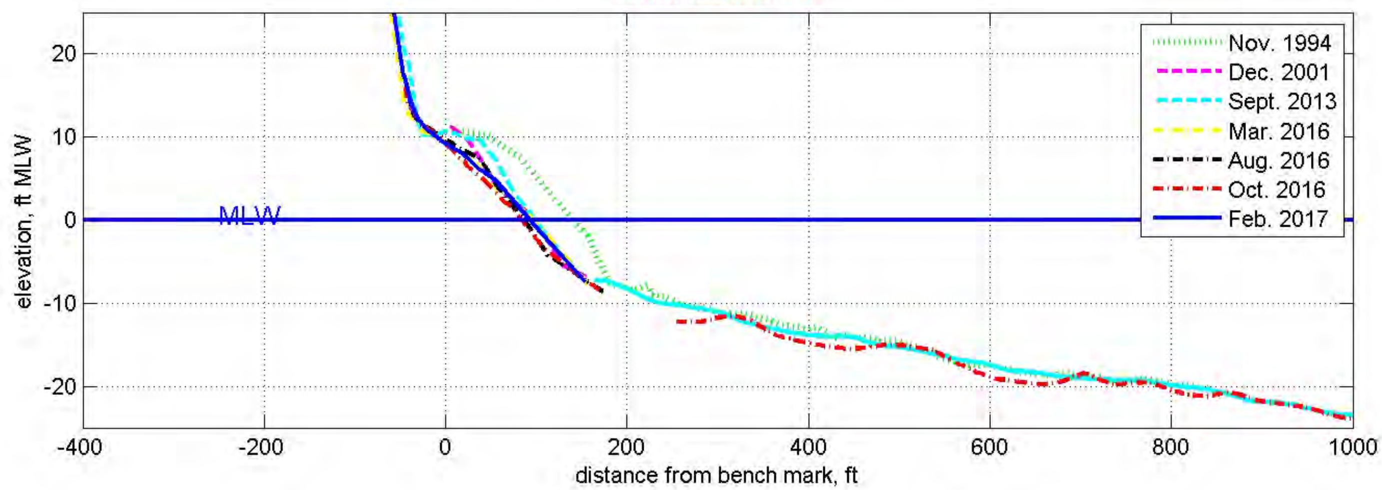

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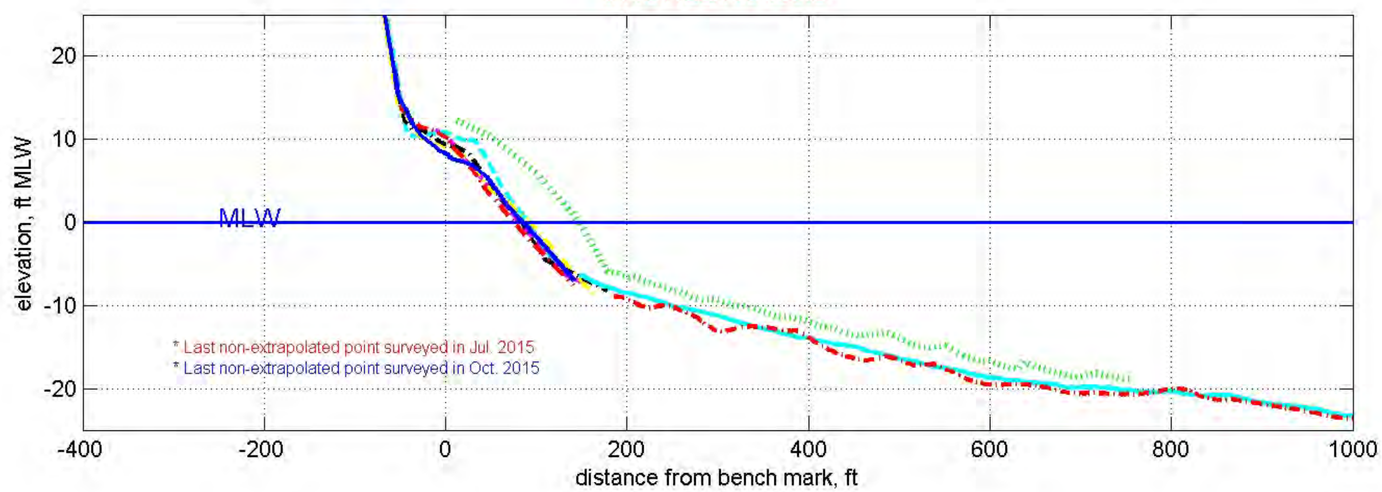

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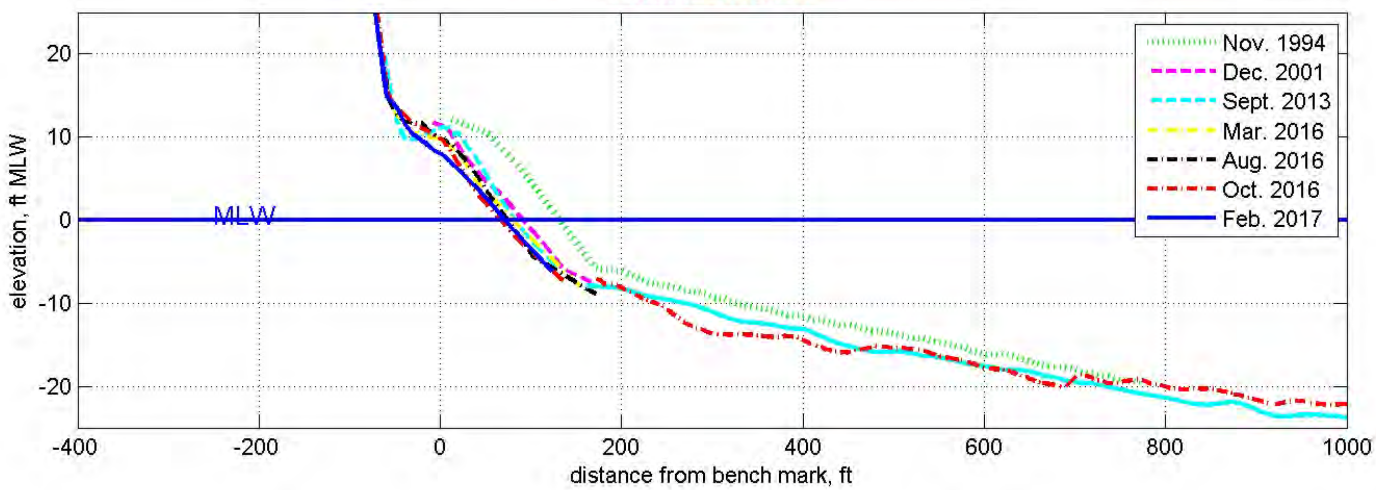

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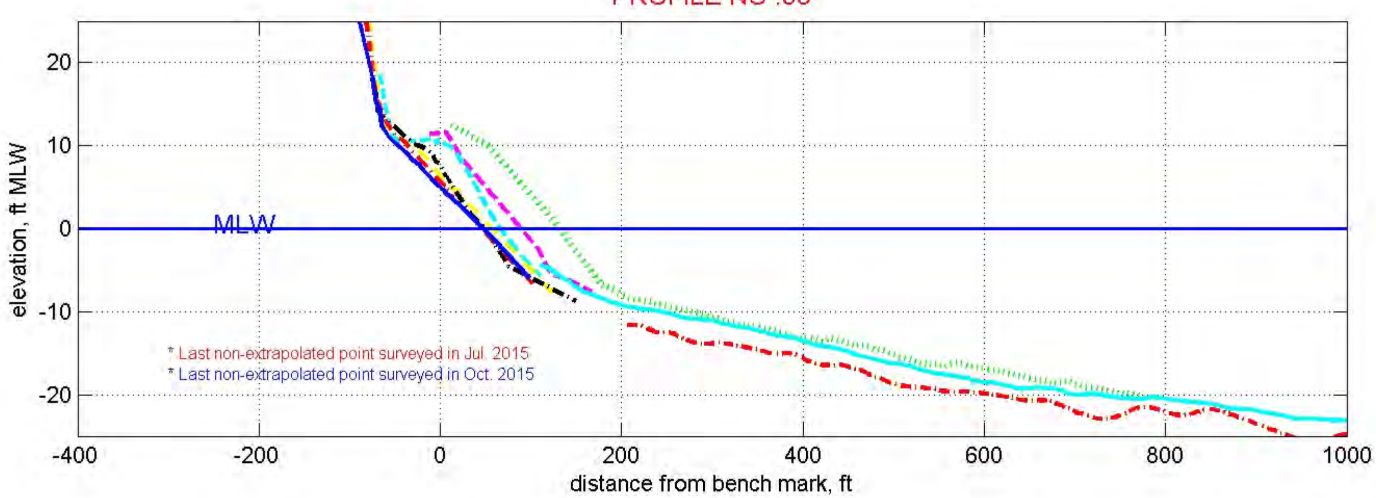

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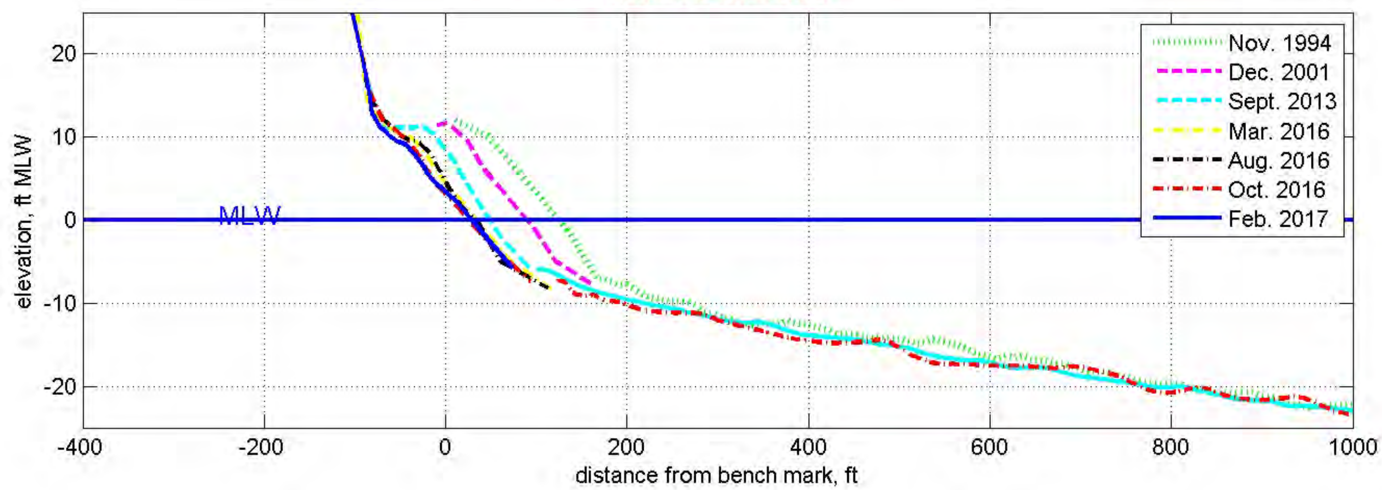

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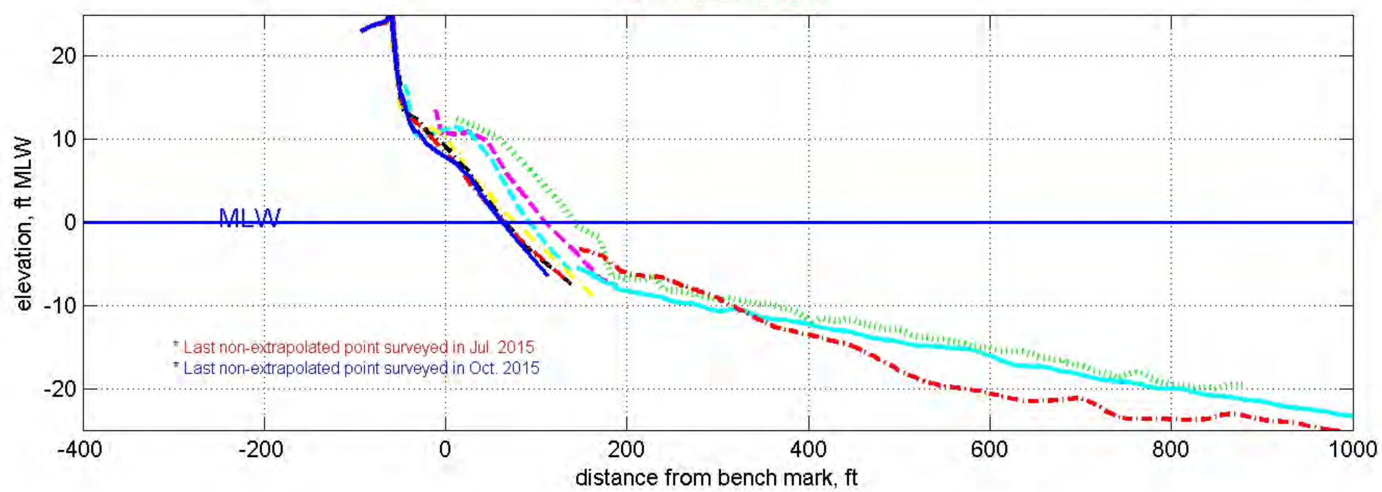

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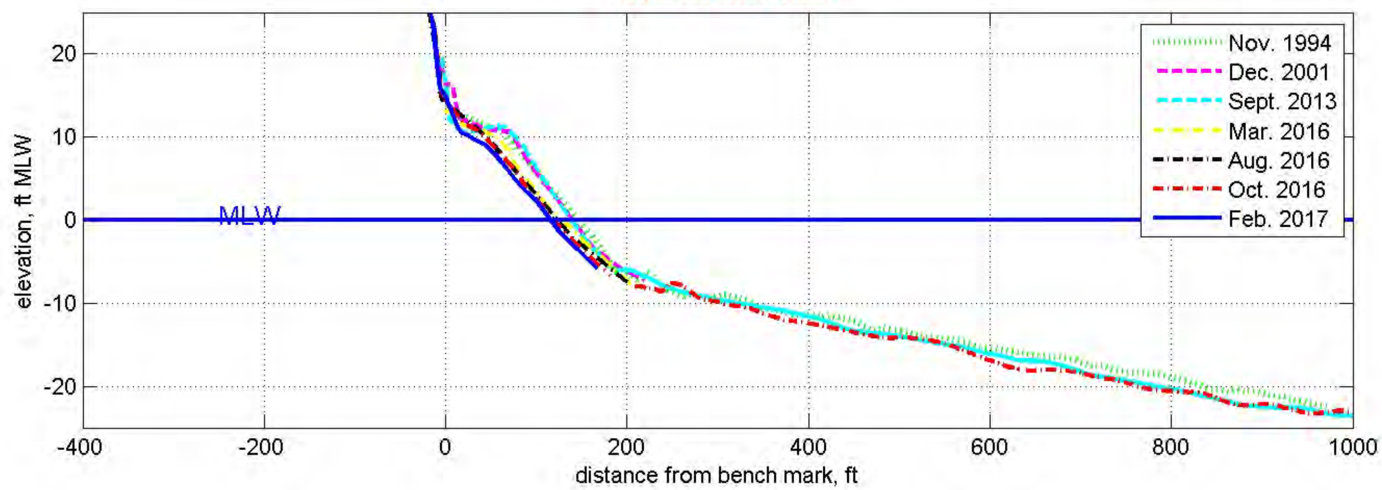

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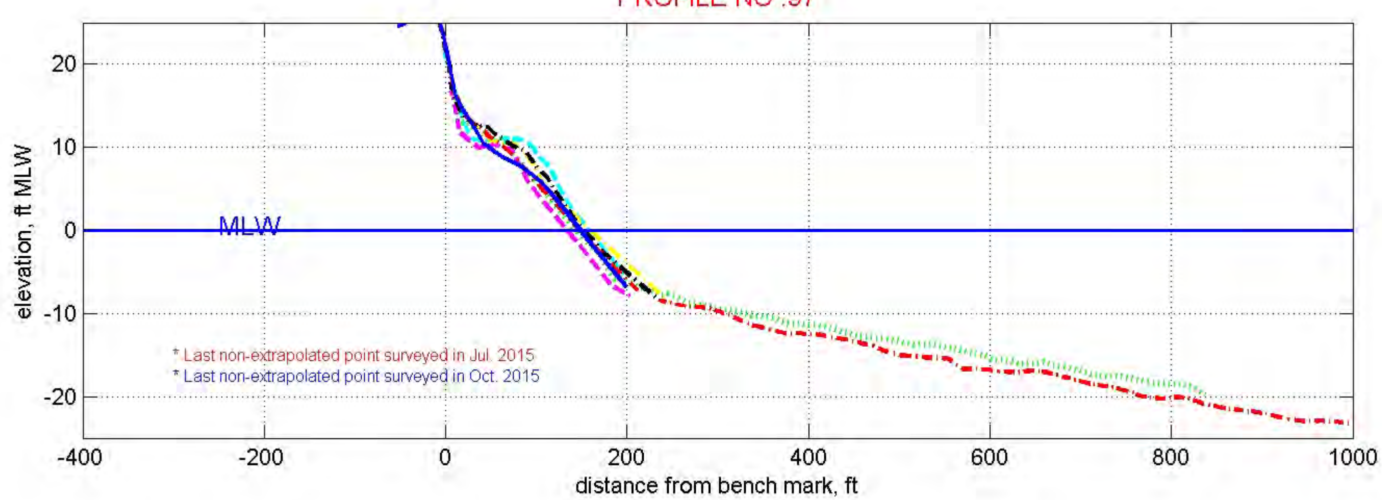

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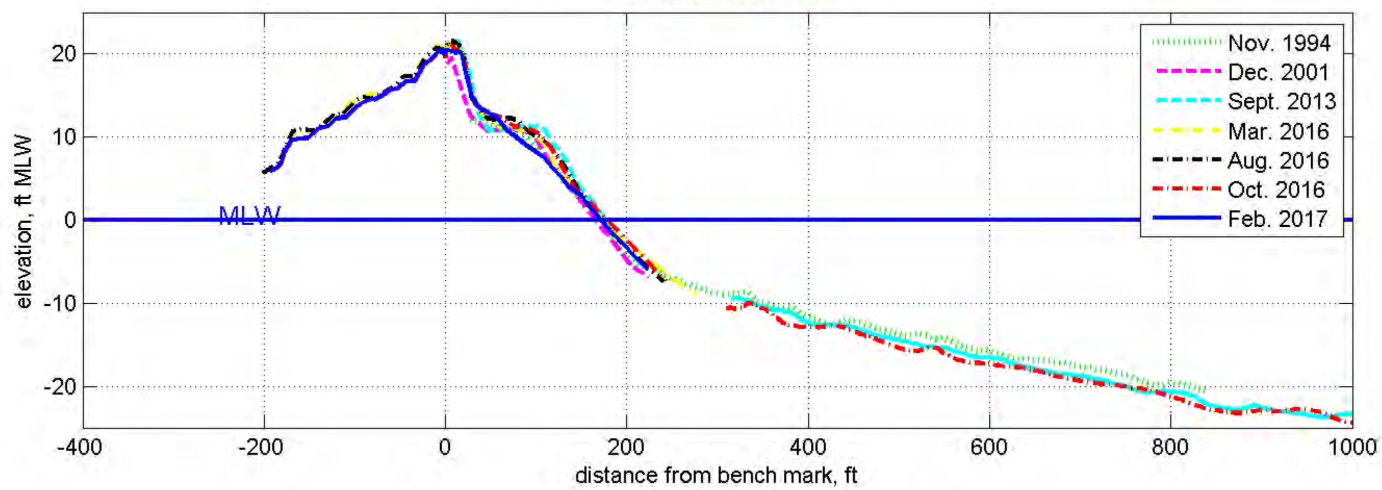

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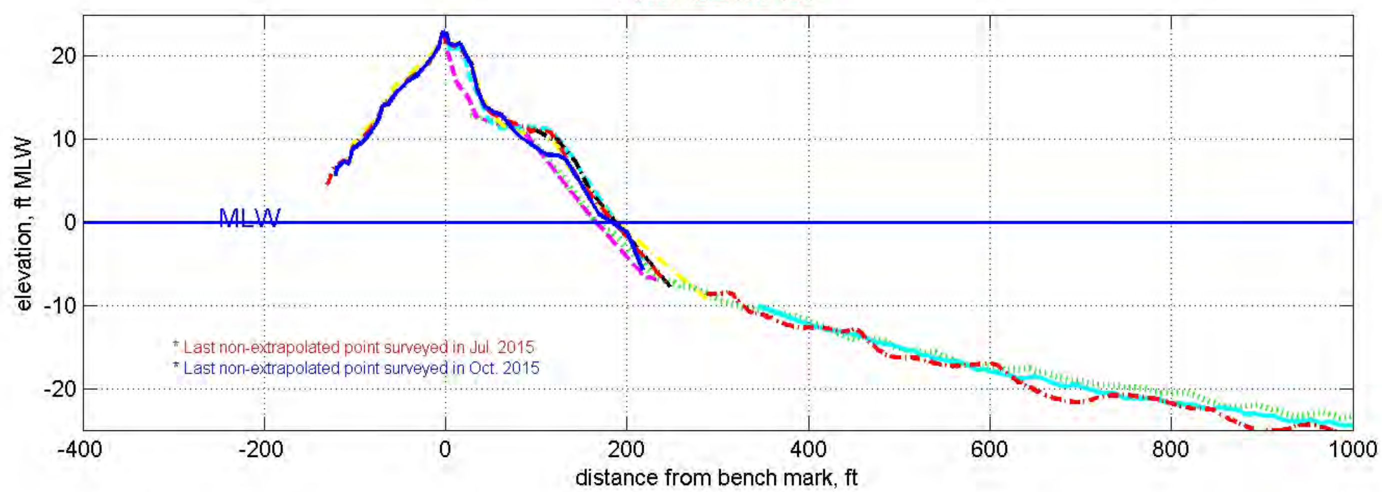

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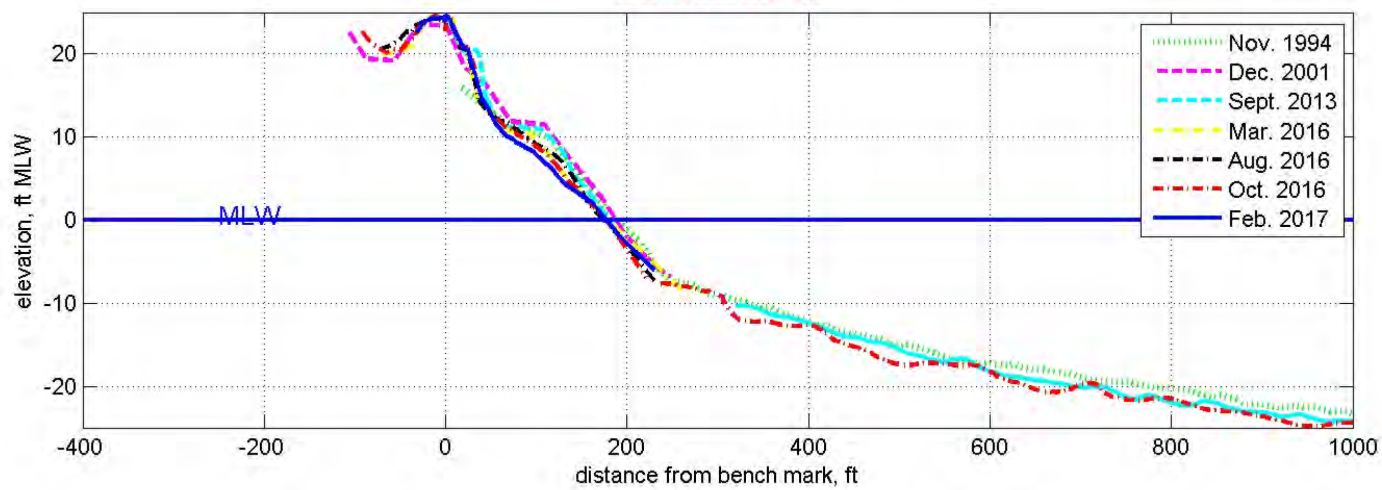

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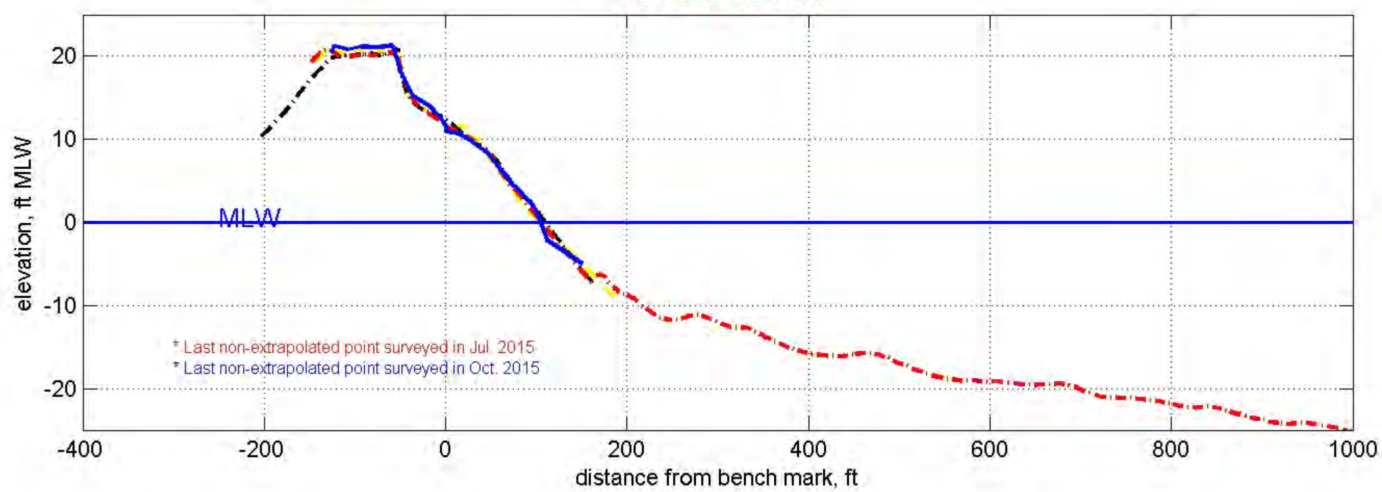

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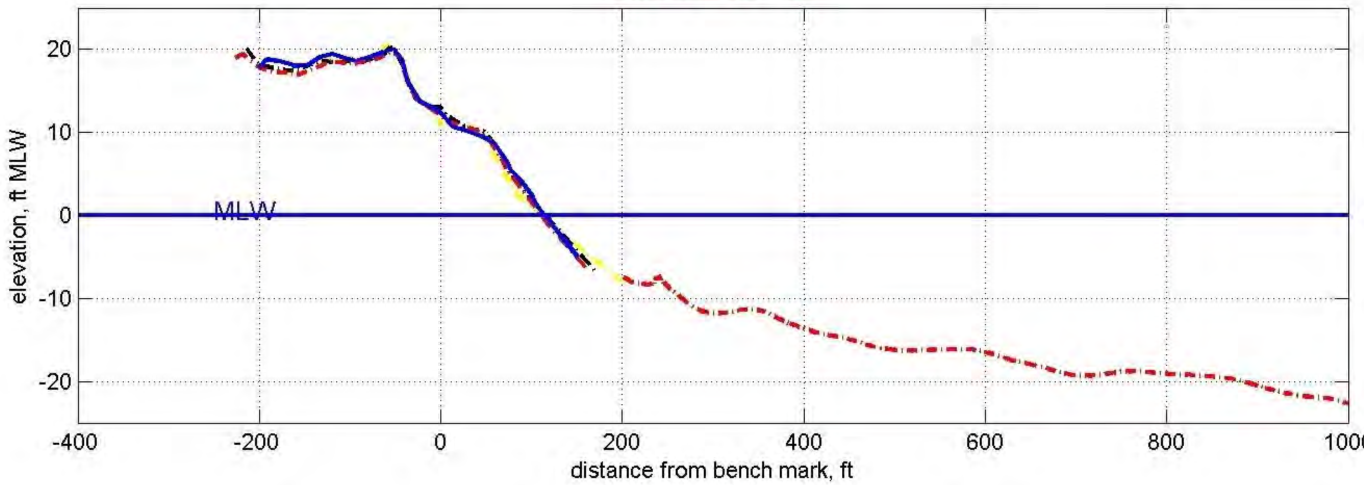

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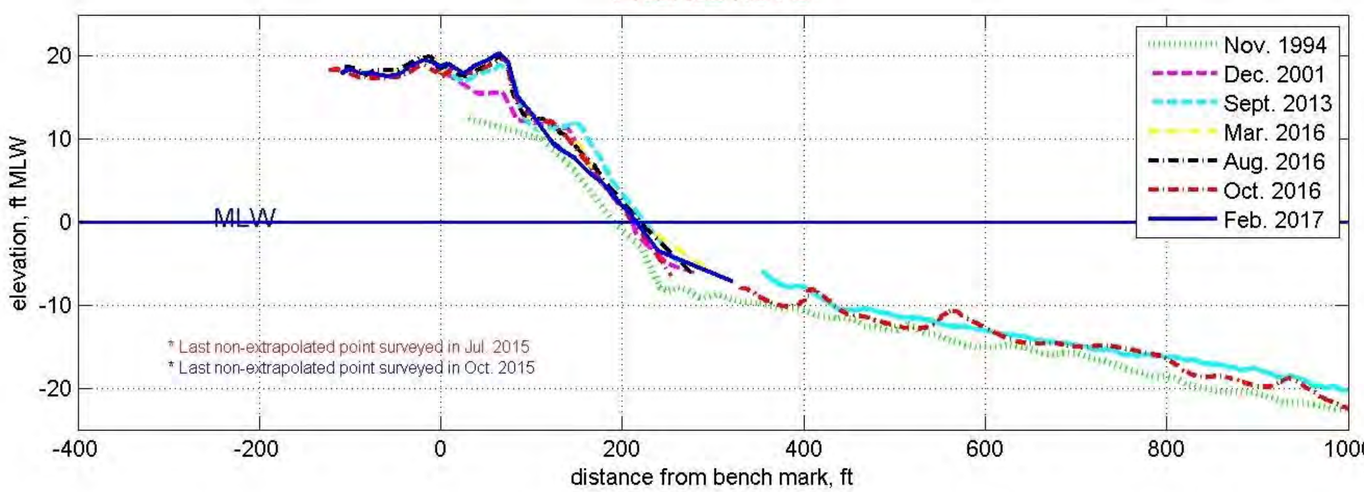

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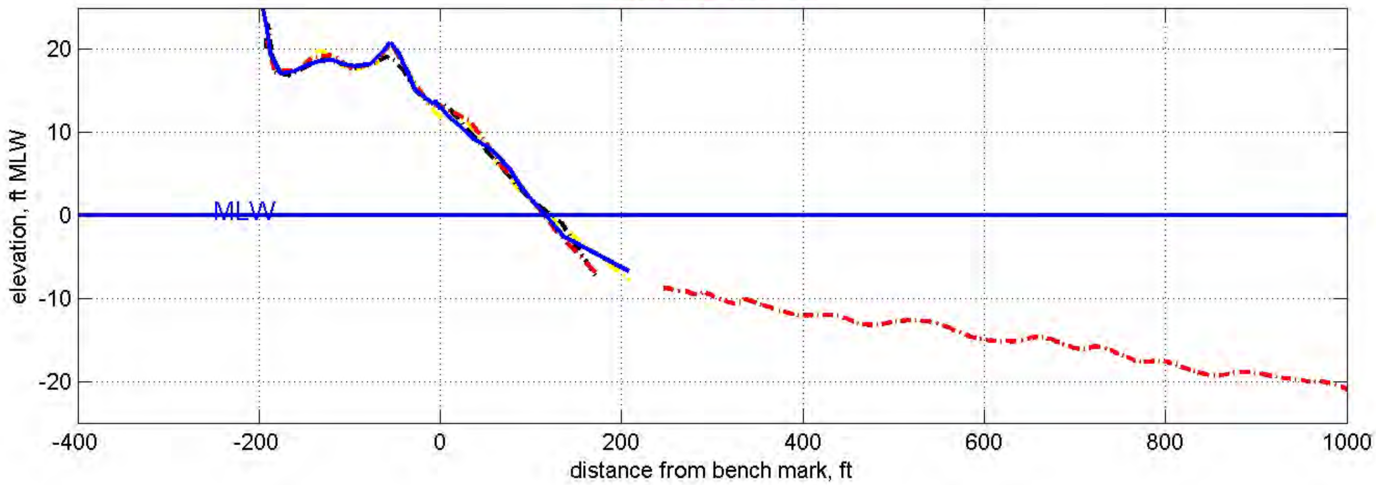

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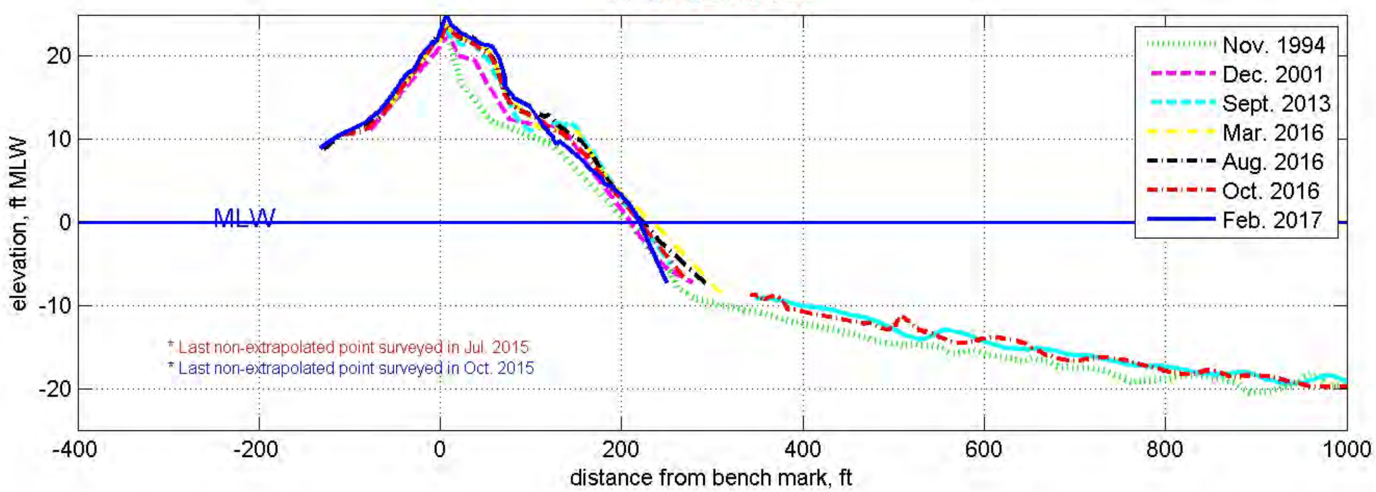

APPENDIX B – ELECTRONIC COPY OF RAW PROFILE DATA

Attachment D

2001-2007 Wetland Well Monitoring Data

BANK RETREAT CALCULATIONS FOR NORTH & SOUTH CONTROL AREAS

Transect	Lot	Bank Retreat 1994-2013 (ft)	Bank Retreat 2003-2013 (ft)
NORTH CONTROL AREA			
1	119	26.19	
2	119	24.06	
3	119	28.10	
4	119	25.72	
5	117	28.21	
6	117	29.35	
7	117	25.88	
8	117	20.53	
9	117	24.68	
10	117	30.79	
11	115	29.74	
12	115	25.69	
13	115	25.87	
14	115	20.98	
15	115	30.76	
16	113	35.10	
17	113	36.12	
18	113	28.31	
19	113	25.38	
20	113	29.07	
21	109	25.74	
22	109	26.24	
23	109	24.15	
24	109	30.21	
25	109	48.68	
26	109	55.92	
27	109	52.49	
28	109	51.87	
29	109	47.26	
30	107A	46.15	
31	107A	43.91	
32	107A	47.46	
33	107	51.08	
34	107	56.18	
35	107	53.84	
36	107	57.67	
37	107	57.25	
38	105	50.17	
39	105	50.00	
40	105	58.46	
41	105	82.29	
# TRANSECTS		41	
AVERAGE		38.2	
AVERAGE ANNUAL RETREAT (FT/YR)		**2.0**	
SOUTH CONTROL AREA			
91	85		67.72
92	85		67.36
93	85		60.96
94	85		60.55
95	85		54.88
96	85		59.06
97	85		66.80
98	85		72.34
99	85		67.27
100	85		67.24
# TRANSECTS			10
AVERAGE			64.4
AVERAGE ANNUAL RETREAT (FT/YR)			**6.4**
CONTROL AREA AVERAGE			
Weighted average retreat for North and South Control (ft/yr)			**2.9**

CONTROL AREAS - STANDARD CALCULATION OF BANK CONTRIBUTION VOLUME

Bank Height			
Location	Top of Bank (ft MLW)	Toe of Bank (ft MLW)	Bank Height above Toe (ft)
119 Baxter	104	11	93
117 Baxter	105	11	94
115 Baxter	105	11	94
113 Baxter	103	11	92
109 Baxter	101	11	90
107A Baxter	100	11	89
107 Baxter	98	11	87
105 Baxter	93	11	82
85 Baxter	78	11	67
Average height			87.6
Standard Calculation of Compensatory Mitigation			
Bank Retreat (ft)	Bank Height (ft)	Volume (cy) ((Retreat * Height)/27))	
2.9	88		**9.3**

BANK RETREAT CALCULATIONS FOR GEOTUBE AREA

Transect	Lot	Bank Retreat 1994-2013 (ft)	Bank Retreat 2003-2013 (ft)
GEOTUBE AREA			
43	105	79.80	
44	105	77.42	
45	105	75.89	
46	105	74.74	
47	101	79.44	
48	101	76.83	
49	101	77.28	
50	101	73.68	
51	101	75.07	
52	101	76.28	
53	101	78.83	
54	101	77.47	
55	101	67.77	
56	Public Access	74.51	
57	99	70.24	
58	99	68.06	
59	99	75.69	
60	99	80.43	
61	99	75.06	
62	99	77.30	
63	99	84.02	
64	99	85.45	
65	99	85.86	
66	97	81.02	
67	97	77.16	
68	97	84.74	
69	97	91.43	
70	97	99.19	
71	97	99.03	
72	97	100.42	
73	97	98.05	
74	93	85.60	
75	93	95.37	
76	93	98.80	
77	93	104.46	
78	93	108.22	
79	91	97.67	
80	91	71.14	
81	91		31.87
82	91		20.52
83	87		13.15
84	87		22.83
85	87		55.13
86	87		76.78
87	87		84.53
88	87		81.09
89	87		61.64
90	87		48.33
# TRANSECTS		38	
AVERAGE TRANSECTS 43-80		83.1	
AVERAGE ANNUAL RETREAT (FT/YR)		4.4	
# TRANSECTS			10
AVERAGE TRANSECTS 81-90			49.6
AVERAGE ANNUAL RETREAT (FT/YR)			5.0
GEOTUBE AREA WEIGHTED AVERAGE ANNUAL RETREAT			**4.5**

GEOTUBE AREA - STANDARD CALCULATION OF BANK CONTRIBUTION VOLUME

Bank Height			
Location	Top of Bank (ft MLW)	Toe of Bank (ft MLW)	Bank Height above Toe (ft)
105 Baxter	93	10	83
101 Baxter	85	10	75
99 Baxter	80	10	70
97 Baxter	78	10	68
93 Baxter	78	10	68
91 Baxter	74	10	64
87 Baxter	77	10	67
Average height (ft)			**71**
Standard Calculation of Compensatory Mitigation			
Bank Retreat (ft)	Bank Height (ft)	Mitigation Volume (cy) ((Retreat * Height)/27))	
4.5	71	**11.8**	

Attachment E

Bank Retreat Calculations for North and South Control Areas

Table 1. Depths of Groundwater (ft) in Wetlands Monitoring Wells (2001-2007)

	Average	Minimum	Maximum		May 14, 2001	Jun 14, 2001	July 25, 2001	Aug 19, 2001	Sep 17, 2001	Oct 18, 2001	Nov 21, 2001	Dec 23, 2001
Well E-1	6.82	5.04	7.35		6.8	7.35	5.05	5.65	5.04	7.18	7.17	7.15
Well E-2	3.32	1.75	4.22		2.18	1.75	4.22	3.95	3.75	4.11	3.96	4.19
Well E-3	7.61	5.85	8.30		6.15	5.85		6.08	7.5	7.72	8.25	8.3
Well E-4	6.43	3.62	7.68		5.41	4.3	3.62	4.12	7.35	6.68	7.42	7.4
Well E-5	4.75	1.33	7.08		4.93	4.05	4.12	4.53	5.31	7.06	7.07	7.08
Well E-6	3.83	1.42	6.90		6.9	2.8	2.65	2.85	4.45	5.92	6.47	3.27
Well E-7	6.27	2.80	12.50		12.5	11.5	8.4	9.25	9.3	9.7	9.33	10.22
Well E-8	5.22	3.15	7.95		7.82	4.75	5.75	6.38	6.4	6.94	5.24	7.35

	Average	Jan 28, 2002	Feb 26, 2002	Mar 30, 2002	May 8, 2002	May 24, 2002	June 26, 2002	July 30, 2002	Aug 30, 2002	Oct 2, 2002	Oct 29, 2002
Well E-1	6.82	7.15	7.15	7.15	7.14	7.19	7.13	7.1	7.12	7.1	7.15
Well E-2	3.32	3.95	3.82	3.66	3.79	3.77	3.76	3.99	3.65	3.65	3.61
Well E-3	7.61	8.15	8.08	7.9	7.94	7.94	7.89	7.88	7.92	7.8	7.85
Well E-4	6.43	7.68	7.59	5.82	6.26	5.9	7.2	7.44	7.5	7.5	7.5
Well E-5	4.75	4.33	4.07	2.75	3.96	3.44	5.12	6.41	5.98	5.81	5.99
Well E-6	3.83	3.45	3.33	2.4	3.14	2.85	3.88	5.6	4.87	4.7	4.95
Well E-7	6.27	9.01	7.02	4.76	5.08	4.95	5.89	7.7	5.5	5.69	6.18
Well E-8	5.22	7.14	6.93	6.3	5.95	5.77	5.45	5.7	5.94	5.93	5.93

	Average	Jan 6, 2003	Feb 1, 2003	Feb 24, 2003	April 3, 2003	May 5, 2003	June 2, 2003	July 1, 2003	July 28, 2003	Aug 28, 2003	Sep 25, 2003
Well E-1	6.82	7.12	7.1	7.08	7.05	7.04	7.02	7.02	7.03	7.01	7
Well E-2	3.32	3.45	3.45	3.45	3.45	3.5	3.39	3.42	3.47	3.47	3.45
Well E-3	7.61	7.7	7.74	7.68	7.6	7.64	7.55				
Well E-4	6.43	6.02	6.42			6.23	6.02				
Well E-5	4.75	2.57	4.68	2.21	1.33	4.06	3.8	3.89	5.45	5.28	5.14
Well E-6	3.83	2.05	3.2	2.49	1.42	2.62	2.82	2.45	4.02	3.89	3.74
Well E-7	6.27	4.34	5.07	4.85	3.41	4.5	4.5	4.5	5.65	5.5	7.14
Well E-8	5.22	5.3	5.12	4.98	4.68	4.46	4.55	4.4	4.35	4.3	4.4

	Average	Dec 2, 2003	Aug 9, 2004	Sep 2, 2004	Oct 6, 2004	Nov 5, 2004	Nov 30, 2004	Jan 13, 2005	Mar 15, 2005	Apr 13, 2005	May 11, 2005
Well E-1	6.82	6.92	6.3	6.8	6.8	6.8	6.8	6.3	6.8	6.6	6.7
Well E-2	3.32	3.35	3.15	3.15	3.15	3.05	2.95	2.35	2.85	2.65	2.65
Well E-3	7.61										
Well E-4	6.43										
Well E-5	4.75	4.23	4.7	6.7	4.8	3.1	4.7	4.2	4.9	4.3	4.5
Well E-6	3.83	3.17	4.6	5.6	4.35	2.8	3.6	3.2	3.5	3.1	3.8
Well E-7	6.27	6.61	7.2	7.85	5.6	6.5	5.6	5	3.6	3.3	4
Well E-8	5.22	4.76	6.25	4.3	4.55	4.45	4.05	3.45	3.65	3.55	4.15

	Average	Jun 9, 2005	Jul 13, 2005	Aug 17, 2005	Sep 21, 2005	Oct 19, 2005	Dec 7, 2005	Dec 28, 2005	Jan 25, 2006	Mar 1, 2006	Apr 6, 2006
Well E-1	6.82	6.6	6.6	6.6	6.7	6.7	6.5	6.6	6.4	6.5	6.4
Well E-2	3.32	2.55	2.35	2.55	2.45	2.35	2.35	2.35	2.25	2.25	2.15
Well E-3	7.61										
Well E-4	6.43										
Well E-5	4.75	4.7	5.8	6.2	6.3	6.7	5	4.9	4.7	4.9	5.2
Well E-6	3.83	3.4	5.2	5.6	5.8	6.4	4.6	3.5	4	3.9	4.5
Well E-7	6.27	3.2	4.1	4.6	4.8	7.9	2.8	5.4	5.2	5.3	6
Well E-8	5.22	3.65	4.55	4.75	4.95	4.05	3.15	4.25	3.85	3.65	3.65

	Average	Apr 27, 2006	May 31, 2006	Jun 21, 2006	Jul 25, 2006	Oct 4, 2006	Nov 3, 2006	Dec 6, 2006	Dec 27, 2006	Feb 5, 2007
Well E-1	6.82	6.4	6.5	6.5	6.4	6.4	6.5	6.4	6.4	6.3
Well E-2	3.32	2.25	2.25	2.35	2.15	2.15	2.35	2.35	2.35	2.45
Well E-3	7.61									
Well E-4	6.43									
Well E-5	4.75	5.7	5.3	4.5	4.9	5.8	5.9	6	6.2	6.2
Well E-6	3.83	5.1	4.5	4.1	4.1	5.6	5.8	6.3	5.7	5.9
Well E-7	6.27	7.2	6.3	5.9	5.9	4.4	9	9.1	8.1	8.3
Well E-8	5.22	3.75	3.75	3.75	3.55	7.95	4.35	4.55	4.65	4.55

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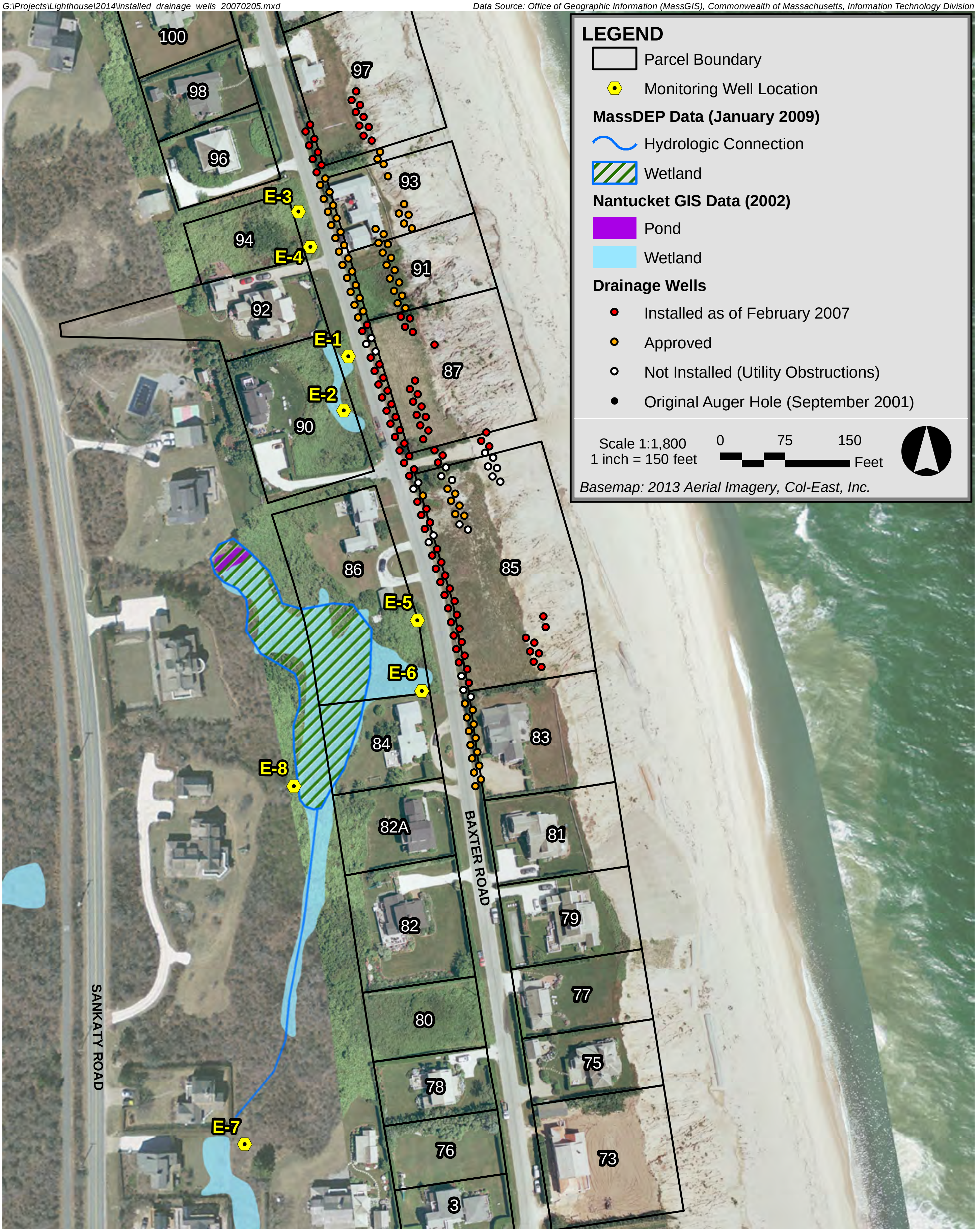
Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



Baxter Road and Sconset Bluff Storm Damage Prevention Project   Nantucket, MA

Epsilon ASSOCIATES INC.

Figure 1

Monitoring Well Locations and MassDEP Wetlands