Final Monitoring Plans for Coastal Resiliency Projects

Final report for New Jersey Department of Environmental Protection
Final Monitoring Plans for Coastal Resiliency Projects

Final report for
New Jersey Department of Environmental Protection

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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Atlantic City Living Shoreline Project Monitoring Plan

Project Details

Site: NJDEP-NFWF Atlantic City Living Shoreline Project

Dates Active: March 1, 2015 - March 2018

Project Lead: Elizabeth Terenik

Partners: NJDEP, NFWF, Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE), Arthur W. Ponzio and Associates, Autala Associates, City Dept. of Planning and Development, Stevens Institute of Technology

Project Design Team: Arthur W. Ponzio and Associates, Autala Associates, City Dept. of Planning and Development

Monitoring Plan Design and Implementation Team: PDE: Joshua Moody Sarah Bouboulis, LeeAnn Haaf, and Sandra Demberger; BBP: Jessie Buckner and Martha Maxwell Doyle; NJDEP: Evan Sherer

Project Type: Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Hybrid Living Shoreline

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The site is located in the northern section of Atlantic City in the sub-area known as Gardner's Basin on North Rhode Island Ave. Gilchrest Restaurant is located to the north of the project site and a work boat dock is located to the south (Appendix A).

Northern Extent: 39.375202, -74.421227

Southern Extent: 39.374961, -74.421141
Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The treatment will consist of two stone sills configured in an overlapping manner to allow for passage of fauna into and out of the treatment area. The water-ward sill will be installed at an elevation so that the top of the sill is located at 1.8' relative to NGVD Datum 1988 (as are all elevations in this plan) and will have a front slope of 1.5:1 and a rear slope of 1:1. The landward stone sill will be positioned approximately 5.0' landward and will close a gap at the southern end of the treatment area that allows for fauna passage. Heights and physical specs are the same as the water-ward sill. Fill between the sills and existing land will consist of loam sand to an elevation of 1.0'-3.0' at the landward extent. Area of salt meadow created between the sill and upland will be approximately 300 square feet and will planted with Spartina alterniflora planted 18" on center. At the landward extent of the treatment a berm will be constructed from 3.0-6.0' with a slope of 2:1 and will be planted with a combination of native landscape plants and mowed grasses. See engineering designs for more detail.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation until 3/2018.
Project Goal and Objectives

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal

Erosion Control: The goal of the installation is to stabilize shoreline and provide flood protection to local infrastructure located behind the Area of Interest (AOI).

Objectives

1. Living shoreline appears visually similar to natural shoreline
2. Erosion control structure maintains its established position and structural integrity
3. Contiguous vegetated edge moves waterward from its baseline position
4. Marsh platform is positioned between mean water and mean high water
5. Vegetation community develops high level of diversity and is robust
6. Shellfish community becomes established in living shoreline

Monitoring Design

Sampling Frame

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table
A map of the sampling frame is included in Appendix A. Sampling frame will extend from mean low water to the landward extent of the regarded area, and from the wooden deck at the northern extent to the concrete wall at the southernmost extent. Sampling frame will include existing outfall pipe in the southern area of the treatment (Appendix A).

**Sampling Frame Coordinates**

39.375212, -74.421062  
39.375198, -74.421240  
39.374959, -74.421127  
39.375104, -74.420941

**Monitoring Metrics Table**

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. *Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training.* Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at **ALL** visits to a project site as well as a monitoring task on all monitoring dates.
### Sampling Design Type and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling:** a survey design in which RTK-GPS point survey data are collected at specific, targeted locations in order to capture the features of interest at an appropriate resolution. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   1. **Position of Erosion Control Structure:** 1m intervals along the top, sides and base of structures
   2. **Position of Contiguous Vegetated Shoreline:** 1m intervals along boundary
3. Position of Vegetation Community Boundaries: 1m intervals along boundary

4. Vertical Position: Elevation of Treatment Area: 3m x 3m grid (maximum extent) across treatment area

2. Stratified Plot Sampling: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations along transects which are re-sampled periodically. Three transects will be placed along the AOI, numbering 1-3 left to right looking landward. Within each transect there will be a fixed endpoint waterward of built structures and three fixed sampling plots placed in the following strata: low marsh zone; high marsh zone; upland zone. Metrics within strata are:
   1. Vegetation Robustness
   2. Shellfish Population Density

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:
   1. Appearance
   2. Structural Integrity of Materials
   3. Shellfish Population Density (Full Survey)

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial
survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc…) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
Table 2. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Collection Window</th>
<th>Monitoring Stage</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td>05/02/2016</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td>Position of erosion control structures</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural integrity of materials</td>
<td></td>
<td>1. Survey points collected at 1m intervals along top, base, and sides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical position: elevation of treatment area</td>
<td></td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of contiguous vegetated shoreline</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of vegetation community boundaries</td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation robustness</td>
<td>1. Collected in pre-determined fixed monitoring plots (Ct Sci blade heights collected in same plots)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shellfish population density</td>
<td>1. Observation of shellfish presence at any location across site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After 1</td>
<td></td>
<td></td>
<td></td>
<td>08/03/2017 &amp; 09/18/2017</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td>Position of erosion control structures</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
<td></td>
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<tr>
<td>Structural integrity of materials</td>
<td></td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical position: elevation of treatment area</td>
<td></td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of contiguous vegetated shoreline</td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of vegetation community boundaries</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vegetation robustness</td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Shellfish population density</td>
<td>1. Collected in pre-determined fixed monitoring plots (Ct Sci blade heights collected in same plots)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Observation of shellfish presence at any location across site</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Site Maps

Atlantic City Hybrid Living Shoreline

Figure 1. Atlantic City site location.
Figure 2. Sampling frame for Atlantic City.
Figure 3. As-built structure, habitat, plot, and transect locations.
Brigantine Living Shoreline Project Monitoring Plan

Project Details

Site: NJDEP-NFWF Brigantine Shoreline Project

Dates Active: March 1, 2015 - March 2018

Project Lead: Jeannine Murphy, Edward Dennis

Partners: NJDEP, NFWF, Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE), Remington, Vernick and Walberg, Inc; City of Brigantine

Project Design Team: Remington, Vernick and Walberg, Inc; City of Brigantine

Point of Contact: Edward Dennis, Jeannine Murphy

Monitoring Plan Design and Implementation Team: PDE: Joshua Moody Sarah Bouboulis, LeeAnn Haaf, and Sandra Demberger; BBP: Jessie Buckner and Martha Maxwell Doyle; NJDEP: Evan Sherer

Project Type

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Vegetated earthen berms

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location.

Project location consists of several sites which are dead-end roads intersecting with Brigantine Boulevard, northeast of the Absecon Inlet (locations are: Hydrangea Way, Magnolia Way, and Cherokee Way (See Appendix A).

Northeastern Extent: 39.3945475,-74.3981661

Southwestern Extent: 39.3895063,-74.4139589
Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The treatments for each site consist of the construction of earthen mounds (or berms) up to 9 feet tall (relative to NAVD88). Mounds will be stabilized via brush layering of *Iva frutescens* and *Baccharis halmifolia*. Outfall pipes will be constructed at the base of the berm to allow storm water to drain during rain events. Berms were designed to occupy open spaces between 9 ft tall bulkheads on private residences. Berms will be vegetated with native flora; habitat will be created (via native floral plantings) along the back of the berm and in unpaved areas of the sites. See drafts of blueprints submitted for permitting for more detail on difference between sites as parcel size, topographies, and existing structures vary.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific endpoint goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation until 3/2018.

Project Goal and Objectives

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration
and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal
Hydrologic Enhancement and Habitat: To provide storm surge protection and storm water management to infrastructure adjacent to, and in the vicinity of each project AOI through the creation of high marsh and near-marsh upland fringe.

Objectives
1. Living shoreline appears visually similar to natural shoreline
2. Water control structures (berms) maintains its established position and structural integrity
3. Contiguous vegetated marsh edge moves waterward from its baseline position
4. Marsh platform is positioned between mean water and mean high water
5. Vegetation community develops high level of diversity and is robust

Monitoring Design
Sampling Frame
Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below).

Sampling frames vary from site to site, but in general consist of 2-5 meters before the base of the berm on the water or marsh ward side and extending back, over the berm, to Brigantine Boulevard. The width of each site is also variable, but can be considered the width of the berm itself, parallel to Brigantine Boulevard,
usually between hardened structures. Sampling frame coordinates will be finalized after first monitoring event.

**Sampling Frame Coordinates**

**Hydrangea Way**
- 39.391085, -74.409522
- 39.391113, -74.409356
- 39.391237, -74.409621
- 39.391279, -74.409501

**Magnolia Way**
- 39.392457, -74.406453
- 39.392500, -74.406295
- 39.392591, -74.406520
- 39.392637, -74.406421

**Cherokee Blvd**
- 39.392979, -74.404667
- 39.393101, -74.404418
- 39.393265, -74.405061
- 39.393373, -74.404836
Monitoring Metrics Table

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training. Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at ALL visits to a project site as well as a monitoring task on all monitoring dates.

Table 3. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>Living shoreline appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>1. Photo-doc at fixed points</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Does the living shoreline appear to be visually similar to a natural shoreline</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides of berms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrologic Enhancement</td>
<td>Water control structure maintains its established position</td>
<td>Position of erosion</td>
<td>1. Photo-doc</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Is the vertical position of the marsh appropriate for marsh vegetation?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td></td>
<td></td>
<td>control structures</td>
<td>2. RTK-GPS survey</td>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides of berms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrologic Enhancement</td>
<td>Water control structure maintains structural integrity</td>
<td>Structural integrity of</td>
<td>1. Photo-doc</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Are the installation materials remaining intact?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td></td>
<td></td>
<td>materials</td>
<td></td>
<td></td>
<td>2. RTK-GPS survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Habitat</td>
<td>Marsh surface is between mean water and mean high water</td>
<td>Vertical position</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td>Is the marsh surface currently or on a trajectory to be positioned vertical between mean water and mean high water?</td>
<td>1. BA 1-way ANOVA Analysis</td>
</tr>
<tr>
<td>Habitat and Hydrologic</td>
<td>Vegetated edge moves waterward from baseline position</td>
<td>Position of contiguous</td>
<td>1. Measured distance of</td>
<td>Fall</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td>Is the contiguous vegetated edge moving laterally from its baseline position?</td>
<td>1. Distance of edge position</td>
</tr>
<tr>
<td>Enhancement</td>
<td></td>
<td>vegetated shoreline</td>
<td>boundaries along transects</td>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td>along transect tape compared</td>
</tr>
<tr>
<td>Habitat</td>
<td>Vegetation community is diverse</td>
<td>Position of vegetation</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
<td>1. Distance of edge position</td>
</tr>
<tr>
<td></td>
<td></td>
<td>community boundaries</td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td>along transect tape compared</td>
</tr>
<tr>
<td>Habitat and Hydrologic</td>
<td>Vegetation community develops to be robust</td>
<td>Vegetation robustness</td>
<td>1. Integrate vegetation</td>
<td>Fall</td>
<td>1. Collected in pre-determined/ fixed monitoring plots (OR Sci blade heights collected in same plots)</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>1. BA 1-way ANOVA Analysis for each community</td>
</tr>
<tr>
<td>Enhancement</td>
<td></td>
<td>height and vertical/</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>horizontal obstruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sampling Design Type and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table
1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling**: a survey design in which RTK-GPS point survey data are collected at specific, targeted locations in order to capture the features of interest at an appropriate resolution. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   A. Position of Water Control Structure: 1m intervals along the top, sides and base of structures
   
   B. Position of Contiguous Vegetated Shoreline: 1m intervals along boundary
   
   C. Position of Vegetation Community Boundaries: 1m intervals along boundary
   
   D. Vertical Position: Elevation of Treatment Area: 3m x 3m grid (maximum extent) across treatment area

2. **Stratified Plot Sampling**: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations along transects which are resampled periodically. Three transects will be placed along the AOI, numbering 1-3 left to right looking landward. Within each transect there will be a fixed endpoint waterward of the pre-existing marsh edge and three fixed sampling plots placed in the following strata: low marsh zone; high marsh zone; upland (berm) zone. Metrics within strata are:

   1. Vegetation Robustness

3. **Site Level Sampling (Measured or Observational)**: a sampling scheme in which either: data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:

   2. Appearance

   3. Structural Integrity of Materials
Sampling Temporal Resolution and Table

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc…) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
Table 4. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Collection Window</th>
<th>Monitoring Stage</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Appearance</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Position of water control structures</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structural integrity of materials</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical position: elevation of treatment area</td>
<td></td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td>05/09/2016</td>
</tr>
<tr>
<td></td>
<td>Position of contiguous vegetated shoreline</td>
<td></td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td>05/09/2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Position of vegetation community boundaries</td>
<td></td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vegetation robustness</td>
<td></td>
<td>1. Collected in pre-determined fixed monitoring plots (Cit Sci blade heights collected in same plots)</td>
<td></td>
</tr>
<tr>
<td>After 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Appearance</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Position of water control structures</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides</td>
<td></td>
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<tr>
<td></td>
<td>Structural integrity of materials</td>
<td></td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical position: elevation of treatment area</td>
<td></td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td>09/01/2017</td>
</tr>
<tr>
<td></td>
<td>Position of contiguous vegetated shoreline</td>
<td></td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td>09/01/2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
</tr>
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<td></td>
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<td></td>
<td>1. Collected in pre-determined fixed monitoring plots (Cit Sci blade heights collected in same plots)</td>
<td></td>
</tr>
</tbody>
</table>
Site Maps

Figure 4. Brigantine site location.
**Figure 5.** Monitoring Transect layout and vegetation zones for Brigantine site Hydrangea Way.

**Figure 6.** Monitoring Transect layout and vegetation zones for Brigantine site Cherokee Blvd.
Figure 7. Monitoring Transect layout and vegetation zones for Brigantine site Harbor Beach.
Green Creek, Cape May County NJ, Tidal Sustainability Project Monitoring Plan

Project Details

Site: NJDEP-NFWF Green Creek Tidal Estuary Project

Dates Active:

Project Lead: Cape May County: Planning Dept., Engineering Dept., Public Works, Mosquito Control Dept., and County Counsel

Partners: NJDEP Office of Coastal and Land Use Planning, NFWF, Cape May County, Middle Township Government, Rutgers Haskin Shellfish Research Laboratory, Cape May Oyster Cooperative, USFWS, and Louis Berger and Associates

Project Design Team: Louis Berger and Associates

Monitoring Plan Design: Partnership for the Delaware Estuary, Joshua Moody

Project Type

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Dune Restoration and Tidal Gate Installation

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The Green Creek tidal estuary area is located in Middle Township, Cape May County. A historically tidal marsh area, it was disconnected from tidal influence in early 1900s for salt marsh hay farming activities until the mid-1990s when natural tidal flow was restored. Wing walls were constructed to address sedimentation in the tidal inlets that required frequent dredging.
Significant widening of the creek entrance since 1995, along with damage to the dune system during Super-Storm Sandy in 2012, has resulted in persistent creek erosion, water retention in the interior salt marsh areas, and continued dune deterioration. The project locations runs south southwest from approximately 100m south of the Rutgers Cape Shore Laboratory at Delsea Woods to 120m south of Schellinger Creek (Appendix A, Figure 1).

Northern Extent: 39° 04’ 20.64”N, 74° 54’ 47.59”W
Southern Extent: 39° 03’ 6.88”N; 74° 55’ 35.80”W

**Treatment Description**

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

After conducting an alternative analysis, the preferred alternative intervention consisted of: dune enhancement; sluice gate installation; and modified inlets. Current dune systems across 6.4 acres of fringing sand habitat will be elevated from a 2015 elevation of 4.1’-4.45’ NAVD 88 to 6.5’ NAVD 88. Sluice gates would be installed in the mouths of Green and Schellinger Creeks to allow for natural tidal flow, sediment transport, and faunal migration under typical tidal conditions, which could be closed under enhanced surge/tidal flow scenarios (e.g. intense storm events) to prevent enhanced inundation of the landward marsh system, protected by the augmented dune system. Additionally the inlets of Green and Schellinger Creeks would modified to narrow inlets and add sinuosity. (Appendix A, Fig. 2)

**Endpoints**

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).
This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation.

**Project Goal and Objectives**

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

**Goal:**

Habitat Enhancement: The goal of the installation is to stabilize shoreline and reduce tidal inundation to the landward marsh and forest systems, facilitating conditions for natural and resilient habitat development

**Objectives:**

1. Raise and maintain elevation of existing dune system to 6.5' NAVD 88
2. Maintain sluice structure position and structural integrity
3. Maintain augmented channel inlet widths
4. Stabilize tidal inundation across weather events
5. Reduce spatial extent of salt water intrusion
6. Stabilize vegetation community boundaries (i.e. low marsh, high marsh, upland forest)
7. Facilitate appropriate vegetation community development:
   a. Along the edge of the primary drainage channels (low marsh)
   b. Across the marsh platform (high marsh)
8. Maintain marsh platform elevation between mean water and mean high water
Monitoring Design

Sampling Frame

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below). A map of the sampling frame is included in Appendix A.

Sampling for the Green Creek Tidal Estuary Project will be conducted in two areas of interest (AOI; north and south) comprised of land owned by either the United States of America or the Township of Middle. Sampling will be replicated in the north and south areas, evaluated independently, and if not statistically different, evaluated as a single data set. This spatial design will account for spatial variability across the project area. If permission is granted from private land owners, the sampling frame can be expanded (Appendix A, Fig. 3).

Sampling Frame Coordinates

A. North: TBD
B. South: TBD

Monitoring Metrics Table

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training. Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at ALL visits to a project site as well as a monitoring task on all monitoring dates.
Table 5. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Enhancement</td>
<td>Treatment area appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
<td>Spring and Fall</td>
<td>Collected at TID photo points</td>
<td>Does the installation appear to be visually similar to a natural shoreline?</td>
<td>Observational comparison</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Raise and maintain level of existing dune system to 6' NAVD 88</td>
<td>Position of erosion control structures</td>
<td>RTK-GPS survey</td>
<td>Spring and Fall</td>
<td>Survey points collected at 10m intervals along bay, center, and base of both sides of dunes</td>
<td>Are the lateral and vertical position of the augmented dune system changing?</td>
<td>1. Lateral: GIS spatial comparison of position and elevation over time 2. Vertical: 1-way ANOVA analysis of elevation of subsistence (TID) of dune system</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Maintain dune structure position and structural integrity</td>
<td>1. Position of erosion control structures 2. Structural integrity of materials</td>
<td>1. RTK-GPS survey 2. Photo doc / visual observation</td>
<td>Spring and Fall</td>
<td>1. Survey points collected in each corridor and center of top of structure 2. Visual observation of entire structure</td>
<td>Are the installation materials remaining at their installed position?</td>
<td>1. GIS spatial comparison of position and elevation over time per point 2. Observational comparison</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Maintain augmented dune inlet widths</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
<td>Spring and Fall</td>
<td>Survey points collected at 10m intervals along channel edge at augmented areas</td>
<td>Are the augmented channels remaining at their installed position?</td>
<td>USGS-DS5 analysis</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Stabilize tidal inundation across weather events</td>
<td>Stream flow</td>
<td>Flow meter</td>
<td>Monthly</td>
<td>Flow meters installed at TID resolution</td>
<td>Is stream flow during storm events similar to stream flow during non-storm events?</td>
<td>Before/After 1-way ANOVA analysis with storm/non-storm events and before/after as factor levels</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Reduce spatial extent of saltwater intrusion</td>
<td>Salinity</td>
<td>Salinity gauge</td>
<td>Monthly</td>
<td>Wells installed in triplicate at TID intervals from creek mouth to forest</td>
<td>Is salinity declining from creek mouth to appropriate level for forest at upland boundary?</td>
<td>Track measured values over time per location</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Stabilize vegetation community boundaries</td>
<td>Horizontal position: vegetation community boundaries</td>
<td>RTK-GPS survey</td>
<td>Fall</td>
<td>Survey points collected at appropriate intervals along vegetated boundaries</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
<td>USGS-DS5 analysis</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Facilitate appropriate vegetation community development</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
<td>Fall</td>
<td>Collected in pre-determined fixed-monitoring plots</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>Before/After 1-way ANOVA per habitat with time point as factor</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Maintain marsh platform elevation between mean water and mean high water</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey (or) 2. LEAR Data</td>
<td>Spring</td>
<td>Collected at 10-20 feet above mean water level</td>
<td>Is the marsh surface currently at or on a trajectory to be positioned vertical between mean water and mean high water?</td>
<td>GIS-based map algebra (DEM) or fixed-point change over time analysis</td>
</tr>
</tbody>
</table>

Sampling Design Type and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. Targeted Point Sampling: a survey design in which RTK-GPS (or other) point survey data are collected at specific, targeted locations or resolutions, in order to capture the features of interest at an appropriate scale. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   A. Position of Erosion Control Structure:
i. Dune: Survey points collected at 20m intervals across top/base (each side)/centerline of dune system

ii. Sluice Structures: Survey points collected in each corner and center of top of each structure

B. Horizontal Position: Feature of Interest:

i. Channel Inlet Widths: Survey points collected at 1m intervals along augmented areas

ii. Vegetation Community Boundaries: Survey points collected at TBD intervals along identified boundaries

C. Vertical Position: Elevation of Treatment Area: Either/Or

i. 20m x 20m (or TBD) grid system survey across treatment area

ii. LiDAR at available resolution

2. Stratified Plot Sampling: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations which are re-sampled periodically. Metrics within strata are:

A. Stream Flow: Sampling points at a minimum of 3 locations between mouth of Green and Schellinger Creeks and their upland margins

B. Salinity: Sampling points at a minimum of 3 locations between mouth of Green and Schellinger Creeks and their upland margins (concurrent with stream flow monitoring)

C. Vegetation Robustness: A minimum of 3 replicates per community type (i.e. low marsh, high marsh, upland) per AOI (north and south) spanning two levels of community development (i.e. observationally dense and observationally sparse)

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: a) data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or b) it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by
targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:

A. Appearance

B. Structural Integrity of Materials

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc...) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
Table 6. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Monitoring Stage</th>
<th>Collection Window</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Spring and Fall</td>
<td>Appearace</td>
<td>Photo-doc at fixed points</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>Spring and Fall</td>
<td>Position of erosion control structures</td>
<td>RTK-GPS survey</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>Spring and Fall</td>
<td>1. Position of erosion control structures 2. Structural integrity of materials</td>
<td>1. RTK-GPS survey 2. Photo-doc; visual inspection</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>Spring and Fall</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>Stream flow</td>
<td>Flow meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>Salinity</td>
<td>Salinity gauge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>Horizontal position: vegetation community boundaries</td>
<td>RTK-GPS survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey (or) 2. LIDAR Data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| After 1          | Spring and Fall   | Appearace | Photo-doc at fixed points |
|                 | Spring and Fall   | Position of erosion control structures | RTK-GPS survey |
|                 | Spring and Fall   | 1. Position of erosion control structures 2. Structural integrity of materials | 1. RTK-GPS survey 2. Photo-doc; visual inspection |
|                 | Spring and Fall   | Horizontal position: feature of interest | RTK-GPS survey |
| Monthly          | Stream flow       | Flow meter |
| Monthly          | Salinity          | Salinity gauge |
| Fall             | Horizontal position: vegetation community boundaries | RTK-GPS survey |
| Fall             | Vegetation robustness | Vegetation robustness |
| Spring           | Vertical position: elevation of treatment area | 1. RTK-GPS survey (or) 2. LIDAR Data |
Site Maps

Figure 8. Proposed project location for the Green Creek Tidal Estuary Sustainability Project. Map produced by Louis Berger and Associates.
Figure 9. Spatial extent of proposed project components. Map produced by Louis Berger and Associates.
Figure 10. Sampling frame indicated by red boxes. Sampling frame includes land owned by the United States of America and Township of Middle. Sampling frames is divided into two areas, north and south, in which replicate sampling designs will be implemented.
Lower Township Shoreline/Wetlands Restoration and Protection Project Monitoring Plan

Project Details

Site: Lower Township Shoreline/Wetlands Restoration and Protection Project Monitoring Plan

Dates Active:

Project Lead: Joseph Maffei, P.E. Engineering Design Associates

Partners: NJDEP Office of Coastal and Land Use Planning, NFWF, Cape May County, Lower Township Government, Stockton Coastal research Center, and Joseph Maffei Engineering Design Associates, P.A.

Project Design Team: Joseph Maffei Engineering Design Associates, P.A.

Monitoring Plan Design: Partnership for the Delaware Estuary, Joshua Moody

Project Type

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Dune Restoration and Tidal Gate Installation

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The Cox Hall Creek Wildlife Management Area and Delaware Bay Shoreline to the north between Mallow Road and West Miami Avenue. This area has been identified as vulnerable to coastal storms and currently consists of various flood protection measures such as: dunes; bulkheads; vegetated shorelines; and revetments. The area of interest (AOI) experiences continuous vertical and lateral erosion impacting habitat for many wildlife species, suitable beach area,
and private property of local homeowners. Additionally, the Cox Hall Creek WMA had an outfall pipe and control structure installed in 2010 as part of a wetlands restoration project. The current restoration efforts seeks to enhance these structures to facilitate natural tidal flow into the WMA (Appendix A, Figure 1).

Northern Extent: 39° 02’ 14.54”N, 74° 56’ 12.66”W
Southern Extent: 38° 59, 46.16”N; 74° 57’ 22.91”W

Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The shoreline restoration project will consist of the creation of sand dunes, vertical beach enhancement, and placement of wave attenuation devices. The dune restoration aims for a dune height of 16’ with a crest width of 44’ along the length of the system. The estimated fill volume is 1,032,008 yards$^3$ of material. The shoreline restoration and protection element of the project includes the construction of wave attenuation devices in areas of shallow water at various points along the shoreline to reduce wave action and decrease erosion. These devices will be constructed of 12” pre-fabricated concrete block with a foundational width of 10’ and crest width of 4’. Each section length is will be 30’ with a minimum gap width of 5’ between sub-sections. In the Cox Hall subsection, the 340 linear feet of 48” diameter outfall pipe with riser and water control structures has been determined to be functioning at maximum capacity. To ensure proper ecological conditions for the tidal salt marsh wetlands in the Cox Hall Creek WMA, including the suppression of the invasive common reed *Phragmites australis*, and additional 48” diameter pipe will be installed adjacent to the existing pipe with a larger, 72” diameter water control structure. Additionally, the existing culvert will be replaced with an 8’ x 4’ box culvert.
Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation.

Project Goal and Objectives

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal

Habitat Enhancement: The goal of the installation is to stabilize shoreline and reduce tidal inundation to the private land along the Delaware Bay shoreline, and to restore natural tidal flow to salt marsh marshes in the landward interior, facilitating conditions for natural and resilient habitat development

Objectives

1. Raise and maintain elevation of existing dune system
2. Maintain wave attenuation and water control structure position and material structural integrity
3. Stabilize vegetation community boundaries (i.e. low marsh, high marsh, upland forest)
4. Facilitate appropriate vegetation community development:
5. Along the edge of the primary drainage channels (low marsh)
6. Across the marsh platform (high marsh)

7. Maintain marsh platform elevation between mean water and mean high water

**Monitoring Design**

**Sampling Frame**

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below). A map of the sampling frame is included in Appendix A.

Sampling for the Lower Township Shoreline/Wetland Restoration and Protection Project will be conducted along the installed (wave attenuation device and dune system) structures as well as the adjacent fringing wetland areas.

**Sampling Frame Coordinates**

North: TBD

South: TBD

**Monitoring Metrics Table**

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training. Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at ALL visits to a project site as well as a monitoring task on all monitoring dates.
Table 5. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

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<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Treatment area appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
<td>Spring and Fall</td>
<td>Collected at TID photo points</td>
<td>Does the installation appear to be visually similar to a natural shoreline?</td>
</tr>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Raise and maintain elevation of existing dune systems</td>
<td>Position of erosion control structures</td>
<td>RTK-GPS survey</td>
<td>Spring and Fall</td>
<td>Survey points collected at 20m intervals along top, center, and base of both sides of dunes</td>
<td>Are the lateral and vertical position of the augmented dune system changing?</td>
</tr>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Maintain near attenuation and water control structure position and material structural integrity</td>
<td>1. Position of erosion control structures 2. Structural integrity of materials</td>
<td>1. RTK-GPS survey 2. Photo-doc; visual inspection</td>
<td>Spring and Fall</td>
<td>Survey points collected to each corner and center of top of structure 2. Visual observation of entire structure</td>
<td>1. Are the installation materials remaining at their installed position? 2. Are the installation materials retaining their structural integrity?</td>
</tr>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Stabilize vegetation community boundaries</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
<td>Fall</td>
<td>Survey points collected at appropriate intervals along vegetated boundaries</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
</tr>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Facilitate appropriate vegetation-community development</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
<td>Fall</td>
<td>Collected in pre-determined fixed-monitoring plots</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
</tr>
<tr>
<td>Habitat</td>
<td>Enhancement</td>
<td>Maintain marsh platform elevation between mean water and mean high water</td>
<td>Vertical position: elevation of treatment area</td>
<td>RTK-GPS survey (or) 1. LEAR Data</td>
<td>Spring</td>
<td>Collected at to-be-determined resolution (survey grid or transect) 2. Available resolution</td>
<td>Is the marsh surface currently or as a trajectory to be positioned vertical between mean water and mean high water?</td>
</tr>
</tbody>
</table>

**Sampling Design Type and Spatial Resolution**

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling:** a survey design in which RTK-GPS (or other) point survey data are collected at specific, targeted locations or resolutions, in order to capture the features of interest at an appropriate scale. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   1. **Position of Erosion Control Structure:**
      a. Dune: Survey points collected at 20m intervals across top/base (each side)/centerline of dune system
      b. Erosion Control Structures: Survey points collected in each corner
and center of top of each structure

2. Horizontal Position: Feature of Interest:
   a. Vegetation Community Boundaries: Survey points collected at TBD intervals along identified boundaries

3. Vertical Position: Elevation of Treatment Area: Either/Or
   a. 20m x 20m (or TBD) grid system survey across treatment area
   b. LiDAR at available resolution

2. Stratified Plot Sampling: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations which are re-sampled periodically. Metrics within strata are:
   1. Vegetation Robustness: A minimum of 3 replicates per community type (i.e. low marsh, high marsh, upland) at TBD intervals behind dune system (where appropriate) and in Cox Hall Creek WMA spanning two levels of community development (i.e. observationally dense and observationally sparse)

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: a) data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or b) it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:
   1. Appearance
   2. Structural Integrity of Materials

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial
survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc...) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.

**Table 6.** Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Monitoring Stage</th>
<th>Collection Window</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Spring and Fall</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring and Fall</td>
<td>Position of erosion control structures</td>
<td>RTK-GPS survey</td>
<td></td>
</tr>
</tbody>
</table>
|                  | Spring and Fall   | 1. Position of erosion control structures  
|                  |                  | 2. Structural integrity of materials | 1. RTK-GPS survey  
|                  | Fall              | Horizontal position: vegetation community boundaries | RTK-GPS survey |
|                  | Fall              | Vegetation robustness | Vegetation robustness |
|                  | Spring            | Vertical position: elevation of treatment area | 1. RTK-GPS survey (or)  
|                  |                  |                  | 2. LIDAR Data |
| After 1          | Spring and Fall   | Appearance | Photo-doc at fixed points |
|                  | Spring and Fall   | Position of erosion control structures | RTK-GPS survey |
|                  | Spring and Fall   | 1. Position of erosion control structures  
|                  |                  | 2. Structural integrity of materials | 1. RTK-GPS survey  
|                  |                  |                  | 2. Photo-doc; visual inspection |
|                  | Fall              | Horizontal position: vegetation community boundaries | RTK-GPS survey |
|                  | Fall              | Vegetation robustness | Vegetation robustness |
|                  | Spring            | Vertical position: elevation of treatment area | 1. RTK-GPS survey (or)  
|                  |                  |                  | 2. LIDAR Data |


Site Maps

Figure 11. Proposed project location for the Lower Township Restoration/Wetland Restoration Project. Map produced by Engineering Design Associates.
Secaucus Living Shoreline Project Monitoring Plan

Project Details

Site: NJDEP-NFWF Secaucus Tidal Stream Restoration and Enhancement

Dates Active: March 1, 2015 – March 2018

Project Lead: Brian Thumpayil

Partners: NJDEP, NFWF, Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE), Township of Secaucus, Remington, Vernick and Arango Engineers

Project Design Team: Township of Secaucus, Remington, Vernick and Arango Engineers

Monitoring Plan Design and Implementation Team: PDE: LeeAnn Haaf, Sarah Bouboulis, Joshua Moody, and Sandra Demberger; BBP: Jessie Buckner and Martha Maxwell Doyle; NJDEP: Evan Sherer

Project Type

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Tidal stream restoration and enhancement

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The project is located along the Hackensack River in Secaucus, NJ in two pre-existing drainage ditches. Ditch 1, the northern ditch, is located on the northern border of the Secaucus Meadowlands Extended Stay America, and north of Route 3. Ditch 2, the southern ditch, is located just south of Route 3, between a
small marina owned and operated by the town of Secaucus and the Secaucus/Meadowlands Red Roof Plus.

Ditch 1:
Riverward Extent: 40.801, -74.065
Inland Extent: 40.800, -74.064

Ditch 2:
Riverward Extent: 40.799, -74.066
Inland Extent: 40.799, -74.065

Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The tidal stream restoration treatments for each ditch are as follows:

Ditch 1: Ditch 1 will be dredged to a depth of -2.5’ at the landward end (i.e. check valve) and a depth of -5.5’ at the Hackensack River end. Three planting areas have been selected, two on the southwest side and one on the northeast side. These areas are located ~25’-70’ from the landward end.

Ditch 2: Ditch 2 will be dredged to a depth of -4.2’ at the landward end (i.e. check valve) and a depth of -4.2’ at the Hackensack River end. One planting area has been selected on the northeast side located ~40’-55’ from the landward end.

Both ditches will receive new check valves. See engineering specs for details.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation until 3/2018.
Project Goal and Objectives

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal

Hydrologic Enhancement: This project aims to protect valuable infrastructure and low lying areas from minor tidal surges and periodic flooding by enhancing drainage capacity of pre-existing tidal ditches.

Objectives

1. Living shoreline appears visually similar to natural shoreline
2. Design is appropriate for stream volume and maintains structural integrity
3. Vegetation community becomes stable and robust
4. Water salinity maintains appropriate levels in channel for persistence of vegetation community
5. Monitoring Design

Monitoring Design

Sampling Frame

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below).

Sampling frame includes the area between the headwaters at the check valve to the mouth of each ditch, and the extent of the current vegetation along the
length of the ditch. Additionally, newly planted areas, three at Ditch 1 and one at Ditch 2, will also be sampled.

**Sampling Frame Coordinates – Ditch 1**

1. 40.800654, -74.065134  
2. 40.800514, -74.065271  
3. 40.800053, -74.064336  
4. 40.800060, -74.064486

**Sampling Frame Coordinates – Ditch 2**

1. 40.797701, -74.068090  
2. 40.797549, -74.068311  
3. 40.797001, -74.067194  
4. 40.797095, -74.067523

**Monitoring Metrics Table**

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. *Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training.*  *Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff.* Photo documentation is a mandatory monitoring task at *ALL* visits to a project site as well as a monitoring task on all monitoring dates.
Table 9. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Using shoreline appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>1. Photo-doc at fixed points</td>
<td>Annual</td>
<td>Collected at pre-determined photo points</td>
<td>Does the shoreline appear to be visually similar to a natural shoreline?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Design is appropriate for stream volume</td>
<td>Stream Volume</td>
<td>1. Photo-doc 2. RTK-GPS survey</td>
<td>Annual</td>
<td>Collected at pre-determined photo points 2. Survey points collected at 1m intervals along transects, banks, and sides</td>
<td>Is the flow appropriate for the structural materials?</td>
<td>1. Observational comparison 2. GIS measurement of lateral position &amp; change in elevation at fixed points</td>
</tr>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Channel structure maintains integrity</td>
<td>Channel Morphometry</td>
<td>1. Photo-doc</td>
<td>Annual</td>
<td>Collected at pre-determined photo points</td>
<td>Are the installation materials remaining intact?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Vegetated community is stable</td>
<td>Position of contiguous vegetated shoreline</td>
<td>1. Measured distance of boundaries along transects 2. RTK-GPS survey</td>
<td>Annual</td>
<td>Data collected along each fixed transect (n=3) 2. Survey points collected at 1m intervals along vegetated edge</td>
<td>Is the vegetation community maintaining its lateral position?</td>
<td>1. Distance of edge position along transect edge compared 2. USGS 9548 Analysis</td>
</tr>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Vegetation community develops to be robust</td>
<td>Vegetation robustness</td>
<td>1. Integrated vegetation height and vertical/ horizontal obstruction 2. Survivalweight of planted plugs</td>
<td>Annual</td>
<td>Collected at pre-determined fixed monitoring plots 2. Counts (Cx 5c) blade heights collected in same plots</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>1. BA 1-way ANOVA Analysis for each community</td>
</tr>
<tr>
<td>Hydrologic: Enhancement</td>
<td>Water chemistry metrics are appropriate for surrounding habitat</td>
<td>Water Salinity</td>
<td>1. YVI measurements</td>
<td>Annual</td>
<td>Collected within channels</td>
<td>Is the salinity the channel appropriate for maintaining the vegetation community present?</td>
<td>1. BA 1-way ANOVA; changes over time</td>
</tr>
</tbody>
</table>

Sampling Design Type and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. Targeted Point Sampling: a survey design in which RTK-GPS point or biological/physical survey data are collected at specific, targeted locations in order to capture the features of interest at an appropriate resolution. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:
   1. Channel Morphometry: 1m intervals along transects perpendicular to stream direction
   2. Position of Contiguous Vegetated Shoreline: 1m intervals along boundary

2. Stratified Plot Sampling: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations along transects which are re-
sampled periodically. At each ditch, six transects will be placed perpendicular to the ditches, numbering 1-6 moving from the headwaters to the mouth. On each transect there will be one 1m² sampling plot located approximately 10m apart in the ditches center and in vegetated zones. Metrics within strata are:

1. Stream Volume
2. Vegetation Robustness
3. Water Salinity

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:

1. Appearance

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc...) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
Table 10. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Collection Window</th>
<th>Monitoring Stage</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Appearance</td>
<td>1. Photo-doc at fixed points</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stream Volume</td>
<td>1. Photo-doc</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. RTK-GPS survey</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Channel Morphometry</td>
<td>1. Photo-doc</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position of contiguous</td>
<td>1. Measured distance of boundaries along</td>
<td>05/31/2016 06/01/2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vegetated shoreline</td>
<td>transects</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vegetation robustness</td>
<td>2. RTK-GPS survey</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Integrate: vegetation height and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>vertical/horizontal obstruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After 1</td>
<td>Water Salinity</td>
<td>1. YSI measurements</td>
<td>07/18/2017</td>
</tr>
</tbody>
</table>
Site Maps

Figure 12. Location of Secaucus Living Shoreline Site.
Figure 13. Sampling frames for Ditch 1 and Ditch 2.
Figure 8. Locations of Monitoring Transects and Plots.
Somer’s Point Wetland Elevation Enhancement Project Monitoring Plan

Project Details

Site: Malibu Beach, Egg Harbor Township, Atlantic County, New Jersey

Dates Active:

Project Lead: Wes Swain

Partners: City of Somers Point; Mott Associates; Arthur W. Ponzio & Associates, Inc.; Rutala Associates, and the Partnership for the Delaware Estuary (PDE); Barnegat Bay Partnership (BBP)

Project Design Team: Calmar Associates LLC; Mott Associates; Arthur W. Ponzio & Associates, Inc.; Rutala Associates, and the City of Somers Point

Monitoring Plan Design: Partnership for the Delaware Estuary, Joshua Moody

Project Type

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Tidal salt marsh restoration through beneficial re-use of dredge materials

Project Location

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The Somers Point wetland elevation enhancement project is located on a 95.7 acre site in the Malibu Beach Wildlife Management Area, owned by the NJDEP’s Division of Fish and Wildlife. The site is positioned between Patcong Creek to the west and north, Somer’s Point-May’s Landing Road (Rt 559) to the south, and the Garden State Parkway to the east. This area has witnessed significant erosion over the years, and coupled with relative sea-level rise, is vulnerable to coastal hazards. Further erosion may also impact Route 152, an emergency evacuation route for the residents of Absecon Island (Appendix A Fig. 1).
Northern Extent: 39° 19’ 03.74” N; 74° 37’ 20.90” W  
Southern Extent: 39° 18’ 54.19” N; 74° 37’ 26.70” W  
Western Extent: 39° 18’ 59.18” N; 74° 37’ 39.25” W  
Eastern Extent: 39° 18’ 56.04” N; 74° 37’ 18.26” W

Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The City of Somers Point will utilize the funds to undertake the removal and placement of approximately 1,500 cubic yards of dredge material from a publicly owned area of Bay Avenue where the Higbee Marina is located. Somers Point has also applied for a National Boating Infrastructure Grant thorough the New Jersey Department of Transportation to reconstruct Higbee Marina. The proposed dredging is the first step towards the reconstruction of the marina. The rebuilt marina will provide approximately 26 docking spaces for boats of 26 feet or more in length with a 14-foot width and finger piers 20 foot in length at each slip of which 20 will be dedicated to use by transient boaters.

The testing of the 1,500 cubic yards of dredge material will be conducted by a subcontractor and/or laboratory chosen by the City of Somers Point. The testing will include toxicity and size of grains. The goal is to keep clean sediment in the system and enhance resiliency.

The City of Somers Point will oversee the application of 1,500 cubic yards of dredge material. Should this site be determined by the State to be unsuitable, other potential sites will be considered.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).
This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation.

Project Goal and Objectives
List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal
Habitat Enhancement: The goal of the installation is to stabilize shoreline and reduce tidal inundation along Rt 559 and proximal freshwater wetlands, facilitating conditions for critical shorebird salt marsh habitat development.

Objectives
2. Maintain marsh platform elevation between mean water and mean high water
3. Reduce spatial extent of salt water intrusion
4. Stabilize vegetation community boundaries (i.e. low marsh, high marsh, upland forest)
5. Facilitate appropriate vegetation community development:
6. Along the edge of the primary drainage channels (low marsh)
7. Across the marsh platform (high marsh)

Monitoring Design
Sampling Frame
Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to
be listed. These coordinates are to be collected during the first survey (see Table 2 below). A map of the sampling frame is included in Appendix A.

Sampling for the Somer’s Point Elevation Enhancement Project will be conducted across the Area of Interest (AOI; Appendix A, Fig. 1).

**Sampling Frame Coordinates**

Northern Extent: 39° 19’ 03.74” N; 74° 37’ 20.90” W  
Southern Extent: 39° 18’ 54.19” N; 74° 37’ 26.70” W  
Western Extent: 39° 18’ 59.18” N; 74° 37’ 39.25” W  
Eastern Extent: 39° 18’ 56.04” N; 74° 37’ 18.26” W

**Monitoring Metrics Table**

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. **Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training.** Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at **ALL** visits to a project site as well as a monitoring task on all monitoring dates.
Table 11. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Enhancement</td>
<td>Treatment area appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
<td>Spring and Fall</td>
<td>Collected at TBD photo points</td>
<td>Is the installation appearance to be visually similar to a natural shoreline?</td>
<td>Observational comparison</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Maintain marsh platform elevation between mean water and mean high water</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey (or) 2. LEAR data</td>
<td>Spring</td>
<td>1. Collected at to-be-determined resolution (surveys grid or transect) 2. Available resolution</td>
<td>Is the marsh surface currently at or on a trajectory to be positioned vertical between mean water and mean high water?</td>
<td>GIS-based map algebra (DEM) or fixed-point change over time analysis</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Reduce spatial extent of salt water intrusion</td>
<td>Salinity</td>
<td>Salinity gauge</td>
<td>Monthly</td>
<td>At a minimum of 3 locations between creek mouth and upland margin</td>
<td>Is salinity declining from creek mouth to appropriate level for forest at upland boundary?</td>
<td>Track measured values over time per location</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Stabilize vegetation community boundaries</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
<td>Fall</td>
<td>Survey points collected at appropriate intervals along vegetated boundaries</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
<td>USGS 206B analysis</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Facilitate appropriate vegetation community development</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
<td>Fall</td>
<td>Collected in pre-determined fixed monitoring plots</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>Before/After 3-Way ANOVA per habitat with time point as factor</td>
</tr>
</tbody>
</table>

**Sampling Design Type and Spatial Resolution**

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling**: a survey design in which RTK-GPS (or other) point survey data are collected at specific, targeted locations or resolutions, in order to capture the features of interest at an appropriate scale. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   1. **Vertical Position**: Elevation of Treatment Area: Either/Or
      a. 20m x 20m (or TBD) grid system survey across treatment area
      b. LiDAR at available resolution with validation of TBD% sample points

   2. **Horizontal Position**: Feature of Interest Vegetation Community Boundaries: Survey points collected at TBD intervals along identified boundaries

2. **Stratified Plot Sampling**: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations which are re-sampled
periodically. Metrics within strata are:

1. Salinity: Sampling points at a minimum of three locations between the mouth and upland margins of three intra-mash drainage creeks (n=9 sampling points minimum)

2. Vegetation Robustness: A minimum of 3 replicates per community type (i.e. low marsh, high marsh, upland) per AOI (north and south) spanning two levels of community development (i.e. observationally dense and observationally sparse)

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: a) data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or b) it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:

   1. Appearance

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc…) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
### Table 12. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Monitoring Stage</th>
<th>Collection Window</th>
<th>Metric</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>Spring and Fall</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey (or) 2. LiDAR Data</td>
</tr>
<tr>
<td></td>
<td>Monthly</td>
<td>Salinity</td>
<td>Salinity gauge</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
</tr>
<tr>
<td><strong>After 1</strong></td>
<td>Spring and Fall</td>
<td>Appearance</td>
<td>Photo-doc at fixed points</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey (or) 2. LiDAR Data</td>
</tr>
<tr>
<td></td>
<td>Monthly</td>
<td>Salinity</td>
<td>Salinity gauge</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Horizontal position: feature of interest</td>
<td>RTK-GPS survey</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Vegetation robustness</td>
<td>Vegetation robustness</td>
</tr>
</tbody>
</table>
Site Maps

Figure 15. Proposed project location for the Somer’s Point Elevation Enhancement Project. Top map shows project location and sampling frame (yellow polygon). Bottom map show regional site location (yellow box).
Spring Lake Living Shoreline Project Monitoring Plan

Project Details

**Site:** NJDEP-NFWF Spring Lake, Monmouth Co., NJ Restoration Project

**Dates Active:** August 2015 – March 2018

**Project Lead:** Peter Avakian, Matthew Mariano, Bryan Dempsey, Georgia Marino

**Partners:** NJDEP, NFWF, Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE), Mayor of Spring Lake, Leon S. Avakian, Inc, Najarian Associates

**Project Design Team:** Georgia Marino (Najarian Associates) and Peter Avakian (Leon S. Avakian Inc.)

**Monitoring Plan Design and Implementation Team:** Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE)

**Project Type**

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Bio-based shoreline (grading)

**Project Location**

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

**Western Extent:** 40.141195, -74.037206

**Eastern Extent:** 40.142015, -74.034534

**Treatment Description**

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail
should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

Shoreline and riparian area of interest extends from a constructed bridge (west) to a point that represents a confluence of North Branch Wreck Pond Brook into Wreck Pond. The shoreline and riparian areas will be graded to create a gradual slope (from MLW, -0.7’ to 3’ NAVD88 over horizontal distance of ~80’) that is more conducive to intertidal vegetation growth. A berm (6’) will also be constructed and planted with native trees, shrubs, and grasses. Exact elevations and planting are likely to vary as water levels are scheduled to change in response to the refitting of an outfall pipe which is the Pond’s connection to the Atlantic Ocean. The outfall pipe will be replaced to allow the passage of diadromous fishes, and the exact effect on water (tides and chemistry, alike) is unknown.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation until 3/2018.

Project Goal and Objectives

List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

Goal
Habitat: To reduce flooding of infrastructure by grading the shoreline, creating marsh habitat, and planting native plants in the riparian area.

Objectives

1. Living shoreline appears visually similar to natural shoreline
2. All installation materials maintain their installed positions and retain their structural integrity
3. Vegetation community is positioned at the correct vertical datum for persistence
4. Vegetation community lateral boundaries persist
5. Vegetation community becomes stable and robust
6. Water salinity maintains appropriate levels in channel for persistence of vegetation community

Monitoring Design

Sampling Frame

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below).

Sampling frame includes the area between the headwaters at the check valve to the mouth of each ditch, and the extent of the current vegetation along the length of the ditch. Additionally, newly planted areas, three at Ditch 1 and one at Ditch 2, will also be sampled.

Sampling Frame Coordinates – Ditch 1

1. 40.800654, -74.065134
2. 40.800514, -74.065271
3. 40.800053, -74.064336
4. 40.800060, -74.064486
Sampling Frame Coordinates – Ditch 2

1. 40.797701, -74.068090
2. 40.797549, -74.068311
3. 40.797001, -74.067194
4. 40.797095, -74.067523

Monitoring Metrics Table

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. **Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training.** **Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff.** Photo documentation is a mandatory monitoring task at ALL visits to a project site as well as a monitoring task on all monitoring dates.

**Table 13. Monitoring Metrics Table.** Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Enhancement</td>
<td>Living shoreline appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>1. Photo-doc at fixed points</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Does the living shoreline appear to be visually similar to a natural shoreline</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Erosion control structure maintains its established position</td>
<td>Position of erosion control structures</td>
<td>1. Photo-doc, RTK-GPS survey</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points, 2. Survey points collected at 1m intervals along top, base, and sides</td>
<td>Is the vertical position of the marsh appropriate for marsh vegetation?</td>
<td>1. Observational comparison, 2. GPS measurement of lateral position &amp; change in elevation at fixed points</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Erosion control structure maintains structural integrity</td>
<td>Structural integrity of materials</td>
<td>1. Photo-doc</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Are the installation materials remaining intact?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Marsh surface is between mean water and mean high water</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td>Is the marsh surface currently or on a trajectory to be positioned vertical between mean water and mean high water?</td>
<td>1. BA 1-way ANOVA Analysis</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Vegetation community retains their lateral boundaries</td>
<td>Position of contiguous vegetated shoreline</td>
<td>1. Measured distance of boundaries along transects, 2. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Data collected along each fixed transect (n=3), 2. Survey points collected at 1m intervals along vegetated edge</td>
<td>Is the contiguous vegetated edge moving laterally from its baseline position?</td>
<td>1. Distance of edge position along transect tape compared</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Vegetation community is diverse</td>
<td>Position of vegetation community boundaries</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Data collected within each fixed transect (n=3), 2. Survey points collected at 1m intervals along vegetated edge</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
<td>1. Distance of edge position along transect tape compared</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Vegetation community develops to be robust</td>
<td>Vegetation robustness</td>
<td>1. Integrates vegetation height and vertical/horizontal obstruction</td>
<td>Fall</td>
<td>1. Collected in pre-determined fixed monitoring plots (2 Fireblade heights collected in seven plots)</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>1. BA 1-way ANOVA Analysis for each community</td>
</tr>
<tr>
<td>Habitat Enhancement</td>
<td>Maintain proper salinity and tidal regimes for vegetation community</td>
<td>Water Salinity and Tidal Levels</td>
<td>1. YSI, 2. HOKO Water Level Loggers</td>
<td>Fall</td>
<td>Collected in pre-determined fixed monitoring plots</td>
<td>Is the salinity and tidal datum appropriate for the vegetation community?</td>
<td>1. Change over time</td>
</tr>
</tbody>
</table>

Sampling Design Type and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g.
systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling**: a survey design in which RTK-GPS point or biological/physical survey data are collected at specific, targeted locations in order to capture the features of interest at an appropriate resolution. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   1. Position of Erosion Control Structure: 1m intervals along transects perpendicular to stream direction
   2. Vertical Position of Treatment Area: minimum of 3m x 3 m grid survey
   3. Position of Contiguous Vegetated Shoreline: 1m intervals along boundary
   4. Position of Vegetation Community Boundaries: 1m intervals along boundary

2. **Stratified Plot Sampling**: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations along transects which are re-sampled periodically. At each ditch, six transects will be placed perpendicular to the ditches, numbering 1-6 moving from the headwaters to the mouth. On each transect there will be one 1m² sampling plot located approximately 10m apart in the ditches center and in vegetated zones. Metrics within strata are:

   1. Vegetation Robustness
   2. Water Salinity and Tidal Levels

3. **Site Level Sampling (Measured or Observational)**: a sampling scheme in which either: data will likely not vary across the AOI (e.g. water temperature, wave climate, etc..) and sub-sampling is not required; or it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:
1. Appearance

2. Structural Integrity of Materials

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc…) for use in statistical analysis. As of now there is no additional annual monitoring planned for this site.
Table 7. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Collection Window</th>
<th>Monitoring Stage</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td>05/17/2016</td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td>Position of erosion control structures</td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural integrity of materials</td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical position: elevation of treatment area</td>
<td>1.</td>
<td>Survey points collected at a minimum of 3m x 3m resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of contiguous vegetated shoreline</td>
<td>1.</td>
<td>Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of vegetation community boundaries</td>
<td>1.</td>
<td>Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation robustness</td>
<td>1.</td>
<td>Collected in pre-determined fixed monitoring plots (Ct Sc blade heights collected in same plots)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Salinity and Tidal Levels</td>
<td>1.</td>
<td>YSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. HOBO Water Level Loggers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td></td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td>Position of erosion control structures</td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along top, base, and sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural integrity of materials</td>
<td>1.</td>
<td>Collected at pre-determined photo points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical position: elevation of treatment area</td>
<td>1.</td>
<td>Survey points collected at a minimum of 3m x 3m resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of contiguous vegetated shoreline</td>
<td>1.</td>
<td>Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position of vegetation community boundaries</td>
<td>1.</td>
<td>Data collected along each fixed transect (n=3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Survey points collected at 1m intervals along vegetated edge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation robustness</td>
<td>1.</td>
<td>Collected in pre-determined fixed monitoring plots (Ct Sc blade heights collected in same plots)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Salinity and Tidal Levels</td>
<td>1.</td>
<td>YSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. HOBO Water Level Loggers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Site Maps

Figure 16. Location of Spring Lake shoreline restoration project.
Figure 17. Location of Spring Lake shoreline restoration project.
Figure 18. Spring Lake sample frame and close up of project location.
Figure 19. Transect, monitoring plot, and photo point positions for Spring Lake shoreline restoration project.
Upper Township Living Shoreline Project Monitoring Plan

Project Details

**Site:** NJDEP-NFWF Reconstruction of Bayview Ave Boat Ramp

**Dates Active:** March 1, 2015 – March 2018

**Project Lead:** Paul Dietrich

**Partners:** NJDEP, NFWF, Barnegat Bay Partnership (BBP), Partnership for the Delaware Estuary (PDE), Township of Upper, County of Cape May, Waters Edge Environmental, and Nature Conservancy

**Project Design Team:** Township of Upper, County of Cape May, Waters Edge Environmental

**Monitoring Plan Design and Implementation Team:** PDE: Joshua Moody Sarah Bouboulis, LeeAnn Haaf, and Sandra Demberger; BBP: Jessie Buckner and Martha Maxwell Doyle; NJDEP: Evan Sherer

**Project Type**

Description of the overall project including the type of living shoreline being installed (bio-based, hybrid, etc...) or restoration technique being employed that requires a structured monitoring program.

Bio-Based Living Shoreline (Coir Log Treatment)

**Project Location**

Provide GPS coordinates of project centroid and short description of the project area/location. Provide map in Appendix A.

The project is located in the Strathmere section of the Township of Upper in Cape May County, New Jersey. It is located along Strathmere Bay at the western end of Bayview Drive, and is part of the Carson Inlet and Sound/Ludlam Bay watershed.

Northeastern Extent: 39.195, -74.663
Southwestern Extent: 39.194, -74.664

Treatment Description

Description of treatment and control (if applicable) designs including: relationships to existing structures on site; replications; and components. Detail should be reflective of the current stage of project and should be updated throughout the course of the project to reflect any, and all, changes or adaptive management activities. Previous entries should not be altered, but a new section should be added by date. This section will serve as a journal of the conception and evolution of treatments/installations.

The treatment will consist of two coir-log cusps, placed so that they create a "tiered", or "step", topography moving from the water into the already existing marsh. The water-ward cusp will be installed at an elevation of -2.41', bringing the landward fill height to -0.34', just above mean water (MW, -0.47') relative to NAVD Datum 1988 (as are all elevations). The landward cusp will be placed at -0.34', approximately MW, bringing the subsequent landward fill height to 1.47' at mean high water (MHW). Backfill behind coir logs will consist of clean sediment with organic content suitable for vegetation growth. Net fill below high tide line will be 3.292 cf and net fill below mean high tide line will be 2,747 cf. *Spartina alterniflora* will be planted up to the mean higher high water (MHHW, 1.85'); planted 12” on center. Above MHHW, planted vegetation will consist of *Iva frutscens* and *Baccharis halinifolia*; planted on 5” centers. At the landward extent of the treatment, the bulkhead protecting the renovated boat ramp will be constructed to be 1’ above the boat ramp floor along the entire extent of the vertical descent. This is intended to minimize the reflective wave energy transmitted from the bulkhead to the living shoreline, while also providing protection to the boat ramp.

Endpoints

Description of the parametric value or temporal scale that will dictate the completion of the project according to permit(s).

This project does not have specific end point goals, but aims to track changes to the physical and biological conditions of interest as a result of the installation until 3/2018.

Project Goal and Objectives
List project goal and provide reasoning for this goal being selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...). State project objectives as desired outcomes of the project which are in alignment with its defined goal. To select an appropriate goal(s), see: A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs (Yepsen et al. 2016)

**Goal**

Erosion Control and Habitat: To stabilize shoreline, create habitat and provide flood protection to local infrastructure located behind the Area of Interest (AOI) through the installation of a multi-tiered bio-based living shoreline.

**Objectives**

1. Living shoreline appears visually similar to natural shoreline
2. Erosion control structure maintains its established position and structural integrity
3. Contiguous vegetated edge moves waterward from its baseline position
4. Marsh platform is positioned between mean water and mean high water
5. Vegetation community develops high level of diversity and is robust
6. Shellfish community becomes established in living shoreline

**Monitoring Design**

**Sampling Frame**

Description of the area within which data will be collected, referenced to existing structures, relative position within the local tidal spectrum, and three-dimensional features of interest (e.g: tops of structural components). GPS coordinates (4 minimum) demarcating the bounds of the sampling frame are to be listed. These coordinates are to be collected during the first survey (see Table 2 below). A map of the sampling frame is included in Appendix A.

Sampling frame will extend from mean low water to the landward extent of the regarded area, and from the wooden deck at the northern extent to the concrete
wall at the southernmost extent. Sampling frame will include existing outfall pipe in the southern area of the treatment (Appendix A).

Sampling frame will extend from 1-meter water ward of the water ward cusp to the bulkhead bordering the boat ramp (Appendix A). Sampling frame will also include potentially created marsh to the east of the boat ramp, depending on final construction decisions. Sampling there would include changes in topographic profiles and extents.

**Sampling Frame Coordinates**

39.194574 -74.663424

39.194304 -74.663635

39.194139 -74.663370

39.194268 -74.663339

**Monitoring Metrics Table**

Metrics of interest required by monitoring plan and associated methods used for data collection. Provide monitoring table from Monitoring Frame work, including reasoning for methodologies chosen. Methods in red indicate techniques that require specialized equipment, knowledge, permitting, or training. Methods in green indicate techniques that do not require and specialized, equipment, knowledge, permitting, or training besides on-site instruction for from trained staff. Photo documentation is a mandatory monitoring task at ALL visits to a project site as well as a monitoring task on all monitoring dates.
Table 15. Monitoring Metrics Table. Green and red writing indicate low and high rigor methods, resolutions, and analysis methods respectively.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Metric</th>
<th>Methods</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Analysis Question</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion control</td>
<td>Living shoreline appears visually similar to a natural shoreline</td>
<td>Appearance</td>
<td>1. Photo-doc at fixed points</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined points</td>
<td>Does the living shoreline appear to be visually similar to a natural shoreline?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Erosion control</td>
<td>Erosion control structure maintains its established position</td>
<td>Position of erosion control structures</td>
<td>1. Photo-doc 2. RTK-GPS survey</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points 2. Survey points collected at 1m intervals along top, base, and sides</td>
<td>Is the vertical position of the marsh appropriate for marsh vegetation?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Erosion control</td>
<td>Erosion control structure maintains structural integrity</td>
<td>Structural integrity of materials</td>
<td>1. Photo-doc</td>
<td>Spring and fall</td>
<td>1. Collected at pre-determined photo points</td>
<td>Are the installation materials remaining intact?</td>
<td>1. Observational comparison</td>
</tr>
<tr>
<td>Erosion control &amp; Habitat</td>
<td>Marsh surface is between mean water and mean high water</td>
<td>Vertical position: elevation of treatment area</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td>Is the marsh surface currently or on a trajectory to be positioned vertical between mean water and mean high water?</td>
<td>1. BA 1-way ANOVA Analysis</td>
</tr>
<tr>
<td>Erosion control &amp; Habitat</td>
<td>Vegetated edge moves seaward from baseline position</td>
<td>Position of contiguous vegetated shoreline</td>
<td>1. Measured distance of boundaries along transects 2. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Data collected along each fixed transect (n=3) 2. Survey points collected at 1m intervals along vegetated edge</td>
<td>Is the contiguous vegetated edge moving laterally from its baseline position?</td>
<td>1. Distance of edge position along transect tape compared 2. USGS DSS Analysis</td>
</tr>
<tr>
<td>Erosion control &amp; Habitat</td>
<td>Vegetation community is diverse</td>
<td>Position of vegetation community boundaries</td>
<td>1. RTK-GPS survey</td>
<td>Fall</td>
<td>1. Data collected along each fixed transect (n=3) 2. Survey points collected at 1m intervals along vegetated edge</td>
<td>Are the positions of the different vegetation communities moving laterally from their baseline position?</td>
<td>1. Distance of edge position along transect tape compared 2. USGS DSS Analysis</td>
</tr>
<tr>
<td>Erosion control &amp; Habitat</td>
<td>Vegetation community develops to be robust</td>
<td>Vegetation robustness</td>
<td>1. Integrate vegetation height and vertical/ horizontal obstruction</td>
<td>Fall</td>
<td>1. Collected in pre-determined fixed monitoring plots (CN Sci blade heights collected in same plots)</td>
<td>Is vegetation robustness changing from its baseline measurement in each vegetation community?</td>
<td>1. BA 1-way ANOVA Analysis for each community</td>
</tr>
<tr>
<td>Erosion control &amp; Habitat</td>
<td>Seafish establish residence in the living shoreline</td>
<td>Seafish population density</td>
<td>1. Observation across site</td>
<td>Fall</td>
<td>1. Observation of seafish presence at any location across site</td>
<td>Are seafish becoming established at any location in the living shoreline?</td>
<td>1. Presence absence comparison over time</td>
</tr>
</tbody>
</table>

### Sampling Design Types and Spatial Resolution

Description of the sampling methodologies/techniques employed (e.g. systematic non-random grid sampling, targeted point sampling, stratified random sampling, etc...), the spatial resolution at which the methodologies will be employed, and their associated metrics from Table 1. All metrics from Table 1 need to be accounted for under one of the Sampling Design Types listed below.

1. **Targeted Point Sampling:** a survey design in which RTK-GPS point survey data are collected at specific, targeted locations in order to capture the features of interest at an appropriate resolution. An RTK point will capture the latitude, longitude and elevation for the following metrics at the resolutions listed below:

   1. **Position of Erosion Control Structure:** 1m intervals along the top, sides and base of structures
   2. **Position of Contiguous Vegetated Shoreline:** 1m intervals along boundary
   3. **Position of Vegetation Community Boundaries:** 1m intervals along
4. Vertical Position: Elevation of Treatment Area: 3m x 3m grid (maximum extent) across treatment area

2. Stratified Plot Sampling: a sampling scheme in which the treatment area is divided into strata among which sampling is targeted. Within each strata replicate plots (n=3) are placed in fixed locations along transects which are resampled periodically. Three transects will be placed along the AOI, numbering 1-3 left to right looking landward. Within each transect there will be a fixed endpoint waterward of built structures and three fixed sampling plots placed in the following strata: low marsh zone; high marsh zone; upland zone. Metrics within strata are:

1. Vegetation Robustness
2. Shellfish Population Density

3. Site Level Sampling (Measured or Observational): a sampling scheme in which either: data will likely not vary across the AOI (e.g. water temperature, wave climate, etc.) and sub-sampling is not required; or it is not advisable to limit the scope of monitoring within treatment area (e.g. stratified sampling locals), as the data of interest may be aggregated and thus not captured by targeted sampling (e.g. shellfish aggregates). At this site, metrics that will be evaluated across the site are:

1. Appearance
2. Structural Integrity of Materials
3. Shellfish Population Density (Full Survey)

**Sampling Temporal Resolution and Table**

Description and table of planned sampling events including large scale factor level events such as site characterization, baseline data collection, as-built surveying and annual monitoring, as well as seasonally focused monitoring such as vegetation monitoring occurring during maximum growth seasons and aerial survey during leaf-off seasons.

Sample data is characterized as being collected "Baseline", "As Built" and "After #" (e.g. first data collection effort after installation = After 1; second effort = After 2, etc…) for use in statistical analysis. As of now there is no additional
annual monitoring planned for this site.

Table 86. Monitoring task timeline table. As in monitoring metric table, green and red indicate efforts for low and high rigor methods respectively.

<table>
<thead>
<tr>
<th>Collection Window</th>
<th>Monitoring Stage</th>
<th>Metric</th>
<th>Method</th>
<th>Collected On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td>Appearance</td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position of erosion control structures</td>
<td>1. Collected at pre-determined photo points</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural integrity of materials</td>
<td>1. Collected at pre-determined photo points</td>
<td>05/23/2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vertical position: elevation of treatment area</td>
<td>1. Survey points collected at a minimum of 3m x 3m resolution</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position of contiguous vegetated shoreline</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position of vegetation community boundaries</td>
<td>1. Data collected along each fixed transect (n=3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vegetation robustness</td>
<td>1. Collected in pre-determined fixed monitoring plots (CIT Sci blade heights collected in same plots)</td>
<td>08/04/2017 &amp; 10/03/2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shellfish population density</td>
<td>1. Observation of shellfish presence at any location across site</td>
<td></td>
</tr>
</tbody>
</table>

| After 1           |                  | Appearance                           | 1. Collected at pre-determined photo points                            |              |
|                   |                  | Position of erosion control structures | 1. Collected at pre-determined photo points                            |              |
|                   |                  | Structural integrity of materials     | 1. Collected at pre-determined photo points                            |              |
|                   |                  | Vertical position: elevation of treatment area | 1. Survey points collected at a minimum of 3m x 3m resolution |              |
|                   |                  | Position of contiguous vegetated shoreline | 1. Data collected along each fixed transect (n=3)                  |              |
|                   |                  | Position of vegetation community boundaries | 1. Data collected along each fixed transect (n=3)                  |              |
|                   |                  | Vegetation robustness                | 1. Collected in pre-determined fixed monitoring plots (CIT Sci blade heights collected in same plots) |              |
|                   |                  | Shellfish population density         | 1. Observation of shellfish presence at any location across site     |              |
Site Maps

Upper Township Living Shoreline

Figure 20.9 Location of Upper Township Living Shoreline.
Figure 21. Sampling Frame.
Figure 22.10 Transect and sampling plot locations.
Field Methods

Method for Fixed Photo Point Observations

Partnership for the Delaware Estuary (PDE) Method

Prepared By: Sarah Bouboulis

Description

This method describes the collection of fixed photo points at restoration projects. Photo documentation of a site will be taken from predetermined and demarcated photo points to assess the changes over time of the area. Because locational positioning of restoration structures and relevant areas of interest (e.g. current vegetation line, location of outfalls etc.) is being measured in other ways, it is not critical that photo-point photographs are an exact replicate of previous photos, but rather capture the entire area of interest.

Summary of Approach

Changes over time are critical to document, whether it be for a permit or educational use. By taking pictures at fixed locations, more exact changes can be documented over time. Importantly, when taking fixed photo points, it is crucial to find the location of the fixed position and to identify the features that you are supposed to capture in the photograph. To ensure that this occurs, detailed descriptions of location, direction, and features should be documented so that all photos capture the same area. In addition to fixed photo points, supplementary photographs should be taken at the discretion of the photographers to document other interesting conditions at the site.

Equipment and Materials

Camera

Photo Journal/Station Location Guide

Topographic and/or site map with photo point locations

Extra batteries for camera (if applicable)

GPS unit (if applicable)

Optional:

Aerial photos and previous photos if available

GoPro with Telescoping Pole for overhead images
Ruler (for scale on close up views of streams and vegetation)

Posts for dedicating fixed photo points if the site plan allows for installation

**Procedures**

1. In the photo journal, record information about the site including site ID, date, photographer name, camera being used and start time. An example can be seen below:

   **Upper Township Project**
   
   July 6, 2016
   
   D. Stout
   
   PDE Camera 1
   
   Start 10:30 AM

2. Ensure that the date and time in the camera are set correctly. If they are not correct and you cannot figure out how to reset them; make a note of the incorrect time on the datasheet.

3. Confirm photographer location with either existing marker (steel fence post), GPS, or by referencing the description contained within the station location guide. When creating descriptions for the station location guide, descriptions should be detailed enough that someone unfamiliar with the project could capture the same image.

4. Locate the definitive features for the given photo-point and correctly align the features of interest described within the station location guide/photo journal.

5. Take a photograph.

6. With digital cameras, confirm photograph is as close to a complete duplication as possible to the original photograph.
   
   a. Pay particular attention to the corners of the old photo. Does your photo have the same features in each corner?
   
   b. Does your photo look like it is too close or too far away? If so, move accordingly.
   
   c. Is the horizon the same?

7. Record all of the photo numbers in the photo journal along with a detailed description of the features that the photo contains.

8. If possible, attach GoPro to the telescoping pole. Use the station location guide/photo journal to set the height of the telescoping pole. GoPro has a smartphone application
that allows you to see what your GoPro will capture. Line up the camera to capture the features described in the station location guide/photo journal. Take the photo. Record the photo number(s) in the photo journal/datasheet.

9. Once all required photos have been taken, survey the site to see if there are any additional features of interest that should be captured (e.g. extensive bycatch, presence of significant wrack, unexpected plants). Record descriptions of any additional photos taken in the photo journal with photo numbers.

10. If applicable, fill out data sheet. For long term monitoring, it is critical to document factors about the photograph that are not contained within the picture. The following information should be recorded with all photo-points and supplementary photographs:
   a. Photo file name
   b. Date the photograph was taken
   c. Name of photographer
   d. Location (site and stream)
   e. Description of photograph

11. Photos are to be transferred off of the camera shortly after they are collected.

12. It is important to have file and data management of pictures. Follow appropriate project specific protocols for archiving photos (i.e., PDE-Best Practice #2 Procedure for Archiving Photo Data)

Methods for Vegetation Growth

Partnership for the Delaware Estuary (PDE) Method

Prepared By: LeeAnn Haaf

Description

This describes methods for collecting data at 1 m² vegetation plots to assess vegetation growth, by linking the blade height to the growth of the plant layer.

Equipment

- Quadrats made from ½” diameter PVC with inside area 1 m²
- 2 meter sticks
- GPS unit, with sites
- Camera
- Writing Utensil
Clip board
Maps of sites
Datasheets
Plant Field Guide

**Preparation**

Upload sites onto GPS.

**Procedure**

**Locating Plots**

1. Coordinates of plots should be loaded into GPS before work begins
2. Plots should be marked with at least one PVC stake
3. Maps of the site may be useful if vegetation is thick or cloud cover limits GPS accuracy
4. Proceed with data collection as described below

**Data Collection**

1. Lay 1.0 m² quadrat over permanent PVC markers or with middle of quadrant at GPS point
   a. Avoid disturbing canopy structure by reassembling quadrat in place
2. Record: Location and its respective plot number; initials of crew on datasheet
3. Use plant guide to correctly identify plants in the plot
   i. If plant is unknown, take sample & photo (note photo # on data sheet), identified *within 48 hours* of sampling
4. Measure blade heights – on blade height datasheet
   a. Measure the height, in centimeters, of the first 25 stems of individual plants
      i. Do not use multiple leaves from the same plant
      ii. Start with a corner closest to the water’s edge, working diagonally towards opposite corner
      iii. Stems and species are recorded in the order they occur
   b. Make any notes if measurements capture average height of all plants in the plot
Field and Calculative Methods for the Measurement of Vegetation Robustness
Partnership for the Delaware Estuary (PDE) Method

Prepared By: Joshua Moody

Description

This method describes the field and calculative steps for measuring the vegetation robustness within a 1m² quadrat at a specific location. It does not include methods for determining the placement or replication of quadrats within an AOI. Vegetation robustness requires the calculation of vertical and horizontal light obstruction, which are subsequently integrated in the final calculation. The method has been organized into the following sections:

1. Vertical Vegetation Obstruction
   1.1. Field methods
   1.2. Calculation
2. Horizontal Vegetation Obstruction
   2.1. Field Methods
   2.2. Calculation
3. Vegetation Robustness Calculation

Summary of Approach

Vegetation robustness is a unitless index that integrates the vertical and horizontal density of the vegetation, calculated as the attenuation of light in both directions. Vertical and horizontal obstruction are calculated independently for the same area as percentages of the light attenuated in its specified direction. The two percentages are subsequently averaged for the final vegetation robustness, or multi-directional attenuative ability, calculation.

Vertical vegetation obstruction is calculated within a 1m² quadrat using a light meter to measure the difference in luminosity above (i.e. ambient conditions) and below (i.e. at the substrate surface) the vegetation canopy. The ratio of penetrative to ambient light is calculated and subtracted from 1 to calculate the vegetation obstructive capacity (i.e. the percentage of light attenuated by the canopy). Horizontal vegetation obstruction is calculated within a 1m² quadrat using a vegetation obstruction board to calculate the visual obstruction horizontally across the landscape within a vegetation zone, normalized.
by the maximum vegetation height. The vegetation obstruction board has a series of ten 10cm alternating red and white stripes that are viewed at multiple elevations (0.25m, 0.50m, and 0.75m above the substrate), depending on vegetation height. Horizontal vegetation obstruction is calculated as the percentage of bars obstructed of those available based on vegetation height. Vegetation robustness is finally calculated by averaging the vertical and horizontal obstruction percentages, and is interpreted as a corollary of vegetation density (e.g. high vegetation robustness can be interpreted as a relative high vegetation density and low vegetation robustness can be interpreted as a relative low vegetation density).

Equipment: Vertical Vegetation Obstruction

- 1m² quadrat
- Light meter
- Data sheet
- Pens/pencils

Equipment: Horizontal Vegetation Obstruction

- 1m² quadrat
- Meter stick
- Vegetation Obstruction board 1m in length with ten 10cm alternating red/white stripes and a 4m cord attached to one end
- 2 Vegetation obstruction height sticks demarcated at 0.25m, 0.50, and 0.75m

Procedure

45.1 Vertical Vegetation Obstruction

Field Methods

45.1.1 Place quadrat flush with substrate at appropriate location

45.1.2 Before recording measurements, make sure that light conditions are representative for current time (e.g. a cloud is not passing over in an otherwise clear sky)

45.1.3 Position light meter in center of quadrat above vegetation (i.e. no shadows covering sensor of light meter) and record luminosity
45.1.4 Repeat in each corner of the quad above the vegetation canopy recording luminosity at each corner (n=5 measurements above canopy)

45.1.5 Position light meter in center of quad on the substrate and record luminosity

45.1.6 Repeat in each corner of the quad at the substrate level recording luminosity at each corner (n=5 measurements below canopy at substrate)

Calculation

45.1.7 Vertical Vegetation Obstruction= 1-((x̅ substrate luminosity)/( x̅ ambient light))

45.2 Horizontal Vegetation Obstruction

Field Methods

45.2.1 Place quadrat flush with substrate at appropriate location

45.2.2 Place meter stick in center of quad and measure the maximum height of the vegetation and record on the data sheet

45.2.2.1 If max vegetation height is 1cm-49cm only count bars at 0.25m height

45.2.2.2 If max vegetation height is 50cm-74cm only count bars at 0.25m and 0.50m heights

45.2.2.3 If max vegetation height is greater than 75cm count bars at 0.25m, 0.50m, and 0.75m heights

45.2.3 Place vegetation board in center of quadrat oriented so that the face that will be read is directed towards the same vegetation type within the quadrat (i.e. if the quadrat contains tall *Spartina alterniflora* make sure that the face of board is pointing towards the same continuous band of tall *Spartina alterniflora* not another vegetation community such as short *S. patens* etc...)

45.2.4 A second person takes the end of the 4m rope attached to the vegetation board and walk 4m within the same band of vegetation (i.e. same type so reading is conducted through 4m of a similar vegetation type) and turns to face the vegetation board

45.2.5 The first person holds the vegetation board at the 0.25m position on the first height stick
45.2.6 The second person positions themselves so that their visual field is at the 0.25m level on the second height stick and counts the numbers of bars that they can see at least a portion of.

45.2.7 This number is recorded on the data sheet as number of bars visible at 0.25m.

45.2.8 Steps 2.15-2.17 are repeated for the 0.50m and 0.75m heights if applicable (see 2.1.2).

Calculation

45.2.9 \( \text{Horizontal Vegetation Obstruction} = \frac{\text{bars available} - \text{bars visible}}{\text{bars available}} \)

45.2.9.1 Bars Available: the total number of bars at all levels that could be obstructed based on vegetation height. If the vegetation is 0.8m tall, all three levels (0.25m, 0.50m, and 0.75m) will be assessed for horizontal obstruction, and therefore there is a potential of 30 bars available for obstruction (10 at each height level). If the vegetation is 0.30m, then there are 10 bars available for obstruction (10 at the 0.25m height).

45.2.9.2 Bars Visible: the total numbers of bars counted at all heights assessed.

45.3 Vegetation Robustness Calculation

45.3.1 \( \text{Vegetation Robustness} = \frac{\text{Vertical Obstruction} + \text{Horizontal Obstruction}}{2} \)

Method for HOBO Water Level Logger Deployment and Assessing Hydroperiods on Tidal Marsh Platforms

Partnership for the Delaware Estuary (PDE) Method

Prepared By: LeeAnn Haaf

Description

HOBO (Onset® brand) water level loggers are placed into protective PVC housing and installed on the surface of a tidal marsh platform to monitor the hydroperiod of that location over approximately one month.

Equipment

Onset HOBO water level loggers (including launching software and hardware)
3” PVC housings (prefabricated for HOBO use)
Stakes (wood or ½”-1” PVC)
Zip ties
Mallet
RTK GPS unit

Procedure

Deployment

1. HOBO water level loggers are launched (i.e. beginning logging data) according to the provided manual instructions.
   a. This requires HOBO’s software and USB hardware.
   b. HOBO deployment can be delayed, date/time of start should be the day of deployment (preferably a morning time, before they are installed)
   c. Ensure that each HOBO has a unique label (Fig 1.)

2. Loggers are then securely attached to 3” PVC housings using zip ties.
   a. PVC housing should only be slightly longer than the HOBO and holes should be drilled on one side of the housing to assist surface water flow to reach the HOBO, but dissuade precipitation from interfering with data collection.
   b. Zip ties can go through the HOBO’s screw cap, and across the body of the HOBO, but care should be taken to avoid strapping zip ties across the pressure sensor (Fig 2).
   c. Be sure to match HOBO unit label with housing’s label; label must be recorded for each deployment location
Fig 1. Titanium water level HOBO by Onset®.

Screw cap (for data retrieval)

Duct tape with unique label

Pressure sensor

Fig 2. a) PVC housing with holes drilled into the bottom section; b) placement of HOBO within the housing.
3. For marsh surface installation, an RTK GPS point should be taken to ensure that accurate elevation data is available for the logging location (RTK GPS point name should reflect the HOBO’s label); HOBO within PVC housing can thereafter be installed onto the marsh surface using PVC or wood stakes and gently hammered in with a mallet
   a. Care should be taken with hammering stakes in as HOBOs can be damaged with the vibrations; it is suggested that stakes be hammered in, and once in position, zip tied to the HOBO’s housing.
   b. The correct position of the housing is perpendicular to the main water way; housing should also be flush with the marsh surface.
4. An ambient air pressure HOBO (another water level logger) should be maintained as a control for each deployment site or array.
   a. Water level loggers measure water level by pressure, so an ambient air pressure controls help ensure accuracy.
   b. Housing for an air pressure control should be a 3” dia. PVC that is ~5-6’ long with a T joint PVC cap (ensuring air flow, but limiting precipitation interference); height should ensure that water levels do not touch the HOBO.
      i. This should be securely inserted into the marsh (1-2’ deep); PVC can be hammered with a mallet, but do so only if it is planned that HOBO is zip tied after PVC is in place.
5. Once secured to the marsh surface, HOBOs can remain for up to 3 months (recording every 15 minutes); when multiple locations are to be surveyed, a minimum of one month is suggested to account for one full lunar cycle.
   a. There is other seasonal variations that may occur, so these factors should be noted and considered for each deployment and data analysis thereafter.
      Major storm surge event should also be noted to further account for anomalous water levels.
6. At the end of deployment, HOBOs can be collected and data retrieve from each unit.

Data Download (Spencer Roberts 12/23/2015)
Part 1 is needed to determine a reference water level

1. After HOBO data is exported and saved, open .csv for each plot in Excel.
2. In all plot files except for the control, add two columns for Control Pressure and Control Temperature
3. Copy and paste the control temperature and control pressure data into each of the plot spreadsheets
4. Create two additional columns
a. The first – the **delta pressure** aka the difference between the plot pressure and the control at each time point
b. The second – The **delta temperature** aka the difference between the plot temperature and the control at each time point

5. Combine all the plot .csv files into one database file
6. Sort this master spreadsheet by value in the **delta pressure**
7. Look for all values where the **delta pressure** equals 0
   a. We are especially interested in the LMR/ Riverine plots
   b. We are going to assume if the pressure is the same, then potentially the plot HOBO was exposed
   c. With these LMR sites highlighted, lookup the NOAA tides for this day or some of these days for reference.
   d. We are looking for the times when the pressure is 0 and we can confirm the tide was at low/ falling and close to low tide
      i. i.e. if it was low tide, aka the most likely time for the LMR plot to not be inundated, and the **delta pressure** was 0 for that time then these are the most likely times the **water level** was equal to 0 and will become our reference
   e. It is possible there will be multiple times/ points where everything screams **water level** = 0, that is fine, pick one and highlight or bold it for the next step

Part 2 is utilizing the HOBO software to give us water level tables
1. Open each HOBO file for each plot, except the Control
2. The HOBOware program will prompt you in a pop-up window
   a. Make sure Barometric Compensation Assistant is highlighted, click on **Process**
3. For fluid density, select the water salinity type that fits best
4. Check use reference water level
   a. Make sure is set to 0 m or ft
   b. In the scroll down menu select the time you highlighted in the Master file
5. Next select **Use Barometric Datafile** and select the Control HOBO file
6. To finish click **Create New Series** and then **Plot**
7. If the reference water level is good, then there should be none or minimal point less than 0 on the graph
8. In a tidal situation, there will be peak and bases to these peak at 0 (or not if the wetland the percent inundation is high)
9. If things seem off, try again and make sure **Constant Barometric Pressure** is not selected and it is using the Control file as a reference for barometric pressure
10. If there are a lot of values under 0, then try a different reference water level time point from the Master database.
11. A new data table from the water level graph can be saved/ exported for further analysis in excel

**RTK Point Collection and ArcGIS Methods for Topographic Elevation Modeling in an Area of Interest**

*Partnership for the Delaware Estuary (PDE) Method*

*Prepared By: Joshua Moody*

**Description**

This method describes the procedure for field-based surveys to collect geospatial point-data using and RTK-GPS, and subsequent ArcGIS methods for building Digital Elevation Models (DEMs) of the survey areas and to compare multi-year DEMs to calculate elevational changes through time. The method has been organized into the following sections:

4. Field-based RTK-GPS data collection methodologies for:
   4.1. Topographic grid survey of an area of interest (AOI)
   4.2. Feature of interest survey within an AOI
5. Subsequent desktop-based ArcGIS methodologies for:
   5.1. Building a topographic Digital Elevation Model (DEM) of the AOI
   5.2. Comparison of multi-year datasets to measure elevational changes within an AOI

**Summary of Approach**

Field-based RTK-GPS surveys of an AOI are collected using two approaches: a platform grid survey; and a feature-based survey. A platform grid survey describes methods in which RTK-GPS survey points are collected at equal interval along transects separated by the same distance, to create a uniform grid of survey points (e.g. 10m x 10m). After an AOI has been delineated (i.e. marginal boundaries have been establish), a resolution for the grid survey is determined. Grid resolution can be of any extent, but is typically between 2m² and 10m², and is determined by the balance between resolutonal needs (i.e. topographic complexity) of the AOI and temporal and budgetary constraints that may limit the time available to survey. Areas of interest that are topographically uniform or where elevation
changes in a singular fashion with distance (e.g. linear, exponential, etc...) will have a lower resolutinal need than AOIs with a high degree of topographic complexity, and high resolution surveys require more resources (e.g. time, budget, staff, etc...).

Once a grid resolution has been established (in this method a 10m² is used), the grid survey can be undertaken. Transects are spaced across the AOI at intervals that match the resolution of the survey and demarcated at each end using 5’ PVC posts. Measuring tapes are used to ensure that the resolution between transects is maintained by checking distances at each end and in the center. RTK-GPS survey points are collected at each end and at the distances equal to the resolution along the length of each transect. Based on the goals of the survey and unique characteristics of each AOI, in addition to latitude, longitude, and elevation, data regarding the vegetation type, substrate, or other characteristic of interest should be collected at each point. The grid survey can be considered a single feature and will be modeled as a continuous surface using a GIS.

Feature-based surveys describe a method in which specific features (vegetation communities, creeks, infrastructure, etc...) are delineated and survey points are collected along their boundaries and within their perimeters. Survey points for each feature are collected within the boundary of that feature to ensure that any elevation measurement are representative of elevation found within the feature boundaries. For example, boundary points of a feature slightly elevated from the surrounding area (e.g. a tuft of vegetation isolated in an intertidal mudflat) must be taken on the elevated surface of the feature, not at the lower elevation representative of the surrounding area. The number of points collected for each feature is not static, and will be dependent on the complexity of the feature. It is important to collect enough survey points to be able to accurately define the geometry of the feature as well as the topographic variability within its boundaries. Each feature is to be given a unique identifier to facilitate isolation and independent topographic modeling within a GIS.

After RTK-GPS field-based survey points have been collected, they are imported into a GIS (this document references ArcGIS) to insure proper projection. The grid survey data is then isolated to create a digital elevation model (DEM) using the Empirical Bayesian Kriging (EBK) tool Geostatistical Analyst extension. To account for potential non-linear degeneration of the surface of the AOI across its extent, maximum overlap of points (5) is allowed and an empirical transformation using a K-Bessel (or detrended K-Bessel) semivariogram model is recommended. The DEM is subsequently exported as a Raster shapefile to be used in conjunction with individual DEMs created for each feature that was
surveyed as per described above. Using the Mosaic to New Raster tool (Raster->Raster Dataset->Mosaic) add each DEM beginning with the DEM produced from the grid-based survey (foundational surface upon which features will be layered) so that the features sit on top of the grid surface (32-bit Float, Bands=1, Operator=LAST). This is now a comprehensive DEM of the topography of the AOI for the period of time when the survey was conducted.

In order to calculate changes over time, rasters created for multiple time periods will need to be compared. To do this, an attribute table for each comprehensive DEM needs to be created containing the elevation value of each pixel. The Raster Calculator is used to multiply the value field by 100, and is subsequently copied (Data Management->Raster->Raster Dataset->Copy Raster) as a 32-bit integer raster (add lowest model value in No Data field). The Build Attribute Table tool (Data Management->Raster->Raster Properties->Build Raster Attribute Table) is used to create the table, and a new field (Elev, Type=Float 8,5) is added, and subsequently back-calculated to the original elevation value (Value in comprehensive DEM = Value in 32-bit integer raster/100). Elevation models for multiple years are now able to be compared using the Raster Calculator to subtract newer models from the baseline model; pixels with negative values lost elevation, and pixels with positive values gained elevation.

**Equipment**

- Ten 5' PVC posts
- RTK GPS
- Three Survey Tapes (100 m long)
- Field Notebook/ Pens
- ArcGIS 9.0 or higher
- ArcGIS Geostatistical Analyst Extension

**Procedure**

**Field-Based RTK-GPS Data Collection Methodologies**

47.1 **Topographic Grid Survey of an Area of Interest (AOI)**

47.1.1 Demarcate transects
47.1.1.1 Assistant 1 stands at transect 1 edge, located at one extent of the AOI and places one 5’ PVC post in ground.

47.1.1.2 Assistant 2 attaches survey tape to the PVC post at transect 1 edge and walks across the AOI to transect end and places second PVC post in ground and attaches survey tape.

47.1.1.3 Assistants 1 and 2 measure a distance equal to the grid resolution (e.g. 10m in this example for a 10m² grid survey) from each transect 1 endpoint post into the AOI and place the transect 2 endpoint posts into the ground.

47.1.1.4 A survey tape is attached to each endpoint post on transect 2

47.1.1.5 The distance between transects 1 and 2 is checked at the mid-point to ensure distance is equal to the grid resolution

47.1.2 Collect RTK-GPS survey points along each transect

47.1.2.1 A new job is started in survey unit for the grid-based survey

47.1.2.2 Surveyor collects point at end point of transect 1

47.1.2.3 Surveyor moves distances along the survey tape stretched along transect 1 equal to the grid resolution (e.g. 10m) and collects a points until the transect is completely surveyed

47.1.2.4 Surveyor repeats steps at all subsequent transects

47.1.2.5 Job file is exported as ESRI fixed format file

47.2 Feature of Interest Survey Within an AOI

47.2.1 Identify features of interest

47.2.1.1 All features of interest are listed and described in field notes

47.2.2 Collect Survey Points for each feature of interest

47.2.2.1 A new job is started in survey unit for the feature survey

47.2.2.2 First feature is given unique name followed by enough “blank numbers” to cover the number of points to be collected (e.g. VegIsland0 if you expect less than 10 points to be collected; VegIsland00 if you expect less than 100 points to be collected)

47.2.2.3 Surveyor collects survey points along borders of first feature to completely capture geometry

47.2.2.4 Surveyor collects survey points within the interior of first feature at a resolution to capture its internal topographic variability
47.2.2.5 Repeat steps for each feature of interest
47.2.2.6 Job file is exported as ESRI fixed format file

Desktop-Based ArcGIS Methodologies

47.3 Building A Topographic Digital Elevation Model (DEM) of an AOI

47.3.1 Import all point data in to GIS and project in appropriate coordinate system

47.3.2 Isolate grid-based survey a single point dataset

47.3.3 Create a new shapefile outlining the boundaries of the AOI

47.3.3.1 Right click on appropriate folder in ArcCatalog
47.3.3.2 New->Shapefile
47.3.3.3 Name: Polygon; Feature Type: Polygon; Spatial Reference: Appropriate projection system; Click OK
47.3.3.4 Right click new shapefile->Edit Features->Start Editing
47.3.3.5 Outline the extent of the survey area to set boundaries and save as AOI

47.3.4 Isolate each feature from the feature-based survey as an individual point dataset

47.3.4.1 Open attribute table and highlight rows of a single feature (e.g. creek, vegetation clump, etc…)
47.3.4.2 Right click on full point file in the table of contents (left sidebar)
47.3.4.3 Export->Data->Export: Selected Features

47.3.5 Create new shapefiles outlining the boundaries of each feature from the feature-based survey (now an individual point dataset) as with the AOI in 2.1.c

47.3.6 Open Geostatistical Wizard in Geostatistical Analyst Toolbar

47.3.7 Create Topographic Digital Elevation Model (DEM) from grid-based survey

47.3.7.1 Methods: Empirical Bayesian Kriging under Geostatistical methods
47.3.7.2 Import Data

47.3.7.2.1 Source Dataset: grid-based survey point data; Data Field: elevation field; Click Next

47.3.7.3 Set the General Properties and Run Model

47.3.7.3.1 Subset Size: 100; Overlap Factor: 5; Number of Simulations: 100; Output Surface Type: Prediction; Transformation: Empirical; Semivariogram Type: K-Bessel;
Search Neighborhood: Default; Predicted Value: Default; Click Next

47.3.7.4 Investigate semivariogram prediction errors and QQ plot to insure model is meets the users requirements (information to assess model can be found at: http://desktop.arcgis.com/en/arcmap/10.3/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm) Hit Finish

47.3.7.5 Right click model->Save as Layer File

47.3.7.6 Right click model->Data->Export to Raster

47.3.7.7 Data Management->Raster->Raster Processing->Clip

47.3.7.8 **Input Raster:** Raster DEM from EBK model (2.1.f.iv); **Output Extent:** AOI (2.1.c.v); Check **Used Input Features for Clipping Geometry** box; **Output Raster Dataset:** Appropriate location; **NoData Value:** the lowest elevation value noted in the DEM; Do NOT check **Maintain Clipping Extent; Click OK**

47.3.8 Follow steps in 2.1f Create Topographic Digital Elevation Model (DEM), for each feature of interest isolated as a single point file in step 2.1.d, but using the polygon of each feature as the clipping extent in the final step

47.3.9 Layer the DEMs to create a single, site-wide topographic DEM

47.3.9.1 Raster->Raster Dataset->Mosaic To New Raster

47.3.9.2 Add each DEM **BEGINNING with the gridd-based DEM (***this one first***)**

47.3.9.3 Add appropriate destination, name, and spatial reference; **Pixel Type:** 32-bit Float; **Number of Bands:** 1; Click OK

47.3.10 Make 32-bit Signed Copy

47.3.10.1 Spatial Analyst Tool->Map Algebra->Raster Calculator

47.3.10.2 Create equation to multiply the values of each pixel by 100: **Final DEM** (step 2.1.i) * 100; set appropriate output location/name; **Click OK**

47.3.10.3 You now have an identical DEM with the value (elevation increased by two orders of magnitude)

47.3.10.4 Data Management-> Raster->Raster Dataset->Copy Raster

47.3.10.5 Add Raster created in 2.1.j.ii; set appropriate output location; **NoData Value:** lowest value in 2.1.j.ii output; **Pixel Type:** 32-bit Signed; **Click Environments…; Processing Extent:** AOI; **Click OK**

47.3.11 Build Attribute Table

47.3.11.1 Data Management->Raster->Raster Properties->Build Raster Attribute Table

47.3.11.2 Enter raster from 2.1.j
47.3.12 Back-calculate original elevation values
   47.3.12.1 Open raster attribute table
   47.3.12.2 Table Options->Add Field
   47.3.12.3 Name: Elev; Type: Float (Precision=8; Scale=5); Click OK
   47.3.12.4 Right click on raster->Edit Features-> Start Editing
   47.3.12.5 Right click on Elev field heading in attribute table->Field Calculator
   47.3.12.6 Elev=Value/100
   47.3.12.7 Click OK

47.4 Comparison of Multi-Year Datasets to Measure Elevational Changes within an AOI
   47.4.1 Spatial Analyst Tool->Map Algebra->Raster Calculator
   47.4.2 Create equation to subtract older (original Time 1) time-point DEMs from newer datasets; Time2 – Time 1; set appropriate output raster; Click OK
   47.4.3 Negative values indicate the magnitude of loss of elevation at that location since the Time 1 data was collected, positive values indicate the magnitude of gain in elevation since the time 1 data was collected

Methods for Percent Vegetative Growth
Partnership for the Delaware Estuary (PDE) Method
Prepared By: LeeAnn Haaf

Description
This describes methods for collecting vegetative cover data at 1 m² vegetation plots. This type of data is used to track changes over time and infer relationships between the plant community and abiotic factors.

Equipment

1 1.0 m² PVC quadrat

GPS unit - with sites

Writing utensil

Clip board

Plant field guide
**Preparation**

Upload sites onto GPS.

**Procedure**

1. Lay 1.0 m² quadrat over permanent PVC markers or with middle of quadrant at GPS point
   a. Avoid disturbing canopy structure by reassembling quadrat in place
2. Record: Location and its respective plot number; initials of crew on datasheet
3. Use plant guide to correctly identify plants in the plot
   a. If plant is unknown, take sample & photo (note photo # on data sheet), identified *within 48 hours* of sampling
4. Estimate cover visually and agree on approximate covers amongst field crew
   a. Percent cover should reflect one species at a time; overlap may occur, so percentages may not add to 100%—avoid doing arithmetic in the field; *only use “total” cover anecdotaly to prevent confusion*

**References**

These methods have been adapted from Braun-Blanquet’s cover-abundance scale


**Best Practice # 18 Field Protocol for Vegetation: Survivorship**

**Description:** Collect data at 1 m² vegetation plots to assess vegetation survivorship of planted plugs at restoration sites.

**Materials**

Required for sampling

- 1.0 m² PVC quadrat
- 2 meter stick
- GPS unit-with sites
- Camera
Protocols

A stratified random sampling technique to determine the location of permanent survey plots will be used. The number of sampling plots depends on the vegetation community, final number of plantings, number and size of planting areas and spacing of plantings. Data should be collected at 3 or more sampling plots to allow for statistical analysis, when possible. Since some of the habitat types that are being re-vegetated could be very narrow bands, it is possible that the plots will not fall within each habitat type.

1. Plots should be marked with at least one PVC stake
2. Maps of the site may be useful if vegetation is thick or cloud cover limits GPS accuracy
3. Lay 1.0 m² quadrat over permanent PVC markers or with middle of quadrant at GPS point
4. Record presence or absence of each live plug including each species
5. Record observations regarding plant health (e.g., vigor, evidence of herbivory, evidence of dieback shoots, severe insect infestation, etc.) on data sheet

Best Practice #14 Set-Up and Use of the Trimble RTK GPS

Materials

- Data Logger (Controller)
- Antenna (Receiver)
- Pole (2 sections inside case)
- Mifi
- Battery Pack (2) – for Antenna
- Controller handle (clip) – attaches data logger to the pole
- Case for mifi (waterproof)
- Tape measure/Measuring stick
- Charging device (1), Charging cords (2)
- Pelican Hard Case

Protocols
Day Before

1. Charge three parts:
   a. **Battery pack(s)** for Antenna - removable packs fit into charger which has cord to plug into electrical outlet
   b. **Mifi** – cord connects device to electrical outlet (USB)
   c. **Data Logger** – cord connects device to electrical outlet

Survey Day

**Assembly & Setup**

1. Turn on mifi and place into waterproof case
2. Assemble the pole by screwing 2 parts together
3. Place charged battery pack into Antenna
4. Turn on Antenna
5. Screw Antenna onto top of pole
6. Measure distance from the base of antenna to the bottom of the pole (typical 1.94m)
7. Turn on Data Controller

**Data Controller Settings**

1. Main Menu → Setup Internet → wifi
2. Main Menu → Measure → Create New Job → Give the job a name
3. Main Menu → Measure → Measure Points → VRS Rover → VRS-CMRX

**Logging Points**

Point density of sampling will be determined on a site by site basis. At some sites constructed structures may be GPSed, at others transects may run though the project area, and at others shoreline or creek morphology might be captured. See each projects Monitoring Plan.

1. You should now be on the data capture screen
2. Insert “height to antenna” measurement in height field (#6 under assembly)
3. Naming Scheme – All points need to have a name, but the code-field is optional
   a. Point names will auto-advance in sequential order (numbers or alphabetical), unless otherwise modified.
   b. Code field is just another attribute field to capture additional data. PDE staff often use the code to capture vegetation or sediment types.
4. Press “Enter” (bottom right)
5. Press “Capture Observation” (bottom right)

**Error Handling**

1. Errors will occur if Mifi is moved too far away from the device.
2. Mifi can get too hot if left in its case for too long on sunny days. Keep the case cool and remove the device from its case if needed.
3. High RMS – Points will not log if movement is too high. In this case, abandon the point and recapture.
4. Cannot connect with satellites – reconnect
Day After

Uploading Files
1. Plug RTK handset into computer using USB cord
2. Power handset ON (green button on bottom left-hand corner)
3. On your computer, when the window pops up click ➔ Connect without setting up your device
   a. Click ➔ File Management
      i. ➔ Browse the Contents of your Device
         1. ➔ Trimble data
            a. ➔ Living Shorelines
               i. ➔ Export
                  1. Select Site Files
                  2. Copy (Ctrl-c)
                  3. Open T:\Science Stuff\GIS\Living Shorelines\SITE Name\RTK_Data
                  4. Paste Site Files (Ctrl-v)
                  5. DO NOT DELETE FROM HANDSET
4. On the handset screen, click “X” in the top-right corner to exit
5. Hold power button down for 5 seconds and follow prompts to Shutdown
6. Return handset to library and make sure that the RTK is signed in.
7. Email Data Specialist to alert about new data creation

SOP #42 Field Protocol for Vegetation Assessment at Marsh Futures Bio-Assessment Plots

 Prepared By: Joshua Moody 4/30/2015
Adapted from L. Haaf, Best Practice #5

Aim of Project: Collect data within three 1 m² replicate vegetation plots within each elevation zone of an Area of Interest (AOI) as selected by GIS analysis of survey data. Data will be used to assess current relative vegetation health by comparing data collected within each plot to long term MACWA data. Collected data exhibiting values indicative of poor vegetative health in relation to long term MACWA data will be used to negatively adjust relative vulnerability of site specific AOI elevation zones.

Materials

Required for sampling
- 1- 1.0 m² PVC quadrat
- Digital light meter
- Slide Hammer and Measuring Pipe
- Vegetation Obstruction Board and 2 Elevation Posts
- 1 meter stick
- RTK GPS

- GPS unit-with lat/long of sites loaded
- Camera
- Writing utensil
- Clip board
- Maps of sites in plastic sheet covers
- First aid kit
- Datasheets
- Drinking water
- Bungees to hold quadrats/meter stick
- Extra batteries
- Cell phones
- Extra writing utensils

**Protocols**

**Locating Vegetation Plots**

**In Office:**

6. Assessment plot location selected by team in advance and coordinates of plots should be loaded into GPS
7. Print maps of plot locations for each AOI denoting each plot's elevation zone

**In Field:**

1. Use GPS and maps to locate plot position
2. Proceed with data collection as described below

**Data collection**

5. Position 1.0 m² quadrat so it is flush with substrate
   a. Avoid disturbing canopy structure by reassembling quadrat in place through base of vegetation
6. Record: AOI location; plot name from map (elevation zone and replicate number); weather; data and initials of crew on datasheet
7. RTK five points within the plot: one at center and one in each corner
   a. Use RTK to verify that elevation is appropriate for its indicated marsh zonation. If it is not, shift plot to area of appropriate elevation and make note on data sheet
   b. In RTK plot is named appropriately based on naming structure and coded with dominant vegetation
8. Take a Photo of Plot
   a. Have a crew member hold meter stick over plot; stand ≥10 ft away to capture plot and surrounding environment
   b. If possible, picture should be taken with camera facing the closest body of water (e.g. Bay, large river). This insures that picture is continuously taken from same vantage point.
   c. Take additional photos if there are any outstanding features within a plot that may have an effect on vegetation (e.g. creek running through plot, excessive bioturbation, denuded area, panne in close proximity, etc...)
9. Estimate Plant Coverage
   a. Use plant guide to correctly identify plants in the plot
      i. If plant is unknown, take sample & photo (note photo # on data sheet), identified within 48 hr of sampling
   b. Estimate cover visually and agree on approximate covers amongst field crew
      i. Percent cover should reflect one species at a time; overlap may occur, so percentages may not add to 100%
10. Take Light Measurements (Foot Candles x 10)
    a. Ensure that field crew shadows are not cast into plot, as they will interfere with light readings
    b. Keep light sensor (white dome) clean of dirt, dust, or debris
    c. Visually average readings, look for consistency
    d. Top readings are taken ABOVE the plot canopy
       i. Take 5 top readings; one at each of the quadrat corners, and 1 in the middle of the quadrant
    e. Bottom readings are taken at ground level
       i. Take 5 bottom readings; one at each of the quadrat corners, and 1 in the middle
ii. Light meter is not waterproof, so avoid contact with mud or water

11. Measure Horizontal Obstruction
   a. First member of field team (aka holder) places vegetation obstruction board in the center of the plot oriented perpendicular to band of vegetation within which the plot is located
   b. Second member of field team (aka viewer) uses attached 4m cord to position themselves 4m from vegetation obstruction board within the same band of vegetation the plot is located in
      i. The viewer should be looking through 3m vegetation similar to the vegetation within the plot
      ii. As the viewer walks the 4m to the viewing position, it is important to walk outside the bounds of the view-path so that the vegetation between the viewer and the vegetation obstruction board is not disturbed
   c. Holder places elevation post on marsh surface and centers vegetation obstruction board at the 0.25m mark.
   d. Viewer places elevation post on surface of the marsh and positions themselves eye level to the 0.25m mark.
   e. Viewer counts the number of stripes visible though 4m vegetation band
   f. Steps c-e are repeated for 0.5m elevation and 0.75 meter elevation

12. Measure Blade Heights
   a. Measure the height, in centimeters, of the first 25 stems of individual plants
      i. Do not use multiple leaves from the same plant
      ii. Start with a corner closest to the water’s edge, working diagonally towards opposite corner
      iii. Stems and species are recorded in the order they occur
   b. Make any notes if measurements capture average height of all plants in the plot

13. Bearing Capacity
   a. Record any standing water on the surface of marsh surface
   b. First member of field team places measuring pipe on surface of marsh (gently pushing away any debris that is not part of the marsh surface) and positions their line of sight flush to the marsh surface
   c. Second member of field team places slide hammer on top of measuring pipe
      i. When placing slide hammer, make sure not to apply any pressure which would result in the measuring pipe sinking deeper into the marsh surface than it does from the weight of the hammer alone.
   d. Record initial depth measuring pipe penetrates marsh surface in centimeters
   e. Second member of field team lifts arm of slide hammer to its maximum height and allows it to drop naturally without assisted force
   f. Record Strike 1 total depth of penetration on data sheet
      i. Note: Do not record the depth penetrated for each strike independently, but the total depth penetrated after each strike (e.g. Initial penetration before any strikes is 1cm. After strike 1, penetration is 6cm. Record 6cm for strike 1, not 5cm for the additional depth penetration due to strike 1)
   g. Repeat for Strike 2-4

Change in Lateral Position of a Boundary of Interest
Prepared by: Joshua Moody

**Description**

This standard operating procedure (SOP) describes methods for field-based surveys to collect geospatial point-data using and RTK-GPS, and subsequent ArcGIS methods for calculating the change in lateral position of boundary such as: contiguous vegetated edge of marsh; vegetation community boundaries; edges of marsh platform pannes; or any other “edge” that may laterally shift over time. The SOP has been organized into the following sections:

1. Field-based RTK-GPS data collection methodologies
2. Desktop-based ArcGIS methodologies for creating boundary polyline shapefiles
3. Desktop-based ArcGIS USGS Digital Shoreline Analysis Software (DSAS) methodologies for measuring lateral shift in a boundary position over time

**Summary of Approach**

Field-based RTK-GPS surveys of a boundary of interest, including contiguous vegetated edge of marsh, vegetation community boundaries, edges of marsh platform pannes, or any other “edge” that may laterally shift over time, are conducted at a scale appropriate to the needs of the data and the available resources (e.g. budget, time, etc…). Typically survey points along the boundary of interest are collected where directional change does not occur, and at each location where a change in direction does occur (e.g. corners, curves, or any other node with a directional shift of the boundary). Along lengths of the boundary of interest where no directional change occurs, survey points are collected at 3m intervals.

After survey data are collected, they are imported into ArcGIS, projected correctly, and are used to create a polyline shapefile of the boundary. A new shapefile is created in the appropriate folder in ArcCatalog (right click appropriate folder in arch catalog -> new polyline shapefile), using the Edit tool and engaging the snapping tool, a polyline is drawn to represent the boundary using the collected point survey data as the template. After multiple measurements of the boundary are collected representing the timeframe of interest (weekly, monthly, annually, etc…) the change in lateral position of the boundary is measured using the USGS Digital Shoreline Analysis Software (DSAS) available here: http://woodhole.er.usgs.gov/project-pages/DSAS/version4/index.html

Before attempting analysis using DSAS make sure that the version of ArcGIS being used is compatible with the software. The basic instructions provide with the link above are used to conduct the analysis. An offshore baseline shapefile is created for the boundary and is saved to a common geodatabase which is used as a location for DSAS to base subsequent shoreline measurements. Attribute tables for both the baseline file and the shoreline file are organized per the DSAS instructions, included adding a “Date” and ID field, and DSAS “Default Parameters” are established. The created baseline is selected as “offshore”. Transect Spacing is set to 1m, Transect length to an appropriate length to bisect all temporal boundary shapefiles, and Cast Direction is set to LEFT (default). The shoreline shapefiles for the site are entered, and the “Date” field selected. Shoreline uncertainty is set to 4.4 meters, which is the default, “Closest Intersection” is selected for intersection parameters. Complete all Metadata fields and select “Smoothed Baseline Cast” for “Set Casting Method.” After the parameters are set, Cast Transects. Using the casted
transects layer, statistics are calculated. Select Net Shoreline Movement (NSM) and End Point Rate (EPR) at a 95% confidence interval was used (default), and “Intersect” and “Rates” databases are created as products.

Clip Transects (Clip tool) to fit within the boundaries of the existing shorelines. This requires entering the transect layer and the “intersect” database created via the statistical calculations. Join the “rates” database to the clipped transect file to spatially visualize which NSMs and EPRs apply to specific transects. The “rates” data can then be copied and pasted into Excel for NSM and EPR evaluation among all lateral positions (transects) over time (data sets).

**Equipment**

RTK GPS

Field Notebook/ Pens

ArcGIS 9.0 or higher

USGS Digital Shoreline Analysis Add-In **Procedure**

1. **Field-based RTK-GPS data collection methodologies:**
   1.1. Identify boundary of interest
   1.2. Collect Survey Points for each boundary of interest
      1.2.a. A new job is started in survey unit for the boundary survey
      1.2.b. Boundary is given unique name followed by enough “blank numbers” to cover the number of points to be collected (e.g. Boundary0 if you expect less than 10 points to be collected; Boundary00 if you expect less than 100 points to be collected)
      1.2.c. Surveyor collects survey points along borders of boundary to completely capture geometry
      1.2.d. Repeat steps for each boundary of interest
      1.2.e. Job file is exported as ESRI fixed format file
      1.2.f. Repeat steps 1.2a-1.2e at each time interval of interest (week, monthly, annually, etc…)

2. **Desktop-based ArcGIS methodologies for creating boundary polyline shapefiles**
   2.1. Import all point data in to GIS and project in appropriate coordinate system
   2.2. If necessary, isolate boundary survey data and export to a single point dataset
   2.3. Create a new polyline shapefile for the boundary of interest in the appropriate location of ArcCatalog
      2.3.a. Open ArcCatalog
      2.3.b. Right click on appropriate folder-> New-> Shapefile-> Ployline
      2.3.c. Add appropriate name, projection, and saving location
   2.4. Turn on Snapping tool from the snapping toolbar
2.5. Open Editor toolbar

2.6. Right click on newly created polyline shapefile->Edit Features-> Start Editing

2.7. Begin at one end of the boundary and “connect the dots” along the length of the boundary creating a polyline

2.8. On the Editor Toolbar select Save Edits and then Stop Editing

3. Desktop-based ArcGIS USGS Digital Shoreline Analysis Software (DSAS) methodologies for measuring lateral shift in a boundary position over time


3.2. Follow instructions in manual using default settings (as described in Summary of Approach section above) to compare change in lateral boundary position over the time frame of the dataset. Default parameters include:

3.2.a. Baseline Designation: Offshore

3.2.b. Attribute Table: include Date and ID fields

3.2.c. Transect Spacing: 1m

3.2.d. Transect Length: 15m (or greater than the estimated net maximum change in distance between time points along the boundary; use measure tool to estimate in the Data View)

3.2.e. Cast Direction: Left

3.2.f. Shapefile Names: Date field

3.2.g. Shoreline Uncertainty: 4.4m

3.2.h. Intersecting Parameters: Closest Intersection

3.2.i. Set Casting Method: Smoothed Baseline Cast

3.2.j. Statistics to be Calculated: Net Shoreline Movement (NSM) and End Point Rate (EPR) with 95% Confidence Interval

3.2.k. Products: Intersect and Rate databases

3.3. Clip Transects to AOI

3.3.a. Geoprocessing->Clip-> enter transect layer and intersect database

3.4. Spatially Join Rates database with clipped transect shapefile

3.4.a. Analysis Tools->Overlay-> Spatial Join
Data Sheets

PDE Living Shoreline Field Data Collection Sheet

<table>
<thead>
<tr>
<th>Site:</th>
<th>Staff:</th>
<th>Date:</th>
<th>Transect:</th>
</tr>
</thead>
</table>

1. Shellfish Population Density and Demographics:

- Quadrat Survey: Total counts of shellfish in monitoring plots. *Plot a* at waterward extent
  - Ribbed Mussels
  - Oysters

- Full Survey: Total number of mussels in treatment

Describe Treatment Including Full Dimensions:

Totals:

- Ribbed Mussels
- Oysters

Demographics: Measure up to 25 randomly chosen shellfish to the nearest mm

<table>
<thead>
<tr>
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<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
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<td>13</td>
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</tr>
</tbody>
</table>

Notes:

2017 Partnership for the Delaware Estuary
# PDE Living Shoreline Field Data Collection Sheet

## 2. Vegetation Robustness
Conduct A, B, and C

### A) General Plot Characteristics:
Record dominant species (up to 4) and their percent covers in each plot.

<table>
<thead>
<tr>
<th>Plot</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant Species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Cover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B) Vertical Vegetation Obstruction:
Settings
Take light meter readings (=5 top and bottom); make sure units are appropriate and consistent.

<table>
<thead>
<tr>
<th>Top</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Bottom</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>Notes</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
</tr>
</tbody>
</table>

### C) Horizontal Vegetation Obstruction
Measure general height of vegetation in plot and take horizontal readings at each level below that height.

General Vegetation Height Measured in Plot Center (cm):

<table>
<thead>
<tr>
<th>Height</th>
<th>25cm</th>
<th>50cm</th>
<th>75cm</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
</tbody>
</table>

## 3. Bearing Capacity
Record the initial sinking depth with hammer on shaft and compaction depth after 5 blows.

<table>
<thead>
<tr>
<th>Blow</th>
<th>Initial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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2017 Partnership for the Delaware Estuary