Professional Monitoring Data Summary for the Implemented Coastal Resiliency Projects

Final report for

New Jersey Department of Environmental Protection
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The Partnership for the Delaware Estuary brings together people, businesses, and governments to restore and protect the Delaware River and Bay. We are the only organization that focuses on the entire environment affecting the river and bay — beginning at Trenton, including the greater Philadelphia metropolitan area, and ending in Cape May, New Jersey and Lewes, Delaware. We focus on science, encourage collaboration, and implement programs that help restore the natural vitality of the river and bay, benefiting the plants, wildlife, people, and businesses that rely on a healthy estuary.

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# Table of Contents

**Figures** .................................................................................................................. 7

**Document Scope** .................................................................................................... 12

**Purpose of the Document** ........................................................................................ 12

**Metrics: Descriptions and Relevance** ..................................................................... 12

**Atlantic City Living Shoreline Project** .................................................................. 13

- Project Location ......................................................................................................... 13
- Pre-existing Conditions ............................................................................................... 13
- Monitoring Strategy ..................................................................................................... 13
- As-Built Conditions ...................................................................................................... 14
- Data Analysis ................................................................................................................ 14
- Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries ........................................................................................................... 14
- Vegetation Robustness ................................................................................................ 15
- Position of the Contiguous Vegetated Shoreline ....................................................... 15
- General Conclusions ................................................................................................... 16

**Brigantine: Cherokee Living Shoreline Project** ...................................................... 16

- Project Location ......................................................................................................... 16
- Pre-existing Conditions ............................................................................................... 16
- Monitoring Strategy ..................................................................................................... 17
- As-Built Conditions ...................................................................................................... 17
- Data Analysis ................................................................................................................ 18
- Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries ........................................................................................................... 18
- Vegetation Robustness ................................................................................................ 18
- Position of the Contiguous Vegetated Shoreline ....................................................... 18
- Shellfish Presence/Absence ........................................................................................ 19
- General Conclusions ................................................................................................... 19
Brigantine: Harbor Beach Living Shoreline Project .............................................................. 19

Project Location .................................................................................................................. 19
Pre-existing Conditions ....................................................................................................... 19
Monitoring Strategy ............................................................................................................ 20
As-Built Conditions ............................................................................................................ 20
Data Analysis ....................................................................................................................... 21
Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community
Boundaries ........................................................................................................................... 21
Vegetation Robustness ......................................................................................................... 21
Position of the Contiguous Vegetated Shoreline ................................................................. 21
Shellfish Presence/Absence ................................................................................................. 21
General Conclusions ........................................................................................................... 22

Brigantine: Hydrangea Living Shoreline Project ................................................................. 22

Project Location .................................................................................................................. 22
Pre-existing Conditions ....................................................................................................... 22
Monitoring Strategy ............................................................................................................ 22
As-Built Conditions ............................................................................................................ 23
Data Analysis ....................................................................................................................... 23
Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community
Boundaries ........................................................................................................................... 23
Vegetation Robustness ......................................................................................................... 24
Position of the Contiguous Vegetated Shoreline ................................................................. 24
Shellfish Presence/Absence ................................................................................................. 25
General Conclusions ........................................................................................................... 25

Secaucus Living Shoreline Project ....................................................................................... 25

Project Location .................................................................................................................. 25
Pre-existing Conditions ....................................................................................................... 25
Monitoring Strategy ............................................................................................................ 25
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-Built Conditions</td>
<td>26</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>26</td>
</tr>
<tr>
<td>Vegetation Robustness</td>
<td>26</td>
</tr>
<tr>
<td>Vertical Position Along a Transect: Ditch Elevation</td>
<td>26</td>
</tr>
<tr>
<td>General Conclusions</td>
<td>27</td>
</tr>
<tr>
<td><strong>Upper Township Living Shoreline</strong></td>
<td>27</td>
</tr>
<tr>
<td>Project Location</td>
<td>27</td>
</tr>
<tr>
<td>Pre-existing Conditions</td>
<td>27</td>
</tr>
<tr>
<td>Monitoring Strategy</td>
<td>28</td>
</tr>
<tr>
<td>As-Built Conditions</td>
<td>28</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>29</td>
</tr>
<tr>
<td>Vertical Positions of Treatment Area within the Tidal Prism</td>
<td>29</td>
</tr>
<tr>
<td>Vegetation Robustness</td>
<td>30</td>
</tr>
<tr>
<td>Position of the Contiguous Vegetated Shoreline</td>
<td>31</td>
</tr>
<tr>
<td>Shellfish Presence/Absence</td>
<td>31</td>
</tr>
<tr>
<td>General Conclusions</td>
<td>31</td>
</tr>
</tbody>
</table>
Figures

Figure 1 Location (red box) of the Atlantic City living shoreline. .................................................. 32

Figure 2 Pre-existing land cover at the Atlantic City living shoreline. ................................. 33

Figure 3 Monitoring plot locations and as-built land cover at the Atlantic City living shoreline. ............................................................................................................................. 34

Figure 4 Boxplots describing the elevations (m NAVD88) of the different planted vegetation communities at the Atlantic City living shoreline. Box borders identify the 75 (upper) and 25 (lower) quartiles, dark line within box indicates the median, and tails show the max and min values. MHHW=mean higher high water; MHW=mean high water; and MTL=mean tide line. Datum data provided by NOAA station 8534720, Atlantic City, NJ. ................................. 35

Figure 5 Mean vegetation robustness score at the Atlantic City living shoreline by vegetation type and time period relative to living shoreline construction. Low Marsh= Spartina alterniflora; High Marsh= mixed Spartina patens and Distichlis spicata; Upland=mixed community of vegetation appropriate for persistence above mean higher high water. Before=2016; As Built=2017. As no vegetation was present before installation, the scores were zero. ............................................................................................................................. 36

Figure 6 Mean change in position of the vegetated edge (m) at the Atlantic City living shoreline, here described as the lateral change in position between the lawn pre-construction (2016) and the S. alterniflora waterward edge post-construction (2017). Positive scores indicate waterward movement and negative scores indicate landward movement. ............................................................................................................................. 37

Figure 7 Position of the vegetated edge at the Atlantic City living shoreline in 2016 and 2017. ............................................................................................................................. 38

Figure 8 Locations of the three Brigantine living shoreline projects. Each project is denoted by a colored square in the map. ................................................................................................. 39

Figure 9 Pre-existing vegetation cover at the Brigantine Cherokee Blvd living shoreline project. ............................................................................................................................. 40
Figure 10  Monitoring plot locations and as-built land cover at the Brigantine Cherokee Blvd living shoreline.

Figure 11  Mean elevation change at the fixed monitoring plots by vegetation type and time period relative to living shoreline installation at the Brigantine Cherokee Blvd living shoreline. Low Marsh=Spartina alterniflora; Phragmites=Phragmites australis; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. Pre=2016; As-Built=2017. Red line indicates mean high water.

Figure 12  Mean vegetation robustness score at the Brigantine Cherokee Blvd living shoreline by vegetation type and time period relative to living shoreline construction (As Built was in 2017). Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.

Figure 13  Mean change in position of the vegetated edge (m) at the Brigantine Cherokee Blvd living shoreline, by vegetation type and year (2016= pre-construction, 2017=as-built). Positive values indicate waterward movement, and negative values indicate landward movement.

Figure 14  Position of the vegetated edges of interest at the Brigantine Cherokee Blvd living shoreline in 2016 and 2017.

Figure 15  Pre-existing land cover at the Brigantine Harbor Beach living shoreline in 2016.

Figure 16  Monitoring plot locations and as-built land cover (features) of the 2017 Brigantine Harbor Beach living shoreline.

Figure 17  Mean elevation (m NAVD88) of the monitoring plots at the Brigantine Harbor Beach living shoreline by vegetation type and time period. Low Marsh=Spartina alterniflora; Unvegetated=areas with <1% vegetation cover; High Marsh= mix of Distichlis spicata, Salicornia spp, and Spartina patens. Pre=2016; As-Built=2017. Red line indicates mean high water.

Figure 18  Mean vegetation robustness score at the Brigantine Harbor Beach living shoreline by vegetation type and time period relative to living shoreline construction. High
Marsh= mix of Distichlis spicata, Salicornia spp, and Spartina patens; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. As Built=2017. Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.

**Figure 19** Pre-existing land cover at the Brigantine Hydrangea Way living shoreline

**Figure 20** Monitoring plot locations and as-built land cover at the Brigantine Hydrangea Way living shoreline.

**Figure 21** Mean elevation change at the fixed monitoring plots by vegetation type and time period relative to living shoreline installation at the Brigantine Hydrangea Way living shoreline. High Marsh Mix=Spartina patens and Distichlis spicata; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. Pre=2016; As-Built=2017. Red line indicates mean high water.

**Figure 22** Mean vegetation robustness score at the Brigantine Hydrangea Way living shoreline by vegetation type and time period relative to living shoreline construction. High Marsh Mix= Spartina patens and Distichlis spicata; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. Before=2016; As Built=2017. Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.

**Figure 23** Mean change in position of the vegetated edge (m) at the Brigantine Hydrangea Way living shoreline, here described as the lateral change in position of the upland vegetation border pre-construction (2016) and post-construction (2017). Upland Mix=community of vegetation appropriate for persistence above mean higher high water. Positive scores indicate waterward movement and negative scores indicate landward movement.

**Figure 24** Position of the vegetated edges of interest at the Brigantine Hydrangea Way living shoreline in 2016 and 2017.

**Figure 25** Location (pink box) of the Secaucus tidal stream restoration project.

**Figure 26** Monitoring plot locations at the Secaucus tidal creek restoration project. Elevation data were collected at the 2016 locations (green circles), and elevation and
vegetation robustness data were collected at the 2017 locations (black squares).............. 57

**Figure 27** Transect survey point locations at the Secaucus tidal creek restoration project. Elevation data were collected in 2016 (red circles) and 2017 locations (green circles) at ditch 1 & 2. Transects are numbered consecutively, increasing from the mouth (transect 1) to the head area (transect 6). ................................................................. 58

**Figure 28** Mean vegetation robustness score at the Secaucus tidal creek restoration project by ditch and creek-side. Ditch 1 is the northern ditch and ditch 2 is southern ditch. North=north side of drainage creek; South=south side of drainage creek. Vegetation robustness was not measured at these plots in 2016 and these measurements will serve as the baseline post-restoration moving forward. ................................................................. 59

**Figure 29** Cross-sectional elevation profiles (m NAVD88) of ditch 1 by transect in 2016(blue line) and 2017(orange line). Measurements were taken at each monitoring plot (n=5-6 per transect, denoted on x-axis) and connected with a best-fit line. ....................... 60

**Figure 30** Cross-sectional elevation profiles (m NAVD88) of ditch 2 by transect in 2016(blue line) and 2017(orange line). Measurements were taken at each monitoring plot (n=5-6 per transect, denoted on x-axis) and connected with a best-fit line. ....................... 61

**Figure 31** Maximum depth (m NAVD88) increase in 2017 relative to 2016 measurements per transect (x-axis) in ditch 1 (a) and ditch 2(b). Maximum depth increase was largely located at the channel center (plot 3). See figures 30-31 and text for details. ....................... 62

**Figure 32** Location (pink box) of the Upper Township living shoreline.......................... 63

**Figure 33** Pre-existing land cover at the Upper Township living shoreline................. 64

**Figure 34** Monitoring plot locations (2016 & 2017)and as-built and cover at the Upper Township living shoreline. ................................................................. 65

**Figure 35** Boxplots describing the elevations (m NAVD88) of the different planted vegetation communities at the Upper Township living shoreline West (a) and East (b) locations. Box borders identify the 75 (upper) and 25 (lower) quartiles, dark line within box indicates the median, and tails show the max and min values. MHHW=mean higher high water; MHW=mean high water; and MTL=mean tide line. Low Marsh=Spartina alterniflora; High Marsh= mixed Disticlis spicata, Spartina patens, and upland vegetation.
Breakwater at West location describes the rip rap in front of the waterward-most coir logs. Low marsh 1 & 2 at the West location describe the lower and upper S. alterniflora areas, respectively. Original low marsh (West location) describes pre-exiting S. alterniflora on-site. Datum data provided by NOAA station 8535101 Corson Inlet, NJ................................. 66

Figure 36 Mean elevation change at the fixed monitoring plots by vegetation community type and time period relative to living shoreline installation at the Brigantine Cherokee Blvd living shoreline. All Low Marsh=Spartina alterniflora; High Marsh Upland Mix= mixed community of Spartina pates, Distichlis spicata, and vegetation appropriate for persistence above mean higher high water. Before=2016 pre-living shoreline installation; As-Built=2017 post-living shoreline installation. Red line indicates mean high water (0.484m NAVD88) and green line indicated mean tide line (-0.10m NAVD88). Mean elevations denoted in boxes beneath x-axis labels per vegetation community type and time period..... 67

Figure 37 Mean vegetation robustness score at the Upper Township living shoreline by vegetation community type and time period relative to living shoreline construction. All Low Marsh= Spartina alterniflora; High Marsh Upland Mix= mixed community of Spartina pates, Distichlis spicata, and vegetation appropriate for persistence above mean higher high water. Pre-existing Low=Spartina alterniflora community present prior to living shoreline installation. Before=2016; As Built=2017. As no vegetation was present before installation, the scores were zero.......................................................... 68

Figure 38 Position of the vegetated edges of interest at the Upper Township living shoreline in 2017. As vegetation presence across the entire site was minimal in 2016, the 2017 as-built measurements serve as a baseline for community development comparison over time. As the pre-existing Spartina alterniflora at West location is hoped to integrate with 2017 planted vegetation, a distinction was not made in this map regarding their individual boundaries. .......................................................... 69
Document Scope

The following sections summarize high rigor data collected in 2016 (pre-built site conditions) and 2017 (as-built site conditions) for resiliency projects installed as a result of the Building Ecological Solutions to Coastal Community Hazards grant awarded to the New Jersey Department of Environmental Protection (NJDEP). Projects addressed in this document are: Atlantic City; Brigantine; Secaucus; and Upper Township. This document presents, exclusively, the high rigor data collected at fixed monitoring plots and along features of interest by the Partnership for the Delaware Estuary and Barnegat Bay Partnership, in conjunction with NJDEP staff. Photographic data and data collected by citizen scientists are not addressed in this document. For a description of the full suite of metrics collected at each project location (including citizen science and photographic data), please see the project-specific monitoring plans.

Purpose of the Document

These data are intended to serve as baseline and as-built conditions for each resiliency project. As companions to this document, each project has an associated spreadsheet and ArcGIS file. The spreadsheets track changes in the plot and feature-based metrics collected at each site per year. The ArcGIS file provides the locations of each monitoring plot, the as-built vegetation community, and features of interest per year. Plot and feature-based metric data collected at future time points can be added to the associated spreadsheets to track development and trajectories. Future survey data can be imported into the ArcGIS file to track positional changes.

Metrics: Descriptions and Relevance

The following metrics are evaluated in this document:

**Position of Contiguous Vegetated Shoreline:** Describes the latitudinal and longitudinal position of the shoreline (defined as the waterward line of vegetation). This metric can be used to measure the horizontal marsh movement rate (i.e. erosion or accretion).

**Position of Vegetation Community Boundary:** Describes the latitudinal and longitudinal position of a singular vegetation community. This can refer to either a single species (e.g. *Spartina alterniflora, Phragmites*), or a group of species that collectively describe a community (e.g. mixed upland vegetation). This metric can be used to measure the
horizontal movement rate or change in area of a community of interest.

**Shellfish Presence/Absence:** Describes whether shellfish are present in a particular area of a living shoreline project. Changes over time can be indicative of the stability of the habitat.

**Vegetation Robustness:** Vegetation robustness integrates the horizontal and vertical obstruction of a parcel of vegetation into an overall unit-less index between 0-1. A score of 0 indicates low robustness, and a score of 1 indicates full robustness. By integrating the horizontal and vertical obstruction through the marsh canopy, a full picture of the three-dimensional structure of the vegetation with in the parcel is obtained. Changes in this metric over time describe the developmental trajectory of the vegetation within the parcel.

**Vertical Position: Elevation Along a Transect:** Describes the elevation change along a line that traverses a particular feature of interest of a landscape. This metric can be used to evaluate the change over time along a cross-section or over a gradient.

**Vertical Position: Elevation of Treatment Area:** Describes the vertical position of a point or area on the landscape. This metric can be used to determine the likely inundation frequency of a specific area of a project, and/or the trajectory of vertical change.

**Atlantic City Living Shoreline Project**

**Project Location**
The project site was located in the northern section of Atlantic City in the sub-area known as Gardner's Basin on North Rhode Island Ave. It was located along a navigable canal that experienced a mix of private and commercial boat traffic. The project site was adjacent to Gilchrest Restaurant to the north (including a parking lot just landward of the installation), and a commercial dock to the south (Fig. 1).

**Pre-existing Conditions**
The intertidal area along the shoreline was comprised rocky substrate with some macroalgae present. The intertidal area gently sloped up to narrow band of lawn with a ~2’ terrace at their interface. There was no infrastructure preventing pedestrian entrance to the intertidal area (Fig. 2).

**Monitoring Strategy**
Three monitoring transects were established at the project location. Transects were oriented
perpendicular to the shoreline, and extended from approximately mean low water (MLW) to the gravel parking lot. Fixed monitoring plots were established at three locations along each transect that coincided with the projected locations of the three habitats targeted for installation: low marsh *Spartina alterniflora*; high marsh *Spartina patens* and *Distichlis spicata*; and a mixed upland community. Since the final design of the treatment was under development during the 2016 monitoring season, slight adjustments to some of the plot locations needed to be made in 2017 to assure their placement along each transect were coincident with each of the three previously mentioned habitats. Since the land cover was uniform across large areas of the site prior to installation (pre-existing condition was barren land cover or lawn with minimal vegetation cover), the adjustment to the plot locations did not have any effect on pre-installation metric values being transferred small distances to near locations (Fig 3; shown here with 2017, as-built, land cover).

In each monitoring plot, the follow data were collected: vegetation robustness; shellfish presence/absence; and vertical position (i.e. elevation). Additionally a feature based survey targeted the positions (lateral and vertical) of the erosion control structures (i.e. breakwaters), the contiguous vegetated edge, and vegetation community boundaries. In 2016, the vegetated edge at this site was considered the waterward extent of the lawn. In 2017, the vegetated edge was considered the waterward extent of the planted *Spartina alterniflora*.

**As-Built Conditions**

A living shoreline was constructed on the intertidal and lawn areas. The treatment was designed to create low (tall-form *Spartina alterniflora*) and high (*Spartina patens* and *Distichlis spicata*) marsh areas along the intertidal region. Above mean high water (MHW), a berm was built to help alleviate flooding in the parking lot, and was planted with a mix of upland vegetation types. To protect the treatment from the high energy boat wakes common in this area, the waterward margin was fortified with rip rap. A gap was left along the southern end of the rip rap to allow for faunal movement into and out of the treatment (Fig. 3).

**Data Analysis**

**Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries**

Post installation, all vegetation species were positioned at appropriate elevations (m
NAVD88) within the local tidal prism (Station Datum 8534720, Atlantic City, NJ) for growth and persistence. The low marsh vegetation (*Spartina alterniflora*) comprised the largest percent area of the treatment (140.6 m$^2$, 47%; Fig. 3), and was primarily positioned between the mid-tide line (mean water; MTL) and mean high water (MHW), the generalized ideal tidal range (Fig. 4). A small portion of the low marsh vegetation (~25%, between the 75 percentile and maximum value) was positioned slightly higher, between MHW and mean higher high water (MHHW; Fig. 4). If the treatment experiences a loss of elevation (e.g. compaction, scour), plants positioned between these elevations will like be able to thrive. It can be beneficial to plant just outside of the ideal vertical positions of installed vegetation, to allow the plants to be able to compensate for potential elevation changes post-installation.

The high marsh vegetation comprised the smallest percent of the total habitat area (26.6 m$^2$, 9%; Fig. 3), between MHW and just above MHHW. Although slightly elevated relative to the ideal vertical position, this planting zone is located adjacent to the low marsh zone (Fig. 3) and there may be opportunity for plants to migrate to lower, more ideal, tidal positions. The upland vegetation community covered 44% of the total habitat area (133.4m$^2$; Fig. 3), and was positioned well above MHHW, outside of areas likely to receive tidal inundation (Fig. 4). The breakwater structures were situated so that the majority of the structures’ vertical extent was below MHW. This will likely allow for daily tidal inundation across the treatment area, but may result in internal ponding if the water cannot escape on the receding tide (Fig. 4). The boundaries between these communities depicted in Figure 3, represent their as-built positions, which will likely shift as the treatment settles and plants respond to their positional inundation regimes.

**Vegetation Robustness**

Vegetation robustness increased in each monitoring plot post installation (Fig. 5). Change in vegetation robustness increased with elevation (i.e. from plot A to plot C), and all planted vegetation (As-built) had rooted and was producing above ground biomass. Low marsh vegetation (Plot A) showed the smallest increase in vegetation robustness (mean=0.02) among vegetation community types, which was not unexpected, as the low marsh area typically has highly stressful physical conditions which may increase time needed for vegetation establishment. The upland vegetation community (Plot C) showed the greatest initial increase in vegetation robustness (mean=0.62), indicating that the plant community began to thrive immediately. The change in high marsh (Plot B) vegetation robustness (mean=0.31) was approximately half of the upland increase.

**Position of the Contiguous Vegetated Shoreline**
The contiguous vegetated edge moved waterward an average (across all transects) of 7.98 m (Fig. 6) from the original position of the lawn edge in 2016 (Fig. 7). The maximum movement occurred along transect C at the southern end (10.18 m), and the minimum change occurred along transect A at the northern end (5.48 m). The extent measured here was to edge of the waterward-most vegetation planted in 2017, not to the boundary of the erosion control structure. In Figure 6, the Average of 2016 Lawn (m) represents the original location of the lawn edge in 2016, which was given a value of zero, from which to measure future changes against. That is why no value appears in the bar graph.

**General Conclusions**

The living shoreline was installed so that its vertical extents were appropriate for the growth and persistence of low marsh, high marsh, and upland vegetation communities. The final relative positions of these communities will be dependent on small elevation changes within the treatment area. The boundaries of these communities may shift over time, and the relative percentage of total area occupied by each community may shift year to year. It will be important to monitor the internal slope of the treatment area to insure that post-settlement topography allows for water flow out of the treatment area in order to prevent ponding. The final elevation profile of the internal treatment area will ultimately dictate the vegetation community boundaries. Vegetation health trajectories can take time to accurately evaluate, as the biological responses to the *in situ* conditions can take multiple growing seasons to emerge. It will be important in the coming years to monitor the vegetation closely, as patterns of growth and die-off can be indicative of specific stressors. For example, areas of plant die-off can serve as indicators of potential water retention.

**Brigantine: Cherokee Living Shoreline Project**

**Project Location**

The Cherokee living shoreline site was located adjacent to an empty lot located along Brigantine Boulevard in Brigantine, NJ (Fig. 8). The location (39°23'34.97"N, 74°24'16.65"W) was along a small embayment off of Absecon Inlet, with private residences to the east and west. A small amount of local boat traffic occurs spring through fall, but no commercial grade vessels utilize the adjacent waterway.

**Pre-existing Conditions**
The waterward edge was characterized by a low marsh fringe (*Spartina alterniflora*) populated with ribbed mussels (*Geukensia demissa*). The difference in elevation between the fringing marsh and the abutting subtidal area was approximately two feet, and the water was approximately one foot deep at low tide along the marsh edge. Landward of the marsh fringe, a monoculture of *Phragmites* was present which extended to the adjacent parking lot. (Fig. 9).

**Monitoring Strategy**

Three monitoring transects were established at the project location. Transects were oriented perpendicular to the shoreline, and extended from the pre-existing marsh edge to the (estimated) top of the berm. Fixed monitoring plots were established at three locations along each transect that coincided with the projected locations of the three habitats: low marsh in pre-existing *Spartina alterniflora*; a planned high marsh area; and a newly established berm with a mix of upland vegetation. Since the final design of the treatment was under development during the 2016 monitoring season, slight adjustments to some of the plot locations needed to be made in 2017 to assure that the monitoring plots along each transect were located in each of the three previously mentioned habitats. Adjusted locations of 2017 monitoring plots were situated so that the ground cover at each adjusted location matched the ground cover at the 2016 location. The maximum adjusted distance was less than 7m, and the new locations were considered representative of the 2016 locations based on proximity (Fig 10; shown here with 2017, as-built, land cover). Of note, plot A on transect 2 (center transect) was unintentionally not surveyed in 2017, but was marked *in situ* with a PVC post. The estimated location is denoted with a star on Fig. 10.

In each monitoring plot, the follow data were collected: vegetation robustness (2017 only); shellfish presence/absence; and vertical position (i.e. elevation). Additionally a feature based survey targeted the positions (lateral and vertical) of the drainage structures, the contiguous vegetated edges, and vegetation community boundaries. The two vegetated edges were considered the waterward extent of *Spartina alterniflora* and *Phragmites*.

**As-Built Conditions**

The treatments for each Brigantine living shoreline site consisted of the construction of earthen mounds (or berms) up to 9 feet tall (relative to NAVD88). Mounds were stabilized via brush layering of *Iva frutescens* and *Baccharis halmifolia*. Outfall pipes were constructed at the base of the berms to allow storm water to drain during rain events. Berms were designed to occupy open spaces between 9 ft tall bulkheads on private residences and were vegetated with native flora. See drafts of blueprints submitted for permitting for more detail on difference between sites as parcel size, topographies, and existing structures vary.
Data Analysis

Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries

Post installation, the vegetation species targeted for retention were positioned at appropriate elevations (m NAVD88) within the local tidal prism (Station Datum 8534720, Atlantic City, NJ) for growth and persistence. The pre-existing low marsh vegetation (*Spartina alterniflora*) experienced a decline in average elevation (33cm; Fig. 11) and area (~39m$^2$; Figs. 9 & 10) between 2016 and 2017. The elevation was still appropriate for persistence (positioned above MTL -0.133m NAVD88), although the decline in elevation should continue to be monitored. The loss of area may be a result of installation efforts, and re-emergence is possible in subsequent growing seasons.

The total area of *Phragmites* was reduced by 77% between 2016 (272 m$^2$; Fig. 9) and 2017 (62 m$^2$; Fig. 10), and 354m$^2$ of upland vegetation was installed in 2017 (Fig. 10). The elevation of the *Phragmites* plots (plot B) experienced a decline in elevation between 2016 and 2017 (38cm) but was still positioned above MHHW (0.606m NAVD88; Fig. 11). The vertical position of the upland vegetation was also well above MHHW and appropriate for the vegetation types (Fig. 11). The crest of the berm raised the maximum elevation of the treatment area an average of 1.55m between 2016 (mean elevation 1.15m NAVD88) and 2017 (2.70m NAVD88).

Vegetation Robustness

Vegetation robustness data were not collected in 2016. Although measurements of vertical obstruction were obtained, measurements of horizontal obstruction were not, as the vegetation robustness metric was still in the development stage in 2016. Vegetation robustness was measured for each vegetation type in 2017 (Fig. 12), which can serve as the baseline for evaluation the vegetation community development moving forward. All vegetation types (i.e. *S. alterniflora*, *Phragmites*, and mixed upland vegetation) exhibited vegetation robustness greater than 50%, with *S. alterniflora* and the mixed upland vegetation having densities that would be indicative of a healthy vegetation population.

Position of the Contiguous Vegetated Shoreline

The Cherokee Blvd living shoreline had two boundaries of interest in 2016: The waterward edge of the low marsh *S. alterniflora*; and the waterward edge of the *Phragmites*. Both
boundaries experienced a landward movement between 2016 and 2017 (Figs. 13 & 14). The low marsh vegetation moved landward an average of ~4cm, while the *Phragmites* boundary shifted landward an average of ~3cm. These averages are within the margin of error of the survey equipment and can be interpreted as stable positions between years.

**Shellfish Presence/Absence**

Ribbed mussels were present in all plots in the low marsh (*S. alterniflora*, plot A).

**General Conclusions**

The Cherokee living shoreline was installed so that the berm structure was positioned well above likely inundation levels, and with appropriate drainage on both sides of the structure. The pre-existing low marsh vegetation appeared to be laterally stable, but has shown a decline in elevation, which should be monitored in the future. Additionally, although the area of *Phragmites* was reduced during installation, it will be important to track the position of its boundaries (waterward and landward) as well as its vegetation robustness. Ideally the boundaries on either side of the *Phragmites* will experience a shift towards the center, narrowing its range, and vegetation robustness will decline indicating a within-area decline in vegetation biomass.

**Brigantine: Harbor Beach Living Shoreline Project**

**Project Location**

The Harbor Beach living shoreline site is located in a double-wide empty lot adjacent to residential housing off of Brigantine Boulevard in Brigantine, NJ (Fig. 8). The location (39°23’38.73”N, 74°23’56.44”W) is along a small embayment off of Absecon Inlet, with private residences to the east and west. A small amount of local boat traffic occurs spring through fall, but no commercial grade vessels utilize the adjacent waterway.

**Pre-existing Conditions**

The waterward edge was characterized by a wide low marsh fringe (*Spartina alterniflora*) populated with ribbed mussels (*Geukensia demissa*). The difference in elevation between the fringing marsh and the abutting subtidal area was approximately two feet, and the water was approximately two feet deep at low tide along the marsh edge. Landward of the low marsh area was an approximate 5.5m wide unvegetated band where wrack had been collecting. This band abutted an unconsolidated berm populated by a mix of upland
vegetation and *Phragmites*. (Fig. 15).

### Monitoring Strategy

Two monitoring transects were established at the project location. The reason three transects were not established at this sites, as at other sites, was due to the narrow width. Transects were oriented perpendicular to the shoreline, and extended from the pre-existing marsh edge to the (estimated) top of the berm. Fixed monitoring plots were established at three locations along each transect that coincided with the locations of the three habitats present at the site: low marsh; high marsh; and upland. Since the final design of the treatment was under development during the 2016 monitoring season, slight adjustments to some of the plot locations needed to be made in 2017 to assure that the monitoring plots along each transect were located in each of the three previously mentioned habitats.

Adjusted locations of 2017 monitoring plots were situated so that the ground cover at each adjusted location matched the ground cover at the 2016 location. The maximum adjusted distance was less than 3m, and the new locations were considered representative of the 2016 locations based on proximity (Fig 16; shown here with 2017, as-built, land cover).

In each monitoring plot, the follow data were collected: vegetation robustness (2017 only); shellfish presence/absence; and vertical position (i.e. elevation). Additionally a feature based survey targeted the positions (lateral and vertical) of the drainage structures, the contiguous vegetated edges, and vegetation community boundaries. The waterward vegetated edge of the low marsh *S. alterniflora*, was not surveyed in 2016, as at the time it was considered outside the area of project application. This boundary was surveyed in 2017 to serve as a baseline to measure erosion waterward of the berm in the coming years.

### As-Built Conditions

The treatments for each Brigantine living shoreline site consisted of the construction of earthen mounds (or berms) up to 9 feet tall (relative to NAVD88). Mounds were stabilized via brush layering of *Iva frutescens* and *Baccharis halimifolia*. Outfall pipes were constructed at the base of the berms to allow storm water to drain during rain events. Berms were designed to occupy open spaces between 9 ft tall bulkheads on private residences and were vegetated with native flora. See drafts of blueprints submitted for permitting for more detail on difference between sites as parcel size, topographies, and existing structures vary.

No alteration of the low marsh area occurred. Landward of the low marsh fringe, a band of high marsh vegetation (a mix of *Distichlis spicata*, *Spartina patens*, and some *Salicornia*) was planted to try and establish a transitional marsh area waterward of the upland mix on the berm. Wrack had continued to collect in this area, and vegetation propagation was slow.
and sparse.

**Data Analysis**

**Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries**

Post installation, the vegetation species targeted for retention were positioned at appropriate elevations (m NAVD88) within the local tidal prism (Station Datum 8534720, Atlantic City, NJ) for growth and persistence. The pre-existing low marsh vegetation (*Spartina alterniflora*) saw virtually no change in average elevation (~1cm; Fig. 17) and area (~133m² in 2016 and 138m² in 2017; Figs. 15 & 16) between 2016 and 2017.

The unvegetated area saw a decline in total area of 43% between 2016 (60m²; Fig. 15) and 2017 (34m²; Fig 16). Within the 2016 unvegetated polygon, a 10m² area of high marsh was constructed that was not previously present (Fig. 16). Although positioned slightly high in the tidal prism (Fig. 17; above MHHW), the vegetation may migrate to a lower elevation and establish itself in future years. Upland vegetation increased in area between 2016 (74m²) and 2017 (121m²) by 39% (Figs. 15 & 16), but plot elevation declined by 19cm (Fig. 17). This decline is not of concern, as the vertical position of the vegetation is well above its lower threshold of MHHW (0.606m NAVD88).

**Vegetation Robustness**

Vegetation robustness data were not collected in 2016. Although measurements of vertical obstruction were obtain, horizontal obstruction were not. The vegetation robustness metric was still in the development stage in 2016, and was therefore not collected at each site. Vegetation robustness was measured for each vegetation type in 2017 (Fig. 18), which can serve as the baseline for evaluation the vegetation community development moving forward. *S. alterniflora* (0.79) and the mixed upland vegetation (0.68) both exhibited high vegetation robustness, indicative of healthy populations. The mixed high marsh community was struggling to produce above ground biomass and had a low robustness score (0.06).

**Position of the Contiguous Vegetated Shoreline**

The position of waterward vegetated edge was surveyed as a baseline in 2017. As there was no 2016 measurement, no change between 2016 and 2017 was measured.

**Shellfish Presence/Absence**
Ribbed mussels were present in all plots in the low marsh (*S. alterniflora*, plot A) plots.

**General Conclusions**

The Harbor Beach living shoreline was installed so that the berm structure was positioned well above likely inundation levels, and with appropriate drainage on both sides of the structure. The pre-existing low marsh vegetation appeared to be robust, and the change in lateral position should be monitored in the future. Additionally, the elevation and robustness of the vegetation planted on the newly constructed berm was indicative of a health community at an appropriate vertical position for persistence. The newly planted high marsh vegetation was not showing signs of growth and may either succumb to desiccation due to slightly high elevation, or may be smothered by wrack accumulation. This zone should be monitored closely in the coming years.

**Brigantine: Hydrangea Living Shoreline Project**

**Project Location**

The Hydrangea Way living shoreline site was located in an empty lot adjacent to residential housing off of Brigantine Boulevard in Brigantine, NJ (Fig. 8) along a small embayment off of Absecon Inlet, with private residences to the east and west. A small amount of local boat traffic occurs spring through fall, but no commercial grade vessels utilize the adjacent waterway.

**Pre-existing Conditions**

The waterward edge was characterized by a wide low marsh fringe (*Spartina alterniflora*) populated with ribbed mussels (*Geukensia demissa*). The difference in elevation between the fringing marsh and the abutting subtidal area was approximately two feet, and the water was approximately two feet deep at low tide along the marsh edge. Landward of the low marsh area was a ~6.3m wide unvegetated band behind which, an unconsolidated berm largely populated with *Phragmites* was present. (Fig. 19).

**Monitoring Strategy**

Two monitoring transects were established at the project location. The reason three transects were not established at this sites, as at other sites, was due to the narrow width. Transects were oriented perpendicular to the shoreline, and extended from the pre-existing marsh edge to the (estimated location of the) top of the berm. Fixed monitoring plots were
established at three locations along each transect that coincided with the locations of the three habitats present at the site: low marsh *Spartina alterniflora*; mixed high marsh consisting of *Spartina patens and Distichlis spicata*; and a mixed community of upland vegetation. Since the final design of the treatment was under development during the 2016 monitoring season, slight adjustments to some of the plot locations needed to be made in 2017 to assure that the monitoring plots along each transect were located in each of the three previously mentioned habitats. Adjusted locations of 2017 monitoring plots were situated so that the ground cover at each adjusted locations matched the ground cover at the paired 2016 location. The maximum adjusted distance was less than 6m, and the new locations were considered representative of the 2016 locations based on proximity (Fig 20; shown here with 2017, as-built, land cover).

In each monitoring plot, the follow data were collected: vegetation robustness (2017 only); shellfish presence/absence; and vertical position (i.e. elevation). Additionally a feature based survey targeted the positions (lateral and vertical) of the drainage structures, the contiguous vegetated edges, and vegetation community boundaries. The waterward vegetated edge of the low marsh *S. alterniflora*, was not surveyed in 2016, as at the time it was considered outside the area of project application. This boundary was surveyed in 2017 to serve as a baseline to measure erosion waterward of the berm in the coming years. Additionally, no monitoring plots were established in the low marsh area waterward of the treatment in 2016. Theses plots were established in 2017 and the health of the low marsh area in front of the treatment will continue to be monitored in the coming years.

**As-Built Conditions**

The treatments for each Brigantine living shoreline site consisted of the construction of earthen mounds (or berms) up to 9 feet tall (relative to NAVD88). Mounds were stabilized via brush layering of *Iva frutescens* and *Baccharis halmifolia*. Outfall pipes were constructed at the base of the berms to allow storm water to drain during rain events. Berms were designed to occupy open spaces between 9 ft tall bulkheads on private residences and were vegetated with native flora. See drafts of blueprints submitted for permitting for more detail on difference between sites as parcel size, topographies, and existing structures vary. No alteration of the low marsh area occurred.

**Data Analysis**

**Vertical Positions of Treatment Area within the Tidal Prism and Vegetation Community Boundaries**
Post installation, the vegetation species targeted for retention were positioned at appropriate elevations (m NAVD88) within the local tidal prism (Station Datum 8534720, Atlantic City, NJ) for growth and persistence. Additionally, the low marsh *Spartina alterniflora* waterward of the treatment was positioned at an appropriate elevation (between MLW and MTL; Fig. 21) and covered an expansive area (~576m² in 2016 and 138m² in 2017; Figs. 19 & 20).

The high marsh area land- and waterward boundaries did not show a high degree of shift between 2016 and 2017 (Figs 19 & 20). Although the area of each year’s polygon in GIS did show an increase in high marsh area between 2016 and 2017, likely due to a change in the lateral extent of the area surveyed. It is recommended that future surveys extend to the 2017 boundaries. A small decline in plot elevation (~8cm; Fig. 21) was measured between 2016 and 2017 and did not place the vegetation outside the vertical tolerance thresholds. Elevation of this zone should continue to be monitored.

The unvegetated area experienced a decline in total area of 79% between 2016 (80m²; Fig. 19) and 2017 (17m²; Fig 20), coupled with an increase in upland vegetation from 87m² to 127m² (figs. 19 & 20). In 2016, the upland vegetation was dominated by *Phragmites*, which was non-existent in the 2017 upland vegetation community. This increase of upland vegetation cover of non-invasive species was a direct result of the excavation and planting of the living shoreline berm. Elevations in monitoring plots showed a slight increase (~31cm) between 2016 and 2017 (Fig. 21), which was positioned well above the upland vegetation inundation threshold of MHHW.

**Vegetation Robustness**

Vegetation robustness data were not collected in 2016. Although measurements of vertical obstruction were obtained, measurements of horizontal obstruction were not, as the vegetation robustness metric was still in the development stage in 2016. Vegetation robustness was measured for each vegetation type in 2017 (Fig. 22), which can serve as the baseline for evaluation the vegetation community development in the future. *Spartina alterniflora* exhibited high vegetation robustness (0.62), indicative of a healthy growth. The mixed high marsh (0.37) and upland vegetation (0.39) both exhibited lower vegetation robustness and should be continued to be monitored to identify directional trajectories.

**Position of the Contiguous Vegetated Shoreline**

The position of waterward *S. alterniflora* vegetated edge was surveyed as a baseline in 2017. As there was no 2016 measurement, no change between 2016 and 2017 was measured. The boundary of the mixed upland vegetation moved waterward between 2016
and 2017 an average of 2.92m (Figs. 23 & 24).

Shellfish Presence/Absence

Ribbed mussels were present in all plots in the low marsh (S. alterniflora, plot A).

General Conclusions

The Hydrangea Way living shoreline was installed so that the berm structure was positioned well above likely inundation levels, and with appropriate drainage on both sides of the structure. The pre-existing low marsh vegetation appeared to be robust, and the change in lateral position and robustness trajectories should be monitored in the future. Additionally, the elevations of the vegetation planted on the newly constructed berm and in the high marsh were appropriate for growth and persistence, but as of 2017, vegetation robustness was less than 0.5 in both communities. Although this is not definitively indicative of poor health, as the communities may be developing positive directional trajectories, it should continue to be monitored to ensure that vegetation is becoming adequately established.

Secaucus Living Shoreline Project

Project Location

The Secaucus project site consisted of the deepening of two storm water drainage ditches located along route 3 in Secaucus, NJ that drained run-off from the city of Secaucus to the Hackensack River (Fig. 25). Ditch 1 (40°48'01.20"N, 74°03'52.53"W) was located north of route 3 west-bound along the Meadowlands Parkway between an Extended Stay America hotel to the south and residential housing to the north. Ditch 2 (40°47'56.91"N, 74°03'56.50"W) was located south of route 3 west-bound along the Meadowlands Parkway between a Red Roof Inn to the south and a private marina lot to the north.

Pre-existing Conditions

Existing ditches were shallow and lined with Phragmites australis. Concern was over low precipitation run off capacity from the street above, and the goal was to deepen the ditches and install updated outfall gates. The area was known to be contaminated with PCBs, with the potential for other contaminants. Therefore, as no disturbance to the existing vegetation was permissible and no ecological uplift that may attract wildlife to the area was desired, methods to augment/establish new vegetation were largely abandoned.

Monitoring Strategy

The preliminary strategy included cost prohibitive equipment (flow meters) and/or equipment
placement that would require its removal during construction activities (in channel flow meters, tide gages), which was deemed logistically infeasible. Plantings were originally planned to occur in bare spots surrounded by *Phragmites*; these plots were established in 2016. However, it was discovered that these plots were outside of regular tidal inundation and likely would be overtaken/shaded by the existing *Phragmites*. New vegetation monitoring plots were established in 2017 at the mouth of each ditch, on the north and south sides in triplicate. Vegetation in these plots were monitored for vegetation robustness (Fig. 26) as a result of the ditch dredging.

Additionally, RTK-GPS transects were established to survey cross sectional changes of each ditch (which would be used as a proxy for ditch volumetric changes). These transects were establish at six locations, spanning the length of each ditch. Five survey points were established along each transect to track elevation changes over time (Fig. 27).

### As-Built Conditions

Ditches were dredged and new outfall pipe gates were installed. *Spartina alterniflora* was planted at ditch mouths.

### Data Analysis

#### Vegetation Robustness

Ditch 1 2017 vegetation robustness ranged between 0.06 and 0.44 on the north side, and 0.07 and 0.90 on the south side. Ditch 2 2017 vegetation robustness ranged between 0.07 and 0.17 on the north side (1 missing data point), and 0 and 0.30 on the south side. Ditch 1 had higher vegetation robustness than ditch 2 on both the north and south sides. Vegetation robustness was higher on the south side of ditch 1 (0.57) and ditch 2 (0.19) than on their northern sides. Only the south side of ditch 1 had a vegetation robustness score higher than 0.50, indicating that vegetation was generally sparse across the plots (Fig. 28).

#### Vertical Position Along a Transect: Ditch Elevation

Dredging activities increased the area for water to drain through both ditch 1 and 2 between 2016 and 2017 (Figs. 29 & 30). Ditch 1 maximum (per transect) depth increased between 5cm and 55cm, with an average depth increase of 36cm (Fig 31a). This average was highly influenced by the low change in depth that occurred along transect 4 which saw the lowest increase (5cm). Removing transect 4 data, the average increase in depth was between 26cm and 55cm with an average of 42cm. Ditch 2 maximum (per transect) depth increased between 48cm and 62cm, with an average depth increase of 54cm (Fig 31b). Maximum
depth increase generally declined moving from the mouth to head of ditch 2, but showed no distinct pattern in ditch 1 (Figs. 31 a & b). Coincident locations of 2016 and 2017 transect survey plots were more accurate along ditch 2 than ditch 1 (Fig. 27) which may have resulted in the higher variability among time periods (i.e. 2016 & 2017) in ditch 1 (i.e. points did not always measure exact same location). The average distance between the original transect plot sampling point in 2016 and the return location in 2017 was 0.4m in ditch 2 and 2.1m in ditch 1. Tracking to plots along transects in subsequent years should use RTK-GPS tracking abilities (used on ditch 2) rather than hand-held GPS (used on ditch 1) to return to 2016 plot locations.

**General Conclusions**

The dredge activity seems to have deepened the channels along both ditches. Ditch 1 may be accumulating sediment in the mouth (transects 1 and 2) and in the central region (transect 4). Vegetation robustness is low along most monitoring plots in the mouths of both ditches. Future monitoring should focus on sediment accumulation in the ditches and tracking the trajectories of the vegetation response.

**Upper Township Living Shoreline**

**Project Location**

The living shoreline was located in the Strathmere section of the Township of Upper in Cape May County, New Jersey (39°11’40.18”N; 74°39’48.04”W) which is part of the Carson Inlet and Sound/Ludlam Bay watershed. The site was located along Strathmere Bay at the western end of Bayview Drive, which ends at a public boat ramp and kayak launch (updated in 2017 at the same time the living shoreline was installed). The living shoreline was installed in two sub-sites of the site: east and west. The eastern section of the site was a small sloping beach located between the boat ramp to the west and residential housing to the east. The western location was adjacent to the western end of the boat ramp and east of a vast expanse of salt marsh (Fig. 32)

**Pre-existing Conditions**

Prior to installation, both sides of the site were characterized by an expanse of intertidal rock and pebble that sloped from the end of the street to the subtidal area. There was a small patch of low marsh *Spartina alterniflora* on the western side between the marsh drainage creek and the parking lot. No other vegetation or shellfish were present on either side of the
Monitoring Strategy

A total of five monitoring transects were established at the project location. Transects 1-3 were located on the west sub-site (the larger of the two sites, west of the boat ramp), and transects 4-5 were positioned on the east sub-site (smaller of the two sites, east of the boat ramp; Fig. 34). Transects were oriented perpendicular to the shoreline, and extended from estimated locations of ~1m waterward of the rip rap to the central area of the mixed high marsh upland vegetation. Fixed monitoring plots were established at 3-5 locations along each transect that coincided with three zones planned for installation: a unvegetated zone waterward of the installation materials; a low marsh *S. alterniflora* zone (two zones at the west sub-site (low marsh 1 & 2) and in one zone in the east sub-site); and a mixed high marsh and upland community zone in both sub-sites. Of note, transect two was unable to extend the full length of the treatment in the west sub-site due to the curved shape (transects would have crossed, Fig. 34). To allow for triplicate monitoring plots in each post-install zone, a second monitoring plot was placed along transect 3 in the mixed high marsh upland vegetation (2017 land cover plot D, Fig. 34). Since the final design of the treatment was under development during the 2016 monitoring season, adjustments to some of the plot locations needed to be made in 2017 to align with the installed zones. Adjusted locations of 2017 monitoring plots were situated so that the ground cover at each adjusted location matched the ground cover at the 2016 location. The maximum adjusted distance was less than 8m in the unvegetated area waterward of the treatment, and less than 5m in the treatment areas. The new locations were considered representative of the 2016 locations based on proximity (Fig 34; shown here with 2017, as-built, land cover).

In each monitoring plot, the follow data were collected: vegetation robustness (2017 only); shellfish presence/absence; and vertical position (i.e. elevation). Additionally a feature based survey targeted the positions (lateral and vertical) of the contiguous vegetated edges, and vegetation community boundaries. The waterward vegetated edges were not surveyed in 2016, as there was no vegetation present prior to installation. These boundaries were surveyed in 2017 to serve as a baseline to measure future lateral movement.

As-Built Conditions

Two bio-based living shoreline treatments were installed at Upper township site in early summer 2017. The west sub-site was ~25m long and fortified along its waterward margin with small amount of riprap. Rip rap was placed so that that space was present between the individual rocks to allow for faunal and water movement into and out of the treatment (Fig. 34). Two low marsh (*S. alterniflora*) zones were installed, separated by a tier of coir-logs in
the central area of the west sub-site treatment. The Low Marsh 1 West was 92m² and Low Marsh 2 West was 79m² (Fig. 34). Additionally, a pre-existing area of low marsh within the treatment area was measured to comprise 16m². Of note, this original area of low marsh was measured to be smaller post installation (Fig. 34) than pre-installation (Fig. 33) due to unequal survey boundaries, not shrinkage of this area. Future surveys should follow the western boundary of the 2017 to delineate and track this community. The upper low marsh area transitioned into a mixed high marsh and upland vegetation area. It was assumed that the different vegetation communities would reposition themselves to appropriate locations along the boundary of MHHW. The east sub-site was ~7m in length with a sloped transition from a low marsh (S. alterniflora, 20m²) zone into a mixed high marsh upland vegetation zone (26m², Fig. 34).

Data Analysis

Vertical Positions of Treatment Area within the Tidal Prism

Post installation, the different vegetation species were positioned at appropriate elevations (m NAVD88) within the local tidal prism (Station Datum 8535101, Corson Inlet, NJ) for growth and persistence. In the west sub-site, the low marsh vegetation (S. alterniflora) was largely positioned between MTL and MHW, its generalized optimum growing range (Fig. 35a). There were some measurements of plants above and below this range, but the boundaries of the vegetation will likely contract as the site settles and vegetation emerges next season. The original low marsh vegetation present pre-installation was also positioned slightly higher than the generalized optimum growing range, indicating that the vegetation here may receive more frequent inundation, and therefore is positioned slightly higher than expected (Fig 35a). The mixed high marsh and upland vegetation (denoted as High Marsh in Fig. 35a), was largely above MHHW, but does straddle the boundary. High marsh vegetation is typically positioned near this boundary and upland vegetation above it. As the planted material was positioned across an elevation range that contains vertical positions suitable for both vegetation types, the mixed community will likely segregate itself to each group’s (i.e. high marsh and upland types) respective inundation regimes.

Monitoring plot data showed that the average as-built plot elevations for the low marsh and mixed high marsh upland vegetation in the west sub-site were positioned at appropriate locations to track their intended vegetation types (Fig. 36). Low marsh 1 plots were positioned just above MTL, and show an increase in elevation (9cm; Fig. 36) from the pre-installation conditions. The low marsh 2 area also saw an increase in average elevation (~10cm; Fig. 36) at the monitoring plots and are positioned centrally within the optimum
growing range (MTL-MHW). The high marsh upland mix plots showed a slight average decline in elevation (10 cm; Fig. 36), but were positioned well above MHW and MHHW (0.601 m NAVD88), and will likely be useful for tracking mix upland vegetation rather than high marsh.

In the east sub-site, the low marsh vegetation was generally well positioned between MTL and MHW (Fig. 35b). Although some measurements of low marsh vegetation were taken above this range, the fact that some of the pre-existing marsh was also positioned slightly higher than average (Fig. 35a Original Low Marsh), indicated that this elevation is suitable for S. alterniflora at this site. The mixed high marsh and upland community was positioned above MHW (Fig. 35b) and, as with the west sub-site, was positioned across an elevation range suitable for both vegetation communities. Monitoring plot data were not collected pre-installation (Fig. 36). The low marsh monitoring plots were located at the upper portion of the generalized growth range, but as noted above, due the high positioning of the pre-existing low marsh at the west sub-site, this location may be suitable. If vegetation robustness at these plots (B) decline, it may be helpful to measure vegetation robustness at a slightly lower elevation within this zone to assess if the decline is due to elevation or another outside factor. The mixed high marsh upland vegetation monitoring plots were positioned at a similar elevation to the ones in the west-subsect and therefore may prove to be more suitable for tracking mixed upland rather than high marsh vegetation (Fig. 36). High marsh vegetation boundaries should be tracked in the coming year using RTK-GPS surveys.

Vegetation Robustness

Vegetation was non-existent along most of the site in 2016, with the exception of the small patch of S. alterniflora at the western boundary of the west sub-site, but no measurements were taken there at the time as the metric was still in the developmental phase. As such, the 2017 vegetation robustness measurement from the pre-existing patch of low marsh vegetation (S. alterniflora) can serve as a target vegetation robustness for S. alterniflora at this site. The pre-existing low marsh vegetation robustness measured 0.63 in 2017, while all measurements of newly planted low marsh vegetation across both sub-site were between 0.03 and 0.05 (Fig. 37). Further, vegetation robustness of mixed high marsh and upland vegetation were between 0.08 and 0.09 in both sub-sites. These data show that the newly planted vegetation in 2017 had not yet developed to a great degree. In 2018, fall measurements of vegetation robustness should be more informative regarding the growth trajectories of the installed vegetation.
Position of the Contiguous Vegetated Shoreline

As no shoreline was available for survey in 2016, the 2017 data (Fig. 34) can serve as the baseline against which to track community boundary changes.

Shellfish Presence/Absence

As of 2017, no shellfish were present in any plots at either site. Shellfish recruitment may require the prior establishment of the vegetative community, and therefore may be slow to show any changes.

General Conclusions

The Upper Township living shoreline was installed across the appropriate elevations for its target vegetative community. Both the low marsh and mixed high marsh and upland vegetation were planted in appropriate positions within the local tidal datum for growth and persistence. There will likely be shifts in the boundaries of these communities in the coming years as the substrate settle and the plant acclimate to their site-specific conditions. It will be important to track the changes in these boundaries using high resolution surveys, as these data will provide important information regarding the preferred conditions for these plant types along the NJ Atlantic coastal bays. Vegetation robustness data will show the growth trajectories of the different vegetation types, and should provide important information in 2018 that can guide additional plantings and/or augmentation.
Figure 1  Location (red box) of the Atlantic City living shoreline.
Figure 2 Pre-existing land cover at the Atlantic City living shoreline.
Figure 3 Monitoring plot locations and as-built land cover at the Atlantic City living shoreline.
Figure 4 Boxplots describing the elevations (m NAVD88) of the different planted vegetation communities at the Atlantic City living shoreline. Box borders identify the 75 (upper) and 25 (lower) quartiles, dark line within box indicates the median, and tails show the max and min values. MHHW=mean higher high water; MHW=mean high water; and MTL=mean tide line. Datum data provided by NOAA station 8534720, Atlantic City, NJ.
Figure 5 Mean vegetation robustness score at the Atlantic City living shoreline by vegetation type and time period relative to living shoreline construction. Low Marsh = Spartina alterniflora; High Marsh = mixed Spartina patens and Distichlis spicata; Upland = mixed community of vegetation appropriate for persistence above mean higher high water. Before = 2016; As Built = 2017. As no vegetation was present before installation, the scores were zero.
Figure 6 Mean change in position of the vegetated edge (m) at the Atlantic City living shoreline, here described as the lateral change in position between the lawn pre-construction (2016) and the S. alterniflora waterward edge post-construction (2017). Positive scores indicate waterward movement and negative scores indicate landward movement.
Figure 7 Position of the vegetated edge at the Atlantic City living shoreline in 2016 and 2017.
Figure 8 Locations of the three Brigantine living shoreline projects. Each project is denoted by a colored square in the map.
Figure 9  Pre-existing vegetation cover at the Brigantine Cherokee Blvd living shoreline project.
Figure 10  Monitoring plot locations and as-built land cover at the Brigantine Cherokee Blvd living shoreline.
Figure 11 Mean elevation change at the fixed monitoring plots by vegetation type and time period relative to living shoreline installation at the Brigantine Cherokee Blvd living shoreline. Low Marsh=Spartina alterniflora; Phragmites=Phragmites australis; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. Pre=2016; As-Built=2017. Red line indicates mean high water.
Figure 12  Mean vegetation robustness score at the Brigantine Cherokee Blvd living shoreline by vegetation type and time period relative to living shoreline construction (As Built was in 2017). Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.
Figure 13  Mean change in position of the vegetated edge (m) at the Brigantine Cherokee Blvd living shoreline, by vegetation type and year (2016=pre-construction, 2017=as-built). Positive values indicate waterward movement, and negative values indicate landward movement.
Figure 14  Position of the vegetated edges of interest at the Brigantine Cherokee Blvd living shoreline in 2016 and 2017.
Figure 15  Pre-existing land cover at the Brigantine Harbor Beach living shoreline in 2016.
Figure 16 Monitoring plot locations and as-built land cover (features) of the 2017 Brigantine Harbor Beach living shoreline.
Figure 17  Mean elevation (m NAVD88) of the monitoring plots at the Brigantine Harbor Beach living shoreline by vegetation type and time period. Low Marsh=Spartina alterniflora; Unvegetated=areas with <1% vegetation cover; High Marsh= mix of Distichlis spicata, Salicornia spp, and Spartina patens. Pre=2016; As-Built=2017. Red line indicates mean high water.
Figure 18  Mean vegetation robustness score at the Brigantine Harbor Beach living shoreline by vegetation type and time period relative to living shoreline construction. High Marsh= mix of Distichlis spicata, Salicornia spp, and Spartina patens; Upland=mixed community of vegetation appropriate for persistence above mean higher high water As Built=2017. Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.
Figure 19  Pre-existing land cover at the Brigantine Hydrangea Way living shoreline
Figure 20  Monitoring plot locations and as-built land cover at the Brigantine Hydrangea Way living shoreline.
Figure 21  Mean elevation change at the fixed monitoring plots by vegetation type and time period relative to living shoreline installation at the Brigantine Hydrangea Way living shoreline. High Marsh Mix=Spartina patens and Distichlis spicata; Upland= mixed community of vegetation appropriate for persistence above mean higher high water. Pre=2016; As-Built=2017. Red line indicates mean high water
Figure 22  Mean vegetation robustness score at the Brigantine Hydrangea Way living shoreline by vegetation type and time period relative to living shoreline construction. High Marsh Mix= Spartina patens and Distichlis spicata; Upland=mixed community of vegetation appropriate for persistence above mean higher high water. Before=2016; As Built=2017. Vegetation robustness was not measured in 2016 and the 2017 scores are considered the baseline moving forward.
Figure 23  Mean change in position of the vegetated edge (m) at the Brigantine Hydrangea Way living shoreline, here described as the lateral change in position of the upland vegetation border pre-construction (2016) and post-construction (2017). Upland Mix=community of vegetation appropriate for persistence above mean higher high water. Positive scores indicate waterward movement and negative scores indicate landward movement.
Figure 24 Position of the vegetated edges of interest at the Brigantine Hydrangea Way living shoreline in 2016 and 2017
Figure 25  Location (pink box) of the Secaucus tidal stream restoration project.
Figure 26 Monitoring plot locations at the Secaucus tidal creek restoration project. Elevation data were collected at the 2016 locations (green circles), and elevation and vegetation robustness data were collected at the 2017 locations (black squares).
Figure 27 Transect survey point locations at the Secaucus tidal creek restoration project. Elevation data were collected in 2016 (red circles) and 2017 locations (green circles) at ditch 1 & 2. Transects are numbered consecutively, increasing from the mouth (transect 1) to the head area (transect 6).
Figure 28 Mean vegetation robustness score at the Secaucus tidal creek restoration project by ditch and creek-side. Ditch 1 is the northern ditch and ditch 2 is southern ditch. North=north side of drainage creek; South=south side of drainage creek. Vegetation robustness was not measured at these plots in 2016 and these measurements will serve as the baseline post-restoration moving forward.
Figure 29 Cross-sectional elevation profiles (m NAVD88) of ditch 1 by transect in 2016 (blue line) and 2017 (orange line). Measurements were taken at each monitoring plot (n=5-6 per transect, denoted on x-axis) and connected with a best-fit line.
Figure 30  Cross-sectional elevation profiles (m NAVD88) of ditch 2 by transect in 2016 (blue line) and 2017 (orange line). Measurements were taken at each monitoring plot (n=5-6 per transect, denoted on x-axis) and connected with a best-fit line.
Figure 311 Maximum depth (m NAVD88) increase in 2017 relative to 2016 measurements per transect (x-axis) in ditch 1 (a) and ditch 2(b). Maximum depth increase was largely located at the channel center (plot 3). See figures 30-31 and text for details.
Figure 32  Location (pink box) of the Upper Township living shoreline.
Figure 33  Pre-existing land cover at the Upper Township living shoreline.
Figure 34  Monitoring plot locations (2016 & 2017) and as-built and cover at the Upper Township living shoreline.
Figure 35 Boxplots describing the elevations (m NAVD88) of the different planted vegetation communities at the Upper Township living shoreline West (a) and East (b) locations. Box borders identify the 75 (upper) and 25 (lower) quartiles, dark line within box indicates the median, and tails show the max and min values.

MHHW=mean higher high water; MHW=mean high water; and MTL=mean tide line. Low Marsh=Spartina alterniflora; High Marsh= mixed Distichlis spicata, Spartina patens, and upland vegetation. Breakwater at West location describes the rip rap in front of the waterward-most coir logs. Low marsh 1 & 2 at the West location describe the lower and upper S. alterniflora areas, respectively. Original low marsh (West location) describes pre-exiting S. alterniflora on-site. Datum data provided by NOAA station 8535101 Corson Inlet, NJ
Figure 36  Mean elevation change at the fixed monitoring plots by vegetation community type and time period relative to living shoreline installation at the Brigantine Cherokee Blvd living shoreline.  All Low Marsh=Spartina alterniflora; High Marsh Upland Mix= mixed community of Spartina pates, Distichlis spicata, and vegetation appropriate for persistence above mean higher high water.  Before=2016 pre-living shoreline installation; As-Built=2017 post-living shoreline installation.  Red line indicates mean high water (0.484m NAVD88) and green line indicated mean tide line (-0.10m NAVD88).  Mean elevations denoted in boxes beneath x-axis labels per vegetation community type and time period.
Figure 37  Mean vegetation robustness score at the Upper Township living shoreline by vegetation community type and time period relative to living shoreline construction. All Low Marsh= Spartina alterniflora; High Marsh Upland Mix= mixed community of Spartina pates, Distichlis spicata, and vegetation appropriate for persistence above mean higher high water. Pre-existing Low=Spartina alterniflora community present prior to living shoreline installation. Before=2016; As Built=2017. As no vegetation was present before installation, the scores were zero.
Figure 38  Position of the vegetated edges of interest at the Upper Township living shoreline in 2017. As vegetation presence across the entire site was minimal in 2016, the 2017 as-built measurements serve as a baseline for community development comparison over time. As the pre-existing Spartina alterniflora at West location is hoped to integrate with 2017 planted vegetation, a distinction was not made in this map regarding their individual boundaries.