# Expanding Living Shorelines to Fresh Waters of the Delaware Estuary: A Monitoring Plan to Guide Expectations

Kurt M. Cheng, Matthew J. Gentry, Leah M. Morgan, Ella R. Rothermel, Joshua A. Moody, Danielle A. Kreeger

Partnership for the Delaware Estuary, 110 S. Poplar St, Suite 202, Wilmington, DE 19801

## INTRODUCTION

Living shorelines are an important nature-based tool for ecological enhancement including shoreline stability and providing habitat for a variety of flora and fauna. Living shorelines come in a variety of forms and are often tailored to address site-specific conditions and objectives of the project. Shoreline projects have been sited in tidal areas, predominantly in brackish to marine environments. Such projects have been seldom explored in tidally-influenced freshwater shorelines, however, these habitats support diverse aquatic flora and fauna, industry, recreation, and are generally accessible to the public. Additionally, they may be subject to urban land use and significant runoff and combined sewer overflows. Freshwater shorelines may be ideally positioned to benefit from increased carrying capacity of filter-feeding animals (i.e. freshwater mussels) to help address water quality issues among other environmental and social concerns.

To properly evaluate the ability of a living shoreline to meet its goals, a monitoring plan needs to be developed that employs relevant metrics and methods appropriate for the user and inquiry. Identifying metrics and developing a monitoring plan guides expectations and assesses the efficacy of installations. A monitoring framework currently exists to guide living shoreline planning in estuarine environments but does not accommodate for freshwater conditions and the unique challenges these environments present. This project is a first foray into the freshwater tidal zone.

## OBJECTIVES

- Develop a monitoring plan to assess the status and trends of a tidally-influenced freshwater living shoreline.
- Utilize the monitoring plan to guide the assessment of a newly-constructed prototype living shoreline in the Schuylkill River.
- Evaluate the efficacy and applicability of the monitoring plan to the prototype shoreline project based on preliminary field monitoring.

## MONITORING PLAN

The monitoring plan identifies relevant metrics and methods to accomplish objectives and reach goals (Table 1). Temporal and spatial resolutions govern data quality and applicability.

**Table 1.** Abbreviated list of goals and associated information to facilitate project planning.

| Goal | Objective | Metric | Methods | Temporal Resolution | Spatial Resolution | Analysis Question |
|---|---|---|---|---|---|---|
| Stability | Structural Stability | Condition of deployed materials | Targeted Point Sampling: RTK-GPS Survey | Baseline, Spring, Summer, Fall | Targeted points in each structure | How does the installation change and hold up over time? |
| Stability | Structural Stability, Substrate Stability | Bathymetry | Site Level Sampling: Hydrone Survey | Baseline, Spring, Summer, Fall | Entire site scan | Did the topography of the substrate and structures change? |
| Habitat Enhancement | Submerged Aquatic Vegetation (SAV) Establishment & Enhancement | Submerged aquatic vegetation (SAV) distribution | Stratified Plot Sampling: SAV presence, diversity, stem heights | Baseline, Spring, Fall | Targeted points in each structure | How does the installation impact SAV community composition? |
| Habitat Enhancement | Freshwater Mussel Population Development | Shellfish density / distribution | Stratified Plot Sampling: PIT-tag monitoring | Spring, Summer, Fall | Count mussels at fixed points and random samples across structures | Are mussel community densities shifting across the structures over time? |
| Ecosystem Services | Water Quality Uplift | Seston Composition | Site Level Sampling | Baseline (Spring), Summer, Fall | Seston samples collected at a single spot for entire site | How does seston composition change seasonally? |

## SITE & LIVING SHORELINE DESIGN

- The installation site was comprised of an intertidal mudflat in southwest Philadelphia (Fig. 1) on the outskirts of the Bartram's Garden property.
- Local bathymetry and substrate limited installation siting. Footprints for each installation and reference areas were 6' x 20' along the shore with buffer zones in between.
- Three install configurations were designed to test their effects on physical processes (i.e. sediment dynamics) as well as feasibility of installation and monitoring (Fig. 2). Monitoring zones were chosen to structure biological and physical monitoring.

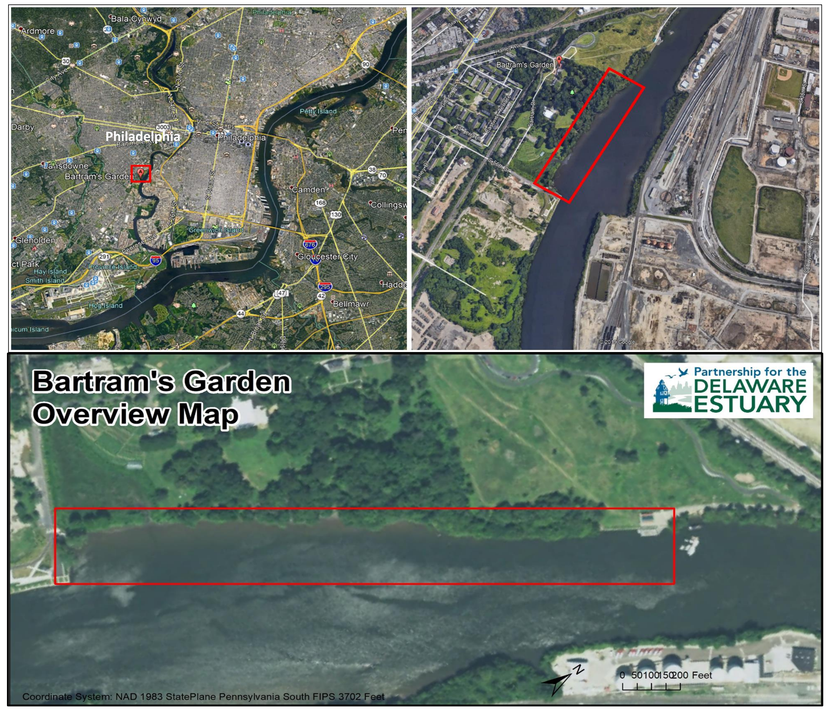


**Figure 1**. Aerial views of Philadelphia, Pennsylvania (top left); Bartram's Garden property (top right); footprint of living shoreline structure installation (bottom).

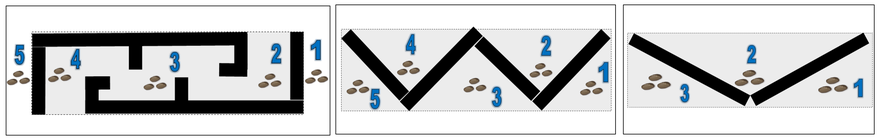


**Figure 2.** Three gabion structure designs. Black shaded areas represent gabions, gray areas indicate the install footprint. Mussel icons indicate locations of mussel deployment. Blue numbers indicate monitoring zones. Structures were referred to by shape: "V" (right), "W" (middle), and "G" (left).

## INSTALLATION & MONITORING

- Baseline data were collected on physical and biological metrics (e.g. mussel presence, grain size, elevation).
- Gabion structures with recycled oyster shell (Fig. 2) were assembled, deployed, and anchored into the three designs.
- Tagged Alewife Floater mussels (*Utterbackiana implicata*) were deployed among all structures and one of two reference areas.
- A suite of relevant metrics are currently being monitored through 2022, such as mussel survivorship, sediment grain size, structure elevation, bathymetry, water quality (dissolved and particulate), and other macroinvertebrate presence.

**Figure 2**. Gabion structures filled with recycled oyster shell.

## CURRENT STATUS & OBSERVATIONS

The tidal Schuylkill River is characterized by strong currents and a considerable tidal range (approximately 6 feet). Large debris and non-point source pollution from runoff are commonplace and points of concern. This experimental installation has proven to be resilient to date:

- All structures have remained in place with no loss, obvious shifting, or damage after multiple hurricanes and other severe weather events (Fig. 4).
- Sediment accretion occurred within the first two months around all structures and severe weather deposited additional unexpected sediment.
- Unique monitoring methods (e.g. canoe monitoring) have allowed data collection while limiting disturbance to the benthic environment.
- Monitoring zones may be efficacious for select metrics.

**Figure 4.** Image of the "W" (top) and "G" (bottom) shaped living shoreline structures at Bartram's Garden.

## NEXT STEPS

- Continue site monitoring to create a robust dataset and assess long term changes and trends.
- Incorporate data gathered and lessons learned to revise and improve tidal freshwater shoreline monitoring methodologies.
- Apply the revised monitoring plan to other tidal freshwater living shoreline projects throughout the Delaware Estuary.

## ACKNOWLEDGMENTS

We thank the generous funding which enabled this project from the National Fish and Wildlife Foundation Grant 0403.18.063122, the Pennsylvania Coastal Zone Management Program administering NOAA grant NA18NOS4190123, and the Philadelphia Water Department (PWD). We are especially grateful to all of the PWD and PDE field personnel for their installation and monitoring efforts.