# Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

## Appendix E
## Alternatives Development

**Draft Integrated Feasibility Report & Environmental Assessment**
**February 2017**

**Prepared by the New York District**
**U.S. Army Corps of Engineers**

THE PORT AUTHORITY OF NY & NJ

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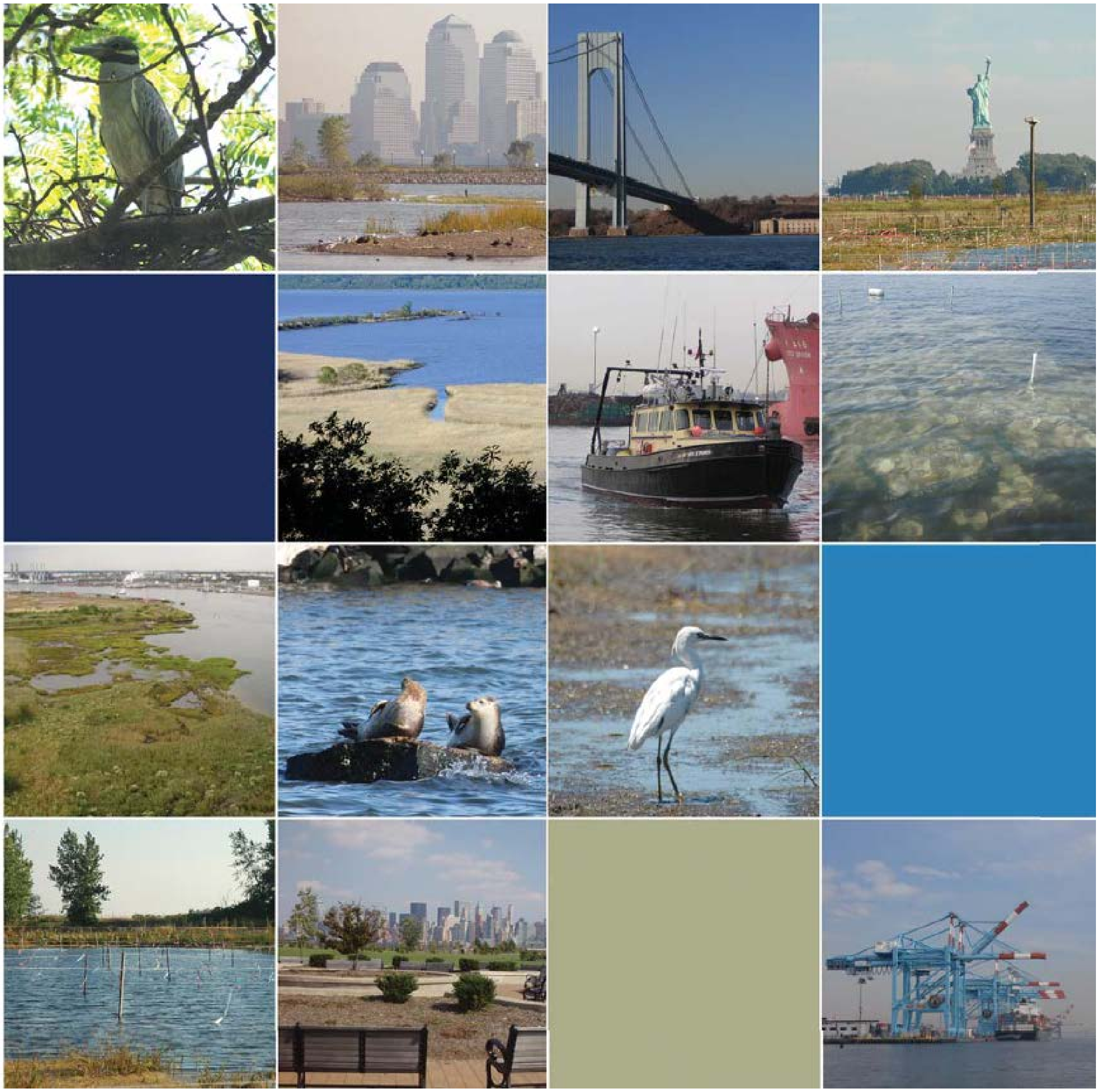

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# Appendix E: Alternative Development

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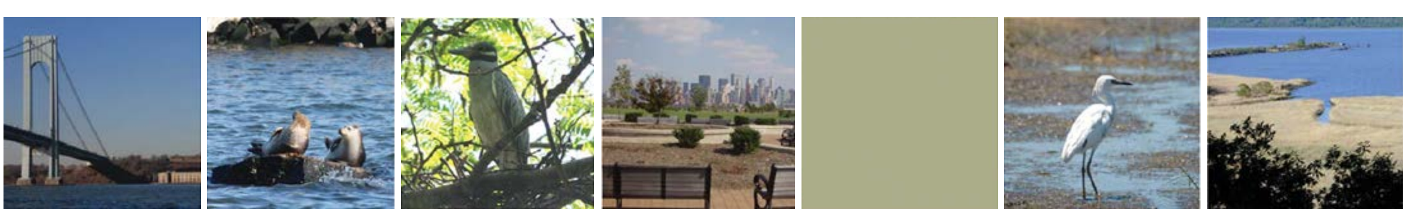

## Sub-Appendices



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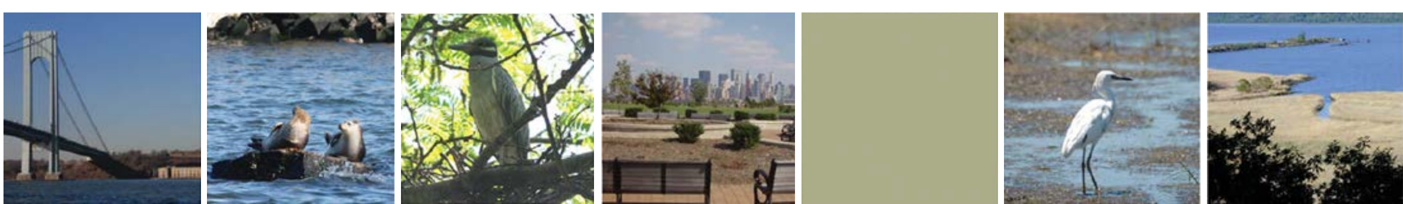
## Acronyms and Abbreviations

| | |
|---|---|
| AAFCU | Average Annualized Functional Capacity Unit |
| CE/ICA | Cost Effectiveness and Incremental Cost Analyses |
| EPW | Evaluation of Planned Wetlands |
| FCU | Functional Capacity Unit |
| HRE | Hudson-Raritan Estuary |
| SVAP | Stream Visual Assessment Protocol |
| TSP | Tentatively Selected Plan |
| USACE | United States Army Corps of Engineers |





# 1 Introduction

This appendix presents the details for initial site screening and alternative development for sites included in this Integrated Feasibility Report/Environmental Assessment (FR/EA) within the Hudson-Raritan Estuary (HRE). Alternative development at each site includes an assessment of baseline existing conditions, selection of restoration measures, development of alternatives, and the evaluation of the benefits of each alternative. Baseline conditions were measured using the Evaluation of Planned Wetland (EPW) assessment, the Natural Resource Conservation Service (NRCS) Stream Visual Assessment Protocol (SVAP), and other field surveys.

The Unites States Army Corps of Engineers (USACE) and multiple non-federal sponsors commenced six (6) complimentary USACE feasibility studies in the 1990s and early 2000s that focused on the restoration of different areas of the HRE. In an effort to streamline parallel efforts, and maximize efficiencies, resources, and benefits, the feasibility studies were integrated into the overall HRE Feasibility Study. The studies, referred to as “source” studies include:

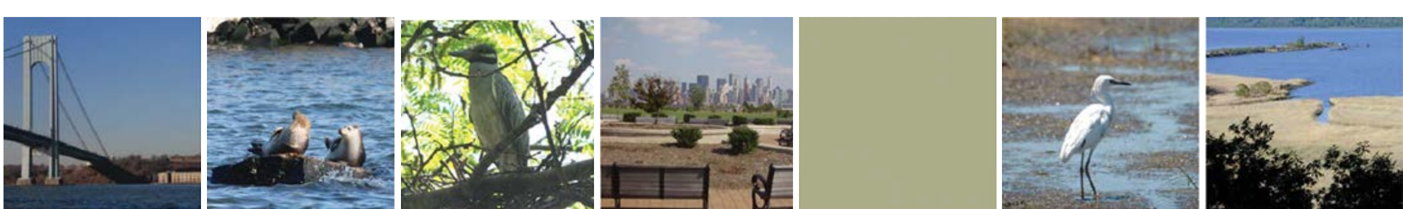
- Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study;
- Flushing Bay and Creek Ecosystem Restoration Feasibility Study;
- Bronx River Basin Ecosystem Restoration Feasibility Study;
- HRE Ecosystem Restoration Feasibility Study;
- HRE- Lower Passaic River Ecosystem Restoration Feasibility Study; and
- HRE- Hackensack Meadowlands Ecosystem Restoration Feasibility Study.

The analyses completed as part of these “source” studies were incorporated into and this FR/EA. For discussion purposes, this appendix has been divided into sub-appendices based on formulation (waterbody, “source” study or restoration type).

**Table 1. Alternative Assessment Package for each Waterbody, “Source” Study or Restoration Type**

| Package | Site Name |
|---|---|
| Jamaica Bay | Dead Horse Bay |
| | Fresh Creek |
| | Hawtree Point |
| | Bayswater State Park |
| | Dubos Point |
| | Brant Point |
| Jamaica Bay Marsh Islands | Stony Creek |
| | Duck Point |
| | Elders Point Center |
| | Pumpkin Patch West |
| | Pumpkin Patch East |
| Flushing Creek | Flushing Creek, New York City Department of Environmental Protection (NYCDEP) Site #DRG-FC |
| Bronx River | River Park/West Farm Rapids Park |
| | Bronx Zoo and Dam |
| | Stone Mill Dam |
| | Shoelace Park |





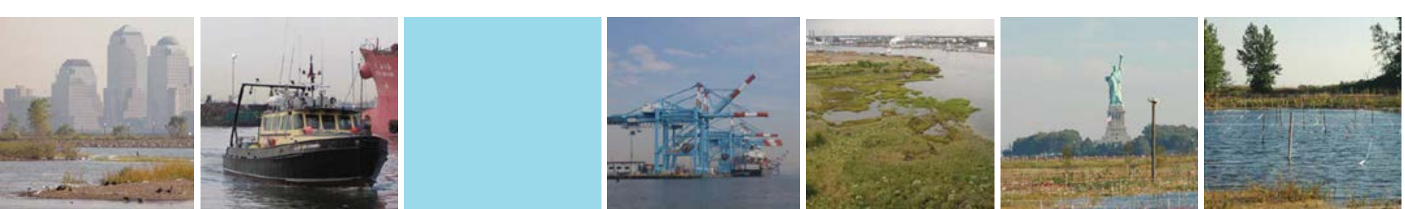
| Package | Site Name |
|---|---|
| | Muskrat Cove |
| | Bronxville Lake |
| | Crestwood Lake |
| | Garth Woods/Harney Road |
| | Westchester County Center |
| Lower Passaic River and Hackensack River | Metromedia Tract |
| | Meadowlark Marsh |
| | Oak Island Yards |
| | Kearny Point |
| | Essex County Branch Brook Park |
| | Dundee Island Park |
| | Clifton Dundee Canal Green Acres |
| HRE Oyster Restoration | Jamaica Bay, Head of Bay |
| | Soundview Park |
| | Bush Terminal |
| | Governors Island |
| | Naval Weapons Station Earle |

### 1.1 Jamaica Bay (Appendix E-1)

The Jamaica Bay detailed assessment and alternative development package includes relevant historical baseline data, a screening of restoration opportunities, an EPW assessment, and alternative development for each shoreline/perimeter site. The EPW scores were originally calculated for each restoration alternative in 2004 and were used to conduct cost effectiveness/incremental cost analysis (CE/ICA). The recommended alternative for each site was identified and approved as the Tentatively Selected Plan (TSP) at the 2010 Alternative Formulation Briefing (AFB). The existing conditions of the six (6) project sites were documented in 2004 and verified/confirmed that conditions did not change as part of the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study in August 2015. Potential modifications to the ecosystem restoration designs were suggested by the Rockaway-Jamaica Bay Reformulation Study in order to improve secondary coastal storm risk management benefits.

### 1.2 Jamaica Bay Marsh Islands (Appendix E-2)

The Jamaica Bay marsh islands detailed assessment and alternative development package includes an EPW assessment and alternative development for each site. The alternatives development at Jamaica Bay marsh islands are based on the lessons learned from successful construction of five (5) other marsh islands: Elders Point East, Elders Point West, Yellow Bar, Black Wall and Rulers Bar. A single alternative was prepared for each marsh island considering cost effectiveness and constructability. The EPW assessment conducted for the five (5) other marsh islands were assumed to be similar to the marsh islands proposed in this FR/EA with similar ecological benefits for every acre of wetland restored.



### 1.3 Flushing Creek (Appendix E-3)

The Flushing Creek detailed assessment and alternative development package includes a site screening evaluation, an EPW assessment, and alternative development for Flushing Creek. As part of the initial Flushing Creek and Bay “source” study, problems and opportunities were identified, alternatives were developed and recommended alternative was identified within the study area in 2007. NYCDEP did not concur with recommended plan given there was an intent to better coordinate NYCDEP’s Long Term Control Plan and environmental dredging. Subsequently, NYCDEP conducted additional field investigations in Flushing Creek and three (3) additional conceptual alternatives were developed optimizing the 2007 alternative. These alternatives were developed based on the assumption that NYCDEP was considering to dredge a portion of Flushing Creek. These alternatives and acreages were used as the basis for an EPW assessment in 2014 that compared the project values associated with the baseline condition and the three (3) alternatives developed for the proposed project site. EPW scores were used to calculate average annual functional capacity units (AAFCUs) for Flushing Creek site to be used for the CE/ICA (Appendix M).

### 1.4 Bronx River (Appendix E-4)

The Bronx River detailed assessment and alternative development package includes historical data collected for baseline conditions and the screening of restoration opportunities to determine the focused array of sites to be evaluated in detail as part of the Bronx River “source” study. EPW and SVAP assessments and alternative development were conducted for each site within the focused array. The EPW assessment was performed on each site for existing and proposed conditions for each of the three (3) alternatives as well as future without project conditions. EPW scores were used to calculate AAFCUs for each site and alternative. The AAFCUs for year 50 presented in this appendix were used to differentiate the ecological benefits of each alternative to determine the Tentatively Selected Plan (TSP) at each site using CE/ICA) (Appendix M).

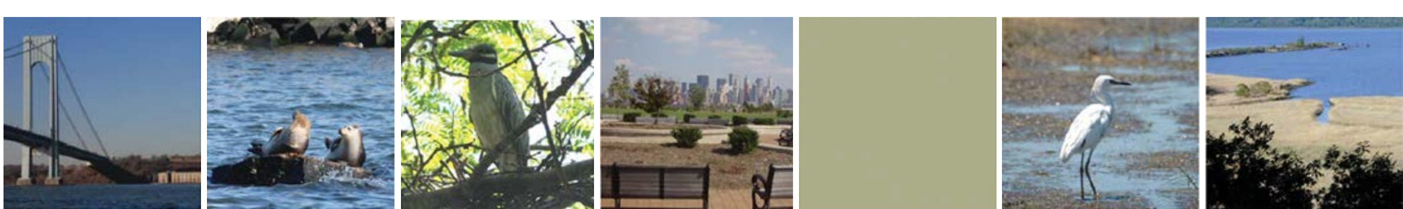
### 1.5 Lower Passaic River and Hackensack River (Appendix E-5)

The Lower Passaic River and Hackensack River detailed assessment and alternative development package includes screening of restoration opportunities, existing conditions, EPW assessment, SVAP for freshwater riverine sites, and alternative development for each site within the focused array. EPW scores were used to calculate AAFCUs for each site and alternative, as well as future without project conditions. The AAFCUs for year 50 presented in this appendix were used to differentiate the ecological benefits of each alternative to determine the TSP at each site using CE/ICA.

### 1.6 HRE Oyster Restoration Sites (Appendix E-6)

The HRE oyster sites detailed assessment and alternative development package is based on the previously implemented pilots and research within the region. The oyster package contains pertinent monitoring data collected from the oyster pilot projects, an evaluation of restoration techniques and development of alternatives at each restoration site. An EPW assessment was not applicable for assessment of the oyster sites. One (1) alternative per site was developed to provide ecological and functional uplift in terms of shoreline stabilization, habitat improvement, water quality improvements, and carbon sequestration.





# 2 General Detailed Assessment and Alternative Development

## 2.1 Baseline Conditions

In addition to baseline surveys and site specific data collected for each “source” study, recent field data collection was conducted to characterize baseline existing conditions for estuarine and freshwater riparian restoration sites in Jamaica Bay, the Bronx River, Flushing Creek, Lower Passaic River, and Hackensack River. A specific field approach focused on accomplishing three (3) broad goals:

- Collect data as required for the EPW, SVAP, and upland buffer baseline assessments and accurately characterize existing conditions.
- Review the single existing HRE restoration alternative that had been prepared via desk-top available data and confirm the adequacy of the restoration approach.
- Identify additional restoration measures to support additional alternatives, focusing on highest ecological benefit/uplift, long-term success, and economic feasibility.

### 2.1.1 Evaluation of Planned Wetlands Process

The Evaluation for Planned Wetlands handbook (Bartoldus et al., 1994) describes EPW as “…a rapid-assessment procedure used to determine whether a planned wetland has been adequately designed to achieve defined wetland function goals. The EPW allows the designer and decision maker to identify characteristics which are important to each function and determine how and if the planning goals are attainable.” Details on the EPW process described below were taken from the handbook.

The wetland assessment area (WAA) represents a designated wetland area to which the planned wetland will be compared. For all sites, the WAAs represent existing conditions and the planned wetlands are the design alternatives. The EPW evaluates a site on six (6) major wetland functions. The functions used in the EPW are defined in Table 2.

**Table 2: Definitions of EPW Functions**

| Function | Definition |
|---|---|
| Shoreline bank erosion control (SB) | Capacity to provide erosion control and to dissipate erosive forces at the shoreline bank. |
| Sediment stabilization (SS) | Capacity to stabilize and retain previously deposited sediments. |
| Water quality (WQ) | Capacity to retain and process dissolved or particulate materials to the benefit of downstream surface water quality. |
| Wildlife (WL) | Degree to which a wetland functions as habitat for wildlife as described by habitat complexity. |
| Fish<br>Tidal (FT)<br>Non-tidal stream/river (FS)<br>Non-tidal pond/lake (FP) | Degree to which a wetland habitat meets the food/cover, reproductive, and water quality requirements of fish. |
| Uniqueness/heritage (UH) | Presences of characteristics that distinguish a Wetland as unique, rare, or valuable. |

The EPW uses a unitless element score to represent the functional capacity of the physical, chemical or biological characteristics of the wetland or landscape. The element score ranges from 0.0 to 1.0, where 0.0 represents unsuitable conditions and 1.0 represents the optimal condition. A low score indicates a low potential for functional capacity of that wetland or landscape characteristic and a high score implies a greater potential to increase the wetland or landscape's functional capacity. The element score for each EPW function are used to calculate a functional capacity index (FCI).

The FCI is a dimensionless number ranging from 0.0 to 1.0 that describes a wetland's relative capacity to perform a function, where 0.0 indicates no functional capacity and 1.0 indicates optimal function capacity. The FCI and WAA are then used to derive the functional capacity units (FCUs). The FCIs represents the "quality" of functional capacity per unit area, whereas the FCUs represent the "quantity" of functional capacity. FCUs are calculated by multiplying FCI times the area of the planned/anticipated impacts.

### 2.1.2 Stream Visual Assessment Protocol (SVAP) Process

The freshwater riparian restoration sites along the Bronx River and Branch Brook, a tributary of the Lower Passaic River and a small portion of Meadowlark Marsh on the Hackensack River, utilized the SVAP to assess hydrologic and morphologic stream conditions that were not addressed within the scope of the EPW assessment. Developed by NRCS in 1998, the SVAP is a qualitative field reconnaissance technique that assesses channel and floodplain conditions, riparian areas, water quality and aquatic habitat. It was developed as an assessment for existing physical conditions within a stream reach so it may not detect external impacts that may affect the project site.

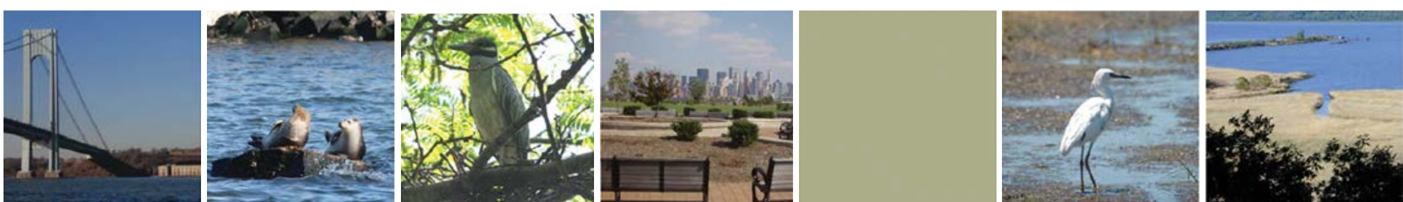
Stream conditions are documented on a standard two (2) page worksheet. Up to 15 assessment categories, such as channel condition, bank stability, riparian zone quality, and in-stream fish cover, are scored from one (1) to 10. Based on the characteristics of the site not all categories may apply. The overall assessment score is determined by adding up the value for each element and dividing by the number of categories assessed. The numerical score represents the overall quality of the stream condition, with an overall score below six (6) considered poor and a score over nine (9) considered excellent.

## 2.2 Restoration Measures

Restoration measures are features or activities that can be implemented at each site to address the water resource problems and meet planning objectives which are based on the relevant target ecosystem characteristics (TECs).

Generally, discrete habitat types are found in differing ranges and densities within each planning region. Thus, most restoration opportunities, and therefore most restoration measures, are similar within a planning region. Cost-effective and site-appropriate restoration measures, scales, and combinations of feature and activity types were identified and evaluated at each restoration site to improve the native habitats within the site. This supports the intent to develop a mosaic of habitats within each site, given the limited opportunities and available habitat within the highly urbanized environment.

Table 3 identifies the proposed TECs and HRE restoration measures. These measures were combined to generate conceptual plans at each site within the study area which were then bundled for each site to form planning alternatives.

Restoration measures considered include:

- Habitat restoration and creation (improve biodiversity, biomass, and functional habitat);
- Wetland, forest, riparian, oyster reef, and submerged aquatic vegetation restoration;
- Invasive species removal and replanting;
- Tributary connection improvements;
- Fish ladders, dam removal, and weir modifications to allow upstream and downstream migration of anadromous and catadromous fish;
- Functional habitat restoration along shorelines;
- Shoreline softening;
- Bank stabilization;
- Hydrologic/hydrodynamic improvements; and
- Channel modification, instream structures, and dredging.

**Table 3: Target Ecosystem Characteristics and Proposed Restoration Measures**

| TEC | Restoration Measures | |
|---|---|---|
| Wetlands | • Fill removal<br>• Grading<br>• Hydrologic restoration<br>• Invasive species removal<br>• Native vegetation planting | • Open marsh water management<br>• Sediment/material placement<br>• Wetland creation/restoration<br>• Wetland protection |
| Habitat for Waterbirds | • Contaminated sediment removal<br>• Grading<br>• Invasive species removal<br>• Marsh island restoration | • Native vegetation planting<br>• Predatory species management<br>• Sediment/material placement |
| Coastal and Maritime Forests | • Associated habitat creation/restoration<br>• Fill removal<br>• Forest creation/restoration<br>• Forest preservation | • Grading<br>• Invasive species removal<br>• Native vegetation planting<br>• Sediment/material placement |
| Oyster Reefs | • Deploying live shellfish<br>• Sediment/material placement | • Submarine structure placement |
| Eelgrass Beds | • Eelgrass planting<br>• Eelgrass seeding | • Sediment/material placement |

| TEC | Restoration Measures | |
|---|---|---|
| Shorelines and Shallows | • Associated habitat creation/restoration<br>• Bank Stabilization<br>• Fill removal<br>• Grading<br>• Invasive species removal<br>• Native vegetation planting | • Riparian forest and scrub/shrub habitat creation/restoration<br>• Riparian vegetation protection<br>• Shallow water creation/restoration<br>• Shoreline softening |
| Habitat for Fish, Crab, and Lobsters | • The Habitat for Fish, Crab, and Lobsters TEC is subject to restoration measures listed above in support of the Wetlands, Oyster Reefs, Eelgrass Beds, and Shorelines and Shallows TECs. | |
| Tributary Connections | • Barrier removal<br>• Bed restoration<br>• Channel modification/realignment<br>• Channel modification/realignment with instream structures | • Fish attractor installation<br>• Fish passage system installation<br>• Hydrologic restoration<br>• Sediment control best management practice (BMP) installation<br>• Sediment removal |
| Enclosed and Confined Waters | • Contaminated sediment removal or capping<br>• Debris removal<br>• Landfill removal or stabilization | • Sediment control BMP installation<br>• Sediment/material placement<br>• Shoreline softening<br>• Water quality BMP installation |
| Sediment Contamination | • Contaminated sediment removal or capping<br>• Grading | • Hazardous material disposal<br>• Native vegetation planting |
| Public Access | • Fill removal<br>• Public access improvement | • Public education<br>• Sediment/material placement |

Details about the restoration measures for each TEC are included in the subsequent sections.

### 2.2.1 Wetlands TEC

The Wetlands TEC promotes creating and restoring coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage. Wetlands can become established in brackish to saline waters of the intertidal zone where sufficient substrate stability and nutrient supply exists. Potential restoration opportunities for wetlands include areas that historically supported salt and freshwater marshes and have the appropriate elevation, fetch distance, and distance between navigation channels and the shoreline.



#### 2.2.1.1 Hydrologic Restoration

Techniques that are commonly used to enhance tidal hydrology to create or restore coastal wetlands include the removal or relocation of non-essential tide gates, levees, or flood protection berms that restrict the flow of water to adjacent lowlands. Other techniques involve lowering the elevation of coastal lands to allow tidal flow, creating or deepening tidal channels through the marsh, and plugging or filling mosquito ditches (discussed further in Section 2.2.1.5). Freshwater wetlands can also be created or enhanced through hydrologic restoration using similar measures.

#### 2.2.1.2 Fill Removal

To restore coastal and freshwater wetlands which have been impacted by fill, historic or pre-disturbance elevations must be reestablished with earthmoving equipment. Elevation criteria to be used in re-contouring projects can be obtained by surveying nearby reference marshes located in similar geomorphic and landscape settings. Following the removal of dredged material or upland fill, new soils can be placed on the site and graded to the proper elevations. Soil organic matter content and grain size should match that of reference marshes. In cases where organic matter content of new soil is low, restoration practitioners can add organic matter (usually terrestrial vegetation mulch) to enhance soil quality. Where fill material cannot be reused on restoration sites, disposal options must be evaluated. In densely populated urban area, such as the HRE study area, this may represent a considerable challenge, especially when the fill material is contaminated. Removing unwanted sediments can involve:

- Removing vegetation from fill materials, which in the HRE is often comprised of nonnative species.
- Excavation to design grade, which, for coastal wetlands, is often sloping towards the shoreline, with deeper areas for tidal channels and pools and sometimes higher elevations to establish multiple marsh community types. For freshwater wetlands the grades will vary depending upon the wetland type to be established (e.g., hummock and pool or bowl-shaped).

#### 2.2.1.3 Invasive Species Removal

In degraded wetlands where the degree of flooding is sufficient, or where removal of water control structures or dikes is not feasible, restoration may focus primarily on removal of invasive species and replanting with native intertidal vegetation. Invasive vegetation can pose a significant threat to existing coastal and freshwater wetlands, as well as ongoing and planned wetland restoration projects within the HRE.

The primary invasive species of concern within the HRE is common reed (*Phragmites australis*). In southern New England, to the north of the HRE study area, many coastal wetland restoration projects have focused on the elimination of common reed through an increase in flooding with saline tidewaters. The gradual accumulation of sulfides, an important component of seawater, in flooded marsh soils inhibits the ability of the plant to take up nutrients. Eventually the reed stands lose vigor and height, and die back (Chambers, 1997). This process can take up to several years.

It is also possible to eradicate common reed using herbicides, burning, and manual harvesting. The herbicide Rodeo® in combination with an organic surfactant has been used successfully to eradicate common reed in New Jersey. Herbicides typically require multiple applications over several growing seasons and careful monitoring in order to identify and control reinvasion. Burning is controversial, as it may invigorate existing stands by removing standing dead biomass. Harvesting is labor intensive, and

the cuttings must be disposed of in such a way as to prevent spreading of seeds and rhizomes to other locations.

Often, the most successful attempts involve multiple control strategies, such as repeated harvesting, with burning to remove accumulated litter. Harvesting has also been effective in removing common reed in combination with herbicide application. Burning in combination with herbicide applications appears to be more successful than prescribed burns alone. Burning is not advised in wetlands adjacent to residential areas, and therefore would not be feasible within most wetlands in the HRE.

#### 2.2.1.4 Sediment/Material Placement

Wetlands within the HRE study area require raising the marsh surface where they have subsided and the native marsh vegetation has drowned, and in places where the shoreline topography is steep. Depending on the project, the equipment used may include dredges and/or heavy construction equipment to distribute dewatered sediment to the appropriate elevation. Sediment/materials placement activities often involve:

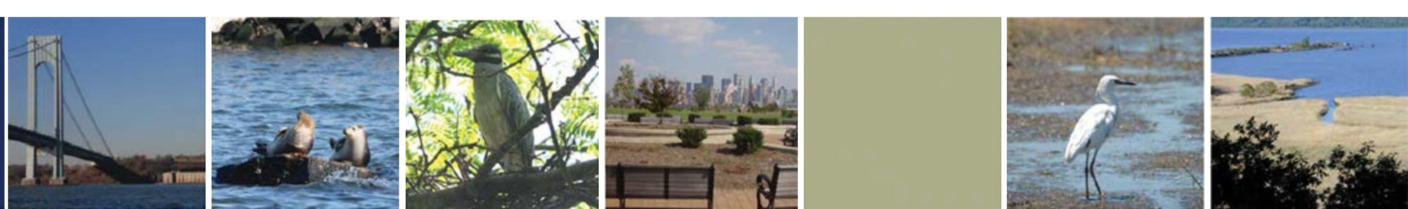
- Deploying sediments, either dredged materials or clean fill, into areas of open water or littoral wetlands (as in the case of marsh island restoration), or onto eroded or degraded coastal shorelines. This technique may involve creating mounds designed to provide a variety of elevations and slow water velocities, further trapping sediment to build elevation naturally.
- Spraying a thin layer of dredge sediments over an existing wetland. This technique is used when the wetland is failing to keep pace with sea level rise or subsidence, but has not yet been fully converted to open water.
- Manually planting native vegetation.

#### 2.2.1.5 Open Marsh Water Management

To restore coastal wetlands that have been altered by mosquito ditches, open marsh water management is a habitat restoration and mosquito control technique that is specifically intended to recreate the natural flow patterns in ditched marshes (Barry and Fish, 1995). Under an open marsh water management program, existing drainage ditches are abandoned or plugged, and natural tidal creeks are reconnected to newly excavated ponds in the upper intertidal marsh. This allows fish that prey on mosquito larvae to reestablish populations in areas that were previously inaccessible to them (e.g., pools and creeks in high marsh areas). Such programs have been successfully implemented in many ditched marshes throughout the Northeast, notably in Connecticut and Rhode Island.

Three (3) types of wetland alterations are performed under open marsh water management. Tidal ditches, pond radials, and ponds are dug using equipment such as a rotary ditcher, amphibious crane, or other suitable construction equipment (New Jersey Department of Environmental Protection, 2016). The rotary ditcher is similar to a typical hydraulic excavator found on any construction site, but uses low impact tracking pontoons that allow the machine to function on land and in water. Cut sediments are mixed with available marsh water during excavation and the slurry is sprayed in a thin layer over the surrounding marsh surface. The material is carefully distributed to avoid significant increases in marsh surface elevation. In locations where the marsh sediment has high sand or clay content and to create ponds, conventional excavation equipment, including cranes and bulldozers, can be used. Final grading of excavated material is generally completed using smaller manual equipment, such as a front-end blade attached to a marsh all-terrain vehicle (Lesser, 2007).





### 2.2.2 Habitat for Waterbirds TEC

The Habitat for Waterbirds TEC promotes restoring and protecting roosting, nesting, and foraging habitat (i.e., inland trees, wetlands, shallow shorelines) for long-legged wading birds. The purpose of this TEC is to restore the island habitat to increase the nesting populations on all islands used as rookeries in the HRE.

Restoration opportunities for waterbird islands primarily occur where existing islands can be restored to improve nesting and feeding habitat for target species. Island habitats should be restored with long-term sustainability in mind. This may entail restoring wetlands and marsh islands by removing contaminated sediments, managing invasive and predatory species, and raising the elevations of low-lying areas with clean fill (e.g., dredged sand from ongoing channel maintenance projects), prior to restoring native vegetation communities.

#### 2.2.2.1 Contaminated Sediment Removal

Removal of sediments initially requires testing for contaminants and hydrological or manual dredging methods described in Section 2.2.9.

#### 2.2.2.2 Invasive Species Removal

Waterbird habitat within the HRE is susceptible to many invasive species, whose removal and control is prioritized. Common reed, oriental bittersweet (*Celeastrus orbiculatus*), tree of heaven (*Ailanthus altissima*), glossy buckthorn (*Rhamnus frangula*), honeysuckle (*Lonicer* spp.), mile-a-minute weed (*Persicaria perfoliata*), Kudzu (*Pueraria lobate*), and Asian long-horn beetle (*Anoplophora glabripennis*) are just a few of the invasive species found in waterbird habitat (Harbor Herons Subcommittee, 2010). Invasive plant removal is discussed in Sections 2.2.1.3 and 2.2.3.1.

The Asian longhorned beetle is an invasive, nonnative species that has been known to occur in parts of the HRE study area. The beetle is a wood-boring pest that can decimate the tree population of an area. The Asian long-horned beetle remains a great threat to Isle of Meadows and Shooters Island, based on their proximity to other infestations and the forest communities present, especially gray birch and maples (Craig, 2010). To control the expansion of the beetle, the United States Department of Agriculture (2015) recommends removing all infested trees and potential host trees. Following their removal, the trees should be chipped or burned, and the stumps should be ground or treated with herbicide. In addition, high-risk trees in proximity to the infested trees should also be removed or treated with insecticide, depending on level of infestation, host tree density and distribution, potential environmental impacts, and logistical resources. The tree removal site should then be restored.

#### 2.2.2.3 Predatory Species Management

Carefully planned and executed predator control is one of the few enhancement activities recommended to take place on islands with existing nesting activity, and can result in substantial benefits in breeding population and improved hatchling and fledgling success. Physical, chemical, and biological controls can be used for removal. Avian predators have been successfully controlled with avian toxicants that require federal and state permits. Bird repellents containing methiocarb have also been successfully used in Europe and the United States to deter feeding on eggs (Avery et al., 1995; Neves et al., 2006; Harbor Herons Subcommittee, 2010). Deploying repellent eggs two (2) to three (3) weeks prior to egg laying was suggested to condition avian predators to avoid eggs (Avery et al., 1995; Harbor Herons Subcommittee, 2010).

Raccoons, opossums, and rats are common mammalian species that invade nesting islands and eat heron eggs (Hudson Estuary Program, 2012). These species can be removed by legal trapping methods, such as by cage, leghold and Conibear traps, and lethal methods (Shwiff et al., 2005; Harbor Herons Subcommittee, 2010). Leghold traps would only be used in New York, as they are illegal in New Jersey. Predator removal methods would need to be coordinated closely with management agencies and permits would likely be required for all predator removal methods used.

#### 2.2.2.4 Restoration of Marsh Islands

Expanding disappearing islands or creating new islands involves placing fill material by spraying a high-pressure slurry to obtain a thin layer or piping dredge slurry onto the site. This is followed by grading with heavy construction equipment. Sediments are then stabilized using coir toe stabilization, hay bales, and silt fencing to control runoff. The area is then planted with transplants or new plugs, and seeds of native species (Nordenson et al., 2015). In many instances, saltmarsh cordgrass (*Spartina alterniflora*) and other species plugs and seeds are harvested locally.

### 2.2.3 Coastal and Maritime Forests TEC

The Coastal and Maritime Forests TEC promotes creating a linkage of forests accessible to avian migrants and dependent plant communities. Important characteristics to consider when determining suitable locations for maritime forest restoration include adjacency to beach or dune habitat, distance from shore, the absence of existing wetlands, and the minimum community size for species establishment and survival. Only existing upland communities will be considered suitable restoration areas, because maritime forest communities require easily drained soils.

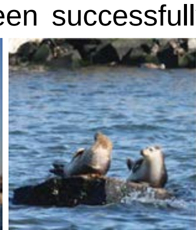
Restoring existing forests includes removing invasive species and replanting appropriate native vegetation. Expanding and creating new maritime and coastal forests initially involves site preparation activities, such as excavation and placement of fill using heavy construction machinery, followed by planting native vegetation.

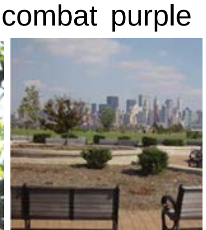
#### 2.2.3.1 Invasive Species Removal

Invasive species management is outlined in the *Guidelines for Urban Forest Restoration* (New York City Department of Parks and Recreation [NYC Parks], 2014) and can be accomplished by utilizing mechanical, chemical, and biological controls. Mechanical control involves cutting or pulling of plant material. In many cases, trees can be felled selectively with a chainsaw or girdling. Another method utilized for smaller areas is by covering vegetation with black or clear plastic on a sunny or warm day. Chemical control involves acute application of herbicides to target invasive plants. Herbicide treatment should be timed appropriately to maximize effectiveness on target species and avoid impacts to native vegetation. Several application methods are prescribed including the cut stump method, in which herbicide is sprayed on a freshly cut tree stump, the basal bark method, which entails spraying herbicide directly onto a tree trunk, and foliar spray methods that involve spraying herbicide on all foliage. The most intensive application method used for species such as common reed involve mowing and applying herbicide using a sprayer or a glove saturated with herbicide.

Natural pests or predators can also be released as a form of biological control of undesirable plants. Biological controls are generally used for large areas where other methods are not economical. Biological controls are rigorously tested to prevent negative impacts on native species. In New York City, beetles have been successfully deployed to combat purple loosestrife (*Lythrum salicaria*), and





mile-a-minute weevil (*Rhinoncomimus latipes*) has been released for control of mile-a-minute vine (*Persicaria perfoliata*). These controls can be used in combination with one another in variable sequences, dependent on the particular conditions at a project site.

#### 2.2.3.2 Forest Expansion

Expanding maritime forests generally involves the placement of clean fill material generated from shoreline excavation or dredging of surrounding waterways. Dredged materials have a high sand content with low nutrients, low organic matter, low moisture, circumneutral pH, and high permeability that is appropriate for native maritime forest vegetation (NYC Parks, 2014). In many cases within the HRE study area, new forest areas are also created over existing landfills. Landfills accept variable types of materials from solid waste to construction debris. In some cases, debris is excavated and disposed of in another location. In many cases, however, the land fill would be capped with an impermeable membrane and several feet of clean soil.

Restoration areas would require capping, placement of fill and clean soil, and grading to design elevations to prepare the site for planting activities. Excavation and grading require the use of earth-moving construction equipment. Soil erosion and sediment control BMPs would be used to minimize erosion and sedimentation of surrounding areas during site preparation and construction activities. Following site preparation, native canopy trees, understory trees, shrubs, forbs, ferns, and other native maritime coastal community species would be planted manually to aid in soil stabilization.

### 2.2.4 Oyster Reefs TEC

The Oyster Reefs TEC promotes establishing sustainable oyster reefs within the HRE. Oysters have specific habitat requirements, including a range of water quality and bathymetric preferences. Potential restoration opportunities are those locations where oyster beds were established historically and that meet a specific range of salinity, dissolved oxygen, total suspended solids, and water depth.

#### 2.2.2.1 Reef Construction and Seeding

A variety of materials have been used as cultch, or settling substrate, in oyster restoration and management programs along the Atlantic and Gulf coasts. These materials include processed oyster and surf clam shell from the seafood industry, and dredged oyster shell from buried reefs, also known as fossil shell. Shells can be deployed loose, or in plastic mesh bags or similar containment materials. Natural substrate has been used more widely for restoration, but supply is limited and demand is high from the restoration and aquaculture sectors. Although shell is preferred because oyster larvae have an affinity for it, it is not always available. Artificial substrate such as limestone marl, granite, or crushed concrete, sometimes in combination with shells, may also be used when not enough shell substrate is available, or in high-energy areas where substrate would otherwise be unstable and may require a more stable or higher reef structure. Other commonly-used artificial substrates for shellfish reef restoration include wire mesh cages, racks, steel rebar structures, or weighted plastic mats containing natural or artificial substrate. Such solutions are effective, but naturally occurring materials are often preferred for restoration.

For small-scale reef projects, Seawall Reef, a patented product by Oyster Reef Design, Inc., is a commercially-available alternative. The substrate consists of sheets of polyethylene mesh rolled into cylinders and lashed together to form special configurations, which may be anchored to the substrate. The individual cylinders are approximately seven (7) inches in diameter and 48 inches long, and may be stacked to create a desired profile.

Another manufactured substrate product is reef balls, pre-fabricated concrete domes with apertures of varying diameter. These have been used successfully to construct subtidal and intertidal reefs in the southeastern United States from Virginia to Florida. The first permitted installation of reef balls in New York City waters took place in 2006 at the West Harlem Piers, in the Hudson River off of upper Manhattan. The installation was in association with redevelopment of the shoreline and construction of a fishing pier by the New York City Economic Development Corporation. While not intended as an oyster restoration effort, the 50 reef balls placed at this site have been colonized by a variety of epifaunal invertebrates and macroalgae, enhancing utilization of the seafloor in the vicinity of the West Harlem Piers site by estuarine and migratory finfish. More recently, NYCDEP, in collaboration with Cornell University's Cooperative Extension Service, established a demonstration oyster reef comprising an array of 12 pre-fabricated concrete reef balls that were remote-set with oysters and placed in Gerritsen Creek, Jamaica Bay (USACE and PANY/NJ, 2009a).

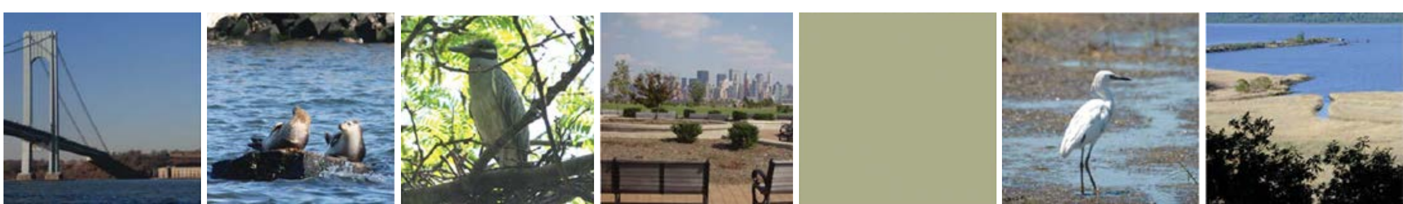
In addition to reef/substrate construction, shellfish restoration efforts in the HRE include placing native shellfish in the restoration area because the local population is not large enough to produce viable larvae. Within the HRE, shellfish for restoration purposes are largely obtained from the oyster hatchery and nurseries at New York Harbor School, as part of the Billion Oyster Project. Oysters may also be obtained from natural beds (e.g., wild stock) or purchased from commercial harvesters. Because reef-forming oysters attach to hard substrates and each other, they may be distributed as individuals, or as multiple juveniles already attached to substrate (i.e., as spat on shell). Spat on shell may be deployed loosely or may also be placed in cages or gabion blocks below the low tide line to reduce predation or poaching and to create a reef structure (NOAA, 2015).

Reef substrate and spat on shell are generally deployed from a boat or barge when the restoration site is far from shore. At nearshore, shallow-water project sites, restoration practitioners and community volunteers may carry substrate such as oyster shell bags to the reef location when manageable. Large volumes of loose shells can be sprayed off barges with high-pressure hoses, or placed with large equipment, such as a backhoe, or with specialized hopper-conveyer belt systems built into the deployment vessel. Heavy substrates such as concrete or limestone are typically placed using heavy equipment located either onshore or loaded onto a barge (NOAA, 2015).

Oyster restoration in the HRE can be accomplished by a variety of different methods, which could vary from suspending live oysters in a mesh net from a pier to creating an oyster bed where tons of crushed shell and rock are placed on the seabed and then planted with live oysters. The primary restoration techniques employ methods found to be effective in previous studies, including those conducted by the Oyster Restoration Research Project, New York Harbor School, and Billion Oyster Project. The following are the restoration techniques that are considered for the various, potential oyster restoration sites as part of the HRE Feasibility Study:

- **Spat on Shell:** Spat on shell is constructed by placing a base of rock or rubble on the bottom of the bay and a veneer layer of mollusk shell is placed on top of the base material. The top layer consists of the oyster spat settled on shell. Spat on shell alone is suitable for use in lower energy environments with firm substrate. Spat on shell also can be used in combination with other restoration techniques that adequately shelter the material from strong currents and smothering by sediments, and prevent its sinking into loose substrate.
- **Reef Balls:** A reef ball is a half dome concrete structure. Within the top and surface of the reef ball, holes are placed allowing water to flow through the structure and allowing fish and other aquatic creatures to inhabit the structure's interior. Although used successfully to construct





subtidal and intertidal reefs (USACE and PANY/NJ, 2009a), reef balls are better used in subtidal areas where the water surface is at least 10 feet above the balls to avoid damage from waves and currents (Hardy, 2011, as cited in Black, 2011).

- **Oyster Condos:** Oyster condos are triangular structures constructed with welded rebar, designed to hold gabion bags of oysters upright in the water column.
- **Oyster Castles:** Oyster castles are tiered structures, constructed with stacked, interlocking concrete blocks to resist constant wave motion. The blocks, which are partially hollow, are made of shell, limestone, and concrete, with each block typically weighing about 30 pounds. An oyster castle is designed to provide instant habitat for oyster spat and growth. In addition, previous studies have determined that the placement of the castles fosters sedimentation shoreward of the structures and thereby encourages the regrowth of natural vegetation. This provides a shoreline erosion prevention benefit that is a mix of engineering and nature.
- **Wire Cages/Gabions:** This technique employs wire cages that are filled with oyster shells pre-seeded with spat, and are placed on the bottom. Use of cages and gabion blocks reduce predation or poaching and create a reef structure (NOAA, 2015).
- **Super Trays:** Super trays are square or rectangular, high-density polyethylene crates that allow for the placement of oysters vertically in the water column. To restore oysters, as opposed to constructing oyster reefs, sets of interlocking super trays can be suspended from a structure or a float. Their construction allows water to circulate and flow through the trays, thereby dispersing veliger (larvae) to the water column and, ultimately, to nearby constructed reefs or beds, or other areas of hard substrate.
- **Anchored Bags:** Anchored bags are mesh bags, filled with oysters and other reef materials, and placed on the bottom. In intertidal or shallow areas, the reef materials are deployed into patches and mounds in the estuarine waters and along shorelines. Shell and marl filled bags also can be deployed with shallow draft barges into mounds and interconnected patch reefs.

### 2.2.5 Shorelines and Shallows TEC

The Shorelines and Shallows TEC promotes creating or restoring shoreline and shallow sites with a vegetated riparian zone, an intertidal zone with a stable slope, and illuminated shallow water. The purpose of this TEC is to restore hardened shorelines, including restoration of transitional zones from aquatic habitat to shallow waters to buffer areas, and removal of invasive species. This would establish natural “living shorelines” comprising a vegetated riparian zone, which is an important transitional habitat between land and water, an intertidal zone that is regularly submerged during high tides and has a stable slope, and an illuminated littoral zone that remains inundated with shallow water. For this analysis, potential locations for shoreline and shallow restoration include hardened shorelines with sufficient adjacent undeveloped upland to allow for the establishment of a vegetation buffer. Suitable locations also have enough area to establish an intertidal zone with a minimum suitable slope and proper water depth.

Man-made shorelines (e.g., bulkheads, piers, wharfs, jetties, and riprap shorelines) may be removed to recreate natural shorelines or can be softened by adding structurally complex features. Many piers or other shoreline structures within the HRE cannot be removed because of adjacent development, port activities, or because they provide protection from waves or vessel-induced wakes. These structures represent potential opportunities for softening via addition of structural features that encourage colonization by epifauna, and may provide refugia for fish and other natant macrofauna. However, some manmade shoreline features are no longer necessary or functional, and may represent opportunities for shoreline softening via removal. Additional shoreline and shallow enhancement opportunities involve creation of sandy intertidal habitat for shorebird nesting and foraging, and creation

of shallow, subtidal habitat to promote the development of bivalve communities (e.g. blue mussels and hard clams).

#### 2.2.5.1 Armoring Structures Removal

Armoring structures include man-made shoreline features such as bulkheads and riprap. Removal of these features requires the use of heavy construction equipment such as excavators. Equipment can be either land or water-based, depending on the water depth adjacent to the structures and the distance to the shoreline. Prior to construction, site preparation activities would include placement of BMPs, such as hay bales and silt fencing, as applicable, to prevent soils erosion and sedimentation. Once the features are manually removed, the site would likely require additional grading to achieve a natural sloping shoreline. Additional measures, such as planting with native vegetation, may be required to stabilize the sediments and provide species habitat.

#### 2.2.5.2 Structural Materials and Fill Placement

In areas where armoring structures cannot be removed, shorelines can be softened by adding structural features that support terrestrial and aquatic species and desirable ecological functions. Timber, live stakes, root wads, and vegetative mats are natural shoreline softening materials (NYSDEC, 2016). Other types of fill material may also be placed in the intertidal zone where armor has been removed and a naturally sloping shoreline needs to be created with new material. Rocks, light-weight fill, sand, and sediments can be placed and graded to desirable elevations to create an appropriate slope. Structural materials could be placed along the shoreline using heavy construction equipment, such as a front loader or a water-based bucket loader. Following material placement, fine grading can be completed manually, without the use of heavy equipment. Additional measures, such as planting with native vegetation, may be required to stabilize the sediments and provide species habitat.

#### 2.2.5.3 Shoreline Habitat Creation

Shoreline habitat would be created by planting appropriate vegetation native to the HRE study area to stabilize sediments and reduce water velocity. Planting would be completed following the placement of materials to create an appropriately sloped shoreline. The surface substrate can be placed with larger construction equipment, but final grading would likely be completed manually or by small mechanical equipment from the shoreline. Upon completion of grading, plants and shrubs would be planted within the substrate at appropriate elevations, based on slope and location in relation to mean low water and mean high water.

### 2.2.6 Habitat for Fish, Crab, and Lobsters TEC

The Habitat for Fish, Crab, and Lobsters TEC promotes creating functionally related habitats in each of the eight regions of the HRE. The purpose of this TEC is to establish habitat complexes of three (3) or more habitat types that are identified by other TECs (i.e., wetlands, oyster reefs, eelgrass beds, intertidal flats, and shallow littoral zones) to create a diversity of habitat for fish, crab, and lobster recruitment and survival. Potential restoration opportunities include areas where at least three (3) existing or proposed TEC habitat types are in close proximity.

The HRE Comprehensive Restoration Plan designates eight target species to represent the demersal or benthic fish and large crustaceans of the HRE study area. These species and the habitats that are critical to their life stages, as well as hypothetical TEC mosaics that would support their recruitment and survival, are provided in Table 5. The target species are either abundant or economically important and



all are well studied. Targeting habitat restoration for these species should also benefit other species in the HRE study area.

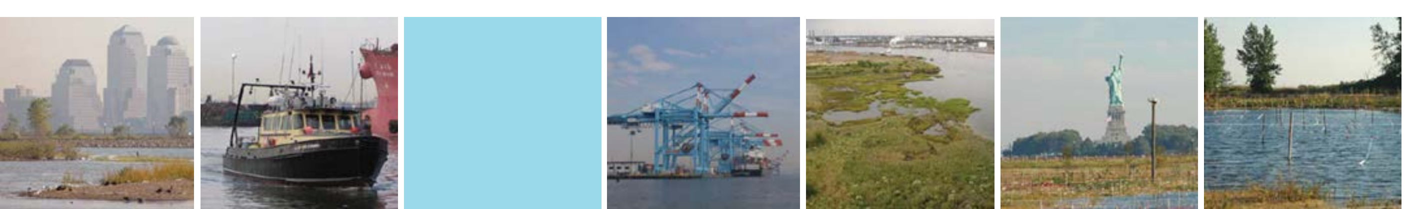
**Table 4: Target Species, Critical Habitat, and Hypothetical Target Ecosystem Characteristic Mosaic for Fish, Crab, and Lobsters TEC.**

| Target Species | Critical Habitat | TEC Mosaic |
|---|---|---|
| Summer flounder (*Paralichthys dentatus*) | Spawning: continental shelf<br>Immature: sandy inshore/offshore habitat<br>Adult: estuary/coastal, ocean | Wetlands<br>Eelgrass Beds<br>Shorelines and Shallows |
| Winter flounder (*Pseudopleuronectes americanus*) | Spawning: mud, sand, gravel sediment<br>Immature: estuary/coastal, aquatic vegetation<br>Adult: coastal | Wetlands<br>Eelgrass Beds<br>Shorelines and Shallows |
| Black sea bass (*Centropristis striata*) | Spawning continental shelf<br>Immature: estuary/coastal, structured habitat<br>Adult: ocean, coastal, reefs | Wetlands<br>Oyster Reefs<br>Eelgrass Beds<br>Shorelines and Shallows |
| Striped bass (*Morone saxitilis*) | Spawning: oligohaline Hudson River<br>Immature: estuary/near salt front<br>Adult: freshwater/coastal | Wetlands<br>Eelgrass Beds<br>Shorelines and Shallows<br>Tributary Connections |
| American eel (*Anguilla rostrata*) | Spawning: Sargasso Sea<br>Immature: continental shelf → estuary → tributary<br>Adult: tributary → ocean | Shorelines and Shallows<br>Tributary Connections |
| Horseshoe crab (*Limulus polyphemus*) | Spawning: continental shelf<br>Immature: shallows, burrow in benthic habitat<br>Adult: estuary/coastal, ocean | Shorelines and Shallows<br>Sediment Contamination |
| American lobster (*Homarus americanus*) | Spawning: continental shelf<br>Immature and Adult: rocky, sediment, marsh, eelgrass | Wetlands<br>Oyster Reefs<br>Eelgrass Beds<br>Sediment Contamination |
| Blue crab (*Callinectes sapidus*) | Spawning: mouth of estuaries<br>Immature and Adult: ocean → estuary/freshwater, structured habitat | Wetlands<br>Oyster Reefs<br>Tributary Connections<br>Sediment Contamination |

Source: Bain et al., 2007, references therein.

### 2.2.7 Tributary Connections TEC

The Tributary Connections TEC promotes reconnecting and restoring freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms. The purpose of this TEC is to remove riverine and estuarine blockages, and to add features to allow the movement of migratory fish. The focus of this TEC is on restoring connections between streams and corridors within streams, including but not limited to restoring natural stream channels, adjacent freshwater wetlands, riparian uplands, and tributary connections through barrier removal or fish passage construction.



Man-made barriers to fish passage include dams, tide gates, and road culverts. The full removal of a dam may involve activities such as diverting the waterway, placing fill for equipment access, removing the structure using explosives or heavy construction equipment, removing sediment build-up and restoring the channel and shoreline habitat to match upstream and downstream conditions, and installing applicable soil erosion and sediment control BMPs (NOAA, 2015). If removing the barrier is not possible, a fish passage system may be installed to allow migrating fish species to bypass the barrier. These systems usually are made of metal, concrete, or natural materials that permit fish to swim up a series of steps (NOAA, 2015). Fish passage systems must be maintained to ensure continued long-term operation.

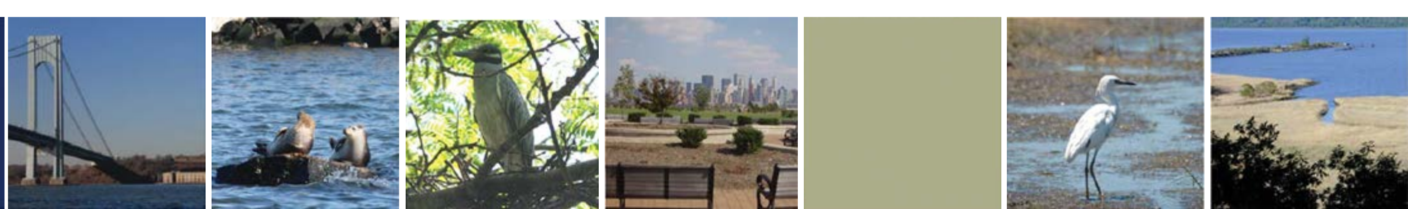
Whether partially or completely closed, tide gates are barriers to all upstream fish migration. The control schedule of existing tide gates can be modified so that gates remain completely open during key migratory periods (e.g., upstream fish runs of anadromous fish, etc.). Self-regulating tide gates, which allow normal amplitude tides to enter and exit, but are designed to close in the event of storm tides, can be installed in place of conventional gates. Culverts under roads or rail beds may inhibit fish passage due to an excess drop at the culvert outlet, high velocity or turbulence, inadequate water depths within the culvert barrel, or debris/sediment accumulation at the culvert inlet or within the barrel (Gibson et al., 2005). Similar to dam passage, fish passage systems can be constructed to reach the outlet of an elevated culvert and the upstream channel may be modified to allow deeper water to flow through the culvert.

The USACE New York District in collaboration with USACE Engineering, Research and Development Center developed a procedure to prioritize removal of major migratory barriers, specifically dams. The prioritization scheme is based on four (4) primary components: habitat quantity upstream of a dam, habitat quality upstream of a dam, the effects of multiple dams in sequence in the context of diadromous fish (i.e., if a fish cannot pass the most downstream dam, then upstream dam removal provides no benefits), and a rapid, screening-level relative cost estimate. These methods are demonstrated in one (1) of eight (8) planning regions, the Harlem River, East River, and Western Long Island Sound Planning Region (McKay et al. 2017, Appendix C) where they were applied to prioritize potential barriers for removal over a range of costs. In this demonstration, the prioritization technique was used to examine 49 potential dam removal sites. A combinatorial algorithm was applied to develop plans with more than 489,000 combinations of removal sites (e.g., remove barrier-A, barrier-B, neither, or both). From this analysis, 49 proposed sites were screened and refined to a recommended plan containing 12 sites, which provides 66 percent of the total potential habitat gain at 19% of the relative cost. The advantages and challenges of barrier prioritization are then discussed more broadly with an emphasis on efficacies that can arise as a result of spatial prioritization methods.

### 2.2.8 Enclosed and Confined Waters TEC

The Enclosed and Confined Waters TEC promotes improving water quality in all enclosed waterways and tidal creeks within the estuary to match or surpass the quality of their receiving waters. The purpose of this TEC is to improve water quality (i.e., bacterial concentrations, dissolved oxygen, and sediment organic carbon) within these areas. The TEC targets restoring or enhancing poorly flushed, enclosed, and over-excavated subtidal areas of the HRE study area that exhibit periodic or continuous poor water quality. Potential restoration opportunities for this TEC include actions within dead-end tidal creeks, bathymetric depressions, and inter-pier areas that do not meet their state designated uses based on water quality and/or experience hypoxic or anoxic conditions during portions of the year.





To help improve water quality, contaminated sediments can be removed by dredge and cap methods discussed in Section 2.2.9. A reduction in pollutant input and an increase in water exchange and dissolved oxygen levels would also benefit an enclosed or confined waterway. A range of activities, from applying simple BMPs to installing complex flushing/circulation systems, can help accomplish this. In addition, softening shorelines would potentially improve the water quality in tidal creeks, by creating vegetated habitat that may reduce pollutant runoff into the waterway. Softening shoreline methods are discussed in Section 2.2.5. Shoreline debris removal should also be considered, as accumulated debris can reduce shoreline vegetation growth.

Stormwater BMPs or green infrastructure can be used to reduce stormwater runoff volume or reduce stormwater pollutants, by treating or filtering the runoff. A simple BMP example would be to pass a local ordinance to curb pets. An example of green infrastructure would be a bioretention system, where stormwater is temporarily stored and infiltrated into the ground over time, reducing the amount of stormwater runoff into the receiving waterbody.

Poor circulation is an important aspect of the degraded water quality in these waterbodies. Improving circulation of stagnant or dead-end basins is complex, and would require connecting the head of the basin to another waterbody through underground infrastructure/piping. Borrow pits are another example of areas with reduced water quality. Clean fill should be considered to improve water quality in these features.

### 2.2.9 Sediment Contamination TEC

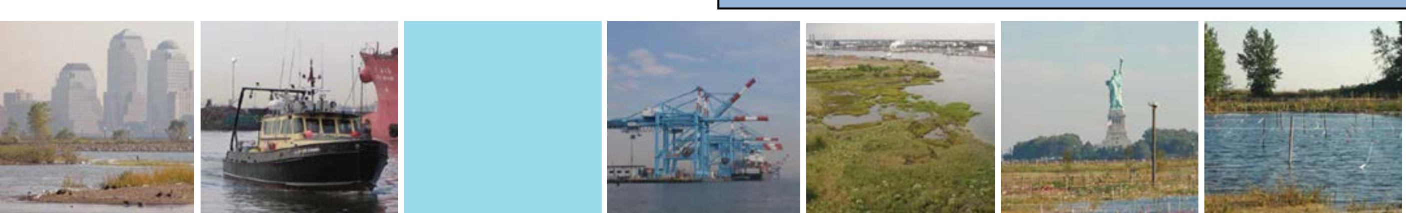
The Sediment Contamination TEC promotes isolating or removing one (1) or more sediment zone(s) that is contaminated until such time as all HRE sediments are considered uncontaminated based on the all related water quality standards, related fishing/shelling bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria, or protocols. The initial step in removing sediments is testing them to determine the depth and level of contamination. Testing involves taking sediment core samples to a specified depth according to a sampling plan and determining if the contaminant of concern is hazardous or non-hazardous. Based on the findings and the nature of the sediment, removal and cap placement can be undertaken.

Sediments to be removed can be excavated, or dredged hydrologically or manually, or a combination thereof. Both hydrological and manual dredging can be performed from the water using barges,

**Hazardous, Toxic, and Radioactive Wastes**

USACE Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects (Engineering Regulation 1165-2-132, June 26, 1992), at paragraph 4.a(1), defines HTRW as follows:

> *Except for dredged material and sediments beneath navigable waters proposed for dredging, for purposes of this guidance, HTRW includes any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq. (CERCLA). (See 42 U.S.C. 9601(14).) Hazardous substances regulated under CERCLA include "hazardous wastes" under Sec. 3001 of the Resource Conservation and Recovery Act, 42 U.S.C. 6921 et seq.; "hazardous substances" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, "hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412; and "imminently hazardous chemical substances or mixtures" on which EPA has taken action under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606; these do not include petroleum or natural gas unless already included in the above categories. (See 42 U.S.C. 9601(14).)*



and manual dredging and excavation can also be performed using land-based equipment.

Following removal activities, if the excavated sediments are non-hazardous, the material could be retained on site, and graded and planted as upland coastal habitat (maritime forest or grassland, for example), and then covered with 12 to 24 inches of growing media. If the exposed underlying sediments are contaminated, they would be covered with a cap of growing medium. The placement of this growing media over the excavated sediments, as well as the improved surface conditions, would inherently improve the physical and chemical conditions for the future vegetative community on site, and provide a barrier to the remaining contamination's entering the water column.

If the excavated sediments are found to be hazardous, the material needs to be treated and disposed of at facilities approved to accept the hazardous material. The cost associated with disposal of contaminated dredged materials varies and depends on the concentration of contaminants. The processes employed to bind or remove the contaminants prior to the overland transport and ultimate upland disposal are sometimes not cost-effective.

Remedial action by others will achieve this TEC while reducing risks to human health and the environment, as well as reducing loading in the Port of New York and New Jersey's navigational channels and reducing the cost of dredged material management. In addition, the proposed restoration actions may indirectly result in a reduction of contaminated sediments through placement of clean fill over contaminated sediment, or other measures.

### 2.2.10 Public Access TEC

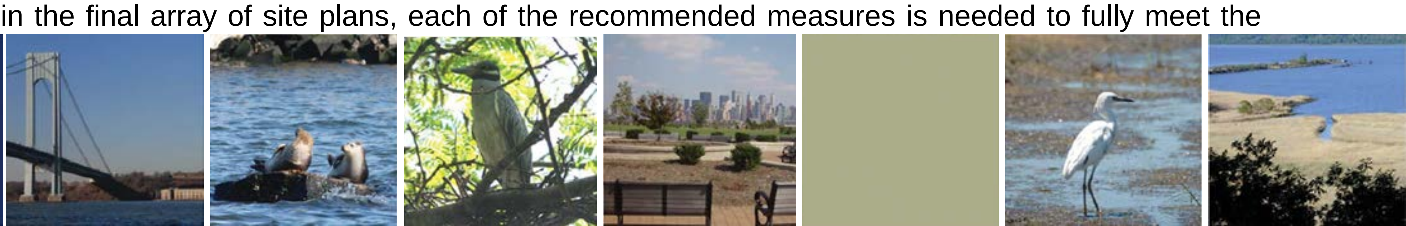
The Public Access TEC promotes improving direct access to the water and creating linkages to other recreational areas, as well as providing increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation. The goal of this TEC is to improve public access throughout the region, as well as education opportunities throughout the watershed, to promote public ownership of restoration. Creating public access points requires construction activities along the waterfront to create features such as parks, promenades, overlooks, and boat launches. In some cases, a parcel may require a simpler approach, such as creation of a natural trail system or educational signs. In other areas, the Public Access TEC requires acquisition of new properties to link recreation areas or provide access to the waterfront where it is currently unavailable.

Per USACE Ecosystem Restoration - Supporting Policy Information (Engineering Pamphlet 1165-2-502, September 30, 1999), the USACE may participate in facility development to provide access to and along the project features. Ideally, these facilities would be a part of a larger non-USACE recreation plan, such as a regional trail system, or provide access to other non-federal recreation facilities or areas. Public access will not be included in the plan formulation strategy for selecting or evaluating the potential restoration opportunities. However, the potential for public access will be considered for each of the potential restoration sites during the site planning phase.

## 2.3 Development of Site-Specific Alternatives

Alternatives were developed for each of the 33 sites outlined in each assessment and alternative development package. Site appropriate restoration measures were chosen based on existing conditions, and site-specific problems, opportunities, objectives, constraints, and considerations. In most cases, these measures were designed to build upon each other, meaning that increased functionality is a product of the interactions of all measures proposed at a given site. At each of the sites in the final array of site plans, each of the recommended measures is needed to fully meet the





objective or objectives that will be addressed at that site. Anything less than implementing all of the recommended measures at each site will not be sufficient to meet the objectives.

For estuarine and freshwater riparian restoration sites (in Bronx River, Flushing Creek, Lower Passaic River and Hackensack River), alternatives were developed through the following multi-step, iterative process in which the sponsors and stakeholders were closely involved. As a benchmark, all restoration alternatives addressed, at a minimum, the most serious environmental stressors at the specific site. The alternatives prepared for each restoration site were developed by varying and combining site-appropriate restoration measures (e.g., wetland restoration, sediment load reduction) aimed at meeting region- and site-specific objectives. In selecting restoration measures, the following were considered:

- The capacity of the measures to address site-specific water resource problems was assessed through comparison with applicable screening criteria.
- Rigorous scrutiny occurred to avoid any measures that were impractical or too costly relative to the ecological uplift provided.
- The various measures for each alternative were selected to work in concert with each other, to provide the greatest ecological uplift for each site.
- The measures for all sites were selected to act synergistically to address key stressors in a particular watershed.

Typically, three (3) restoration alternatives or concept plans were developed, varying the type and magnitude of TECs achievable within the site, differing in functionality and ecological benefits. The three (3) alternatives comprised the following:

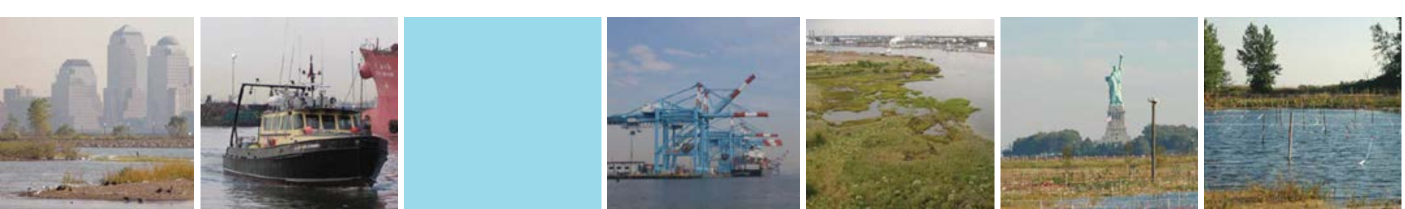
- Alternative A maximizes the restoration potential for each site through the placement of a “mosaic of habitats” and solutions for stressors of water resources. Typically, this alternative has the highest anticipated restoration benefits and the greatest ecological lift through a range of benefits.
- Alternative B focuses largely on correcting the most significant environmental stressors and restoring targeted habitats and ecological functions for a particular site. The alternative removes key stressors and has moderate to high ecological lift.
- Alternative C focuses on correcting the most significant environmental stressors for a particular site. The alternative has moderate ecological lift, achieved only through removing key stressors.

Restoration concept designs were discussed with non-federal study sponsors and potential construction sponsors at design charrettes or coordination meetings.

Alternatives ranging from one (1) to six (6) were developed for each Jamaica Bay site as part of the Jamaica Bay “source” study (Appendix E-1).

The three (3) alternatives that were developed as part of HRE were optimized from the previously selected preferred alternative as part of the Flushing Creek and Bay “source” study. Appendix X-C contains additional site screening and alternatives development conducted in order to identify the original Flushing Creek preferred alternative in 2007.

The development of alternatives for the Jamaica Bay marsh islands and oyster restoration are specifically outlined in Appendices E-2 and E-6, respectively.

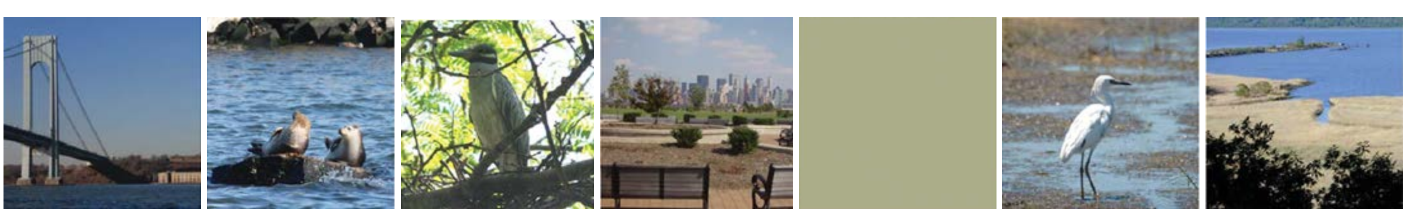


## 2.4 Evaluation of Alternatives

For estuarine and freshwater riparian restoration sites, the EPW scores were calculated for alternatives A, B, and C for two (2), 20, and 50 years after construction. These scores were then compared to baseline and future without project conditions within the WAAs (Appendices E3, E-4 and E-5). The number of Jamaica Bay shoreline site alternatives ranged from one (1) to six (6) where EPW scores were calculated for 50 years after construction (Appendix E-1).

The alternatives developed for the freshwater riparian restoration sites along the Bronx River (Appendix E-4) and Branch Brook, a tributary of the Lower Passaic River and a small portion of Meadowlark Marsh in the Hackensack River (Appendix E-5) were evaluated using the SVAP to assess hydrologic and morphologic stream conditions that were not within the scope of the EPW. SVAP metrics were calculated for each alternative for comparison with existing conditions to demonstrate the improvement of overall quality of stream conditions.





## References

C.C. Bartoldus, E W Garbisch,& M.L. Kraus (1994) Evaluation for Planned Wetlands, A Procedure for Assessing Wetland Functions and a Guide to Functional Design. Environmental Concern Inc.