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August 12, 2016

Nantucket Conservation Commission
2 Bathing Beach Road
Nantucket, MA 02554

Subject: Interim Monitoring Update
SE48-2824, Sconset Bluff Geotextile Tube Project

Dear Commissioners:

On behalf of the Sconset Beach Preservation Fund (SBPF), we are submitting an interim update on the Project's monitoring for the Sconset Bluff Geotextile Tube Project. It is anticipated that all monitoring results will be reviewed in detail during the project's annual review later this fall. The following information is intended to provide an interim update on the bluff and shoreline monitoring conducted to date.

The interim update is provided as a PowerPoint presentation, as many of the monitoring results are best explained graphically.

We look forward to reviewing the attached information with the Commission at the August 24, 2016 hearing.

Sincerely,
EPSILON ASSOCIATES, INC.

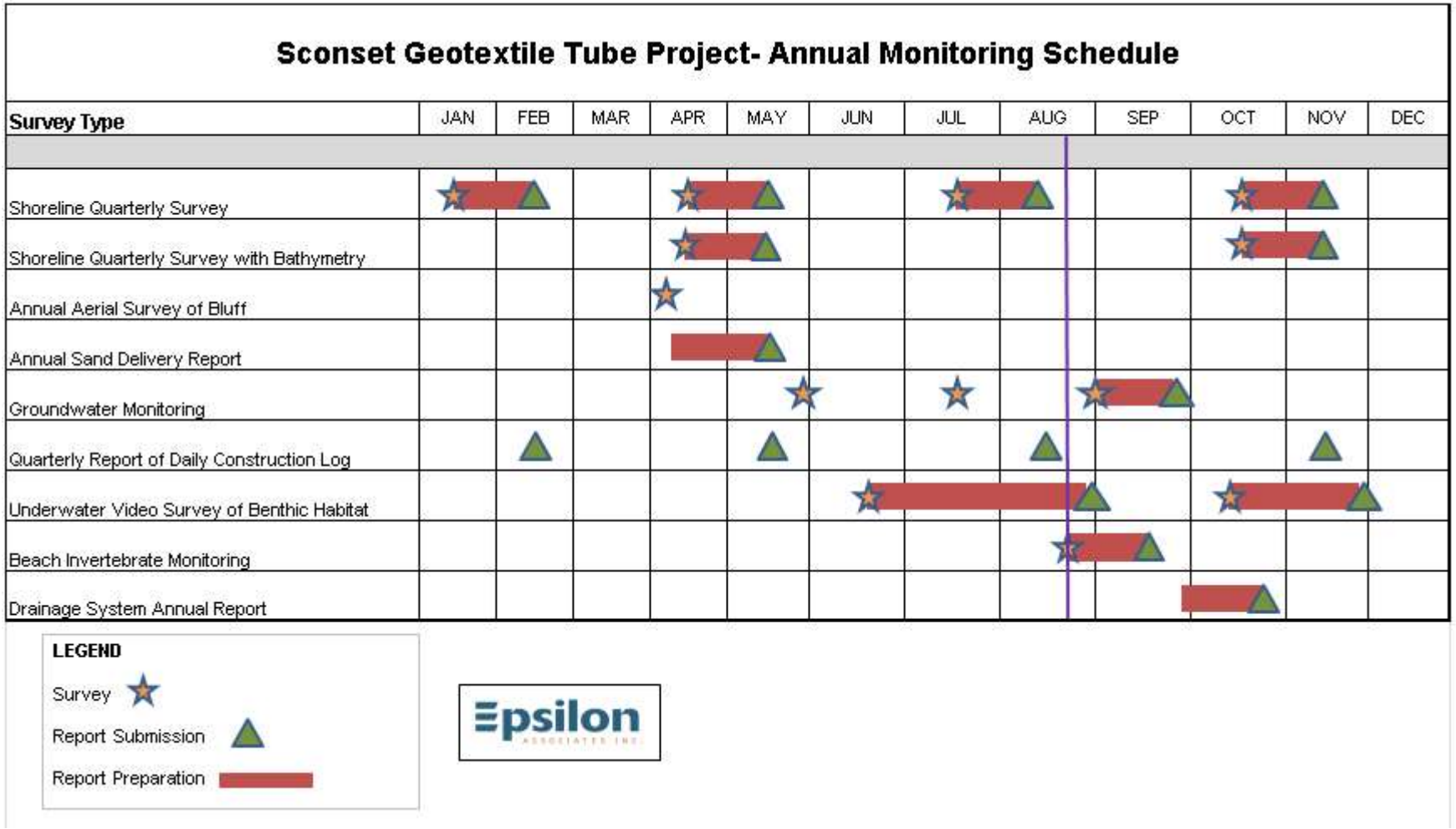
Maria Hartnett
Associate

Sconset Bluff Geotextile Tube Project – Interim Update

Key Findings

- Base of bluff has been stabilized by the geotextile tubes.
- Bluff survey indicates that mitigation sand template is contributing more than the unprotected bluff.
- Shoreline in geotube area and immediately adjacent areas is in expected location based on historic data (or even farther seaward), with no indication of accelerated erosion in front of or adjacent to the geotubes.
- All mitigation sand has been delivered, with about ~14,000 cy currently in the template.
- Bluff face appears to be stabilized.

Monitoring Schedule



- Interim update today is focused on aerial survey of bluff, sand delivery, and shoreline surveys.
- Much of today's information comes from the "April 2015 - March 2016 Sand Delivery and Contribution Report" submitted in June 2016.

Annual Aerial Survey

- An aerial survey was performed of the Project area on April 2, 2016.
- A UAV was used to capture imagery and elevation data for the bluff face and geotextile area.
- The images were stitched together using photogrammetric techniques to create a photomosaic. These were geo-referenced using control points for location accuracy.
- An aerial survey will be performed **annually** going forward.
- 2016 survey results were compared to most recent aerial survey (July 2013).

Annual Aerial Survey

- The elevation data from the survey was processed and used to produce a digital elevation model and 1-foot contours of Sconset Bluff.
- A 3D model of the bluff face above the geotextile tubes as well as north and south of the bluff was also generated from this data.

2013-2016 Sand Contribution from Unprotected Bluff

- The results of the 2016 aerial survey were compared to the 2013 aerial survey for those unprotected areas immediately adjacent to the geotextile tube project.
- <u>For the north unprotected area</u>, the section of bluff within 800 feet immediately to the north of the geotextile tubes was used.
- <u>For the south unprotected area</u>, the section on bluff within 210 feet immediately to the south of the geotextile tubes was used. Areas farther south than this could not be used because they had coir or jute terraces installed and so were not representative of the unprotected bluff.

Bluff Volume Loss in Unprotected Areas Adjacent to Geotextile Tubes

Line	Area	Volume Lost (CY)	Length (Feet)	Duration (Years)	Erosion Rate (CY/LF/Yr)
1	North Unprotected Area	31,329	800	2.75	14.2
2	South Unprotected Area	4,370	210	2.75	7.8
3	Total Bluff Erosion for Adjacent Unprotected Areas	35,699	1,010	2.75	12.9

2013-2016 Sand Contribution from Unprotected Bluff

- The change in the bluff volume in these unprotected areas was calculated from the toe of the bluff (elevation +11 MLW) to the top of the bluff.

Bluff Volume Loss in Unprotected Areas Adjacent to Geotextile Tubes

Line	Area	Volume Lost (CY)	Length (Feet)	Duration (Years)	Erosion Rate (CY/LF/YR)
1	North Unprotected Area	31,329	800	2.75	14.2
2	South Unprotected Area	4,370	210	2.75	7.6
3	**Total Bluff Erosion for Adjacent Unprotected Areas**	**35,699**	**1,010**	**2.75**	**12.9**

- Unprotected bluff contribution volume of 12.9 cy/lf/yr was 59% of the mitigation volume of 22 cy/lf/yr.

2013-2016 Change in Bluff Volume Above Geotextile Tubes

- The change in the bluff volume from 2013 to 2016 was calculated by first generating a 3D digital elevation model from the 2016 survey data of that portion of the bluff above the elevation of the geotextile tube sand cover, which was at approximately +34 feet Mean Low Water (MLW) at the time of the April 2016 survey.
- Similarly, the 2013 photogrammetry survey data was used to construct a 3D model to compare against the 2016 survey. The 2013 data was subtracted from the new survey data and the volumetric change was calculated in GIS based on the results.
- Change in bluff volume was -851 cy.

Changes in Bluff Volume, July 2013 - April 2, 2016

Line	Sand Delivery Amounts	Total CY
Sand Added to Bluff Face (Dec 2013-3/31/2016) (Not Counted as Mitigation)		
1	Total Volume Delivered to Bluff Face (Dec 2013 - March 31, 2014)	2,600
2	Total Volume Delivered to Bluff for Vegetation (April 2015)	3,418
3	Total Volume Delivered to Bluff to Fill Gully South of Viewing Area (Nov/Dec 2015)	931
4	Total Volume Delivered to Bluff to Fill Gully at Viewing Area (Jan 2016)	120
5	Total Volume Delivered to Bluff Face (Not Counted as Mitigation)	**7,069**
Change in Bluff Volume (July 2013 - April 2, 2016)		
6	Measured Change in Bluff Volume Above Geotube Sand Cover	**-851**

When the addition of 7,069 cy of sand is taken into account, the bluff face above the geotube sand cover would have decreased in volume by approximately 7,920 cy (851 cy +7,069 cy) but for the addition of 7,069 cy added to fill gullies and smooth the bluff surface for vegetation.

Current View of Bluff Face

- Bluff face now fully vegetated (initial vegetation spring 2015; additional vegetation spring 2016)
- Stormwater system installed in January/February 2016

Volume of Sand in Sand Template

- As of April 2016, the volume of sand in the sand template is 14,022 cy, which is about 14.8 cy/lf.
- The volume of sand above the fourth tier is about 2,200-2,300 cy. It is anticipated that sand on top of the sand template, including sand on top of the fourth year, will continue to be pushed down to recover the geotextile tubes as needed. Additionally, the 2,200-2,300 cy that are presently unavailable, but will become available in the future as the sand is pushed down, is less than the Project surplus of just over 3,000 cy.

Sand Delivery Summary

- All required sand has been delivered for the past 3 years.
- Mitigation Volume: start with base required mitigation (22 cy/lf/yr * project length), subtract countable surplus from previous year (surplus is countable only if surplus sand was delivered <u>and</u> surplus sand was still in the template at the start of the next year), and subtract any bluff erosion to yield the adjusted required mitigation volume.

Summary of Sand Delivery in Cubic Yards (CY), December 2013 - March 31, 2016

Line	Sand Amounts	12/13-3/31/14	4/1/14-3/31/15	4/1/15-3/31/16	4/1/16-3/31/17
Base Required Mitigation Volume					
1	Required Mitigation Volume (22 cy/lf * Project Length of 852' for 3 tiers, 947' for 4 tiers w/ret.)	18,744	18,744	20,834	20,834
Mitigation Volume Adjustments					
	Surplus Sand From Prior Year				
2	Surplus Delivered in Prior Year (From Line 9 in Preceding Column)	0	5,207	6,892	3,062
3	Volume on Template at Start of Sand Year	0	5,900	8,500	14,022
4	Countable Surplus Present in Sand Template (Line 2; Not to Exceed Line 3)	0	5,207	6,892	3,062
	Bluff Erosion				
5	Net Contribution from Erosion of Bluff Face (pre-veg & during 4th tier const.; see Table 5)	0	6,000	1,920	
6	**Adjusted Required Mitigation Volume (Line 1 - Line 4 - Line 5)**	18,744	7,537	12,022	17,772
Mitigation Volume Summary					
7	Total Volume Delivered for Mitigation (see Line 9 in Table 2; Line 4 in Table 3; Line 8 in Table 4)	23,951	14,429	15,085	TBI
8	**Mitigation Surplus/Deficit (Line 7 - Line 6 - Line 8)**	**5,207**	**6,892**	**3,062**	
Sand Delivery Summary					
9	Total Volume Delivered for Geotube Construction (See Line 6 in Tables 2 and 4)	12,653	0	2,931	0
10	Total Volume Delivered for Mitigation (see Line 11 in Table 2; Line 4 in Table 3; Line 8 in Table 4)	23,951	14,429	15,085	TBI
11	Total Volume Delivered to Bluff Face (Not Counted as Mitigation; See Ln 10 in Tbl 2 & Ln 12 in Tbl 4)	2,600	0	4,469	0
12	**Total Volume Delivered by Truck (Sum Lines 10-12)**	**39,204**	**14,429**	**22,485**	**TBI**

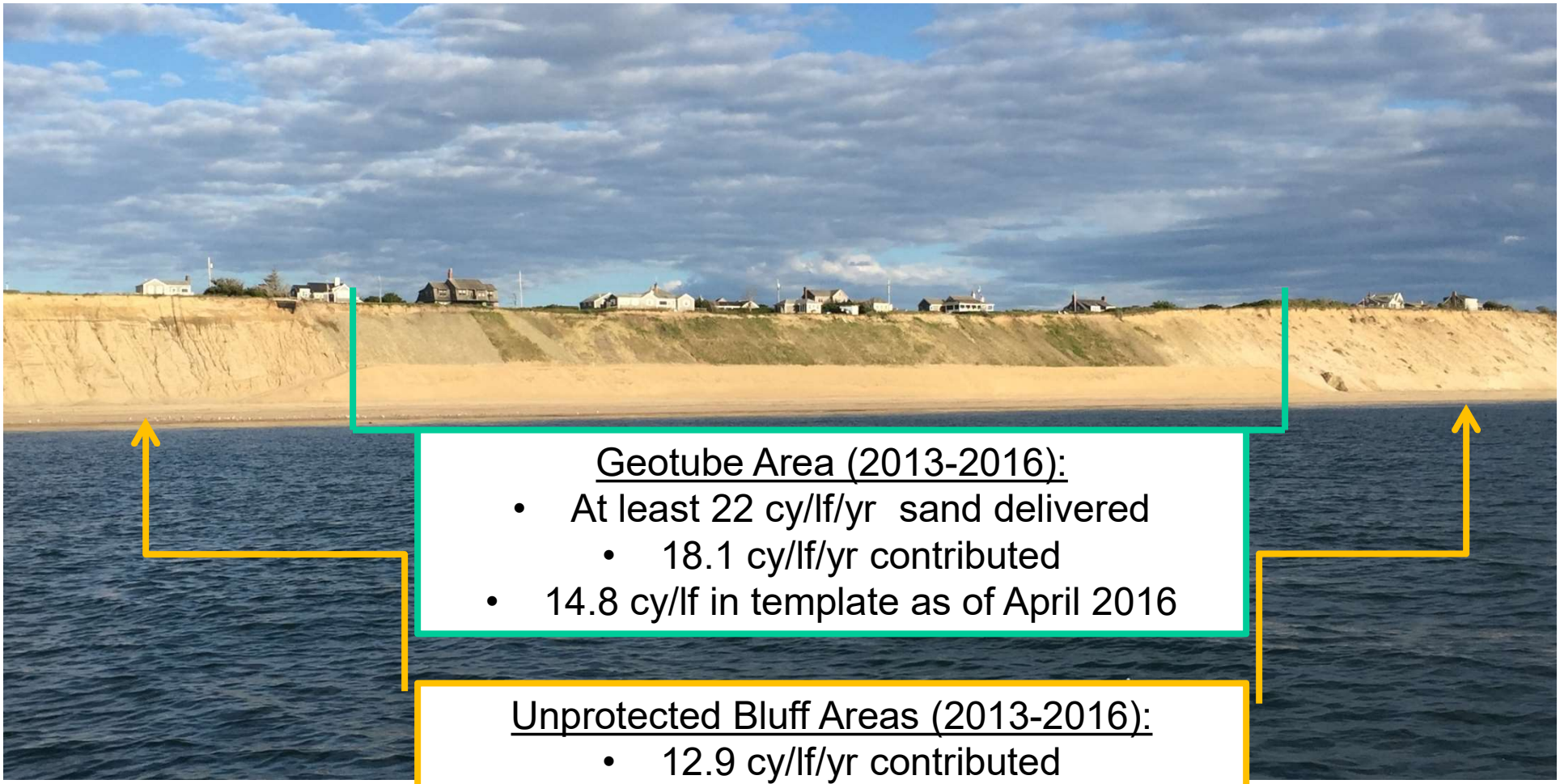
Volume of Sand Contributed to Littoral System

- All 22 cy/lf/yr have been **delivered and are available.**
- Of the 22 cy/lf/yr, we estimated how much has been **contributed.**
- Over the last three years, an average of about 18.1 cy/lf/yr have been contributed.

Summary of Sand Contribution in Cubic Yards (CY), December 2013 - March 31, 2016

Line	Sand Amounts	12/13-3/31/14	4/1/14-3/31/15	4/1/15-3/31/16
Template Sand Contribution				
1	Volume on Template at Start of Sand Year (Line 3 in Table 1)	0	5,900	8,500
2	Total Volume Delivered for Mitigation (2015 and 2016: Line 7 in Table 1; 2014: Lines 6+7 in Table 2)	20,244	14,429	15,085
3	Volume on Template at End of Sand Year (Line 3 in Table 1, using vol. on temp. at start of following yr)	5,900	8,500	14,022
4	**Total Volume Contributed from Sand Template**	**14,344**	**11,829**	**9,563**
5	**Total Volume Contributed from Sand Template (cy/lf/yr)**	**16.8**	**13.9**	**10.1**
Bluff Face Contribution				
6	Net Contribution from Erosion of Bluff Face (Line 5 in Table 1)	0	6,000	0
Construction Contribution				
7	Contribution from Construction (Line 8 in Table 2; Line 5 in Table 1)	3,707	0	1,920
Total Annual Sand Contribution				
8	Total Volume Contributed	18,051	17,829	11,483
9	**Total Volume Contributed in cy/lf/yr**	**21.2**	**20.9**	**12.1**
10	**Average Sand Contribution from 2013-2016 (cy/lf/yr)**			**18.1**

Summary



Geotube Area (2013-2016):

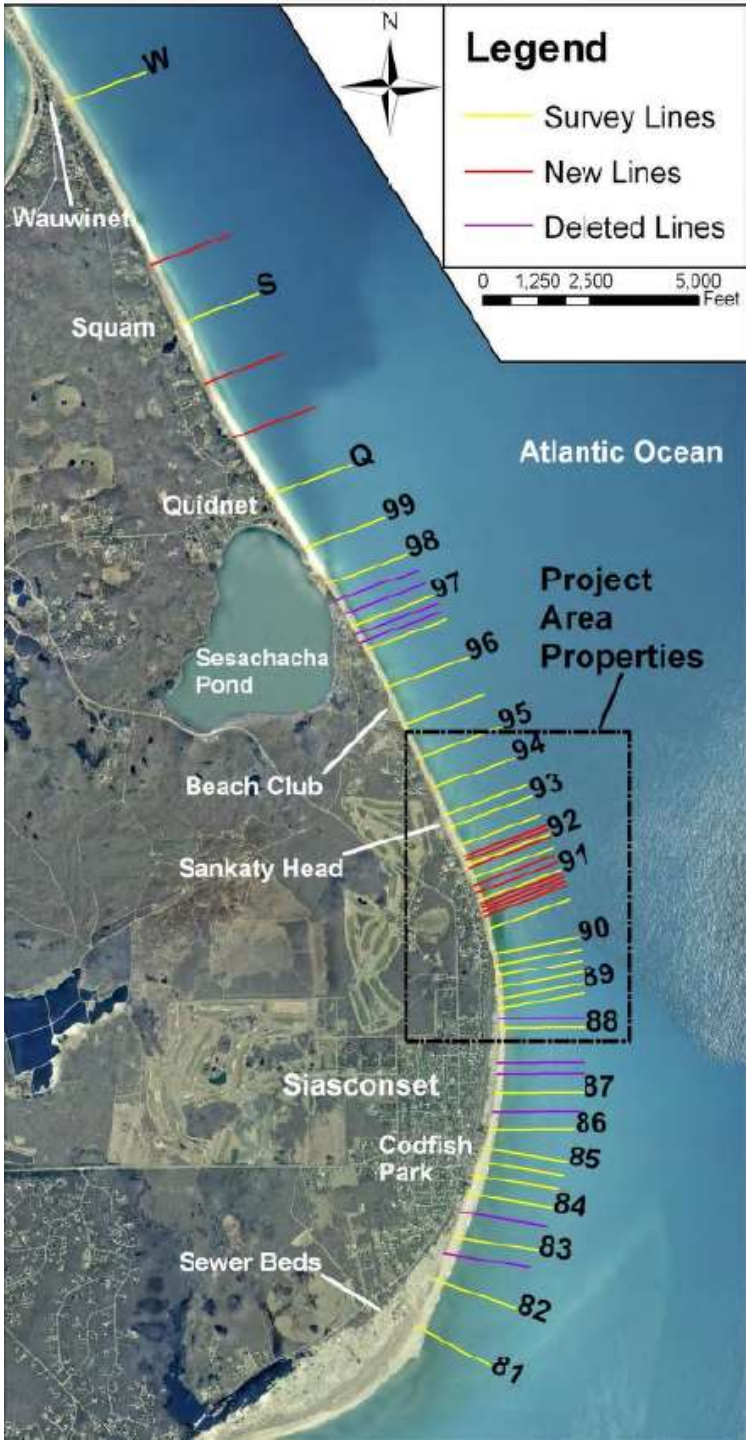
- At least 22 cy/lf/yr sand delivered
  - 18.1 cy/lf/yr contributed
- 14.8 cy/lf in template as of April 2016

Unprotected Bluff Areas (2013-2016):

- 12.9 cy/lf/yr contributed

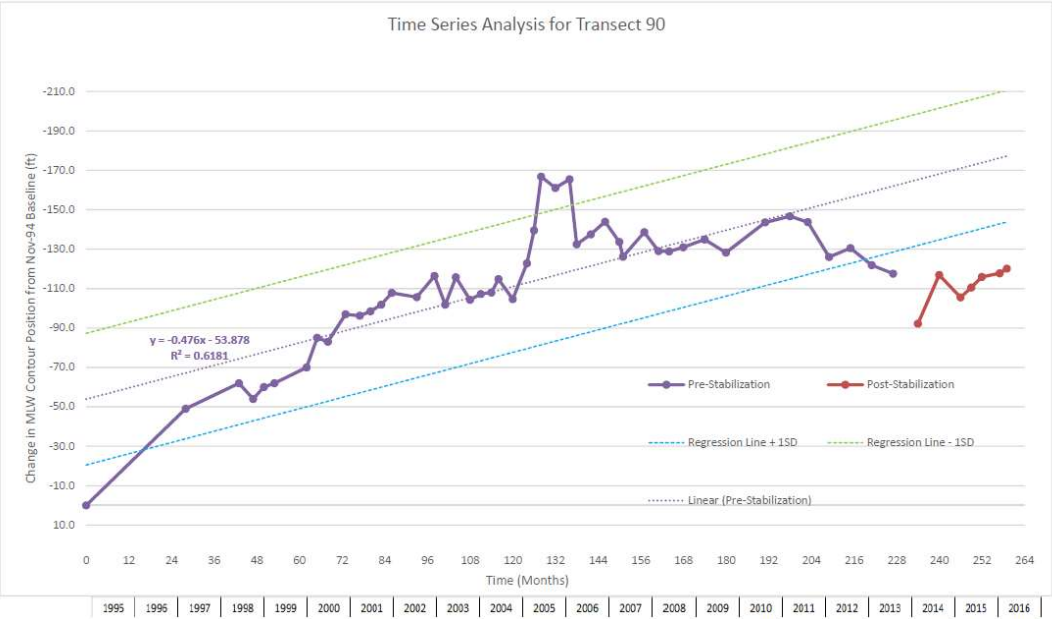
Shoreline Monitoring

- Shoreline monitoring at 46 transects along 6 miles of shoreline conducted quarterly
- Shoreline monitoring measures:
  - Change in position of the shoreline (MLW line) and
  - Change in volume
- Bathymetry (-5 MLW out to 3,000 feet offshore or -35 MLW isobath) conducted in the spring and fall



Analysis of Historic Shoreline Monitoring Trends

- There is an overall trend of erosion (landward movement of the MLW line). A regression line was fit to the shoreline position (MLW line).
- There is quite a bit of natural variability; however, a range of expected shoreline position values can be defined based on the regression line (average erosion) +/- 1 standard deviation (referred to as the “typical range”).
- Even under natural conditions, observed shoreline positions may exceed the typical range, with periods of greater than expected shoreline accretion or erosion that may last 12+ months.
- Given the natural variability, an adverse affect from the project would be detected through the observation of sustained shoreline positions that exceed the predicted typical erosion.



Shoreline Monitoring Trends

- The following slides review historic trends for 6 profiles (shown in yellow on the adjacent figure) within and directly adjacent to geotextile tubes

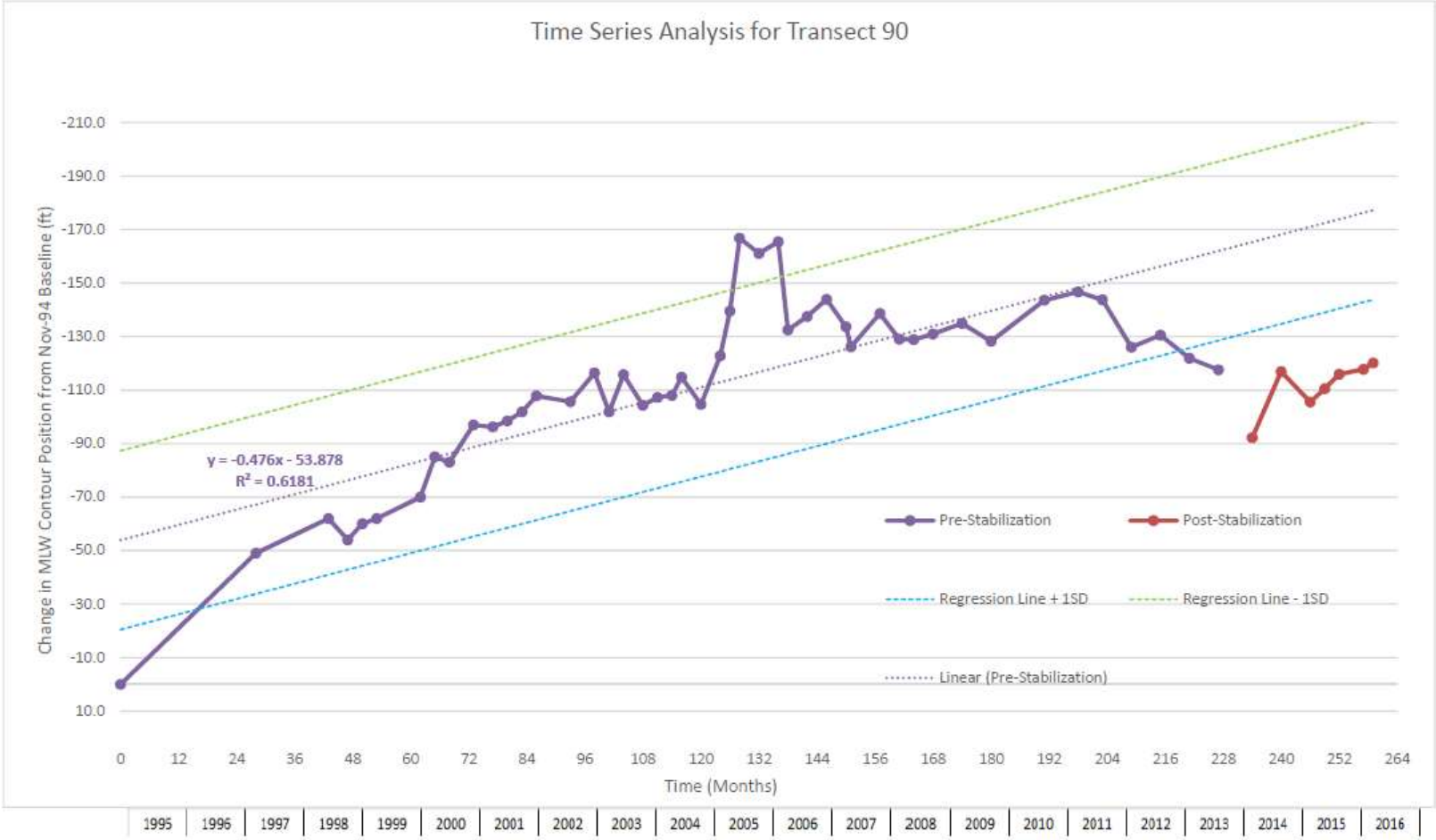
Shoreline Monitoring- Profile 90 (1200' south of geotubes)

Features:

- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data; not unusual for values to exceed typical range for 12+ months
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



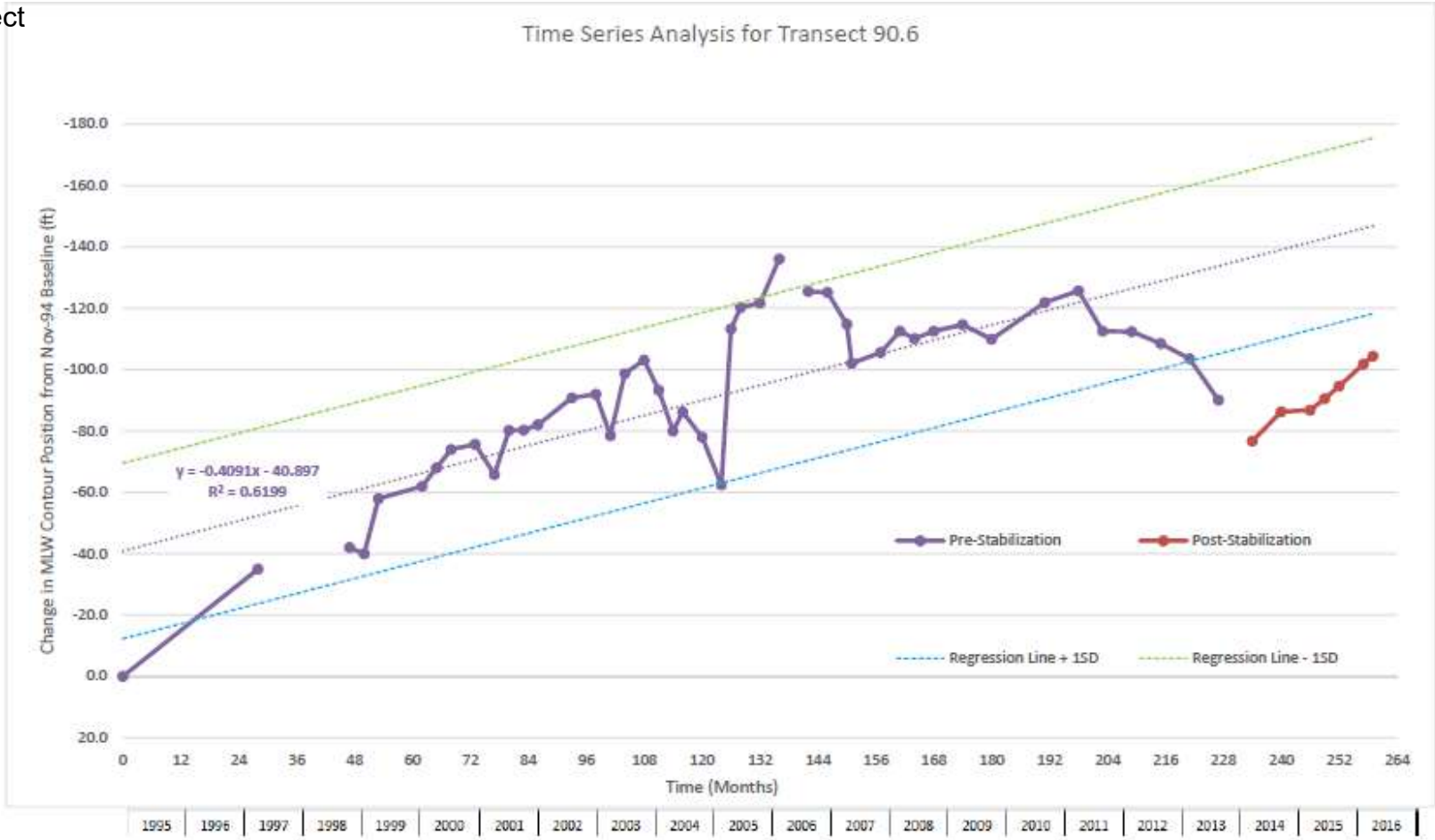
Shoreline Monitoring- Profile 90.6 (600' south of geotubes)

Features:

- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



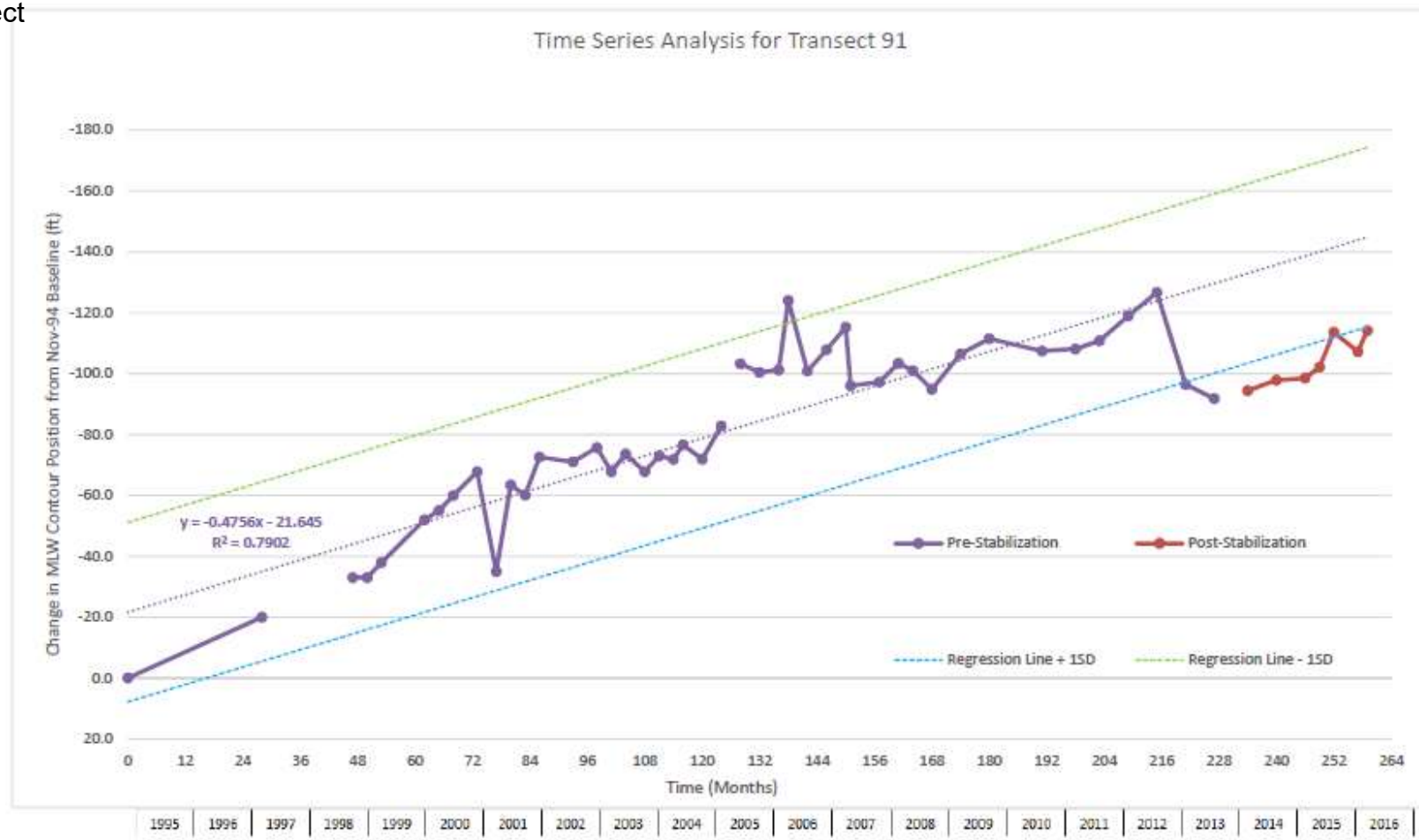
Shoreline Monitoring- Profile 91 (in geotube area)

Features:

- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



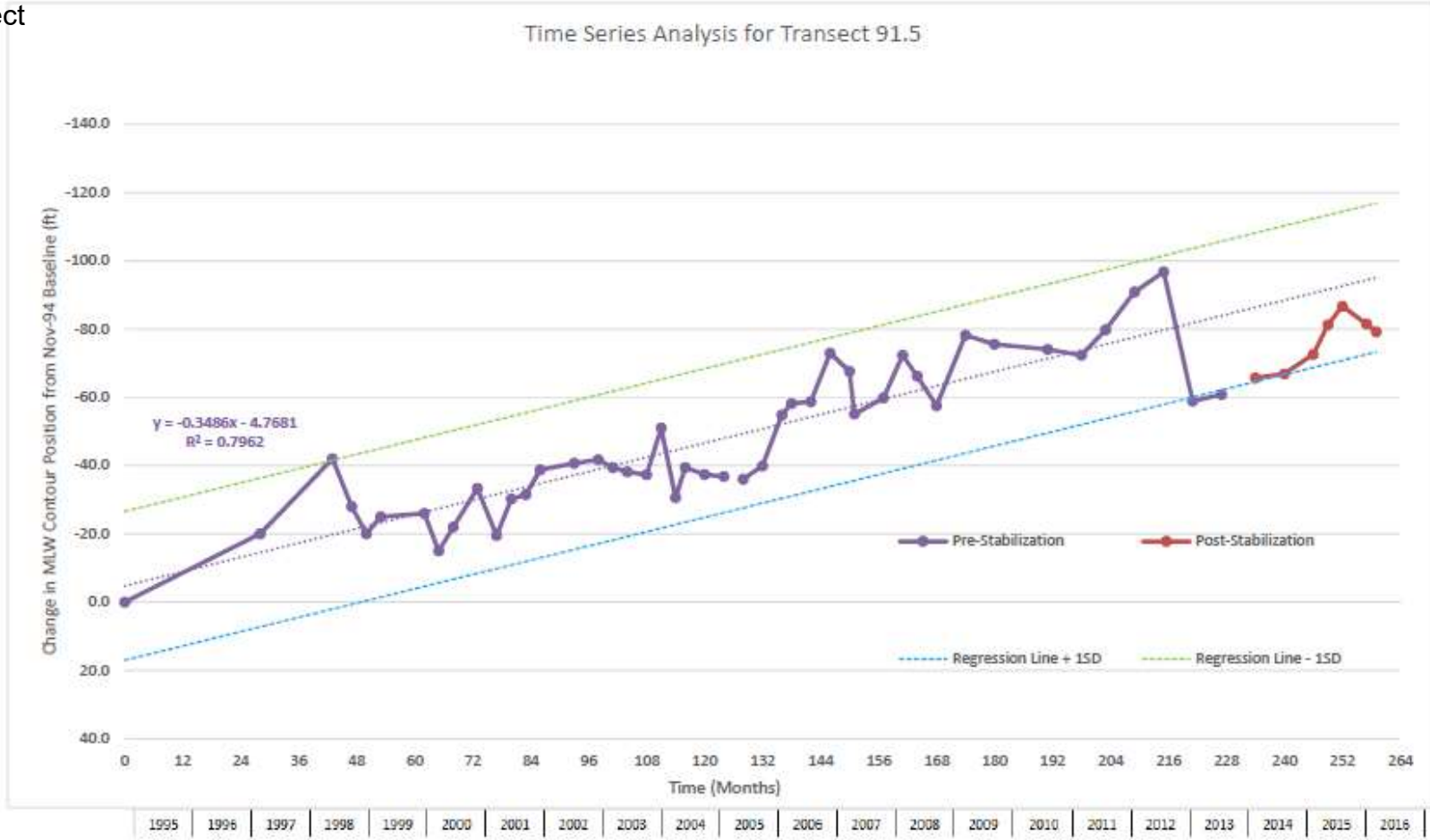
Shoreline Monitoring- Profile 91.5 (in geotube area)

Features:

- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



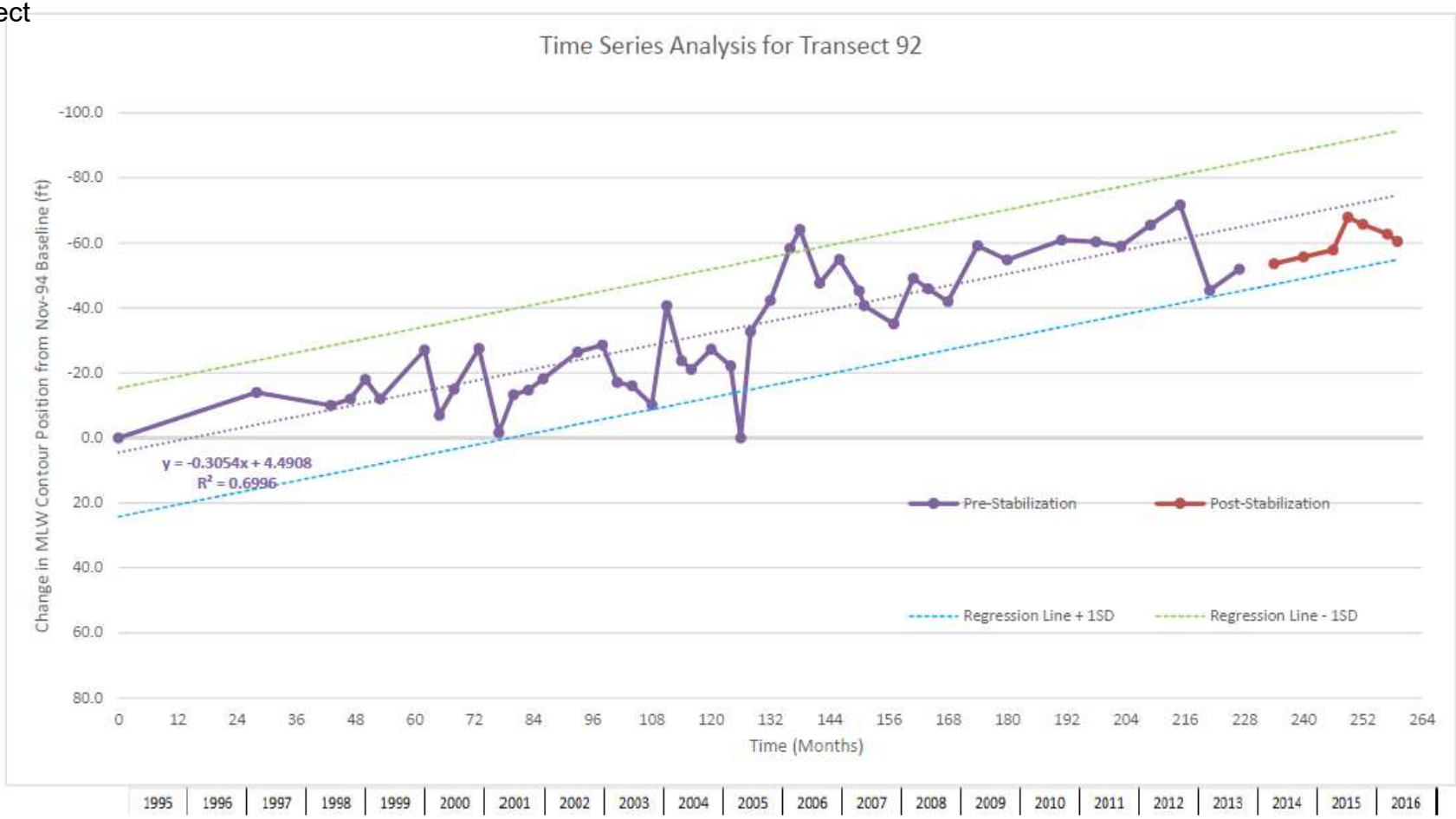
Shoreline Monitoring- Profile 92 (100' north of geotubes)

Features:

- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



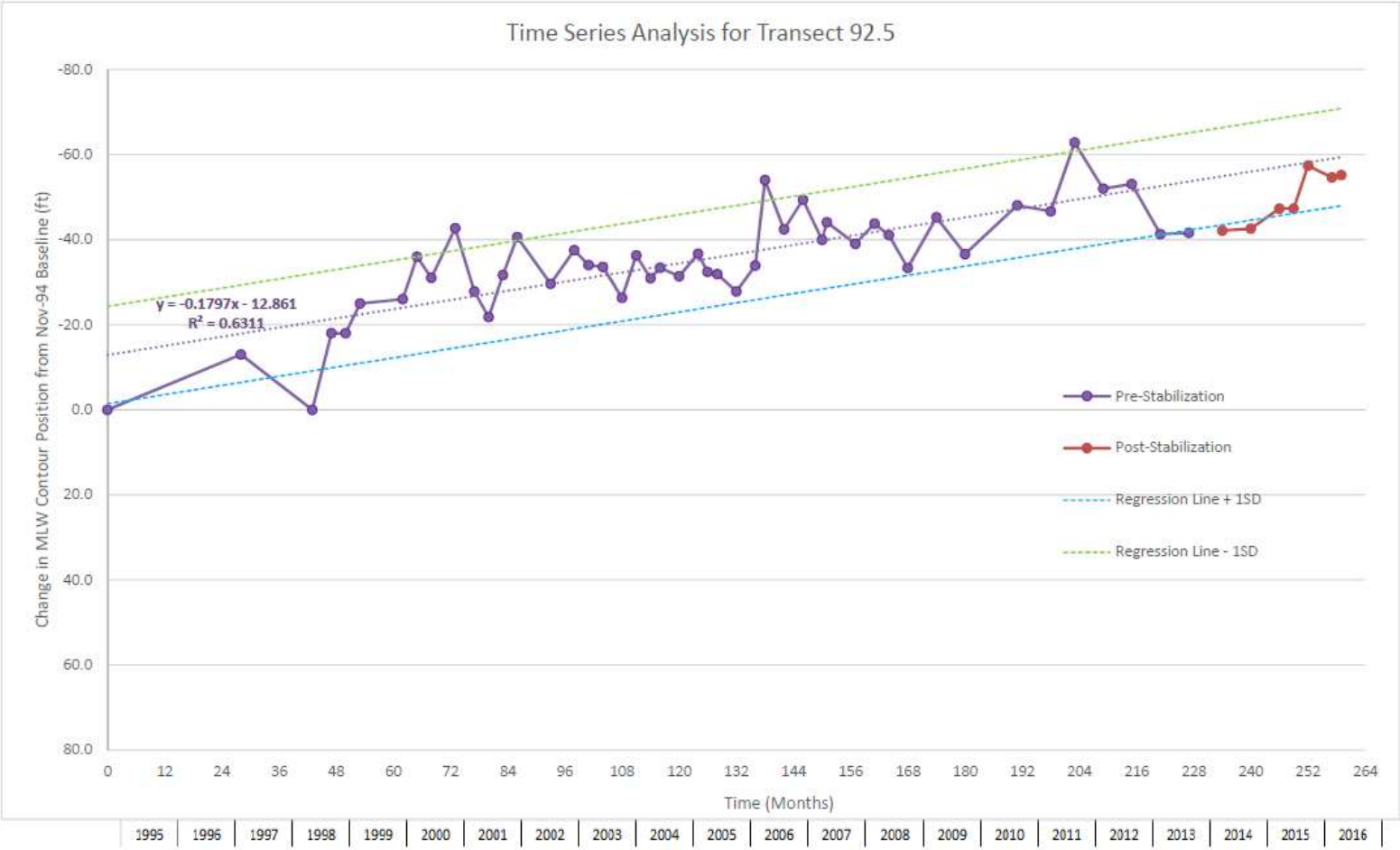
Shoreline Monitoring- Profile 92.5 (500-600' north of geotubes)

Features:

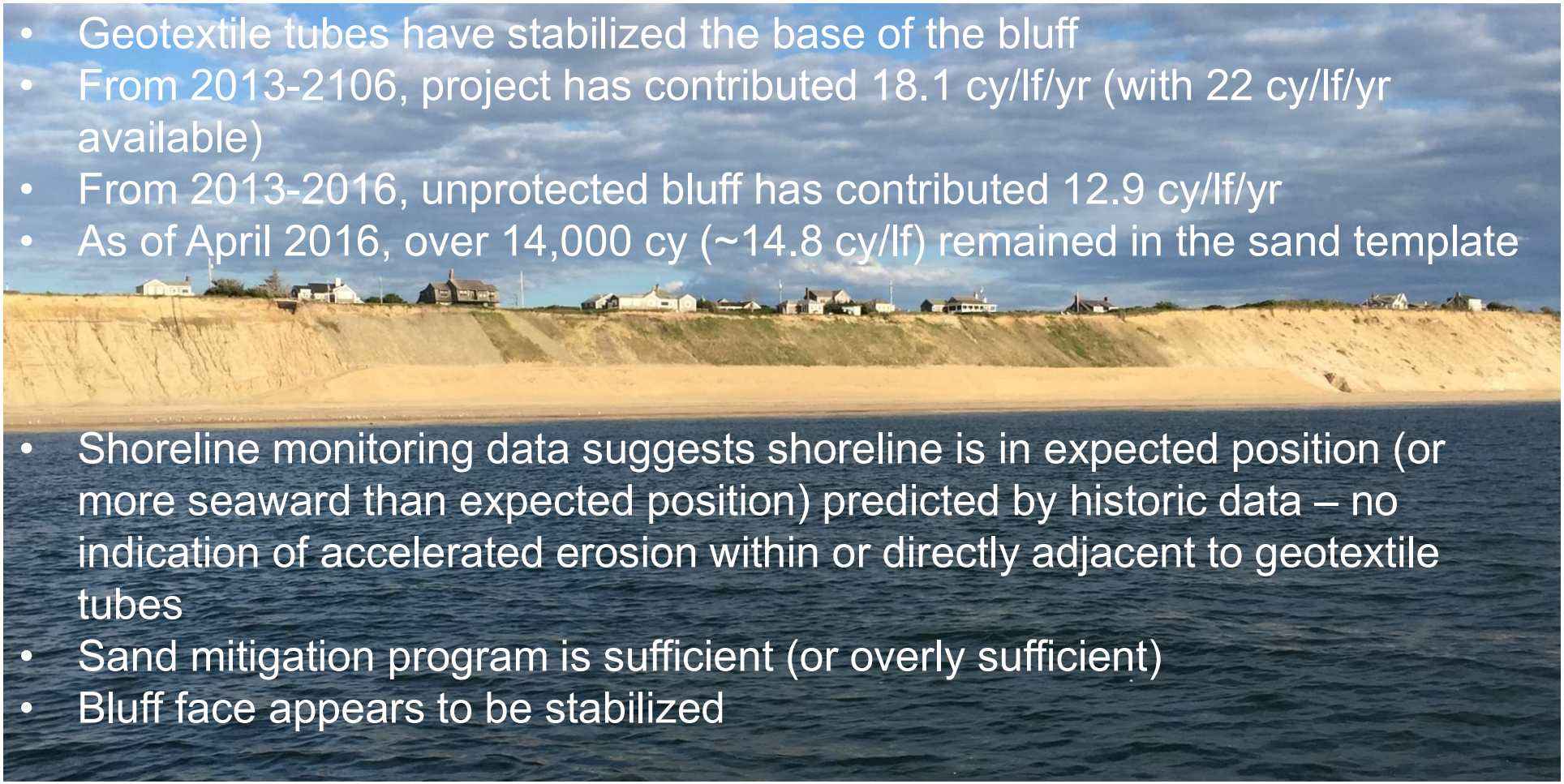
- **Purple Line:** 19 years of historic data (1994 - September 2013)
- **Purple Dotted Line:** Regression line fit to historic data. There is an overall trend of shoreline erosion.
- **Green and Blue Lines:** Range of typical values defined by +/- 1 standard deviation to the regression line.
- **Red Line:** Data from post-geotube installation period (2014 – present)

Observations:

- Historic variability in data
- Given historic variability in data, would need a sustained trend of values below the green line
- Post-geotube installation shows shoreline position is farther seaward than predicted by historic data – no indication of adverse effect



Conclusions



- Geotextile tubes have stabilized the base of the bluff
- From 2013-2106, project has contributed 18.1 cy/lf/yr (with 22 cy/lf/yr available)
- From 2013-2016, unprotected bluff has contributed 12.9 cy/lf/yr
- As of April 2016, over 14,000 cy (~14.8 cy/lf) remained in the sand template
- Shoreline monitoring data suggests shoreline is in expected position (or more seaward than expected position) predicted by historic data – no indication of accelerated erosion within or directly adjacent to geotextile tubes
- Sand mitigation program is sufficient (or overly sufficient)
- Bluff face appears to be stabilized