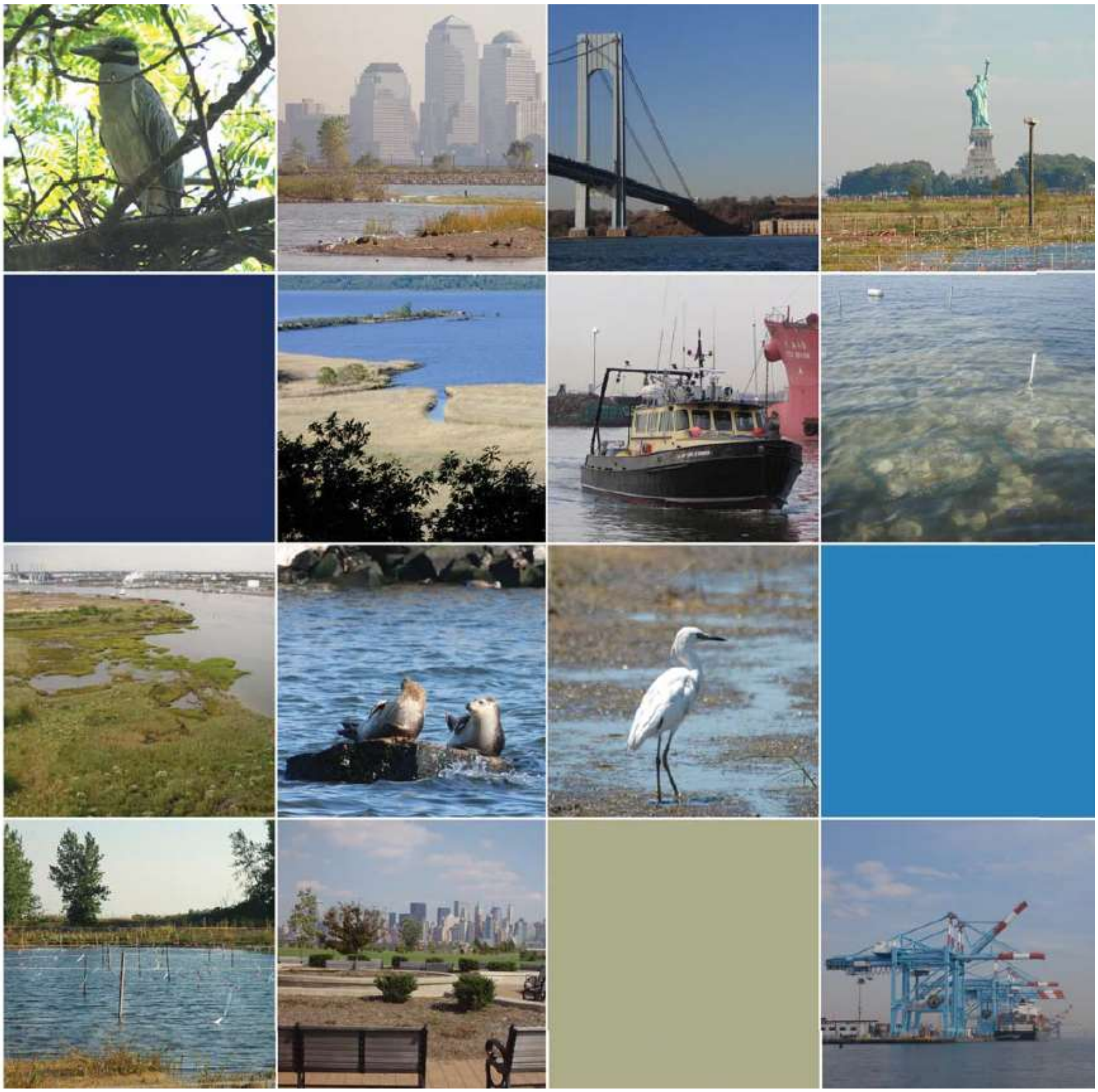
Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Foreword & Chapter 1: Introduction

Final Integrated Feasibility Report & Environmental Assessment

April 2020

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



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Foreword

The Plan Formulation appendix presents the details on site screening and alternatives development to supplement the plan formulation behind the sites included in this Final Interim Integrated Feasibility Report/Environmental Assessment (FR/EA) for the Hudson-Raritan Estuary (HRE) ecosystem restoration study. Alternatives development at each site includes an assessment of baseline existing conditions and future without project conditions, development of measures and alternatives, and the evaluation of benefits and costs for each alternative.

This report is an interim response to the HRE study authority. Out of the hundreds of restoration sites considered, 20 are recommended in this final report to meet the ecosystem restoration needs of this region at this time. As conditions change, other restoration opportunities could be pursued for future feasibility studies under new feasibility cost sharing agreements.

The Unites States Army Corps of Engineers (USACE) and multiple non-federal sponsors initiated six (6) 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 this FR/EA, to result in an initial array of 33 sites. As the boundary of each source study was delineated by watershed boundaries, sites within each watershed (i.e., Jamaica Bay, Bronx River, Lower Passaic River, etc.) were evaluated through cost effectiveness/incremental cost analysis (CE/ICA) in relation to each other, but not across watersheds. Ecosystem characteristics vary strongly from one end of the HRE to another, making inter-watershed comparisons less meaningful than intra-watershed evaluations. This process identified the recommended plan of 20 sites. The following sections are summaries of the plan formulation for the 33 sites in the initial array that were considered to arrive at this Final Report recommending 20 sites, organized and presented by:

- Chapter 1-Introduction;
- Chapter 2-Jamaica Bay Perimeter;
- Chapter 3-Jamaica Bay Marsh Islands;
- Chapter 4-Flushing Creek;
- Chapter 5-Bronx River;
- Chapter 6-Lower Passaic River;
- Chapter 7-Hackensack River; and
- Chapter 8-Oyster Reef Restoration.

This process is depicted in Figure D1-1 and Table D1-1.

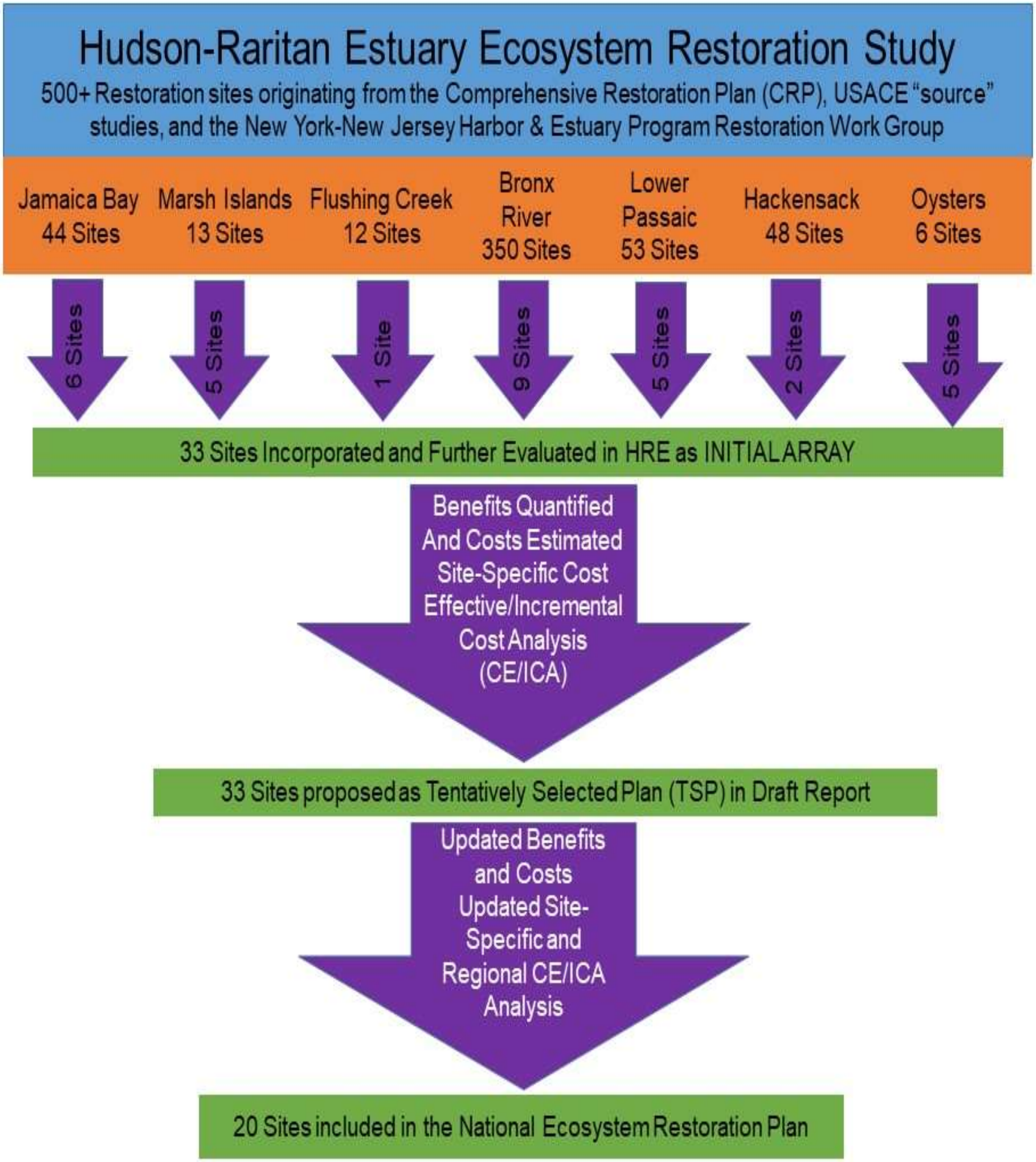

Figure D1-1. Screening of HRE Sites

Table D1-1: Hudson Raritan Estuary Ecosystem Restoration Feasibility Study and Source Study Summary

"Source" Study	HRE	Jamaica Bay	Flushing Creek	Bronx River	HRE-Hackensack	Lower Passaic River
Sponsor	PANYNJ	NYCDEP	NYCDEP and PANYNJ	NYCDEP Westchester County	NJ Sports and Exposition Authority (NJSEA)	NJDOT-NJDEP
Prior "Source" Study Planning Activities (1996-2013)	2001-2013	1996-2013	1999-2008	2003-2012	2003-2013	2003-2013
	* Preparation of 8 Planning Region study area reports * Development of Target Ecosystem Characteristics (TECs) with Partners * Preparation of the HRE Comprehensive Restoration Plan (CRP) (2009) outlining overall goals, targets, opportunities and implementation strategies * Developed concept designs for 275 sites	* 44 restoration opportunities identified * Sites advanced with other authorities, i.e., CAP -Spring Creek North, Gerritsen Creek, Jamaica Bay Marsh Islands. * 6 perimeter sites	* Many preliminary alternatives screened resulting in one site proposed. * NYCDEP requested additional coordination with DEP's Long Term Control Plan requiring modification of the selected plan.	* Bronx River Watershed opportunities report (350 restoration opportunities) * Sites screened for habitat and water quality improvements ranked low, medium, high and very high priority * 23 Sites: high-ranked habitat and high-ranked water quality improvement benefits	* 50 sites identified in Meadowlands Environmental Site Information Compilation (MESIC) (2004) * 18 "Critical Restoration Sites" & 23 Opportunities	* Coordinated WRDA/CERCLA [Superfund] effort with USEPA, NOAA, USFWS and State of NJ for cleanup/restoration * Investigation of environmental dredging pilot * 53 Restoration Opportunities identified in 17-mile segment (& Tributaries) * Sites identified as Tier 1 (could be implemented near-term) and Tier 2 (required remediation prior to restoration)
Sites included in Tentatively Selected Plan-Draft FR/EA (Feb 2017)	5 Oyster Reefs and 5 Jamaica Bay Marsh Islands	6 Perimeter Sites	1 site (Flushing Creek)	9 sites (5 Bronx County and 4 Westchester County)	2 Sites (Metromedia Tract and Meadowlark Marsh)	3 Tier-1 sites 2 Tier-2 sites
Sites included in Recommended NER Plan – Final FR/EA (Jan 2020)	3 Oyster Reefs and 5 Jamaica Bay Marsh Islands	2 Perimeter Sites	1 site (Flushing Creek)	5 sites (3 Bronx County and 2 Westchester County)	2 Sites (Metromedia Tract and Meadowlark Marsh)	1 Tier-1 site 1 Tier-2 site

Jamaica Bay - Perimeter Sites (Appendix D: Chapter 2)

This section provides details on the assessment of existing and future without project conditions, and alternatives development for perimeter sites from Jamaica Bay as supplementary information to the plan formulation in the Main Report. Within the Recommended National Ecosystem Restoration (NER) plan, two perimeter sites are recommended for wetland restoration within Jamaica Bay, out of the six sites that were included in the draft report. Much of the detail in this appendix is derived from the Jamaica Bay, Marine Park and Plumb Beach, New York, Environmental Restoration Feasibility Study (Jamaica Bay "source" study) and subsequently developed in the East Rockaway to Rockaway – Jamaica Bay Reformulation Study.

The HRE FR/EA draft report evaluated six (6) restoration sites toward the continued goal of developing a comprehensive restoration strategy to improve the environmental quality of Jamaica Bay and restore its historical productivity and diversity.

Jamaica Bay Planning Region – Perimeter Sites
Dead Horse Bay
Fresh Creek
Hawtree Point
Bayswater Point State Park
Dubos Point
Brant Point

Through updated CE/ICA during feasibility level analysis after the draft report, three sites were removed from the recommendation including: Hawtree Point, Dubos Point, and Bayswater State Park. This left three sites to be recommended by HRE: Dead Horse Bay, Fresh Creek, and Brant Point. However, Brant Point restoration was incorporated as an NNBF within the high frequency flood risk reduction features recommended in the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study's Chief's Report (August 2019). Therefore, only two sites – Dead Horse Bay and Fresh Creek – will be included in the HRE Recommended Plan.

Jamaica Bay Planning Region – Perimeter Recommended NER Plan Sites
Dead Horse Bay
Fresh Creek

The alternatives recommended for the Jamaica Bay Perimeter emphasize ecosystem restoration activities that involve modification of hydrology and/or aquatic habitat. Habitats targeted include wetlands, riparian and other aquatic systems, but also include adjacent maritime forest and grasslands as appropriate. These latter habitats were perhaps the most severely impacted over time with few remaining, yet they functioned as an integral part of the total ecosystem. They add substantially to the value and functions of the adjacent wetland and aquatic communities but were not formulated objectives of any of the alternatives considered. These actions are essential to the project as a whole as they offer the most cost effective disposal option for excavated soil. This is because excavation of the lowland areas is a necessary aspect of many of the restoration alternatives at the HRE sites, and on-site soil/sediment material placement would be the cheapest way to place the materials that are excavated from the lowlands to restore wetlands. To transport the excavated soils/sediments to a different locality would be expensive, which would add more cost to the restoration action. For this reason, it is the best option for USACE to plan to place the material on-site as much as possible. In addition, this added soil/sediment to upland areas will provide an ecological benefit as a buffer to help protect and sustain the marsh communities restored by this project in the long-term. These adjacent habitats are integral components of wetland systems acting as transitional zones between habitats, providing wildlife and secondary water quality benefits; as well as functional and structural support to hydraulic, sediment transport, and bank stability conditions of the restored wetland. In their 2000 publication Fischer and Fischenich provide a synopsis of design recommendations for riparian corridors and vegetated buffer strips[1]. These recommendations vary based on the desired habitat function or target species; however, due to limited space in the urban setting of the Hudson Raritan Estuary, buffer habitat was generally restricted to under 30m width.

[1] Fischer, R. A., and Fischenich, J.C. (2000). "Design recommendations for riparian corridors and vegetated buffer strips," *EMRRP Technical Notes Collection* (ERDC TN-EMRRP-SR-24), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp

Jamaica Bay - Marsh Islands (Appendix D: Chapter 3)

Prior to colonization, there were an estimated 16,000 acres of salt marsh in Jamaica Bay (USFWS 1997). In the early 1900s, Jamaica Bay was still home to large tracts of salt marsh surrounded by dendritic tidal channels and flats. The ecosystem provides essential habitat for shellfish, finish, and water fowl (NYCDEP 2016). In recent times, the area has been subject to dredging, filling, construction, pollution, overharvesting and eradication of several species. The ecosystem is still ecologically rich, but approximately 2,036 acres of tidal salt marsh were lost from the marsh islands between 1924 and 1999, with the system-wide rate of loss rapidly increasing over time (NYSDEC, 2001). From 1994 to 1999, an estimated 220 acres of salt marsh were lost at an average rate of 44 acres per year. Left alone, the marshes were projected to vanish by 2025, destroying wildlife habitat and threatening the bay's shorelines.

The National Park Service built a coalition tasked with researching the cause of the loss of marsh island area in Jamaica Bay. Their final report indicates a dual mechanism of marsh island loss: perimeter erosion and interior ponding/subsidence. The panel developed several hypotheses for causes of this erosion and subsidence: sea level rise, sediment loss, dredging, shoreline hardening, nutrient enrichment and resulting proliferation of sea lettuce, waterfowl grazing, and boat traffic. The panel urged the community to continue researching specific hypotheses and to implement restoration projects as soon as possible. The agencies met on several occasions to discuss this new and very serious issue and eventually a consensus evolved that the islands would be investigated under a separate parallel track using the CAP authority and this HRE Ecosystem Feasibility Study.

NYSDEC and NYCDEP requested assistance in implementing several marsh island restoration projects. USACE has already restored five (5) marsh islands amounting to over 160 acres of habitat. The 2006 Ecosystem Restoration Report and Environmental Assessment for the Jamaica Bay marsh islands recommended restoration at Elders Point East, Elders Point West, and Yellow Bar Hassock. These three (3) islands were restored in 2007, 2010, and 2012, respectively. Black Wall and Rulers Bar were also restored in 2012 as part of a beneficial use of dredged material in partnership with community organizations and local agencies. Coordination with NYSDEC and the NPS recommended that the maximum perimeter of each of the restored islands should not exceed their 1974 footprints, estimated to be the inflection point at which the existing marsh vegetation began to rapidly deteriorate.

The HRE Final Integrated FR/EA recommends the restoration of five (5) marsh islands in Jamaica Bay to complement the five (5) marsh islands that the USACE has already restored in the area. Habitat targets include high marsh, low marsh, and tidal creeks.

Jamaica Bay Planning Region – Marsh Islands Recommended NER Plan Sites
Duck Point
Stony Creek
Pumpkin Patch West
Pumpkin Patch East
Elders Center

Flushing Creek (Appendix D: Chapter 4)

This section provides details on the assessment of existing and future without project conditions, and alternatives development for the Flushing Creek site as supplementary information to the plan formulation in the Main Report. Within the Recommended NER plan, one site was recommended on Flushing Creek including 19.29 acres of habitat including wetland (9.76 acres low marsh/2.47 acres high marsh), scrub/shrub (1.8 acres), maritime forest (3.89 acres), and shallow water habitat (1.37 acres). The Engineering Appendix includes the grading and planting plans for the Recommended NER Plan. Much of the detail in this appendix is derived from the Flushing Creek and Bay Ecosystem Restoration Feasibility Study (“source” study) and subsequently advanced in the HRE Feasibility Study.

The “source” study was initiated in 1999 and was included within the larger Harlem River, East River and Western Long Island Sound Planning Region. During the ”source” study, an array of preliminary restoration opportunities, including tidal and freshwater wetland restoration, breakwaters, reorientation of the federal navigation channel, daylighting of portions of Flushing Creek and streambank restoration, were identified at various locations throughout the Flushing Bay and Creek Study Area. The screening of initial alternatives and sites and alternative development from the “source” study and activities following integration in HRE is included in this appendix.

Restoration alternatives were further developed that focused on variations of Flushing Creek dredging, capping and adjacent habitat restoration within the riparian, tidal wetland, and benthic zones of the project area. Following site screening, the specific project area of focus was located between the Long Island Railroad (LIRR) and the Interborough Rapid Transit Railroad (IRTRR). The selected plan focused on Flushing Creek dredging and adjacent marsh restoration, including 4.4 acres of riparian restoration, 1.8 acres of wetland restoration on the left descending bank of Flushing Creek, and 4.2 acres of wetland restoration on the right descending bank.

Harlem River, East River and Western Long Island Sound Planning Region – Flushing Creek Recommended NER Plan Site
Flushing Creek – CRP Site 188 (between the LIRR and IRTRR)

In 2007, the site’s selected alternative was not supported by the NYCDEP at the time, as the agency wanted the USACE to include additional environmental dredging activities in the Tentatively Selected Plan (TSP). Progress was then suspended due to lack of funding, and the study was inactivated and subsequently rolled into the HRE Feasibility Study in 2013. Following integration, three (3) alternatives were developed for the Flushing Creek site. NYCDEP determined that they would conduct environmental dredging of the creek, 100% borne by NYCDEP, as part of the City’s Long Term Control Plan. Dredging of the creek was a key assumption for the future without project (FWOP) conditions (during 2013-2018). In 2018, NYCDEP indicated they were no longer planning on dredging the creek and the assumption of the FWOP conditions had changed. The site was then reformulated based on the updated assumption that the creek would remain undredged. Benefits (Appendix E) and costs (Appendix I) were prepared and CE/ICA was conducted (Appendix J) to identify the recommended alternative at the site and then remained a part of the Recommended Plan following the Planning Region CE/ICA analysis (Appendix J).

Bronx River Sites (Appendix D: Chapter 5)

This section provides details on the assessment of existing and future without project conditions, and alternatives development for the Bronx River sites as supplementary information to the plan formulation in the Main Report. As part of the Bronx River Feasibility Study, studies were conducted in the Bronx River to identify and evaluate the water resources problems, needs and opportunities that would support environmental restoration, and an aquatic wetland habitat necessary for a healthy Bronx River Basin ecosystem. The Bronx River Ecosystem Restoration Feasibility "Source" Study conducted by the USACE, the New York City Department of Environmental Protection (NYCDEP) and the Westchester County Planning Department and other partner activities (New York City Parks [NYC Parks], Bronx River Alliance and other academic and private entities) have documented the river's degradation and need for restoration. The Bronx River Feasibility Study identified a total of 350 restoration opportunities (USACE, 2007). Of these 350 sites, 23 were deemed to have Federal interest because of their potential for high value habitat restoration and water quality improvements (the latter being an auxiliary benefit from a USACE perspective), and were selected for further investigation. The sites were screened and nine (9) sites were determined to be included in the focused array.

Harlem River, East River and Western Long Island Sound Planning Region – Bronx River Sites
River Park/West Farm Rapids Park
Bronx Zoo and Dam
Stone Mill Dam
Shoelace Park
Muskrat Cove
Bronxville Lake
Crestwood Lake
Garth Woods / Harney Road
Westchester County Center

The nine (9) sites were identified among the 23 that were among the priorities of the Non-federal sponsors (NYCDEP, NYC Parks and Westchester County) were evaluated further. See Appendix J for the CE/ICA process to arrive at the sites included within the Recommended Plan. This chapter presents the results of the "source" study including the site screening and alternative development of each site. These 9 sites were identified as the Tentatively Selected Plan during 2017 and were further analyzed resulting in five (5) sites included in the Recommended Plan. See Appendix J for the CE/ICA process to arrive at the sites included within the Recommended Plan. This chapter presents the results of the "source" study including the site screening and alternative development of each site.

Harlem River, East River and Western Long Island Sound Planning Region – Bronx River Recommended NER Plan Sites
Bronx Zoo and Dam
Stone Mill Dam
Shoelace Park
Bronxville Lake
Garth Woods / Harney Road

Lower Passaic River and Hackensack River (Appendix D: Chapters 6 and 7)

The Lower Passaic and Hackensack Rivers are located within the Newark Bay, Hackensack River and Passaic River Planning Region. The area has been heavily developed and industrialized since the mid-nineteenth century. This industrial activity has resulted in the degradation of wetlands, discharges of effluents into the streams and rivers, and dumping of industrial waste, thereby contaminating river sediments and adversely impacting fish and wildlife habitat. Shorelines, tidal shallows, natural river channels and riparian forests have been greatly modified by construction of bulkheads, other shoreline alterations, and channel dredging. Dams and tide gates reduce stream connectivity and freshwater flow to Newark Bay, and block upstream and downstream passage of migratory fish.

The restoration opportunities within this planning region had been identified pursuant the HRE-Lower Passaic River and HRE-Hackensack Meadowlands “source” feasibility studies. The Lower Passaic River “source” study was initiated in 2003 with New Jersey Department of Transportation (NJDOT) as non-federal sponsor as part of a Governmental Partnership with U.S. Environmental Protection Agency (USEPA) and Natural Resource Trustees (National Oceanic Atmospheric Administration [NOAA], U.S. Fish and Wildlife Service [USFWS], New Jersey Department of Environmental Protection [NJDEP]). The “source” study was a joint Remedial Investigation/Feasibility Study (RI/FS) with USEPA combining both the USACE Water Resource Development Act (WRDA) and USEPA Superfund Program (Comprehensive Environmental Response, Compensation, and Liability Act, 1980 [CERCLA]) to comprehensively remediate and restore the Lower Passaic River basin. The study area included the lower 17 miles of the Lower Passaic River from Newark Bay to the Dundee Dam including tributaries Saddle River, Second River and Third River. The restoration planning within the area was conducted in coordination with the Superfund Program including shared data collection efforts informing site selection. Remedial Action decisions (i.e., Focused Feasibility Study for the remediation of the lower 8.2 miles and non-time critical removal action at river mile [RM] 10.9) have influenced the sequence and type of recommendation for restoration (e.g., construction near-term, construction following remedial actions [“deferred”] or future feasibility study).

As part of the HRE-Hackensack Meadowlands Ecosystem Restoration “source” feasibility study, the USACE and the New Jersey Meadowlands Commission (now the New Jersey Sports and Exposition Authority [NJSEA]), prepared the Meadowlands Environmental Site Information Compilation (MESIC) Report (USACE, 2004) and the Meadowlands Comprehensive Restoration Implementation Plan (MCRIP) (USACE, 2010). A total of 52 restoration opportunities were identified along the mainstem of the Passaic River (23) and its tributaries (29). Significant data collection during the coordinated RI/FS was utilized to inform the restoration planning effort. Sites were screened in coordination with NJDEP, partner agencies, the Community Advisory Group (CAG), and a design charrette with NJDEP and the National Oceanic and Atmospheric Administration (NOAA) (June 2015). Through the site screening process during the “source” studies, a total of seven (7) project sites were identified for focused investigations and alternative development.

Newark Bay, Hackensack River and Passaic River Planning Region – Passaic and Hackensack River Sites	
River	**Site**
Passaic River	Oak Island Yards
	Kearny Point
	Essex County Branch Brook Park
	Dundee Island Park
	Clifton Dundee Canal Green Acres
Hackensack River	Metromedia Tract
	Meadowlark Marsh

Following integration of these studies into the HRE Feasibility Study, alternatives were developed, benefits were quantified, costs were prepared and site-specific and regional CE/ICA were conducted at each site. Clifton Dundee Canal Green Acres and Dundee Island Park were removed from the recommended plan following regional CE/ICA. Kearny Point was subsequently removed from the recommendation following coordination with United States Fish and Wildlife Service (USFWS) and NOAA indicating a remedial action had occurred and would prevent further restoration onsite. The final Recommended NER Plan includes 4 sites.

Lower Passaic River and Hackensack River Recommended NER Plan Sites
Oak Island Yards
Essex County Branch Brook Park
Metromedia Tract
Meadowlark Marsh

Oyster Reef Restoration (Appendix D: Chapter 8)

Oyster reefs and their restoration were identified as a TEC for the HRE with a target statement and overarching goal to "Establish sustainable oyster reefs at several locations" (USACE, 2016 and PANYNJ, 2014). The Oyster Reefs TEC was assigned a short-term objective of establishing 20 acres of reef habitat across several sites by 2020, and a long-term objective of establishing 2,000 acres of oyster reef habitat by 2050. These acreages were selected as the targets because they are fractions of the known historical oyster beds in the HRE and were a realistic achievable goal given the status of oyster reef restoration in the region. The oyster fishing industry in the estuary thrived in the mid-late 19th century and was estimated to cover approximately 200,000 acres (810 kilometers^2; Kennish 2002, Bain et al. 2007). The long-term goal of 2,000 acres is 1% of the historic oyster coverage, and the short-term goal is 0.01% of the historic coverage.

Conceptual plans were developed for small-scale restoration at five (5) sites in the draft feasibility report, which were subsequently refined to three (3) sites for this final report. See Appendix J for the CE/ICA process to arrive at the sites included within the Recommended Plan.

The designs incorporate restoration techniques that have been tested during pilot programs implemented between 2010 and 2019, and include combinations of restoration techniques most suitable for the conditions, such as bathymetry, tidal currents, and substrate at each site. The proposed small-scale oyster reef restoration restores over 50 acres of reef structure which, allowing for natural mortality associated with restoration, should meet and exceed the year 2020 objective. The Recommended Plan exceeds the goal for 2020 (20 acres), but is far below the goal for 2050 long term target of 2000 acres. The restoration recommended in this interim FR/EA Report contributes significantly to the overall targets for the region work with partners. It was assumed that additional future oyster reef restoration would be recommended through future feasibility study spin-offs. It is envisioned that, between the HRE Feasibility Study oyster reef restoration projects and continuing restoration efforts by the sponsors and other entities in the HRE study area, there will be considerably more functioning oyster reef habitat by 2050.

This chapter presents background on the prior projects implemented at the locations within the Recommended Plan, measures and techniques for oyster reef restoration and alternative development at each site. These recommendations for near-term construction will be an important first step in oyster habitat restoration objectives and associated sub-objectives to incorporate diverse habitat to improve feeding, breeding and nursery grounds for fish and communities. Secondary benefits include incorporating habitat structure to provide secondary coastal storm risk management benefits (e.g., wave attenuation, shoreline stability, and shoreline resiliency) to serve as potential natural and nature-based features and improving water quality through filtration.

It is well documented that oyster reef restoration would provide significant ecological uplift to the HRE. Oysters are valuable organisms that can provide a multitude of ecological benefits including providing habitat for various aquatic species, filtering the water column, and, in some geographic areas, encouraging the growth of tidal shallows and salt marshes. Additionally, oysters can contribute to the reduction of climate change impacts by attenuating storm surges and sequestering carbon.

Previous oyster reef restoration activities, including the Oyster Restoration Research Project (ORRP) and other actions by the Harbor School/BOP, NY/NJ Baykeeper, the Hudson River Foundation and NYCDEP, have already provided encouraging results as oysters have been observed to survive for multiple years after placement on artificial substrate. The HRE Feasibility Study has taken the data provided by these restoration activities and has built upon them, serving as the foundation of recommendations for specific restoration techniques, site considerations, and management of existing reefs. The Recommended NER Plan for oysters includes 3 oyster reefs located in three different Planning Regions.

Oyster Reef Restoration Recommended NER Plan Sites
Lower Bay: Naval Weapons Station Earle
Upper Bay: Bush Terminal
Jamaica Bay: Head of Jamaica Bay

1. Introduction

1.1 General Alternative Development

Once sites were identified for further evaluation alternative development was conducted similarly at each site. The typical methods for alternative development and the management measures utilized to meet planning objectives are presented below.

1.1.1 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. Baseline conditions were measured using the Evaluation of Planned Wetland (EPW) assessment (Bartoldus et al., 1994), the Natural Resource Conservation Service (NRCS) Stream Visual Assessment Protocol (SVAP) [for background information only], Oyster Habitat Suitability Index (Swannack et. al., 2014), Watershed-Scale Upstream Connectivity Toolkit (WUCT) (ERDC, 2018) and other field surveys; all of which are presented in the Environmental Benefits Appendix.

A specific field approach focused on accomplishing three (3) broad goals:

Collect data as required for the appropriate ecological functional assessment model and characterize existing conditions.
Review a 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 varying levels of ecological benefit/uplift, long-term success, and economic feasibility.

1.1.2 Restoration Management 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 TECs. Management measures were informed by field investigations and derived from a variety of sources. Sources for management measures included reconnaissance reports and prior restoration planning during each “source” study; prior public scoping process and U.S. Army Engineer Institute of Water (IWR) Management Measures Digital Library for Ecosystem Restoration.

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 D1-2 provides a sample of restoration and management measures associated with proposed TECs that were used alone or in combination to develop alternatives for each site associated with planning objectives. Further description of these measures and construction techniques for the measures proposed at each site can be found in the Engineering Appendix.

Table D1-2. Planning Objectives, Associated Target Ecosystem Characteristics and Proposed Restoration Measures

Objectives	Target Ecosystem Characteristics/Habitat Types	Restoration Measures
Objective #1: Restore the structure, function, and connectivity, and increase the extent of estuarine habitat in the HRE. Objective #3: Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay.	 Wetlands (low marsh, high marsh, emergent, forested, scrub/shrub)  Habitat for Waterbirds	• Fill removal • Dredging • Grading/Recontouring • Hydrologic restoration • Invasive species removal • Native vegetation planting • Sediment/material placement • Wetland re-vegetation
Objective #2: Restore the structure and function, and increase the extent of freshwater riverine habitat in the HRE.	 Tributary Connections (fish passage and riverine habitat),  Shorelines and Shallows	• Barrier removal • Bed restoration • Channel modification/realignment • In-stream structures • Fish attractor installation • Fish passage system installation • Hydrologic restoration • Dredging • Sediment forebays • Streambank restoration • Shoreline softening • Invasive Species Removal • Native Plantings • Fill removal • Grading • Riparian forest and scrub/shrub habitat restoration • Shallow water restoration

Objectives	Target Ecosystem Characteristics/Habitat Types	Restoration Measures
Support Objectives 1 and 3: Needed buffer and improved functioning wetlands and riparian habitat	Coastal and Maritime Forests	• Sediment/Soil placement • Associated habitat restoration • Fill removal • Forest restoration • Forest preservation • Grading • Invasive species removal • Native vegetation planting
Objective #4: Increase the extent of oyster reefs in the HRE.	Oyster Reefs	• Deploying live shellfish • Sediment/material placement • Submarine structure placement ✓ Spat on Shell ✓ Oyster Condos ✓ Oyster Castles ✓ Super Trays ✓ Gabions
Objectives #1, #2, #3, #4	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, and Shorelines and Shallows TECs.
Measures resulting in secondary benefits contributing to other regional Comprehensive Restoration Plan TECs (Note: Alternatives were not formulated for these targets)		
	Enclosed and Confined Waters	• Contaminated sediment removal or capping • Debris removal • Sediment control BMP installation • Sediment/material placement • Shoreline softening
	Sediment Contamination	• Contaminated sediment removal or capping • Grading • Native vegetation planting
	Public Access	• Fill removal • Public access improvement • Public education • Sediment/material placement

1.2 Evaluation of Alternatives

Each alternative was evaluated with benefits quantified (Benefits Appendix), costs estimated (Cost Appendix) and site-specific CE/ICA conducted (Appendix J). Once the 33 sites were selected, an additional round of CE/ICA analysis was conducted to compare the costs and benefits of the TSP alternative at each site within the same planning region or habitat type (e.g., oysters or marsh islands). The results of this analysis caused 9 sites to be screened out of the Recommended NER Plan (CE/ICA Appendix). The sites that were removed are presented in Table D1-3.

Table D1-3: Sites Removed from Recommended NER Plan Based on CE/ICA Analysis

Planning Region	Site Name
Jamaica Bay Perimeter	Hawtree Point
	Dubos Point
	Bayswater State Park
Harlem River, East River and Western Long Island Sound	Muskrat Cove
	River Park/West Farm Rapids Park
	Crestwood Lake
	Westchester County Center
Newark Bay, Hackensack River and Passaic River	Dundee Island Park
	Clifton Dundee Canal Green Acres

Following the regional CE/ICA, two other sites were removed from the Recommended NER Plan. Brant Point, in Jamaica Bay, was determined to be implemented as part of the High Frequency Flood Features approved in the East Rockaway and Jamaica Bay Reformulation Study's Chief's Report (USACE, 2019). Kearney Point, at the confluence of Lower Passaic River and Newark Bay, was also removed from the Recommended NER Plan following coordination with the USFWS and NOAA indicating that restoration would not be able to occur due to the upland remedial action that was implemented on site. The final HRE Recommended NER Plan includes a total of 20 restoration sites (Table D1-4).

Table D1-4: Sites Remaining in Recommended NER Plan

Planning Region	Site Name
Jamaica Bay – Perimeter Sites	Dead Horse Bay
	Fresh Creek
Jamaica Bay – Marsh Islands	Duck Point
	Stony Creek
	Pumpkin Patch West
	Pumpkin Patch East
	Elders Center
Harlem River, East River and Western Long Island Sound	Flushing Creek
	Bronx Zoo and Dam
	Stone Mill Dam
	Shoelace Park
	Bronxville Lake

	Garth Woods/Harney Road
Newark Bay, Hackensack River and Passaic River	Oak Island Yards
	Essex County Branch Brook Park
	Metromedia Tract
	Meadowlark Marsh
Oyster Reef Restoration (Multiple Planning Regions)	Naval Weapons Station Earle
	Bush Terminal
	Head of Jamaica Bay

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

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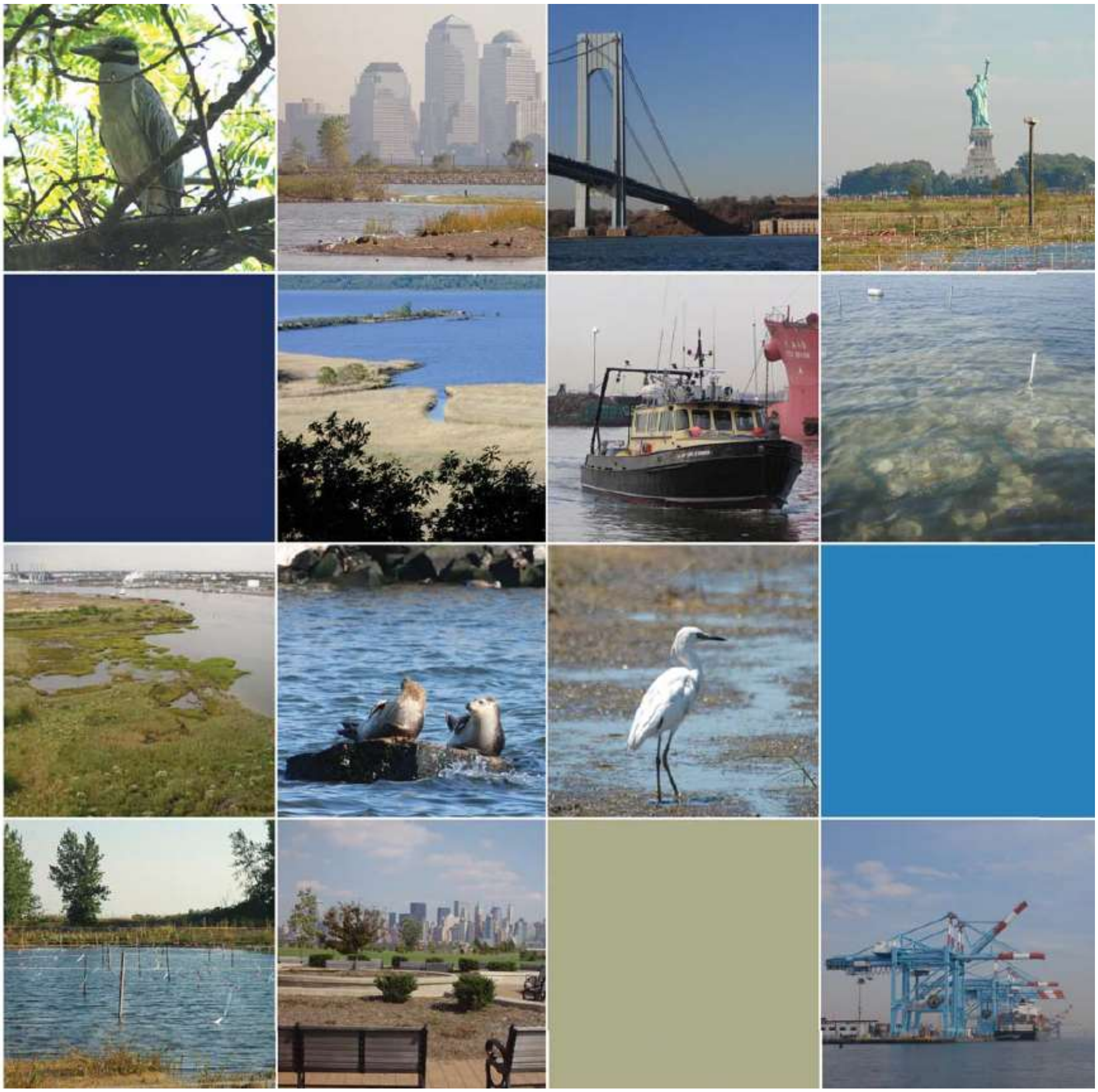
Appendix D
Plan Formulation Appendix
Chapter 2: Jamaica Bay Perimeter

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

THE PORT AUTHORITY OF NY & NJ



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2. Jamaica Bay Perimeter Sites

Jamaica Bay is about eight (8) miles long, four (4) miles wide, and covers an area of approximately 26 square miles. The bay spans the southern portions of the two (2) most populated boroughs in the New York City, Brooklyn (Kings County) and Queens (Queens County), and the western boundary of Nassau County. The bay is fringed by remnant salt marshes, heavily modified tidal creeks, disturbed upland ecosystems, parks, landfills, dense residential communities, commercial and retail facilities, public transportation, and John F. Kennedy International Airport. The bay itself is composed of salt marsh islands, mudflats, tidal creeks, navigational channels, and open water.

In the 19th and 20th centuries, through a series of human actions, extensive habitat losses resulted in the severe degradation of much of the remaining habitats and the bay's chemical, physical, and biological environment. These actions included the filling of marshes and open water areas, hardening of shorelines, altering of the bathymetry of the bay bottom, inputs from raw and treated sewage, combined sewage overflow, and landfill leachates, which impaired the ability of Jamaica Bay to function as an ecological system.

The Jamaica Bay, Marine Park, Plumb Beach Feasibility Study (Jamaica Bay "source" study) was initiated in 1996 to improve the environmental quality of Jamaica Bay and restore its historical productivity and diversity. At initiation of the Jamaica Bay "source" study, the problems with the loss of marsh islands had not been identified and therefore focused on the perimeter of the bay. A total of 44 sites were initially identified as restoration candidates (USACE 1997) which were screened resulting in eight (8) sites which were ultimately selected for more detailed study and design in the Jamaica Bay "source" study. These eight (8) sites were identified as the Tentatively Selected Plan of the Jamaica Bay "source" stand were approved at the Alternative Formulation Briefing in January 2010. These 8 sites were then rolled into HRE where they were screened down to 6 sites for the initial array. This chapter presents the results of the "source" study including the site screening and alternative development for the perimeter sites.

2.1 Project Area Context

Jamaica Bay is a tidal waterway in an urban area which is connected to the lower bay of New York Harbor by Rockaway Inlet. The bay is located 17 miles south and east of the Battery in Manhattan and 22 miles from midtown Manhattan. The Belt Parkway bisects its northern boundary and two (2) large man-made intrusions, Flatbush Avenue and Cross Bay Boulevard, bisect it east to west.

The study area is located within portions of the Gateway National Recreation Area (GNRA), which includes the Jamaica Bay Wildlife Refuge. Both GNRA and the wildlife refuge are operated by the National Park Service (NPS). The GNRA is the nation's first urban park and was created in 1972 to preserve the scenic beauty, flora/fauna, and recreational opportunities of the estuaries and beaches in New York City and Sandy Hook, New Jersey; it encompasses 26,000 acres, 9,155 of which are part of the wildlife refuge (GNRA, 2003). The wildlife refuge, located along Cross Bay Boulevard, is the only urban wildlife refuge in the New York Bight region. In 2015, 3.8 million people visited the Jamaica Bay portion of the Gateway National Recreation Area, roughly three (3) times the number that visit Everglades National Park and comparable to the number of visitors to Yellowstone and Yosemite National Parks (Sanderson, et. al., 2016).

Lying within the Atlantic Coastal Plain geological province, Jamaica Bay consists of loose unconsolidated cretaceous to recent sediments resting on deeply buried crystalline rock floor. The loose sediments are associated with past glaciation periods that resulted in an outwash plain. This sandy plain merged into the historical tidal marshes and barrier island beaches. Over time, physical and biological processes molded Jamaica Bay into a highly productive ecosystem.

Under the National Estuary Act of 1987, the United States Environmental Protection Agency (USEPA) has designated the New York Bight and NY/NJ Harbor as an estuary of national significance. Within the Comprehensive Conservation and Management Plan, signed by the governors of both states as well as the heads of all the major federal, state and local agencies with jurisdiction in the estuary and managed under the Harbor Estuary Program, Jamaica Bay is specifically targeted as a valuable ecosystem in need of protection and restoration. The bay was also identified as significant estuarine habitat by the United States Fish and Wildlife Service (USFWS) in *Significant Habitats and Habitat Complexes of the New York Bight Region* (USFWS, 1999), as a major migratory stopover point along the Atlantic Flyway migration route under the National Waterfowl Management Plan, and a significant coastal habitat under the Coastal Zone Management Act. As an ecological area in a city, the Jamaica Bay system also provides critical seasonal or year-round support to 214 species that are on either state or federal endangered and threatened species list (NYCDEP, 2007).

In the long term, wetland habitat restoration in Jamaica Bay would directly benefit multiple life stages of resident, transient, and migratory fish species, by providing forage, spawning, nursery, and refuge habitat. Restoration of tidal channels and basin re-contouring, by improving tidal flushing and restoring natural salinity regimes, would contribute to an improved habitat for fish (Dibble and Meyerson, 2012), inhibit further expansion and colonization of the invasive common reed (*Phragmites australis*) in coastal marshes (Raposa, 2008; Chambers et al., 2012), and may allow the establishment of native aquatic vegetation. Shoreline restoration would also reduce long-term turbidity levels by reducing shoreline erosion. Oyster restoration would provide beneficial fish habitat (Grabowski and Peterson, 2007; Peterson et al., 2003; Scyphers et al., 2011). Additionally, establishment of oyster reefs would provide water filtration and an attendant reduction in turbidity (Coen et al., 2007) and larval, juvenile, and adult oysters would provide a prey resource for many fish species, which would provide long-term benefits to fish and aquatic macrophytes.

According to NMFS correspondence, four (4) different species of protected marine turtles and the endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) may be present in the bay. The New York Natural Heritage Program (NYNHP) identified several rare, federal- or state-listed bird species on or within one-half mile of potential restoration sites. These include the state-endangered Peregrine falcon (*Falco peregrinus)* and Short-eared owl (*Asio flammeus)*; the state-threatened Piping plover (*Charadrius melodus*), Northern harrier (*Circus cyaneus)*, Upland sandpiper (*Bartramia longicauda)* and Common tern (*Sterna hirundo);* and the state-protected Barn owl *(Tyto alba)* and Laughing gull (*Leucophaeus atricilla).* The USFWS also identified the endangered Roseate tern (*Sterna dougallii*) and threatened Red knot (*Caliris canutus rufa)*.

Butterfly species white-m hairstreak (*Parrhasius m-album)* and red-banded hairstreak (*Calycopis cecrops)* were observed in Floyd Bennett Field near Dead Horse Bay. New York state-listed vascular plants were documented at or near the Dubos Point, Brant Point, Bayswater Point State Park, Dead Horse Bay, and Head of Jamaica Bay restoration sites. All of these threatened or endangered species could benefit from the restoration taking place in Jamaica Bay.

Jamaica Bay was also the subject of a New York City law (Local Law 71), enacted in 2005, requiring the development of a protection plan to preserve and restore its natural and related values. Specifically, the Jamaica Bay Watershed Protection Plan Update (NYCDEP, 2016) addresses wetland loss, water quality, habitat loss, and ecological degradation. The City of New York and the NPS signed an agreement in 2012 to co-manage Jamaica Bay as an integrated social ecological system. Under the new partnership, approximately 10,000 acres of federal and city-owned parks in and around Jamaica Bay would be jointly managed and initiatives created to improve ecosystem services such as recreation space, public access, and public education, while advancing research on issues related to resilience in Jamaica Bay (NYC Parks, 2015). The Jamaica Bay – Rockaway Parks Conservancy was formed in 2013 to support this partnership.

The Science and Resilience Institute at Jamaica Bay (SRIJB), also established in 2013, aimed at increasing understanding of urban watersheds through resiliency-focused research and to engage government and community stakeholders to work together towards a more resilient ecosystem. The SRIJB is supported by a research consortium led by the City University of New York and represents a partnership among academic institutions, government agencies, non-governmental organizations and community groups.

The implementation of the Jamaica Bay “source” study and ongoing HRE restoration feasibility were conducted in coordination with project partners and various advisory committees including:

- New York City Department of Environmental Protection (NYCDEP) Jamaica Bay Watershed Protection Plan Advisory Committee composed of USACE, NPS, Port Authority of New York and New Jersey (PANYNJ), National Resources Defense Council (NRDC), Jamaica Bay EcoWatchers, Stony Brook University and a representative from Community Activists.
- The SRIJB Public Agency Committee (PAC) comprised of representatives from public agencies that are involved in planning, management and regulatory oversight of Jamaica Bay. The PAC includes the USACE, NPS, USEPA, Federal Emergency Management Agency (FEMA), US Department of Housing and Urban Development (HUD), New York State Department of Environmental Conservation (NYSDEC), New York State Governor’s Office of Storm Recovery (NYSGOSR), New York State Department of Transportation, PANYNJ, New York City Department of City Planning, NYCDEP, New York City Department of Parks and Recreation (NYC Parks), New York City Office of Emergency Management and New York City Office of Recovery and Resilience,
- SRIJB Stakeholder Advisory Committee (SAC) is comprised of representatives from community-based, environmental, environmental justice and other civic organizations in Jamaica Bay. The SAC includes The American Littoral Society, Jamaica Bay

EcoWatchers, The Nature Conservancy, The Trust for Public Land, Hudson River Foundation, Eastern Queens Alliance, Environmental Defense Fund, National Park Conservation Association, National Wildlife Foundation, NYC Audubon, Regional Plan Association and Rockaway Waterfront Alliance.

- SRIJB Consortium is composed of nine (9) research institutions including City University of New York, Columbia University Earth Institute, Cornell University, Institute of Marine and Coastal Sciences/Rutgers University, NASA Goddard Institute for Space Studies, New York Sea Grant, Stony Brook University, Stevens Institute of Technology, Wildlife Conservation Society.
- Jamaica Bay Task Force, which includes members from most organizations listed above.

As a result of the above and ongoing coordination with partners, many of the recommendations within this FR/EA are important components of the regional plan to restore Jamaica Bay. These restoration projects were also identified as important components of the regional strategies and recommendations to provide CSRM benefits and ecosystem services to the surrounding communities following Hurricane Sandy. PlaNYC (NYC, 2013a), the New York City Special Initiative for Rebuilding and Resiliency's (SIRR) plan (NYC, 2013b), New York State 2100 Commission Report *Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure* (NYS, 2003), and other documents, provided recommendations to create a more resilient New York City during the recovery efforts of Hurricane Sandy. For Jamaica Bay specifically, the SIRR identified the study and installation of wetlands for wave attenuation in Howard Beach and further flood risk reduction improvements within Jamaica Bay (Coastal Protection Initiative 14) and complete living shorelines and floating breakwaters for wave attenuation in Brant Point, Queens (Coastal Protection Initiative 17). Within the New York State 2100 report, the tidal wetlands of Jamaica Bay were singled out as examples of protective natural infrastructure as a part of the state's flood risk management strategy.

The six (6) sites further evaluated in this FR/EA, would have provided ecosystem benefits and potential CSRM secondary benefits serving as NNBFs within Jamaica Bay while complementing other ongoing coastal restoration efforts at Spring Creek North and formerly planned coastal restoration at Spring Creek South and Howard Beach- New York Rising Community Reconstruction Plan (NYSGOSR, March 2014).

2.1.1 Initial Screening (Phase 1)

The first phase of screening for the Jamaica Bay sites started with 41 restoration sites in addition to the Jamaica Bay Marsh Islands. These sites were presented in Jamaica Bay Navigational Channels and Shoreline Environmental Surveys Final Report (1997) (Table D2-1). Phase 1 screening eliminated nine (9) sites (Table D2-2) based on the following characteristics that were expected to greatly increase the monetary costs and reduce the ecological benefits of any restoration proposal, such that the costs would outweigh the benefits:

- Held largely by private property owners.
- Physical space constraints such as buildings, public roadways, and utilities that did not allow adequate space for the development of viable wetland restoration projects.
- Former industrial uses in which soils had been contaminated (known HTRW contamination).
- Water quality modeling results.
- The site already contained valuable existing habitat.

Table D2- 1. Phase 1 Screening of the Jamaica Bay Sites

Site Name	USACE Site #	PHASE 1 SCREENING (1995-1997)				
		Located on Private Property	Physical Space Constraints	Known HTRW contamination	Water Quality Modeling	Valuable Existing Habitat
Marsh Islands*	-					
Fresh Creek	7					
Dubos Point	26					
Brant Point	28					
Dead Horse Bay	36					
Paerdaget Basin	5					
Spring Creek South	10					
Gerritsen Creek	1B					
Hawtree Basin	11					
Bergen and Hawtree Basins	12					
Grassy Bay	14					
Hook Creek	16					
Mott Peninsula	17					
Mott Basin	18					
Head of Mott Basin	19					

Site Name	USACE Site #	PHASE 1 SCREENING (1995-1997)				
		Located on Private Property	Physical Space Constraints	Known HTRW contamination	Water Quality Modeling	Valuable Existing Habitat
Gerritsen/White Horse Bay Inlet	1D					
Bannister Creek	20					
Healy Avenue	21/22					
Norton Basin	23					
Norton Peninsula	24					
Conch Basin	25					
Sommerville Basin	27					
Vernam-Barbados Basins	29					
Ranger Road Bulkhead, Floyd Bennett Field	2					
Beach 90th Street	30					
Roxbury – U.S. Army Barracks	32					
Plumb Beach	35					
Beach 85th Street	37					
Four Sparrow Marsh	4					
Hendrix Creek	8					
Vandalia Dunes	9					
Spring Creek Park	38					
Bergen Beach	39					
Shellbank Creek	1A					
White Island	1C					
U.S. Coast Guard Facility, Floyd Bennett Field	3					

Site Name	USACE Site #	PHASE 1 SCREENING (1995-1997)				
		Located on Private Property	Physical Space Constraints	Known HTRW contamination	Water Quality Modeling	Valuable Existing Habitat
Canarsie Beach	6					
JFK International Airport	13					
JFK International Airport Runway 4L	15					
Sewer Treatment Plant	31					
Rockaway Point	33					
Breezy Point	34					

* Marsh Islands identified separately and analyzed on their own in Chapter 3.

Following the Initial Phase 1 screening 32 sites remained as potential restoration opportunities, in addition to the Jamaica Bay Marsh Islands. After this Phase of screening, public meetings were held throughout the study area to receive input on the restoration concepts from the local stakeholders.

Table D2- 2. Sites Removed in Phase 1 Screening.

Site Name	USACE Site #	Reason Site Was Screened Out
Shellbank Creek	1A	Much of the site area was owned by private property owners.
White Island	1C	Known HTRW contamination at the site.
U.S. Coast Guard Facility, Floyd Bennett Field	3	Restoration would impinge on mission critical Coast Guard activities.
Canarsie Beach	6	There is already upland shrub and low marsh habitats that provide good fish and wildlife diversity at the site.
JFK International Airport	13	Restoration would interfere with daily operation of the airport.
JFK International Airport Runway 4L	15	NYCDEP water quality modeling results showed that the restoration concept would not improve water quality.
Sewer Treatment Plant	31	A bulkhead immediately joins a roadway at this site. Not enough room to work on the bulkhead without compromising the road.

Site Name	USACE Site #	Reason Site Was Screened Out
Rockaway Point	33	This site is presently used by piping plover and least tern. Construction activities could interfere with these endangered species.
Breezy Point	34	This site is presently used by piping plover and least tern. Construction activities could interfere with these endangered species.

2.1.2 Second Screening (Phase 2)

At the initiation of Phase 2 screening, three (3) new sites were added to the list of potential restoration sites. This was done in response to feedback USACE received from local stakeholders during the public meetings. Two of these additional sites had been proposed in the HRE Comprehensive Restoration Plan (CRP): Bayswater Point State Park and Hawtree Point, and one arose from stakeholder coordination: Broad Channel. This brought the total number of sites examined by this “source” study to 44: 41 from the Jamaica Bay Navigational Channels and Shoreline Environmental Surveys Final Report and three (3) sites from the CRP and Stakeholder coordination. Since 9 sites had already been screened out in Phase 1 screening, Phase 2 screening commenced with 32 sites and the Jamaica Bay Marsh Islands.

In the second phase of screening, the 35 sites were screened using five criteria: 1) site access; 2) new data on potential site contamination; 3) the need to modify Combined Sewer Outfalls (CSO) and storm drains if the restoration concept was implemented; 4) likelihood of restored site to remain stable after construction; and 5) suitability for Submerged Aquatic Vegetation (SAV) restoration (where SAV restoration was part of the restoration concept). This screening was different than Phase 1 screening. Instead of eliminating sites as restoration potential, this screening ranked the sites into higher priority (Priority #1- less costly) sites for restoration and lower priority (Priority #2- more costly) sites for restoration   It was the goal of the USACE to focus on the high priority sites first, since they were assumed to be easier to implement assuming less issues associated with the five criteria above. Though the Priority #2 sites were considered lower priority than the Priority #1 sites, they still could be the focus of future spin-off studies using the HRE Study Authorization. To initiate a spin-off study in the future, a second feasibility study report under a new feasibility cost sharing agreement would need to be undertaken.

To accomplish this second screening phase, the USACE consulted with technical experts from NPS, USFWS, USEPA, NYSDEC, New York State Department of State (NYSDOS), NYCDEP, NYC Parks and interested local groups. This group of technical experts collaborated to evaluate each of the 35 sites (Table D2-3) using the five criteria listed above. This screening characterized 10 Priority #1 Sites: Gerritsen Creek, Spring Creek, Fresh Creek, Broad Channel, Dead Horse Bay, Hawtree Point, Brant Point, Dubos Point, Paedergat Basin and Bayswater Point State Park. There were 25 sites identified as Priority #2 sites. The Priority #2 sites were thus removed from further consideration in the initial array (Table D2-4). It was also during this time that the study team identified the environmental degradation of the marsh islands and started analyzing them on their own, separate from the perimeter sites. The analysis and recommendations for the Jamaica Bay Marsh Islands are presented in Chapter 3 of this report.

Table D2- 3. Phase 2 Screening of Jamaica Bay Perimeter Sites

Site Name	USACE Site #	PHASE 2 SCREENING (2000)			
		3 Additional Sites Added in 2000	Priority 1	Priority 2	Justification for Lower Priority
Hawtree Point	CRP 161	From CRP	1		
Bayswater State Park	CRP 148	From CRP	1		
Fresh Creek	7		1		
Dubos Point	26		1		
Brant Point	28		1		
Dead Horse Bay	36		1		
Paerdaget Basin	5		1		
Spring Creek South	10		1		
Gerritsen Creek	1B		1		
Broad Channel	X	Public Meetings	1		
Hawtree Basin	11			2	Site access & contamination
Bergen and Hawtree Basins	12			2	Site access & contamination
Grassy Bay	14			2	Contamination & unsuitable SAV restoration
Hook Creek	16			2	Contamination
Mott Peninsula	17			2	Stability after construction
Mott Basin	18			2	Site access, CSO & tidal circulation
Head of Mott Basin	19			2	Contamination & CSO
Gerritsen/White Horse Bay Inlet	1D			2	Site access, contamination & stability after construction
Bannister Creek	20			2	Site access & contamination
Healy Avenue	21/22			2	Site access, contamination, stability & tidal circulation
Norton Basin	23			2	Contamination & CSO
Norton Peninsula	24			2	Site access & contamination
Conch Basin	25			2	Contamination & CSO

Site Name	USACE Site #	PHASE 2 SCREENING (2000)			
		3 Additional Sites Added in 2000	Priority 1	Priority 2	Justification for Lower Priority
Sommerville Basin	27			2	Contamination & tidal circulation
Vernam-Barbados Basins	29			2	Contamination, CSO & tidal circulation
Ranger Road Bulkhead, Floyd Bennett Field	2			2	Contamination & stability
Beach 90th Street	30			2	Contamination & tidal circulation
Roxbury – U.S. Army Barracks	32			2	Tidal circulation & cultural resources
Plumb Beach	35			2	Stability & tidal circulation
Beach 85th Street	37			2	Contamination
Four Sparrow Marsh	4			2	Contamination
Hendrix Creek	8			2	Contamination, stability & CSO
Vandalia Dunes	9			2	Contamination
Spring Creek Park	38			2	Potential Contamination
Bergen Beach	39			2	Site access, contamination & tidal circulation
Marsh Islands	X				Marsh Islands identified as an issue, analyzed on their own in Chapter 3.

Table D2- 4. Lower Priority # 2 Sites that were removed following Phase 2 Screening.

Site Name	USACE Site #	Justification for Priority # 2 Designation
Hawtree Basin	11	Site access and contamination issues
Bergen and Hawtree Basins	12	Site access and contamination issues
Grassy Bay	14	Contamination and unsuitability for SAV restoration
Hook Creek	16	Contamination
Mott Peninsula	17	Stability after construction
Head of Mott Basin	19	Contamination and CSO issues
Gerritsen/White Horse Bay Inlet	1D	Site access, contamination, and stability after construction

Site Name	USACE Site #	Justification for Priority # 2 Designation
Bannister Creek	20	Site access and contamination
Healy Avenue	21/22	Site access, contamination, stability after construction, and tidal circulation
Norton Basin	23	Contamination and CSO issues
Norton Peninsula	24	Site access and contamination
Conch Basin	25	Contamination and CSO issues
Sommerville Basin	27	Contamination and tidal circulation issues
Vernam-Barbados Basins	29	Contamination, CSO, and tidal circulation issues
Ranger Road Bulkhead, Floyd Bennett Field	2	Contamination and stability
Beach 90th Street	30	Contamination and tidal circulation
Roxbury-U.S. Army Barracks	32	Tidal circulation and cultural resource concerns
Plumb Beach	35	Stability and tidal circulation
Beach 85th Street	37	Contamination
Four Sparrow Marsh	4	Contamination
Hendrix Creek	8	Contamination, stability after construction, and CSO issues
Vandalia Dunes	9	Contamination
Spring Creek Park	38	Contamination
Bergen Beach	39	Site access, contamination, and tidal circulation

In April of 2000, the NPS and USACE entered into an interagency agreement to conduct baseline assessments for the 10 Priority #1 sites. These federal agencies, along with the City University of New York Aquatic Research and Environmental Assessment Center at Brooklyn College, established the Jamaica Bay Ecosystem Research and Restoration Team (JABERRT), comprising 18 scientists from nine (9) institutions. From 2000 to 2001, JABERRT completed an extensive literature search and conducted a detailed inventory and bio-geochemical characterization of Jamaica Bay, publishing its final report in 2002 (USACE, 2002). This report, along with the existing conditions report (USACE, 2002a), and conceptual designs and cost report (USACE, 2003) prepared for the Jamaica Bay Feasibility Study, served as the basis for identifying existing conditions and recommending restoration alternatives at each of the remaining Jamaica Bay sites.

2.1.3 Third Screening

The third phase of screening started with the 10 Priority# 1 sites that were evaluated using two criteria including: 1) water quality modeling results that showed no improvement in dissolved oxygen due to the project; and 2) any sites that would be implemented under the Continuing Authorities Program (CAP). Two (2) sites were screened out in this phase (Table 6) and are outlined below.

- Poor results of Water quality modeling: The Broad Channel restoration concept was to install culverts to restore tidal circulation. NYCDEP carried out initial water quality modeling and found that there was no net improvement in dissolved oxygen levels due to the project, and that poor water quality in one location could be transported to other areas. Since the proposed restoration at these sites would not improve habitat for fish, crab, and lobsters, these two sites were screened out.
- Implementation as a CAP project: Gerritsen Creek was incorporated into the CAP, Section 1135, to expedite implementation and advance construction when a new non-Federal sponsor, New York City Department of Parks (NYCDPR) – Natural Resources Group, received targeted restoration funding from a state bond act. In addition, Spring Creek North (a Priority# 2 site) also advanced under the CAP Section 1135 authority.

Table D2- 5. Phase 3 Screening for Jamaica Bay Perimeter Sites

Site Name	USACE Site #	PHASE 3 SCREENING (2006-2007)		
		Water Quality Modeling Results	Implemented by CAP	Eelgrass Restoration
Hawtree Point	CRP 161			
Bayswater State Park	CRP 148			
Fresh Creek	7			
Dubos Point	26			
Brant Point	28			
Dead Horse Bay	36			
Paerdaget Basin	5			
Spring Creek South	10			
Gerritsen Creek	1B			
Broad Channel	X			

After the third screening, 8 sites were recommended by the Jamaica Bay "source" study. In addition to their overall ecological value to the bay system as a whole, the eight (8) perimeter sites also act as a buffer for the center of bay from the densely urban setting, and will protect, ecologically and from future storm events, future restoration attempts in the center of the bay.

Table D2- 6. Sites removed after Phase 3 Screening

Site Name	USACE Site #	Justification for Screening Out
Gerritsen Creek	1B	Implemented by CAP
Broad Channel	X	Poor water quality modeling results

2.1.4 Fourth Screening

At this point, the Jamaica Bay "source" study was incorporated into the HRE Study, and the fourth and final round of screening was implemented. This fourth round of screening removed two sites that had already been advanced by the study sponsors through other programs (Table D2-7). Between 2007 and 2010, the NYCDEP implemented restoration at Paerdegat Basin, and NYSDEC advanced the Spring Creek South perimeter site pursuant a FEMA Hazard Mitigation Grant awarded in 2013. The northern portion of Spring Creek was advanced by CAP program under Section 1135 (Project Modifications to Improve the Environment) (USACE, 2016).

Table D2- 7. Phase 4 Screening for Jamaica Bay Perimeter Sites

Site Name	USACE Site #	PHASE 4 (2010)
		Advanced by Regional Partners
Hawtree Point	CRP 161	
Bayswater State Park	CRP 148	
Fresh Creek	7	
Dubos Point	26	
Brant Point	28	
Dead Horse Bay	36	
Paerdaget Basin	5	
Spring Creek South	10	

Table D2- 8. Sites Removed after Phase 4 Screening

Site Name	USACE Site #	Justification for Screening Out
Paerdegat Basin	5	Advanced by regional partners
Spring Creek South	10	Advanced by regional partners*

*Note: Spring Creek South was advanced by NYSDEC under a FEMA Hazard Mitigation Grant Program (HMGP). This project advanced to approximately 65% designs during the Preconstruction Engineering Design (PED) Phase and was not approved by FEMA to be implemented under the HMGP. Given the overwhelming agency, stakeholder and political support and importance of this site, a request has been made to advance this project as a new phase spin-off feasibility study and be completed as quickly as possible.

This final screening left six sites which were further evaluated by this study: Dead Horse Bay, Fresh Creek, Hawtree Point, Bayswater State Park, Dubos Point, and Brant Point (Table D2-9).

Table D2- 9. Jamaica Bay Perimeter Sites Evaluated by HRE

Site Name	USACE Site #
Hawtree Point	CRP 161
Bayswater Point State Park	CRP 148
Fresh Creek	7
Dubos Point	26
Brant Point	28
Dead Horse Bay	36

2.1.5 Post Hurricane Sandy Re-evaluation

As identified in the previous sections, a robust analysis of potential Jamaica Bay restoration sites was conducted between 2000 and 2010. However, Hurricane Sandy devastated the region and significantly impacted Jamaica Bay in October, 2012. As a result of this devastation, the Jamaica Bay “source” study was included in the Second Interim Report to Congress (11 March 2013) pursuant the Disaster Relief Appropriations Act (Public Law 113-2, January 2013). An *Initial Assessment to Confirm Federal Interest* (USACE, 2014; Attachment A) was prepared in order to re-examine these restoration sites as opportunities for Natural and Nature Based Features (NNBFs) that would provide coastal storm risk management (CSRM) benefits, coastal resiliency, and sustainability within Jamaica Bay. The Second Interim Report includes the objective of: "Improving resilience of our coastal areas by pursuing an approach that reflects the relationships between natural, social, and built systems."

Subsequently, the planning effort was included in the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study for consideration of these restoration projects to serve as NNBFs as part of the perimeter plan providing CSRM benefits to the surrounding communities. The existing conditions and baseline ecosystem function at each site was validated in August 2015 by the reformulation team and the restoration designs were reevaluated. Since the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study recommended a coastal storm barrier as the Recommended Plan, the restoration sites were included back into the HRE study for further evaluation.

2.2 Site-specific Existing Conditions and Future Without Project (FWOP) Conditions

Upon selection of the six (6) sites, site-specific detailed existing conditions and future without project conditions were developed. The existing conditions and restoration goals are summarized in Table D2-10 below. The *Existing Conditions, Future Without Project Conditions, Goals and Objectives Report* (USACE 2002a) includes a more detailed discussion of the six (6) sites.

The future without project conditions at all sites will involve further expansion of invasive species and possible water quality degradation if improvements are not made to the water treatment plants and combined sewer outfalls (CSOs) that discharge into the bay. Current measures to improve water quality include the NYCDEP and NYSDEC CSO Abatement Program that will conduct environmental dredging of several tributaries to remove CSO mounds that contribute to nuisance odors and dissolved oxygen deficits within affected waterbodies. Fresh Creek is among the targeted waterbodies for this program.

Commercial and residential development pressures, both upland such as more impervious surfaces, earth moving activities, rerouting of rainfall runoff, and below mean low water (MLW) such as modifications to the Belt Parkway and other roadway bridges, JFK International Airport runway modifications, navigation channel maintenance activities, bulk-heading, are likely to cause further degradation. Erosion and illegal filling and dumping at certain of the proposed restoration sites along the periphery of the bay are also expected to continue, causing further degradation of the habitat and loss of wetlands.

Existing and FWOP conditions for each restoration site are provided below.

Table D2-10. Existing Conditions and Restoration Goals at each Jamaica Bay Perimeter Sites

Site Name	Vegetative Characteristics	Physical Characteristics	Potential Restoration Actions
Dead Horse Bay	• Common reed dominates • Some grassland communities and secondary woodlands occur in the upland areas • Very small, fragmented areas of salt marsh cordgrass still persist along the perimeter of the bay	• Dredging has created deep water channels to the southwest of the study area • A large marina exists at the mouth of the former Deep Creek between the north and south segments of the site • Shoreline along south has experienced severe erosion and significantly been reduced in area	• Reestablishment of salt marsh area in the north and south sections • Incorporate a tidal creek system in the north restoration area • Stabilize the solid waste landfill from erosive forces in the southwest and south shorelines (implemented by NPS) • Dispose of excavated soil onsite to restore a transition zone from wetland to upland • Restore the tidal marsh west peninsula
Fresh Creek	• Generally consists of a mix of common reed, mugwort, secondary woodlands, and Japanese knotweed • Small patchy areas of salt marsh cordgrass and spike grass	• Straightened channel approximately 16 feet deep, then shallower to the head end of the creek	• Restore the remaining salt marshes • Replace monotypic stands of vegetation with diverse native plantings • Restore tidal marsh systems to increase total marsh acreage and offset both historical and future losses • Restore a transition zone from wetland to existing upland habitat • Restore bathymetry and improve benthic community
Hawtree Point	• Dominated by common reed and mugwort as well as grasses, such as switchgrass	• Extensive alteration and filling • A deep water channel runs along the south side	• Replace monotypic stands of vegetation with diverse native plantings • Restore tidal marsh systems to offset both historical and future losses • Restore transition zone from wetland to existing upland habitat

Site Name	Vegetative Characteristics	Physical Characteristics	Potential Restoration Actions
Bayswater Point State Park	• Stand of mature woodlands • Continuous band of salt marsh along the northeastern shore	• Wave-driven erosion of the western shore has caused a loss of tidal wetlands in the area	• Replace common reed areas with intertidal marsh and tidal creek system • Restore buffer of shrub edge habitat • Use shoreline erosion control structures to protect from erosion loss and also to create macro-invertebrate habitat
Dubos Point	• Large inland salt marsh • Black cherry woodland in western end overrun with Oriental bittersweet	• Deteriorated bulkhead and eroded western shoreline	• Replace monotypic stands of vegetation with diverse native plantings • Use shoreline erosion control structures to protect from erosion loss and also to restore macro-invertebrate habitat
Brant Point	• Dominated by common reed and mugwort • Some scrub/shrub and salt marsh communities	• Shoreline along the north and west have experienced severe erosion and significantly been reduced in area	• Replace monotypic stands of vegetation with diverse native plantings • Restore tidal marsh systems to offset both historical and future losses • Use shoreline erosion control structures to protect from erosion loss • Restore transition zone from wetland to upland habitat

2.2.1 Dead Horse Bay

The Dead Horse Bay project area is within National Park Service's Gateway National Recreation Area and is adjacent to Floyd Bennett Field in Kings County, New York. The name Dead Horse Bay comes from a horse rendering facility in the southwestern portion of the project area. Prior to 1941, this site was essentially undisturbed. NYC Parks covered most of the marsh area and the southern portion of the open water with landfill in the 1950s. Historical topographic maps show that the filling took place between 1948 and 1951. The fill used was described as "great mounds of garbage from Queens and Brooklyn flattened into compact layers with sand carpeting 1 to 2 feet thick." The 1941 coastal chart shows that tidal marsh remained in the northern portion of the site, even after construction of the Belt Parkway. Fill of this area apparently occurred during the 1950s in connection with the construction of the Marine Park. With the entire area historically filled, a solid waste landfill is located to the south and erosion claims the west peninsula of Dead Horse. Figures 2-1 and 2-2 show an aerial photograph and baseline existing conditions of the site. Environmental stressors on the site include historic loss of marshes, erosion and exposure of the solid waste landfill exposing the landfill. The site also suffers from the presence of extensive areas of non-native, invasive plant species.

In Dead Horse Bay North, dredged material was placed on-site and filled in the historical wetlands. Both north and south parcels are almost completely dominated by invasive species. Some small areas of secondary woodland and bayberry thickets are present. Since the site is owned by the National Park Service no anthropogenic threats are anticipated in the future. Some small areas adjacent to roadways may be littered. The northern portion of the site will remain essentially heavily dominated by invasive species and considerably degraded from its past ecological values in the foreseeable future.

In 2018, NPS determined that the Dead Horse Bay project site would require an Environmental Engineering/Cost Analysis (EE/CA) or Remedial Investigation/Feasibility Study pursuant to CERCLA to determine the extent of contamination and determine the need for a remedial action. NPS will collect samples for HTRW to determine the appropriate remedial action. The action is expected to focus on the Dead Horse Bay South, which will no longer be considered for restoration. Data collection for the investigation could advance the Corps' PED data needs which will aid in advancing the feasibility level designs (~20+%) to 100%. Soils in Dead Horse Bay North are expected to be clean in order to advance restoration. However, if remedial actions are required as a result of the site-wide RI/FS, NPS (or Potential Responsible Parties) would pay 100% of the costs for remediation prior to implementing the restoration project at Dead Horse Bay North. USACE restoration actions must be coordinated with the NPS remedial actions on the South for soil placement. Given the timing for future actions are dependent upon remedial actions by NPS, the site has been designated as a Tier 2 site (similar to Oak Island Yards on the Lower Passaic River).

Figure D2-1. Aerial Photograph of Dead Horse Bay Project Site

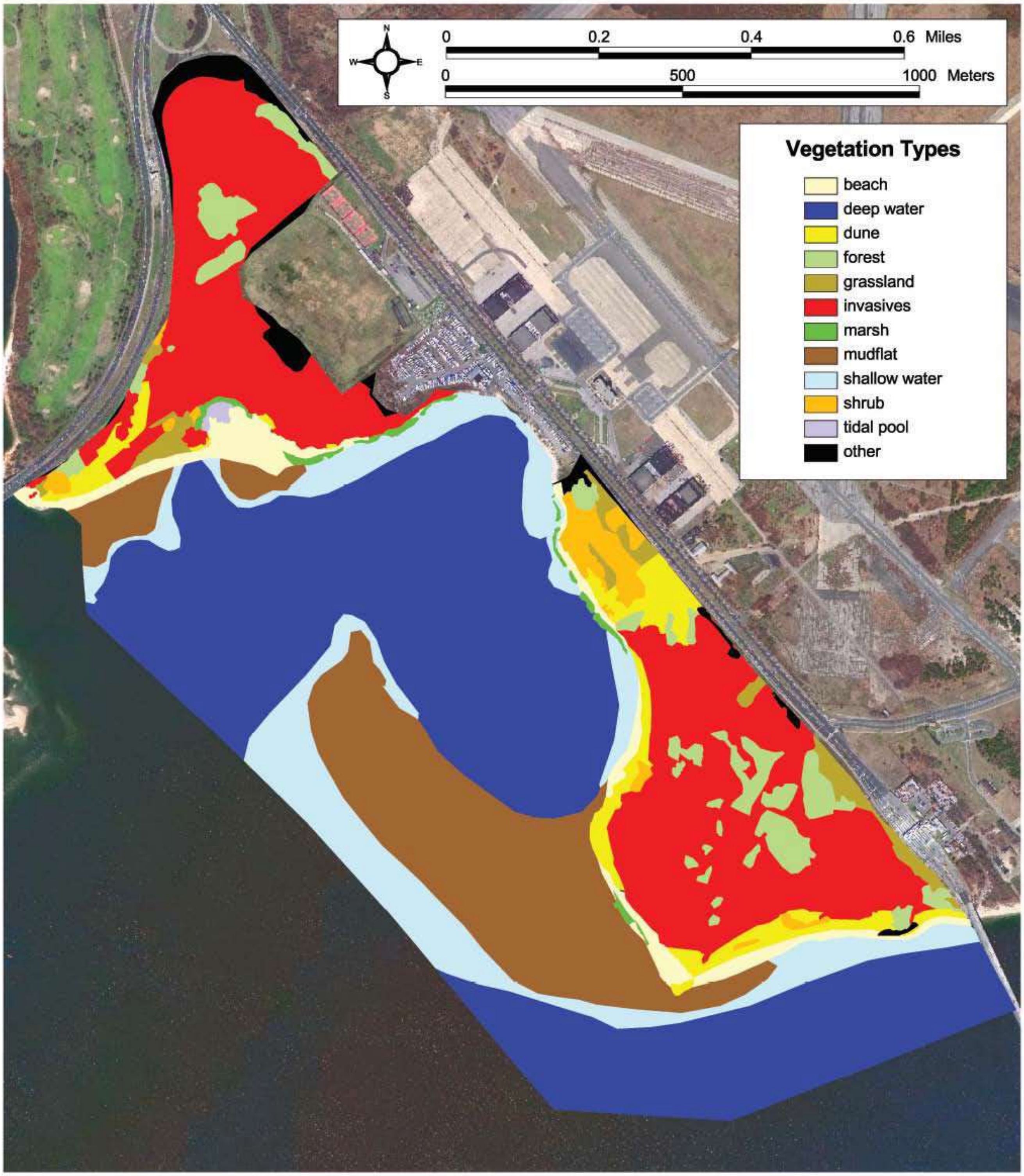

Figure D2-2. Dead Horse Bay Existing Conditions

2.2.2 Fresh Creek

The Fresh Creek project area is located in and along the tidal wetlands and adjacent upland bordering Fresh Creek, a tributary to Jamaica Bay in Kings County, New York. The project area is on public parkland, owned by NYC Parks and has no permanent residence. The area was historically a marshland surrounding a small tidal creek. The creek was dredged and widened in the early 1920s and much of the marsh was filled by the USACE.

The soil is composed of poorly-sorted sandy gravel. All soil samples showed substantial amounts of gravel, sand and silt. The deposition of historic fills has been irregular at this site. The project area is located within the floodplain of Fresh Creek/Jamaica Bay. Due to extensive filling and bulkheading, the areal extent floodplain has been severely reduced from its historical limits. Only the tidal basin and its attached tidal wetlands are currently located within the 100-year floodplain.

The site encompasses 146.1 acres that includes beach, grassland marsh, mudflat, salt marsh, coastal scrub/shrub forest, mature woodland mature woodlands, shrubs, and invasive plants (Figures 2-3 and 2-4). With the exception of mature woodlands along the Belt Parkway, secondary woodlands on the eastern portion of Fresh Creek, and salt marsh communities at the head, middle, infringing the lower sections of the Basin, the remaining areas are comprised entirely of invasive species. It is anticipated that invasive species may encroach further into these higher quality vegetation areas but will not grow below mean high water due to salinity and inundation levels.

The Fresh Creek site is surrounded by dense urban development and subject to combined sewer overflow (CSO) and storm water outfalls. Due to past dredging and existing combined sewer outfalls, along with the historic loss of wetland due to filling the Fresh Creek site has poor water quality and poor benthic habitat. In August 2016, NYCDEP initiated a $56.5 million upgrade to reduce flooding, improve reliability of drinking water delivery and making the roadways safer that will improve the health of Fresh Creek and Jamaica Bay by nearly 200,000,000 gallons of CSO input annually. NYCDEP has continued to improve water quality within Jamaica Bay through the implementation of NYCDEP's Nitrogen Control Program and Jamaica Bay CSO Long Term Control Plan (which includes multiple Watershed Restoration Pilot Studies) and green infrastructure projects to control stormwater runoff. The level of water quality impacts in the area are not expected to be significant enough that would influence the sustainability of the proposed restoration action.

Figure D2-3. Aerial Photograph of the Fresh Creek Site

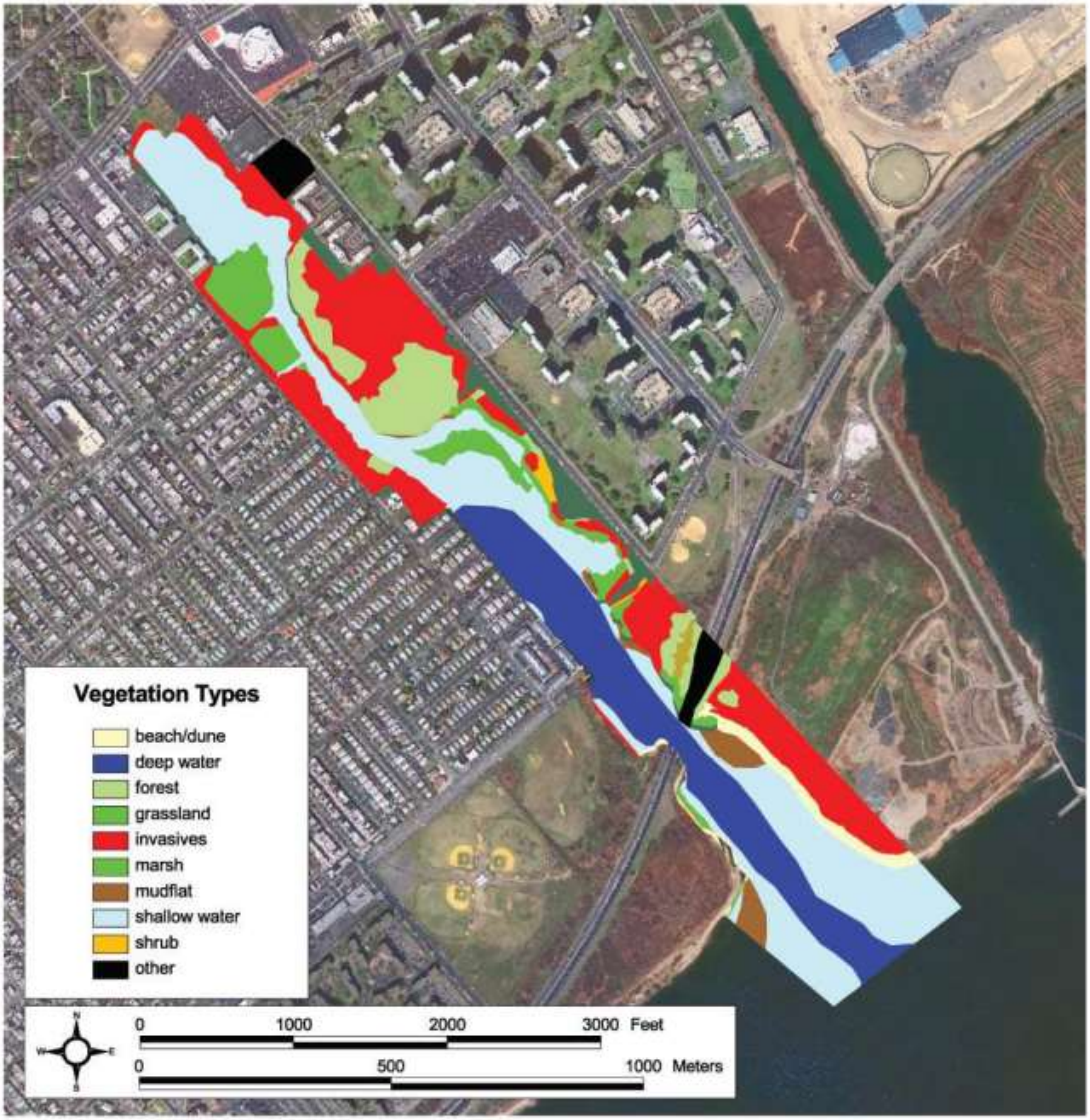

Figure D2-4. Fresh Creek – Existing Conditions

2.2.3 Hawtree Basin

In the early 1900s, a canal was dug at the southern end of Hawtree Creek to create Hawtree Basin. Hawtree Point was filled during the development of the communities of Howard Beach and Hamilton Beach. The Hawtree Point site is located on public land with no permanent residents and includes Charles Memorial Park, which encompasses approximately 2.1 acres. The total area of the site is approximately 16.7 acres (Figures 2-5 and 2-6).

The developed shoreline is characterized by pile- and bulkhead-supported houses that extend over the water. Along undisturbed portions of the existing tidal marsh, the banks of the channels have a steep gradient that rises into the marsh. Narrow mud flats fringe the undeveloped tidal marshes at low tide. The soils consist of organic peat within the tidal marsh, and silts within the channel.

Within undeveloped portions of the site, the cover type consists of a high marsh community dominated by salt meadow cordgrass, with patches of marsh elder and common reed. A narrow, ten-foot wide fringe of saltmarsh cordgrass is present along the channel edge. The area to the south consists of unvegetated sediments and sparse stands of saltmarsh cordgrass. Patches of low marsh are present between buildings located around the project site. Hawtree Point contains non-native plants that are continually disturbed by the use of all-terrain vehicles (ATVs) along the shoreline.

The wetland areas on site cover only about 1.6 acres and are surrounded by invasive species including mugwort, common reed, and Japanese knotweed. Much of the upland at this site is occupied by the Charles Memorial Park that includes recreational facilities and a large mown area. There are also approximately 1.64 acres of invasive species, 0.44 acres of grassland, and 0.08 acres of secondary woodland. Without restoration, it is anticipated that the site will remain heavily dominated by invasive species, considerably degraded from its past ecological values.

On the west side of the railroad tracks, an existing park is present with athletic fields. It appears that this park is fully developed so future expansion is not likely to occur. East of the railroad tracks the Port Authority of New York and New Jersey own the property. It appears that it has been used in the past as a dumping ground for construction debris and mixed soils. It is anticipated that this activity would continue in the future.

Figure D2-5. Aerial Photograph of the Hawtree Point Site

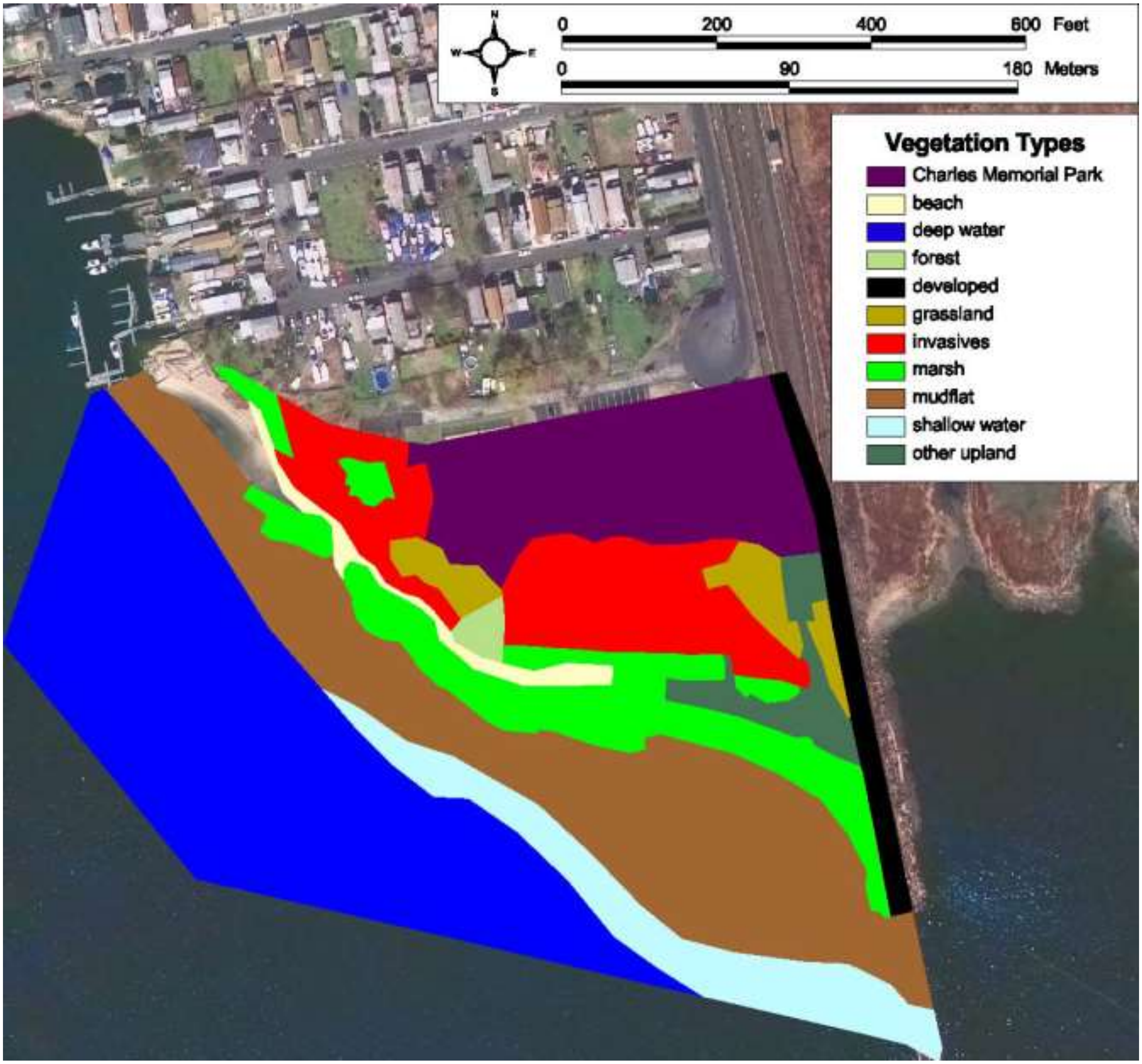

Figure D2-6. Hawtree Point Existing Conditions Baseline Map

2.2.4 Bayswater Point State Park

The New York State Department of Parks and Recreation owns and manages Bayswater State Park. The project sponsor has indicated that no change in current use is planned in the foreseeable future. Passive recreation is the primary focus of use for this state park. Historical documents indicate that the predominant upland areas within the site are natural rather than fill. The area is currently vegetated with a grassland, small tidal marshes, monocultures of invasive species (common reed), and native and opportunistic woody vegetation. In 1991, when the park was dedicated, a member of the Audubon Society noted, “Bayswater Point has a number of special natural features including the last patch of mature native oak forests on Jamaica Bay.” The deteriorating bulkhead is no longer protecting the shoreline against erosion. Figures 2-7 and 2-8 shows an aerial photograph and the existing conditions of the Bayswater Point State Park site. Environmental stressors on the site include the presence of extensive areas of non-native invasive plants and potential loss of habitat due to erosion and deteriorating seawall.

In the absence of federal action, the areas currently dominated by invasive species will remain so indefinitely. This site experiences severe erosional forces which have caused the existing seawall to fall into disrepair. As such, existing marshes, beaches, and grasslands could be lost. In 2014, NYS Parks and Recreation identified that the statewide Invasive Species Strike Team freed a significant area Bayswater State Park from rampant invasive species (NYS PRHP, 2014). The New York State Office of Parks, Recreation and Historic Preservation, the land owner has indicated no plans to change the general land use or to do major restorations at the site.

Figure D2-7. Aerial Photograph of Bayswater Point State Park Project Site

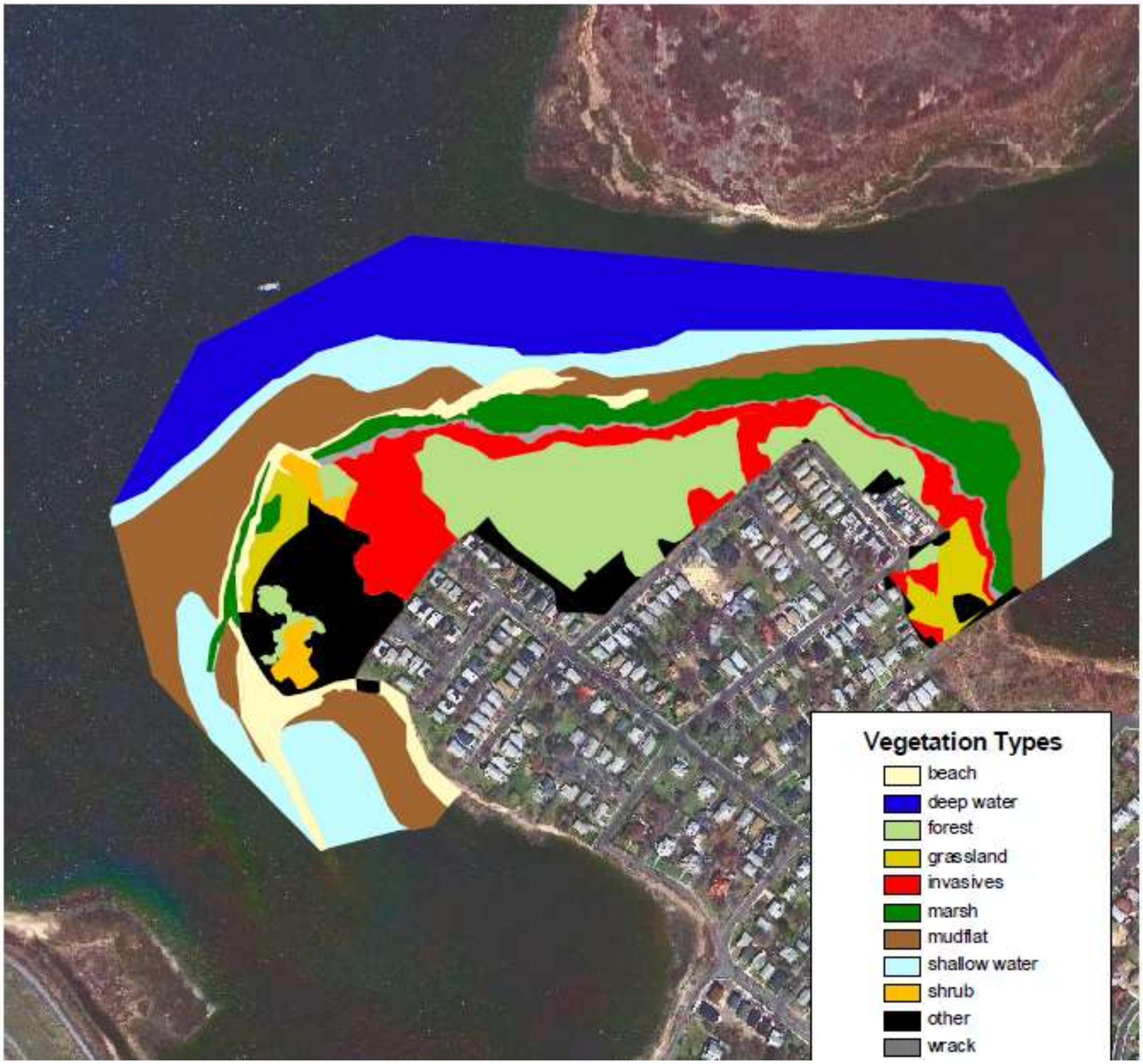

Figure D2-8. Bayswater Point State Park Existing Conditions Baseline Map

2.2.5 Dubos Point

Prior to the 1920s, Dubos Point was covered by a large salt marsh; however, subsequent development and filling activities have disturbed the site. This site was filled in the past for a housing development in the early twentieth century and has since evolved into a marsh system. Common reed exists, but is sparsely distributed. The shoreline of the entire site is bordered by approximately 50-foot-wide bands of low marsh. The zonation of cover types vary from tidal marsh to upland scrub/shrub and old fields. The scrub/shrub is formed primarily by winged sumac, bayberry, black cherry, blackberry and marsh-elder mixed with common reed and goldenrods. The old field community is a mix of forbs and grasses. The soils within the uplands are derived from fill material consisting of loamy sand and large pieces of concrete. Figures 2-9 and 2-10 shows an aerial photograph of the site and the existing conditions on the Dubos Point site.

The vegetation composition may shift in the future as witnessed in other areas to more non-native, invasive plant species since expansive areas of native communities are present. Along the west facing side erosive energy settings are evident. This has caused the loss of the bulkhead and removal of nearshore low marsh systems with the creation of tidal marsh farther inland. On the east facing shoreline, the bulkhead, though degraded, is in better condition than the west side. Little evidence of erosion is noted with intertidal marsh forming behind this feature. Continual loss of land with inward migration of salt marsh is anticipated more so in the western portion as compared to the eastern side.

Dubos Point is owned by New York City Parks and is used for passive recreational activities. NYC Parks indicated that this type of use will not change. Besides management activities, no capital improvements are planned in the foreseeable future. Dumping and invasive species threatening the native plant communities are expected to continue into the future.

Figure D2-9. Aerial Photograph of Dubos Point Site

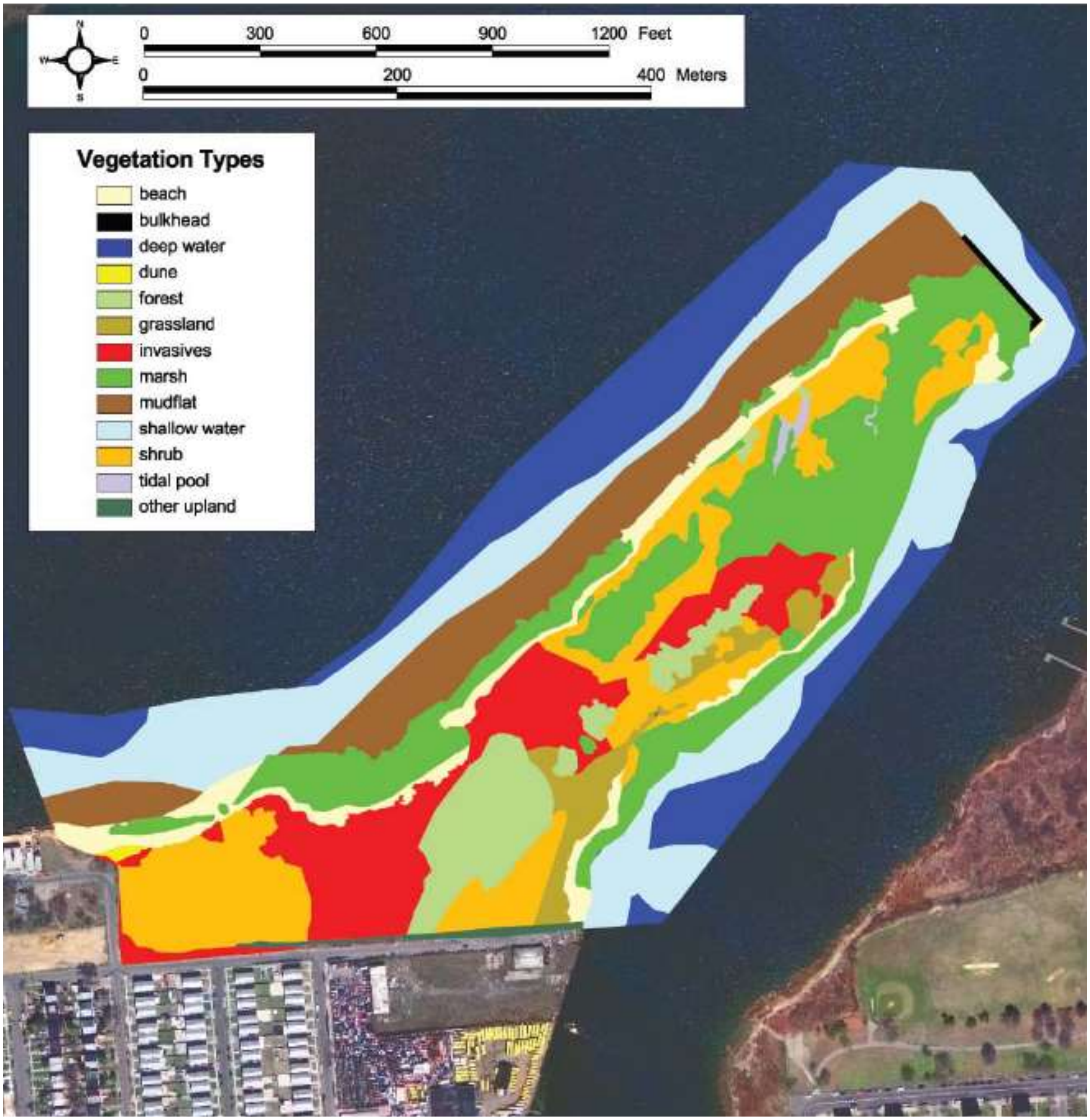

Figure D2-10. Dubos Point Existing Conditions

2.2.6 Brant Point

The project area is located in the southern portion of Jamaica Bay in Queens County, NY and is under the jurisdiction of New York City Parks and Recreation (NYC Parks). Brant Point was part of the Arverne development until the turn of the 20th century; development of this area was restricted to a section of the peninsula. The uplands are largely disturbed and consist of fill material. The shoreline consists of a steep-banked, high marsh zone. The high marsh area contains salt meadow cordgrass as the dominant plant species within an area along the shoreline. Toward the interior of the site, marsh-elder, seaside goldenrod, and common reed become more prominent. The fill areas contain old field and scrub/shrub cover types with a high proportion of invasive species, such as mugwort, common reed, and common ragweed. A grounded barge offshore has acted as an erosion control device and created high quality benthic habitat behind the structure. However, the site still suffers from shoreline erosion and loss of wetlands and has a high proportion of invasive plant species. Excessive dumping of soil, trash, and other debris and the covering of the historic marsh with fill material has compromised the natural habitat. Figures 2-11 and 2-12 shows an aerial photograph and the existing conditions of the Brant Point site.

Figure D2-11. Aerial Photograph of Brant Point Project Site

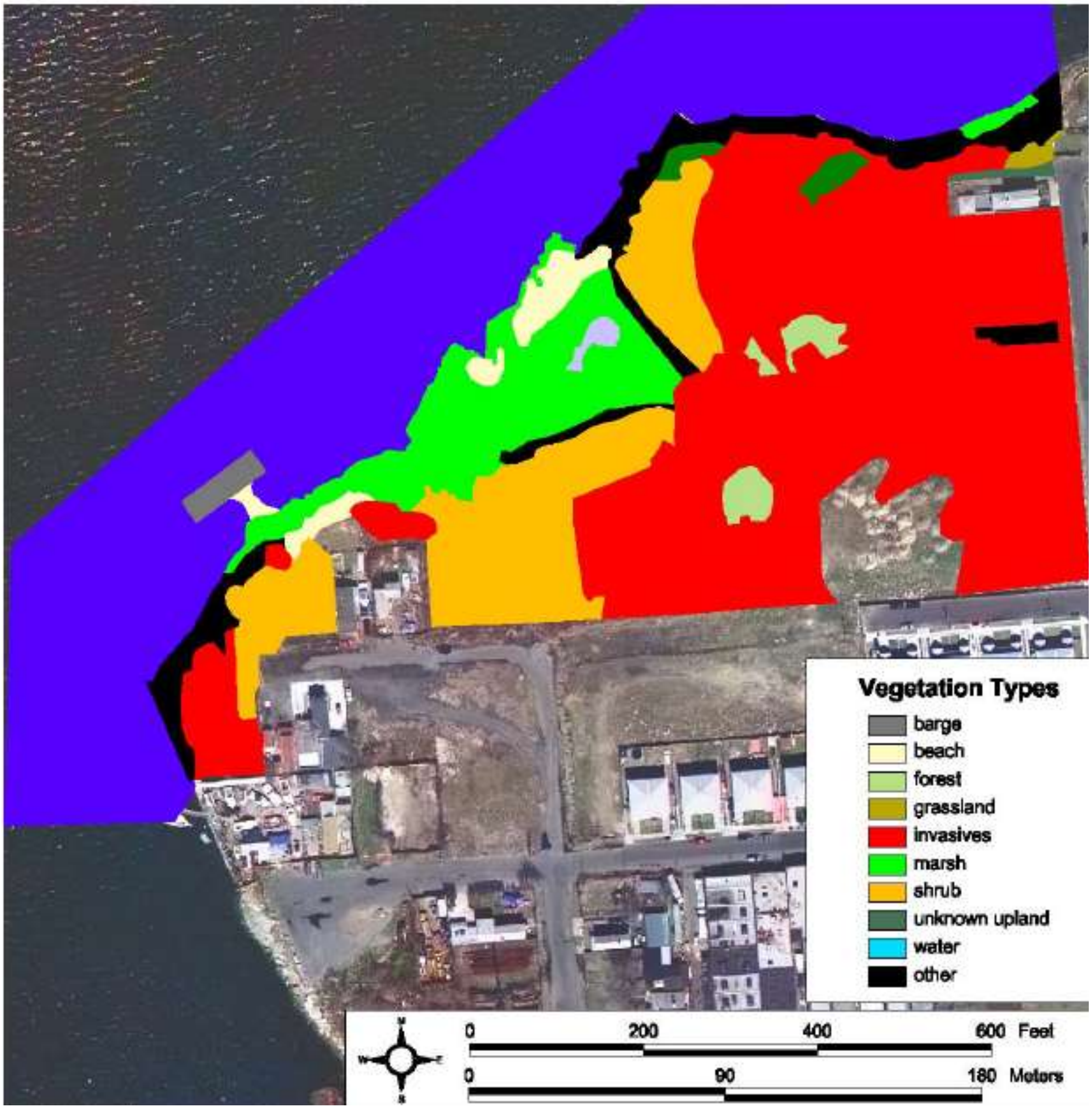

Figure D2-12. Brant Point Existing Conditions Baseline Map

2.3 Alternative Development

Alternatives were developed for the six sites based on existing data (JABERRT, 2002), Evaluation of Planned Wetlands assessment (Benefits Appendix), field observations, and photographic records. Alternatives were evaluated based on local site constraints, standard biological and physical parameters for salt marsh restoration, and other design guidelines developed during a series of planning and design team meetings. The basic alternative layouts were developed in accordance with the guiding ecological principles for salt marsh restoration. Projects that involve restoring wetlands are subject to a set of chemical, physical, geological and biological design requirements. The first and foremost set of requirements is connected to the physiological limitations and environmental requirement for marsh vegetation establishment and growth, predominantly focusing on achieving the proper target elevations relative to the tide and benchmark data from a nearby reference marsh. Alternatives were developed using a combination of the measures outlined in Table D2-10.

Once the alternatives were developed, benefits were quantified (Appendix E) and first level costs were prepared (Appendix I) in order to conduct CE/ICA (Appendix J) to determine the Tentatively Selected Plan alternative at each site. It must be stressed that the below alternatives were developed during the "source" study and had the TSP approved at the Alternative Formulation Briefing in January 2010. Costs were updated for the selected alternatives followed by an additional regional CE/ICA evaluation comparing the TSP alternative among the six (6) shoreline/perimeter sites within Jamaica Bay. Restoration at Hawtree Point, Dubos Point and Bayswater Point State Park were subsequently removed from the Recommended Plan following the regional CE/ICA. In addition, Brant Point was integrated into the high frequency flood features as part of the East Rockaway and Jamaica Bay Reformulation Study and was also removed from the Recommended Plan. The alternative development is presented in the following sections for all sites. Sites that were removed from the recommended plan are presented for information only.

The below section also highlights how Relative Sea Level Change (RSLC) Analysis results were used to develop the final recommended alternative for each site to ensure the restoration was sustainable and provided adequate ecological benefits over the 50 year planning horizon.

SITES IN THE RECOMMENDED NER PLAN

2.3.1 Dead Horse Bay (Tier 2)

Four (4) alternative solutions were developed for Dead Horse Bay and the specific design elements associated with each restoration alternative are discussed below. These original alternatives were developed during the "source" study prior to the NPS decision to conduct a CERLCLA investigation and implement a remedial action including the landfill at Dead Horse Bay South. Based on the NPS removal action planned for Dead Horse Bay South and the site-wide RI/FS, the site has been designated a Tier 2 site for the final recommendation. The Recommended Plan alternative was evaluated for Relative Sea Level Rise Analysis and results are presented in the Engineering Appendix.

Dead Horse Bay – Alternative 1

Alternative 1 replaces an existing disturbed upland (comprised of historic fill) monotypic common reed stands in the northern portion of the site with a fringe marsh system and adjacent native maritime forest (Figure D2-13). The eroding shoreline and landfill in the southern portion of the site will be covered with approximately 46,000 cubic yards of clean fill and sand from the northern portion of the site, as a least-cost disposal option for the excavated materials. The sand will also be used to create dunes along the edge of the water. Overall this alternative will create dunes on approximately 31 acres and restore 10 acres of low marsh and three (3) acres of high marsh. The purpose of the dunes is to provide early successional habitat for Piping Plover. This habitat type will act as a buffer habitat to wetland. In relation to the other aquatic restoration mentioned, 87 acres of maritime forest will be restored to act as a protective buffer and provide habitat for the species that utilize the area. Upland restoration via on-site placement of soil (rather than off-site disposal) was determined to be the most cost effective method of placement. Habitat restoration that will improve the function of the wetland restoration and buffer transition zone are secondary, incidental benefits.

Dead Horse Bay – Alternative 2

Alternative 2 includes all the elements of Alternative 1 (Figure D2-13). It adds the excavation and on-site re-use of 31 acres of landfill closest to the water which sits on top of and covers up the old existing marsh in Dead Horse Bay south. The use of geotextile tubes is necessary to stabilize the remaining landfill and to prevent future erosion along the southern bank. With removal of the landfill, the fringe marsh will be able to support native wetland plant species with high habitat value. A portion of the dune habitat in Figure D2-13 would be marsh in Alternative 2.

Dead Horse Bay – Alternative 3

Alternative 3 maximizes marsh habitat by creating a tidal channel at Dead Horse Bay North (northern portion of the site) and regrading the existing degraded upland common reed stand to salt marsh elevations (Figure D2-14). A tidal channel of approximately four (4) acres will be built in the northern parcel and approximately 31 acres of low marsh and seven (7) acres of high marsh will be restored. At Dead Horse Bay South, the eroding shoreline will be left as is, but approximately 664,000 cubic yards of clean fill and sand from the northern portion of the site will be placed on top. The sand will be used to create dunes along the edge of the water and to restore the maritime forest. Overall this alternative creates approximately 28 acres of dunes on the site and consequently restores over 60 acres of maritime forest. The purpose of the dunes is to provide early successional habitat for Piping Plover. This habitat type will act as a buffer habitat to wetland. Roughly nine (9) acres of existing beach will be preserved in the north. Upland restoration via on-site placement of soil at Dead Horse Bay South (rather than off-site disposal) was determined to be the most cost effective method of placement. Habitat restoration that will improve the function of the wetland restoration and buffer transition zone are secondary, incidental benefits.

To stabilize the tidal creek and protect the existing beach habitat at Dead Horse Bay North, training structures will be created on the banks at the mouth of the creek. The structure is estimated to extend 150 to 200 feet in length, out to a depth of six (6) to eight (8) feet, from both banks of the tidal creek. The training structure will be four (4) feet wide at the top and 25 feet wide at the base, extending to just over MHW. The other hard points are situated mostly on existing beach and upland areas, but will also raise above MHW to protect during storm surges. The structure will be made of rock with an overall trapezoidal shape. The rocks will be placed randomly within the shape to create various size interstitial spaces that can be used as refuges by various species. During the plans & specifications phase, transplanting oysters or mussels onto the rock structures as they are built will be considered to restore a healthy habitat with shellfish before algae and epiphytes colonize the rock.

Dead Horse Bay – Alternative 4 (Tentatively Selected Plan in the Draft Report)
Alternative 4 includes all the elements of Alternative 3, as well as the excavation and on-site re-use of 31 acres of landfill in the southern portion (Figure D2-14). With removal of the landfill, the fringe marsh will be able to support native wetland plant species with high habitat value. The removed trash will be replaced with approximately 669,000 cubic yards of clean fill and sand from the northern portion of the site. The area will also be stabilized with geotextile tubes beneath the dunes to avoid erosion of the site back into the remaining landfill. Materials will be excavated from the water's edge and reused on site to the extent possible, creating dunes further inland that are capped by clean sands from the restoration at the north of the site. Excavated materials that cannot be reused onsite will be removed and processed at a registered landfill facility. The sand will be used to create dunes along the edge of the water and to restore a buffer to the maritime forest. Overall, the project will remove landfill and create dunes on approximately 27.7 acres of the site and will restore 61 acres of maritime forest on the southern parcel of the project area. Roughly nine (9) acres of existing beach will be preserved in the north.

To stabilize the tidal creek and protect the existing beach habitat, training structures will be created on the banks at the mouth of the creek. The structure is estimated to extend 150 to 200 feet in length, out to a depth of six (6) to eight (8) feet, from both banks of the tidal creek. The training structure will be four (4) feet wide at the top and 25 feet wide at the base, extending to just over MHW. The other hard points are situated mostly on existing beach and upland areas, but will also raise above MHW to protect during storm surges. The structure will be made of rock with an overall trapezoidal shape. The rocks will be placed randomly within the shape to create various size interstitial spaces that can be used as refuges by various species.

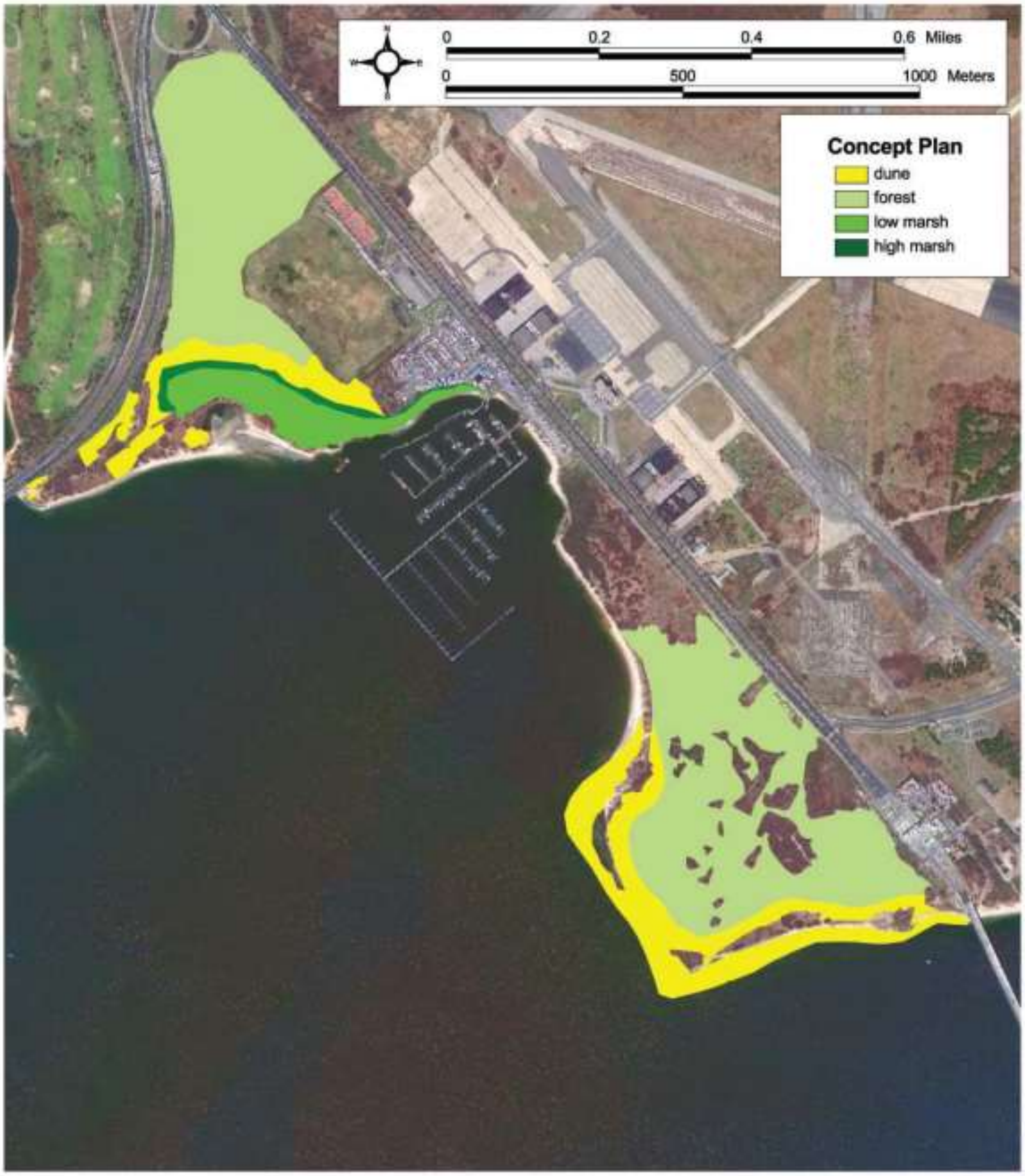

Figure D2-13. Dead Horse Bay – Alternative 1. In Alternative 2, some dunes would instead be emergent wetlands.

Figure D2-14. Dead Horse Bay – Alternative 3. In Alternative 4, some of the dunes in Dead Horse Bay South would be replaced with marsh.

Dead Horse Bay – Recommended Plan

The Recommended Plan at Dead Horse Bay has optimized Alternative 4 (the TSP) following NPS decision to conduct a Remedial Investigation/Feasibility Study pursuant to the CERCLA process in February 2018 (Figure D2-15). The restoration at this site will be restored following coordination with NPS. The Southern portion of the site will no longer be a part of the restoration plan with the exception of being the location of placement of excavated soil from Dead Horse Bay North.

The Recommended Plan only focuses on the northern portion of the site and maximizes marsh habitat by restoring a tidal channel in the northern portion of the site and regrading the existing upland. The proposed design requires the excavation of approximately 483,090 cubic yards (CY) of material over an area of approximately 40.9 acres. Approximately 46,710 CY of material from clearing and grubbing operations will be removed offsite. The remaining 436,380 CY of material will be placed at the Dead Horse Bay South site in coordination with the potential NPS remedial action. A constructed 3,240 linear feet (approximately 2.31 acres) tidal channel will extend through the entire project site. The tidal channel will help sustain the planted wetlands and scrub-shrub vegetation communities.

Tidal wetland areas will be cleared and grubbed of all existing invasive species including of *Phragmites australis* and will be regraded and replanted with native wetland species. Scrub shrub areas will also be cleared and grubbed of all existing invasive species, regraded and planted with native salt-tolerant species appropriate for a scrub-shrub vegetation community.

In total, this plan restores 19 acres of low marsh, 5.4 acres of high marsh, 6.2 acres of scrub shrub, 8 acres of upland and 2.31 acres of tidal creek. The upland is a narrow transition area between the scrub/shrub and infrastructure. In the absence of restoration, the north parcel would remain heavily dominated by invasive species and considerably degraded from its past ecological values

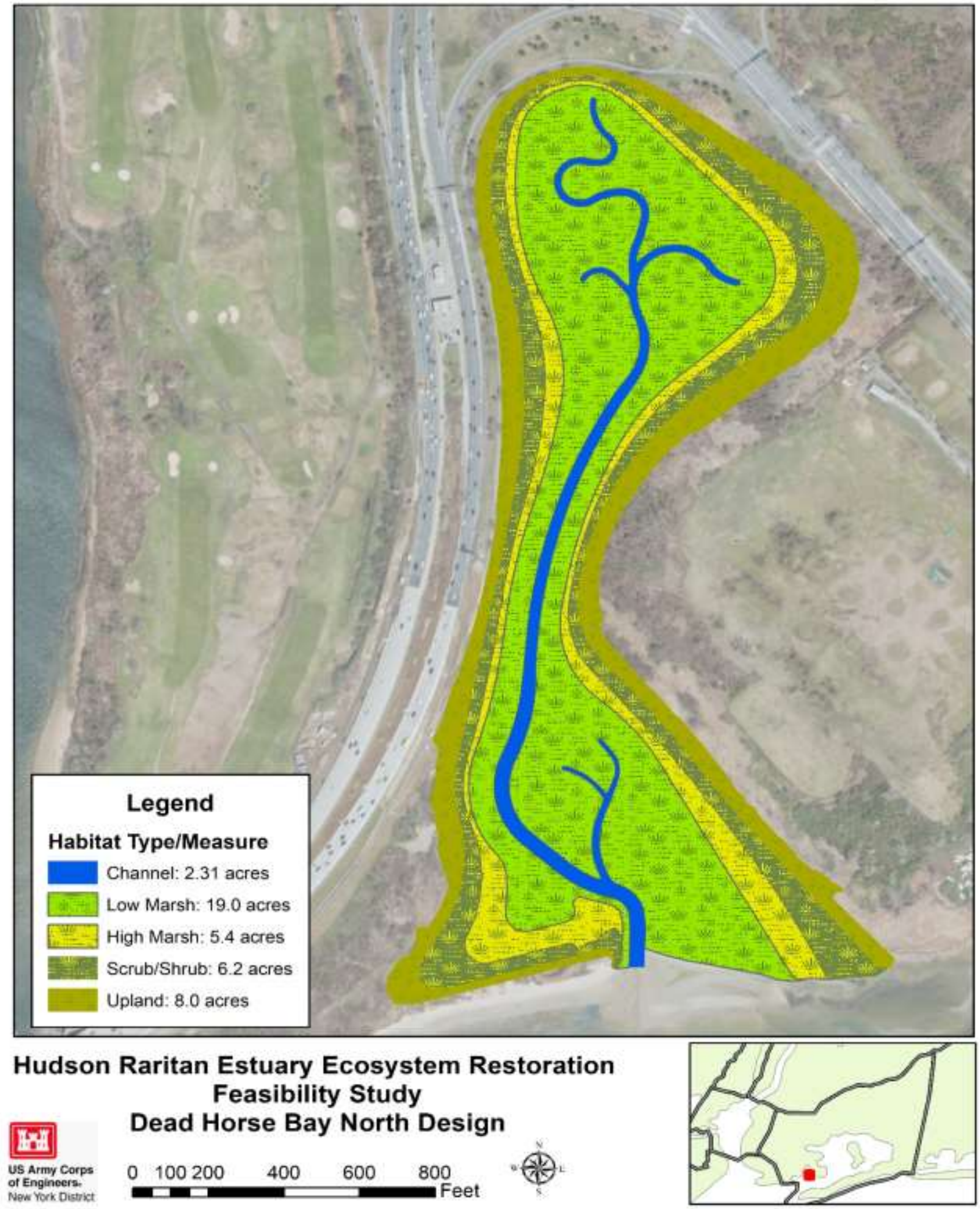

Figure D2-15. Dead Horse Bay (Tier 2) – Recommended Plan Design

2.3.2 Fresh Creek

Five (5) alternative solutions were developed for Fresh Creek during the "source" study and the specific design elements associated with each restoration alternative are discussed below. The Recommended Plan alternative was evaluated for Relative Sea Level Rise Analysis and results are presented in the Engineering Appendix.

<u>Fresh Creek – Alternative 1</u>
Invasive species-dominated areas will be restored to salt marsh or native coastal scrub/shrub, grassland or forest habitat by grubbing, regrading, and planting. Approximately 6.3 acres of low marsh, 1.7 acres of high marsh, and 9.7 acres of transitional coastal shrub zone will be restored (Figure D2-16). As a consequence of the other aquatic restoration mentioned, 4.5 acres of buffer maritime forest will be restored. This alternative does not includes basin filling. Consequently, this alternative has the least impact on the existing bottom habitat.

<u>Fresh Creek – Alternative 2</u>
This alternative is similar to Alternative 1, with the addition of some recontouring within the basin (Figure D2-17). Recontouring would only be done at the head of the basin through about half of the underwater community, regrading the area from -3.2 feet to -4 feet below MLW. This action is expected to improve benthic habitat, flushing at the head of the basin and provide secondary improvements to water quality. Vegetation plantings and acreages in this alternative are the same as in Alternative 1.

<u>Fresh Creek – Alternative 3</u>
This alternative includes basin filling only at the head of the creek, raising the level of the bottom to intertidal levels, restoring marsh and tidal creek habitat. This will decrease residence time of water at the head of the creek, and increase the amount of wetland habitat restored. With this alternative, a 2.1-acre channel will be restored, along with 13.0 acres of low marsh and 2.4 acres of high marsh (Figure D2-18). As in Alternative 1, an incidental 4.5 acres of forest will be restored (due to on-site soil placement), and 11 acres of coastal scrub/shrub will be restored. The amount of coastal scrub/shrub is increased slightly from previous alternatives to restore a transition zone in the northwest corner of the site.

<u>Fresh Creek – Alternative 4</u>
Alternative 4 maximizes the improvement of benthic habitat and hydrology by improving the tidal prism throughout the basin. Recontouring would occur in three (3) steps, from -3.2 feet to 4 feet below MLW from -4 feet to -8 feet below MLW, and from -8 feet to -10 feet below MLW at the mouth. This includes the filling of an existing 19-foot deep dredged channel in the southern portion of the basin. Vegetation plantings and acreages in this alternative are the same as in Alternative 1 (Figure D2-19).

<u>Fresh Creek – Alternative 5 (Tentatively Selected Plan in the Draft Report)</u>
This alternative combines Alternatives 3 and 4 (Figure D2-20). The habitat improvements are exactly the same as Alternative 3. The head of the basin will be filled to restore tidal marshes and creeks, however this alternative includes recontouring the basin to the mouth of Fresh Creek. This is expected to improve wetlands, benthic habitat, hydrology and flushing throughout the basin.

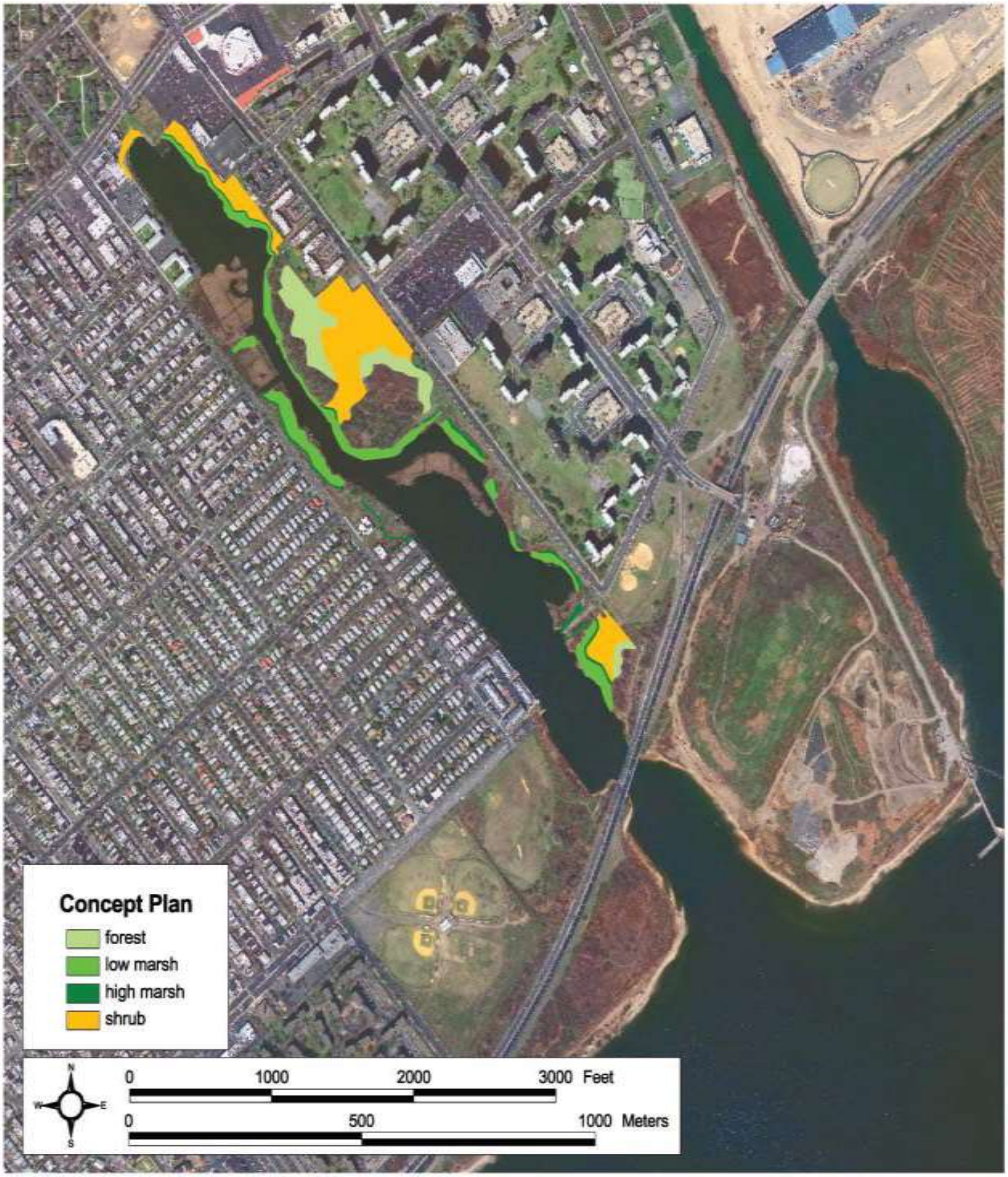

Figure D2-16. Fresh Creek – Alternative 1

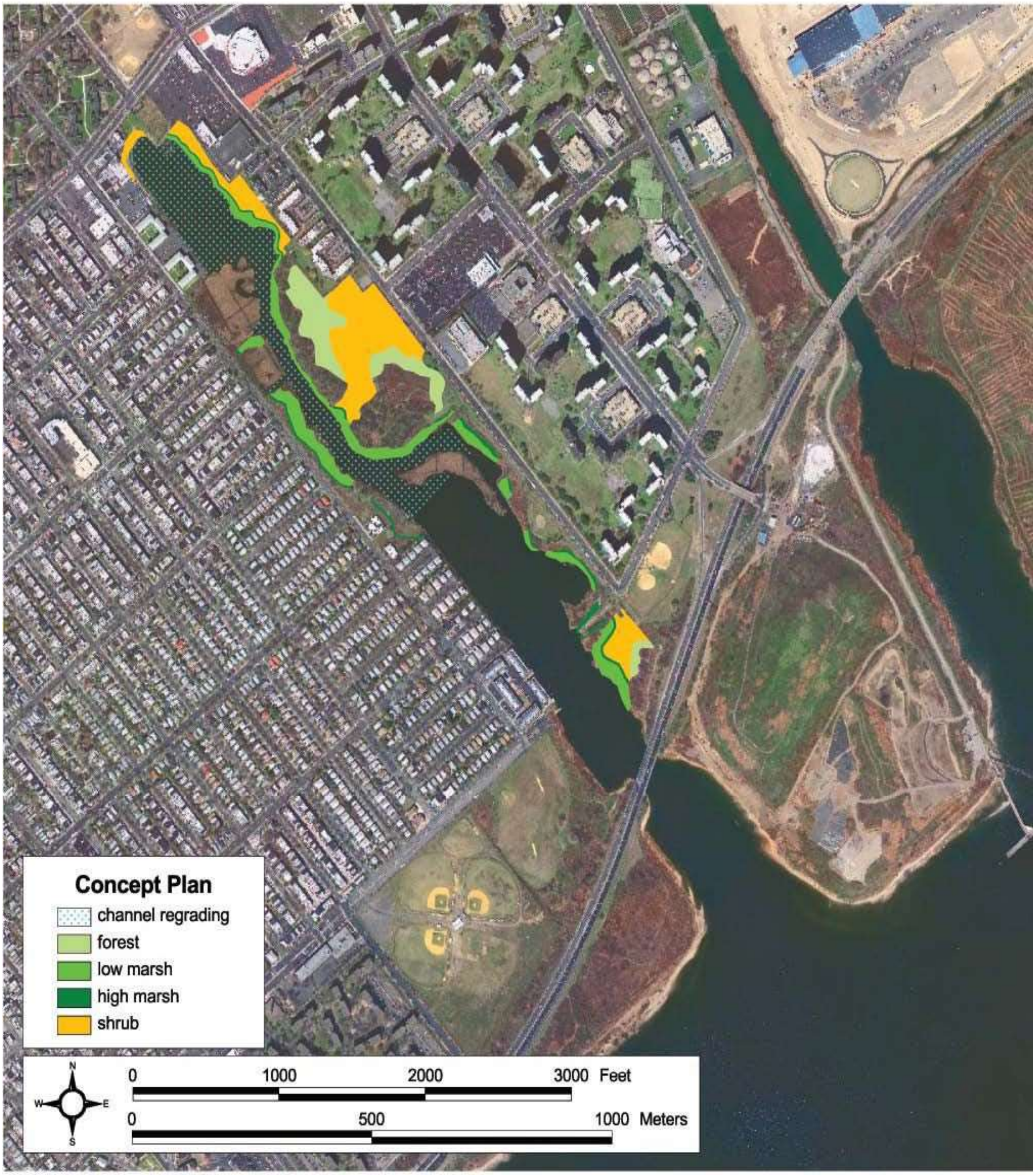

Figure D2-17. Fresh Creek – Alternative 2

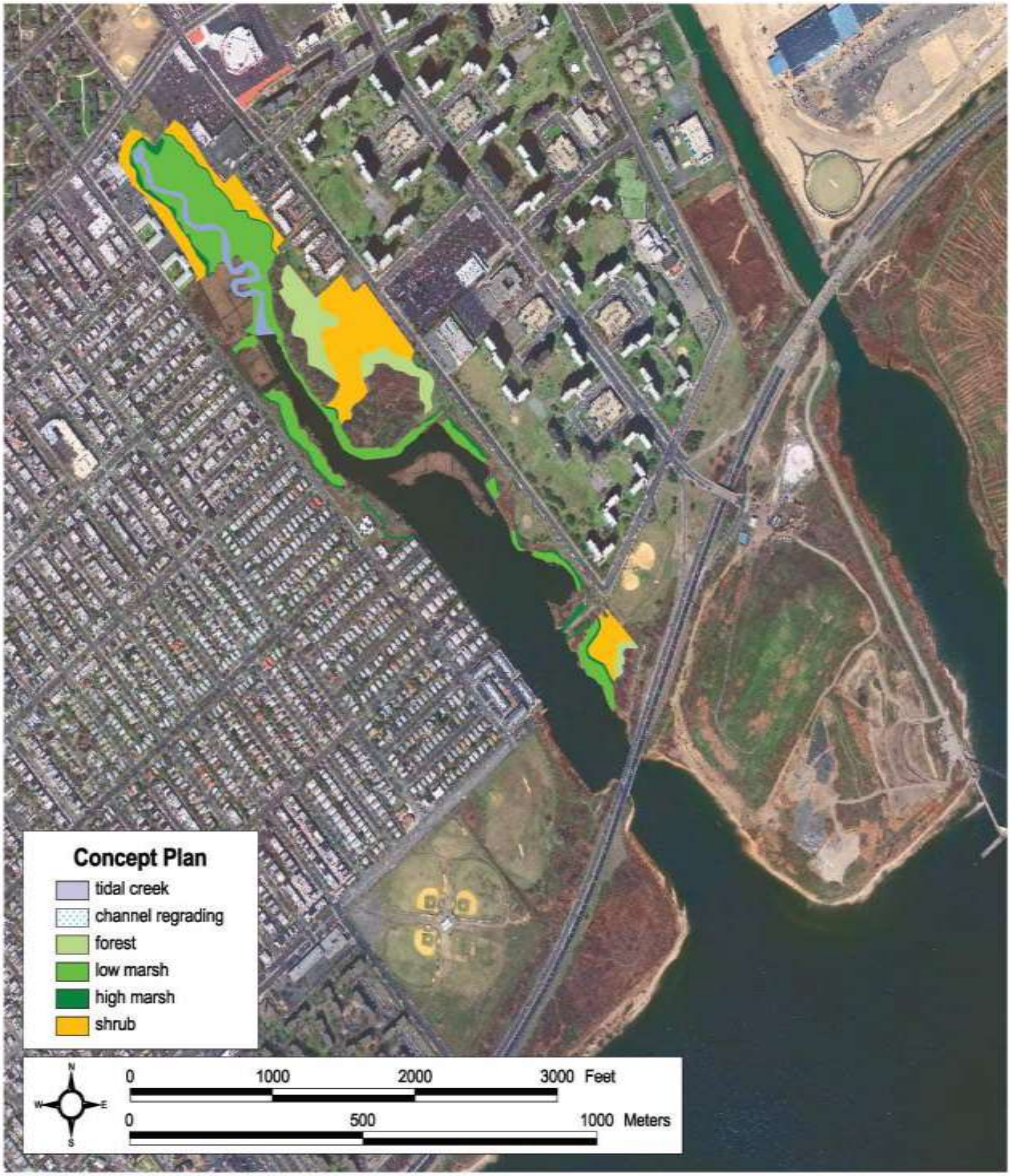

Figure D2-18. Fresh Creek – Alternative 3

Figure D2-19. Fresh Creek – Alternative 4

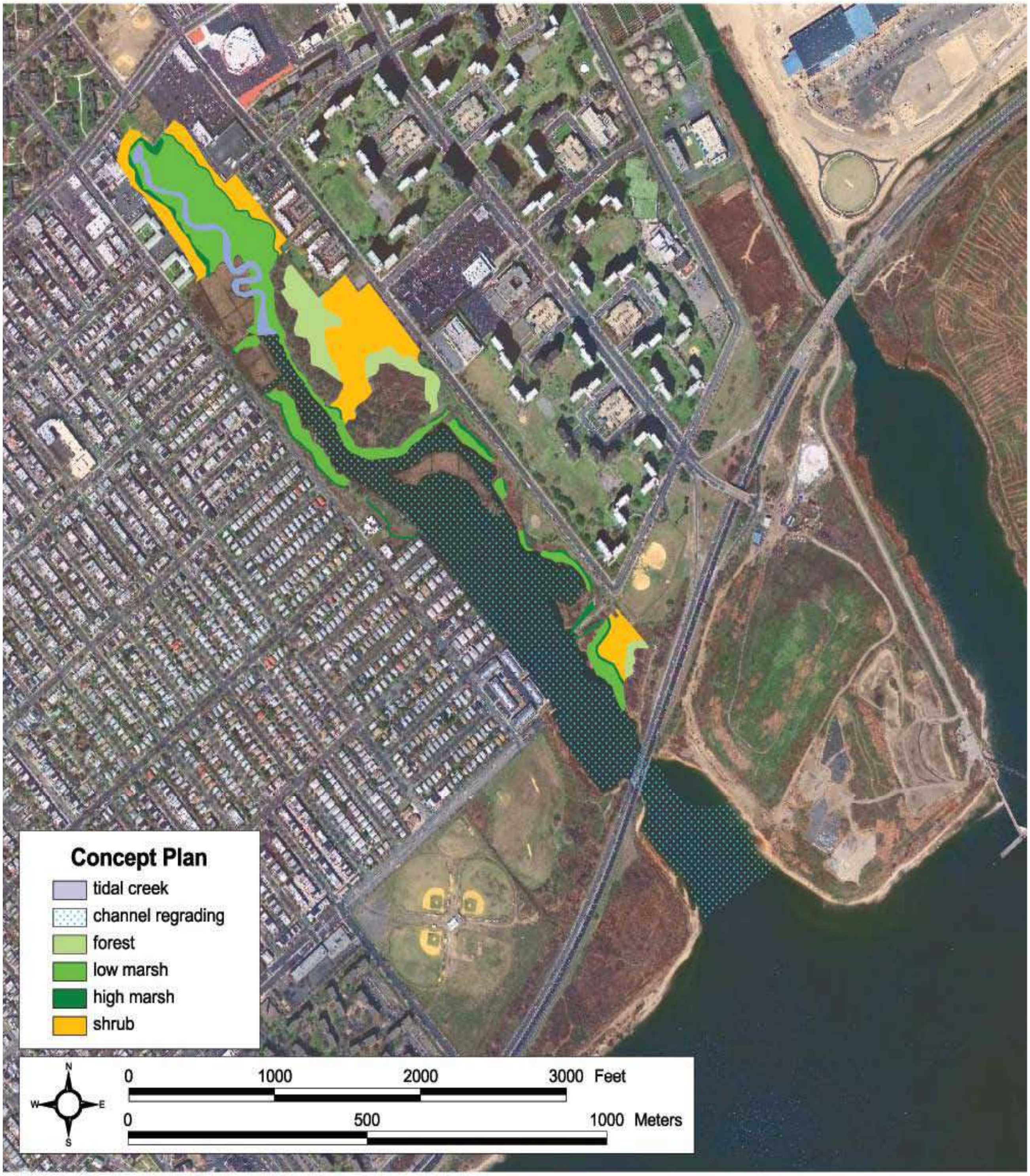

Figure D2-20. Fresh Creek – Alternative 5

Fresh Creek – Recommended Plan

The recommended plan (Figure D2-21) restores a tidal marsh system continuous around the basin and includes wetland restoration at the head of the creek through basin filling and re-contouring. (The existing condition is a result of past dredging and fill activities.). Excavation of 193,220 CY of material over an area of approximately 34.8 acres from the channel, intertidal, and upland will be redistributed on site and capped with clean fill. The least cost soil placement option will result in the restoration of valuable scrub/shrub and maritime forest habitat. Approximately 42,000 CY will be removed off site from clearing and grubbing operations. The existing mouth of the channel will be brought up to an even elevation -10.0 feet NAVD so as to enhance tidal exchange and circulation. It is assumed that material excavated from the upland areas can be placed in the channel to increase the bottom elevation. The placed excavated material will then be capped with 3 feet of clean sand for a more desirable channel bottom. The total length of the tidal channel will be approximately 7,500 linear feet. The channel bottom at the upper reach will gradually slope up from the existing grade and flatten out at an elevation below MTL. Tidal wetland areas will be cleared and grubbed of all existing invasive species including of *Phragmites australis* and will be regraded and replanted with native wetland species. Excavated material will be placed on site, regraded, capped with clean fill and planted with native salt-tolerant species appropriate for a scrub/shrub and maritime forest habitat.

In total this design will restore approximately 16.1 acres of low marsh, 4.4 acres of high marsh, 3.6 acres of scrub/shrub, 10.7 acres of maritime forest, and restoration of 45.08 acres of bed restoration within the tidal channel.

Recommended actions will complement NYC Parks' small-scale restoration efforts and NYCDEP's salt marsh mitigation along the creek. In addition, NYCDEP will continue to improve water quality within Jamaica Bay and in Fresh Creek through the implementation of NYCDEP's Nitrogen Control Program and Jamaica Bay Combined Sewer Outfalls (CSO) Long Term Control Plan and green infrastructure projects to address stormwater runoff (which includes multiple Watershed Restoration Pilot Studies). The level of water quality impacts in the area are not expected to be significant enough that would influence the sustainability of the proposed restoration action.

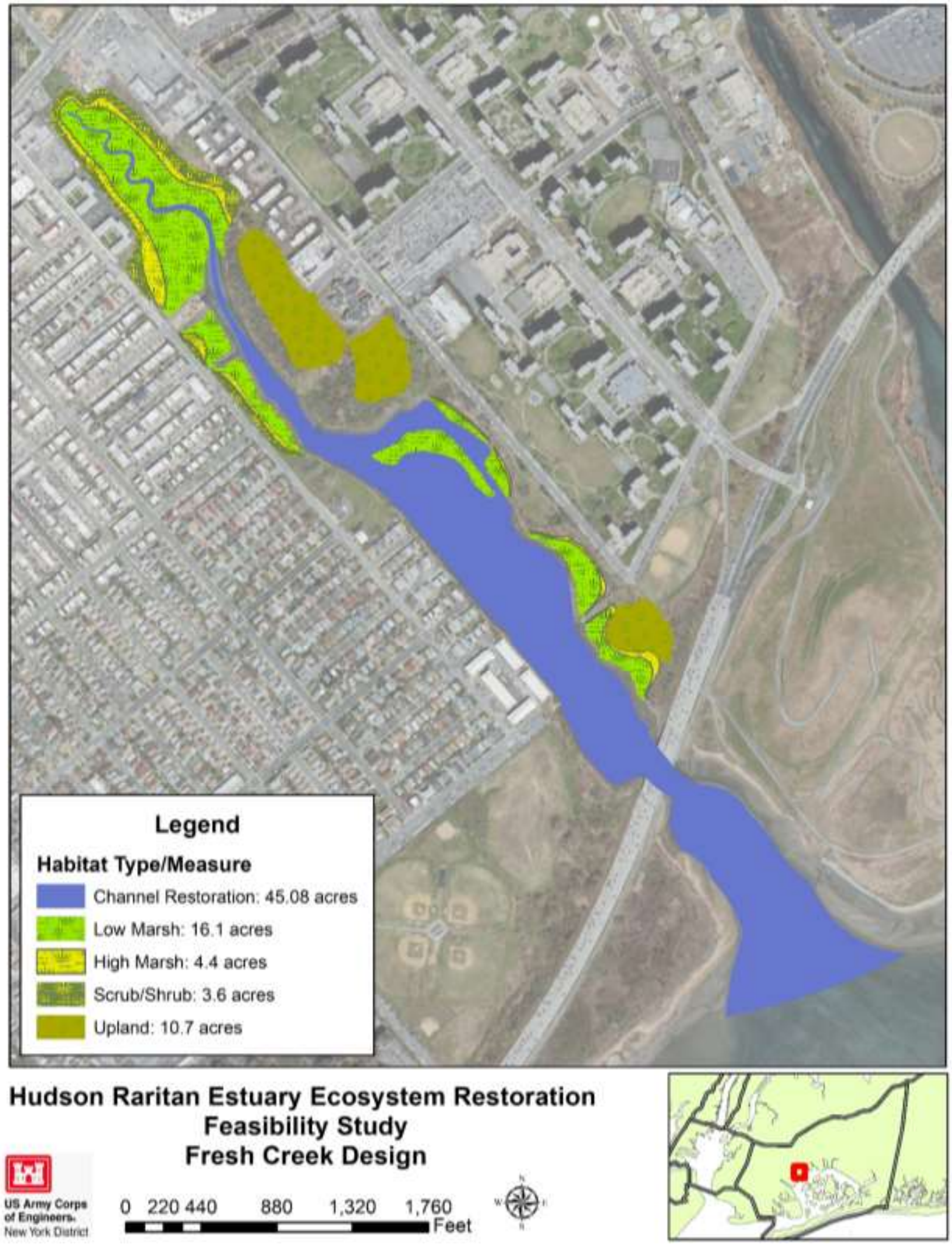

Figure D2-21. Fresh Creek – Recommended Plan Design

SITES SCREENED OUT OF THE RECOMMENDED NER PLAN

2.3.3 Hawtree Point

Hawtree Point – Alternative 1

Alternative 1 recovers 1.7 acres of coastal scrub/shrub and grassland habitat from the existing invasive dominated areas (Figure D2-22). Some regrading and grubbing would remove the invasive species and native grasses and shrubs will be planted at the site. This is the biggest restoration action proposed at the site. It is primarily upland restoration in order to preserve the existing marsh at this site. The existing marsh is threaten by the invasive species that surround it. Removing these invasive and replanting the coastal scrub/shrub will protect the existing marsh from being overtaken by invasive species. This alternative also includes the creation of a natural barrier to motorized vehicles. By placing boulders along the boundary of the restoration area, the newly restored habitats, as well as the preserved existing marshes, will be protected. Through implementation of this project, a 0.07-acre existing patch of salt marsh hay will be excavated and replaced. This area is currently being invaded by the surrounding invasives. Salt marsh hay will be planted in the location after the excavation and regrading of the surrounding land. The net amount of wetland habitat will be the same before and after project implementation. It is acknowledged that upland grasslands and scrub/shrub areas are important bird nesting, cover and feeding habitat for a variety of neotropical migrant land-birds which are the not within the species of nuisance for JFK Airport. Gulls from the landfills are the biggest nuisance species. NAN has been in coordination FAA on numerous restoration projects within the Bay and FAA has provided a list of plant species that will attract non-nuisance bird species.

Figure D2-22. Hawtree Point – Alternative 1

2.3.4 Bayswater Point State Park

Bayswater Point State Park – Alternative 1

Alternative 1 removes invasive-dominated areas by regrading and restoring a tidal channel and associated salt marsh (Figure D2-23). A tidal channel of approximately 0.21 acres will be built to restore about 2.0 acres of low marsh and 0.4 acres of high marsh. Approximately 0.7 acres of beach/dune will also be created. Through selective removal of invasive/non-native vegetation, the mature woodland stands will be restored and replanted with native, appropriate vegetation to prevent the spread of invasive species into the aquatic habitat and to provide a protective buffer for the marsh system.

The low marsh areas will be planted from an elevation of 0.2 feet to 2.3 feet. High marsh areas will be planted from an elevation of 2.3 feet to 2.6 feet. All existing areas of marsh or native species will be preserved to the extent possible. If restoration requires the disturbance of these areas, plants will be salvaged for replanting at the site after regrading is complete. To stabilize the tidal creek and protect the existing beach and salt marsh habitat, training structures will be created on the banks at the mouth of the creek. The training structures will be made of rock placed in a trapezoidal cross section. During the plans and specifications phase, transplanting oysters or mussels onto the rock structures as soon as they are built will be considered as a means to restore a healthy habitat before algae and epiphytes colonize the rock.

Bayswater Point State Park – Alternative 2 (Tentatively Selected Plan)

This alternative is similar to Alternative 1, but with the addition of restoring a tidal pool that will cover approximately 0.6 acres to the west of the creek/marsh complex (Figure D2-24). The plan would remove invasive-dominated communities by regrading and restoring a tidal channel and associated salt marsh. The tidal pool habitat also allows the restoration of an additional 0.5 acres of low marsh. This area currently includes small patches of salt marsh and switchgrass, as well as some mown areas that are mugwort dominated. The restoration plan would also protect the eroding point with the construction of hard structures. The total restoration would total 5.0 acres including 2.6 acres of low marsh, 0.3 acres of high marsh, 0.8 acres of creek/pool serving as transitional habitat for fish, crab and lobster, 0.5 acres of beach/dune (as a transition zone from wetland to upland) and 0.8 acres of hard structures. Hard structures will cover approximately 0.6 acres including armoring of the point and training structures at the mouth of the channel to protect the area from erosion. The dune is a result of cost-effective on-site placement of material. The dune is created in an area that already exists as beach and provides much needed protection in a site that is heavily threatened by erosion.

Bayswater Point State Park – Alternative 3

This alternative also integrates the tidal creek and marsh system of Alternative 1, but adds in the creation of a T-groin system and coastal dune restoration (Figure D2-25). The tidal creek area of restoration is exactly the same as in Alternatives 1 and 2. The T-groin system would allow further inundation of tides restoring 0.4 acres of shallow water and restoring 0.5 acres of low marsh. Approximately 1.0 acre of dunes and beach will also be constructed behind the groins. Low and high marsh will be planted in between rocks where tidal inundation and wave climate permit habitat survival.

Figure D2-23. Bayswater Point State Park – Alternative 1

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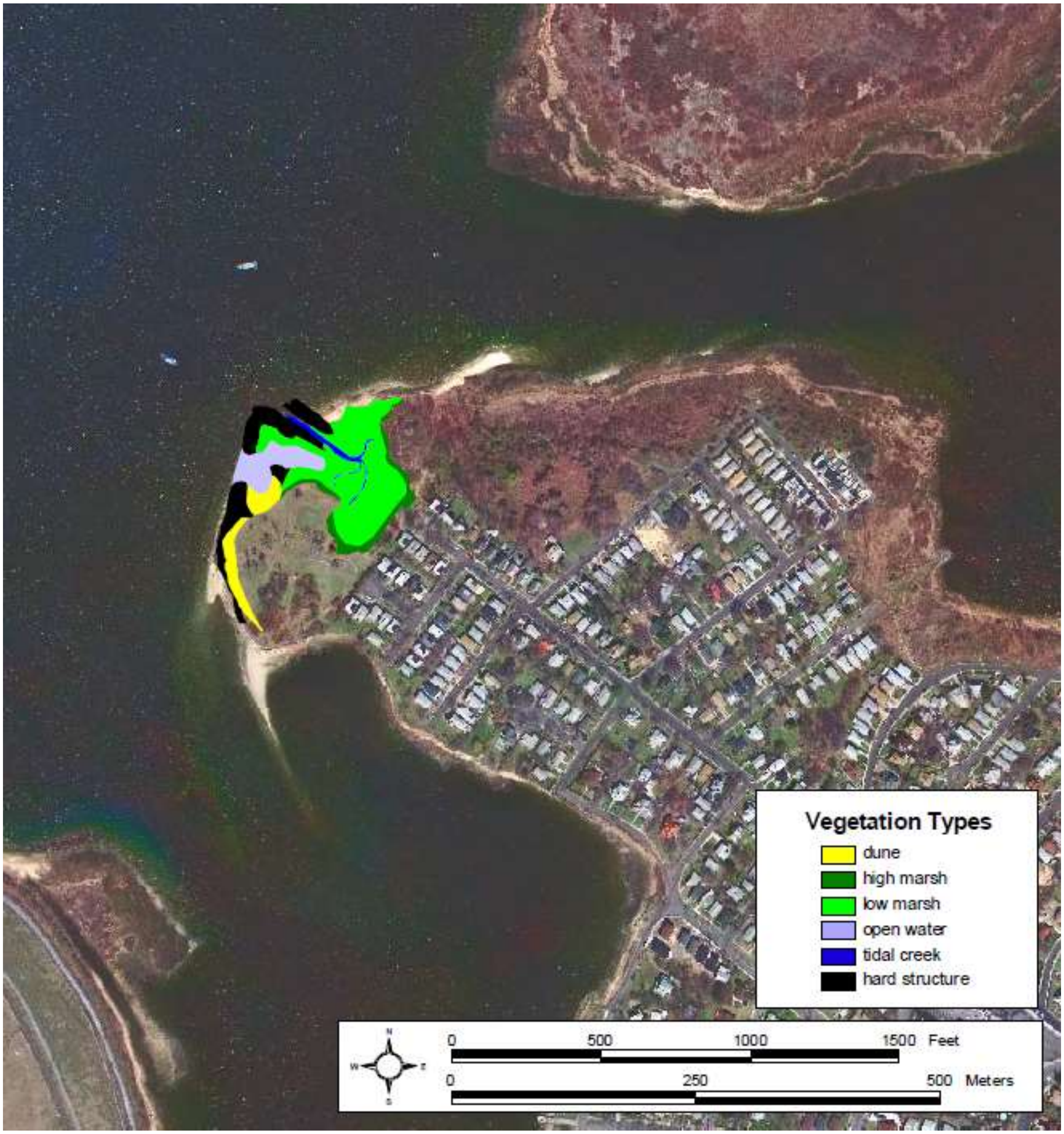

Figure D2-24. Bayswater Point State Park – Alternative 2

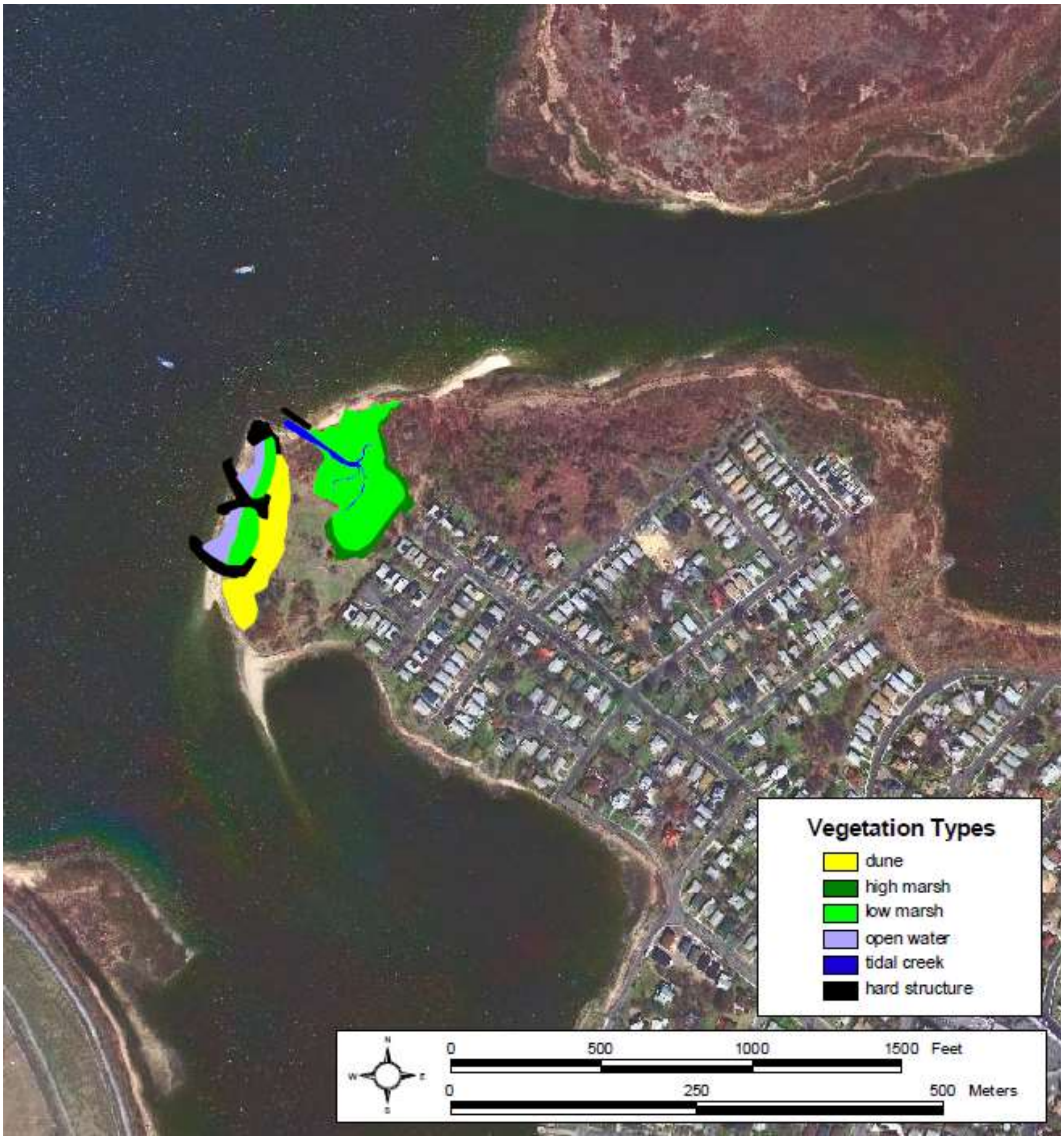

Figure D2-25. Bayswater Point State Park – Alternative 3

2.3.5 Dubos Point

Dubos Point – Alternative 1

This alternative restores marsh by restoring tidal channels in an existing filled common reed stand and regrading the area to salt marsh elevations (Figure D2-26). Tidal channels of approximately 0.7 acres will be built to restore about 3.5 acres of low marsh and 0.6 acres of high marsh. Tidal channels in the northern tip will also be reopened to allow salt water flushing and fish migration to alleviate the local overabundance of mosquitoes. The project will include excavation of approximately 24,400 cubic yards of soil to restore the channels and tidal creeks. This soil will be used for landscaping onsite. By removing mugwort-dominated areas the project will incidentally restore 2.0 acres of maritime forest. Native canopy trees, understory trees, shrubs, forbs, and ferns will be planted here to prevent the spread of invasive species into the aquatic habitat. The low marsh areas will be planted from an elevation of 0.1 feet to 2.5 feet. High marsh habitat will be planted from an elevation of 2.5 feet to 3.4 feet. The existing pilings will remain and will continue to offer some protection to the salt marsh on the point.

Dubos Point – Alternative 2

This alternative is similar to Alternative 1, with the only difference being the amount of toe protection installed (Figure D2-26). This alternative utilizes the existing piles, replacing only the ones that have failed. Restoration plans, vehicle barriers, and vegetation plantings for this alternative are the same as in Alternative 1.

Dubos Point – Alternative 3 (Tentatively Selected Plan)

Alternative 3 includes all the elements of Alternative 1 and maximizes marsh habitat protection by implementing toe protection surrounding the entire western and northern shore (Figure D2-26). The north and west shorelines are exposed to high wave velocities from Jamaica Bay. Soldier piles were installed in the past, and still exist on the site but are beginning to fail. In the areas of failure, the erosion is quite obvious. Toe protection in this alternative includes the use of soldier piles or its equivalent, placed to the level of MLW, along the entire shoreline replacing all of the existing piles.

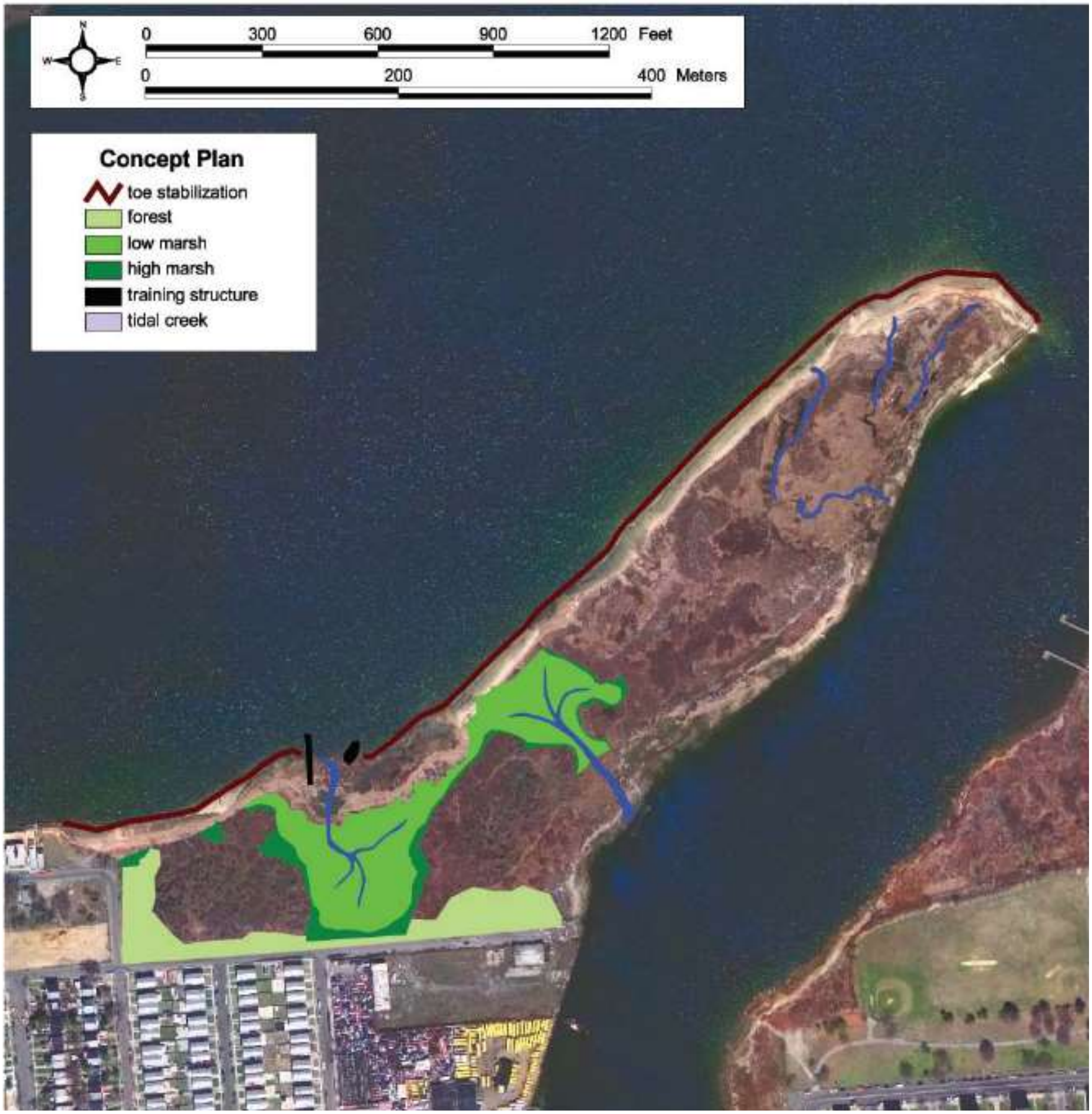

Figure D2-26. Dubos Point Alternatives 1, 2 and 3 (Difference is in the amount of toe stabilization under consideration)

2.3.6 Brant Point

<u>Brant Point – Alternative 1</u>
This alternative protects the existing 1.2 acres of marsh, but also restores an additional 1.9 acres of low marsh, 0.7 acres of high marsh, 2.5 acres of meadow, and 2.4 acres of maritime forest to prevent the spread of invasive species into the aquatic habitat (Figure D2-27). The low marsh areas will be planted with *Spartina alterniflora* from an elevation of 0.0 feet to 2.3 feet. High marsh habitat will be planted from an elevation of 2.3 feet to 3.2 feet. Coastal meadows will be planted with native forbs and shrubs. The maritime forest area will include the planting of canopy trees, understory trees, ferns, forbs, and shrubs. Soil excavated to regrade for the marsh restoration will be used for onsite landscaping.

<u>Brant Point – Alternative 2 (Tentatively Selected Plan)</u>
In addition to the tidal fringe marsh of Alternative 1, Alternative 2 maximizes marsh habitat protection and restores macroinvertebrate habitat by restoring offshore rubble mounds (Figure D2-28). The grounded barge at this site shows that offshore structures are capable of protecting the marshes and restoring beneficial habitat for macroinvertebrates. Three (3) rock mounds are needed to protect the point from the ongoing erosion. These rubble mounds will have a footprint of approximately 0.36 acres total. The mounds will be placed at –2 feet to 3 feet at MLW and will be approximately 7 feet above MHW. The mounds will be approximately 6 feet wide on the top, 40 feet to 45 feet wide at the base, and about 140 feet long. The rocks will be placed randomly within a trapezoidal shape to create interstitial spaces of various sizes that can be used as refugia by various species. During the plans and specifications phase, transplanting oysters or mussels onto the rock structures as soon as they are built will be considered at as a means to restore a healthy habitat with shellfish before algae and epiphytes colonize the rock.

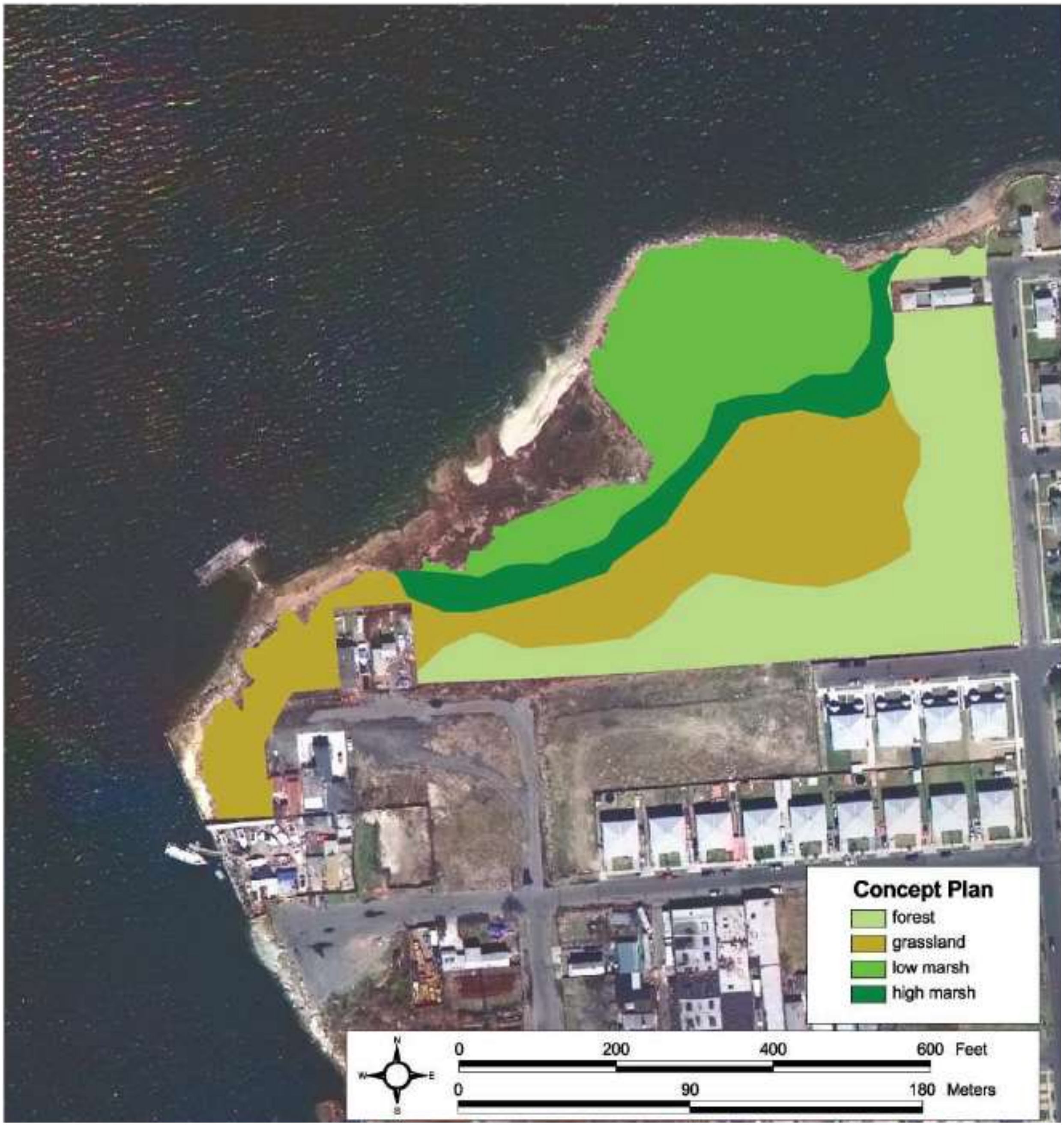

Figure D2-27. Brant Point – Alternative 1

Figure D2-28. Brant Point – Alternative 2

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 3: Jamaica Bay Marsh Islands

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

THE PORT AUTHORITY OF NY & NJ

April 2020

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3. Jamaica Bay Marsh Islands

This section provides details on the assessment of existing and future without project conditions, and alternatives development on Jamaica Bay marsh island sites as supplementary information to the plan formulation in the Main Report. Within the Recommended NER Plan, five (5) marsh island sites are recommended for restoration: Stony Creek, Duck Point, Elders Point, Pumpkin Patch West, and Pumpkin Patch East. These five sites were part of the TSP in the draft report, and their importance has been confirmed through feasibility level investigations.

The Jamaica Bay marsh islands are at the heart of the complex urban ecosystem of Jamaica Bay that is a part of Gateway National Recreation Area, the first urban national park, established in 1972. The marsh islands complex is an integral part of the Jamaica Bay ecosystem and has been targeted for restoration by numerous partners. As stated in Chapter 2, the USACE initiated the Jamaica Bay "Source" study in 1996 and the problems associated with dramatic marsh island loss had not been identified at that time. The Jamaica Bay study process was already into its detailed investigations of the perimeter sites when the NYSDEC completed its Geographic Information System-based surveys and actually quantified the extensive losses suffered since only the mid-1970s. The agencies met on several occasions to discuss this new and very serious issue and eventually a consensus evolved that the islands would be investigated under a separate parallel track using the Continuing Authorities Program (CAP) authority and this HRE Ecosystem Feasibility Study.

Restoration plans for the marsh islands have been evaluated over the past 15 years as pilot and mitigation projects have been developed, recommended, and constructed. The USACE, in partnership with other agencies and community organizations, has developed an extensive body of data and literature that informs the decisions made in this study process. USACE drew from the experiences of researching, designing, and restoration of five (5) prior marsh islands to plan for the restoration of new marsh islands included in the study recommendation. Screening to select the five (5) marsh islands and alternatives development for each are presented in this chapter in order to address Study Objective #3: *Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay.*

3.1. Project Area Context

A coalition group, the New York/New Jersey Harbor Estuary Program (HEP), has targeted Jamaica Bay for consideration for restoration and conservation, particularly based on the presence of rare species, size, connectivity, and threat of development.

Prior to colonization, an estimated 16,000 acres of salt marsh were in Jamaica Bay (USFWS, 1997). In the early 1900s, Jamaica Bay was still home to large tracts of salt marsh surrounded by dendritic tidal channels and flats. The ecosystem provides essential habitat for shellfish, finish, and water fowl (NYCDEP, 2007). In recent times, the area has been subject to dredging, filling, construction, pollution, overharvesting and eradication of several species. The ecosystem is still ecologically rich, but approximately 2,036 acres of tidal salt marsh were lost from the marsh islands between 1924 and 1999, with the system-wide rate of loss rapidly increasing over time (NYSDEC, 2001; Hartig et al, 2002, NYSDEC website 2016). From 1994 to 1999, an estimated 220 acres of salt marsh were lost at an average rate of 44 acres per year. The loss of the marsh islands can be seen below in Figures 3-1 through 3-4. Left alone, the marshes were projected to vanish by 2025, destroying wildlife habitat and threatening the bay's shorelines.

The NPS built a coalition tasked with researching the cause of the loss of marsh island area in Jamaica Bay. The final report indicates a dual mechanism of marsh island loss: perimeter erosion and interior ponding/subsidence. The panel developed several hypotheses for causes of this erosion and subsidence: sea level rise, sediment loss, dredging, shoreline hardening, mussel beds along marsh edges, nutrient enrichment and resulting proliferation of sea lettuce, waterfowl grazing, and boat traffic. The panel urged the community to continue researching specific hypotheses and to implement restoration projects as soon as possible.

In response to these losses, under the USACE’s CAP authority, NYSDEC and the NYCDEP requested assistance in implementing several marsh island restoration projects. Habitat targets include high marsh, low marsh, and tidal creeks. Due to the substantial marsh island loss, these habitats are quite rare in Jamaica Bay at present. The 2006 Ecosystem Restoration Report and Environmental Assessment for the Jamaica Bay marsh islands recommended restoration at Elders Point East, Elders Point West, and Yellow Bar Hassock. These three (3) islands were restored in 2007, 2010, and 2012, respectively. Black Wall and Rulers Bar were also restored in 2012 as part of a beneficial use of dredged material in partnership with community organizations and local agencies. The USACE, NYSDEC and NYCDEP successfully restored these five (5) marsh islands amounting to over 160 acres of island habitat in Jamaica Bay.

Coordination with NYSDEC and the NPS recommended that the maximum perimeter of each of the restored islands should not exceed their 1974 footprints, estimated to be the inflection point at which the existing marsh vegetation began to rapidly deteriorate. To restore these marsh islands on NPS property, USACE obtained Special Use Permits and Real Estate Construction Agreements from 2007 through 2012.

The restoration of marsh islands does not augment NPS’s budget since NPS does not conduct this type of ecosystem restoration on their property. NPS preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation. Lessons learned from these projects have been applied to the alternatives development for the proposed marsh islands recommended in this FR/EA.

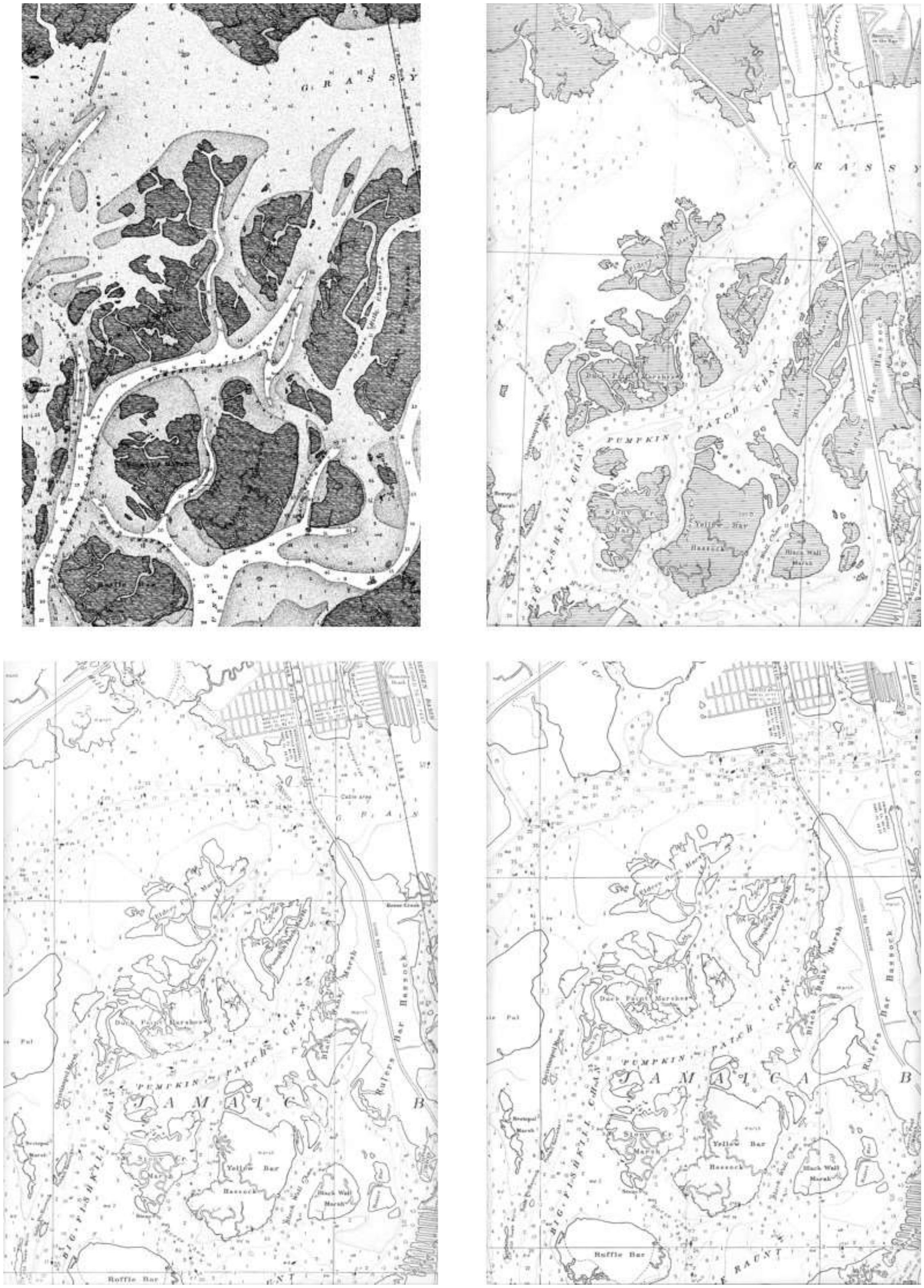

Figure D3- 1. Extent of the Jamaica Bay Marsh Islands Clockwise from top left: A) 1899, B) 1926, C) 1948, and D) 1970. Source: Ancillary Documentation of the Yellow Bar Hassock Feasibility Report.

Figure D3- 2. Jamaica Bay Marsh Island Extent in 1994. Source: Google Earth.

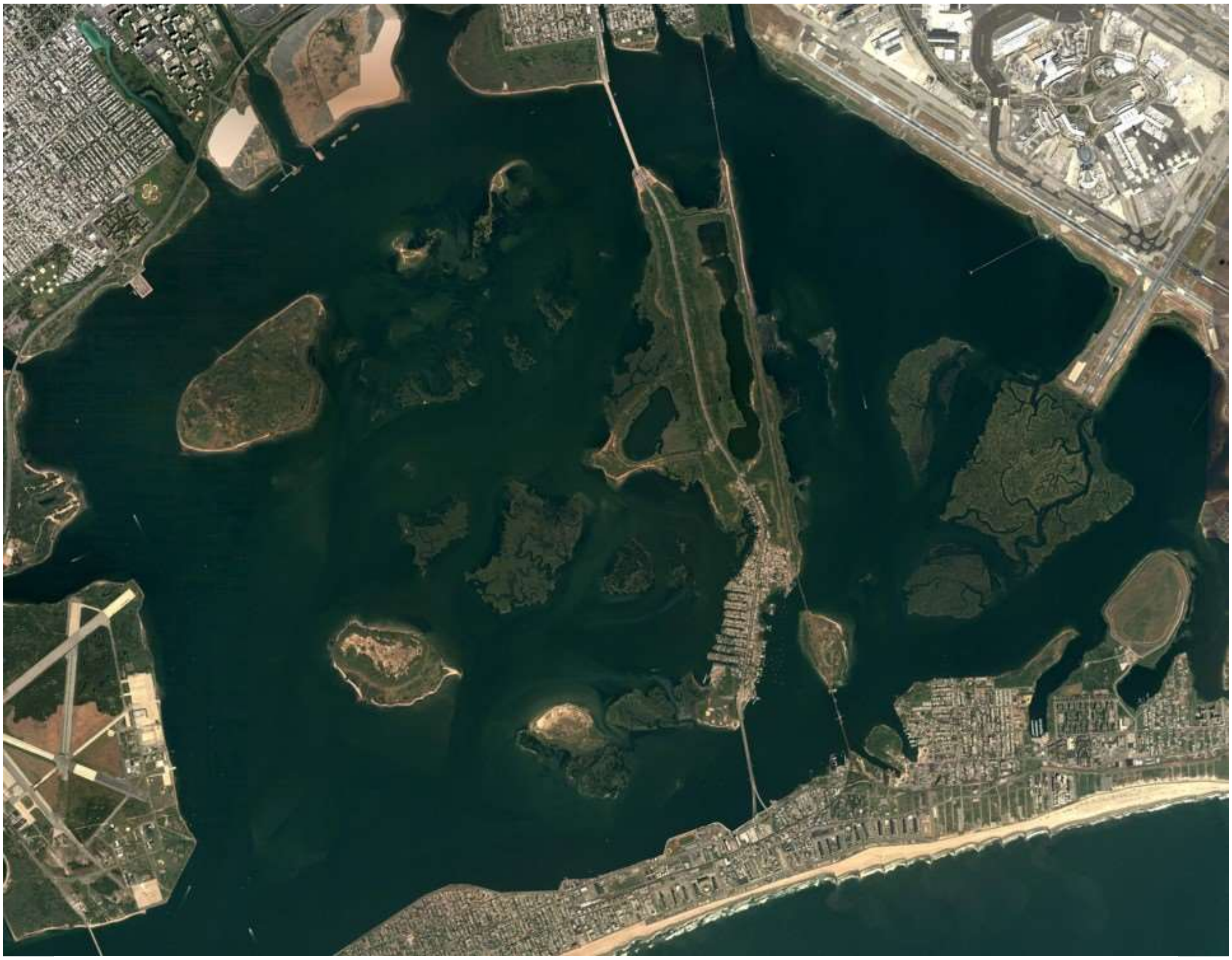

Figure D3- 3. Jamaica Bay Marsh Island Extent in 2004. Source: Google Earth.

Figure D3- 4. Jamaica Bay Marsh Island Extent in 2015. Source: Google Earth.

3.2. Site Screening

The successful construction of marsh island restoration projects are the foundation for the plan formulation of these future marsh island restoration efforts. The following research and actions have provided an excellent basis for the current proposals:

- A 2006 Report titled Jamaica Bay Marsh Islands, Jamaica Bay, NY, Integrated Ecosystem Restoration Report included recommendations for restoration of three (3) marsh islands: Elders Point East, Elders Point West and Yellow Bar Hassock.
- Activities at Elders Point East marsh island in 2006-2007 involved restoring 43 acres of marsh constructed for mitigation purposes to offset environmental impacts of the New York and New Jersey Harbor Deepening Project.
- In 2010, the USACE, in partnership with the Port Authority of New York and New Jersey (PANYNJ), the NYSDEC, NYCDEP and NPS restored approximately 40 additional acres at Elders Point West as a result of the beneficial use of dredged material from the Harbor Deepening Project.
- The restoration plan for Elders Point East and Elders Point West included restoring the existing vegetated areas and the sheltered and exposed mudflats by placing dredged sand up to an elevation suitable for low marsh growth. This included hand planting more than 700,000 plants (grown from local seed stock by the National Resources Conservation Service on Elders Point East and replanting more than 200,000 plants on Elders Point West.
- A 2015 monitoring report for Elders Point East commissioned by USACE entitled Elders Point East Marsh Island Restoration Monitoring Data Analysis covering the years 2007-2012 detailed lessons learned.
- As part of the NY/NJ Harbor-Jamaica Bay Multi-Project Initiative, sand from the Ambrose Channel was beneficially used from the harbor deepening project to restore an additional 87 acres of marsh island habitat within Jamaica Bay. In 2012, 375,000 cubic yards of sand was placed at Yellow Bar Hassock Marsh Island, resulting in 67 acres of new marsh island and approximately 47 acres of wetlands, including approximately 13.3 acres of hummock relocation, 28 acres of low marsh seeding, 17,175 high marsh plants, and 21,859 high marsh transition plants.
- In 2012, additional Ambrose Channel sand was also beneficially used to restore an additional 30 acres of marsh islands at Black Wall (155,000 cubic yards of sand, 20.5 acres) and Rulers Bar (95,000 cubic yards of sand, 9.8 acres) as part of the USACE's Beneficial Use Program with local partners (NYCDEP, NYSDEC, and PANYNJ). NYCDEP and the NYSDEC with local non-profit organizations (EcoWatchers, Jamaica Bay Guardian and the American Littoral Society) completed a community-based planting effort to vegetate the 30 new acres created at Black Wall and Rulers Bar with the above referenced plants in June 2013.

Thirteen potential marsh islands were identified for restoration. While Jamaica Bay as a whole represents a rich opportunity for salt-marsh restoration, a number of intractable constraints resulted in the five (5) restoration sites recommended in the FR/EA (Table D3-1).

3.2.1. First Screening

Beginning with 13 sites, the first round of screening was to remove all marsh island sites east of Cross Bay Boulevard. This was because the Federal Aviation Administration (FAA) was concerned about airplane bird strikes near JFK airport. The marsh islands are avian attractants, so no marsh island restoration will occur east of Cross Bay Boulevard. This initial round of screening removed 4 sites (Table D3-2), leaving 9 to be further evaluated.

Table D3- 1. Screening of Jamaica Bay Marsh Island Sites.

Site Name	Number	Previously Constructed by USACE	1st screening: East of Cross Bay Blvd.	2nd Screening: Shallow Channels
Stony Creek	1			
Duck Point	2			
Elders Point Center	3			
Pumpkin Patch West	4			
Pumpkin Patch East	5			
Black Bank Marsh	6			
Ruffle Bar	7			
Big Egg Marsh	8			
Little Egg Marsh	9			
Black Point Marsh	10			
Silver Hole Marsh	11			
East High Meadow	12			
Joco Marsh	13			
Black Wall	14			
Rulers Bar	15			
Yellow Bar Hassock	16			
Elders Point East Marsh	17			
Elders Point West Marsh	18			

Table D3- 2. Sites Removed in the First Round of Screening.

Sites Removed
Black Point Marsh
Silver Hole Marsh
East High Meadow
Joco Marsh

3.2.2. Second Screening

The second round of screening began with 9 sites, which were screened on how accessible they were for bringing a hopper dredge to the island in order to deposit dredged material. To maneuver, hopper dredges need a fairly deep channel, so all marsh islands that were surrounded by only shallow channels were screened out due to constructability. To bring the sediment to the sites using another method would be much more expensive, and was not considered at this point. Limiting channel depths and the outlines of the historic marsh islands in Jamaica Bay are presented in Figure D3-5. This second round of screening removed four sites (Table D3-3), leaving 5 to be recommended by this FR/EIS (Table D3-4).

Table D3- 3. Sites Removed in Second Round of Screening.

Sites Removed
Black Bank Marsh
Ruffle Bar
Big Egg Marsh
Little Egg Marsh

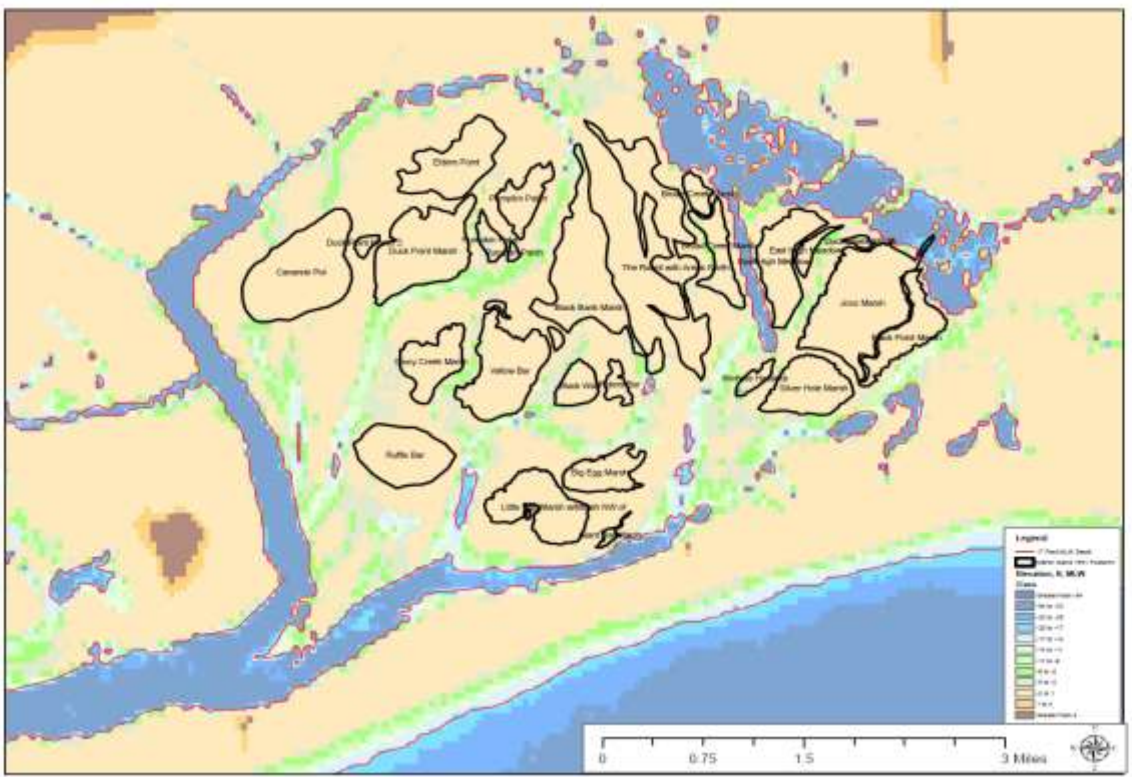

Figure D3- 5. Limiting Channel Depths in Jamaica Bay.

Table D3- 4. Marsh Island Sites Final Array.

Marsh Island Sites Recommended by HRE
Stony Creek
Duck Point
Elders Point Center
Pumpkin Patch West
Pumpkin Patch East

Figure D3-6 illustrates the five (5) selected sites, the five (5) previously constructed sites, and the five (4) sites that were screened out during the second phase of screening. The five (5) recommended sites were selected because their proximity to each other will better allow for the recapture of transported sediment and the system as a whole will promote the sustainability of the individual sites. A more thorough understanding of sediment transport and sediment dynamics between these sites is recommended during the detailed design in the preconstruction, engineering, and design (PED) phase. This investigation will inform the sequence of construction of the recommended islands, the actual designs of each island, particularly in terms of enhancing sediment stability.

3.3. Existing Conditions and Future without Project Condition

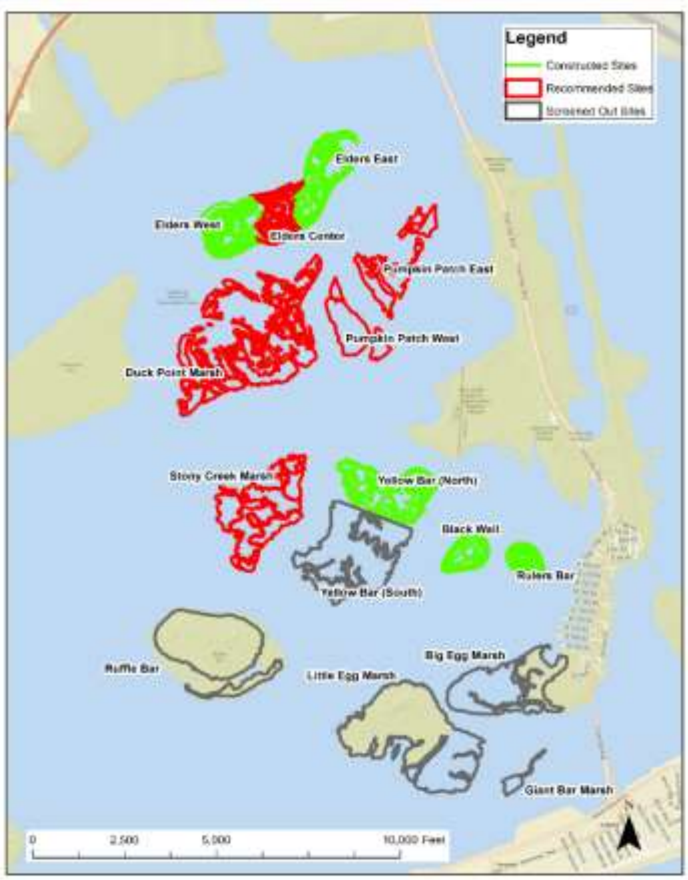

Figure D3- 6. Jamaica Bay Marsh Islands – Previously Constructed, Recommended and Screened-Out Sites.

3.3.1 Duck Point

The existing condition remnant marsh at Duck Point is approximately 17 acres, more than half of which are at the lower end of the low marsh range. Duck Point has experienced a high rate of marsh loss at approximately 2.8 acres per year between 1974 and 1994. In the no-action alternative, this loss would continue and the Duck Point Marsh Island is expected to disappear over time and was calculated to be 0 acres at year 50 using an intermediate relative sea level curve.

3.3.2 Stony Creek Marsh Island

The existing condition remnant marsh at Stony Creek is 34 acres. It is well defined and characterized by relatively high elevations compared to the remaining Jamaica Bay marsh islands as a whole. Geographic Information System analysis estimates that in 1974, the marsh island had an area of approximately 84 acres. Almost 60 percent of the marsh island has been lost in the past 42 years. As with the other marsh islands, it is at risk from sea level rise, continued water quality stressors, and habitat fragmentation. In the no-action alternative, erosion at Stony Creek marsh would likely continue, though the relatively high elevations may provide better short-to-medium term protection than the remaining Jamaica Bay marsh islands as whole. In the no-action alternative, this loss would continue and the Stony Creek Marsh Island is expected to disappear over time and was calculated to be 0 acres at year 50 using an intermediate relative sea level curve.

3.3.3 Pumpkin Patch West and East

The average loss rate for Pumpkin Patch as a whole is approximately 1.3 acres per year, with variation up to 2.5 acres per year between 2003 and 2005. Restoration at Pumpkin Patch initially focused on the restoration of a single large island that would encompass Pumpkin Patch West, Pumpkin Patch East and an area further to the east. The selected plans recommend two (2) separate restoration projects, Pumpkin Patch West and Pumpkin Patch East. Restoration in the area between these two (2) sites and to the east of Pumpkin Patch is not presently recommended due to concerns over sustainability and to the amount of material that would be needed to restore these areas. A future restoration of the area between these two (2) selected plans may be considered after the restoration of Elders Point Center which may have a positive effect on sediment transport and sustainability in this area and could be investigated using hydrodynamic modeling. Pumpkin Patch West is currently approximately 4 acres and East is approximately 8 acres. In the no-action alternative, it is expected that Pumpkin Patch West and East would disappear to be 0 acres at year 50 using an intermediate relative sea level curve.

3.3.4 Elders Point Center

Elders Point Marsh was historically one island but marsh loss in the center of the island created two distinct islands separated by a mud flat. When the restoration of Elders Point East and Elders Point West were planned and implemented, it was infeasible to restore Elders Point Center based on the depth of the substrate in that area. The restoration was limited to an increase in size of 40 acres of new marsh at Elders Point East (2007) and 43 acres of new marsh at Elders Point West (2010). Presently, no marsh island exists above water between the two islands.

However, following the implementation of restoration at Elders Point East (2007) and Elders Point West (2010), sediment has accumulated in the area of Elders Point Center, which has made restoration feasible and cost-effective. The restoration of Elders Point Center will result in a continuous marsh island between Elders Point East and Elders Point West, adding benefits such as reduction in habitat fragmentation and the potential for ancillary coastal storm reduction benefits for nearby mainland communities such as Howard Beach. The design of Elders Center is constrained by the presence of Elders Point East and Elders Point West, two (2) previous restoration projects and by the increasing depths found to the north and the south. The restoration of Elders Point Center results in a contiguous Elders Point marsh island, much like it existed in pre-industrial times. This is especially promising, as the effort adds to the 83 acres already restored at Elders Point East and Elders Point West. As detailed in the Elders Point East monitoring report (USACE, 2015), Elders Point East is projected to match the reference marsh conditions. This progression bodes well for the future of Elders Point Center, as it will already have an ecological community on the adjacent marsh islands. A particularly salient point about Elders Point East is that it hosts egg-laying horseshoe crabs, whose eggs are an important source of food for migratory birds along the Atlantic Flyway.

All Marsh Islands: Absent federal intervention, marsh island loss will continue into the future to a point where all 5 marsh islands would disappear by year 50.

3.4. Alternatives Development

Three (3) alternatives were developed at each of the five (5) marsh island locations. It was assumed that the marsh islands will be restored using dredged material from one of the many periodic channel maintenance operations conducted by the NY District throughout New York Harbor and the NY Bight area. The marsh island sites were designed to take advantage of the existing bathymetry when placing dredged material during construction, ensuring that most material is placed in shallow areas within the 1974 footprint of each island, which is the boundary set by the NYSDEC and National Parks Service.

Past construction provided valuable data on how to restore the marsh islands in the most effective and efficient manner. Basic lessons learned that influenced alternative development included the following:

- Ecological output for a given acre of marsh island is constant based on the prior EPW assessments for Elders Point East, Elders Point West and Yellow Bar Hassock and monitoring results of the islands by NPS and USACE.
- The cost of marsh island construction is dependent upon existing condition depth and the cost of the sand material and material transport.
- The size of the marsh island is influenced by the amount of contiguous and sustainable acreage within the 1974 regulatory footprint within a given range of elevations.
- The range of acreage at each marsh island has a minimum area driven by cost constraints of mobilization and demobilization of dredging and placement of sand. Please see Engineering Appendix for discussion on dredged material delivery method.
- The maximum area/acreage of the marsh island may be described by the existing depth at which sand placement becomes more expensive and less cost-effective.

- Approximately 50 percent subsidence of sand following placement of dredged material was assumed.
- The marsh islands selected for future restoration were based on constructability, existing bathymetry and hydrodynamics within Jamaica Bay.
- Past construction/monitoring indicated success of hummock replanting and use of tri-plugs (*Spartina alterniflora*, *Spartina pattens*, and *Distichlis spicata*) with optimal spacing of 18 inch on center.
- Recommended plans were developed based on minimum sand volumes for maximum wetland acreage and sustainability.
- Marsh islands also have potential to serve as Natural/Nature Based Features providing secondary coastal storm risk management benefits as suggested by the Structures of Coastal Resilience: http://structuresofcoastalresilience.org/locations/jamaica-bay-ny/.

Given that ecological output for an acre of a restored marsh island is constant across space, cost effectiveness analysis of prior marsh restoration efforts indicated that the primary driver of cost and cost-efficiency is the depth of the placement site and the resulting volume of material needed for restoration. Furthermore, prior screenings acknowledged the scalability of the selected plan. The final size of the plan could be scaled up or down within limits dictated by the existing condition bathymetry as well as the imposed constraint of the 1974 marsh island footprint without significantly impacting the cost-efficiency of the selected plan. It was therefore decided that the best plan development approach for the marsh island restoration efforts would be to identify and delineate the site specific constraints at each location and to formulate three alternatives informed by the constraints. The governing constraints used in the design development for each alternative are provided below and relate to the lessons learned articulated above:

- Volume coincides with a single dredge cycle (<450,000 CYD) of the Jamaica Bay Inlet O&M Project.
- Minimum restoration area/volume: a minimum area for each site was defined based on the cost constraints of mobilization and demobilization (mob/demob) and the ratio of mob/demob to the overall project cost such that the cost of mob/demob is estimated to be less than 30 percent. Of the project costs, placement of this minimum area, and to a lesser extent the size of this minimum area, was informed by the location of the highest existing condition elevations and vegetation, the 1974 footprint, and the historic configuration of the marsh island footprint as indicted by historic aerial photography.
- Maximum restoration area: A maximum area for each site was delineated based on existing condition contours. Restoration beyond this contour represents a break point where the per-acre cost of restoration increases considerably. This constraint was well defined at some sites and less so at others and is discussed in detail in the site summaries provided below.
- Sustainability: This constraint consists of a number of related factors including the configuration of the selected plan which is constrained by minimum widths, contiguity, proximity to relatively high velocity currents, and existing channels.
- Relative Sea Level Change Analysis (RSLC) was integrated into alternative development to ensure that all restoration footprints at year 50 provided acceptable quantified benefits and ensure a project that would be considered ecologically sustainable.

Three alternatives for each marsh island were therefore developed based upon these fundamental and governing constraints and the lessons learned from prior efforts. Initial quantity take-offs and costs were then developed and the plans were then further refined based on the guidelines established above. For more detailed engineering information on each of the following alternatives, please refer to the Engineering Appendix. The Engineering Appendix includes detailed descriptions of restoration measures, quantities, planting and grading plans and relative sea level change (RSLC) analysis for low, intermediate and high sea level change curves for each recommended site. In addition, each alternative was evaluated using the intermediate sea level change curve to determine performance, sustainability and habitat acreages in order to quantify the ecological benefits of each alternative (see Benefits and Engineering Appendices). The alternatives developed for each marsh island site are provided below.

3.4.1 Duck Point

A total of three (3) alternatives were developed for the Duck Point Marsh Island. Table D3-5 summarizes the details of these alternatives.

<u>Duck Point – Alternative 1</u>

Alternative 1 includes delivering 96,100 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 42.2 acres, 27.9 acres of which would be marsh. Of the marsh habitat, 15.4 acres are low marsh and 12.5 acres are high marsh.

<u>Duck Point – Alternative 2 (Tentatively Selected Plan)</u>

Alternative 2 includes delivering 213,776 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 62.6 acres, 38.6 acres of which would be marsh. Of the marsh habitat, 24.9 acres are low marsh, 5.6 acres are high marsh and 8.1 acres are scrub/shrub habitat.

<u>Duck Point – Alternative 3</u>

Alternative 3 includes delivering 284,989 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 72.1 acres, 44.4 acres of which would be marsh. Of the marsh habitat, 25.9 acres are low marsh, 15.7 acres are high marsh and 2.9 acres are scrub/shrub.

Table D3- 5. Duck Point Marsh Island Alternatives

Duck Point Marsh Island	Quantity of Dredged Material (CY)	Low Marsh (acres)	High Marsh (acres)	Scrub Shrub (acres)	Total Marsh Restoration (acres)
Alternative 1	96,100	15.4	12.5	-	27.9
Alternative 2	213,776	22.5	13.9	2.2	38.6
Alternative 3	284,989	25.9	15.7	2.9	44.4

<u>Duck Point – Recommended Plan</u>

The recommended plan was optimized based on Alternative 2 and includes delivering 213,776 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 62.6 acres. Three tidal channels are proposed, totaling approximately 2,730 linear feet (1.03 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 7.57 acres of shallow water habitat will be restored around the perimeter of the island. In total this design will restore 24.9 acres of low marsh, 5.6 acres of high marsh, and 8.1 acres of scrub shrub (Figure D3-7). See Engineering Appendix for the grading and planting plans and analysis of RSLC for the recommended plan.

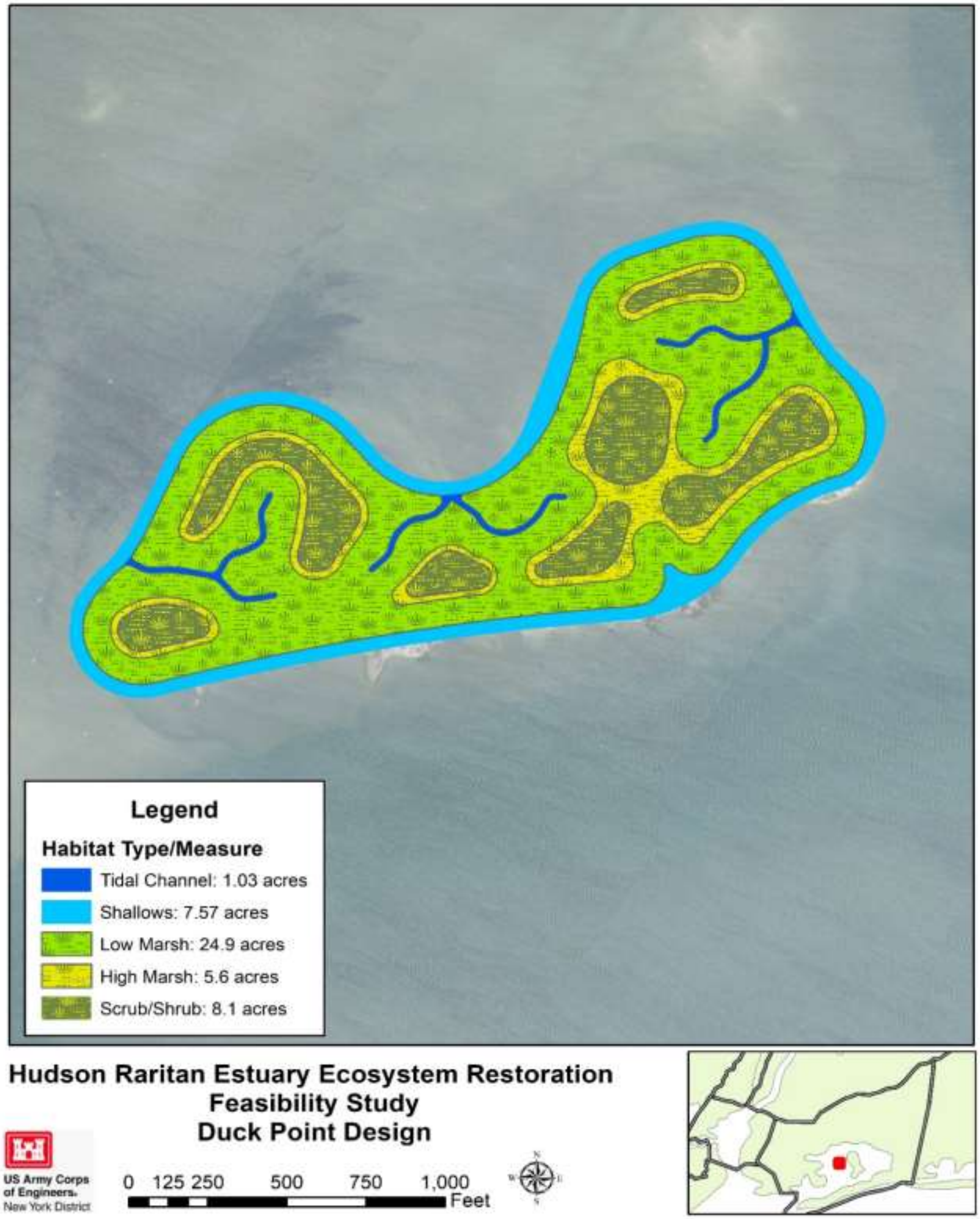

Figure D3- 7. Duck Point - Recommended Plan Design

3.4.2 Stony Creek Marsh

A total of three (3) alternatives were developed for the Stony Creek Marsh Island. Table D3-6 summarizes the details of these alternatives.

Stony Creek – Alternative 1 (Tentatively Selected Plan)

Alternative 1 involves delivering 151,360 cubic yards of clean sand to the island and grading the sediment. This would make the total footprint of the island 69.6 acres, 52 acres of which would be marsh. Of the marsh habitat, 26 acres are low marsh, 25.3 acres are high marsh and 0.7 acres are scrub/shrub habitats.

Stony Creek – Alternative 2

Alternative 2 involves delivering 88,614 cubic yards of clean sand to the island and grading the sediment. This would make the total footprint of the island 53.5 aces, 39.6 acres of which would be marsh. Of the marsh habitat, 28.3 acres are low marsh and 11.3 acres are high marsh.

Stony Creek – Alternative 3

Alternative 3 involves delivering 65,258 cubic yards of clean sand to the island and grading the sediment. This would make the total foot print of the island 53.3 acres, 31.3 of which would be marsh. Of the marsh habitat, 22.9 acres are low marsh and 8.4 acres are high marsh.

Table D3- 6. Stony Creek Marsh Island Alternatives

Stony Creek Marsh Island	Quantity of Dredged Material (CY)	Low Marsh (acres)	High Marsh (acres)	Scrub Shrub (acres)	Total Marsh Restoration (acres)
Alternative 1	151,360	26.0	25.3	0.7	52
Alternative 2	88,614	28.3	11.3	-	39.6
Alternative 3	65,258	22.9	8.4	-	31.3

Stony Creek – Recommended Plan

The recommended plan is optimized based on Alternative 1 and involves delivering 151,360 cubic yards of clean fill to the island and grading the sediment. This would make the total footprint of the island 69.6 acres. Five (5) tidal channels are proposed, totaling approximately 4,640 linear feet (1.43 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 8.67 acres of shallow water habitat will be restored around the perimeter of the island. In total, this design will restore 26 acres of low marsh, 25.3 acres of high marsh and 0.7 acres of scrub/shrub (Figure D3-8). See Engineering Appendix for the grading and planting plans and analysis of RSLC for the recommended plan.

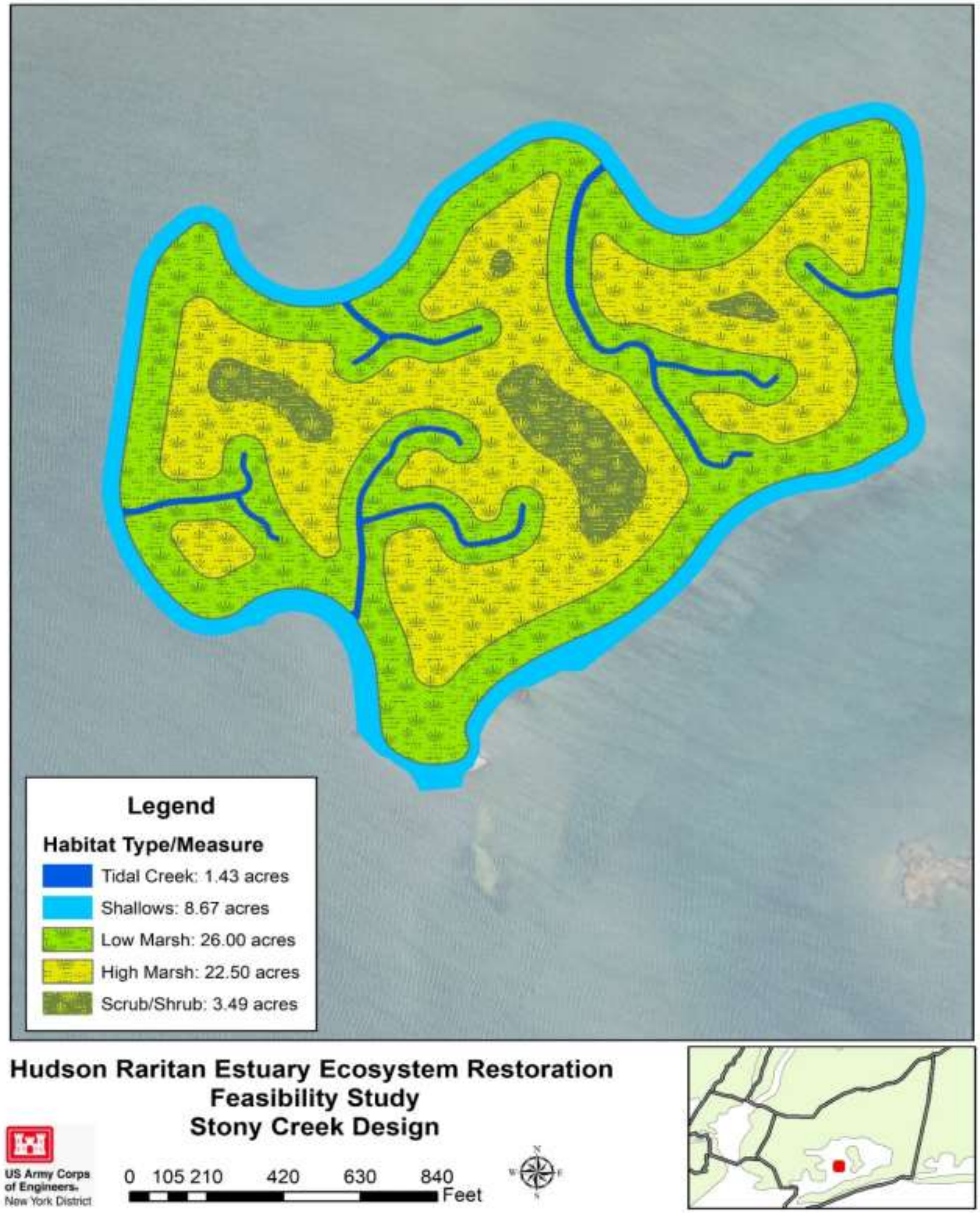

Figure D3- 8. Stony Creek - Recommended Plan Design

3.4.3 Pumpkin Patch West

A total of three (3) alternatives were developed for the Pumpkin Patch West Marsh Island. Table D3-7 summarizes the details of these alternatives.

<u>Pumpkin Patch West – Alternative 1</u>

Alternative 1 includes delivering 206,810 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 30.1 acres, 16.3 acres of which would be marsh. Of the marsh habitat, 10.8 acres are low marsh, and 5.5 acres are high marsh.

<u>Pumpkin Patch West – Alternative 2 (Tentatively Selected Plan)</u>

Alternative 2 includes delivering 327,686 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 32.9 acres, 23.2 acres of which would be marsh. Of the marsh habitat, 13.7 acres are low marsh, 8.6 acres are high marsh, and 0.9 acres are scrub/shrub.

<u>Pumpkin Patch West – Alternative 3</u>

Alternative 3 includes delivering 435,493 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 41.1 acres, 29.6 acres of which would be marsh. Of the marsh habitat, 18.7 acres are low marsh, 10.3 acres are high marsh, and 1.2 acres are scrub/shrub.

Table D3- 7. Pumpkin Patch West Marsh Island Alternatives

Pumpkin Patch West Marsh Island	Quantity of Dredged Material (CY)	Low Marsh (acres)	High Marsh (acres)	Scrub Shrub (acres)	Total Marsh Restoration (acres)	Total Marsh Island Footprint (acres)
Alternative 1	206,810	10.8	5.50	-	16.3	30.1
Alternative 2	327,686	13.7	8.60	0.9	23.2	32.9
Alternative 3	435,493	18.7	10.3	1.2	29.6	41.1

<u>Pumpkin Patch West – Recommended Plan</u>

The recommended alternative (same as Alternative 2) includes delivering 327,686 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 32.9 acres, 23.2 acres of which would be marsh. Three (3) tidal channels are proposed, totaling 2,040 linear feet (approximately 0.74 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 3.88 acres of shallow water habitat will be restored around the perimeter of the island. In total this design will restore 13.7 acres of low marsh, 8.61 acres of high marsh and 0.9 acres of scrub/shrub (Figure D3-9). See Engineering Appendix for the grading and planting plans and analysis of RSLC for the recommended plan.

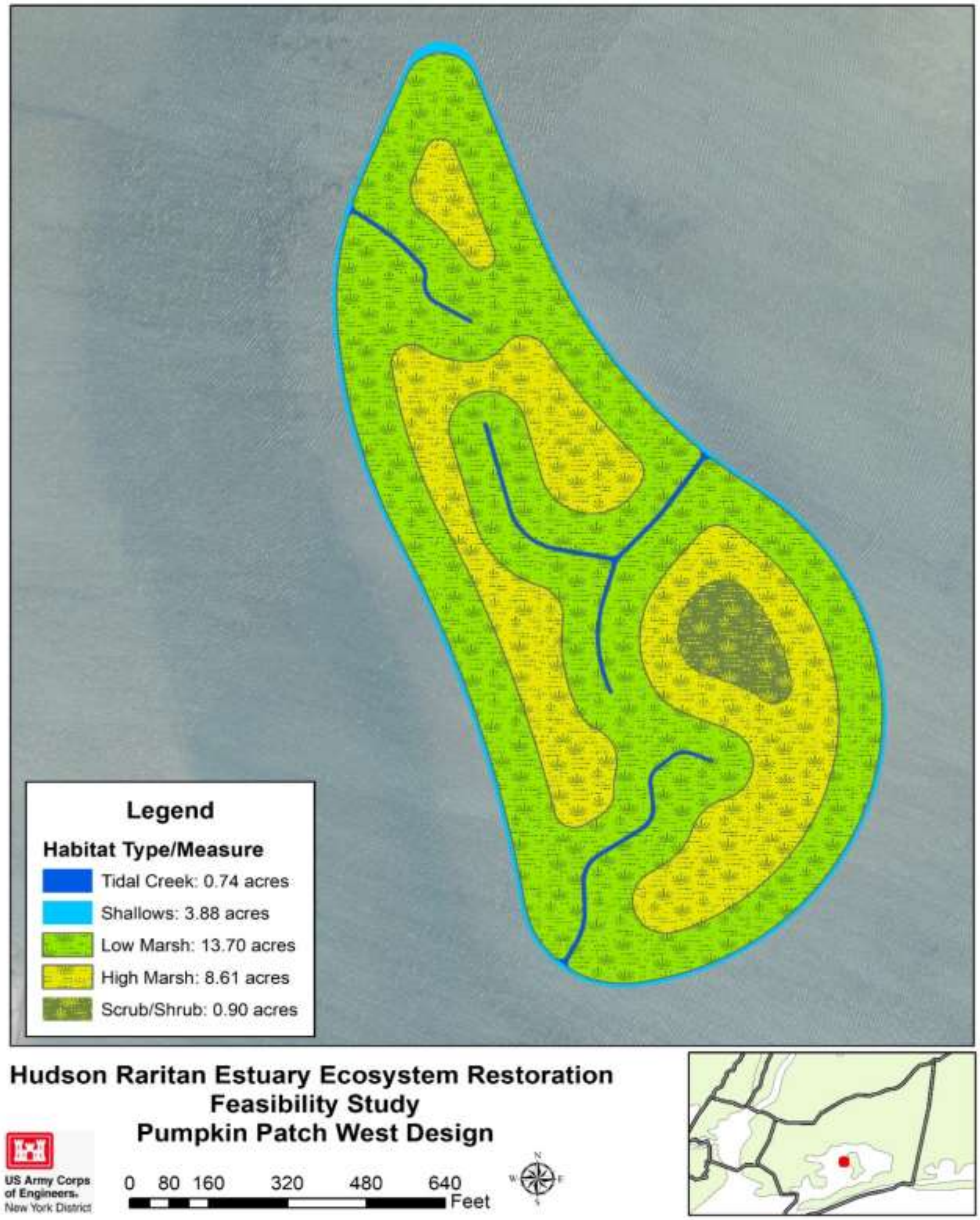

Figure D3- 9. Pumpkin Patch West - Recommended Plan Design

3.4.4 Pumpkin Patch East

A total of three (3) alternatives were developed for the Pumpkin Patch East Marsh Island. Table D3-8 summarizes the details of these alternatives.

Pumpkin Patch East – Alternative 1

Alternative 1 includes delivering 432,790 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 52 acres, 35.3 acres of which would be marsh. Of the marsh habitat, 18.5 acres are low marsh and 16.8 acres are high marsh.

Pumpkin Patch East – Alternative 2

Alternative 2 includes delivering 255,123 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 34.2 acres, 21.3 acres of which would be marsh. Of the marsh habitat, 12.4 acres are low marsh, 7.7 acres high marsh and 1.2 acres of scrub/shrub habitat.

Pumpkin Patch East – Alternative 3 (Tentatively Selected Plan)

Alternative 3 includes delivering 351,952 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 40.5 acres, 28.8 acres of which would be marsh. Of the marsh habitat, 15.6 are low marsh, 10.1 acres are high marsh and 3.1 acres are scrub/shrub habitat.

Table D3- 8. Pumpkin Patch East Marsh Island Alternatives

Pumpkin Patch East Marsh Island	Quantity of Dredged Material (CY)	Low Marsh (acres)	High Marsh (acres)	Scrub Shrub (acres)	Total Marsh Restoration (acres)	Total Marsh Island Footprint (acres)
Alternative 1	432,790	18.5	16.8	-	35.3	52.0
Alternative 2	255,123	12.4	7.7	1.2	21.3	34.2
Alternative 3	351,952	15.6	10.1	3.1	28.8	40.5

Pumpkin Patch East – Recommended Plan

The recommended plan (same as Alternative 3) includes delivering 351,952 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the restored island 40.5 acres of which 28.8 acres would be marsh. Three (3) tidal channels are proposed, totaling 1,530 linear feet (approximately 0.58 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 5.22 acres of shallow water habitat will be restored around the perimeter of the island. In total this design will restore 15.6 acres of low marsh, 10.1 acres of high marsh, and 3.1 acres of scrub shrub (Figure D3-10). See Engineering Appendix for the grading and planting plans and analysis of RSLC for the recommended plan.

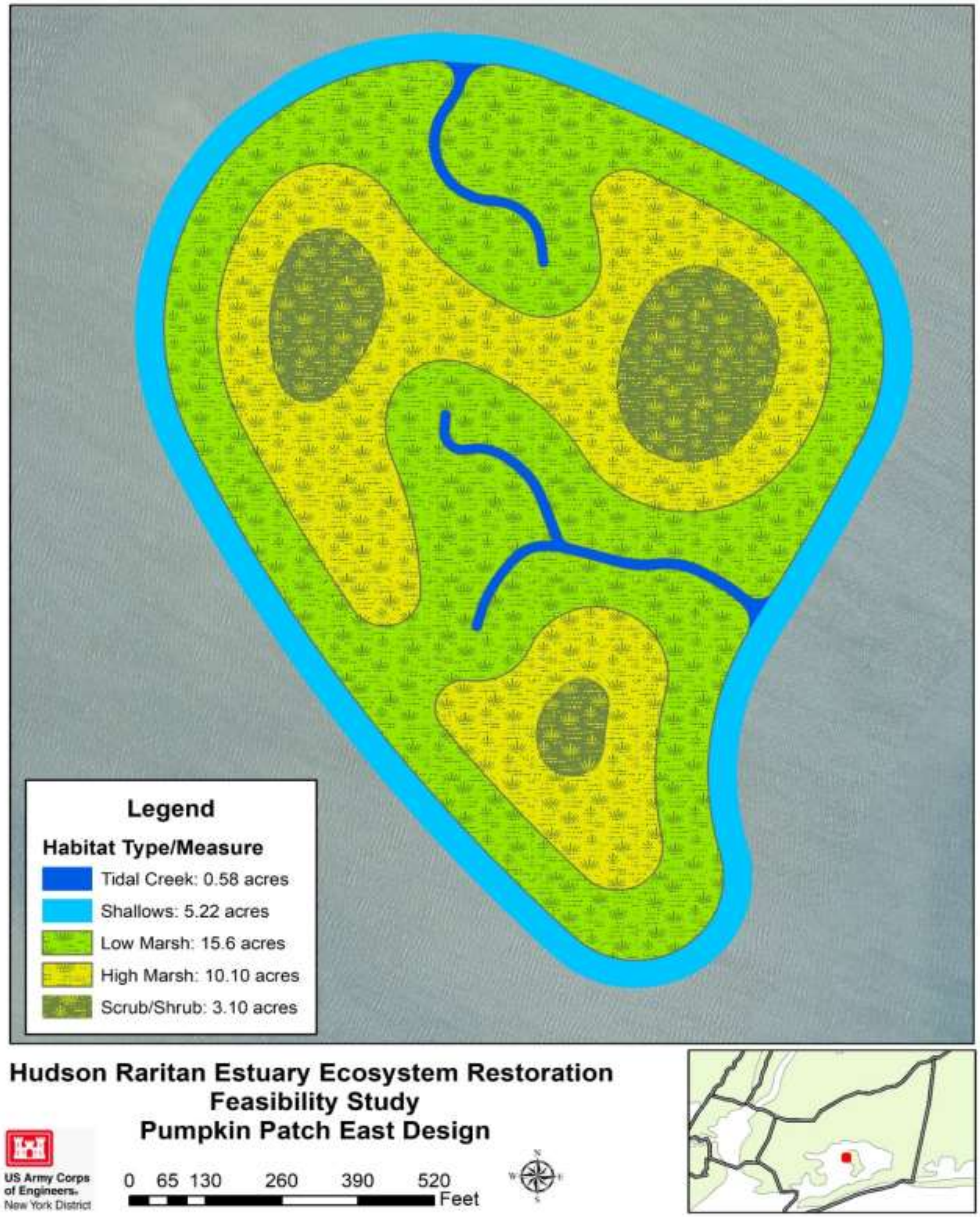

Figure D3- 10. Pumpkin Patch East - Recommended Plan Design

3.4.5 Elders Center

A total of three (3) alternatives were developed for the Elders Center Marsh Island. Table D3-9 summarizes the details of these alternatives.

Elders Point Center – Alternative 1

Alternative 1 includes delivering 236,410 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 33.6 acres, 16.0 acres of which would be marsh. Of the marsh habitat, 8.5 acres are low marsh and 7.5 acres are high marsh.

Elders Point Center – Alternative 2

Alternative 2 includes delivering 217,163 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 28.0 acres, 18.3 acres of which would be marsh. Of the marsh habitat, 9.5 acres are low marsh, 6.9 acres are high marsh and 1.9 acres scrub/shrub.

Elders Point Center – Alternative 3 (Tentatively Selected Plan)

Alternative 3 includes delivering 284,891 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 41.7 acres, 27.5 acres of which would be marsh. Of the marsh habitat, 15.2 acres are low marsh, 10.9 acres are high marsh and 1.4 acres of scrub/shrub habitat.

Table D3- 9. Elders Point Center Marsh Island Alternatives

Elders Point Center Marsh Island	Quantity of Dredged Material (CY)	Low Marsh (acres)	High Marsh (acres)	Scrub Shrub (acres)	Total Marsh Restoration (acres)	Total Marsh Island Footprint (acres)
Alternative 1	236,410	8.5	7.5	-	16.0	33.6
Alternative 2	217,163	9.5	6.9	1.9	18.3	28.0
Alternative 3	284,891	15.2	10.9	1.4	27.5	41.7

Elders Point Center – Recommended Plan

The recommended plan (same as Alternative 3) includes delivering 284,891 cubic yards of clean sand to the marsh island and grading the sediment. This would make the total footprint of the island 41.7 acres, of which 27.5 acres would be marsh. Four (4) tidal channels are also proposed, totaling 2,500 linear feet (approximately 0.95 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 5.49 acres of shallow water habitat will be restored around the perimeter of the island. In total this design will restore 15.2 acres of low marsh, 10.9 acres of high marsh and 1.4 acres of scrub/shrub (Figure D3-11). See Engineering Appendix for the grading and planting plans and analysis of RSLC for the recommended plan.

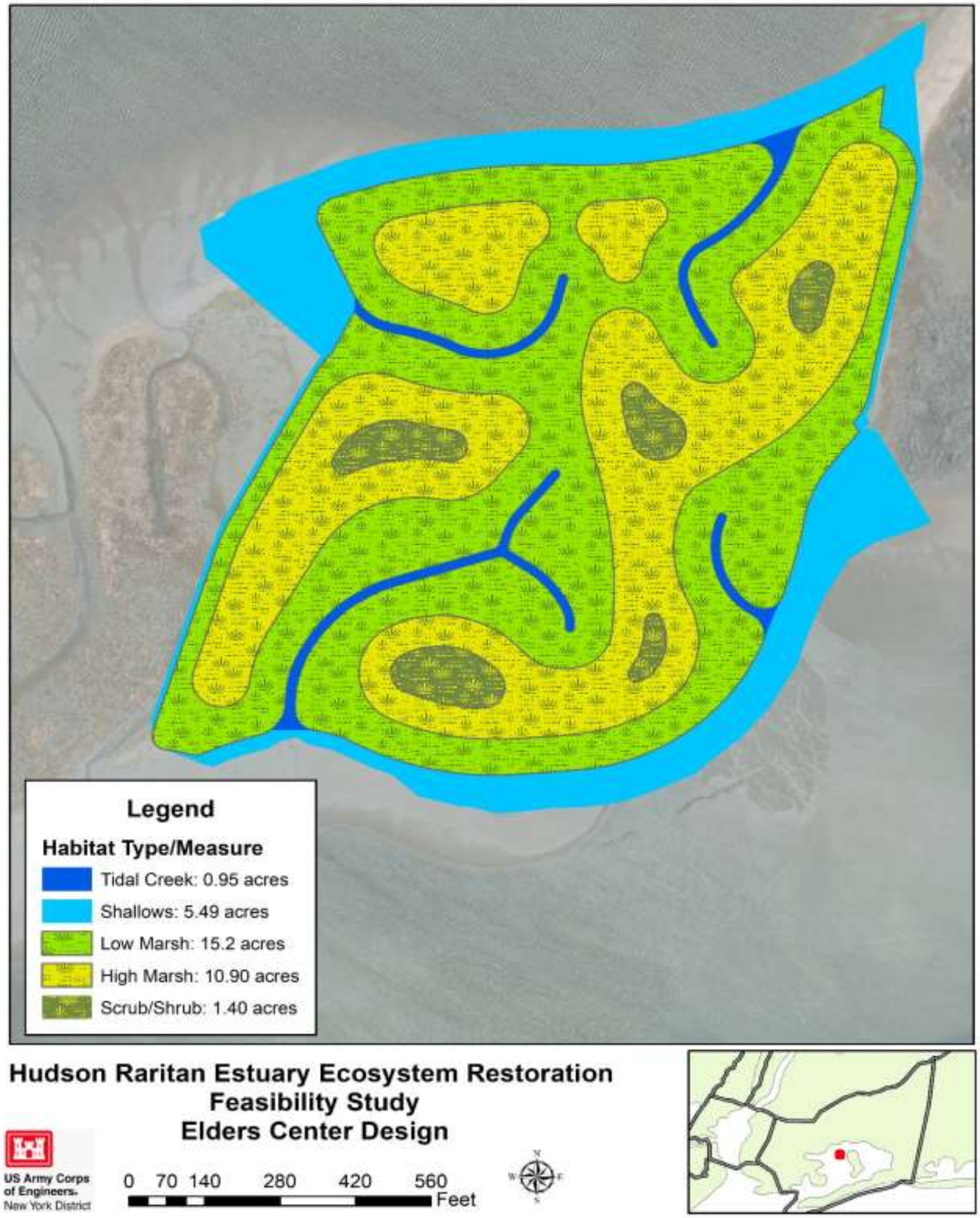

Figure D3- 11. Elders Point Center Recommended Plan Design

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 4: Flushing Creek

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

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4. Flushing Creek

The Flushing Creek and Bay Ecosystem Restoration Feasibility Study ("Source" study) was initiated in 1999 and was included within the larger Harlem River, East River and Western Long Island Sound Planning Region. During the "Source" study, an array of preliminary alternatives including tidal and freshwater wetland restoration, breakwaters, reorientation of the federal navigation channel, daylighting of portions of Flushing Creek and streambank restoration were identified at 12 sites throughout the Flushing Bay and Creek Study Area. The screening of initial sites and alternative development from the "Source" study and activities following integration in HRE is included in this chapter.

4.1 Project Area Context

The Flushing Bay and Creek watershed, located in the Borough of Queens, New York City, is highly urbanized with a dense mixture of residential, transportation, commercial, industrial and institutional development. The watershed includes approximately 20,577 acres, of which 16,700 acres are densely developed lands that comprise portions of the Borough of Queens and all or parts of the communities of College Point, Bayside, Flushing, Willets Point, Queensboro Hill, Kew Gardens, Rego Park, Forest Hills, Corona, North Corona, and East Elmhurst. The study area extends from the northern end of College Point south to approximately Atlantic Avenue and the LIRR. From west to east, the study area extends from East Elmhurst to Bayside. Significant features within the study area include the former Flushing Airport, the eastern shoreline of LaGuardia Airport, and Flushing Meadows-Corona Park. The major area of parkland is Flushing Meadows-Corona Park, which was the site of the 1939 and 1964 World's Fair.

Flushing Bay is an embayment of the East River consisting of approximately 6,200 acres of open water. The project area contains an existing federal navigation project consisting of a 15-foot channel into Flushing Bay and Creek and a six (6)-foot anchorage basin in the back bay. A 1,400-foot sheet pile breakwater was recommended by the USACE in a 1962 Chief's Report, but was never constructed. A 2,800-foot earthen breakwater was constructed in 1964 by the NYC Parks and the World's Fair Corporation. The earthen breakwater functioned to protect the marinas located in the back bay. The outermost 1,400 feet of the earthen breakwater were accepted for maintenance and operations by the USACE in 1967 from the City of New York, in lieu of a federally authorized 1,400-foot steel sheet pile breakwater. The breakwater was deauthorized as a federal project in the Water Resources Development Act (WRDA) of 1992.

In 1995, the top portion of the breakwater was removed to 3.2 feet above mean low water (MLW), approximately to the level of the existing mudflats. The breakwater was removed by the Port Authority of New York and New Jersey in conjunction with construction of a runway safety overrun at LaGuardia Airport. The material removed from the top of the dike was used as fill for the safety overrun. The bay bottom impacted by the overrun was mitigated for by reestablishing wetlands on the north shoreline of the airport as well as offsite at Alley Pond Park in Little Neck Bay. The New York State Department of Environmental Protection (NYSDEC) specified the 3.2-foot MLW remaining dike elevation as requirement for the permit.

The main tributary to Flushing Bay is Flushing Creek. Flushing Creek flows approximately 7,000 feet from the outlet of Meadow Lake before entering Flushing Bay. Prior to landfills and development in preparation for the 1939 World's Fair, Flushing Creek was a sinuous tidal creek that supported an extensive tidal wetland system. Development of the World's Fair site included significant straightening of the stream, filling in wetland areas, and reconfiguring the headwaters of Flushing Creek into two man-made freshwater lakes. Willow Lake (40 acres) and Meadow Lake (100 acres) were created to support World Fair activities.

Present land use in the Flushing Creek watershed is mainly residential, followed by open space and outdoor recreational uses. A small fraction of the land accounts for industrial and transportation-designated areas. The majority of the land used for industrial purposes lies close to the eastern shore of the creek. Figure D4-1 presents an aerial view of Flushing Creek, including surrounding waterbodies (Flushing Bay and Meadow and Willow Lakes) and communities in Queens. Figure D4-2 presents the land use within one (1) quarter-mile of the creek. Flushing Creek was also diverted through underground culverts to flow through a fountain structure prior to reaching the tide gates at Porpoise Bridge.

Within Flushing Meadows-Corona Park, Willow Lake drains into Meadow Lake which discharges to Flushing Creek. Immediately downstream of Meadow Lake, the creek flows under the elevated highway infrastructure for approximately 2,500 feet. When it reaches a culvert, the flows are directed underground for 1,000 feet to the fountain structure. Below the fountain structure, the creek reenters an underground culvert that directs flow for another 1,000 feet at which point the creek is discharged to a pond. This is at the head of the tide gates. The Flushing Creek watershed is small. The low freshwater flows are not sufficient to open the tidal gate. Flushing Creek therefore contributes only a small portion of the total inflow to Flushing Bay.

Development activities in the watershed exhibit a continuous pattern of loss and degradation of tidal wetlands. Development continually has encroached into the natural tidal wetlands complex which originally bounded Flushing Bay and Creek. The remaining wetlands in the area are significantly degraded and are limited to fringe areas. The fringe areas are generally unsuitable for development. Operation of the retention facility and other combined sewer overflow (CSO) abatement measures completed by NYCDEP will significantly improve water quality in Flushing Creek. The abatement facilities will improve adjacent stream reaches, and adjacent areas of the bay.

Figure D4- 1. Aerial of Flushing Creek and Surrounding Waterbodies and Communities

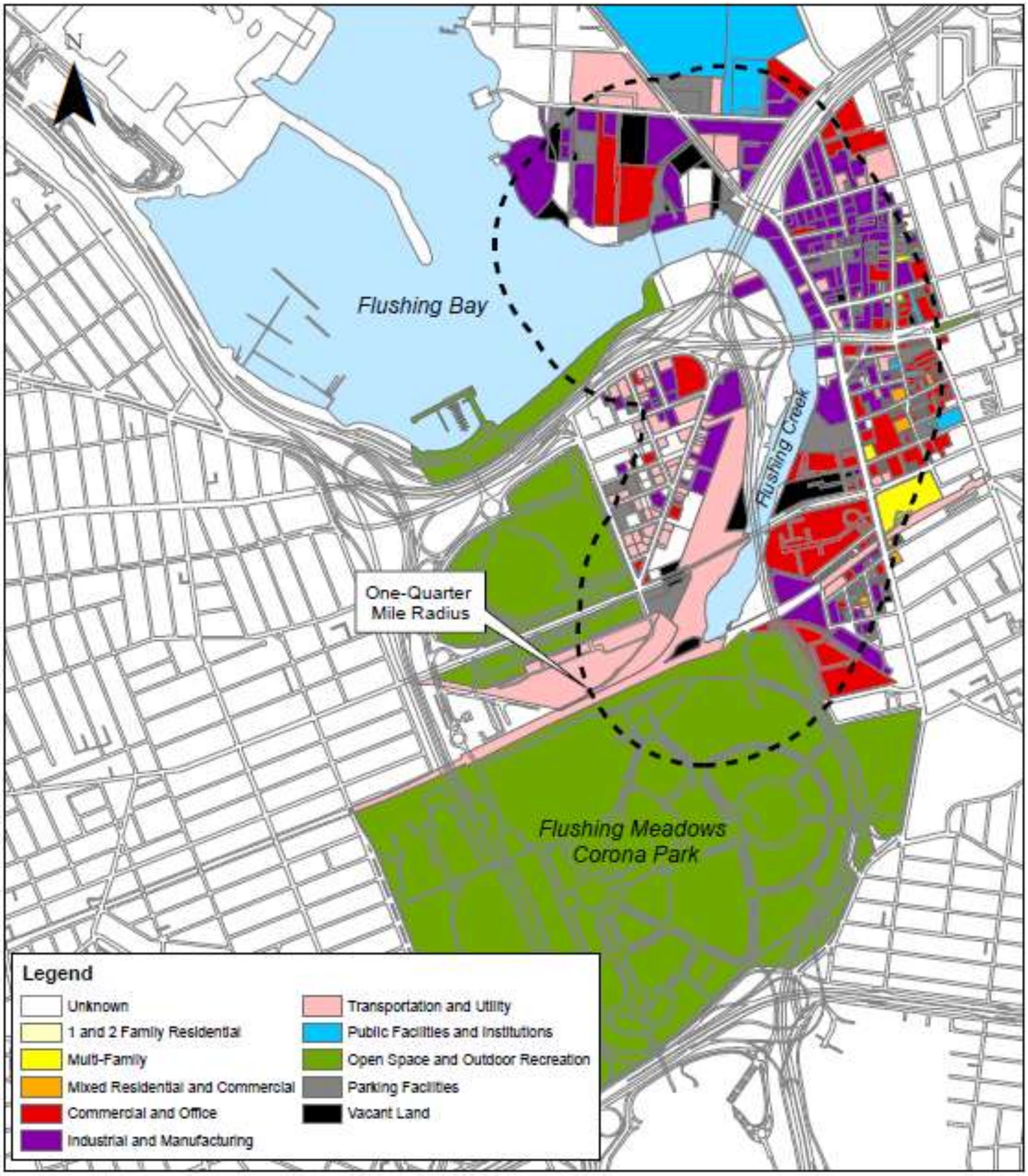

Figure D4- 2. Land Use within One-Quarter-Mile of Flushing Creek

4.1.1 NYCDEP Improvements

NYCDEP has dredged several areas within Flushing Bay and had planned to dredge areas of Flushing Creek west of and adjacent to the Van Wyck Expressway and north of the LIRR. Dredging supports upland restoration and also serves to remove mounds of accumulated sediment that are exposed at low tide that contribute to nuisance odors. No additional dredging will be carried out by NYCDEP in the foreseeable future.

NYCDEP has two other ongoing projects in the Flushing Creek area to abate CSO discharges and improve water quality in the New York Harbor. Currently, long term CSO control is enforced by an Order on Consent between NYCDEP and the NYSDEC (Case #CO2-20110512-25). Flushing Creek is one of several waterbodies that is included in the Order on Consent. Water quality in Flushing Creek has been improved through the following NYCDEP projects[1]:

- Construction of the Flushing Creek CSO Retention Facility: The 43 million-gallon Flushing Creek CSO Retention Facility was certified by NYCDEP as complete and operational in May 2007, and is designed to store and capture combined sewage that previously discharged to Flushing Creek via outfall TI-010.

- Tallman Island Conveyance Enhancements: NYCDEP has initiated work on a number of Tallman Island system conveyance enhancements to maximize the flow delivered to the Tallman Island Waste Water Treatment Plant and reduce CSO discharge to Flushing Creek as well as the East River.

NYCDEP is currently evaluating additional improvements in Flushing Creek in development of the Long Term Control Plan for the waterbody. Dredging of Flushing Creek was required by an early draft of the CSO Order on Consent but was subsequently removed. Under the ecosystem restoration, dredging may be completed in the vicinity of TI-010 and potentially fulfill the intent of the dredging requirements of the Order on Consent. CSO outfall locations as well as the USACE Federal Navigation Channel can be seen in Figure D4-3.

In addition, NYCDEP is implementing green infrastructure plans to help mitigate stormwater from entering the sewer system by installing hundreds of street-side bioswales to manage stormwater on the streets and sidewalks. By 2030, NYCDEP intends to manage eight (8) percent of Flushing Creek's watershed and 13 percent of Flushing Bay's watershed impervious cover with green infrastructure.

[1] DEP, Flushing Creek WWFP. August 2011.

Figure D4- 3. Flushing Creek Project Area, CSO Outfalls and USACE Navigation Channel

4.1.2 Watefront Brownfield Opportunity Area and Brownfield Cleanup Program

The Flushing Creek site is located along the Flushing Waterfront Brownfield Opportunity Area (BOA). The recommendations for the BOA include the creation of mixed-use redevelopment and affordable housing, new open space and waterfront access, improvements to pedestrian flow and vehicular movement, and long-term improvements of water quality in Flushing Creek (https://www.governor.ny.gov/news/governor-cuomo-announces-three-brownfield-opportunity-areas-staten-island-flushing-and-auburn) (Figure D4-4). The proposed development along to 40 acres BOA plan to support a more economically, socially diverse, and improved quality of life to the Downtown Flushing area. Outside of the BOA, to the south of Roosevelt Avenue additional developments including a new hotel and two apartment buildings to occupy a former warehouse site are proposed. The proposed restoration work along the western side near this proposed development could be utilized for public access to green space (Figure D4-5). Restoration work along Flushing Creek would provide improved waterfront views as well as improved water quality, which contribute to the goals of the BOA. Without restoration, the site would remain degraded and future developments would lose the benefit of improved marsh and wetland along the creek.

Photos from: https://www.queensalive.org/flushing-waterfront-boa

Figure D4- 4. Waterfront Brownfield Opportunity Area

Figure D4- 5. Waterfront Brownfield Opportunity Area Concepts

An ongoing brownfield remediation site marks the northeast extent of the project area where the Van Wyck Expressway crosses the creek. The Flushing Industrial Park was historically owned by Con Edison and used as a service center to support electrical and gas utility operations. Upon being sold to C.E. Flushing, LLC, investigations revealed that soil and groundwater on the property contained polychlorinated biphenyls (PCBs), volatile organic compounds, semi-volatile organic compounds, pesticides, and metals. As a result, C.E. Flushing entered a Voluntary Cleanup Agreement with the NYSDEC where subsequent investigations placed Flushing Industrial Park into the NYSDEC Brownfield Cleanup Program.

Under the program, the property was divided into sections (operable units) and parcels. Parcel 4 in Operable Unit 1 extends into Flushing Creek. In 2005, a separate investigation was conducted on Parcel 4 (Site ID C241078A). The investigation revealed the presence of PCBs, polycyclic aromatic hydrocarbons, pesticides, and metals in the sediment that exceeded

NYSDEC sediment screening levels presented in the Technical Guidance for Screening Contaminated Sediments[2]. Alternatives analysis was subsequently conducted to determine the most effective solution to address the PCB-affected sediment in Parcel 4. The selected alternative includes dredging the approximately 1,200 cubic yards of PCB-affected sediment from Parcel 4, which would result in a reduction of both volume and toxicity of PCB-impacted sediments in the creek[3]. The dredged material would be permanently removed and the area backfilled to restore the habitat.

Figure D4-6 shows the Parcel 4 boundary of the remediation project. The Feasibility Study for the remediation project was issued in August 2013. As the design for the Brownfield Remediation Program is ongoing, and due to the PCB contamination, the proposed ecosystem restoration project will not overlap with the C.E. Flushing site.

Figure D4- 6. Brownfield Remediation Site, Parcel 4 Boundary

[2] ARCADIS, RIR, Section 1.1. March 2011.
[3] ARCADIS, Feasibility Study Report: Flushing Industrial Park Operable Unit 2, Section 7. August 2013.

4.2 Development of the Flushing Creek "Source" Study Tentative Selected Plan

The Flushing Creek "Source" study conducted site screening and developed preliminary sites throughout the study area to address the planning objectives. The planning process of identifying the source study TSP is presented here to show the basis for formulating the three HRE Flushing Creek alternatives.

4.2.1 "Source" Study Planning Goal and Planning Objectives

The planning goal was to restore the degraded aquatic ecosystem of Flushing Bay and Creek. The objective for the Flushing Creek study was to develop and recommend the optimal plan to restore the degraded structures, functions, and dynamic processes of the local and regional ecosystems to a less degraded, more natural condition. Achieving this objective would involve consideration of the ecosystem's natural integrity, productivity, stability, and biological diversity.

The specific objectives used to guide the plan formulation process for the "Source" study, consistent with the HRE planning objectives, included:

- Restore and enhance inter-tidal marsh habitat at selected sites along the shorelines of Flushing Bay and Creek to encourage the re-introduction of beneficial flora, such as salt marsh cordgrass, salt grass and salt marsh hay.
- Restore and improve vegetated and non-vegetated sub-tidal habitats for use by migrating waterfowl, invertebrates (including shellfish) and fish.
- Improve existing habitats and support restoration activities through a variety of non-structural measures including:
  - ✓ reduction in sedimentation rates;
  - ✓ comprehensive watershed management planning;
  - ✓ natural filtration through creation of wetlands near CSO outfalls;
  - ✓ fringe plantings in non-point source runoff areas;
  - ✓ reduction in residual combined sewer overflows (in coordination with sponsor actions); and
  - ✓ control of non-point source runoff (in coordination with sponsor actions).
- Improve the suitability of bottom substrate thereby improving the structure and value of the macrobenthic population that support higher trophic level species such as fish.
- Reduce surface runoff, erosion and sedimentation in Flushing Bay and Creek.
- Increase transparency of water increasing the potential for photosynthesis by stream producers.
- Select alternatives or combinations of alternatives that facilitate the maximum improvement to the overall aquatic ecosystem.

Site-specific planning constraints include:

- Avoid impacts to residential and commercial properties;
- Minimize impacts to existing infrastructure (*e.g.*, roads, bridges, etc.);
- Limit induced flooding; and
- Limit re-vegetation of riparian areas to species native to the region.

4.2.2 "Source" Study Preliminary Alternatives/Site Screening

A range of preliminary sites were developed from the restoration opportunities (habitat types or measures) presented below. These preliminary sites were screened and refined in subsequent iterations throughout the planning process.

4.2.3 Preliminary Restoration Opportunities

Tidal Wetland Restoration (Sites 1, 2, 3, 5, 6, 8, 9, & 10)

Opportunities for tidal wetland restoration exist at a variety of locations in the back bay of Flushing Creek and the College Point waterfront. Approximately 21 acres of potential tidal wetland restoration sites were identified in the reconnaissance study. Fourteen (14) acres along the west bank of Flushing Creek and seven (7) acres along the western College Point shoreline were identified. Investigations and site visits identified restoration opportunities for tidal wetlands including 12 acres at Tallman Island on the Powell's Cove (eastern) side of College Point and eight (8) acres on the northern side of College Point facing the East River. Restoration would involve the removal and eradication (i.e., excavation and grading or chemical treatment) of common reed (including the root stock), removal of fill material, regrading to elevations suitable for inter-tidal wetlands, and planting with appropriate wetland species.

Freshwater Wetland Restoration (Sites 2, 4, & 5)

Non-tidal wetlands within the Flushing Bay and Creek watershed are located in Willow and Meadow Lakes at Flushing Meadows-Corona Park and the former Flushing Airport site. These sites are located in areas which were formerly tidal wetlands, but were removed from tidal influence through extensive land filling. The tidal gates are now inoperative because of the reduced freshwater flow.

The reconnaissance study identified approximately 25 acres of restoration opportunities at Willow and Meadow Lakes. This would double the size of the existing wetland complex. The restoration of wetlands at Willow and Meadow Lakes would enhance forage and cover for fish and wildlife while also providing ancillary improvement to water quality adjacent Flushing Meadows-Corona Park. Installation of aeration devices in the lakes, currently being considered by NYC Parks, could aid in reducing eutrophication of the lakes.

The reconnaissance study identified approximately 19 acres of restoration opportunities at Flushing Airport. This would increase the size of the existing wetland complex by over 70 percent. Restoration activities would involve removal and eradication (i.e., excavation and grading or chemical treatment) of common reed (including the root stock), and planting with suitable non-tidal wetland species. The site would be lowered to ensure that sufficient hydrological conditions exist to restore forested, scrub/shrub, emergent sedge meadow and grass meadow wetland habitats. A common reed control program would be implemented to help ensure the success of these restored wetlands.

Dredging of Flushing Bay and Creek (Site 12)

The reconnaissance study recommended that dredging Flushing Bay and Creek be further analyzed in the feasibility study. Components of the dredging alternative could include re-contouring of the bay bottom to improve circulation patterns and water quality in the inner bay and creek. Fine grained organic-rich sediments and capping dredged areas with clean sediments to improve overall benthic habitat, plus the lowering the elevation of existing mudflats to reduce hydrogen sulfide flux would be accomplished.

Partial or Total Removal of the Breakwater at LaGuardia Airport (Site 7)

In 1995, the Port Authority of New York and New Jersey removed the top portion of the earthen breakwater to the level of the exposed mudflats above two (2) feet MLW in conjunction with construction of the LaGuardia Airport runway overrun project. In 1996, a floating breakwater was constructed to protect the World's Fair marina, which had previously been protected by the earthen breakwater. Reduction of the earthen breakwater elevation was performed at the request of the Borough of Queens. The Borough perceived benefits in allowing additional inflows into the back bay during high tides. Hydrodynamic and water quality modeling studies conducted before the reconnaissance study indicate that removal of the earthen breakwater alone will not result in significant water quality improvements in the back bay. This is in large part due to the distance from the earthen breakwater to the shoreline and the presence of three (3) CSO outfalls just offshore in the back bay. However, the reconnaissance study did recommend that removal of the breakwater be assessed for potential habitat improvements that would result from improved circulation and flushing, restoration of the former bay bottom, and for impacts on odor reduction in the back bay.

Reorientation of the Federal Navigation Channel (Site 11)

In analyses conducted prior to the reconnaissance study, deepening of the federal navigation channel was evaluated as an option. Deepening the navigation channel was found to have limited effect on increasing circulation in the back bay. Due to problems identified in the past modeling efforts (WES, 1992), recent and planned CSO abatement activities, and the construction of a floating breakwater in the back bay, additional modeling of the impacts of reorienting or deepening the federal channel was recommended in the reconnaissance study.

Steambank Restoration, Site Cleanup and Debris Removal (Sites 3, 4, 8. 9. &10)

A number of sources of surface erosion were identified during the reconnaissance phase. Eroded banks were observed at numerous locations along the west bank of College Point in Flushing Bay. Some of these sites were also being used for illegal dumping of refuse and construction and demolition material. Erosion control, site cleanup, and debris removal could support tidal wetland restoration efforts in this area.

4.2.4 Preliminary Site Screening

Four (4) evaluation criteria identified in the Economic and Environmental Principles for Water and Land Resources Implementation Studies (Principles and Guidelines) include completeness, effectiveness, efficiency, and acceptability. The preliminary screening of plans in the "Source" study conducted for this analysis was based on all evaluation criteria. A cost and benefit evaluation criteria had not yet been developed for any of the restoration opportunities identified above.

Completeness is defined as accounting for all actions that may be required to support the alternative plan. In this preliminary screening process, hazardous, toxic, and radioactive waste (HTRW) phase I assessments, preliminary cultural resource impact assessments, and property ownership were used as benchmarks for the completeness criterion. Any preliminary plan with identified HTRW, cultural, or property ownership concerns would require additional investigation and planning resources to address these concerns and would need to be reconsidered with respect to its potential for ecological benefits prior to advancement to more detailed analysis.

The effectiveness of an alternative plan is determined by how fully the plan achieves the objective. Preliminary plans that do not achieve the planning objectives were not advanced to more detailed analysis. The efficiency criterion assesses whether the plan achieves the objective at a reasonable cost and includes a preliminary assessment of whether the objective can be achieved by a less costly plan. Preliminary plans that require unreasonably intensive use of resources or that appear to be far more costly than other alternative plans that achieve the same objective may not be advanced in the planning process. The acceptability criterion is used to identify community, property owner, and regulatory agency support or concern for the plan. Preliminary plans that did not have community or property owner support or that raised significant concern by a regulatory agency would need to be reconsidered prior to advancement to more detailed analysis.

4.2.5 Sites Not Receiving Further Consideration

Site 2: Tidal/Freshwater Wetland Restoration – Upper Flushing Creek

During the time that restoration opportunities were being first identified, the NYC Parks was formulating a master plan for Flushing Meadows-Corona Park. NYC Parks expressed interest in the feasibility of restoring tidal and freshwater wetlands along Flushing Creek. This alternative considers improvements to tidal flushing in the upper portion of Flushing Creek enlarging the connection to Lower Flushing Creek. This would be accomplished through modification of the culverts under the railroad bridge and tidal gates at Porpoise Bridge near northern end of Flushing Meadows-Corona Park.

Opportunities exist along both banks of the stream to restore and widen low and high marsh communities into and through the golf area. The project would include excavation, grading, selective filling, planting of low and high marsh, and planting of native upland trees and shrubs species. Wetland restoration opportunities in Flushing Meadows-Corona Park would displace very intensively used recreational areas such as picnic grounds, soccer fields, and areas of the golf course. The loss of highly valued and heavily used recreation land areas likely will be opposed by the community.

Further complicating this restoration alternative is the uncertainty of future plans for the park. Alternative plans were being developed that would convert much of Flushing Meadows-Corona park into a venue for future Olympic Games (See www.Nyc2012.com for a description of venues tentatively planned for Flushing Meadows-Corona Park). Although New York City was not selected as the site of the 2012 Olympics, this alternative was dropped from consideration because of the intensity of existing use and the uncertainty of alternative future uses.

Site 3: Reconstruction and Daylighting of Flushing Creek

This project includes wetland restoration by lowering the grade of the presently ruderal fill area. The project area is located just south of Tallman Island Waste Water Treatment Plant. Elevations would be developed to support low and high tidal marsh, and with planting graded uplands with native trees and shrubs. The project area can continue south and link with the tidal wetlands restoration project recently constructed by the NYC Parks in Powell's Cove Park. This project would double existing tidal marsh acreage up to 3.2 acres of tidal marsh, extend tidal shoreline, and restore about 1.6 acres of transitional and upland woody habitat.

Tidal wetland restoration and upland woody habitat restoration at this location are complicated by the real estate requirements of the restoration and lack of non-federal sponsor support in potential restoration of this area. Potential restoration of this area was not carried forward to more detailed analysis.

Site 4: Wetland Restoration and Rehabilitation at Willow Lake

Willow Lake is presently managed as a minimal public access nature preserve. Formerly part of the World's Fair grounds, the lake and its environs have been allowed to proceed through natural successional processes to its present low feral state. Wetlands have accrued on former paved areas and in abandoned pools. Much of the site is, however, dominated by ruderal herbaceous vegetation, scattered stands of wind propagated trees and shrubs and over grown decorative trees. An ecosystem restoration project would take the form of minor grading, removal of weedy vegetation (particularly common reed), the planting and seeding of native vegetation and construction of wildlife habitat structures such as bird, squirrel and wood duck boxes, bat houses, and osprey (*Pandion haliaetus*) perch. The restoration project would include design and construction of trails and signage for a nature interpretive program. This project could rehabilitate 20 acres of non-tidal isolated and lake shore wetlands and improve up to 30 acres of upland forest wildlife habitat.

This alternative was not considered further in the feasibility study because of the uncertainty concerning future plans for Olympic Games or other athletic venue development.

Site 5: Tidal/Freshwater Wetland Restoration at Meadow Lake

Flushing Creek and Meadow Lake would be restored to a more saline condition under a tidal wetland design. This would facilitate the reestablishment of marine and estuarine biotic communities into the formerly extensive tidal marsh. Improvements in circulation and the creation of conditions less suitable for freshwater algae infestation would be supported. A reduction in the goose problem would also be realized. The reconstructed channel connecting Flushing Creek to Meadow Lake would be designed to allow diurnal tidal cycling, with a maximized (sinuous) channel length. This would support the ability to accommodate tidal ebb and flow timing.

Under a freshwater wetland design, the limited wetland and buffer habitat restoration planned by the NYC Parks would be enhanced by the construction of approximately 20 acres of additional fringe wetlands, grading and planting of floating leaf aquatic plants, and restoration of deep and shallow water emergent marsh.

The effectiveness of restoration at Meadow Lake would require a buffer zone to protect fringing wetlands. The availability of land is very limited along the lake because picnicking regularly takes place right at the water’s edge. The expected strong community opposition to the loss of valuable and heavily used recreation land and the uncertainty concerning future plans for the park caused this alternative to be removed from further consideration.

Site 6: Tidal Wetland Restoration – Inner Flushing Bay

This restoration opportunity would involve rehabilitating the 1.81 acres of common reed high marsh to cordgrass low marsh and expanding the existing cordgrass and tidal mud flat areas. This project would require the placement of additional substrate material at elevations suitable to support low marsh and tidal shoreline. Fill materials could come from removal of the breakwater or from other dredging sites in the New York Harbor vicinity. Total wetlands restored and rehabilitated could be as much as six (6) acres of low marsh and another six (6) acres of new tidal shore mud flat, effectively increasing wetland coverage in the inner bay six-fold.

This potential restoration area is located at the outfall of three (3) CSOs (CSOs 1, 2, and 3). The success of this restoration opportunity would largely depend on the water quality impacts of these CSOs. Existing wetlands and mudflats in this area are highly degraded because of these CSOs. Restoration of additional wetlands and mudflats in this area would include the placement of clean material in the construction of additional wetlands and mudflats. The effects of the CSOs would degrade this material to a level equivalent with existing conditions. This degradation would occur over only a few years because these three (3) CSOs are not scheduled to receive abatement treatment similar to the abatement of overflow from CSO 4. The unabated outflow from CSOs 1, 2, and 3 make any wetland and mudflat restoration ineffective. Therefore restoration in the inner Flushing Bay was not considered for further detailed analysis.

Site 7: Breakwater Removal

Phase I and Phase II water and sediment quality modeling efforts have been conducted in order to identify the benefits of breakwater removal. The results of these modeling efforts were conclusive in that removal of the breakwater would not improve dissolved oxygen levels in the bay or creek nor would removal decrease the deposition of fine grained organic-rich sediments in inner Flushing Bay. After many model refinements, reviews and reassessments, the conclusion was that breakwater removal will not provide ecological benefits in terms of sediment or water quality improvement. It would return a small portion of bay bottom that the dike was built on but this too would suffer from poor water and sediment quality. Breakwater removal would be ineffective as a restoration activity. The breakwater removal was not carried forward into more detailed analysis.

Site 8: Tidal Wetland Restoration – College Point Northern Shoreline

This project would restore tidal low marsh, high marsh wetlands and tidal shoreline to several derelict sections of tidal shoreline between and possibly including some of Herman McNeil Park and the abandoned marina north of Powell's Cove Boulevard and 125th Street. This restoration area is located along the East River. This area periodically receives strong wind driven waves from Long Island Sound. Restoration activities would include placement of structures to reduce wave energy gradients. Restoration would require grading to improve circulation or increase tidal flushing of weed-dominated sections of high marsh, filling of some presently deeper areas and planting. This project area could restore up to six (6) acres of tidal marsh where there is currently less than one (1) acre, and about eight (8) acres of transitional and upland woody habitat. Wetland restoration in this area was removed from further consideration because of the need to place energy abatement structures in the bay and lack of non-federal interest.

Site 9: Tidal Wetland Restoration – Tallman Island Adjacent to Powell's Cove

This project includes wetland restoration by lowering the grade of the presently ruderal fill area. The project area is located just south of Tallman Island Waste Water Treatment Plant. Elevations would be developed to support low and high tidal marsh, and with planting graded uplands with native trees and shrubs. The project area can continue south and link with the tidal wetlands restoration project recently constructed by the NYC Parks in Powell's Cove Park. This project would double existing tidal marsh acreage up to 3.2 acres of tidal marsh, extend tidal shoreline, and restore about 1.6 acres of transitional and upland woody habitat.

Tidal wetland and upland woody habitat restoration at this location is complicated by the real estate requirements of the restoration and lack of non-federal sponsor support in potential restoration of this area. Potential restoration of this area was not carried forward to more detailed analysis.

Site 10: Tidal Wetland Restoration Alternatives – Western Shore of College Point

During reconnaissance two short stretches of beach/eroded headlands along the western side of College Point were considered for vegetative stabilization by the planting of low marsh vegetation. Investigations revealed that these sites face into the prevailing winds and are subjected to very high-energy storm-driven wave surges, due to the long, uninterrupted fetch to the west that precludes the natural establishment of low marsh. The establishment of vegetation in these locations would require the construction of breakwaters or jetties to reduce wave energy. The effectiveness of this site would be extremely limited without the construction of energy attenuation structures. These structures would greatly increase costs for the same small area of restored wetland. It was also assumed that the construction of hardened structures in the bay would not be accepted by the public, given the public's desire for removal of the existing breakwater.

Also on the western side of College Point two areas located between steeply sloped headlands created by the accumulation of construction and demolition fill were considered for restoration. This area is 15 acres of fill, rubble, scrub brush, low trees and ruderal vegetation that was considered for restoration and rehabilitation as forest, low marsh, and tidal shore mud flats. Since the reconnaissance study, the area surrounding these sites has undergone preliminary excavations for residential development. The configuration of the steeply sloped banks would require landward excavation to establish a grade suitable for tidal wetlands. With residential development underway, an opportunity for landward excavation no longer exists. Tidal wetland restoration at these sites would not be effective and is assumed to not be acceptable to the landowner. This restoration activity was removed from further consideration.

Streambank restoration, site cleanup, and debris removal are measures associated with potential wetland restoration sites along the west side of the College Point shoreline. Wetland restoration at this location is not being carried forward for more detailed analysis in the feasibility study. Small areas of one (1) acre or less, identified for site cleanup and debris removal along the shoreline, are being used as illegal dumping areas where household and construction debris have been deposited. Feasibility level analysis of these sites indicates that limited ecological significance is associated with these measures at the west side of College Point and that the completeness of these actions would require measures to maintain site cleanliness and to prevent debris placement. These sites were not carried forward for more detailed feasibility level analysis.

During initial feasibility level investigations of freshwater wetland restoration potential at the former Flushing Airport, the property owner and potential non-federal partner for construction, New York City Economic Development Corporation, formally requested the USACE to initiate an ecosystem restoration study of the former Flushing Airport pursuant to Section 206 of the WRDA of 1996. In a letter dated August 1, 2009, the USACE informed the New York City Economic Development Corporation of its intention to initiate the requested study under that authority. For this reason, this site was removed from the feasibility study. Ultimately, this 206 study was never pursued.

<u>Site 11: Reorientation of the Federal Navigation Channel</u>

The hydrodynamic model (RMA-10), which had been previously calibrated and verified for work being conducted by NYCDEP, was used to produce the transport data for the water quality model (RMA-11). The water quality model calibration was performed in two stages. The first stage is the calibration of the constituents that primarily affect hydrogen sulfide flux. The second stage is the calibration of dissolved oxygen and the other water quality constituents that primarily affect dissolved oxygen. Model development, calibration, and verification has been reviewed and approved by the Waterways Experiment Station.

Model results indicate that dredging or widening the existing navigation channels to improve circulation will increase the transfer of East River water into the inner bay. Although Flushing Bay and Creek exhibit low levels of dissolved oxygen, improvements to bay and creek dissolved oxygen levels due to the effects of the CSO holding tank to be completed in 2004 will raise bay and creek dissolved oxygen levels above East River dissolved oxygen levels. Expanding the channel would be counter-productive to improving dissolved oxygen levels in the inner bay because future without-project condition dissolved oxygen levels in the bay are better than future without-project condition dissolved oxygen levels in the East River. Channel expansion would increase tidal flushing but would decrease dissolved oxygen levels in the inner bay. Dredging or widening the navigation channel was not recommended for further consideration.

4.2.6 Sites Recommended for Full Feasibility Analysis

The following ecosystem restoration opportunities are discrete projects that could be designed and constructed independently, with independent value. The cumulative ecosystem benefits could exceed the individual project benefits if they were implemented as part of a single project or as part of a sequential set of linked projects. When possible, projects would be linked to existing parks and natural areas to enhance connectivity of habitats along the water and land interface in the New York metropolitan area.

Site 1: Tidal Wetland Restoration – Lower Flushing Creek

This site would include restoration and rehabilitation activities designed to widen the existing low tidal marsh and high tidal marsh, by lowering the grade through the presently common reed-dominated high marsh wetlands and adjacent ruderal uplands. The site for this restoration project includes sections of the left descending bank of Flushing Creek between the Van Wyck Expressway (Route 678) crossing at the mouth, to the tidal gates at Porpoise Bridge beyond the New York City Transit Authority yard and rail crossing. An opportunity exists here to restore about 6.5 acres of low tidal marsh where currently scattered areas total about one (1) acre, and to restore forest along 2,000 linear feet of the creek. This restoration opportunity has been included in plan formulation for more detailed analysis.

Site 12: Dredging in the Inner Bay and Flushing Creek

Dredging selected areas of the inner bay and creek, including removal of the top two (2) to eight (8) feet of sediments, coupled with replacement of clean sediments (possibly beneficial use of dredged material), would reduce concentrations of total organic carbon in the sediments and improve substrate quality. Reductions in concentrations of total organic carbon would increase benthic diversity. The dredging alternative could also include re-contouring the bay bottom in the vicinity of high velocity CSO discharges to reduce localized scouring, turbidity, and the conveyance of sediments downstream. Coarse substrate materials could be used to attract fish into the inner bay and creek.

An analysis of future CSO loadings would be required to determine the best areas to dredge and cap in order to maximize the duration of improvements, before concentrations of total organic carbon revert to baseline levels. An assessment of the beneficial impacts from other planned water and sediment quality improvements in the study area and in the East River will be conducted to determine the expected duration of sediment improvements. This restoration opportunity has been included in plan formulation for more detailed analysis.

4.2.7 Source Study Alternative Formulation

Alternatives for restoration focused on combinations of the two sites above: Site #12: Flushing Creek Dredging and Site #1: Tidal Wetland Restoration at Lower Flushing Creek. The project area is located between the LIRR and the IRTRR. The wetland areas adjacent to this reach are of a disturbed nature and are dominated by common reed, field horsetail, chicory, common plantain with a trace of glasswort (*Salicornia*) and mugwort (*Artemisia vulgaris*) within the upper tidal and upland areas. A native shrub marsh elder is present in the high tide to spring tide range. The native salt marsh cordgrass is also present along a narrow band in places that range from one (1) to 20 feet wide.

The estuarine environment of the project area consists of the tidal habitats of Flushing Bay and Creek, adjacent tidal marsh wetlands, and mudflats. In the low marsh area, the upper 50 percent of the inter-tidal zone adjacent to open water and mudflats, salt marsh cordgrass would typically be present. Within the tidal zone from mean high tide to the spring tide elevation, salt grass and salt marsh hay would be present. In most of these marsh areas, the invasive common reed is the dominant species. Common reed is displacing most of the native high marsh vegetation. The majority of non-wetland environments in the bay and project vicinity are highly disturbed, urban settings. Areas not currently occupied by buildings, other structures or paved surfaces are generally weed-dominated fill materials. While most such areas are sparsely vegetated with low herbaceous weeds, some untended areas have begun to succeed to shrubs and trees. No threatened or endangered species are known to inhabit the study area.

4.2.8 “Source” Study Restoration Plan Alternatives

Alternatives were developed that focused on variations of Flushing Creek dredging, capping, and adjacent habitat restoration within the riparian, tidal wetland, and benthic zones of the project area. The specific project area was located between the LIRR and the IRTRR. Additional evaluation indicated that alternatives that included Flushing Creek dredging were too costly and would not be considered cost effective given high costs and limited quantified benefits to benthic invertebrates and aquatic communities. The Tentatively Selected Plan (TSP) from the “Source” study is presented in Figure D4-7. This TSP alternative was not supported by NYCDEP at the time (2007). NYCDEP had wanted the USACE to include additional environmental dredging activities in coordination with NYCDEP’s own environmental dredging activities and Long Term Control Plan.

The USACE evaluated subsequent opportunities to integrate additional dredging into the restoration plans; however, the dredging measures were no longer considered due to cost. Progress was then suspended due to lack of funding, and the study was inactivated for approximately six years.

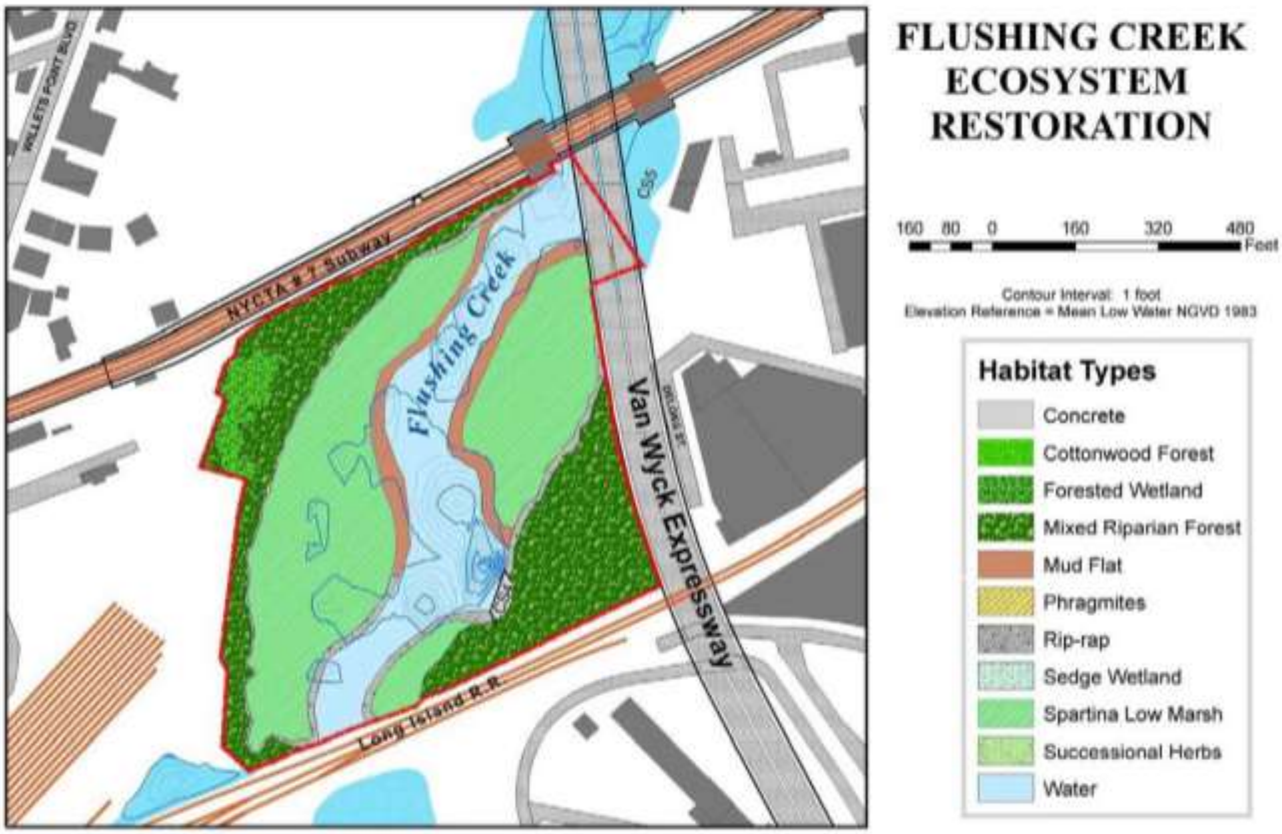

Figure D4- 7. Flushing Creek Tentatively Selected Plan (2007)

4.3 HRE Reevaluation of Restoration Plan Identified in the "Source" Study

The Flushing Creek "Source" study was then subsequently rolled into the HRE Feasibility Study in 2013. The selected plan identified in the "Source" study was reevaluated and optimized as part of the HRE Feasibility Study. Given the high costs of environmental dredging, in 2018 NYCDEP decided not to advance the environmental dredging activities in Flushing Creek. Previously, they had agreed to bear 100 percent of the dredging costs. Once this decision was made, the alternatives needed to be reformulated, since the prior alternatives had all included NYCDEP dredging occurring in tandem with the USACE tidal wetland restoration.

At this time, additional field investigations were conducted by NYCDEP in an area of approximately 17.36 acres between the Roosevelt Avenue Bridge to the north, LIRR bridge to the south and the Van Wyck Expressway to the east. NYCDEP also investigated adjacent areas along Flushing Creek.

4.3.1 Existing and Future Without Project Conditions

The Flushing Creek project site is located in a highly urbanized area in Queens County, New York. In preparation for the World's Fair in 1939, there was significant stream straightening, filling of wetland areas, and headwater reconfiguration of Flushing Creek. Continued development in the area is leading to loss and degradation of tidal wetlands. Remaining wetlands are dominated by invasive species and limited to fringe areas. Currently, the site has low ecological value suffering from bank erosion, profusion of invasive species, low benthic and fish abundance and diversity, and poor water quality. Baseline conditions of fish, benthic invertebrates and vegetation communities as well as Evaluation of Planned Wetlands (EPW) (Benefits Appendix) within the project area were surveyed in 2012 through 2014 by NYCDEP (NYCDEP, 2014).

<u>Fish and Benthos</u>

A benthic and fisheries sampling program was conducted during fall 2012 and spring 2013 to determine the nature of the existing communities within the proposed restoration area. This sampling effort was intended to provide an assessment of overall habitat quality. The sampling design and methods were carried out in accordance with a benthic and fisheries sampling work plan approved by NYSDEC in October 2012.

This study compared benthic communities between intertidal and subtidal habitats at the proposed project and reference locations, and revealed few marked differences in abundance or other community parameters. The invertebrate communities were dominated by common, widely-distributed, pollution-tolerant marine annelids.

The fisheries sampling program represented a unique assessment of the current finfish community inhabiting the upper reaches of Flushing Creek and generally confirmed that the fisheries resources within Flushing Creek are somewhat limited in species diversity and abundance when compared to the nearby larger and more complex East River and Hudson River estuaries. Over the course of the fall 2012 and spring 2013 surveys, 477 finfish representing 12 different species and 31 blue crabs were collected. The most commonly collected species were typical estuary inhabitants and included mummichog (*Fundulus heteroclitus*) at 62.5 percent of the total collection, Atlantic silverside (*Menidia menidia*) at 14.9 percent, gizzard shad (*Dorosoma cepedianum*) at 10.7 percent, and Atlantic menhaden (*Brevoortia tyrannus*) at 8.6 percent. Mummichog, is ubiquitous among shallow estuarine habitats including open shorelines and is a species highly tolerant of low dissolved oxygen conditions.

<u>Wetland Habitat</u>

Intertidal and non-tidal wetlands within the Flushing Creek project area were delineated in October and November in 2013. Four (4) distinct wetland communities (vegetated intertidal wetlands, intertidal mudflats, ephemeral pond, and subtidal shallows) and one (1) upland community (maritime forest) were identified in the proposed project area. Existing conditions are presented in Figure D4-8.

The vegetated intertidal wetlands consisted of common reed and saltmarsh cordgrass; the cordgrass typically being found in the lower portion of the tidal regime and in depressions on the westerly side of Flushing Creek. The stands of saltmarsh cordgrass appeared to be healthy and vigorous, although about 90 percent of the vegetated wetlands were a very dense common reed monoculture. The intertidal mudflats consisted of silt, sand, cinders and gravel interspersed with very soft and deep organic sediments. Extensive mudflats are exposed at low tide along the easterly shoreline downgradient of the existing vegetated wetlands. These near-level areas dewater and flood very rapidly during the tidal cycle. A shallow ephemeral pond is located north of the LIRR tracks and west of Flushing Creek. The pond had no defined inlet or outlet and appears to be no more than two (2) feet deep at full pool. The pond apparently fills from sheet flow from the uplands to the west and north and the LIRR tracks to the south. The littoral zone/subtidal shallows consisted of the inundated portions of Flushing Creek within the project area and appeared to be less than six (6) feet in depth at MLW.

The maritime forest comprised the sparse to moderately dense forested upland areas on the west and easterly sides of Flushing Creek, respectively. The two forested areas appeared to be the result of natural colonization and not the result of any intentional planting or landscaping. The forested area on the easterly side of Flushing Creek featured a moderately dense tree canopy and dense shrub cover in some areas. Dominant trees were honey locust (*Gleditsia triacanthos*), black cherry (*Prunus serotina*) and box elder (*Acer negundo*). Areas beneath the highway overpasses were sparsely vegetated with herbaceous weeds. The forested area on the westerly side of Flushing Creek consisted of a sparse canopy of small (less than six (6) inch diameter) black locust (*Robinia pseudoacacia*) and Eastern cottonwood (*Populus deltoides*) trees with a mugwort and common reed herbaceous layer. Many of the cottonwood saplings and small trees were dead or had extensive dieback of the major branches. This forested area provides sparse cover and a very limited food supply for wildlife.

<u>Sustainability</u>

NYCDEP conducted an assessment of the sustainability of the proposed project from the perspective of the rate of future discharges of solids and contaminants to the creek. A fine grid hydrodynamic model of Flushing Creek in the area upstream of Northern Boulevard was developed to assist in the sustainability evaluation. The model is capable of calculating bottom shear stresses, which are the forces that determine the ultimate fate of CSO solids within Flushing Creek. The model was tested and evaluations considered the following inputs including:

- Historical contaminants in Flushing Creek sediments and historical levels of contaminants being treated at city wastewater treatment plants;
- The impact of facilities recently constructed to reduce CSOs; and
- Future facilities planned to further reduce CSOs.

As presented in Attachment B, the findings of this assessment are that current and future anticipated discharges to the creek tend to favor sustainability; i.e., that contaminated sediment mounds are not likely to form. In addition, the NYCDEP water quality improvements, green infrastructure and environmental dredging that has been completed and planned will ensure the sustainability of the proposed ecosystem restoration.

Future Without Project Conditions

The future without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis. In the absence of federal action, it is anticipated that the degraded condition of the study area ecosystem will continue into the future. Non-federal improvements include water quality improvements associated with the operation of the CS4 retention facility and the New York City waterfront zoning laws that cover 36 acres of Flushing waterfront. The zoning change requires waterfront access and waterfront viewing corridors. These planned improvements, including those in the Brownfield Opportunity Area, may have an effect on ecosystem restoration resulting in improved water quality and revitalization of the area. NYCDEP also planned (2013-2018) to conduct environmental dredging as part of their Long Term Control Plan improving the bathymetry, hydrology and sediment quality of the creek adjacent the site. Without restoration within this area, invasive species, degraded habitat and poor benthic and wildlife habitat would persist.

Figure D4- 8. Flushing Creek – Existing Conditions

4.3.2 HRE Alternatives Development

Three (3) additional restoration alternatives were then developed based on the Target Ecosystem Characteristics and restoration measures presented in Chapter 1 of the Appendix. The first set of alternatives developed under HRE were based on the FWOP assumptions (during 2013-2018) that NYCDEP would environmentally dredge the creek adjacent to the restoration site. In 2018, following the release of the draft FR/EA, NYCDEP indicated their agency no longer had plans to conduct dredging in the creek. Given the change in Future Without Project Conditions, the HRE alternatives were re-formulated with the assumption that no dredging would occur in the future without project conditions. The three (3) new reformulated alternatives are described below. Ecological benefits were quantified (Benefits Appendix), costs were prepared (Appendix I), and Cost Effectiveness and Incremental Cost Analysis (CE/ICA) (Appendix J) were conducted for each Alternative presented below. The Engineering Appendix includes the Relative Sea Level Change Analysis (RSLC) for each alternative using the intermediate sea level curve. The Recommended Plan was also evaluated using low, intermediate and high sea level curves to ensure successful performance and sustainability of the plan.

Flushing Creek – Alternative 1

Alternative 1 (Figure D4-9) would restore a total of 9.77 acres of habitat through the restoration of low marsh (5.53 acres), high marsh (2.28 acres), scrub/shrub (1.1 acres), and maritime forest (1.02 acres). This is the smallest restoration footprint among the alternatives. See the Engineering Appendix for relative sea level change analysis at the intermediate sea level rise curve for this alternative.

Flushing Creek – Alternative 2 (Tentatively Selected Plan in the Draft Report)

Alternative 2 (Figure D4-10) would restore habitat through the restoration of low marsh (8.74 acres), high marsh (4.01 acres), scrub/shrub (1.5 acres), and maritime forest (2.43 acres) with a total habitat restoration of 16.68 acres. This is the medium sized alternative footprint of the three alternatives. See Engineering Appendix for relative sea level change analysis for the intermediate sea level curve for this alternative.

Flushing Creek – Alternative 3

Alternative 3 (Figure D4-11) is the largest of the three alternatives. The conceptual plan restores a total of 21.18 acres including low marsh (10.53 acres), high marsh (4.1 acres), scrub/shrub (2.1 acres) and maritime forest (4.5 acres). See Engineering Appendix for relative sea level change analysis for the intermediate sea level curve for this alternative.

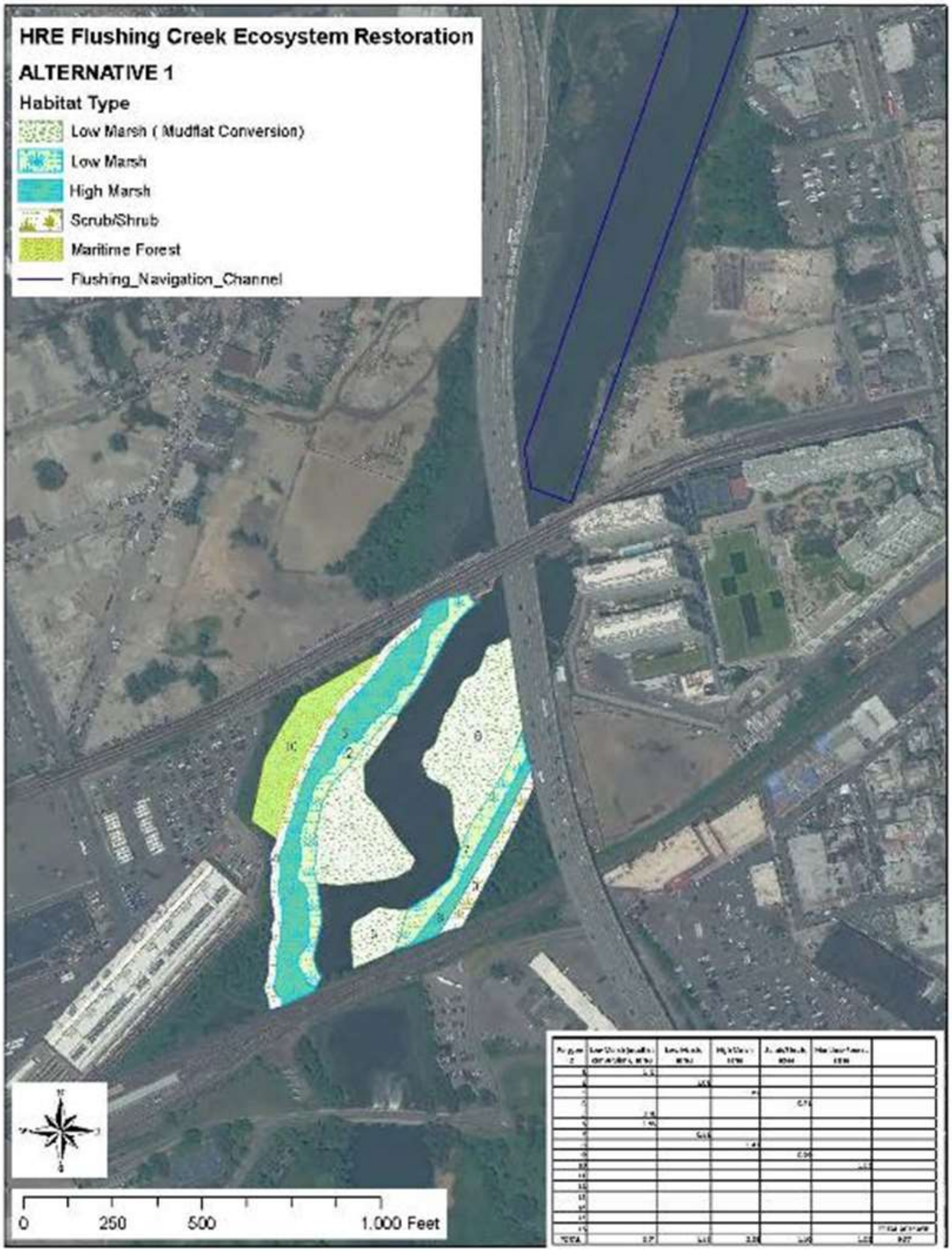

Figure D4- 9. Flushing Creek – Alternative 1

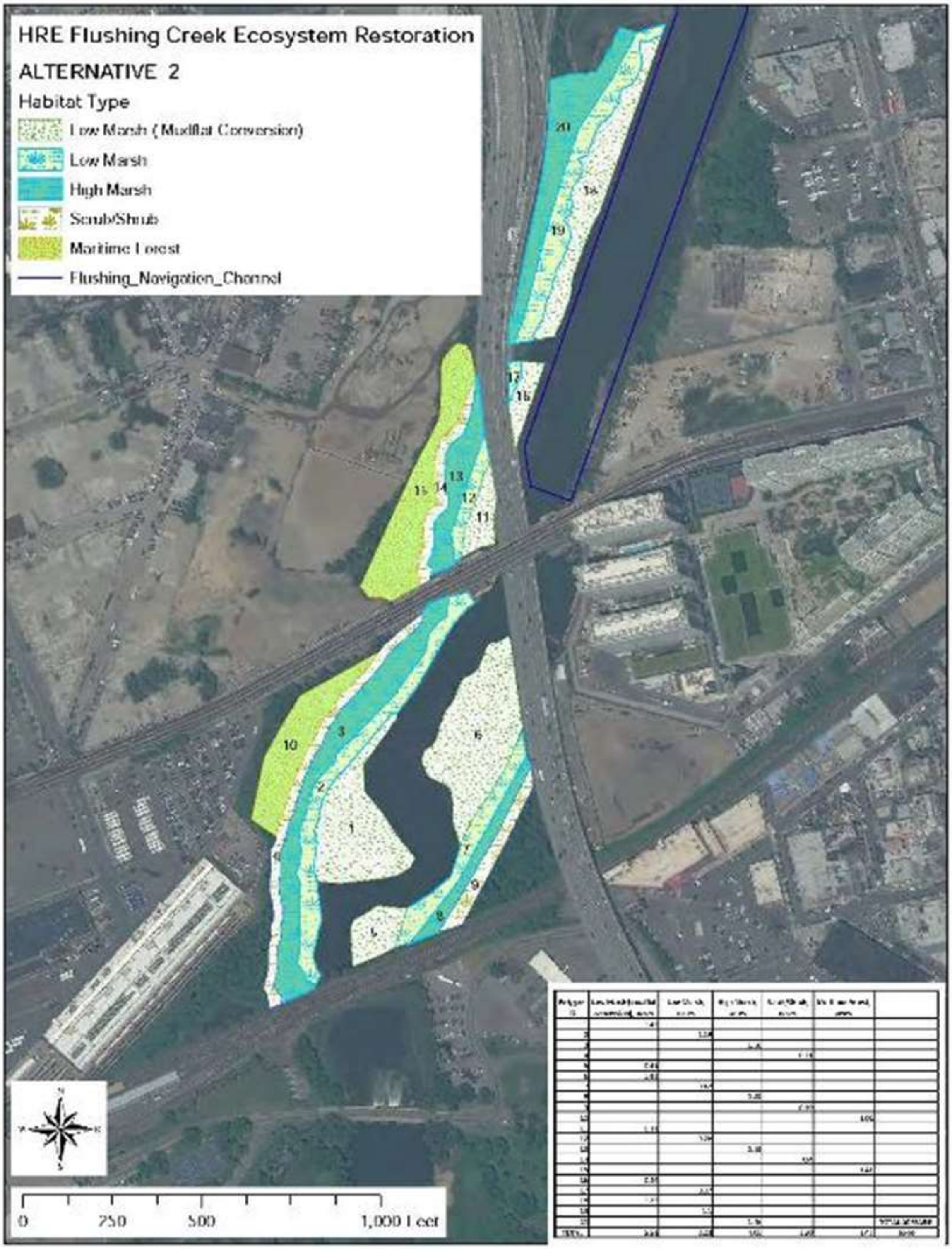

Figure D4- 10. Flushing Creek – Alternative 2

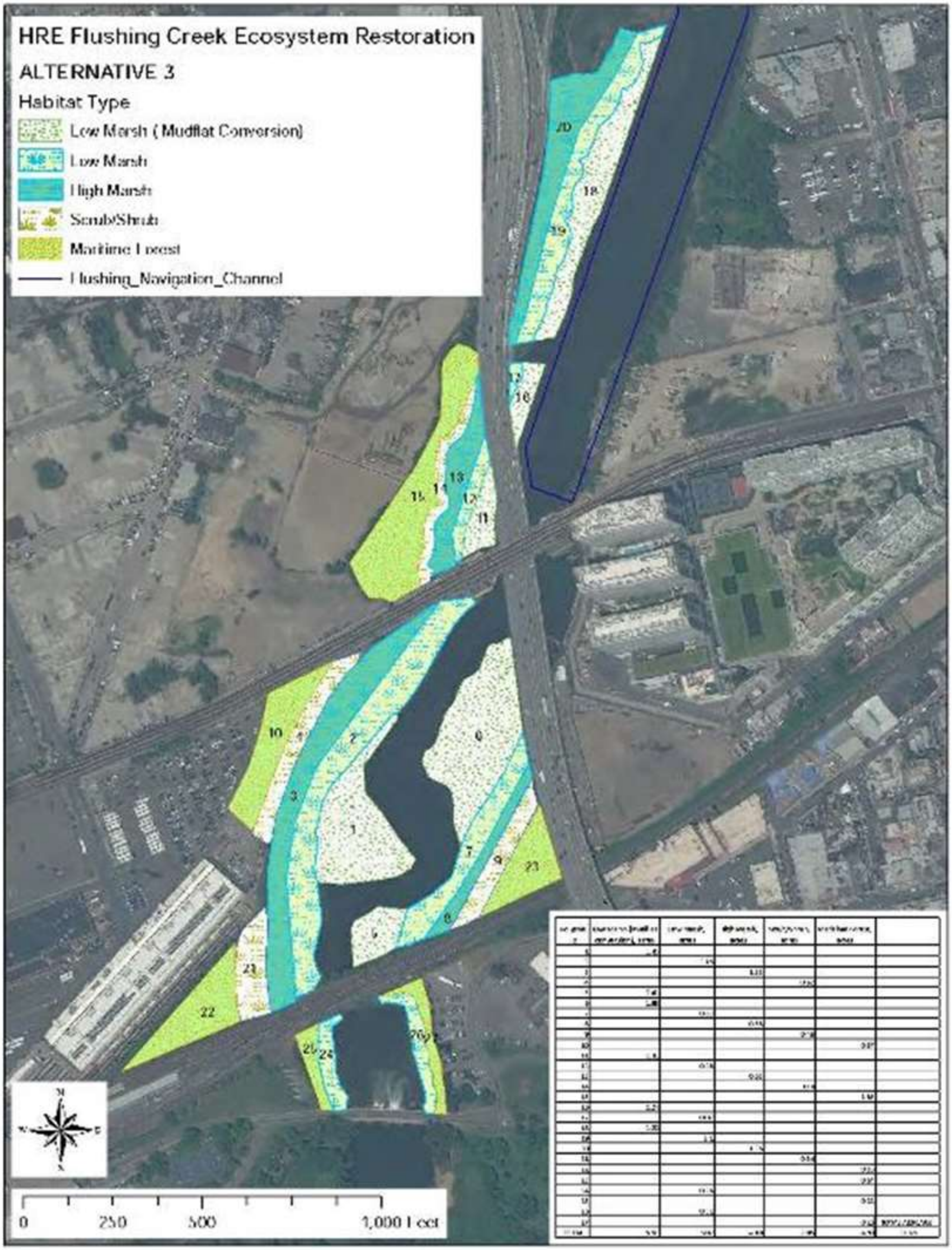

Figure D4- 11. Flushing Creek – Alternative 3

Flushing Creek – Recommended Plan

The recommend plan is the optimized design based on Alternative 2 (Figure D4-12). The optimized recommended plan includes regrading existing common reed-dominated marsh as well as conversion of existing mudflat areas to low marsh. High marsh and scrub shrub area will be established in the transitional zones between low marsh and upland maritime forest. The existing upland forest will be restored to a more diverse and functional maritime forest community. Much of the low marsh restoration is achieved through the conversion of select areas of intra-tidal mudflats, a nuisance source of hydrogen sulfide gas, by the placement of clean growing media to the low marsh design elevations

In total 39,015 CY of excavation will take place throughout the site with 12,200 CY to be taken off site and 26,815 CY to be beneficially re-used onsite to restore upland habitat. Invasives (*Phragmites*) would be removed along with 1-foot of root mat and would be placed off-site. Other invasive species may be smothered or left on site in riparian area if not part of active restoration actions. Material excavated to restore wetlands will be kept on-site and placed in upland and/or adjacent areas as needed. Cover requirements including 2-feet of cover in upland/riparian areas and 1-foot cover in wetland areas. In total this design will restore 9.76 acres of low marsh (3.25 acres low marsh restoration and 6.51 acres of mudflat to low marsh conversion), 2.47 acres of high marsh, and 1.8 acres of scrub/ shrub, and 3.89 acres of maritime forest. Additionally, approximately 1.37 acres of shallow water habitat will be restored along the low marsh. The Engineering Appendix includes the grading and planting plans for the Recommended NER Plan.

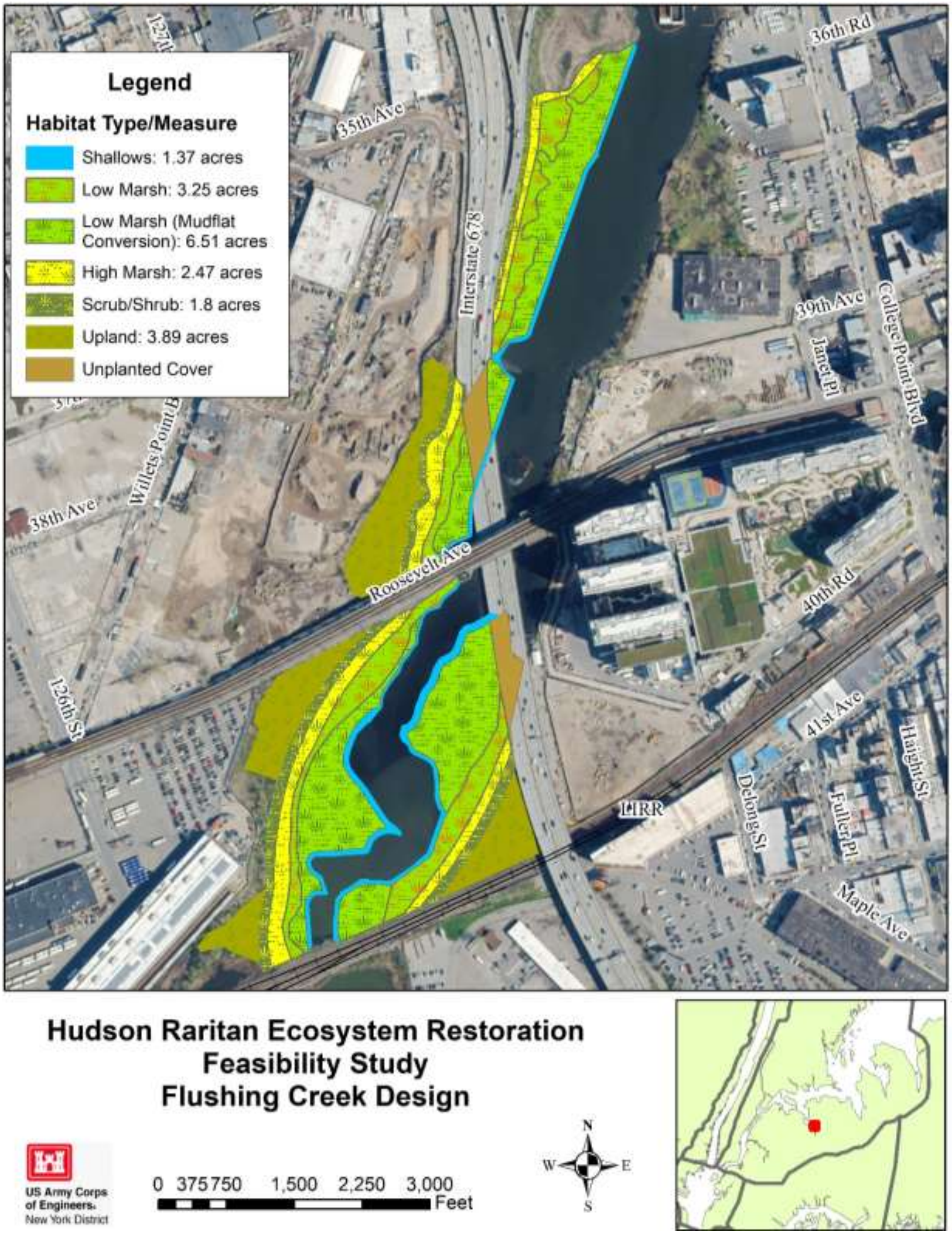

Figure D4- 12. Flushing Creek – Recommended Plan

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 5: Bronx River

Final Integrated Feasibility Report & Environmental Assessment

April 2020

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

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5. Bronx River

The Bronx River flows through suburban and highly urban communities in the Bronx and Westchester Counties, running through numerous parks and parallels and intersects the Bronx River Parkway and the Metro North Harlem commuter rail line. In the past, the Bronx River had a complex ecosystem, but due to industrialization, an upstream dam, channel modification, filling of wetlands, runoff from roadways, and other anthropogenic perturbations, the river ecosystem has depreciated over time. Water quality and aquatic life have suffered from impacts due to dams, pollution and urban development.

The Bronx River Ecosystem Restoration Feasibility "Source" Study conducted by the USACE, the New York City Department of Environmental Protection (NYCDEP) and the Westchester County Planning Department and other partner activities (New York City Parks [NYC Parks], Bronx River Alliance, other academic and private entities) have documented the river's degradation and need for restoration. The Bronx River Feasibility Study identified a total of 350 restoration opportunities (USACE, 2007), evaluated the sites and screened the sites to determine a focused array of 9 sites. These 9 sites were identified as the Tentatively Selected Plan during 2017 and were further analyzed resulting in five (5) sites included in the Recommended Plan. See Appendix J for the Cost Effectiveness and Incremental Cost Analysis (CE/ICA) process to arrive at the sites included within the Recommended Plan. This chapter presents the results of the "source" study including the site screening and alternative development of each site.

5.1. Project Area Context

The Bronx River is 23 miles long, flowing through both suburban and highly urban communities in the Bronx and Westchester Counties. The majority of the river is fresh water, with tidal influences in the most downstream section of the river where it exchanges flow with the East River and the Long Island Sound.

Review of the 1891 and 1892 United States Geological Quadrangles that cover the project area[1] show that the Bronx River north of the Bronx Zoo had a sinuous morphology in a narrow valley and a complex ecosystem of marshes, wetlands, and upland habitat[2]. As described in the Geotechnical and Geological Report in Engineering Appendix C, the natural narrowness of the riverbed is due to existing bedrock.

Centered in a densely populated region and with a long history of industrialization, the Bronx River has been significantly altered and disturbed over the past 200 years. Historic upstream damming, which includes an earthen/gravel dam built in 1885 and the larger Kensico Dam completed in 1917, reduced water flows, causing a narrower normal flow channel with a smaller cross section than existed historically. From 1907 to 1925, efforts were made to clean up the

1 United States Geological Service, 1891, Harlem NY-NJ 15 minute topographic quadrangle map & United States Geological Service, 1892, Tarrytown, NY-NJ 15 minute topographic quadrangle map.
2 Crimmens, Teresa (Bronx River Alliance) & Larson, Marit (City of New York Parks & Recreation, Natural Resources Group, June 2006, Bronx River Alliance Ecological Restoration and Management Plan, Bronx River Alliance, Bronx, New York.

Bronx River from the Bronx Zoological Gardens to the Kensico Dam and resculpt the surrounding lands to create the Bronx River Parkway Reservation, a linear park along a limited access roadway. These efforts, as well as the 1905 building of a sewage trunk line and removal of buildings and dumps along the river, greatly reduced inputs of human sewage in the river. However, other work, including dredging and rechanneling the river to remove stagnant pools and increase flow and draining and filling of adjacent wetlands and marshes, impacted the river's natural historic ecology.

Subsequent to 1925, the Bronx River Parkway was widened and straightened and the already narrow valley was further narrowed by the development of adjacent roadways. The riverbanks were also lined with rock and concrete to aid in straightening the river to match the lines of nearby highways and railroads, reducing natural shoreline habitat. The parkway reservation north of Bronxville has retained much of its original parkland and is listed in National Register of Historic Places, while the parkland south of Bronxville has decreased.

Although some fragments of open space and forest still exist within the river corridor, most of the lower Bronx River watershed has been urbanized, channels straightened, streambanks altered and armored, and surrounding undisturbed habitat developed, such that the river's riffle-pool complex is inconsistent and interrupted. Increased development, non-point source pollution, combined sewer overflow (CSO) discharges, invasive species, excessive runoff, sediment, and road salt and sand have historically and continue to detrimentally affect the river's ecology. In many of the more urban sections of the river's watershed, impervious surfaces in the surrounding watershed exceed 70 percent of the land coverage, leading to excessive runoff and storm-related flooding conditions. The result is a river that rises and falls quickly because stormwater flows to it, not through the soil and tributaries, but through pipes that deliver polluted water directly from surrounding roads and roofs.

The Bronx River's ecosystem has been further impacted by existing dams (Appendix B) that alter water quality and impede fish passage, especially anadromous fish (e.g., alewife, etc.) that used to spawn in the river. However, despite being highly affected by pollution and urban development, the Bronx River and adjacent habitats support aquatic insects, fish, small mammals and diverse vegetation. A request letter was sent to the New York Natural Heritage Program (NYNHP) for known occurrences of threatened and endangered species within or near the project sites. Based on the correspondence with NYNHP, there are no recent records of threatened and endangered species at the project sites.

With respect to cultural resources, a 2015 study conducted by the USACE determined that the restoration measures have the potential to impact significant historic properties including historic and archaeological sites and standing structures identified throughout the Bronx River study area (e.g., historic dams, mill sites, pre-Contact archeological sites, etc.) that may be uncovered during excavation and grading activities. If eligible resources are encountered, and cannot be avoided by project plans, then a Memorandum of Agreement (MOA) between USACE, the State Historic Preservation Office (SHPO) and, possibly, the Advisory Council on Historic Preservation must be developed based on the results of the cultural resource studies conducted for the project and on project plans as they develop.

Since the 1970s, concerted efforts have been made by local community organizations and governmental agencies to improve and/or restore the river and its watershed. A variety of governmental agencies, including Westchester County, the City of New York, the New York State Attorney General, and the USACE, as well as non-governmental organizations, such as the Bronx River Alliance, are currently working on a variety of restoration projects on the river and in its surrounding neighborhoods. A list of these projects can be found in Appendix B, Prior Reports and Ongoing Restoration Efforts within the Hudson Raritan Estuary. The Bronx River Alliance Ecological Restoration and Management Plan[1] defines an appropriate restoration intent, stating:

> *…in the Bronx River corridor, landform features, stream morphology and vegetation patterns have been so heavily altered that most of the characteristics of a healthy river can never be completely restored. Instead, a more realistic objective is to increase the number and length of river reaches which meet the conditions of an ecologically functional river in order to create a system that is sustainable and resilient and that possesses desired ecosystem conditions.*

For this “source” study, the focus of the various restoration and stabilization measures was based on this objective, aiming for increased ecological health, stabilization, and secondary water quality improvements at each of the sites.

5.2. Site Screening

As part of the Bronx River Feasibility Study, studies were conducted in the Bronx River to identify and evaluate the water resources problems, needs and opportunities that would support environmental restoration, and an aquatic wetland habitat necessary for a healthy Bronx River Basin ecosystem. The *Bronx River Basin, New York. Ecosystem Restoration Study Watershed Opportunities Report* (USACE, 2010) summarizes the baseline conditions in the basin and identifies 350 restoration opportunities through the development and use of Geographic Information System (GIS) analysis. The GIS analysis integrated data collected from multiple sources in a spatial form that enabled the USACE and project sponsors to justify and prioritize restoration sites and activities. The opportunities identified via the GIS analysis show areas where those future strategies would provide for wetland and aquatic habitat; potential flood risk management; riparian wildlife habitat; stream channel shading and cooling for aquatic species; water quality improvement through nutrient and pollutant removal, and decrease in erosion or sedimentation (USACE, 2010).

The major environmental problems in the Bronx River Basin are extensive habitat loss and degradation, which have reduced the quantity, diversity, functional and structural integrity of the overall ecosystem, and its ability to provide valuable diverse and sustainable services, negatively affecting human health (USACE, 2010). Also, impacts to water quality are substantial along the entire length of the Bronx River. Industrial and residential sources of pollution have degraded water quality in the Bronx River for more than 100 years (USACE, 1999 as cited in USACE, 2010). Nutrient Loading, pathogens contamination, and sedimentation are major factors to lowering water quality. The 2010 report also identified previous biologic evaluations, hydrologic analyses, wetland assessments, and hazardous, toxic or radioactive waste (HTRW) evaluations.

The identification of 350 restoration opportunities was guided by: relevant Target Ecosystem Characteristics (TECs) developed as part of the Hudson Raritan Estuary Comprehensive Restoration Plan (USACE, 2016); data on habitat impairments (dams, contaminant hotspots); existing catalogues of restoration opportunities (as identified by Westchester County or the Bronx River Alliance); and available open spaces. Of these 350 sites, 23 were deemed to have Federal interest because of their potential for high value habitat restoration and water quality improvements (the latter being an auxiliary benefit from a USACE perspective) (Table D5-1), and were selected for further investigation in this study. Potential restoration measures at these 23 sites included:

- Excavation of historic fill to proper wetland elevations;
- Deposits of clean soil/sediment to provide healthy substrate for native flora & fauna;
- Excavation of hard structures to soften riverbanks;
- River bank restoration;
- Wet excavation to restore stream geomorphology;
- Placement of boulders to create riffles to restore stream geomorphology;
- Removal of invasive vegetation;
- Native plantings (wet meadows) to act as buffer for wetlands;
- Dam removal to restore fish passage;
- Culvert replacement to restore fish passage or improve hydrology;
- Fish ladders and rock ramps to restore fish passage;
- Installation of in-stream structures to redirect flow and recreate a more natural riverine channel in the northern portion of the site; and
- Installation of improved catch basins, sediment forebays, and vegetated swales to act as sediment traps at multiple point source locations.

Table D5- 1. Sites with Federal Interest.

23 Sites with Federal Interest			
River Park/West Farm Rapids Park	Bronx Zoo and Dam	Stone Mill Dam	Shoelace Park
Muskrat Cove	Bronxville Lake	Crestwood Lake	Garth Woods
Harney Road	Westchester County Center	Pond at Fisher Lane	Green Acres Pond
Old Yonkers Mill	Burke Ave Bridge	180th St. Dam and Area South	174th St./Starlight Park – east bank
172nd St. Weir	Bronx Queen / Abandoned Cement Plant	Hunts Point	Soundview Embayment
Soundview Park	Bronx Zoo South – Pond	Kensico Dam and Park	

5.2.1. First Screening

Once incorporated into HRE, the 23 sites were screened using one criteria, if the non-federal sponsor was willing to cost-share the project (Table D5-2). This round of screening removed 13 sites and left 10 sites to be moved forward to feasibility level analysis. The site screening process required sponsor support in order to advance the site further for detailed feasibility evaluation. The requirement of each site having a willing supportive sponsor was mandated and if a site was no longer supported by the non-federal sponsor, it was dropped from further consideration. Of these 23 sites, the local sponsors were consulted as to which of these sites should proceed further given the study funds remaining.

Table D5- 2. Screening Table of Bronx River Sites.

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
1	River Park/West Farm Rapids Park		
2	Bronx Zoo and Dam		
3	Stone Mill Dam		
4	Shoelace Park		
5	Muskrat Cove		
6	Bronxville Lake		
7	Crestwood Lake		
8	Garth Woods		
9	Harney Road		
10	Westchester County Center		
11	Pond at Fisher Lane		
12	Green Acres Pond		
13	Old Yonkers Mill		
14	Burke Ave Bridge		
15	180th St. Dam and area south		
16	174th St./Starlight Park-east bank		
17	172nd St. weir		
18	Bronx Queen / abandoned Cement Plant		
19	Hunts Point		
20	Soundview Embayment		
21	Soundview Park		
22	Bronx Zoo south – pond		
23	Kensico Dam and Park		
24	CSO HP-004		
25	CSO HP-007		
26	CSO HP-008		
27	CSO HP-009		
28	CSO HP-010		
29	Dam – 174th Street Weir		
30	Dam – 182nd Street Weir		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
31	Dam – Bronx Zoo Dam		
32	Dam – Bronxville Lake Dam		
33	Dam – Concrete Dam		
34	Dam – Crestwood Dam		
35	Dam – Harney Road Impoundment		
36	Dam – Hartsdale Dam		
37	Dam –Scarsdale Dam		
38	Dam –Snuff Mill Dam		
39	Hotspot – BRL-H1 Cross County Mall		
40	Hotspot – BRL-H2 Bubble Bath Auto Spa		
41	Hotspot – BRL-H3 Commercial Strip near West Lincoln Avenue and North 8th Street		
42	Hotspot – BRL-H4 Lincoln BBQ Restaurant		
43	Hotspot – BRM-H1 BAM's Gas Station		
44	Hotspot – BRM-H2 Eastchester Municipal Maintenance Yard		
45	Hotspot – BRM-H3 Garth Road Village		
46	Hotspot – BRM-H4 Freeman Industries on Marbledale Road		
47	Hotspot – BRM-H5 Tuckahoe Maintenance Yard on Marbledale Road		
48	Hotspot –BRM-H6		
49	Hotspot – BRM-H7		
50	Hotspot – BRM-H8 Bronx River Reservation Maintenance Facility		
51	Hotspot – BRU-H1 Aggregate Loading Operation on Lafayette Avenue		
52	Hotspot – BRU-H2		
53	Hotspot – BRU-H3		
54	Hotspot – BRU-H4		
55	Hotspot – DB-H1 Business along Railroad Avenue near Lakeview Avenue		
56	Hotspot – DB-H2 Grayrock Florist and Memorials		
57	Hotspot – DB-H3		
58	Hotspot – DB-H4 Westchester County DPW Grasslands Facility		
59	Hotspot – DB-H5		
60	Hotspot – FB-H1 Bed Bath & Beyond Shopping Center on Central Avenue		
61	Hotspot – FB-H2 Best Buy Shopping Center on Central Avenue		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
62	Hotspot – FB-H3 Gulf Gas on Central Avenue and Aqueduct Place		
63	Hotspot – FB-H4 Light Industrial Strip along Fulton Street		
64	Hotspot – GSB-H1 Sprain Brook Nursery		
65	Hotspot – GSB-H2		
66	Hotspot – GSB-H3		
67	Hotspot – GSB-H4		
68	Hotspot – GSB-H5 Sprain Brook Golf Course		
69	Hotspot – GSB-H6		
70	Hotspot – GSD-H1 City of Yonkers Salt Pile		
71	Hotspot – HB-H1		
72	Hotspot – HB-H2 Getty Gas Station on South Central Avenue		
73	Hotspot – HB-H3 Town of Greenburgh Fire Station on South Central Avenue		
74	Hotspot – MP-H1 Crossroads Plaza on Tarrytown Road		
75	Hotspot – MP-H2 Town of Greenburg Storage Yard on Stadium Road		
76	Hotspot – MP-H3		
77	Hotspot – MP-H4		
78	Hotspot – MP-H5 Gas Station at the Intersection of Tarrytown Road and Knollwood Road		
79	Hotspot – MP-H6 Elsmford Maintenance Facility		
80	Hotspot – SB-H1 City of Yonkers Water Works Building/Sign Shop		
81	Instream & Buffer BRL 1		
82	Instream & Buffer BRL 2		
83	Instream & Buffer BRM 1		
84	Instream & Buffer BRM 1B		
85	Instream & Buffer BRM 2		
86	Instream & Buffer BRM 3		
87	Instream & Buffer BRM 3B		
88	Instream & Buffer BRM 4		
89	Instream & Buffer BRU 1		
90	Instream & Buffer BRU 2		
91	Instream & Buffer BRU 3		
92	Instream & Buffer BRU 5		
93	Instream & Buffer BRU 7		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
94	Instream & Buffer BRU 8		
95	Instream & Buffer CB 1		
96	Instream & Buffer CB 2		
97	Instream & Buffer CB 3		
98	Instream & Buffer CB 4		
99	Instream & Buffer CB 5		
100	Instream & Buffer CB 6		
101	Instream & Buffer DB 2		
102	Instream & Buffer DB 3		
103	Instream & Buffer DB 4		
104	Instream & Buffer DB 5		
105	Instream & Buffer MP 11		
106	Instream & Buffer MP 12		
107	Instream & Buffer MP 17		
108	Instream & Buffer MP 2		
109	Instream & Buffer MP 3		
110	Instream & Buffer MP 4		
111	Instream & Buffer MP 5		
112	Instream & Buffer MP 6		
113	Instream & Buffer MP 8		
114	Instream & Buffer MP 9		
115	Instream & Buffer SB 12		
116	Instream & Buffer SB 14		
117	Instream & Buffer SB 15		
118	Instream & Buffer SB 16		
119	Instream & Buffer SB 17		
120	Instream & Buffer SB 18		
121	Instream & Buffer SB 2		
122	Instream & Buffer SB 22		
123	Instream & Buffer SB 23		
124	Instream & Buffer SB 24		
125	Instream & Buffer SB 25		
126	Instream & Buffer SB 3		
127	Instream & Buffer SB 4		
128	Instream & Buffer SB 6		
129	Instream & Buffer SB 7		
130	Instream & Buffer BRM 5		
131	Instream & Buffer BRU 6		
132	Instream & Buffer CB 7		
133	Instream & Buffer DB 1		
134	Instream & Buffer DB 6		
135	Instream & Buffer DB 7		
136	Instream & Buffer MP 1		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
137	Retrofit BRM-R1 Brewster Carter Apartments		
138	Retrofit BRM-R10 Scarsdale Village Hall		
139	Retrofit BRM-R11 Marbledale Vacant Lot		
140	Retrofit BRM-R12 Cross Country Parkway Cloverleaf		
141	Retrofit BRM-R13		
142	Retrofit BRM-R2 Lord & Taylor Shopping Center		
143	Retrofit BRM-R3 Lord and & Taylor Shopping Center		
144	Retrofit BRM-R4 Bronxville Train Station		
145	Retrofit BRM-R5 Immaculate conception Church & School		
146	Retrofit BRM-R6 Concordia College		
147	Retrofit BRM-R7 Pennington Grimes Elementary School		
148	Retrofit BRM-R8 Bronxville School		
149	Retrofit BRM-R9 Bronxville Library		
150	Retrofit CB-R1 Old Kensico Treatment Facilities		
151	Retrofit CB-R2 Legionnaires of Christ Conference Center		
152	Retrofit DB-01		
153	Retrofit FB-R1 TJ Maxx Center on Central Avenue		
154	Retrofit FB-R2 Bed, Bath & Beyond Shopping Center on Central Avenue		
155	Retrofit FB-R3 Large School Complex in Greenburgh		
156	Retrofit GSB-R1 Old Franks Nursery on Central Avenue		
157	Retrofit GSB-R2 Veterans Park North		
158	Retrofit GSB-R3 Veterans Park South (Eastside)		
159	Retrofit GSB-R4 Veterans Park South (Westside)		
160	Retrofit GSB-R5 Ridge Park		
161	Retrofit GSB-R6 Ardsley Park		
162	Retrofit GSB-R7 Old Macy's Distribution Center		
163	Retrofit GSB-R8 McDowell Park		
164	Retrofit GSB-R9 Sprain Brook Golf Course		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
165	Retrofit HB-R1 Hartsdale Train Station		
166	Retrofit HB-R2 Scarsdale Country Club		
167	Retrofit HB-R3 Greenburgh Nature Center		
168	Retrofit MP-R1 Crossroads Plaza on Tarrytown Road		
169	Retrofit MP-R2 Bed Bath & Beyond Shopping Center on Tarrytown Road		
170	Retrofit MP-R20 Westchester		
171	Retrofit MP-R3 Danon Corporate Offices on Hillside Avenue		
172	Retrofit MP-R4 Greenburgh Town Hall		
173	Retrofit MP-R5 Greenburgh Town Hall		
174	Retrofit MP-R6 Greenburgh Library		
175	Retrofit MP-R7 Greenburgh Housing Authority Building on Manhattan and Elm		
176	Retrofit SB-R1 City of Yonkers Water Works Building/Sign Shop		
177	Retrofit SB-R2 Yonkers Ice Rink		
178	Retrofit SB-R3 Toll Plaza on New York State Thruway		
179	Retrofit SB-R4 Sprain Brook Park–n-Ride		
180	Restoration Site-BRL-S1 Bronx River Lower		
181	Restoration Site-BRM-S2 Scout/Parkway Field		
182	Restoration Site-BRM-S3 East Chester		
183	Restoration Site-DB-S1 County DPW		
184	Restoration Site-DB-S2 Monument Co.		
185	Restoration Site-DB-S3 Valhalla Station		
186	Restoration Site-DB-S4 Rock Gym		
187	Restoration Site-DB-S5 Landscaping Business		
188	Restoration Site-MPB-S1 Old Tarrytown Park		
189	Restoration Site-MPB-S2 Knollwood Golf Course		
190	Outfall D10		
191	Outfall D11A		
192	Outfall D12		
193	Outfall D13		
194	Outfall D14		
195	Outfall D15		
196	Outfall D16		
197	Outfall D17		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
198	Outfall D18		
199	Outfall D19		
200	Outfall D20		
201	Outfall D23		
202	Outfall D30		
203	Outfall D31		
204	Outfall D45		
205	Outfall D58		
206	Outfall D6		
207	Outfall D63-64		
208	Outfall McLean		
209	Outfall STRO-10		
210	Outfall STRO-11		
211	Outfall STRO-12		
212	Outfall STRO-13		
213	Outfall STRO-14		
214	Outfall STRO-15		
215	Outfall STRO-16		
216	Outfall STRO-18		
217	Outfall STRO-19		
218	Outfall STRO-18		
219	Outfall STRO-21		
220	Outfall STRO-4		
221	Outfall STRO-5		
222	Outfall STRO-6		
223	Outfall STRO-7		
224	Outfall STRO-8		
225	Outfall STRO-9		
226	Outfall Yonkers Raceway		
227	Restoration Site 182nd St Dam		
228	Restoration Site 211th St		
229	Restoration Site 219th St in Shoelace Park		
230	Restoration Site BRAC		
231	Restoration Site Bronx River Drainage Basin		
232	Restoration Site Bronx River Forest		
233	Restoration Site Bronx Zoo Dam		
234	Restoration Site Bronx Zoo Dams and Ponds		
235	Restoration Site Bronx Zoo East Entrance		
236	Restoration Site Bronxville Land		
237	Restoration Site Between 233rd and Bronx River Parkway		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
238	Restoration Site Bronx River Park at 179th St		
239	Restoration Site Concrete Plant Park		
240	Restoration Site Crestwood Impoundment		
241	Restoration Site Drew Garden		
242	Restoration Site Fisher Lane Pond		
243	Restoration Site Fordham University		
244	Restoration Site Green Acres Pond		
245	Restoration Site Hugo NEU		
246	Restoration Site Lafayette Av Street End		
247	Restoration Site Metro North Rail Road NR 207th		
248	Restoration Site Muskrat Cove		
249	Restoration Site Old Yonkers Mills		
250	Restoration Site Pond North of Harney Road		
251	Restoration Site Ranaqua		
252	Restoration Site River Park at 108th Street		
253	Restoration Site Shoelace Park USACE		
254	Restoration Site Shoelace Park BRA		
255	Restoration Site Snuff Mill Dam/NYBG		
256	Restoration Site Soundview Park Upland		
257	Restoration Site Soundview Park Lagoons		
258	Restoration Site Soundview Park Reef Site		
259	Restoration Site Starlight Park		
260	Restoration Site Starlight Park and Weir System		
261	Restoration Site Westchester County Center		
262	Restoration Site Woodlawn		
263	Restoration Site YMPJ		
264	Pervious Area Closed Eastchester Ball Field		
265	Pervious Area Leewood Golf Course		
266	Pervious Area Eastchester Park		
267	Pervious Area Marbledale Vacant Lot		
268	Pervious Area Immaculate Conception Church/School		
269	Pervious Area Webb Park on Central Avenue		
270	Pervious Area Old Franks Nursery		
271	Pervious Area Veterans Park		
272	Pervious Area Our Lady of Perpetual Help		
273	Pervious Area Vacant Lot on Jackson Avenue		
274	Pervious Area Fern Cliff Cemetery		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
275	Pervious Area Old Macy's Distribution Center		
276	Pervious Area McDowell Park		
277	Pervious Area Vacant Lot at the intersection of Tarrytown Road and Dobbs Ferry Road		
278	Pervious Area Mohawk Camp and School on Old Tarrytown Road		
279	Pervious Area Greenburgh Housing Authority Complex on Manhattan Avenue		
280	Rail Station 233rd Street Station		
281	Rail Station Bronx Co. Embankments		
282	Rail Station Bronxville Station		
283	Rail Station Crestwood Station		
284	Rail Station Fleetwood Station		
285	Rail Station Hartsdale Station		
286	Rail Station Mt. Pleasant Station		
287	Rail Station Mt. Vernon W. Station		
288	Rail Station N. White Plains Station		
289	Rail Station Scarsdale Station		
290	Rail Station Tuckahoe Station		
291	Rail Station Valhalla Station		
292	Rail Station White Plains Station		
293	Wetland CB01		
294	Wetland CB02		
295	Wetland DB02		
296	Wetland DB04		
297	Wetland FB01		
298	Wetland GB01		
299	Wetland GB02		
300	Wetland GB04		
301	Wetland GD02		
302	Wetland HB02		
303	Wetland HB03		
304	Wetland KR03		
305	Wetland KR10		
306	Wetland KR11		
307	Wetland KR12		
308	Wetland KR14		
309	Wetland KR15		
310	Wetland KR19		
311	Wetland KR20		
312	Wetland KR23A		
313	Wetland KR23B		

#	Site Name	23 Sites Prioritized from "Source" Study	1st HRE Screening
314	Wetland KR23C		
315	Wetland KR24		
316	Wetland KR24A		
317	Wetland KR27		
318	Wetland KR28		
319	Wetland KR30		
320	Wetland KR30A		
321	Wetland KR31		
322	Wetland KR33		
323	Wetland KR36A		
324	Wetland KR36B		
325	Wetland KR37		
326	Wetland KR39A		
327	Wetland KR39B		
328	Wetland KR43		
329	Wetland KR45		
330	Wetland KR49		
331	Wetland KR55		
332	Wetland KR56		
333	Wetland KR61A		
334	Wetland KR61B		
335	Wetland KR61C		
336	Wetland LB01		
337	Wetland MB01A		
338	Wetland MB01B		
339	Wetland MB02		
340	Wetland MB04		
341	Wetland MB05		
342	Wetland MP02		
343	Wetland MP03		
344	Wetland SB01		
345	Wetland SB02A		
346	Wetland SB02B		
347	Wetland SB03		
348	Wetland SB05		
349	Wetland SB06		
350	Wetland SB08		

Note: Garth Woods and Harney Road sites were later combined into a single site.

Nine (9) sites were identified among the 23 that were among the priorities of the Non-federal sponsors (NYCDEP, NYC Parks and Westchester County) were evaluated further.

5.3. Site-Specific Existing Conditions and Future without Project Conditions

The existing and Future Without Project (FWOP) conditions at each site are included below (presented downstream to upstream).

5.3.1. River Park/West Farm Rapids Park

The River Park/West Farm Rapids Park site is located within a densely populated, urban area and is approximately 900 feet in length, bisected by 180th Street. The site is substantially affected by anthropogenic pressures. Uplands within the site consist of developed areas, an urban park, and woodlands. The woodlands are fragmented and offer limited, if any, habitat resources to organisms not adapted for an urban environment. The site's uplands are further impaired by garbage and stormwater runoff. Wetland resources on the site are extremely limited, occurring in a few very small pockets and sparsely vegetated.

Most of the shoreline of the river is armored, the armor consisting of vertical concrete debris/stone armoring or engineered walls constructed of tires and other man-made materials. Within the site, the river's benthic substrate largely consists of large pieces of concrete, bricks, other construction debris, and some boulders. Algae and anthropogenic debris are present throughout the river bed. Several large shaded pools occur and riffles are present on the north end of the site, immediately downstream of the dam. A fish ladder was recently constructed in 2015 to link the river upstream of the dam with the river on the River Park/West Farm Rapids Park site, downstream of the dam. Figure D5-1 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix. In the future without project condition, fish will continue to be able to go upstream thru the fish ladder constructed in 2015. Wetland area will continue to decrease as anthropogenic impacts (trash and storm water input) continue. Adjacent habitats will continue to be fragmented.

Figure D5- 1. Existing Conditions at River Park/West Farm Rapids Park.

5.3.2 Bronx Zoo and Dam

The project area is located adjacent to the Bronx Zoo in Bronx County, New York. The Bronx Zoo and Dam site is an over-widened channel that experiences stagnation and constricted flow. Within the Bronx Zoo and Dam site, the river flow is affected by a dam system consisting of two (2) dams abreast of each other, separated by a mid-stream island. These dams were evaluated and found to be National Register eligible in 2005.

The site has a specific spot on the Mitsubishi path on the east bank that discharges salt water into the river, especially during the spring melt. Upstream of the dams, the majority of the wetlands consist of narrow strips of emergent vegetation along the banks of the river. Downstream of the dam, wetlands are limited and consist of very small (approximately 10 square feet) discontinuous pockets of emergent vegetation adjacent to the shoreline.

Upstream of the dams, the uplands consist of lawns and a thin wooded strip along the shoreline that is impacted by heavy vine growth and dense patches of Japanese knotweed. An upland island also exists upstream of the dams and vegetated mostly by invasive species, splits the river into two (2) channels that rejoin between the two (2) dams. The west bank of the upstream portion of the river is mostly armored and directly adjacent to a zoo enclosure; the east bank is fairly steep and lightly vegetated, with bare areas.

Downstream of the dams, the upland areas comprise deciduous woodlands that, on the west bank, are limited to a width of fewer than 20 feet, whereas the woodlands extend for approximately 150 feet on the east side. This site provides low to moderate fish and wildlife habitats as their small size and anthropogenic impacts limit the value of these habitats. Upstream of the dam, the waterbody is broad and shallow with nutrient-laden inputs from the zoo. The dams at the Bronx Zoo present a barrier to fish movements. Removal of these stressors would result in immediate improvements to water quality and would allow for fish, especially anadromous and catadromous species to access greater portions of the Bronx River. Figure D5-2 depicts existing conditions as observed in 2016 during EPW field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, Japanese knotweed will spread from the upland areas of this site. Fish passage will continue to be blocked by the Bronx Zoo Dam. Water quality will continue to be negatively impacted from runoff from the Bronx Zoo.

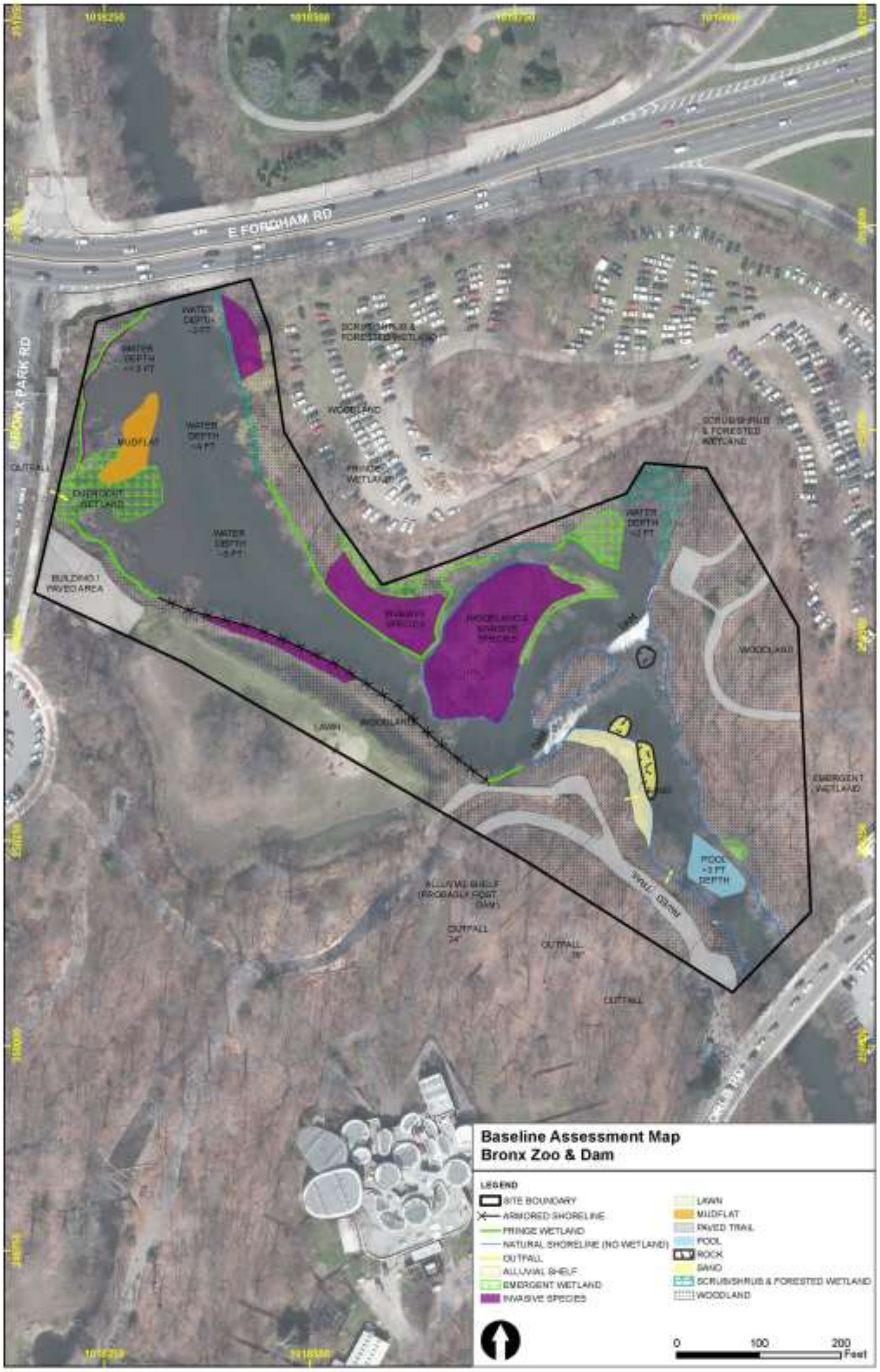

Figure D5- 2. Existing conditions at Bronx Zoo and Dam.

5.3.3 Stone Mill Dam

The project area is within a steep valley in the New York Botanical Garden in Bronx County, New York, which is a National Historic Landmark. The site has wooded side slopes, with grades over 40 percent and numerous, large rock outcrops. Most of the river shoreline and banks consist of bedrock and boulders. Wetlands at the site are practically non-existent and consist only of a few, very small (less than 5 square feet), discontinuous pockets of emergent vegetation adjacent to the shoreline. Stone Mill Dam divides the site into two (2) hydrologic regimes. Above the dam, the river is slow and ponded, forming a large pool that is over four (4) feet deep, with a thick sediment deposit. Below the dam, swifter flows occur and the river bottom consists of cobbles and boulders, with pools in excess of four (4) feet deep. River samples often contain high levels of coliform bacteria and poor water quality due to illegal CSOs. The extreme channel habitats, including sediment laden pond, fast moving rocky channel and dam, impede fish movement and provide low to moderate fish and wildlife habitat. Figure D5-3 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition there are no plans to remove the Stone Mill Dam in the future allowing migratory fish to access higher quality upstream habitat. The small patches of fragmentary wetland will continue to be isolated, offering little habitat value.

Figure D5- 3. Existing conditions at Stone Mill Dam.

5.3.4 Shoelace Park

The project area is adjacent to the Bronx River Parkway in Bronx County, NY. The site currently provides limited fish and wildlife habitat due to nearby urban development, significant habitat fragmentation, sedimentation issues, and dense growth of invasive species. The west side of the site largely consists of the Bronx River Parkway's roadway embankment. The eastern side of the site is parkland, predominantly consisting of maintained lawns that rise on a slope of notable steepness, at approximately 25-to 30-percent grade, to roughly 60 feet in elevation above the river channel. Much of the uplands within the site consist of lawns associated with the Park. In the extreme northern and southern portions of the site, deciduous woodlots occur. Along the banks of the river, dense pockets of Japanese knotweed are present. Erosion gullies were frequently observed on the upland slope. The wetlands on site are limited to very narrow, lightly vegetated strips of emergent vegetation along the banks, with many areas of mudflat along the lower banks. The banks are nearly vertical in some locations and the faces of the banks are sparsely vegetated. The sandy-bottom channel of the river is generally one (1) to three (3) feet deep with limited riffles and pools. At several locations, rock vanes are constructed in the river, presumably in an attempt to modify the flow regime. Improvements to the park would complement existing recreational uses and substantially reduce erosion, sedimentation, and reduce environmental stressors for up to 1.3 miles of shoreline along the Bronx River. Figures 5-4 and 5-5 depict existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, invasive species will continue to encroach across the site and the habitat will remain fragmented. The existing rock vanes in the channel will continue to modify the Bronx River flow regime.

Figure D5- 4. Shoelace Park North existing conditions.

Figure D5- 5. Shoelace Park South existing conditions.

5.3.5 Muskrat Cove

The Muskrat Cove site is located just north of the Shoelace Park Site, flowing through a small, narrow valley located between a Metro North commuter rail line and the Bronx River Parkway. The majority of the terrestrial area of the site consists of wooded slopes, dominated by deciduous species and fragmented by paved walkways, retaining walls, and other infrastructure. The uplands consist of maintained lawns associated with the park and the parkway right-of-way. Portions of the upland slopes are occupied by dense stands of Japanese knotweed.

The wetlands on site are limited to very small, isolated, sparsely vegetated pockets, dominated by jewelweed and purple loosestrife. The river is shallow, alternating between limited pools and occasional riffles. The river bottom is sandy with large boulders. Banks are armored throughout much of the site and, in some areas, vegetation has grown up through cracks in the armor. Where the banks are not armored, the banks are generally steep and some are undercut. Due to the past and ongoing disturbances at the site, small fragmented habitats, presence of invasive species, and armored banks, there exists limited fish and wildlife habitat value. Figure D5-6 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, invasive species will continue to spread from the upland area of the site. The stream banks will continue to be armored which will prevent wetland and shallow habitat from developing at the site.

Figure D5- 6. Existing conditions at Muskrat Cove.

5.3.6 Bronxville Lake

The project area is within a park that is part of the Bronx River Parkway Reservation in Westchester County, New York. The river flows through a broad valley, approximately 400 feet wide. A weir across the river at the southern end of the site creates a lake with two (2) broad and shallow lobes. A park, part of the Bronx River Parkway Reservation, surrounds the lake. The majority of the uplands at this site are maintained lawns with isolated trees located within the park and in the parkway right-of-way. Several small woodland areas, dominated by deciduous species, occur within the site. These areas are fragmented and provide limited habitat value. During the site visit in 2016, Canada geese (*Branta canadensis*) were encountered throughout the site uplands.

Interspersed in the upland lawns, there are several small pockets of mowed wetlands in shallow depressions. Around the edge of the lake are discontinuous narrow strips of wetlands, typically two (2) to five (5) feet wide and sparsely vegetated with emergent vegetation. The vegetation, where present, is dominated by loosestrife and jewelweed. Within the lake, several sediment bars have formed with limited amounts of emergent vegetation.

The broad, shallow lake is subject to nutrient-enriched runoff from the park, and several drainage pipes empty into the lake from the parkway and other upland areas. The river shoreline in the northern portion of the site, and in the southern portion, adjacent to and downstream of the weir, are armored with large boulders. Around the lake, the short banks are generally vertical, with the upper bank predominantly lined with a single row of trees that are impacted with heavy vine growth. To the north, the river channel is narrower with steeper and higher banks.

The site is a suburban park and would only support species common to a suburban environment. The lack of shaded cover, shallowness of the lake, and lack of submerged aquatic vegetation or instream cover limit the habitat value of the lake for aquatic species. The adjacent uplands and pocket wetlands appear to be regularly mowed, resulting in little ecological value. Figure D5-7 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, this site will remain in the Bronx River Parkway Reservation. Invasive species will continue to propagate across the site. The wetland areas will continue to be disparate and unconnected. Few aquatic species would live in the lake due to water depth and lack of instream cover.

Figure D5- 7. Existing conditions at Bronxville Lake

5.3.7 Crestwood Lake

The Bronx River at the Crestwood Lake site flows through a broad valley (approximately 400 to 600 feet wide), the sides of which are approximately 20 feet high. The river enters the northern end of the site along a small segment of shady river channel, with a rock and sand bottom. At the southern end of the site, the river is dammed, forming a broad, shallow lake, approximately three (3) times wider than the width of the river immediately upstream. On the west side of the lake, Troublesome Creek, a small tributary of moderate flow, enters the lake. The lake is subject to nutrient enriched runoff from surrounding lawns and potentially from upstream sources.

Maintained lawns and lawns with single trees, woodlands dominated by deciduous trees and shrubs, and walking trails border the lake. During the site visit, Canada geese (*Branta canadensis*) were encountered throughout the terrestrial areas on the site. A narrow, typically two (2)-to 10-foot wide wetland strip encircles most of the lake, dominated by emergent vegetation (loosestrife, jewelweed, water purslane, etc.) along most of the shore, but dominated by scrub/shrub vegetation within a segment along the southwest corner of the lake and a small segment along the eastern shore. Three (3) dense patches of invasive Japanese knotweed also occupy the lake shore. Large, vegetated sediment bars, densely covered with loosestrife, jewelweed, cattails, mallow, willows, alders, and common reed, as well as smaller mudflats, occupy the middle of the lake. A vegetated sediment bar also is present at the Troublesome Creek tributary confluence.

The site has moderate wildlife habitat value. The lack of shaded cover and shallowness of the lake and the lack of submerged vegetation or instream cover currently limits the habitat value of the lake for aquatic species. The woodlands on site provide habitat or serve as the home ranges for small-to medium-sized mammals, (e.g., squirrels, raccoons, etc.), but their fragmentation and lack of interspersion with the wetlands limits their value. Figure D5-8 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, the stream will continue to be overloaded with nutrients from upstream run off. Invasive species will continue to spread across the wetland areas. Aquatic life in the lake will be limited due to lack of shaded cover, shallowness of the lake and lack of instream cover.

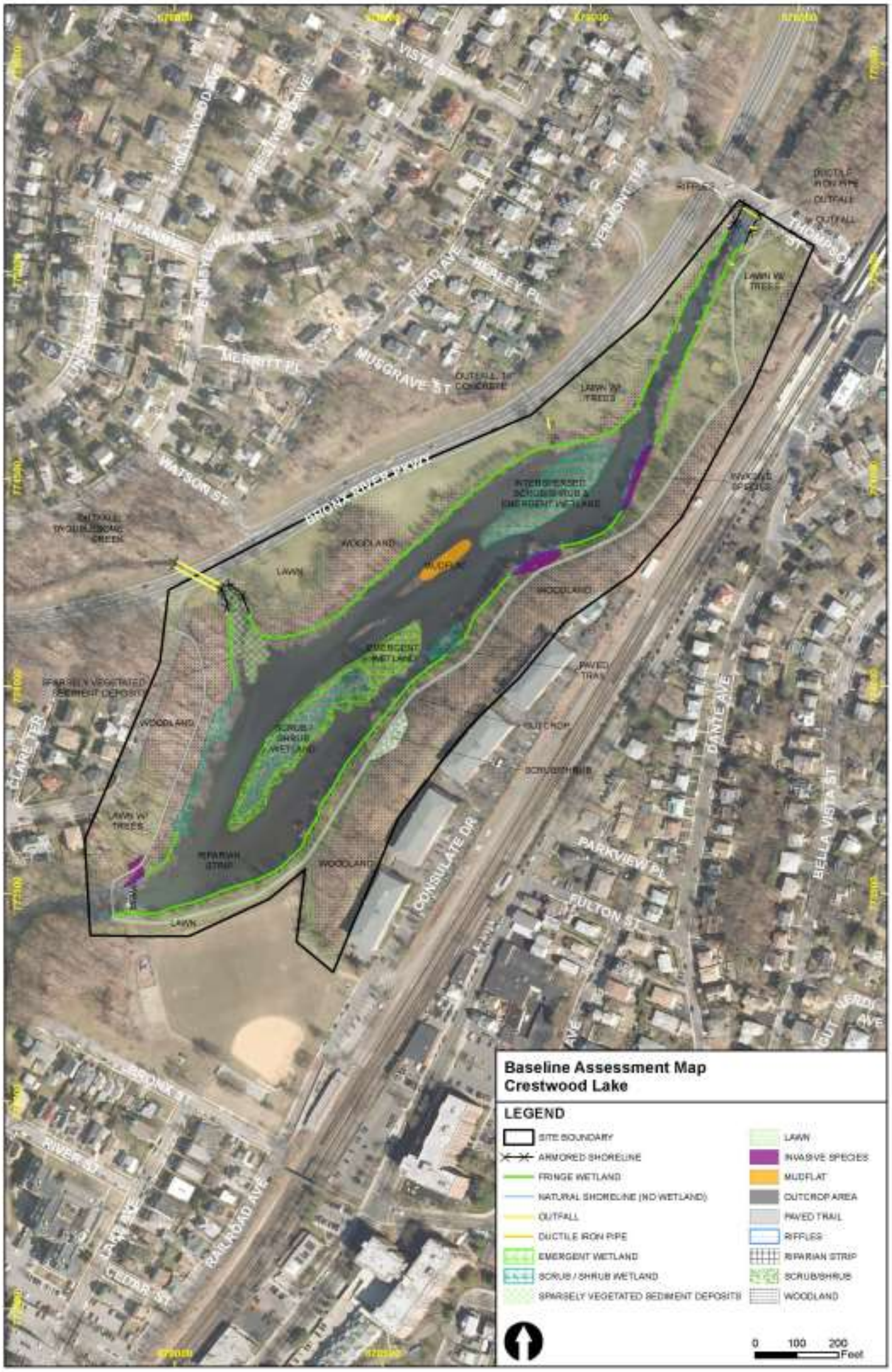

Figure D5- 8. Existing conditions at Crestwood Lake

5.3.8 Garth Woods and Harney Roads

The project area is located north of Harney Road in Westchester County, New York and is bordered to the east and west by the Bronx River Parkway. The Garth Wood site consists of a large forested area, bordered by the northbound lanes of the Bronx River Parkway and traversed by a paved path on the east, and bordered by the Bronx River and the parkway southbound lanes on the west. The northbound lanes of the parkway and a pedestrian bridge cross the river channel near the northern end of the site and the Harney Road site borders the Garth Woods site on the south.

Along this river segment, approximately three quarters (3/4) of the west bank of the Bronx River consists of the vertical walls of the Bronx River Parkway embankment, which is undercut. The remainder of the west bank and the entire east bank are abutted by contiguous floodplain forest. Most of the east bank is low, steep, and sparsely vegetated; boulders and tree roots provide moderate bank stability. The river contains numerous riffles and pools throughout its course, with a benthic substrate of boulders and cobbles. Sediment deposits were observed in the northern portion of the channel during the site visit.

Wetlands on the Garth Woods site consist of narrow strips along the east shore of the river that are very sparsely vegetated with emergent vegetation, and forested, wet depressions within the adjacent forests, mostly within a remnant, abandoned river channel, east and north of the current channel. The forested wetlands are dominated by emergent vegetation, including skunk cabbage, jewelweed, and cinnamon fern. During the site visit, evidence of potential vernal pool habitat also was observed within the forested areas. There are no wetlands along the western shore of the river, along the parkway embankment.

Mostly, the uplands consist of deciduous, floodplain forest, with elms, sycamores, oaks, and maples. Within the upland areas, extensive, dense stands of Japanese knotweed are present, especially bordering the remnant river channel. Large sand deposits occupy portions of the remnant channel. The contiguous forested floodplain and the riffle pool complex of the river provides moderate habitat value for aquatic and riparian species. The site contains thin strips of sparsely vegetated wetlands at Garth Woods and at Harney Road wetlands, often less than two feet wide. The broad and shallow channel and narrow wetland areas provide limited habitat for aquatic species.

The Harney Road site is bounded to the west by woodlands that extend west of the southbound lanes of the Bronx River Parkway, and is bounded to the east by the northbound lanes. The Bronx River flows between the southbound lanes and the northbound lanes of the parkway. Within the site, the river is over-widened, with a width of approximately 60 feet, shallow, with depths often less than two (2) feet, and slow moving. A single deep pool is present at the northern end, just downstream of the Garth Woods site.

Narrow wetland strips, vegetated with jewelweed, purple loosestrife, sedges, and willow shrubs, occupy sections of both shores of the river, and an isolated stand of cattails occupies the eastern shore just upstream of Harney Road. Dense stands of invasive Japanese knotweed occur along two (2) sections of the west bank. Upstream of the road, the river banks are generally vertical and show signs of moderate erosion, and the banks south of Harney Road are armored.

On the west side of the river, a steep road embankment, a narrow strip of lawn, and some patches of trees and shrubs extend from the shore to the southbound lanes of the parkway. On the east side, a shallower slope of maintained lawns, a paved path, and a strip of woodland extends to the northbound lanes. Just north of Harney Road, a buried storm drain is causing sediment deposition and minor erosion. West of the southbound lanes of the parkway, there is a large mowed lawn area with scattered single trees and several mowed pockets of emergent wetlands.

The woodland area on the Harney Road site provides some value to small and mid-sized mammals adapted to suburban environments. No large rooted beds of aquatic vegetation were observed in the river and, due to the broad and shallow channel and narrow wetlands, it is likely that the river in this section currently provides limited habitat value for fish. Figure D5-9 and 5-10 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, invasive species will continue to spread across the site. The river banks south of Harney Road will continue to be armored. There will continue to be little habitat for fish at this site.

Figure D5- 9. Existing Conditions-Garth Woods

Figure D5- 10. Existing Conditions-Harney Road

5.3.9 Westchester County Center

The Westchester County Center site is bounded roughly by the southbound lanes of the Bronx River Parkway to the west, a gas line and the Metro North right-of-way to the east, and the Westchester County Center east parking lot to the south. Site topography is generally flat; the only notable change in elevation being along the eastern boundary of the site, where the rail line embankment rises roughly 20 to 30 feet in elevation. The Bronx River and the parkway northbound lanes traverse the site, flanked by large tracts of maintained lawn with trees, and with woodlands in the southeastern corner of the site. The confluences of two (2) tributaries, Manhattan Brook and the Fulton Brook, occur on the site.

Within the site, the river is generally shallow, with some deep pools. Mostly, the river bottom is sandy, with several mudflats and sparsely vegetated sediment deposits. A large deposit has formed an island just north of the Fulton Brook confluence and is collecting river-borne garbage and debris. The river has a moderate flow, although sediment staining on vegetation, wrack lines, and other hydrologic indicators suggests that this section of the river is subject to strong and high flows during storm events. The river's vertical banks show sign of active erosion and are sparsely vegetated. The extreme southernmost section of the river on site and a section at the Fulton Brook confluence have armored banks.

Within the northern half of the site, wetlands along the river banks are present as narrow fringe wetlands, typically less than one (1) to two (2) feet wide and sparsely vegetated with emergent vegetation. Within the southern half of the site, wetlands along the banks are present as broader patches of emergent wetlands, situated on a topographic shelf that is of lower elevation than the surrounding uplands. These wetlands are dominated by jewelweed and purple loosestrife, but also have dense growth of Japanese hops and other vines. West of and adjacent to the gas line, a few patches of emergent wetlands are present, dominated by jewelweed, iris, purple loosestrife, path rush, and skunk cabbage, with pockets of common reed and some alder and elm. Within the woodlands in the southeastern corner of the site are pockets of wetlands and potential vernal pool habitat.

The majority of the uplands on site consist of flat, maintained park and right-of-way lawns with single or clustered trees. Adjacent to the river banks, thick stands of Japanese Knotweed and numerous vines dominate. Along the easternmost portion of the site, a narrow strip of woodlands occurs, comprising maples, oaks, elms, and other common deciduous woodland species.

The Westchester County Center site currently provides low to moderate fish and wildlife habitat value, primarily to species adapted for a suburban environment. The woodlands in the eastern portion of the site provide greater ecological value as they contain potential vernal pool habitat and buffer wetland habitats. Sediment deposition and non-point source pollution from the two (2) tributaries appear to be negatively impacting the site's aquatic habitats. Figure D5-11 depicts existing conditions as observed in 2016 during Evaluation of Planned Wetlands (EPW) field sampling. EPW baseline results are presented in the Benefits Appendix.

In the future without project condition, this site will continue to be surrounded by highways and parking lots. Invasive species will continue to spread across the site. Pollution will continue to affect the aquatic habitat at the site.

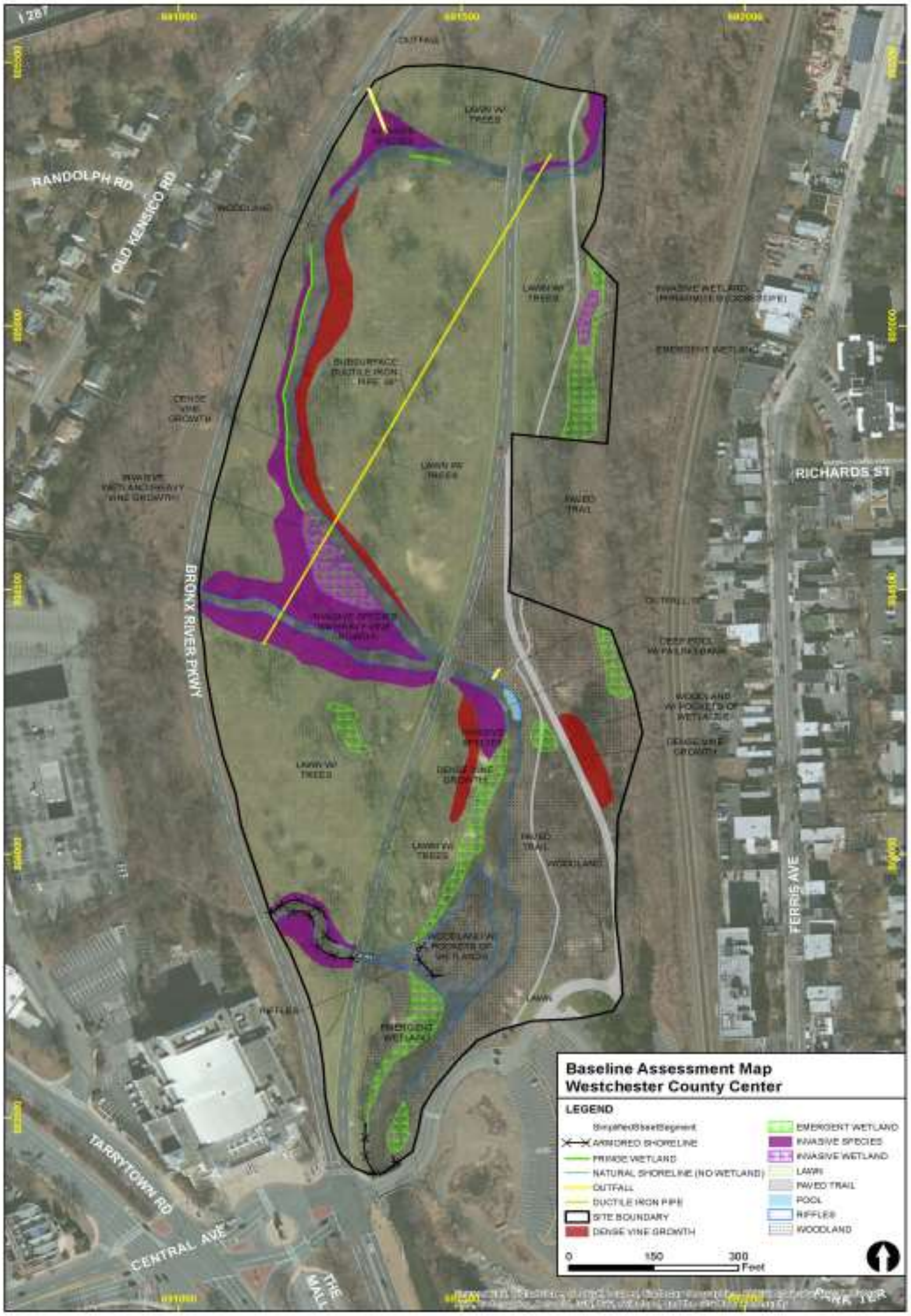

Figure D5- 11. Existing Conditions-Westchester County Center

5.4 Proposed Alternatives

Following integration into the HRE Feasibility Study, the study objectives, restoration measures and appropriate Target Ecosystem Characteristics (TECs) were evaluated at each site.

Three (3) alternatives were developed at each site differing in functionality and ecological benefits. If a site had the potential for multiple design approaches (e.g. establishment of different wetland and/or terrestrial habitat types, multiple reroute locations of the stream, varying locations for wetland establishment), the existing HRE conceptual plan for each site was considered as one design alternative and two (2) additional conceptual plan alternatives were developed for the site. If a single design approach was the most appropriate for a site, but different applications of the approach provided for comparably different results and ecological lift (different scales of a particular alternative), the existing HRE conceptual plan was utilized as the basis to develop three (3) conceptual plan alternatives for the site by applying different restoration measures. Examples of varying measures include: a) type of streambank restoration structures (e.g. hard structure vs. bioengineering vs. plantings, b) acreage of invasive species removal or wetland restoration or c) number of in-stream structures installed.

The restoration measures proposed for the site alternatives are based off of TECs presented in Chapter 1 of this Appendix.

Table D5-3 categorizes and explains each restoration measure and technique proposed for the Bronx River sites. Alternatives for each site were proposed and discussed at design charrettes for Bronx County Sites with NYCDEP and Bronx River Alliance (January 2015) and Westchester County Sites with Westchester County Department of Planning (February 2015).

Table D5- 3. Ecological Restoration Measures

TEC	Measure	Description	Techniques
Wetlands (Coastal Wetlands)	Emergent Wetland Restoration	Excavating and filling areas to restore an emergent wetland to replace upland invasive areas to provide a habitat that is less likely to become revegetated with the same upland invasive species.	
	Forested and/or Scrub/Shrub Wetland Restoration	Excavating and filling areas to restore a forested and/or scrub/shrub wetland to provide continuous fringe habitat around and shade for fish habitat (from trees/shrubs).	

TEC	Measure	Description	Techniques
	Invasive Species Removal with Native Plantings	Removal of non-native plants and replanting those areas with plants native to the ecosystem. Invasive species removal will be in coordination with other ecological restoration measures	
Shorelines and Shallows	Shoreline Softening	The removal of existing structures and armoring and restoring a living shoreline to protect against erosion and to provide and preserve natural habitat.	• Stacked Rock Wall w-Brush Layers • Select Rock/Concrete Removal w-Native Materials • Drilling w-Native Plantings
	Streambank Restoration	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Stacked Rock Wall w-Brush Layers •Tiered Rock Slope w-Native Plant Benches/Pockets • Vegetated Crib Wall
	Riparian Buffer	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Invasive Species Removal with Native Plantings • Select Native Planting
Fish, Shellfish and Benthic Habitat & Sediment Control/Nutrient Load Reduction [Habitat for Fish, Crab, & Lobsters]	Realign Channel w-Instream Structures	Changing the realignment of the channel and utilizing instream structures to modify the channel's hydrologic and hydraulic characteristics.	• Cross Vane • Skewed Cross Vane • J-Hook
	Channel Plug w-Select Native Plantings (Realign	Block water from entering the secondary channel to restore a more adequate	

TEC	Measure	Description	Techniques
	Channel w-Instream Structures)	stream morphology in the main channel section.	
	Channel Modification w-Instream Structures	Modifications within the channel to steer, direct, and/or control the channel away from a specific area. The channel will remain within its current banks, but that sinuosity/more stable geometry will be achieved with the structures.	• Cross Vane • Skewed Cross Vane • J-Hook
	Bed Restoration	Modifications to the channel bed to restore a low flow channel.	• Thalweg Restoration • Bed Material Replacement • Restoration of Riffle-Pool Complex
	Debris Removal	The removal of substantial debris within the channel.	
	Sediment Dredging	Dredging od sediment laden areas within the channel to fix the hydraulic characteristics within the channel.	
	Forebay/Sediment Basin	Restoration of forebay/sediment basin to capture sediment laden water and reduce the amount of sediment from settling in the channel.	
	Sediment Load Reduction	The reduction of sediment erosion in specified location.	• Vegetated Swale • Outlet Protection • Culvert Repair • Sediment Trap • Emergent Wetland/Bio retention Basin
Tributary Connections	Dam Removal		
	Fish Ladders	A structure that allows fish to migrate around obstacles like dams.	

TEC	Measure	Description	Techniques
	Weir Modification (Fish Passage)	Modifying the existing weir to modify the hydraulic characteristics of the weir.	

Shoreline softening is the removal of concrete, rock or debris and/or the addition of vegetation to an armored shoreline. Streambank restoration is a natural bank shoreline with no wetlands. It is assumed that restoration measures will include site specific enhancements that could increase various fish habitat and irregularity of stream bank. As part of shoreline softening and streambank restoration measures, wetland plants will be proposed at elevations near the ordinary high water mark, with the intent of restoring a narrow fringe wetland habitat at the site. Shoreline softening techniques include stacked rock wall with brush layers, select rock/concrete removal with native plant materials, and drilling with native plant materials. Streambank restoration techniques include stacked rock wall with brush layers, tired rock slope with native plant benches and pockets, and vegetated crib walls.

In-stream structures that are associated with channel realignment and channel modification include cross vanes, skewed cross vanes, and j-hooks. The in-stream structures proposed should have little to no maintenance needed to maintain their functionality. One exception may be removal of fallen trees or large debris following major storm events.

Bed restoration techniques include thalweg restoration, bed material replacement, and restoration of riffle-pool complex. The sediment load reduction ecosystem restoration measure includes techniques such as vegetated swales, outlet protection, culvert replacement, sediment trap and emergent wetland/bio-retention. Proposed path and education signage are possible proposed public access techniques.

Invasive species were identified at every site during field investigations. For all alternatives in any areas where existing invasive species were found, any measure that is proposed for that area will include the removal of invasive species. The alternative maps show ecological restoration measures such as shoreline softening and streambank restoration in areas where existing invasive species were observed. The implementation of these measures will include the removal of invasive species if present in the proposed measures locations. Based on the Planting Plan for Mamaroneck River Habitat Improvement provided by Westchester County, some large trees and wetland seed mix will be proposed for some sites. In the future, for all of the sites, an invasive species survey will need to be conducted before implementation of restoration measures at the site. The existing invasive species may change in the future and will need to be surveyed and accounted for before any site restoration measures are implemented. A tree survey should also be conducted at all of the sites in the future prior to any implementation of site restoration measures to account for type, size, and location of existing trees.

Proposed plantings within the Bronx River will take historic aesthetic of the Bronx River Parkway into consideration. Plant height for proposed plantings will be maintained for the purpose of the historic view-shed. Existing plants however, will not be replaced for the purpose of improving the view-shed. The Historic American Engineering Record for the Bronx River Parkway was used as a reference for the design goals and principles used to create the parkway and the surround landscape as well as the view-sheds.

Restoration measures will follow floodway regulations as stated in FEMA's CFR 44 Chapter 60.3 regarding no net rise in floodway elevations. Restoration measures will take into consideration cut/fill requirements per site. Once the feasibility level drawings are prepared, a more detailed cut/fill analyses will be completed to address potential flood inducement constraints per site.

Dam removal and fish ladders were both considered as effective measures to restore fish passage. However, dam removal was not considered further due to the dam's historical significance and the unwillingness of the landowner to remove these structures.

As mentioned previously, for each site three alternatives were selected. The Alternatives A, B and C, generally vary in amount (e.g., acreage, linear feet, etc.) of restoration efforts. Alternative A provides the most restoration activities, with Alternatives B and C providing lesser restoration actions, respectively. Regardless of the amount of restoration provided, each alternative was targeted to address the major environmental stressors on each site. At a regional level, these alternatives were also considered to work in concert with each other (e.g., the providing of fish passages at each dam, etc.) to provide synergistic benefits that improve the TECs and provide a net ecological uplift to the entire Bronx River ecosystem.

The three (3) alternatives that were developed for the nine (9) sites within the Bronx River are presented below. Sites included in the Recommended Plan (including Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park, Bronxville Lake and Garth/Harney) identify the Tentatively Selected Plan alternative from the draft report as well as the optimized Recommended Plan alternative. The remaining four (4) sites (River Park/West Farm Rapids Park, Muskrat Cove, Crestwood Lake and Westchester County Center) present the three (3) alternatives developed prior to their screening out of the Recommended Plan.

SITES IN THE RECOMMENDED NER PLAN

5.4.1 Bronx Zoo and Dam

<u>Bronx Zoo and Dam – Alternative A (Tentatively Selected Plan in the Draft Report)</u>

Alternative A entails removing approximately 0.27 acres of invasive vegetation along both banks and on the upland island upstream of the dams, and planting native vegetation in these locations, as well as at an additional location downstream of the dams (Figure D5-12). In an area between the island and the west bank, 0.35 acres of the river bottom will be excavated and the bed material will be replaced. A section of approximately 0.04 acres of the west bank will be softened by select removal of the existing armor and planting with native species. A fish ladder (approximately 0.04 acres) will be installed to link the excavated channel area upstream of the dams to the river channel below the dams. The fish ladder will open approximately 3,373 linear feet of the Bronx River up for anadromous (e.g., American shad, striped bass, alewife and blueback herring) and catadromous (e.g., American eel) fish. Emergent wetlands of approximately 0.99 acres will be restored along both banks upstream of the dams, and along the west bank immediately downstream of the dams, and approximately 0.29 acres of forested wetlands will be restored in two locations upstream of the dams, along the east bank and on the island. Additional restoration measures will include: removing debris on 0.09 acres between the dams, installing a sediment trap to reduce sediment loads reaching the river, and improving public access.

Bronx Zoo and Dam – Alternative B

The restoration measures included in Alternative A also are included in Alternative B, with the exception of the forested wetland restoration (Figure D5-13). Alternative B will remove approximately 0.56 acres of invasive vegetation from the areas targeted for forested wetland restoration in Alternative A, and will plant them with native vegetation. In Alternative B the extent of emergent wetland restoration along the east bank of the river is also reduced to 0.71 acres. Alternative B provides ecological uplift intermediate between the ones provided by Alternatives A and C.

Bronx Zoo and Dam – Alternative C

Relative to Alternative B, Alternative C further reduces the extent of emergent wetland restoration to 0.54 acres, eliminating a restoration area along the west bank of the river but increases the amount of invasive removal and native planting to 0.79 acres (Figure D5-14). Channel modification by excavating the river bottom and replacing the bed material is eliminated. Similarly, the softening of a section of the west bank is deleted. Alternative C provides the least ecological uplift of the three (3) alternatives.

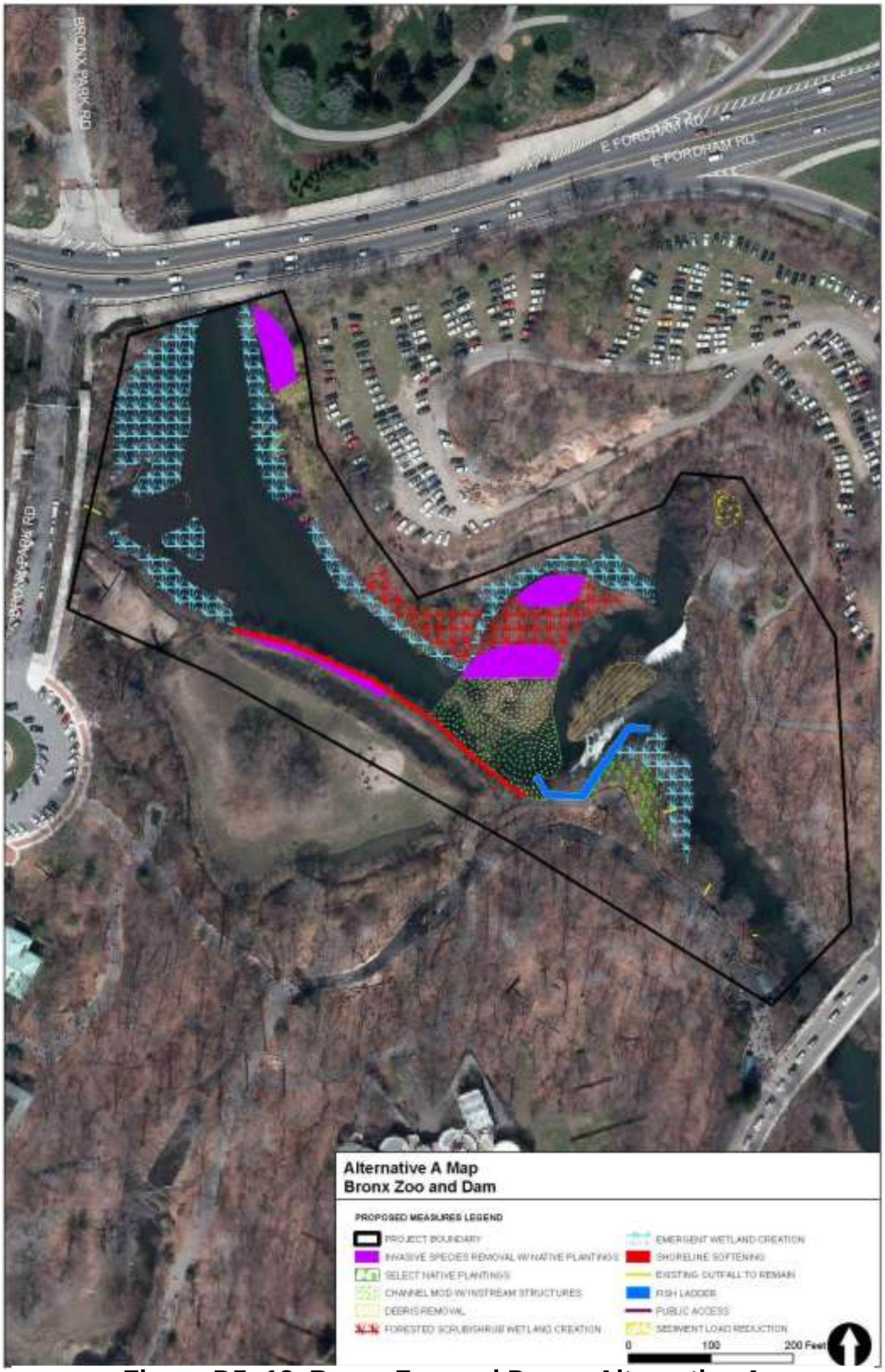

Figure D5- 12. Bronx Zoo and Dam – Alternative A

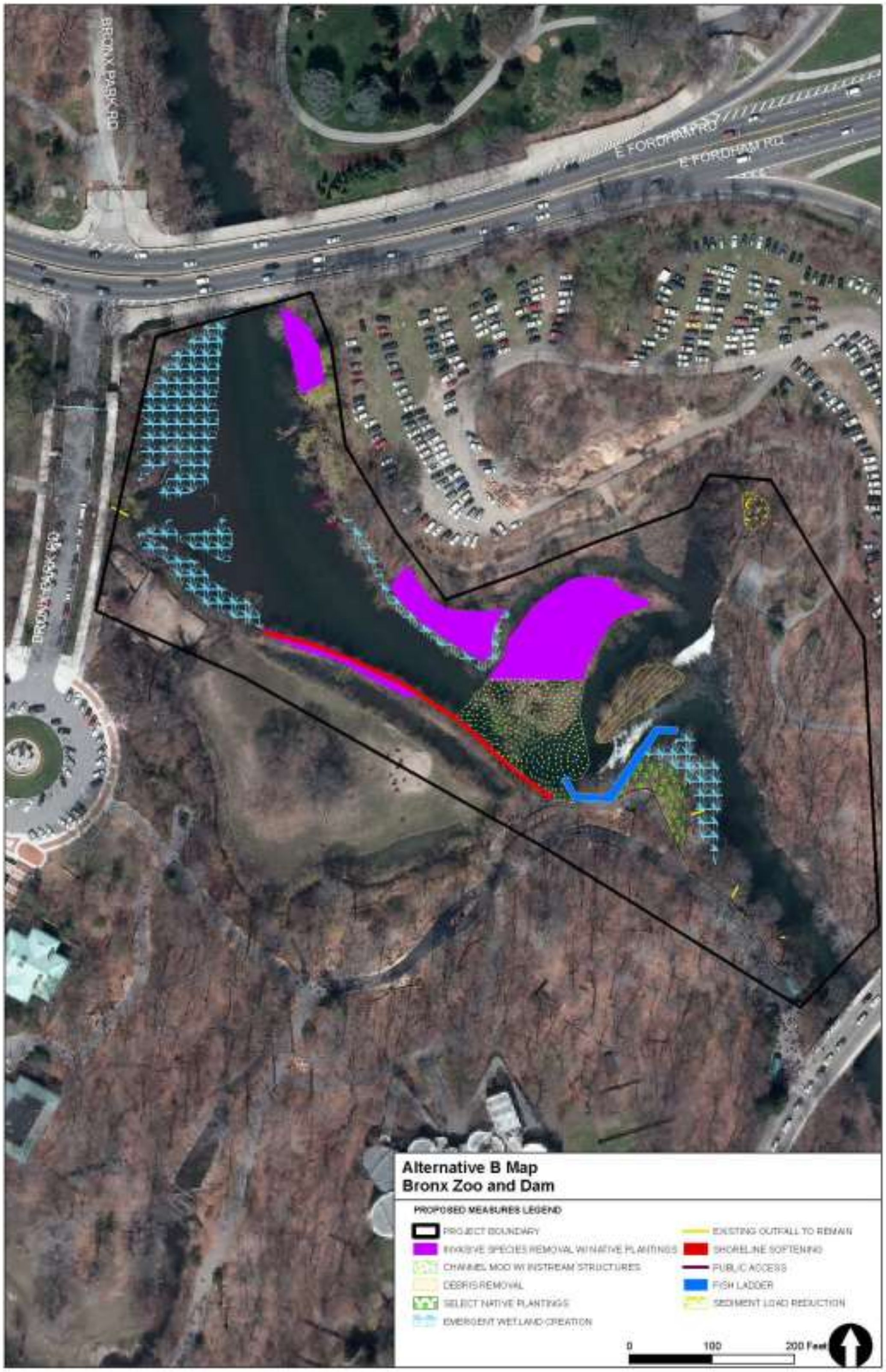

Figure D5- 13. Bronx Zoo and Dam – Alternative B

Figure D5- 14. Bronx Zoo and Dam – Alternative C

Bronx Zoo and Dam – Recommended Plan

The recommended plan is the optimized design based on Alternative A (Figure D5-15). The optimized recommended plan for the Bronx Zoo and Dam site will improve aquatic habitat and provide secondary benefits to water quality. Approximately 0.42 acres of invasive vegetation will be removed and replaced with native plantings. This will occur along both banks, on the upland island upstream of dams, and in additional locations downstream of the dams.

An aluminum fish ladder installation will link 0.8 acres of area upstream of the dams to the river channel below the dams and open Bronx River access to anadromous fish. Boulders will be placed in stream to direct fish to the structure. Restoration of 1.16 acres of emergent wetlands along both banks upstream of the dams and along the west bank downstream of the dams will provide habitat for migratory birds and flood control. Restoration of 0.48 acres of forested wetlands along the east bank upstream of the dams may provide potential habitat for endangered bat species, if present. Restored wetlands will provide habitats for migratory birds and flood control. The restored forested wetlands may provide potential habitat and roosting resources for endangered bat species, if present. Improved fish connectivity will provide access for anadromous species. Removal of invasive species and restoration of wetlands will provide increased native biodiversity for the site.

In total, 3,320 CY of material will be excavated during clearing and grubbing activities and to reach grade for the recommended habitats, excavated material will be beneficially reused on site to the extent possible. Additional restoration measures include removal of debris between dams, sediment trap installation to reduce sediment loads reaching the river, installation of 750 linear feet rock wall upstream of the river, and improved public access to the site. See Engineering Appendix for the grading and planting plans for the site.

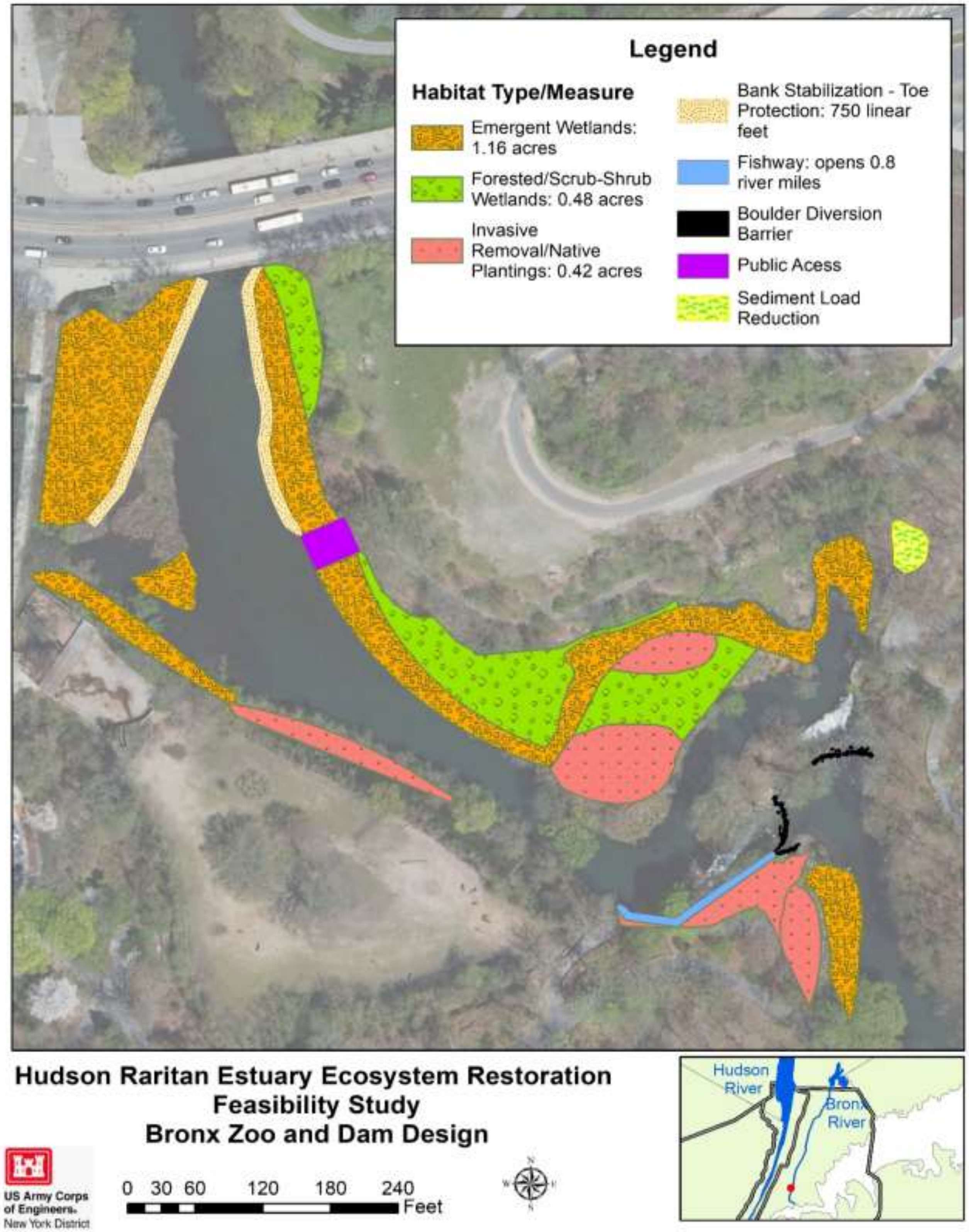

Figure D5- 15. Bronx Zoo and Dam – Recommended Plan

5.4.2 Stone Mill Dam

Stone Mill Dam – Alternative A (Tentatively Selected Plan in the Draft Report)

Alternative A entails installing a fish ladder to link the slow-flowing pool upstream of the dam and the faster-flowing channel downstream of the dam (Figure D5-16). The fish ladder will open up approximately 35,128 linear feet of Bronx River for anadromous and catadromous fish between Stone Mill Dam and Bronxville Lake. Clay-pipe fish attractors will be placed at both the upstream and downstream ends of the fish ladder to function as refuge habitat for fish. Native vegetation will be planted along the east bank of the river over 0.037 acres, abutting the fish ladder. Invasive vegetation will be removed from a small area along the west bank, immediately downstream of the dam, and the area will be planted with native vegetation. Alternative A provides the greatest ecological uplift of the three (3) alternatives.

Stone Mill Dam – Alternative B

The fish ladder and native vegetation plantings along the east bank included in Alternative A are also included in Alternative B (Figure D5-17). In Alternative B, the clay-pipe fish attractors and the invasive species removal followed by select native plantings along the west bank as described in Alternative A are omitted, leaving approximately 0.27 acres of native plantings. Alternative B provides ecological uplift intermediate between the uplift provided by Alternatives A and C.

Stone Mill Dam – Alternative C

Alternative C (Figure D5-18) omits all of the restoration measures included in Alternatives A and B, entailing instead the excavation of 0.09 acres of the river bed and bed material replacement in an area upstream of the dam. Alternative C provides the least ecological uplift of the three (3) alternatives.

Figure D5- 16. Stone Mill Dam – Alternative A

Figure D5- 17. Stone Mill Dam – Alternative B

Figure D5- 18. Stone Mill Dam – Alternative C

Stone Mill Dam – Recommended Plan

The recommended plan is the optimized design based on Alternative A and has been largely designed by the NYC Parks Department (Figure D5-19). The recommended plan for Stone Mill Dam increases and improves tributary connections, shorelines, and shallow water habitat. The installation of a steep pass fish ladder at this site is a critical component of the fish passage projects along the Bronx River and links the slow-flowing pool upstream of dam and the faster-flowing channel downstream of the dam. This measure will open up an additional 22.9 acres of upstream habitat for anadromous fish and restore 0.5 acres of the river bed by adding natural rock at the entrance and exit. Approximately 0.032 acres of invasive removal and native vegetation plantings will occur along the east bank of the river abutting the fish ladder and along the west bank downstream of the dam. In addition, 0.13 acres of native plantings will occur in areas impacted from construction of the fish ladder. See Engineering Appendix for the grading and planting plans for the site.

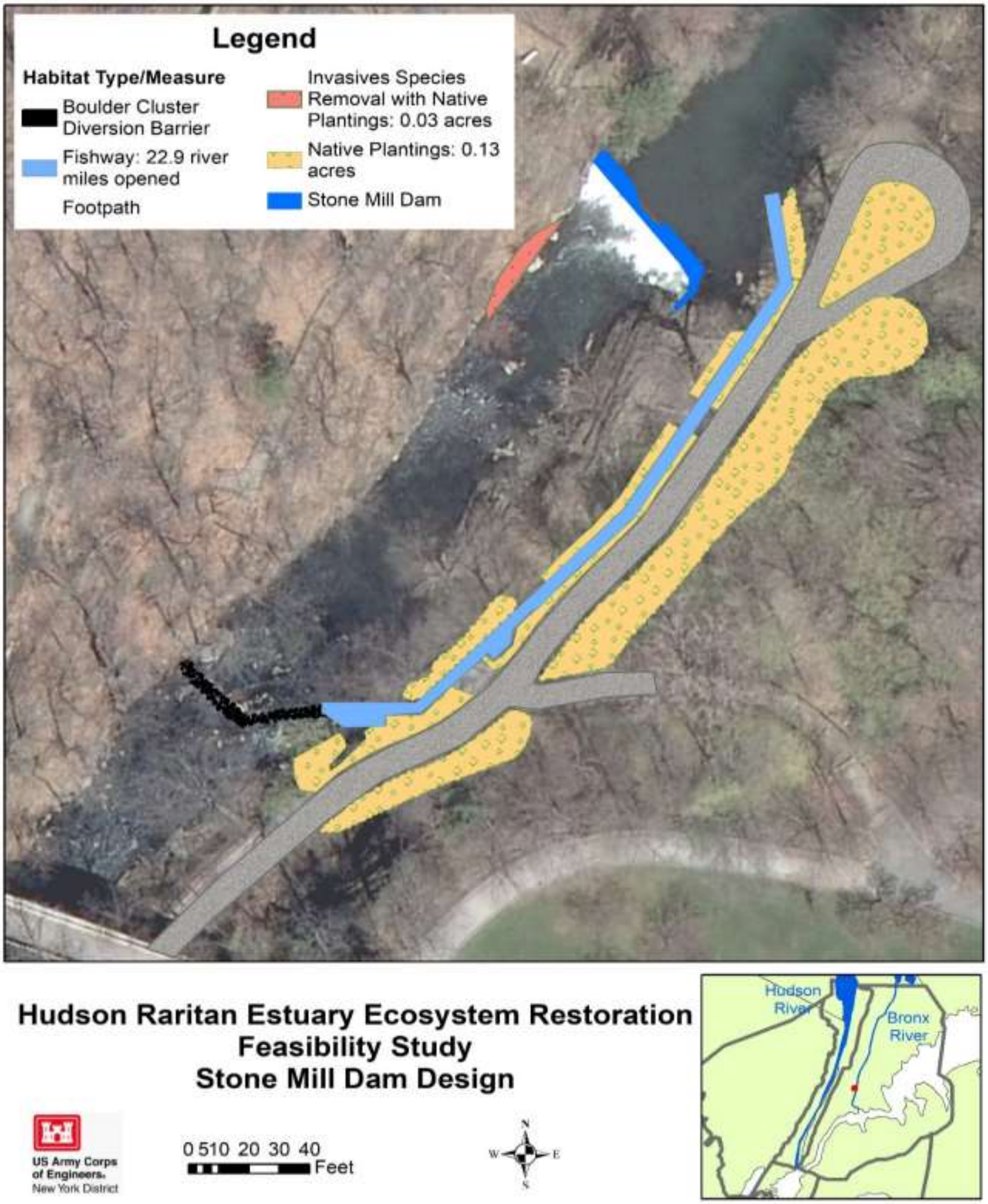

Figure D5- 19. Stone Mill Dam – Recommended Plan

5.4.3 Shoelace Park

Shoelace Park – Alternative A

Alternative A entails invasive removal and native planting of approximately 9.56 acres the entire length of the Bronx River Parkway roadway embankment along the west side of the Shoelace Park site, and the steep slope along the east bank of the river with native, upland trees and shrubs (Figures 5-20 and 5-21). Over 1.1 miles of banks will be upgraded and 1.3 miles of river bed will be upgraded. Over 2.95 acres of forested and scrub/shrub wetlands will be restored along two (2) segments of the river on both banks. Along these segments, the river banks will be stabilized by constructing a wetland planting bench, and 5.44 acres of the river channel will be realigned using in-stream cross vanes and J-hooks. Between the two (2) forested wetland restoration areas and near the southern end of the site, the banks will be stabilized using stacked rock walls with brush layers or crib walls, and the river bottom will be excavated, the bed material will be replaced, and cross vanes will be constructed. Additional restoration measures will comprise installing 2.07 acres of vegetated emergent wetlands/bio-retention basins at several locations adjacent to the east bank, in order to reduce sediment loads reaching the river; 0.73 acres of streambank restoration shoreline softening and along the west bank at the southern end of the site, using a stacked rock wall with brush layers; and improving public access to the river. Alternative A provides the greatest ecological uplift of the three (3) alternatives.

Shoelace Park – Alternative B (Tentatively Selected Plan in the Draft Report)

The restoration measures included in Alternative A are also included in Alternative B, with the exception of the forested and scrub/shrub wetland restoration (Figures 5-22 and 5-23). Throughout most of the length of the river within the site, inclusive of those segments where forested and scrub/shrub wetland restoration is proposed in Alternative A, Alternative B will stabilize the banks for over 1 mile on each shoreline using stacked rock walls with brush layers. Invasive removal and native plantings will cover over 10.2 acres of the site. The river bottom will be excavated, the bed material will be replaced on approximately 1.2 miles, and cross vanes and J-hooks will be constructed over 5.59 acres and approximately 2.06 acres of streambank restoration will occur. The vegetated emergent wetlands/bio-retention basins are still included. Alternative B provides an intermediate ecological uplift, in comparison with Alternatives A and C.

Shoelace Park – Alternative C

Relative to Alternative B, Alternative C eliminates streambank restoration using stacked rock walls with brush layers along both banks of the river for approximately one (1) mile (Figures 5-24 and 5-25). Only 2.01 acres of vegetated emergent wetlands/bio-retention basins at several locations adjacent to the east bank, Alternative C provides the least ecological uplift of the three (3) alternatives.

Figure D5- 20. Shoelace Park North – Alternative A

Figure D5- 21. Shoelace Park South – Alternative A

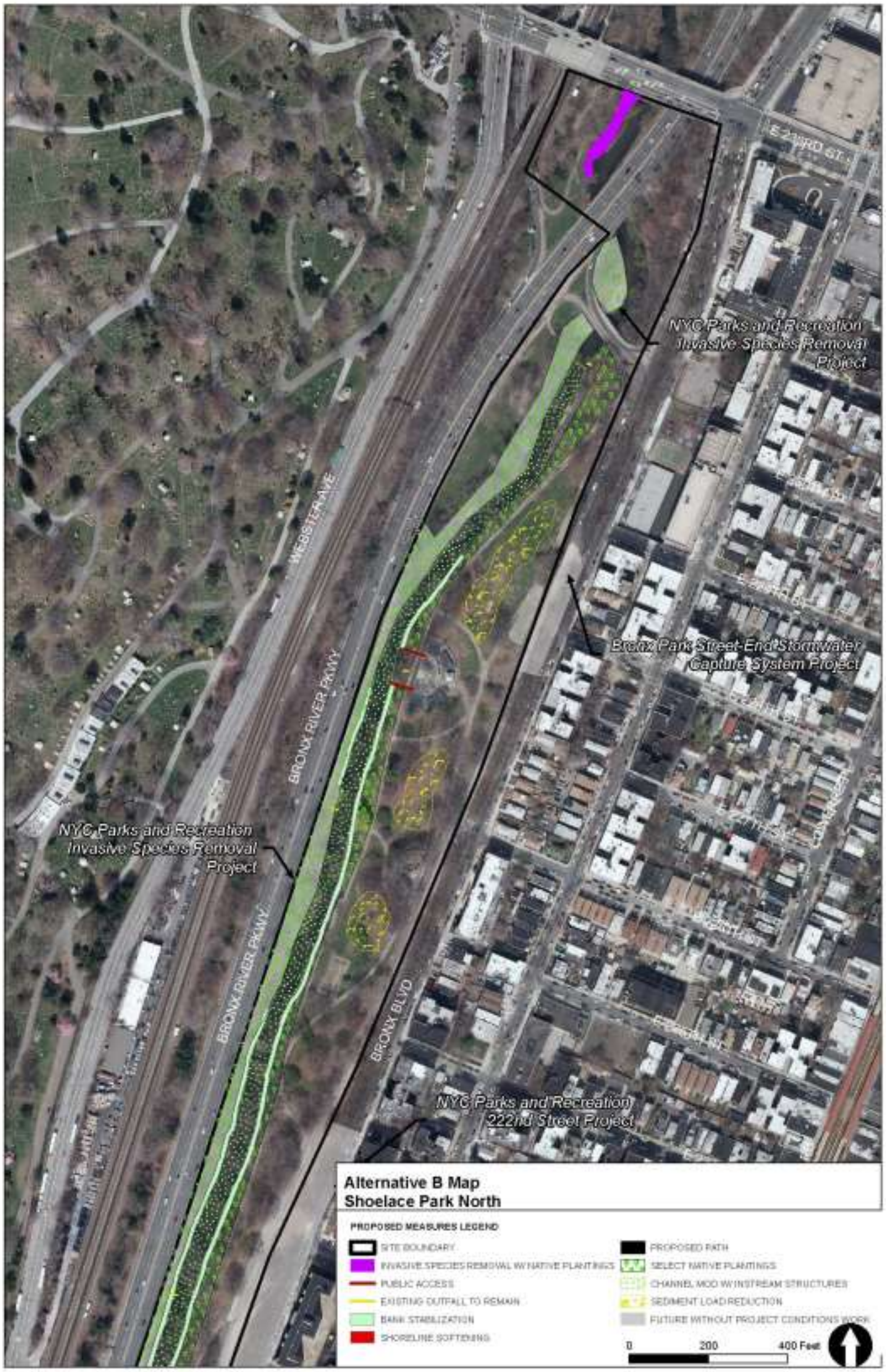

Figure D5- 22. Shoelace Park North – Alternative B

Figure D5- 23. Shoelace Park South – Alternative B

Figure D5- 24. Shoelace Park North – Alternative C

Figure D5- 25. Shoelace Park South – Alternative C

Shoelace Park – Recommended Plan

The recommended plan is the optimized design based on Alternative B (Figure D5-26). The recommended plan increases and improves wetlands, public access, shoreline and shallows, and mudflat habitat. Native upland trees and shrubs will be planted along almost the entire length of the Bronx River Parkway roadway embankment along the west side of the site and on the steep slope along the east bank of the river. Forested and scrub/shrub wetlands totaling 1.1 acres will be restored along two segments of the river on both banks. In stream work includes 5.7 acres of bed restoration which will occur in the form of channel realignment using in-stream cross vanes and J-hooks and bed material replacement. 7,415 linear feet of banks will be stabilized using stacked rock walls with brush layers or crib walls between the forested wetland areas near the southern end of the site, and along the west bank at the southern end of site using a stacked rock wall with brush layers. Invasive species removal with native plantings along 7.9 acres will provide a wooded riparian corridor along the banks of the entire reach. Riparian woodlands and restored forested wetlands would provide habitat resources that are currently very limited in the Bronx urban environment.

Additional restoration measures at Shoelace Park include installation of 2.07 acres of v emergent wetlands/bio-retention basins along the east bank to reduce sediment loads reaching the river. This plan will improve aquatic habitat and provide secondary water quality benefits by modifying the channel with in-stream structures, restoration of natural pools, thalweg and riffle complexes. Invasive species located on site will be reduced and select native plantings will provide wooded riparian corridor along the backs of the entire reach. The riparian woodlands and restored forested wetlands would provide habitat resources that are currently very limited in the Bronx urban environment and reduce nutrient inputs to the water. See Engineering Appendix for the grading and planting plans for the site.

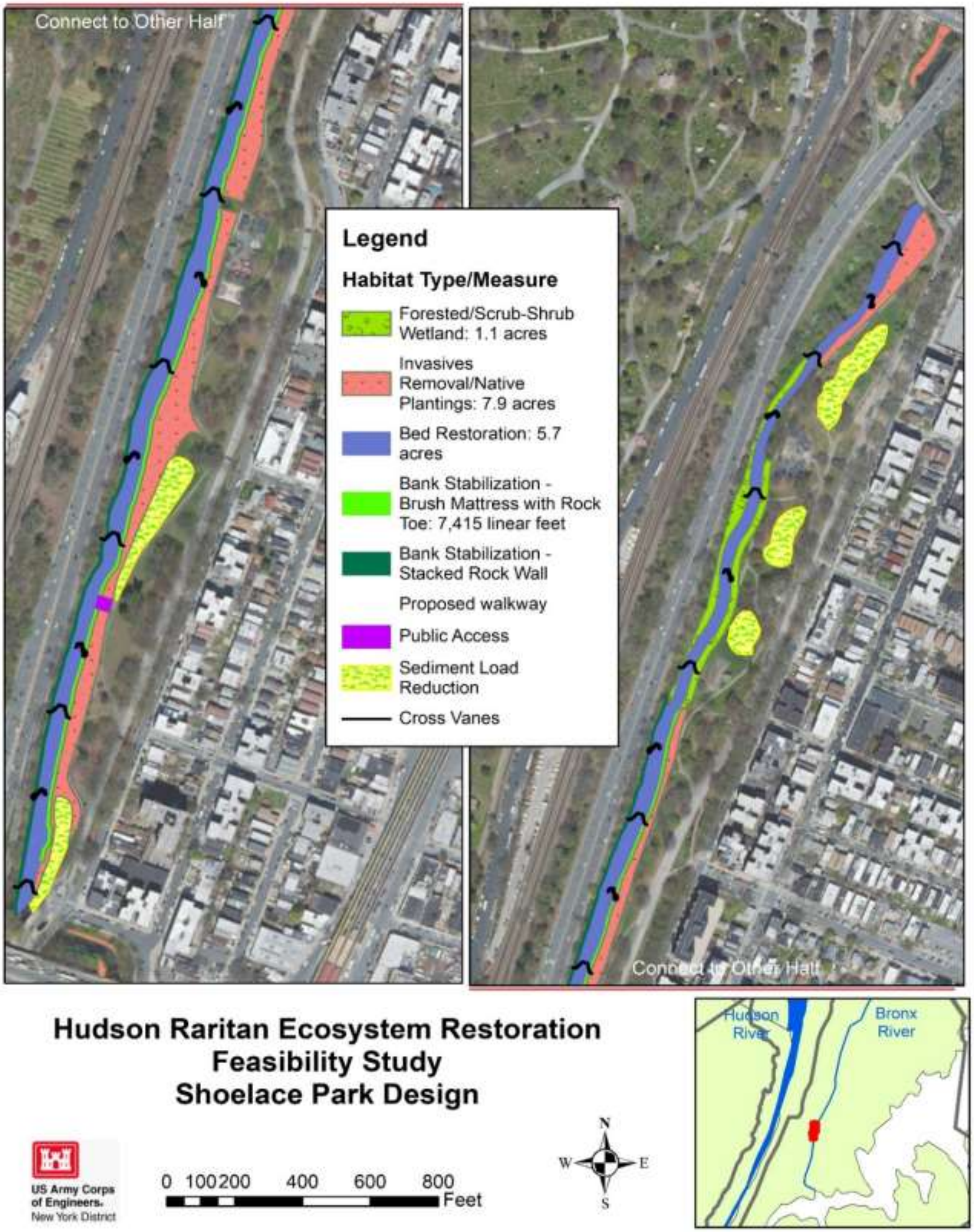

Figure D5- 26. Shoelace Park North and South – Recommended Plan

5.4.4 Bronxville Lake

Bronxville Lake – Alternative A

Alternative A entails planting an area in the northwest portion of the site along the Bronx River Parkway, and a small area along the southeast portion of the lake with native upland trees and shrubs (Figure D5-27). A rip rap forebay (approximately 0.41 acres) will be constructed in the river channel, upstream of the lake, to cause sediment to settle out of the flow. Within the lake, the river channel will be realigned on approximately 1.28 acres by replacing the bed material and constructing in-stream cross vanes. Approximately 3.73 acres of emergent wetlands will be restored between the channel and the lake banks and approximately 1 acres of forested and scrub/shrub wetlands will be restored in three (3) locations around the lake perimeter. The existing rock weir at the southern end of the lake will be modified to facilitate fish passage. The fish passage will open 5,457 linear feet of new habitat in the Bronx River for anadromous and catadromous fish between the Bronxville Lake and Crestwood Lake. An adjacent, small patch of invasive vegetation (approximately 0.02 acres) will be removed and the location will be planted with of native vegetation. Additional restoration measures will comprise installing vegetated swales and emergent wetlands/bio-retention basins at three (3) locations (approximately 0.27 acres) to reduce sediment loads reaching the river, as well as improving public access to the river. Alternative A provides the greatest ecological benefits and uplift of the three (3) alternatives.

Bronxville Lake – Alternative B (Tentatively Selected Plan in the Draft Report)

The restoration measures including the sediment forebay are included in Alternative A are also included in Alternative B, with the exception of the channel realignment with in-stream structures within the lake. Alternative B will restore the bed on approximately 1.30 acres of the channel by excavating the bottom and installing bedding stone (Figure D5-28). The sediment within two (2) small sections of the channel and the adjacent lake bottom will be dredged. Only 0.59 acres along narrow strips of emergent vegetation will be restored along the banks of the lake, emergent wetland will not be restored between the channel and the banks. Rather, sections of the lake bottom will be filled and 2.96 acres of forested and scrub/shrub wetlands will be restored in these areas, and the remainder of the lake bottom will be retained in open water habitat. Approximately 0.27 acres of emergent wetland/bio-retention basins will still be implemented at the site. Invasive vegetation will be removed and the location will be planted with of native vegetation over 1.39 acres. Alternative B provides ecological uplift intermediate between the ones provided by Alternatives A and C.

Bronxville Lake – Alternative C

Relative to Alternative B, Alternative C restricts forested and scrub/shrub wetland restoration to a single 0.56 acre area along the east bank of the river, upstream of the lake, and reduces the extent of emergent wetland restoration to 0.39 acre smaller and narrower strips along the lake shore (Figure D5-29). Invasive vegetation will be removed and the location will be planted with of native vegetation over 1.39 acres. Alternative C will dredge the sediments in both broad, shallow lobes of the lake and will restore the bed along the intervening river channel over 3.13 acres. Additional bed restoration will occur over an area of .38 acres. The existing rock weir at the southern end of the lake will not be modified; rather, a fish passage will be installed to link the lake and the river downstream of the weir. The sediment forebay is still included in Alternative

C and the vegetated swales and emergent wetlands/bio-retention basins at three (3) locations (approximately 0.26 acres) will also be restored to reduce sediment loads reaching the river. Alternative C provides the least ecological benefits and uplift of the three alternatives.

Figure D5- 27. Bronxville Lake – Alternative A

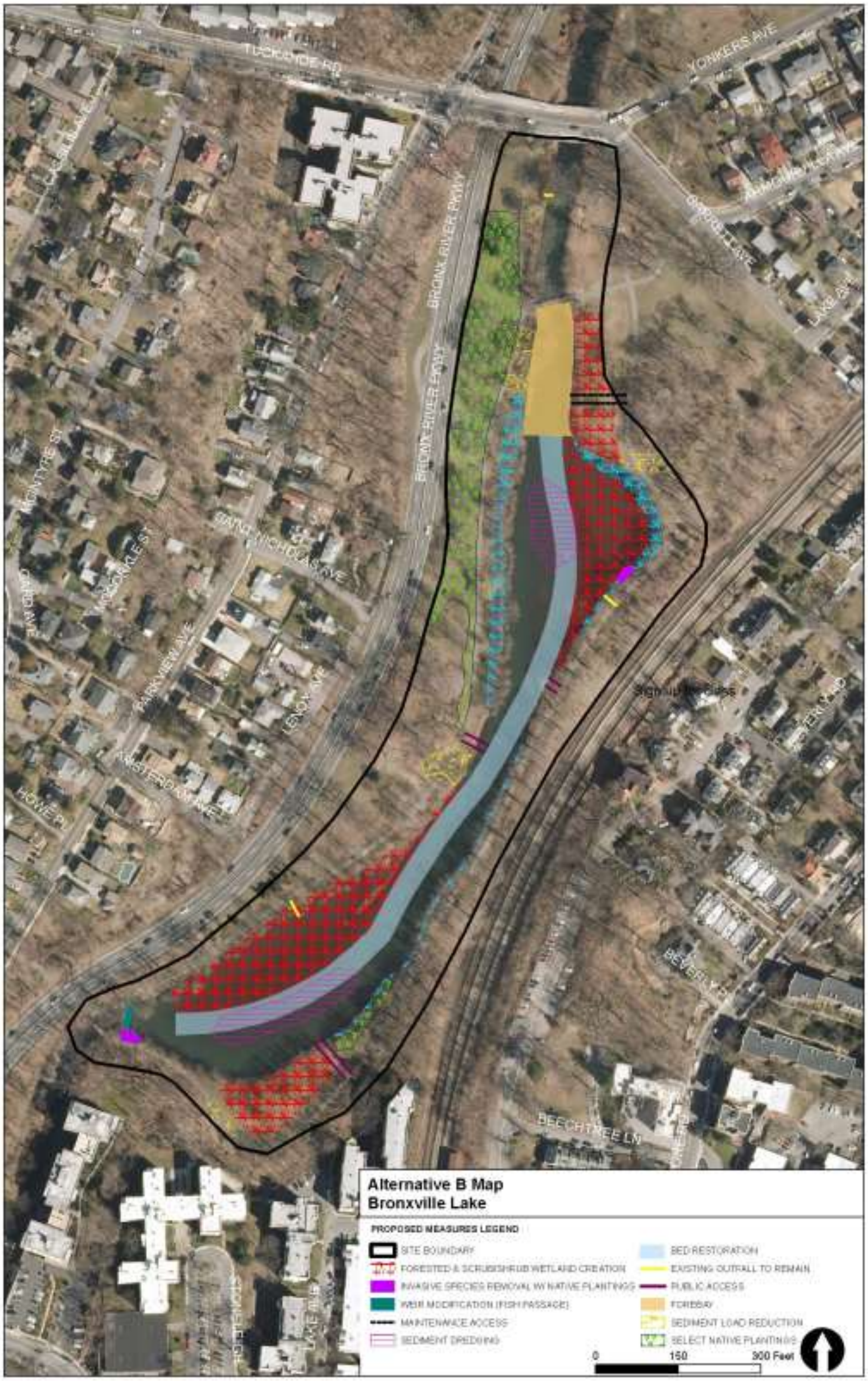

Figure D5- 28. Bronxville Lake – Alternative B

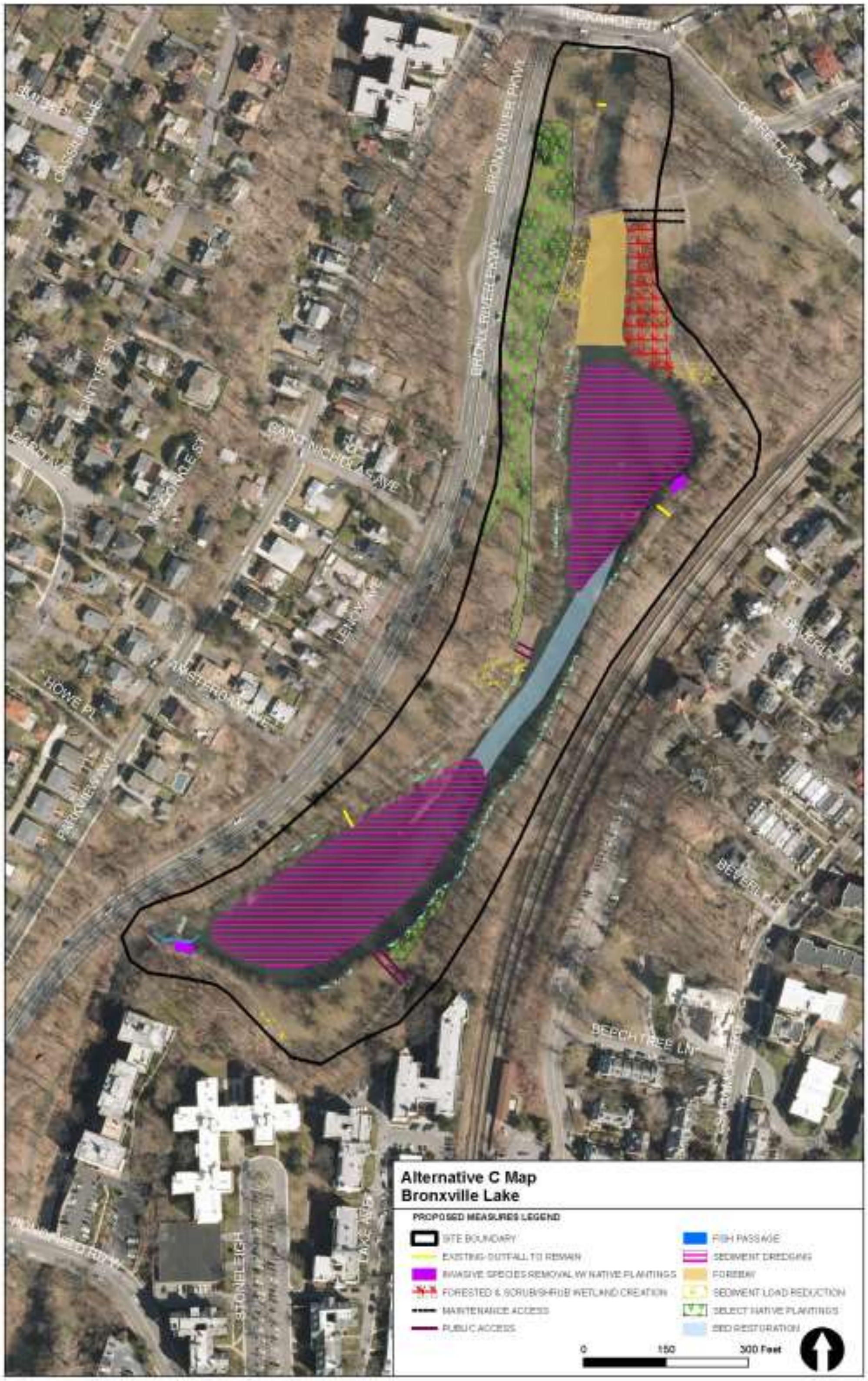

Figure D5- 29. Bronxville Lake – Alternative C

Bronxville Lake – Recommended Plan

The recommended plan is the optimized plan based on Alternative B (Figure D5-30). The recommended plan will improve aquatic habitat and flow regime, and provide secondary water quality improvements. Invasive species removal and replanting with native upland trees and shrubs will occur in 1.39 acres of the northwest portion of the site along the Bronx River Parkway and in a small area along the southeast portion of the lake. Narrow strips of emergent vegetation will be restored along 0.86 acres of the lake banks. Sections of the lake bottom will be filled and 2.49 acres of forested and scrub/shrub wetlands will be restored in these areas; the remainder of the lake bottom will be retained in open water habitat. Sediment within two sections of the channel and adjacent lake bottom will be dredged. The bed of the channel will be restored by excavating the bottom and installing bedding stone along 0.65 acres. A 0.3 acres rip rap forebay will be constructed in the river channel upstream of the lake to cause sediment to settle out of flow. The existing rock weir at the southern end of the lake will be modified to improve hydrology and facilitate fish passage, opening new habitat in the Bronx River to anadromous and catadromous fish. Due to the proximity of major arterial infrastructure, shorelines were engineered with excessive armor of concrete.

Additional restoration measures for Bronxville Lake site include installation of vegetated swales and emergent wetlands/bio-retention basins, at three locations to reduce sediment load to river, and improved public access. Improved flow regime and improved fish connectivity will provide access for anadromous species. Restored wetlands will provide important habitats for migratory birds and increased flood control. Increased native biodiversity through wetland restoration and targeted removal of invasive plant species. Restored forested wetlands have the potential to provide habitat/roosting resource for endangered bat species, if present. Public access will also be improved. See Engineering Appendix for grading and planting plans at the site.

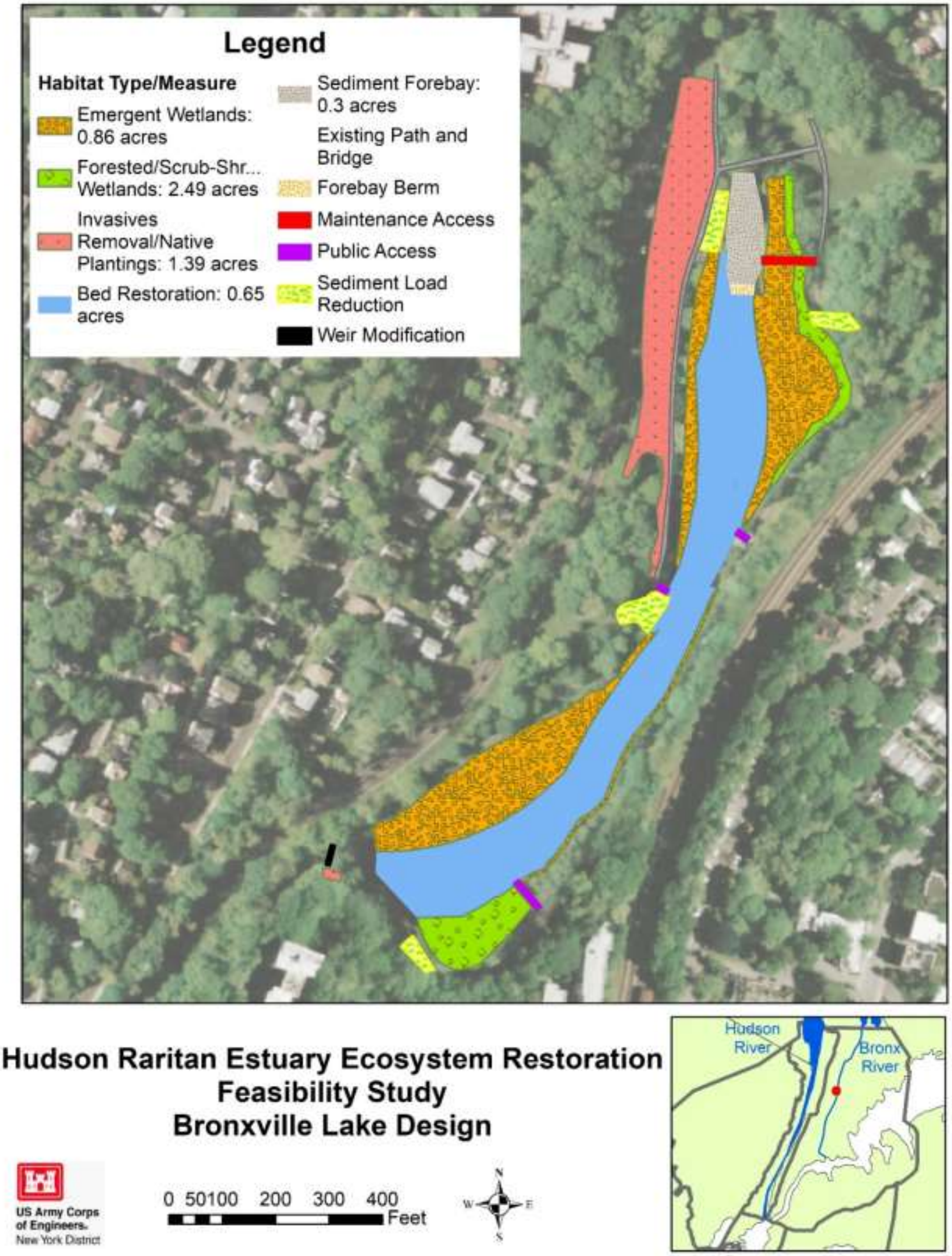

Figure D5- 30. Bronxville Lake – Recommended Plan

5.4.5 Garth Woods/Harney Road

The alternatives developed for Garth Woods/Harney road site include a single alternative for Garth Woods (Alternative A-2) and three (3) alternatives for Harney Road. The single alternative for Garth Woods was developed for a small part of the site in coordination with Westchester County activities.

Garth Woods – Alternative A-2

Alternative A-2 is the only restoration alternative proposed for the Garth Woods site. The Alternative A-2 restoration measures are restricted to the northernmost portion of the site, as restoration of the remainder of the site will be formulated and evaluated independent of this feasibility study by Westchester County. Alternative A-2 entails approximately 0.04 acres of forested and scrub/shrub wetland restoration along the west bank of the river at the upstream end of the site approximately 0.14 acres of select native plantings in the adjacent lawn, on both sides of the paved path; and removing approximately 0.03 acres of invasive species such as Japanese knotweed from a location near the northern border of the site and planting this location with native, upland or wetland shrubs and herbaceous vegetation (Figure D5-31).

Harney Road – Alternative A (Tentatively Selected Plan in Draft Report)

Alternative A entails modifying the existing weir at the southern end of the site to improve hydrology and promote fish passage, modifying approximately 0.86 acres of the river channel upstream of Harney Road and a short off-site section of river channel downstream of the weir by replacing the bed material and constructing in-stream cross vanes, and restoring approximately 0.8 acres of emergent wetlands along both shores of the river (Figure D5-32). Modifying the fish passage impendent would result in providing catadromous and anadromous fish species with 40,448 linear feet of new available habitat in the Bronx River between the Harney Road site and the Kensico Dam. Native upland trees and shrubs will be planted between the restored emergent wetlands on the east shore and the paved path. Three (3) culverts will be constructed under the southbound lanes of the Bronx River Parkway to transfer river water to 2.22 acres of emergent wetlands restored throughout most of the maintained lawn area on the west side. Within these wetlands, a wet meadow will surround a core dominated by cattails. Additional restoration measures will comprise removing approximately 0.03 acres of invasive Japanese knotweed from a location along the west bank of the river, just north of Harney Road, and planting this location with native, upland or wetland shrubs and herbaceous vegetation, installing an 0.03 acre emergent wetland/bio-retention area at the upstream end of the buried storm drain to control erosion at this location and reduce sediment loads reaching the river, and softening a segment (approximately 190 linear feet or 0.01 acres) of the west bank of the river, downstream of the weir, by constructing a stacked rock wall with brush layers. Alternative A provides the greatest ecological uplift of the three (3) alternatives.

Harney Road – Alternative B

The restoration measures included in Alternative A also are included in Alternative B, with the exception of channel modification with in-stream structures, upstream of Harney Road (Figure D5-33). Alternative B will restore the bed of the channel by excavating and replacing approximately 1.34 acres of bed material. Alternative B will not construct culverts under the southbound lanes of the parkway. The extent of emergent wetland restoration within the maintained lawn to the west of the southbound lanes will be restricted to cattail-dominated core described in Alternative A, and 1.46 acres of native upland trees and shrubs will be planted within the Alternative A wet meadow. Emergent wetland restoration is reduced to 0.76 acres including the 0.03 acre emergent wetland/bio-retention area. Invasives will still be removed over an area of 0.02 acre. Weir modification will not incorporate slopes and pools to promote fish passage; the west bank of the river, downstream of the weir, will not be softened; and the off-site section of river channel downstream of the weir will not be modified. Alternative B provides ecological uplift intermediate between the ones provided by Alternatives A and C.

Harney Road – Alternative C

Relative to Alternative B, Alternative C will not restore the river bed; nor will the channel be modified (Figure D5-34). Forested and scrub/shrub wetland restoration will replace emergent wetland restoration over a 0.52 acre area within the maintained lawn to the west of the southbound lanes of the parkway. Patches of emergent wetland over 0.21 acres and the 0.03 acre emergent wetland/bio-retention area will still be restored along the river. The existing weir at the southern end of the site will not be modified; rather, a fish passage will be installed to link the upstream and downstream segments of the river. Invasive vegetation will be removed over 0.02 acres and native plantings will cover approximately 1.46 acres of the site. Alternative C provides the least ecological uplift of the three (3) alternatives.

Figure D5- 31. Garth Woods – Alternative A-2

Figure D5- 32. Harney Road – Alternative A

Figure D5- 33. Harney Road – Alternative B

Figure D5- 34. Harney Road – Alternative C

Garth Woods/Harney Road – Recommended Plan

The recommended plan has been optimized based on Harney Road Alternative A and Garth Woods Alternative A-2 (Figure D5-35). At the Harney Road site, 2.19 acres of the river channel will be modified upstream of Harney Road and a short off-site section of the river channel downstream of the weir by replacing bed material and constructing in-stream cross vanes. Modification of the existing weir at the southern end of site, removing 30 cubic yards of concrete, will improve hydrology and promote fish passage and provide new habitat for catadromous and anadromous fish species between Harney Road and Kensico Dam. 200 linear feet of the west bank downstream of the weir will be softened by constructing a stacked rock wall with brush layer. Along both shores of the river, 0.79 acres of emergent wetlands will be restored. Invasive removal and native species plantings will occur between the emergent wetlands on the east shore and the paved path. Installation of a 0.03 acre emergent wetland/bio-retention area at the upstream end of the buried storm drain will control erosion and reduce sediment loads to the river. Finally, a 1.67 acre wet meadow will be restored in the lawn area on the west side of the Bronx River Parkway.

The Garth Woods restoration is restricted to the northernmost section of the site to complement future habitat enhancement to be performed by Westchester County. On the west bank of the river at the upstream end of the site, 0.035 acres of forested and scrub/shrub wetlands will be restored. Invasive species removal with native plantings will occur along 0.16 acres of the lawn adjacent to the restored wetlands, on both sides of the paved path and near the northern border of the site. Wetland restoration will increase biodiversity, improve aquatic habitat, provide secondary water quality benefits, and increase flood control at both sites. In total 7,260 CY of material will be excavated during clearing and grubbing for invasive species and native plantings activities and emergent wetland, wet meadow, forested scrub/shrub wetland restoration.

The alternatives were designed to complement future habitat enhancements at Garth Woods to be performed by Westchester County. The restoration actions were designed to act in concert with viewscapes of the Bronx River Parkway. Restored forested wetlands may provide potential habitat/roosting resources for endangered bat species, if present. Wetland restoration will provide increased native biodiversity, improved aquatic habitat, and secondary water quality benefits. Reduction of native species will also occur with the implementation of the recommended plan at Garth Woods/Harney Road site. See Engineering Appendix for grading and planting plans for this site.

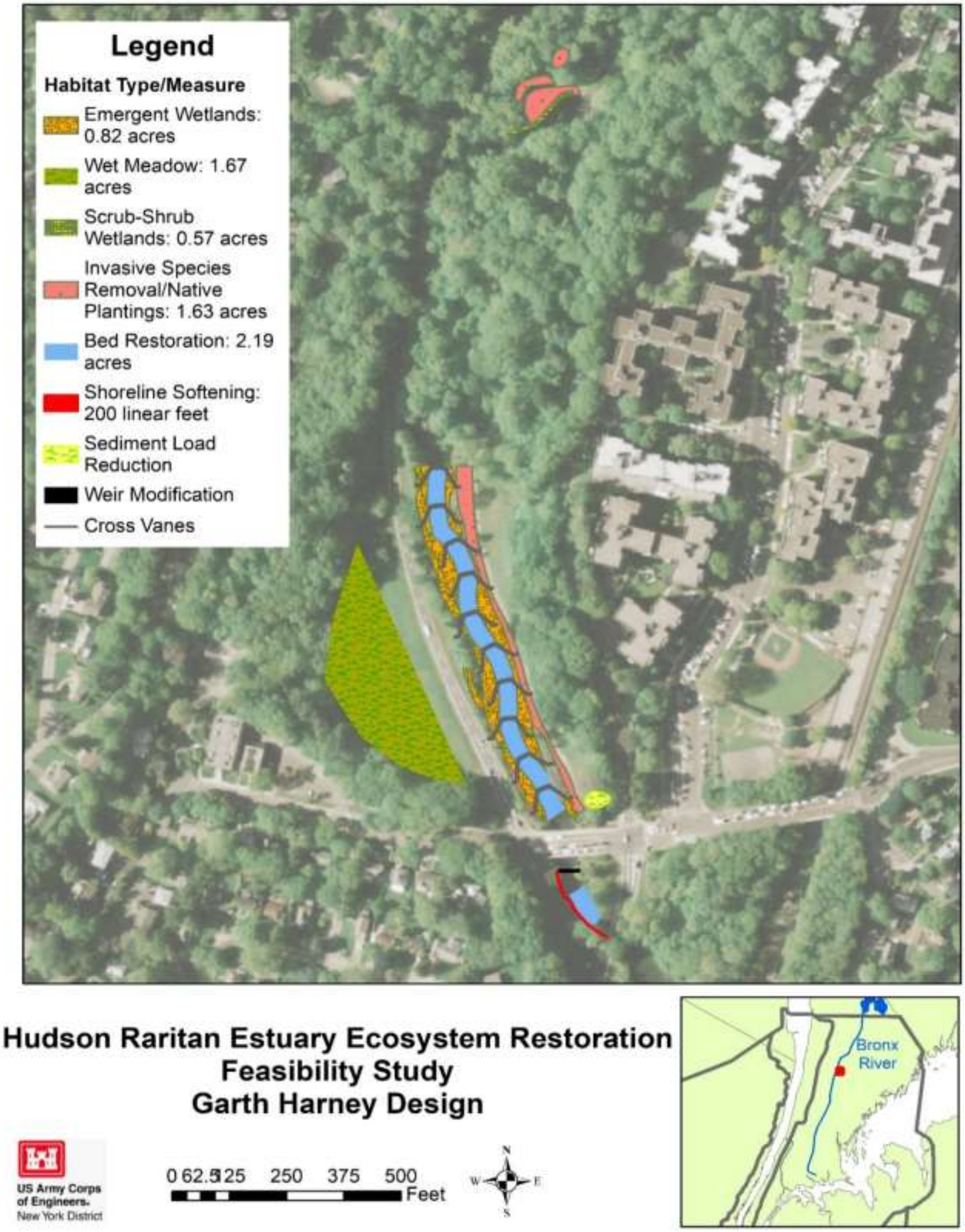

Figure D5- 35. Garth Woods and Harney Road – Recommended Plan

NON-RECOMMENDED SITES

5.4.6 River Park/West Farm Rapids Park

The site provides habitat resources to animals that are largely adapted to an urban environment. Fish habitat is significantly impacted by the presence sewage, garbage, concrete debris, and an upstream dam. The fish ladder would provide improvement to the site's ecology as it would restore a route for anadromous fish and other species to traverse across the dam an access upstream habitats. The three (3) alternatives designed for the River Park/West Farm Rapids Park site focus on ecological restoration of the site's wetland habitat and/or aquatic habitat as well as riparian buffer zone improvements. Natural stream morphology restoration was an important ecological restoration component that was incorporated into each alternative for the site.

The environmental stressors are identified as:
- Limited wetlands on site;
- Considerable anthropogenic impacts (e.g., sewage, debris, etc.); and
- Engineered channel, man-made banks of constructed of debris (e.g., tires, concrete, etc.).

Located in a dense urban environment, improvement of the site would provide immediate environmental improvements that would provide benefits to a local human population that has limited immediate opportunities to experience natural habitats. Moreover, due the prevalence of urban inputs (e.g., outfalls, high density development, etc.) environmental restoration would realize aesthetic, flood control, water quality, and potentially health benefits to the local human population. Moreover, the dam located on site is one of the tallest on the Bronx River and the implementation of ecological improvements, especially those for aquatic fauna (e.g., in-stream structures, bed restoration, debris removal, etc.) will therefore result in positive effects on aquatic fauna and overall water quality. North of the dam, the shorelines of the Bronx River become less developed. The addition of the fish passage at this location, as well as the implementation of other fish ladders on the Bronx River could conceivably allow anadromous fish to once again swim from the mouth to the head of the river. The fish ladder will open approximately 44,163 linear feet of the Bronx River up for anadromous and catadromous fish.

<u>River Park/West Farm Rapids Park – Alternative A</u>

Alternative A (Figure D5-36) entails woodland area along the west side of the River Park/West Farm Rapids Park site, between the dam and 180th Street, with native, upland trees and shrubs. Approximately 0.34 acres of shoreline softening with boulders and facultative plants and 0.04 acres of emergent wetland restoration will be employed along the adjacent east bank of the river, and the river channel will be modified for 0.03 miles using in-stream cross vanes and J-hooks. Downstream of 180th Street, 0.87 acres of invasive vegetation will be removed, and native upland shrubs and herbaceous vegetation will be planted upslope from both banks of the river. In this same river segment, the shoreline will also be softened using stacked rock walls with brush layers along the east bank, and by drilling with native plant materials along the west bank. Debris will be removed from a 0.07 mile stretch of the river bottom throughout most of the river segment downstream of 180th Street. The river channel will be realigned using in-stream cross vanes and J-hooks within a 0.24 acre segment and approximately 0.34 acres of the river bed will be restored by excavating the substrate and replacing it with bedding stone. An additional feature will be improving public access to the river. Alternative A provides the greatest ecological uplift of the three (3) alternatives.

River Park/West Farm Rapids Park – Alternative B (Tentatively Selected Plan in Draft Report)

The restoration measures included in Alternative A also are included in Alternative B, with the exception of channel modification with in-stream structures (Figure D5-37). Where Alternative A employs channel modification between the dam and 180th Street, Alternative B employs only 0.47 acres of bed restoration. The extent of removal of debris from the river bottom is reduced in Alternative B. Alternative B provides ecological uplift intermediate between the uplift created by Alternatives A and C.

River Park/West Farm Rapids Park – Alternative C

Relative to Alternative B, Alternative C eliminates bed restoration, shoreline softening with boulders and emergent wetland plants, and emergent wetland restoration from the river segment between the dam and 180th Street (Figure D5-38). Approximately 0.98 acres of invasives will be removed and native species planted. The extent of shoreline softening in the segment downstream of 180th Street is substantially reduced to 0.06 acres and bed restoration is reduced to 0.36 acres in Alternative C, and only occurs along the east bank, close to the downstream end of the River Park/West Farm Rapids Park site. Alternative C provides the least ecological uplift of the three (3) alternatives.

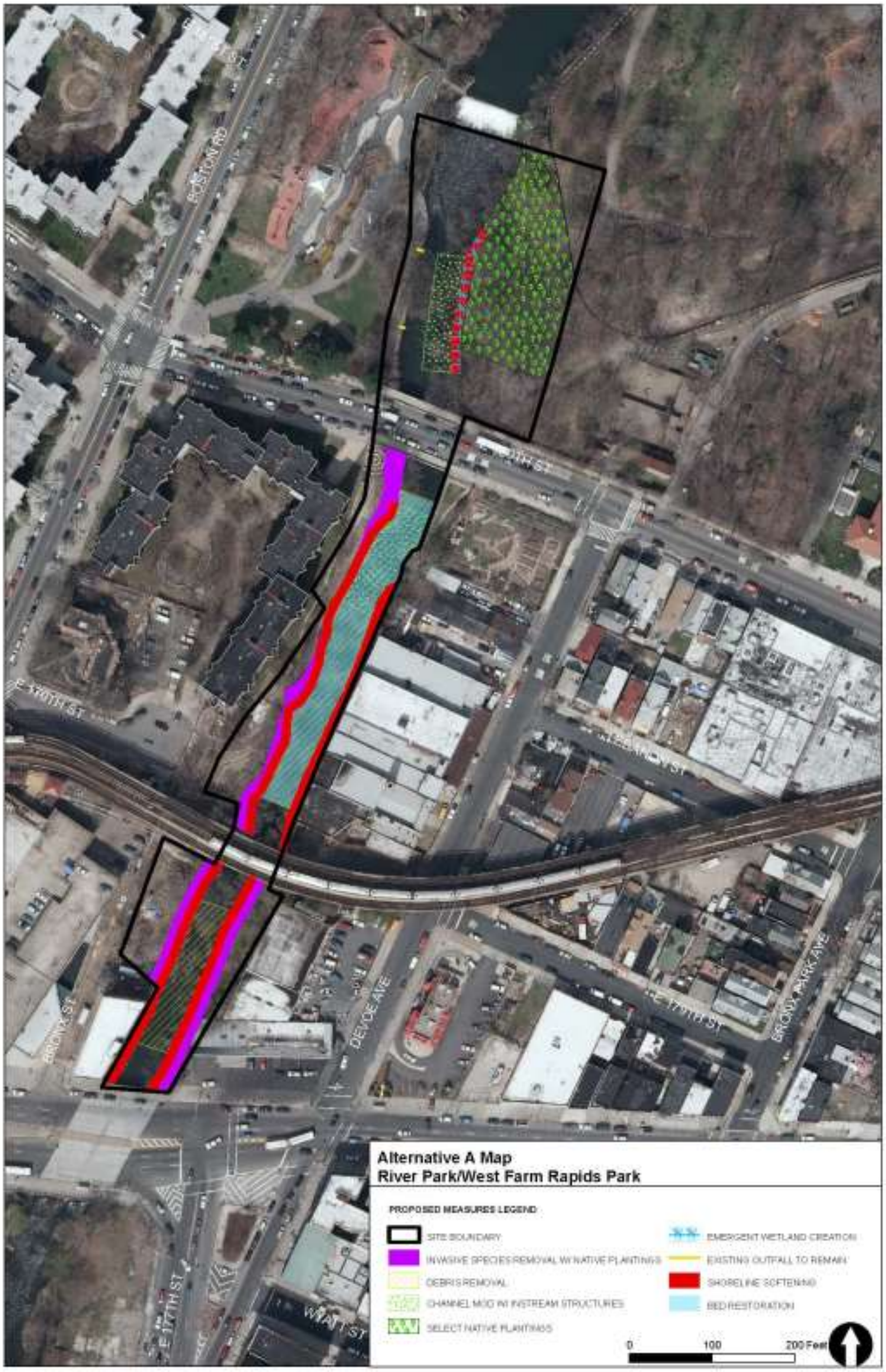

Figure D5- 36. River Park/West Farm Rapids Park – Alternative A

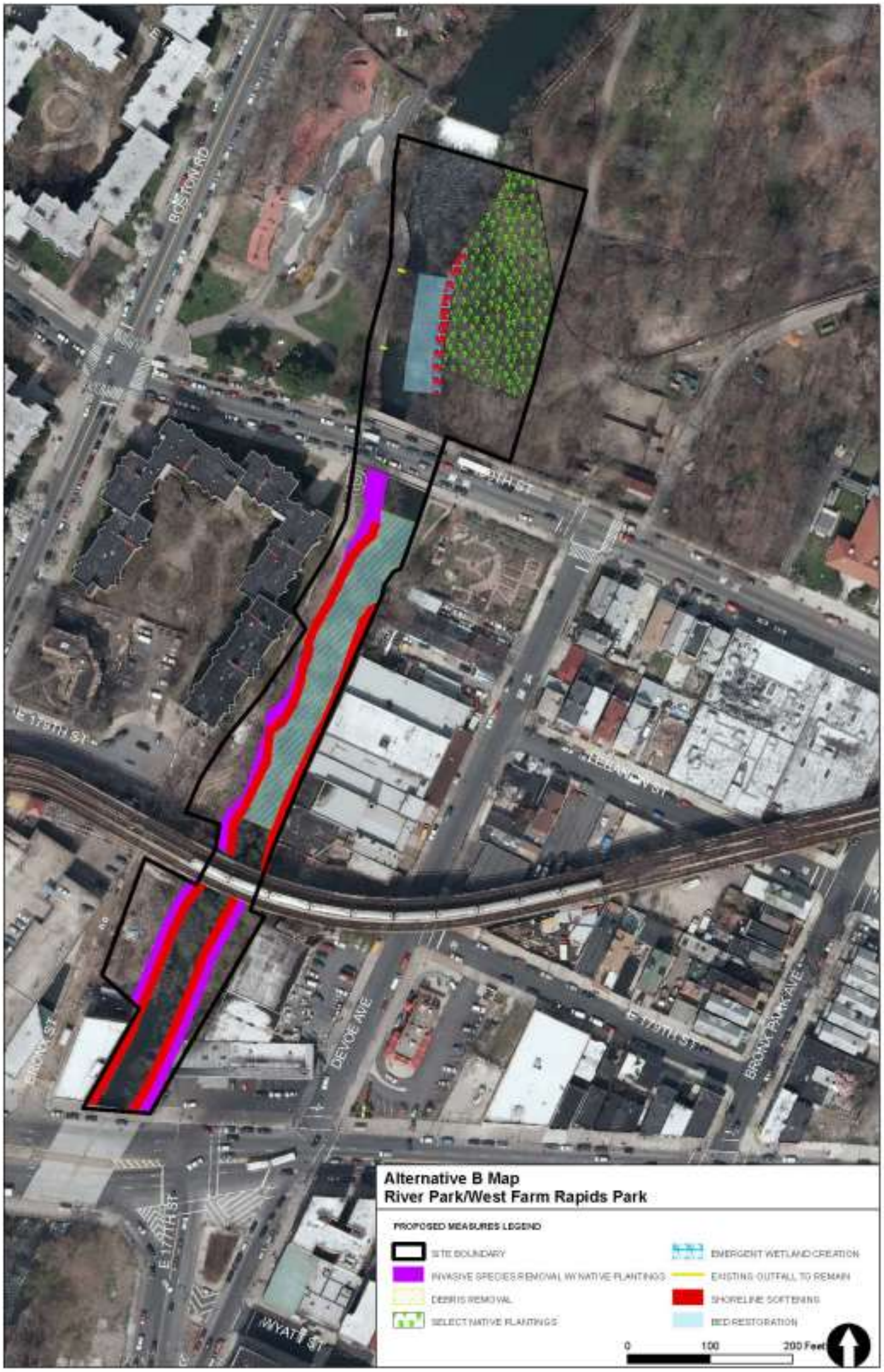

Figure D5- 37. River Park/West Farm Rapids Park – Alternative B

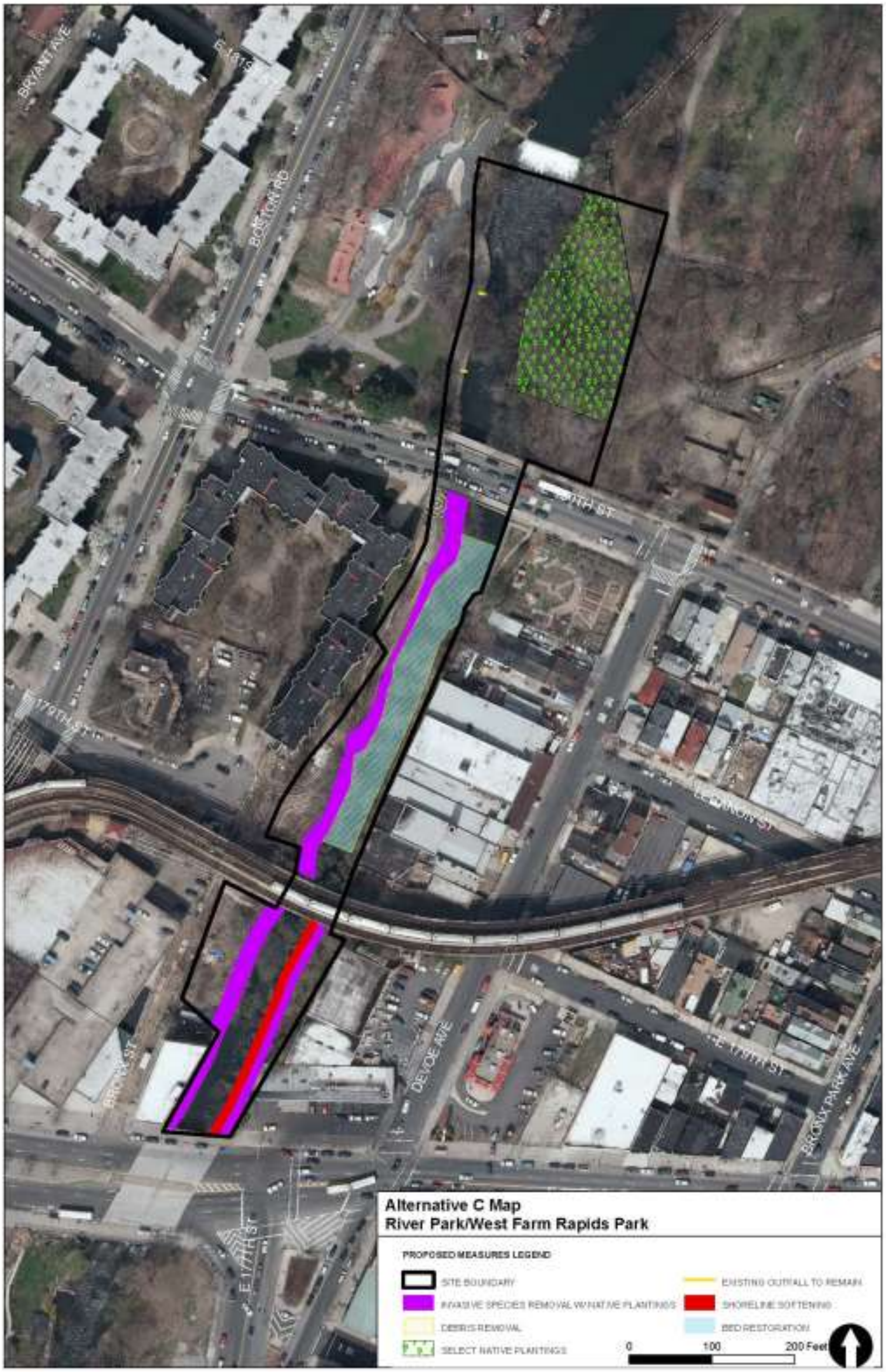

Figure D5- 38. River Park/West Farm Rapids Park – Alternative C

5.4.7 Muskrat Cove

The Muskrat Cove three (3) alternatives are a variation of the same alternative. The measures that are proposed in Alternative A and Alternative B are the same; however, the techniques that are proposed within the measures differ and provide different ecological uplift. For Muskrat Cove, natural stream geomorphology restoration was a main focus when designing the alternatives. Improvements to the wetland, riparian, and aquatic habitat were also ecological restoration goals for the site.

The environmental stressors are identified as invasive species, limited wetlands, engineered banks, poor aquatic habitat, and bank erosion and compromised banks. The river and aquatic environment in the project area was highly engineered with the goal of conveying water past large arterials (e.g., rail lines, roads, etc.) with little thought to potential impacts on the local ecology. The restoration measures consider these needs and were designed to keep the current alignment while utilizing environmental engineering techniques that result in an immediate ecological uplift and increase fish habitat.

Muskrat Cove – Alternative A (Tentatively Selected Plan in Draft Report)

Alternative A entails removing 0.49 acres of invasive vegetation from locations on the upland slopes and along both banks throughout the length of the Muskrat Cove site, and planting these locations with native, upland or wetland shrubs and herbaceous vegetation (Figure D5-39). An additional 10.9 acres of invasives will have a 20% invasives removal and replaced with native plantings. Between Nereid Avenue and the rail line bridge over the river, sections of the river banks (approximately 1,350 linear feet, 0.36 acres) will be stabilized by constructing vegetated cribwalls and other sections will be softened using drilling with native plant materials. Within this portion of the site, 1.24 acres of debris will also be removed from the river and approximately 0.58 acres of shoreline will be softened. Two segments of the channel will be modified by excavating and replacing the bed material on approximately 0.37 acres and constructing in-stream cross vanes and J-hooks. Additional restoration measures will comprise installing a sediment basin at an existing outfall to reduce sediment loads reaching the river and removing a log jam and branch pile in the waterway at the rail line bridge.

Muskrat Cove – Alternative B

The restoration measures proposed in Alternative A are also included in Alternative B. However, within the more upstream of the two (2) river segments where Alternative A will modify the channel with in-stream structures, Alternative B will instead restore the river bed (0.26 acres) (Figure D5-40). In this segment, a riffle-pool complex will be restored by excavating and replacing 0.10 acres of bed material, and placing cut and round boulders.

Muskrat Cove – Alternative C

Relative to Alternative B, Alternative C proposes some of the restoration measures included in Alternative A. Alternative C entails removing invasive vegetation from locations on the upland slopes and along both banks throughout the length of the Muskrat Cove site, and planting these locations with native, upland or wetland shrubs and herbaceous vegetation (Figure D5-41). Alternative C proposes 0.36 acres of streambank restoration between Nerid Avenue and the rail line bridge as well as debris removal in the river and the construction of a sediment basin at an existing outfall to reduce sediment loads reaching the river.

Figure D5- 39. Muskrat Cove – Alternative A

Figure D5- 40. Muskrat Cove – Alternative B

Figure D5- 41. Muskrat Cove – Alternative C

5.4.8 Crestwood Lake

The alternatives proposed for Crestwood Lake are similar to the ecosystem restoration measures that are proposed for Bronxville Lake. The restoration goals for the proposed measures for Crestwood Lake include sediment load reduction, habitat connection and improvements to wetland, riparian and aquatic habitats. Increasing channel flow and reducing stagnation within the channel was also a main focus for the proposed Alternatives.

The environmental stressors are identified as poor aquatic habitat (broad, shallow, with limited flow), nutrient enrichment, barrier to fish passage, sedimentation and erosion, and invasive species. The aquatic habitat at Crestwood Lake is stressed. Nutrient-enriched runoff and the broad shallow slow-flowing waters results in poor water quality. The lake encompasses a 0.25-mile stretch of the river. All alternatives, consider the park-like aesthetic values of the lake, yet are targeted to increase the value of aquatic habitat and improve water quality.

<u>Crestwood Lake – Alternative A (Tentatively Selected Plan in the Draft Report)</u>

Alternative A entails planting three (3) areas, approximately 1.14 acres, in the western portion of the site along the Bronx River Parkway with native, upland trees and shrubs, and removing 0.16 acres of invasive vegetation from three (3) locations along the lake shore and an additional two (2) locations near the weir (Figure D5-42). These locations would then be planted with native, upland or wetland shrubs and herbaceous vegetation. Two (2) rip rap forebays will be constructed, one in the upstream end of the lake and a second at the Troublesome Creek tributary confluence, to cause sediment to settle out of the river and creek flows over 1.89 acres. Within the lake, approximately 1.24 acres of the river channel will be realigned by replacing the bed material and constructing in-stream cross vanes. Throughout the lake, emergent wetland will be restored (approximately 4.79 acres) between the channel and the lake banks. The existing rock weir at the southern end of the lake will be modified to include slopes and pools to promote fish passage. The fish passage will open up 10,499 linear feet of new habitat in the Bronx River for anadromous and catadromous fish between Crestwood Lake and Harney Road site. Additional restoration measures will comprise improving public access to the river. Alternative A provides the greatest ecological benefits and uplift of the three (3) alternatives.

<u>Crestwood Lake – Alternative B</u>

Alternative B eliminates the channel realignment and instead restores approximately 1.24 acres of the bed of the channel by excavating the bottom and installing bedding stone (Figure D5-43). The extent of emergent wetland restored within the lake between the channel and the banks will be restricted to a single location (approximately 0.94 acres), immediately downstream of the forebay at the river inlet, along the west bank of the lake. Invasive vegetation over an area of 0.17 acres will be removed and native vegetation will be planted in addition to 1.14 acres along the western portion of the site. Alternative B provides ecological benefits and uplift intermediate between the uplift provided by Alternatives A and C.

<u>Crestwood Lake – Alternative C</u>

Relative to Alternative B, Alternative C further reduces the extent of emergent wetland restoration to a smaller area of 0.32 acres, immediately downstream of the forebay at the river inlet (Figure D5-44). Invasive vegetation over an area of 0.17 acres will be removed and native vegetation will be planted in addition to 1.14 acres along the western portion of the site. The river channel within Crestwood Lake will not be realigned; nor will the channel bed be restored. Rather, Alternative C will dredge 1.21 acres of the sediment within two (2) small sections of the channel and the adjacent lake bottom to restore deeper pools. Also, under Alternative A, a fish passage will be installed to link the lake and the river downstream of the weir. Alternative C provides the least ecological benefits and uplift of the three (3) alternatives.

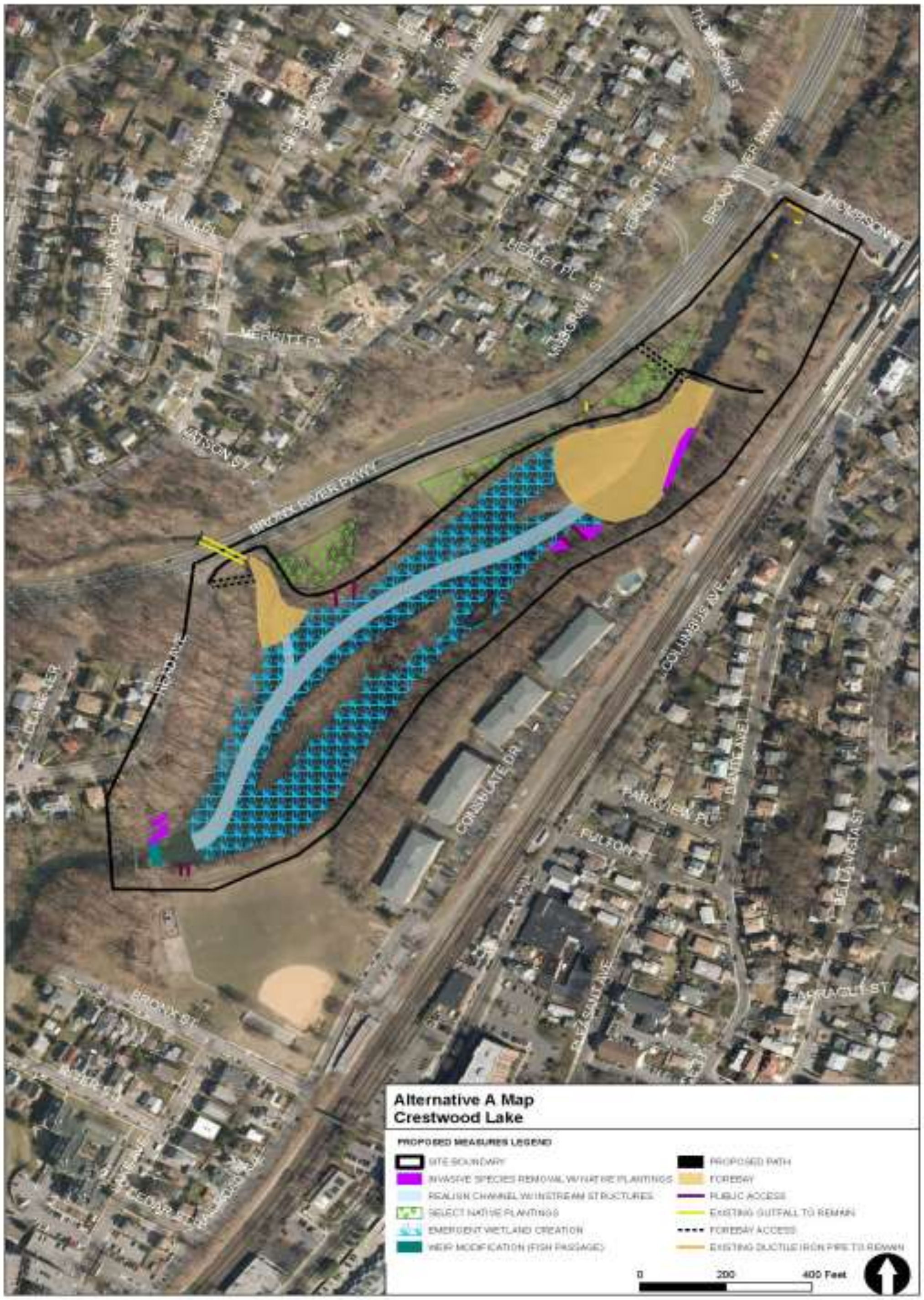

Figure D5- 42. Crestwood Lake – Alternative A

Figure D5- 43. Crestwood Lake – Alternative B

Figure D5- 44. Crestwood Lake – Alternative C

5.4.9 Westchester County Center

The Westchester County Center site is a large site with numerous opportunities for different ecological restoration measures. The restoration measures proposed in the three (3) alternatives provide the site with varying levels of ecological restoration benefits and uplift in order to address the environmental stressors. For the Westchester County Center site, sediment load reduction and wetland habitat improvements proposes significant ecological benefits at the site. Each proposed alternative provides significant ecological benefits and uplift for the Westchester County Center site.

The environmental stressors are identified as garbage and debris, invasive species, bank erosion and sedimentation, and limited wetlands. The project area represents an approximate 0.5-mile long portion of the Bronx River, including the confluence of two (2) tributaries. Located between the north and southbound lanes of the Bronx River Parkway, the site is not likely to be developed. Also, the roadways isolate portions of the site that wildlife would find attractive if appropriate habitats and vegetation were present. There is significant erosion and sedimentation within this stretch of the river. Implementing the restoration alternatives would have positive effects to wildlife; moreover, the placement of wetlands would contribute to lessening flooding in the project area.

Westchester County Center – Alternative A

Alternative A entails realigning approximately 2.0 acres of the river channel and the on-site section of Manhattan Brook, by excavating and replacing the bed material and constructing in-stream cross vanes; and restoring 4.79 acres of emergent wetlands along both shores of the river and along both shores of Manhattan Brook (Figure D5-45). In-stream sediment basins covering 0.09 acres will be constructed in a short segment of Manhattan Brook and in Fulton Brook at its confluence with the river. To restrict river flows to the channel on the west side of the island just north of the Fulton Brook confluence, 0.19 acres of channel plugs will be constructed at the upstream and downstream ends of the channel on the east side of the island, and the plugs will be planted to native upland vegetation. Native, upland trees and shrubs will be planted along 3.42 acres of the west side of the parkway northbound lanes. Additional restoration measures will comprise removing approximately 0.26 acres of invasive vegetation from two (2) locations along the eastern boundary of the site, and planting these locations with select native vegetation, and constructing a 500-foot-long paved path to divert pedestrian traffic away from an emergent wetland restoration area. Approximately 4.79 acres of emergent wetland restoration is proposed along the east and west banks of the channel. Alternative A provides the greatest ecological benefits and uplift of the three (3) alternatives.

Westchester County Center – Alternative B (Tentatively Selected Plan in Draft Report)

The restoration measures included in Alternative A also are included in Alternative B, except the river channel and the on-site section of Manhattan Brook will not be realigned with in-stream structures. Rather, Alternative B will modify segments of approximately 0.99 acres of the river channel by excavating and replacing the bed material, and installing in-stream cross vanes and J-hooks (Figure D5-46). Channel modification of a river segment along the downstream side of the island, and constructing 0.05 acres of native channel plugs at the upstream and downstream ends of the channel on the west side of the island, will shift the Fulton Brook confluence with the river to the east. Alternative B will restore approximately 0.07 acres (285 linear feet) of the west bank of the river with a tiered rock slope and will stabilize a segment of the east bank with a stacked rock wall. Relative to Alternative A, the extent of emergent wetland restoration will be reduced to approximately 2.64 acres and generally, the extent of select native plantings on the site will be increased to 4.13 acres; however, Alternative B will not replant an area along the northern boundary of the site that Alternative A designates for select native plantings. Additional restoration measures in Alternative B will comprise removing invasive vegetation from two (2) locations along the western boundary over 0.27 acres of the site along Manhattan Brook and planting these locations with select native vegetation. Alternative B provides ecological benefits and uplift intermediate between the uplift provided by Alternatives A and C.

Westchester County Center – Alternative C

Alternative C proposes 2.68 acres of emergent wetland restoration along both shores of the river and along both shores of Manhattan Brook (Figure D5-47). In-stream sediment basins will be constructed over 0.09 acres in a short segment of Manhattan Brook and in Fulton Brook at its confluence with the river. Alternative C entails 4.14 acres of native, upland trees and shrubs will be planted along the west side of the parkway northbound lanes and debris remove debris from the upstream portion of the island as well as 0.26 acres of invasive vegetation removal and planting with native vegetation. This alternative will also restore approximately 0.07 acres of the west bank of the river as in Alternative B. Alternative C provides the least ecological benefits and uplift of the three (3) alternatives.

Figure D5- 45. Westchester County Center – Alternative A

Figure D5- 46. Westchester County Center – Alternative B

Figure D5- 47. Westchester County Center – Alternative C

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 6: Lower Passaic River

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

THE PORT AUTHORITY
OF NY & NJ

NYC Parks

NYC Environmental Protection

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6. Lower Passaic River

The Lower Passaic River is located within the Newark Bay, Hackensack River and Passaic River Planning Region. The area has been heavily developed and industrialized since the mid-nineteenth century. This industrial activity has resulted in the degradation of wetlands, discharges of effluents into the streams and rivers, and dumping of industrial waste, thereby contaminating river sediments and adversely impacting fish and wildlife habitat. Shorelines, tidal shallows, natural river channels and riparian forests have been greatly modified by construction of bulkheads, other shoreline alterations, and channel dredging. Dams and tide gates reduce stream connectivity and freshwater flow to Newark Bay, and block upstream and downstream passage of migratory fish.

The restoration opportunities within this region had been identified pursuant the HRE-Lower Passaic River “source” feasibility study. The Lower Passaic River “source” study was initiated in 2003 with New Jersey Department of Transportation (NJDOT) as non-federal sponsor as part of a Governmental Partnership with U.S. Environmental Protection Agency (USEPA) and Natural Resource Trustees (National Oceanic Atmospheric Administration [NOAA], U.S. Fish and Wildlife Service [USFWS], New Jersey Department of Environmental Protection [NJDEP]). The “source” study was a joint Remedial Investigation/Feasibility Study (RI/FS) with USEPA combining both the USACE Water Resources Development Act (WRDA) and USEPA Superfund Program (Comprehensive Environmental Response, Compensation, and Liability Act, 1980 [CERCLA]) to comprehensively remediate and restore the Lower Passaic River basin. The study area included the lower 17 miles of the Lower Passaic River from Newark Bay to the Dundee Dam including tributaries Saddle River, Second River and Third River. The restoration planning within the area was conducted in coordination with the Superfund Program including shared data collection efforts informing site selection. Remedial Action decisions (i.e., Focused Feasibility Study for the remediation of the lower 8.3 miles and non-time critical removal action at river mile [RM] 10.9) have influenced the sequence and type of recommendation for restoration (e.g., construction near-term, construction following remedial actions [“Tier 2” or “deferred”] or future feasibility study).

A total of 53 restoration opportunities were identified along the mainstem of the Passaic River (24) and its tributaries (29). Significant data collection during the coordinated RI/FS was utilized to inform the restoration planning effort. Sites were screened in coordination with NJDEP, partner agencies, the Community Advisory Group (CAG), and a design charrette with NJDEP and the National Oceanic and Atmospheric Administration (NOAA) (June 2015). Through the site screening process a total of five (5) project sites were identified for focused investigations and alternative development (Table D6-1).

Table D6- 1. Lower Passaic River Ecosystem Feasibility Studies Project Sites.

Site
Oak Island Yards
Kearny Point
Essex County Branch Brook Park
Dundee Island Park/ Pulaski Park

Site
Clifton Dundee Canal Green Acres and Dundee Island Preserve

This chapter presents the site screening process that occurred during the "source" study and the alternative development for sites in Lower Passaic River (2016) following integration of this study into the HRE Feasibility Study. Following integration of this study into the HRE Feasibility Study, alternatives were developed, benefits were quantified (Benefits Appendix), costs were prepared (Cost Appendix) and site-specific and regional Cost Effectiveness/Incremental Cost Analysis (CE/ICA) were conducted at each site (Appendix J). This chapter outlines the site screening and alternatives development for the five (5) sites and the subsequent Recommended Plan of two (2) sites within the Newark Bay, Hackensack River and Passaic River Planning Region, specifically along the Passaic River (Table D6-2).

Table D6- 2. Recommended Sites.

Recommended NER Plan Sites
Essex County Branch Brook Park
Oak Island Yards

6.1. Project Area Context

The Passaic River drains portions of the densely populated Bergen, Passaic, Hudson, Essex, and Union counties of New Jersey. Approximately eighty percent (80%) of the land use within the planning region is urban development comprised mainly of residential, commercial, and industrial development. Approximately seven percent (7%) of the region is forested, six and one-half percent (6.5%) is open water, and four and one-half percent (4.5%) is wetland. Less than two percent (2%) is barren land and less than one percent (1%) of land is used for agriculture. This watershed is directly connected to Upper New York Bay and Lower New York Bay through Kill Van Kull and Arthur Kill, respectively.

The Lower Passaic River is identified as the 17-mile, tidally influenced portion of the Passaic River from the Dundee Dam downstream to Newark Bay. The watershed of this reach of the river also includes its tributaries: Saddle River, Second River and Third River. The lower 1.7 miles of the Lower Passaic River are characterized by commercial industry, some of which is dependent on river access, such as the petroleum industry. The Lower Passaic River study area has been heavily industrialized since the mid-nineteenth century. This industrial activity has resulted in the degradation of the wetlands, discharges of effluents into the river, and dumping of industrial waste resulting in contaminated sediments in the river that has adversely impacted fish and wildlife habitat. The project goal of the HRE-Lower Passaic River Ecosystem Restoration Feasibility Study was to coordinate with the USEPA—in addition to the USFWS, NOAA, and the State of New Jersey—to remediate and restore 17 miles of the Lower Passaic River and its tributaries. Data collected for this program are publically available on www.ourpassaic.org.

Lower reaches of the Passaic River provide habitat for marine and estuarine fish and invertebrates, while further upstream, the rivers support a mix of estuarine and freshwater species. The Lower Passaic River is comprised of three river sections – brackish, transitional, and freshwater. The brackish section of the river was defined as the portion that falls between RM 0 and RM 6.0 where the water salinity is defined as almost always mesohaline (5-18 parts per thousand [ppt]) to polyhaline (18-30 ppt). The transitional section was defined as the portion that falls between RM 6 and RM 10 where salinity values fluctuate under typical tidal conditions and saltwater intrusion and mixing. Therefore, water conditions vary continuously from oligohaline (0.5-5 ppt) to mesohaline. The freshwater section upstream of RM 10 to the Dundee Dam.

In all of these sections, the banks of the Passaic River primarily consist of bulkheads, riprap slopes or unvegetated rock and mud flats that quickly slope upwards to developed land or upland parks. Newark Bay's open water is used by many fish and invertebrate species as nursery habitat, although its shorelines and river channels have been greatly modified by dredging, filling, and shoreline stabilization. The hydrology of the rivers has also been altered by numerous water control structures which impede passage for migratory fish. Anadromous fish make annual spawning runs up the 17-mile tidal stretch of the Lower Passaic River to the Dundee Dam, but are blocked from going further.

Extensive development in the region has directly contributed to extensive habitat losses. Many Passaic River tributaries have been converted to storm sewer drainages. Surrounding wetlands were either filled, or mosquito ditches were dug, in order to control mosquito populations. The destruction of shallow water habitats has contributed to poor water quality and has altered the floral and faunal species assemblages. Within the Passaic River watershed, 78 miles of historic rivers, creeks, and tributaries have been lost to filling, draining, or conversion to storm pipes and studies have estimated wetland losses at over 80% (Crawford et al. 1993, Iannuzzi et al. 2002, NJDEP Division of Watershed Management 2002). Considering the river's history and current land use patterns it becomes clear that the study area will never be returned to its historic natural state. However, it is realistic to set goals of restoring a functioning and sustainable urban river system that supports rather than drains community resources.

The lower Passaic River basins and Newark Bay have been a center of industry since the Industrial Revolution. As a result, hundreds of chemical, herbicide, paint and pigment manufacturing plants, petroleum refineries, and other large industrial facilities have been located along their banks. Effluent from these facilities has caused severe contamination of sediments in the rivers. Primary contaminants of concern in the study area include dioxins (2,3,7,8-tetrachlorodidenzo-p-dioxin [TCDD]), mercury, lead, polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and dichlorodiphenyltrichloroethane (DDT). Many of these contaminants pose risks to human and ecological health. Several USEPA Superfund sites exist within this planning region, including the entire 17-mile Lower Passaic River (USEPA, 2016), Newark Bay and portions of the Hackensack River. Pathogenic microbial contamination, floatable-debris, excessive levels of waterborne nutrients, and non-point source discharges further impair water quality. There are strict human consumption advisories for fish and crabs caught from this region. Habitat restoration plans have carefully considered the presence of contamination, the potential for the transport of contaminants, and attractive nuisance issues due to recontamination. In this planning region, the sequencing of restoration opportunities relative to remedial actions are coordinated through integration and partnership with the USEPA Superfund program.

Restoration complements and has been coordinated with ongoing activities within the planning region, specifically along the Passaic River.

- Ongoing USEPA remedial actions within the Lower Passaic River: In addition to the past remedial actions including the Tierra Removal Action adjacent the Diamond Alkali Facility (www.passaicremovalaction.com) and the non-time critical removal action at RM 10.9 in Lyndhurst, the USEPA had released the Record of Decision (ROD) for the cleanup of the lower 8.3 miles of the River (April 2016). In September 2016, USEPA and Occidental Chemical entered into an agreement to prepare the remedial design for cleanup of the lower 8.3 miles of the Passaic to be conducted over four years. Following design, construction is expected to take approximately six (6) years to complete and is estimated at $1.38 billion. Kearny Point and Oak Island Yards Tier 2 sites would be implemented following completion of the remedial action.
- Urban Waters Federal Partnership (UWFP): The Lower Passaic River is one of 19 designated community locations. The UWFP attempts to reconnect urban communities, particularly those that are overburdened or economically distressed by improving coordination among federal agencies and collaborating with community–led revitalization efforts to improve our Nation's water systems and promote their economic, environmental and social benefits. The advancement of restoration within the Lower Passaic is a key component of the UWFP program (https://www.epa.gov/urbanwaterspartners/passaic-rivernewark-new-jersey).
- USACE Passaic River Basin Flood Risk Management Study: The USACE and NJDEP are partnering to carry out the Passaic River Basin General Re-evaluation Study to determine the best flood risk management alternatives (e.g., flood wall levee, non-structural and the tunnel) to help communities throughout the basin. Restoration projects including Dundee Island Park and Clifton Dundee Canal Green Acres sites must be coordinated with this flood risk management study (USACE, 2016).
- NY and NJ Harbor and Tributaries: Many of the restoration opportunities identified during the "source" studies could serve as Natural and Nature-Based Features (NNBFs) providing coastal storm risk management benefits and improved resiliency.
- The Natural Resource Damages (NRD) Assessment and Restoration Program was created to conform with CERCLA. This allows federal and state agencies to implement ecosystem restoration projects provided from the Natural Resource Damages funds. Currently, there is an ongoing assessment of the NRD on the Lower Passaic for over 100 Potential Responsible Parties (PRPs) in the Cooperating Parties Group (CPG) to evaluate the natural resources of the system with regard to contaminated sediments, industrial activities, and limited habitat resources. The CPG signed an agreement with the trustees to pay for the completion of the RI/FS for the 17 mile stretch of the Lower Passaic River. The Diamond Alkali site in Newark was designated as a target site for early action cleanup in the Focused Feasibility Study. The trustees included in this NRD assessment are the USFWS, NOAA, and NJDEP, and with coordination from government agencies and the potential responsible parties, a path forward and additional potential restoration plans will be developed to remediate damages of the Lower Passaic River. The restoration planning outlined for the "source" study, was

coordinated with the resource agencies and the NRD sites were included within the array of sites (http://www.darrp.noaa.gov/northeast/passaic/).

- NJDEP Natural Resource Damage Assessment Grants for restoration at Dundee Island Park and Clifton Dundee Canal Green Acres.
- Green Acres Program: NJDEP developed the Green Acres Program to protect open space and develop parks in New Jersey. Flood plains on the Passaic River are also acquired by Green Acres. Once private land is acquired, it becomes part of a statewide system of parks and natural areas. The Local and Non-profit Assistance Program provides funding and technical assistance to municipal and county governments and non-profit land trusts to acquire land. These efforts result in increased public access to the Passaic River and its tributaries, recreational opportunities, and improved environmental quality of the entire watershed (http://www.nj.gov/dep/greenacres).
- The Passaic Valley Sewerage Commissioners (PVSC) created the Passaic River/Newark Bay Restoration Program in 1998 to promote the recreational and economic uses of Newark Bay, the Passaic River and its tributaries. The Program consists of shoreline clean-ups, floatable debris removal, and "in-house" clean-ups to keep our waterways clean of debris and litter. Education and community outreach is also an important component of the Restoration Program. PVSC also teaches the local children through community outreach about the effects of pollution on the Passaic River (http://www.pvsc.com/rr/index.htm).
- Community groups such as the Ironbound Community Corporation (ICC), Passaic River Coalition, NY/NJ Baykeeper, the Lower Passaic and Saddle River Watershed Alliance and others are working to reincorporate and reconnect the river into the lives of the people living in the adjacent communities. ICC has been working for years to advocate creating safe public access and viewpoints for residents and the community to recreate on the riverbank that has been very influential in the development of their community in Newark. Passaic River Coalition has worked diligently to create new public access points in the form of parks. They led a campaign to encourage businesses and public parkland to “Face the River, Fix the River.” This has been the slogan of the Passaic River Coalition in their effort to establish deed restricted parkland and public access as well as raise awareness of the environmental issues in the area. The Lower Passaic and Saddle River Watershed Alliance (sponsored in part by NJDEP’s watershed management program) has also encouraged stewardship and advocacy of the watershed by holding educational seminars and an annual canoe event. The Alliance also completed a plan in partnership with the National Park Service Recreational Trails Program to design a water trail to encourage public use of the river for non-motorized recreational boating. The Lower Passaic River Canoe & Kayak Trail Plan cites existing public access points and includes plans for future development of new access points and improvements to existing points. The Passaic River Boat Club, Passaic River Rowing Association, and Neried Boat Club all work toward bringing recreational boating back to the Passaic River and actively advocate public access for the Passaic River and conduct cleanups.
- Essex County Branch Brook Park, the nation’s first county park, has the largest collection of cherry blossom trees in the United States and is listed on both the New Jersey (1980) and National (1981) Registers of Historic Places. The restoration efforts are coordinated with the Branch Brook Park Alliance and the Essex County Department of Parks, Recreation and Cultural Affairs to help Essex County restore and revitalize the park.

6.2. Site Screening

Three rounds of screening occurred for restoration opportunities identified in the Lower Passaic River during the implementation of the “source” studies. The screening criteria and process to identify the final array of sites for further evaluation are presented below.

Significant amounts of data collected for the USEPA’s Remedial Investigation and USACE restoration planning efforts were used to inform the site selection and alternatives development. Much of the data has been summarized in the Final Remedial Investigation and Focused Feasibility Study Reports (USEPA, 2014a and 2014b). Specifically, baseline conditions (habitat, sediment quality, biological communities, side scan sonar, geophysical surveys, hydrodynamic surveys, avian community surveys, surface water, bathymetry etc.) within the Lower Passaic River were established through field efforts outlined in Appendix B.

Although significant amounts of data have been collected to characterize baseline conditions in the 17-mile stretch of the Passaic River mainstem, limited data was available for the specific restoration opportunities. Since 2004, restoration opportunities were identified through public outreach, geographic information system (GIS) analysis, baseline surveys conducted as part of the coordinated USEPA and USACE Remedial Investigation/Feasibility Study [RI/FS], field reconnaissance activities (USACE, 2004a, b, c), restoration opportunities report (USACE, 2006) and visioning efforts with municipalities (Figure 1) within the tributaries and the 17-mile river proper. A total of fifty three (53) restoration opportunities were identified from these methods as part of the Lower Passaic Source Study.

In 2007-2008, the USACE conducted baseline vegetation sampling activities in the riparian zone of the brackish, transitional and freshwater sections of the Lower Passaic River. Wetland delineations and bio-benchmark studies were also conducted at a subset of the array of sites outlined in the Restoration Opportunities Report (USACE, 2006) based on site accessibility. Sampling methodology, complete data sets and sample location maps for these activities can be found in the Vegetation Sampling, Wetland Delineation and Bio-benchmark Report (USACE 2008a).

Minimal restoration opportunities were present in the brackish river section due to the highly industrialized nature of both river banks, therefore; only two locations were sampled within the brackish river section (5 vegetation plots). Within the transitional section of the river, a total of six sites were sampled (20 vegetation plots) (Table D6-3).

Table D6- 3. Vegetation Sampling Data Summary

	Brackish (RM 0 to RM 6.0)	Transitional (RM 6.0 to RM 10)
Tree basal area average	479 in^2 (82% native)	2,278 in^2 (86% native)
Shrub cover	24% (80% native species)	25% (63% native species)
Herbaceous cover	81% (20% native species)	78% (29% native species)
Dominant Tree	American elm & Tree of heaven	White mulberry, Box elder & Tree of heaven

	Brackish (RM 0 to RM 6.0)	Transitional (RM 6.0 to RM 10)
Dominant Shrub	Marsh elder	Multiflora rose & red-osier dogwood
Dominant Herbaceous	Japanese knotweed, common reed & Swamp dock	Japanese knotweed & white snakeroot

During the 2007 and 2008 sampling, 143 distinct plant species were observed along the Lower Passaic River. Of these, 45 species were non-native to New Jersey. The results of these sampling activities were used for restoration planning and the Lower Passaic River Plant Restoration Resource Document (USACE 2008b) was developed, using this data, to provide recommended planting lists for the suite of habitats to be restored in each of the three salinity sections. Vision maps were developed for the future navigational use of the river (NJDOT, 2007) which identified potential options and local plans for the Passaic River shoreline.

Proposed CERCLA remedial action decisions and the timing of those actions heavily influenced the sequence and types of restoration actions that could be recommended in the Lower Passaic River study area. A total of 53 sites were identified based on the above study activities and were grouped into the following two categories:

- Tier 1 sites: Opportunities that can advance without remediation, comprising 29 sites.
- Tier 2 sites: Opportunities that require remediation, comprising 24 sites within the mainstem of the river (i.e., sites that may be restored following the USEPA remedial action).

6.2.1. First Round of Site Screening

The 53 sites were prioritized based on screening criteria identified at the re-scoping charrette (January 2013) and coordination with partners (Table D6-4). Based on the direction at a re-scoping charrette, the focus was on Tier 1 sites that could be recommended in the near-term without requiring remediation pursuant the Superfund Program. Sites were screened to determine which sites would be advanced and evaluated further in the feasibility study. The following factors were employed in the screening to select up to 16 sites (due to available funding), as outlined in the scope for field investigation:

- Location within the lower 9 miles of the river (Tier 2 sites);
- Restoration potential, based on Target Ecosystem Characteristic (TEC) type and habitat acreage;
- Known upland on-site contamination;
- Site was to be implemented by others; and
- Determination that the site was an opportunity for a future feasibility study.

This round of screening eliminated 37 sites and brought forward 16. Note: Kearny Point and Oak Island Yards are two Tier 2 sites that were included in the 16 sites to be evaluated further. These sites fulfilled an original goal and intent of the coordinated CERCLA/Water Resource Development Act feasibility study illustrating the intended coordination with the CERCLA Superfund Program, as well as to meet the goals of the project and the restoration of Lower Passaic River. Kearny Point and Oak Island Yards are two mainstem sites providing the most potential for restoration and meeting the project objectives. This aspect of the recommendation is representative of the USEPA/USACE Urban Waters Federal Partnership.

Table D6- 4. Lower Passaic River First Screening

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
1	Kearny Point (Tier 2)	865					
2	Oak Island Yards (Tier 2)	866					
3	Essex County Branch Brook Park	887					
4	Dundee Island Park	900					
5	Clifton Dundee Canal Green Acres	902					
6	Dundee Dam	145					
7	Saddle River Arcola Pool Site	885					
8	Second River Mills	892					
9	Third River Mouth	893					
10	Third River	894					

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
	Clifton Pond						
11	Third River Gen Ridge Country Club	897					
12	Semel Avenue & River Road Parcel	901					
13	Botany Street Small Islands	903					
14	Joe Sesselman Park	905					
15	Joe Sesselman Park Annex	906					
16	Weasel Brook Park	913					
17	Unnamed Tidal Creek Pulaski Skyway (Lawyer's Creek)	867					
18	Jacobus Avenue-Kearny	880					

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
19	Unnamed Tidal Creek-NJ Turnpike	868					
20	Kearny Marsh (Cedar Creek Marsh)	869					
21	Franks Creek Site (1-d Landfill)	870					
22	Path Rail Fringe Marsh	871					
23	Harrison Shoreline Redevelopment	872					
24	PSE&G Shoreline	881					
25	Newark Riverbank Park/Joseph G. Minish Park (Portion)	873					
26	Gateway Park/Joseph G. Minish Park (Portion)	873					
27	Riverfront Park	875					

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
28	Clay Street Lot	876					
29	Franklin-Burlington Plastics Parcel	877					
30	Frank Vincent Park and Boat Ramp	878					
31	Kearny Riverbank Park	879					
32	Saddle River Ox Bow	882					
33	Saddle River Felician College South	886					
34	Saddle River Lodi Cemeteries	884					
35	Saddle River County Park	886					
36	Second River Passaic-Belleville	888					
37	Second River Bloomfield	889					

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
38	Second River Watsessing Park	890					
39	Second River Wigwam Brook Industrial	891					
40	Third River Forest Hills Forest Club	895					
41	Third River JFK Parkway	896					
42	Third River Clarks Pond	898					
43	Third River Alonzo F. Bonsal Wildlife Preservation	899					
44	Dundee Lake Islands at Clifton Elmwood Park	904					
45	Waterfront Access in	907					

#	Site Name	CRP #	First Screening (53 to 16 sites)				
			Within remedial action area (Lower 9 miles) (Tier 2)	Limited Ecosystem Restoration Opportunity	Upland HTRW Concerns	Implemented by Others	Future Feasibility Study Opportunity
	the City of Passaic						
46	Rutherford Memorial Field	908					
47	Route 3 Bridge (PRC) parcels	909					
48	Riverside Co. Park North Hoe Carucci Park/Lyndt Park	910					
49	River Bank Edge Parcels	911					
50	Riverside Park (Bergen Co. South Pk.)	912					
51	Nutley Boat Ramp	923					
52	Kearny Boat Ramp 924	924					
53	Stonewall	925					

6.2.2. Second Round of Screening

Due to inadequate study funding to conduct the necessary field investigations and analysis, a second round of screening was needed to reduce the number of sites. Therefore, the 16 sites were screened using five additional screening criteria: lack of sponsor interest, located in potential upstream remedial action areas (RI/FS identified hot spots of contamination within upstream areas between river miles 9 to 14 and could be remediated in the future), land ownership issues or site slated for future development, concerns with fish passage from Superfund site, and limited ecosystem benefits (Table D6-5). The USACE and the NJDEP, the non-federal sponsor, investigated 11 of these sites in the field, including the collection of Evaluation of Planned Wetland (EPW) data. Included among the 11 sites were two (2) Tier 2 sites for construction following USEPA remedial action, at Kearny Point and Oak Island Yards. The Tier 1 near-term construction sites including Essex County Branch Brook Park, Dundee Island Park, and Clifton Dundee Canal Green Acres Site, were then evaluated similar to other shoreline sites. Kearny Point and Oak Island Yards, Tier 2 sites, were also evaluated further as a result of the original goal and intent of the coordinated CERCLA/Water Resource Development Act feasibility study illustrating the intended coordination with the CERCLA Superfund Program, as well as to meet the goals of the project and the restoration of Lower Passaic River. Kearny Point and Oak Island Yards are two mainstem sites providing the most potential for restoration and meeting the project objectives. This aspect of the recommendation is representative of the USEPA/USACE Urban Waters Federal Partnership. These criteria caused nine (9) sites to be screened out, and seven (7) to advance forward.

6.2.3. Third Round of Screening

The USACE held design charrettes with the NJDEP to discuss the sites and the baseline EPW results, and determine which sites NJDEP would support as the local sponsor for construction (Table D6-5). NJDEP evaluated the data and conducted two site visits, and selected three (3) priority sites, based on the department's assessment of ecological lift and the state's intent to compensate for natural resource damages on the Lower Passaic River. The three (3) sites selected as a priority by NJDEP to further investigate and potentially recommend for near-term construction were Kearny Point, Oak Island Yards, and Essex County Branch Brook. Sites including Botany Street Small Islands and Weasel Brook Park were deleted from further consideration based on low EPW results. In addition, Dundee Island Park and Clifton Dundee Canal Green Acres were deemed for further evaluation due to potential coordination with local restoration efforts.

Table D6- 5. Second and Third Level Screening of Lower Passaic River Sites

#	Site Name	CRP #	Second Screening (16 to 7 sites)				Third Screening (7 to 5 sites)
			Lack of Sponsor Interest	Located in potential Remediation (River mile 9-14)	Land Ownership and/or future development	Fish Passage in Superfund Area	Limited ecosystem benefits
1	Kearny Point (Tier 2)	865	Advanced Tier 2 Site due to high				

#	Site Name	CRP #	Second Screening (16 to 7 sites)				Third Screening (7 to 5 sites)
			Lack of Sponsor Interest	Located in potential Remediation (River mile 9-14)	Land Ownership and/or future development	Fish Passage in Superfund Area	Limited ecosystem benefits
			ecological value				
2	Oak Island Yards (Tier 2)	866	Advanced Tier 2 Site due to high ecological value				
3	Essex County Branch Brook Park	887					
4	Dundee Island Park	900					
5	Clifton Dundee Canal Green Acres	902					
6	Saddle River Arcola Pool Site	885					
7	Dundee Dam	145					
8	Second River Mills	892					
9	Third River Mouth	893					
10	Third River Clifton Pond	894					
11	Third River Gen Ridge Country Club	897					

#	Site Name	CRP #	Second Screening (16 to 7 sites)				Third Screening (7 to 5 sites)
			Lack of Sponsor Interest	Located in potential Remediation (River mile 9-14)	Land Ownership and/or future development	Fish Passage in Superfund Area	Limited ecosystem benefits
12	Semel Avenue & River Road Parcel	901					
13	Botany Street Small Islands	903					
14	Joe Sesselman Park	905					
15	Joe Sesselman Park Annex	906					
16	Weasel Brook Park	913					

A total of five (5) sites were included in the final array of Lower Passaic River as a result of the screening process-Oak Island Yards (Tier 2), Kearny Point (Tier 2), Essex County Branch Brook Park, Dundee Island Park and Clifton Dundee Canal Green Acres were evaluated further in the HRE Feasibility Study. Existing conditions, alternatives development, quantification of benefits (Benefits Appendix), costs (Cost Appendix I) and Cost Effectiveness and Incremental Cost Analysis (CE/ICA) (Appendix J) were conducted for each site.

6.3. Site Specific Existing Conditions and Future Without Project Conditions

The existing conditions of the five (5) project sites, plus the additional reference sites, were assessed during field investigations in the summer of 2015. In addition to data gathered during the field studies, information on site geology, historic river geomorphology, and soils was also compiled and reviewed. Finally, desktop studies of potential uniqueness and heritage elements, as well as water quality classifications, were gathered. The baseline conditions were used as the basis for determining the appropriate restoration actions to be recommended for each site.

A request letter was sent to the New Jersey Natural Heritage Program (NJNHP) for known occurrences of threatened and endangered species within or near the project sites. Based on the correspondence with NJNHP (see Regulatory Appendix), there are recent records of rare species at or within the vicinity of two CRP sites: Kearny Point and Oak Island Yards, as well as at both reference sites. Documented species at the project sites include: short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), osprey (*Pandion haliaetus*), and yellow-crowned night-heron (*Nyctanassa violacea*). Several New Jersey state listed threatened and endangered avian species were observed during site investigations, including: black-crowned night heron (*Nycticorax nycticorax)* at Semel Avenue & River Road Parcel, Dundee Canal Green Acres and Dundee Island Park, and Third River Clifton Pond; and bald eagle (*Haliaeetus leucocephalus*) at Kearny Point.

6.3.1. Oak Island Yards (Tier 2 Site)

The Oak Island Yards site is located along 900 feet of Newark Bay and is bordered by a shipping container yard, railroad tracks, and a HESS petroleum tank farm. A considerable amount of rock and gravel fill has been placed onsite. The area is dominated by non-native invasive vegetation. A ditch with a tide gate is located adjacent to the site, below the railroad track embankment on the southeast border of the site. Since the date of the project mapping aerial photo (2012), the shipping container storage yard has been extended southeast to within approximately 100 feet of the onsite pond and runs the full width of the northwestern boundary of the site. Rock fill extends from the shipping containers all the way to the river along the southeast portion of the site and has also been placed in the river. The remainder of the site is vegetated. Figure D6-1 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix).

A pond surrounded by common reed is present in the center of the site. A small remnant smooth cordgrass marsh and panne measuring approximately 50 feet by 100 feet is present at the northeast corner of the site. A forested wetland area is located in the northeast portion of the site beyond the shoreline. This forested area has a canopy dominated by red maple and eastern cottonwood and a near monoculture of common reed in the understory. A small area of scrub-shrub wetland is found adjacent to the tide gate on the south side of the canal along the southern boundary of the site.

Upland portions of the site include a gravel access road and large fill piles of boulders and riprap. Limited areas of vegetated upland areas are located in the northwest corner of the site adjacent to the forested wetlands. These areas are dominated by invasive plant species, most notably common reed, tree of heaven, and princess tree.

A majority of the banks of Newark Bay at the site contain mounds of boulders and riprap fill material. Two small areas of the site have a sandy shoreline protected by old tide breaks. A small remnant smooth cordgrass marsh measuring approximately 50 feet by 100 feet is present at the northeast corner of the site and is also protected by old tide breaks.

Upland and wetlands at the site are dominated by non-native invasive vegetation, limiting ecological value. The majority of the site contains riprap fill material preventing vegetation growth and further limiting ecological value. The pond area, although surrounded by invasive exotic vegetation, is utilized by *Fundulus heteroclitus* (mummichogs) and a *Butorides virescens* (green heron) was observed foraging. The state-listed black crowned night heron was observed in the ditch adjacent to the site. These species would benefit from habitat enhancement. The remnant smooth cordgrass marsh and panne provide natural habitat for fish and invertebrates, and this ecosystem is uncommon in Newark Bay and the region would therefore benefit from restoration and expansion of this habitat type. Restoration of tidal channels would provide wetland flushing and outwelling of organic nutrients and detritus as well as provide fish habitat. Restoration will not occur until the EPA remedial action is complete.

Figure D6- 1. Oak Island Yards – Existing Conditions

6.3.2. Kearny Point (Tier 2 Site)

The Kearny Point site consists of an approximately 300 to 1,000 foot wide area located along approximately 3,000 linear feet of the northern shore of Newark Bay in Kearny, NJ. The surrounding land use consists entirely of commercial developments and roadways. Adjacent commercial development includes the Hudson County Correctional Center and River Terminal, a massive distribution warehouse that includes the former site of Western Electric's Kearny Works manufacturing plant and the Kearny Yard of Federal Shipbuilding and Drydock Company. Half of the site is an active soil sorting site and half of the site is an undeveloped forested area. Figure D6-2 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix).

A narrow fringe of smooth cordgrass dominated low marsh is located at the base of a bulkhead along the western half of the site. A combination of high marsh vegetated with smooth cordgrass and common reed dominated wetlands are present along the eastern shore of the site. Cement, riprap, and boulders stabilize the shoreline in the western half of the site, while root mats from common reed and smooth cordgrass stabilize the shoreline in the eastern half. The eastern interior portion of the site contains forested wetlands dominated with eastern cottonwood and *Acer saccharinum* (silver maple) with an understory of common reed.

Uplands found within the western half of the site include gravel access roads, massive soil piles, mounds of boulders and active soil sorting areas. Upland areas within eastern half of the site include a forested area which contains a number of non-native and invasive plant species. Trees in this area include eastern cottonwood, silver maple, tree of heaven and princesstree. Herbaceous vegetation in this area is dominated by common reed and Japanese knotweed.

The environmental stressors are identified as:
- Invasive plant species;
- Nutrient inputs;
- Highly degraded wetlands;
- Poor aquatic and wildlife habitat; and
- Shoreline debris.

The site presents high potential for ecological restoration. Presently the site contains very little wetland area and very limited wildlife habitat. Half of the site is devoid of vegetation and a seawall greatly limits the available shoreline wetlands. Even with these constraints, an active *Haliaeetus leucocephalus* (bald eagle) nest is located within one of the eastern cottonwood trees located on site. Shorebirds were observed foraging within the narrow bands of smooth cordgrass marsh and mudflats found along the eastern shoreline and would benefit from ecological enhancement and restoration. Restoration of tidal channels would provide wetland flushing and outwelling of organic nutrients and detritus as well as new fish habitat. Restoration will not occur until EPA cleanup action in the river is concluded. Subsequent coordination with NOAA and USFWS on this site, revealed that a remedial action including capping took place on site in 2015. The presence of a remedial cap prevents future restoration of the site.

Figure D6- 2. Kearny Point-Existing Conditions

6.3.3. Essex County Branch Brook Park

The Branch Brook Park site is located in Newark, New Jersey. The surrounding environment consists primarily of commercial and residential developments and roadways. The site includes a day-lighted section of Branch Brook as well as three (3) larger ponds (Branch Brook Lake, Clarks Pond, and an unnamed pond) that were created using weirs. Branch Brook Park was established by Essex County as the first county park in the nation. The park is notable as having the largest collection of cherry blossom trees in the United States. The park is approximately four miles long and a quarter mile wide and includes open grassland with patches of forest stands that line Branch Brook. The stream and adjacent forest areas contain considerable amounts of anthropogenic trash. The ponds suffer from algal blooms and eutrophication indicative of excess nutrient inputs. Figure D6-3 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix).

A narrow band of forested wetlands is found along the stream. These wetlands are primarily vegetated with *Acer rubrum* (red maple), black willow and *Lindera benzoin* (northern spicebush). Two emergent wetland areas are found in the northern section of this site. These wetland areas are dominated by common reed and broadleaf cattail.

Uplands within the site consist primarily of mowed lawn areas typical of a park setting. Riparian habitats include mixed hardwood trees such as *Fraxinus pennsylvanica* (green ash) and American sycamore. A majority of the south end of the park is forest that is dominated by *Quercus rubra* (red oak), red maple, sweetgum, green ash, and *Acer platanoides* (Norway maple). Shrubland areas are a mixed cover of mowed and unmowed grasses with smaller and newly planted trees such as red maple and red oak.

Most of the stream portions of Branch Brook are stable-with limited erosion issues. Low-flow step weirs manage the water levels within the site. The pond sections have banks that have been stabilized with cement and paver stones. Portions of the stream and ponds suffer eutrophication from excess nutrient runoff.

Figure D6- 3. Essex County Branch Brook Park-Existing Conditions

6.3.4. Dundee Island Park/Pulaski Park

The Dundee Island Park/Pulaski Park site consists of approximately 2,370 linear feet of the western shoreline of the Lower Passaic River located approximately 1.3 miles downstream of the Dundee Dam in Passaic, NJ. An inactive set of railroad tracks and right-of-way border the site to the west and north and a church and commercial properties border the site to the south. The City of Passaic has established Dundee Island Park within the site which includes a soccer field, benches, a playground, trash and recycling bins, a boat launch and fish consumption advisory signage. Flood-driven woody debris and floatable-trash was deposited along the shore of the site. Large ash trees have been removed from the shoreline and bank is now dominated by Japanese knotweed. Within the boundary of the site the bank of the Passaic River is very steep and stabilized with rip-rap and concrete.

Figure D6-4 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix). A very narrow band of forested wetlands is present along the shoreline. These wetlands are primarily vegetated with river birch, black willow and tree of heaven. Riparian uplands within the site consist primarily of shrubland with a mix of native and non-native plant species, grassland, and non-vegetated uplands. The river shore and bottom substrates within the site consist primarily of rip rap, boulders and concrete, although wetland areas are comprised of silt and mud. The stream banks are stable and very steep.

The environmental stressors are identified as:

- Invasive plant species;
- Nutrient inputs;
- Limited wetlands;
- Poor aquatic habitat;
- Shoreline debris; and
- Sparse vegetation.

The site functions as a riparian buffer between the Passaic River and the surrounding commercial and residential development of Passaic. Poorly managed and undirected human visitation throughout the site, the considerable volume of trash and storm-driven trash and debris, steep banks and limited wetland area at the site limit its ecological value. Although the steep banks prohibit wetland restoration, shoreline softening and native plantings will enhance wildlife habitat and provide nutrient removal.

In November 2019, NJDEP, Passaic County and Trust for Public Land (TPL) held a ground breaking ceremony to build an athletic field, concession stand, amphitheater, spray park and river walk on 37 acres adjacent the shoreline. NJDEP has invested $5,000,000 through Green Acres funding and Passaic County's Open Space Trust Fund provided an additional $7,000,000 in the project. The shoreline is still in need of restoration with future conditions characterized with invasive species and minimal habitat.

Figure D6- 4. Dundee Island Park -Existing Conditions

6.3.5. Clifton Dundee Canal Green Acres and Dundee Island Preserve

The Clifton Dundee Canal Green Acres and Dundee Island Preserve site consists of approximately 1,800 linear feet of the western shoreline of the Lower Passaic River downstream of the Dundee Dam in Clifton, NJ. NJ State Route 21 and a commercial property border the landward side of the site. The City of Clifton has established Dundee Island Preserve within the site which includes a trail network, benches, interpretive signage, trash and recycling bins, and fish consumption advisory signage. This site includes the Safas property, which is subject to an NJDEP environmental investigation/cleanup (NJDEP case # E20050092). Large volumes of flood-driven woody debris and floatable-trash have been deposited along the shore of the central portion of the site, immediately below a low, flat peninsula projecting out into the river. An active vagrant campsite strewn with trash was observed during the site visit within the southern portion of the site near Ackerman Ave.

Figure D6-5 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix). Forested and scrub-shrub wetlands occur along portions of the shore of this site. These wetlands are primarily vegetated with river birch, black willow and buttonbush. A thick wrack line of debris washes ashore along some of the wetland areas.

Riparian uplands within the site are primarily forested by native plant species, though some areas are dominated by the invasive plan Japanese knotweed. Large amounts of cement, stone, brick, asphalt and steel debris fill have been historically placed at the site and are now overgrown with vegetation.

The river shore and bottom substrates at the site consist primarily of boulders and cobbles, although wetland areas are comprised of silt, sand and gravel. While portions of the site have been historically filled, some of the river's original floodplain remains. Stream banks are stable-in filled and original floodplain areas.

The environmental stressors are identified as:
- Invasive plant species;
- Nutrient inputs;
- Limited wetlands;
- Poor aquatic habitat; and
- Shoreline debris.

The site functions as an important riparian buffer between the Passaic River and Route 21 and the surrounding commercial and residential development of Clifton. The lack of riparian wetlands, inhabitation by vagrants, and the considerable volume of trash and storm-driven wrack and debris at the site limit its ecological functions and value. Restoration of wetlands would provide flood storage and enhance fish and wildlife habitat. The state-listed black-crowned night heron was observed between this site and the Dundee Dam and would benefit from habitat enhancement. The adjacent Dundee Dam is the upstream end limit of migratory fish passage in the Lower Passaic River; therefore, enhancements to fish habitat would benefit migrating fish species.

Figure D6- 5. Clifton Dundee Canal Green Acres – Existing Conditions

6.4. Proposed Alternatives

Four (4) of the five (5) sites had three (3) different alternatives, differing in functionality and ecological benefits. These sites had the potential for multiple design approaches (e.g. establishment of different upland buffers and/or wetland habitat types, multiple re-route locations of the stream, varying locations for wetland establishment) and varying restoration measures. Examples of variable measures include: a) type of streambank restoration structures (e.g. hard structure vs bioengineering vs plantings, b) acreage of invasive species removal or wetland restoration, or c) number of in-stream structures installed. Only one (1) alternative was prepared for Dundee Island Park since it was a relatively small site with limited restoration opportunities.

The restoration measures proposed for the site alternatives are based on the target ecosystem characteristics (TECs) presented in Chapter 1 of this Plan Formulation appendix. The restoration measures proposed were categorized into the TECs. There are different ecological restoration techniques associated with the proposed ecological restoration measures. Table D6-5 categorizes and explains each restoration habitat type or measure and techniques proposed for the Lower Passaic River and Hackensack River sites.

Shore softening is the removal of concrete, rock or debris and/or the addition of vegetation to an armored shoreline. Streambank restoration is a natural bank shoreline with no wetlands. It is assumed that restoration measures will include site specific actions that could increase various fish habitat and irregularity of stream bank. As part of shoreline softening and streambank restoration measures, wetland plants will be proposed at elevations near the ordinary high water mark, with the intent of restoring a narrow fringe wetland habitat at the site. Shoreline softening techniques include stacked rock wall with brush layers, select rock/concrete removal with native plant materials, and drilling with native plant materials. Streambank restoration techniques include stacked rock wall with brush layers, tired rock slope with native plant benches and pockets, and vegetated crib walls. In-stream structures that are associated with channel realignment and channel modification include cross vanes, skewed cross vanes, and j-hooks. The in-stream structures proposed should have little to no maintenance needed to maintain their functionality. One exception may be removal of fallen trees or large debris following major storm events.

Bed restoration techniques include thalweg restoration, bed material replacement, and restoration of riffle-pool complex. The sediment load reduction ecosystem restoration measures includes techniques such as vegetated swales, outlet protection, culvert replacement, sediment trap and emergent wetlands/bio-retention basins. Benches, wildlife viewing platform/designated area, boat/water access, proposed path, and education signage are all possible proposed public access techniques that could be added in the future and paid for by the non-federal sponsor.

Invasive plant species were identified by the team at every site during field investigations. For all alternatives in any area where existing invasive plant species were found, any measure that is proposed for that area will include the removal of invasive plant species. The alternative maps show ecological restoration measures such as shoreline softening and streambank restoration in areas where existing invasive plant species were observed. The implementation of these measures will include the removal of invasive plant species if present in the proposed measure locations. Based on the Planting Plan for Mamaroneck River Habitat Improvement provided by Westchester County, some large trees and wetland seed mix will be proposed for some sites. In the future, another invasive plant species survey should be conducted before implementation of restoration measures at the site. A tree survey should also be conducted at all of the sites in the future prior to any implementation of site restoration measures to account for type, size, and location of existing trees.

Table D6- 6. Ecological Restoration Measures.

TEC	Habitat Type/ Measure	Description	Techniques
Wetlands (Coastal Wetlands)	Emergent Wetland Restoration	Excavating and grading areas to restore an emergent wetland to replace upland invasive areas to provide a habitat that is less likely to become re-vegetated with the same upland invasive species.	• Excavation and Grading • Select Native Planting
	Forested and/or Scrub/Shrub Wetland Restoration	Excavating and filling areas to restore a forested and/or scrub/shrub wetland to provide continuous fringe habitat around and shade for fish habitat (from trees/shrubs).	• Excavation and Grading • Select Native Planting
	Invasive Species Removal with Native Plantings	Removal of non-native plants and replanting those areas with plants native to the ecosystem. Invasive species removal will be in coordination with other ecological restoration measures	• Invasive Species Removal with Native Plantings
Shorelines and Shallows	Shoreline Softening	The removal of existing structures and armoring and restoring a living shoreline to protect against erosion and to provide and preserve natural habitat.	• Stacked Rock Wall w-Brush Layers • Select Rock/Concrete Removal w-Native Materials • Drilling w-Native Plantings
	Streambank Restoration	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Stacked Rock Wall w-Brush Layers •Tiered Rock Slope w-Native Plant Benches/Pockets • Vegetated Crib Wall

TEC	Habitat Type/ Measure	Description	Techniques
	Riparian Buffer	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Invasive Species Removal with Native Plantings • Select Native Planting
Habitat for Fish, Crab, & Lobsters	Realign Channel w-In-stream Structures	Changing the realignment of the channel and utilizing in-stream structures to modify the channel's hydrology and hydraulic characteristics.	• Cross Vane • Skewed Cross Vane • J-Hook
	Channel Plug with Select Native Plantings (Realign Channel w-In-stream Structures)	Block water from entering the secondary channel to restore a more adequate stream morphology in the main channel section.	• Excavation and Grading • Select Native Planting
	Channel Modification w-In-stream Structures	Modifications within the channel to steer, direct, and/or control the channel away from a specific area. The channel will remain within its current banks, but that sinuosity/more stable-geometry will be achieved with the structures.	• Cross Vane • Skewed Cross Vane • J-Hook
	Bed Restoration	Modifications to the channel bed to restore a low flow channel.	• Thalweg Restoration • Bed Material Replacement • Restoration of Riffle-Pool Complex
	Debris Removal	The removal of substantial debris within the channel.	
	Sediment Dredging	Dredging of sediment laden areas within the channel to fix the hydraulic characteristics within the channel.	
	Forebay/ Sediment Basin	Restoration of forbay/sediment basin to capture sediment laden water and reduce the amount of sediment from settling in the channel.	

TEC	Habitat Type/ Measure	Description	Techniques
	Sediment Load Reduction	The reduction of sediment erosion in a specified location.	• Vegetated Swale • Outlet Protection • Culvert Repair • Sediment Trap • Emergent Wetlands/Bio-retention Basin
Tributary Connections	Fish Ladders	A structure that allows fish to migrate around obstacles like damns.	
	Weir Modification (Fish Passage)	Modifying the existing weir to modify the hydraulic characteristics of the weir.	

Restoration measures will follow floodway regulations as stated in FEMA's CFR 44 Chapter 60.3 regarding no net rise in floodway elevations. Restoration measures will take into consideration cut/fill requirements per site. Once the Feasibility level drawings are prepared, a more detailed cut/fill analyses will be completed to address potential flood inducement constraints per site.

Once the alternatives were developed, benefits were quantified (Appendix E) and first level costs were prepared (Appendix I) in order to conduct CE/ICA (Appendix J) to determine the Tentatively Selected Plan (TSP) alternative at each site. All TSP alternatives within the Planning Region were compared using a regional CE/ICA and resulted in the removal of sites from the Recommended National Ecosystem Restoration (NER) Plan. Restoration at Dundee Island Park and Clifton Dundee Canal Green Acres were subsequently removed from the NER Plan following the regional CE/ICA. In addition, Kearny Point was removed from the NER Plan following coordination with USFWS and NOAA due to prior on-site remedial actions which would preclude restoration. The alternative development is presented in the following sections for all sites. However, only the sites included in the Recommended NER Plan (Oak Island Yards (Tier 2), Essex County Branch Brook Park) present all alternatives and the recommended alternative that had been updated/optimized during feasibility detailed activities. Sites that were removed from the NER Plan (Dundee Island Park, Clifton Dundee Canal Green Acres, and Kearny Point) are presented for information only.

Each alternative for Oak Island Yards was evaluated for Relative Sea Level Change (RSLC) Analysis using the intermediate sea level rise curve. The Recommended NER Plan alternative was evaluated using the low, intermediate and high sea level rise curves. The RSLC analysis was conducted to ensure the restoration was sustainable and provided adequate ecological benefits over the 50 year planning horizon. These results are presented in the Engineering and Benefits Appendices.

SITES RECOMMENDED IN THE NER PLAN

6.4.1 Oak Island Yards (Tier 2 Site)

Oak Island Yards – Alternative A (Tentatively Selected Plan)

Alternative A includes the restoration of approximately 5.85 acres low marsh, 1.31 acres of high marsh, 1.68 acres of forested wetland and 1.86 acres of riparian forested habitat (Figure D6-6). Approximately 1,526 linear feet of tidal channels will be restored in Alternative A, which will provide approximately 0.89 acres of new fish habitat. Approximately 1.40 acres of existing fish habitat will be enhanced. Restoration measures included in Alternative A also include approximately 0.22 acres of streambank restoration and shoreline softening. In order to promote public access, approximately 3,711 linear feet of trail enhancement will occur in concert with the construction of an approximately 0.04 acre pier overlook. The costs of these public access features would be paid for by the non-federal sponsor.

Oak Island Yards – Alternative B

Alternative B includes the restoration of approximately 5.05 acres of low marsh wetland, 2.34 acres of high marsh wetland, and approximately 0.99 acre of forested wetland (Figure D6-7). Similar to Alternative A, Alternative B includes the restoration of 1.86 upland buffer forest habitat. Alternative B restores approximately 1,873 linear feet of new tidal channels which would provide approximately 1.25 acres of new fish habitat. Alternative B enhances approximately 1.40 acres of existing fish habitat. This alternative includes approximately 0.30 acre of streambank restoration and shoreline softening. As in Alternative A, in order to promote public access, Alternative B includes approximately 3,711 linear feet of trail enhancement coupled with the construction of an approximately 0.04 acre pier overlook. Similar to Alternative A, costs for public access features are not included and would be paid for by the non-federal sponsor.

Oak Island Yards – Alternative C

Alternative C includes the same restoration measures in alternatives A and B. Alternative C includes the restoration of approximately 4.70 acres of low marsh wetland and 2.04 acres of high marsh wetland, which are reduced acreages compared to Alternative A and B (Figure D6-8). However, this alternative calls for the restoration of the greatest acreages, approximately 2.21 acres, of forested wetland among the three alternatives. Similar to Alternatives A and B, Alternative C includes the restoration of 1.86 upland buffer forest habitat. Alternative C restores approximately 1,369 linear feet of new tidal channels which would provide approximately 0.54 acres of new fish habitat. Alternative C enhances approximately 1.55 acres of existing fish habitat. This alternative includes approximately 0.28 acre of streambank restoration and shoreline softening. As in the previous alternatives, in order to promote public access, Alternative C includes approximately 3,711 linear feet of trail (paid for by the non-federal sponsor).

Figure D6- 6. Oak Island Yards – Alternative A

Figure D6- 7. Oak Island Yards – Alternative B

Figure D6- 8. Oak Island Yards – Alternative C

Oak Island Yards – Recommended Plan

The recommended plan is the optimized plan based on Alternative A (Figure D6-9). This plan would restore 5.32 acres low marsh, 0.85 acres of high marsh, 0.44 acres of scrub/shrub, and 2.85 acres of maritime forest. Approximately 1.36 acres of tidal channels will be restored providing new fish habitat. Grading and planting plans are included in the Engineering Appendix.

USEPA remedial action would be required prior to restoration. The “source” study for this site (the Lower Passaic River Restoration Study) was initially a joint program with EPA to remediate and restore the river which has been memorialized further as part of the Urban Waters Federal Partnership. EPA will ensure that the appropriate remedial actions will be taken prior to restoration and would be paid for by the responsible parties. The timing of the cleanup will be monitored closely to better plan for the restoration in the future. The EPW benefits calculation assume a clean site and do not account for benefits inherently obtained from the removal of contamination. In addition, the non-federal sponsor (NJDEP) is aware that any further remediation needed on site would be their responsibility (100% of the costs). The restoration at Oak Island Yards would connect valuable habitat with an adjacent 12-acre restoration site currently advancing to buffer against shoreline erosion, improve flood control and remove invasive species as part of the National Fish and wildlife Foundation (NFWF) Hurricane Sandy Coastal Resiliency Competitive Grant Program.

Figure D6- 9. Oak Island Yards – Recommended Plan

6.4.2 Essex County Branch Brook Park

Essex County Branch Brook Park – Alternative A

Alternative A includes restoration measures that affect nearly 100 acres and over 20,000 linear feet of shoreline (Figure D6-10). These measures include the restoration of approximately 26.30 acres of forested scrub/shrub wetland along the stream and edges of ponds. This alternative also includes softening of approximately 10,320 linear feet of shoreline through debris removal and planting with native plants along the stream and ponds throughout the site, and is included in the 26.30 acres above. In order to enhance fish habitat, approximately 23.52 acres of the larger open water ponds will be dredged to deepen these water bodies. Where the stream is confined to a narrower channel, approximately 2.04 acres of stream naturalization and clearing will occur. In steeper upland areas, approximately 8.25 acres will be re-graded and stabilized to be a buffer to the wetland habitats below. New sediment basins totaling approximately 3.80 acres will be constructed throughout the site to capture and treat upland runoff. Invasive plant species removal and native plantings will enhance approximately 5.23 acres of degraded upland riparian forest to act as a wetland buffer/transitional habitat. Finally, to promote public access, approximately 10,453 linear feet of trail enhancement will occur, and 17 interpretive signs will be erected to educate the public and promote awareness of the restoration efforts.

Essex County Branch Brook Park – Alternative B

Alternative B features many of the same restoration measures proposed in Alternative A with some notable differences (Figure D6-11). Alternative B proposes the restoration of approximately 22.90 acres of emergent wetland; these same areas in Alternative A were proposed to be converted to forested wetlands. Similar to Alternative A, Alternative B proposes the deepening of approximately 17.07 acres of the pond areas, but does not propose any stream naturalization and clearing as in Alternative A. Alternative B includes approximately 15,007 linear feet of shoreline softening which is included in the 22.90 acres above. Alternative B features the same bank and slope stabilization as well as invasive plant species removal with native plantings measures proposed in Alternative A. Approximately 5.32 acres of sediment basins will be created in Alternative B. Alternative B also features the creation of 17 interpretive signs for the purpose of public education.

Essex County Branch Brook Park – Alternative C

Alternative C features a reduced number of restoration features (Figure D6-12). This alternative features approximately 10,320 linear feet of shoreline softening as well as approximately 23.52 acres of channel deepening of the pond areas. Alternative C includes the same approximately 5.23 acres of invasive plant species removal with native plantings to enhance the upland buffer riparian forest. Finally, Alternative C includes the construction of 12 interpretive signs.

Essex County Branch Brook Park – Alternative D

Alternative D includes bed restoration in the form of pond deepening and stream naturalization will occur along 18.09 acres of aquatic habitat. Restoration measures also include shoreline softening and 8.91 acres of invasive species removal and native plantings, 8.8 acres of forested scrub/shrub wetland restoration, and 10.25 acres of enhanced emergent wetlands. 3,170 CY will be excavated during stream naturalization and 55,020 CY will be excavated for channel deepening (Figure D6-13).

Restoration measures incorporated into this design would additionally provide enhanced fish habitat. The terrestrial habitat is necessary to provide a buffer to the aquatic habitat and the developed surrounds nearby the site. Grading and planting plans are included in the Engineering Appendix.

Figure D6- 10. Essex County Branch Brook Park – Alternative A

Figure D6- 11. Essex County Branch Brook Park – Alternative B

Figure D6- 12. Essex County Branch Brook – Alternative C

Essex County Branch Brook Park – Recommended Plan (Alternative D)

The recommended plan for this site will enhance both terrestrial and aquatic habitats. Bed restoration in the form of pond deepening and stream naturalization will occur along 18.09 acres of aquatic habitat. Restoration measures also include 8.9 acres of invasive species removal and native plantings, 8.8 acres of forested or scrub/shrub wetland restoration, and 10.25 acres of enhanced emergent wetlands. 3,170 CY will be excavated during stream naturalization and 55,020 CY will be excavated for channel deepening (Figure D6-13).

The selected alternative will also provide shoreline softening and 8.9 acres of invasive plant species removal and/or planting of native vegetation. Restoration measures incorporated into this design would additionally provide enhanced fish habitat. The terrestrial habitat is necessary to provide a buffer to the aquatic habitat and the developed surrounds nearby the site. Grading and planting plans are included in the Engineering Appendix.

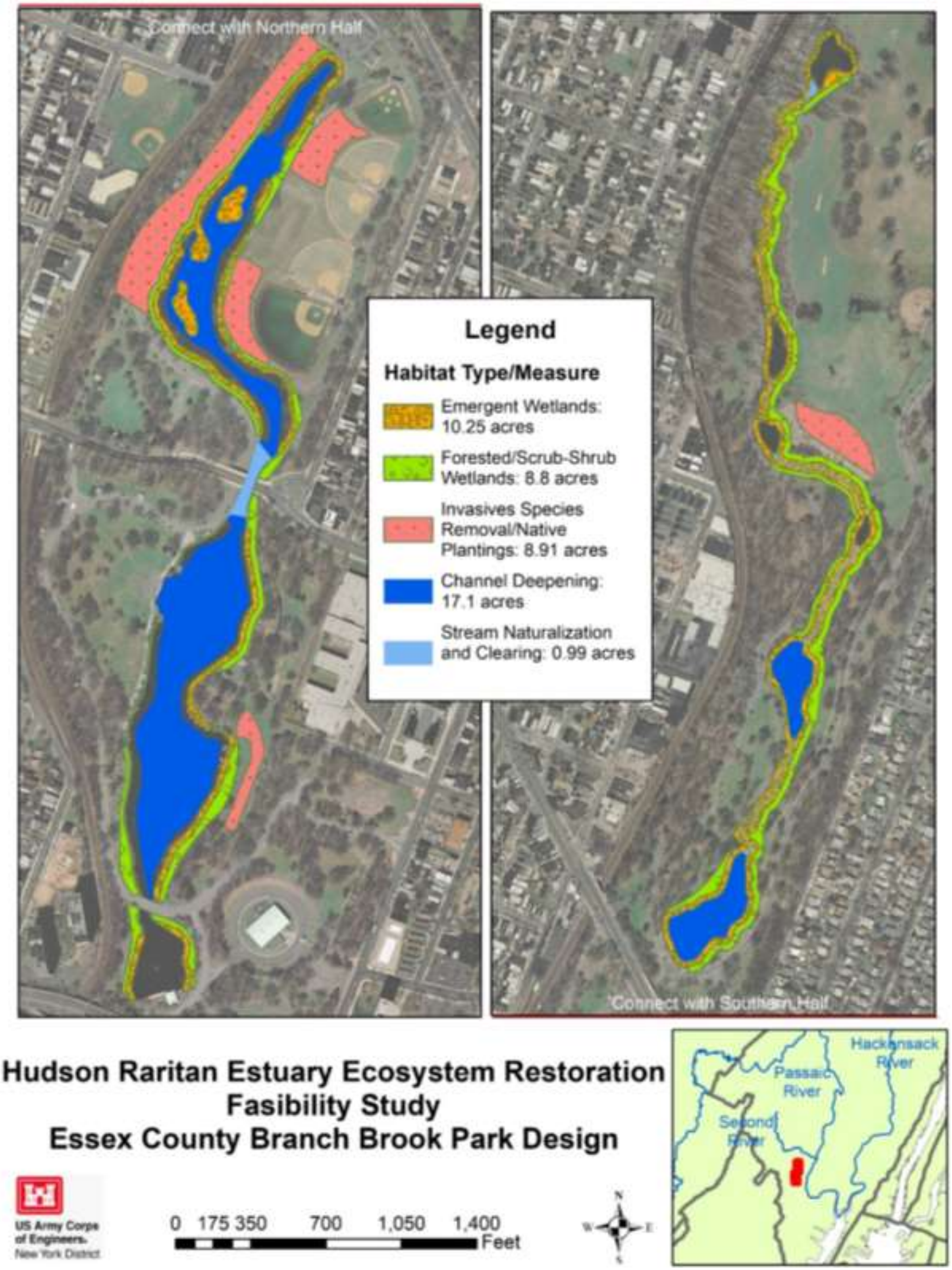

Figure D6- 13. Essex County Branch Brook Park – Recommended Plan

DELETED SITES FROM RECOMMENDED NER PLAN

6.4.3 Kearny Point (Tier 2 Site)

Kearny Point – Alternative A (Tentatively Selected Plan in Draft Report)

Alternative A includes the restoration of approximately 17.83 acres of tidal low marsh wetland and approximately 2.53 acres of tidal high marsh wetland (Figure D6-14). This alternative also includes the restoration of approximately 6.61 acres of forested wetland. Alternative A enhances approximately 6.95 acres of riparian forest presently found on site. Alternative A restores an approximately 3,404 linear feet of tidal channels which will provide approximately 1.82 acres of new fish habitat. Approximately 29.11 acres of existing fish habitat will be enhanced with this alternative through the removal of debris within mudflats, installing boulder and piles, and connecting the mudflats to tidal channels and tidal marsh habitat. Alternative A also includes approximately 1,724 linear feet of streambank restoration and shoreline softening. To provide public access and guide proper public usage of the site, approximately 1,614 linear feet of trail enhancement along with the creation of a 0.07 acre overlook deck is proposed. These public access features are not included in the cost estimate and would be paid for by the non-federal sponsor.

Kearny Point – Alternative B

Alternative B features all of the restoration measures featured in Alternative A with different proposed acreages (Figure D6-15). The major difference between Alternative A and B is that Alternative B proposes higher acreage of upland buffer riparian forest restoration and a subsequent reduction in the acreage of wetland restoration. This translates into approximately 11.28 more acres of riparian forest restoration compared to Alternative A. Alternative B incorporates the restoration of approximately 17.17 acres of low marsh wetland, approximately 2.11 acres of high marsh wetland, and approximately 3.87 acres of forested wetland. Alternative B restores approximately 3,391 linear feet of tidal channels, providing approximately 1.72 acres of new fish habitat. Similar to Alternative A, approximately 29.17 acres of existing fish habitat will be enhanced through this alternative. This alternative includes approximately 1,771 linear feet of streambank restoration and shoreline softening. To provide public access and guide proper public usage of the site, approximately 3,097 linear feet of trail enhancement along with the creation of a 0.07 acre overlook deck is proposed. These public access features are not included in the cost estimate and would be paid for by the non-federal sponsor.

Kearny Point – Alternative C

Alternative C proposes a lesser amount of marsh restoration with higher acreages of forested wetland restoration and upland buffer riparian forest restoration. Alternative C features the restoration of approximately 8.77 acres of low marsh wetland and approximately 1.68 acres of high marsh (Figure D6-16). This alternative restores approximately 11.73 acres, the highest acreage of forested wetland proposed among the alternatives. Additionally, approximately 13.49 acres of upland buffer riparian forest will be restored or enhanced. Alternative C will restore approximately 1,750 linear feet of tidal channel, providing 0.48 acres of new fish habitat. Similar to Alternatives A and B, approximately 29.17 acres of existing fish habitat will be enhanced through this alternative. Alternative C includes approximately 1,776 linear feet of streambank restoration and shoreline softening. To provide public access and guide proper public usage of the site, approximately 4,530 linear feet of trail enhancement is proposed. These public access features are not included in the cost estimate and would be paid for by the non-federal sponsor.

Figure D6- 14. Kearny Point – Alternative A

Figure D6- 15. Kearny Point – Alternative B

Figure D6- 16. Kearny Point – Alternative C

6.4.4 Dundee Island Park

Dundee Island Park – Alternative A

Only one restoration alternative, Alternative A, was developed for this site as there are limited opportunities for restoration available at this site (Figure D6-17). Alternative A includes streambank restoration and shoreline softening (approximately 0.71 acre) through native plantings in concert with removal of portions of the rip rap, boulders and concrete presently used for streambank restoration. Additionally, approximately 1.79 acres of native plantings will occur in the upland buffer section in the northern portion of the site. An approximately 1,580 linear foot trail will be constructed for along the top of the bank to provide public access to the site.

Figure D6- 17. Dundee Island Park– Alternative A

6.4.5 Clifton Dundee Canal Green Acres

Clifton Dundee Canal Green Acres– Alternative A (Tentatively Selected Plan in Draft Report)

Alternative A includes the restoration of approximately 0.10 acres of emergent wetland along the shoreline located in the northern section of the site, just downstream of the dam (Figure D6-18). In the northern third of the site within the river starting at the northern edge, just downstream of the dam, approximately 0.27 acres of fish habitat will be restored, enhanced and preserved by removing fill and debris and incorporating and preserving natural cobble substrate within riffle habitat. The restoration of approximately 2.84 acres of freshwater forested wetlands will occur in the middle and lower half of the site, extending from the shoreline into the interior of the site. Along the entire shoreline and shallows of the site debris will be removed from approximately 0.82 acres. An approximately 0.11 acre sediment basin will be constructed in the center of the site, along the southern boundary, to treat runoff from the uplands and adjacent industrially developed site. The remainder of the riparian upland buffer forest, 5.50 acres, will be enhanced by removing the invasive plant species and planting of native plant species. To promote public access and usage of the site trail enhancement (1,081 linear feet), an overlook (0.1 acre) and a recreational boat launch (718 linear feet access plus 0.15 acre launch) will be constructed in the northern portion of the site. Costs for these recreational features were not included in the project cost estimate and would be paid for by the non-federal sponsor.

Clifton Dundee Canal Green Acres– Alternative B

Alternative B features some of the same measures included in Alternative A (Figure D6-19). Alternative B includes the emergent wetland; fish habitat restoration; debris removal; sediment basin; and overlook detailed in Alternative A. Alternative B does not include any forested wetland restoration, trail enhancement or boat launch. This alternative includes riparian upland buffer forest enhancement of 7.86 acres in the form of invasive plant species removal and native plant species plantings.

Clifton Dundee Canal Green Acres– Alternative C

Alternative C includes fewer restoration measures compared to Alternatives A and B. Alternative C does not include the restoration of additional emergent wetland habitat, fish habitat, or forested wetland habitat. Alternative C includes the 0.82 acres shoreline and shallows debris removal and the restoration of an overlook which are also featured in Alternatives A and B. Alternative C includes the restoration of 7.93 acres of invasive plant removal and native plantings within the riparian forest upland buffer (Figure D6-20). Costs for these recreational features (e.g., overlook) were not included in the project cost estimate and would be paid for by the non-federal sponsor.

Figure D6- 18. Clifton Dundee Canal Green Acres – Alternative A

Figure D6- 19. Clifton Dundee Canal Green Acres – Alternative B

Figure D6- 20. Clifton Dundee Canal Green Acres – Alternative C

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 7: Hackensack River

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

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7. Hackensack River

The Hackensack River is located within the Newark Bay, Hackensack River and Passaic River Planning Region. The area has been heavily developed and industrialized since the mid-nineteenth century. This industrial activity has resulted in the degradation of wetlands, discharges of effluents into the streams and rivers, and dumping of industrial waste, thereby contaminating river sediments and adversely impacting fish and wildlife habitat. Shorelines, tidal shallows, natural river channels and riparian forests have been greatly modified by construction of bulkheads, other shoreline alterations, and channel dredging. Dams and tide gates reduce stream connectivity and freshwater flow to Newark Bay, and block upstream and downstream passage of migratory fish.

As part of the HRE-Hackensack Meadowlands Ecosystem Restoration “Source” feasibility study, the USACE and the New Jersey Meadowlands Commission (now the New Jersey Sports and Exposition Authority [NJSEA]), prepared the Meadowlands Environmental Site Information Compilation (MESIC) Report (USACE, 2004) and the Meadowlands Comprehensive Restoration Implementation Plan (MCRIP) (USACE, 2010). A total of 48 restoration opportunities were identified from the MESIC report. Through the site screening process a total of two (2) project sites were identified for focused investigations and alternative development (Table D7-1).

Table D7- 1. Hackensack River Ecosystem Feasibility Studies Project Sites.

Site
Metromedia Tract
Meadowlark Marsh

This chapter presents the site screening process that occurred during the “source” study and the alternative development for sites in the Hackensack River (2013) following integration of the study into the HRE Feasibility Study. Following integration into the HRE Feasibility Study, alternatives were developed, benefits were quantified (Benefits Appendix), costs were prepared (Cost Appendix) and site-specific and regional Cost Effectiveness/Incremental Cost Analysis (CE/ICA) were conducted at each site (Appendix J). This chapter outlines the site screening and alternatives development for the two (2) sites and the subsequent Recommended Plan of two (2) sites within the Newark Bay, Hackensack River and Passaic River Planning Region, specifically along the Hackensack River.

Table D7- 2. Recommended Sites.

Recommended NER Plan Sites
Metromedia Tract
Meadowlark Marsh

7.1 Project Area Context

The Hackensack River drains portions of the densely populated Bergen and Hudson, counties of New Jersey. Approximately eighty percent (80%) of the land use within the Newark Bay, Hackensack River and Passaic River Planning Region is urban development comprised mainly of residential, commercial, and industrial development. Approximately seven percent (7%) of the region is forested, six and one-half percent (6.5%) is open water, and four and one-half percent (4.5%) is wetland. Less than two percent (2%) is barren land and less than one percent (1%) of land is used for agriculture. This watershed is directly connected to Upper New York Bay and Lower New York Bay through Kill Van Kull and Arthur Kill, respectively.

The Hackensack Meadowlands District is a dominant feature within this region, measuring approximately 19,730 acres. The District contains residential, commercial, industrial, and landfill areas, as well as tidal wetlands and large areas of open space, including the largest remaining brackish wetland complex in the study area, measuring approximately 8,400 acres. As part of the HRE-Hackensack Meadowlands Study effort, USACE and the NJMC identified data gaps and recommended data collection needs to address the Meadowlands region. The MESIC report served to advance the restoration planning and eliminate duplication of data previously collected and recorded.

Lower reaches of the Hackensack River provide habitat for marine and estuarine fish and invertebrates, while further upstream, the rivers support a mix of estuarine and freshwater species. The Hackensack River is primarily brackish and supports wide swaths of tidal marsh with some native vegetation and a significant portion of invasive plants. Newark Bay's open water is used by many fish and invertebrate species as nursery habitat, although its shorelines and river channels have been greatly modified by dredging, filling, and shoreline stabilization. The hydrology of the rivers has also been altered by numerous water control structures which impede passage for migratory fish.

Extensive development in the region has directly contributed to extensive habitat losses. Historic wetland losses have transformed the Hackensack Meadowlands from a rich combination of fresh and saltwater marshland into a less diverse, brackish tidal marsh with a 60% loss in wetland area. Even at this reduced size, the Meadowlands still represents, after Jamaica Bay, the largest remaining tracts of habitat in the HRE study area. Many Hackensack River tributaries have been converted to storm sewer drainages. Surrounding wetlands were either filled, or mosquito ditches were dug, in order to control mosquito populations. The destruction of shallow water habitats has contributed to poor water quality and has altered the floral and faunal species assemblages.

The lower Hackensack River and Passaic River basins and Newark Bay have been a center of industry since the Industrial Revolution. As a result, hundreds of chemical, herbicide, paint and pigment manufacturing plants, petroleum refineries, and other large industrial facilities have been located along their banks. Effluent from these facilities has caused severe contamination of sediments in the rivers. Primary contaminants of concern in the study area include dioxins (2,3,7,8-tetrachlorodidenzo-p-dioxin [TCDD]), mercury, lead, polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and dichlorodiphenyltrichloroethane (DDT). Many of these contaminants pose risks to human and ecological health. Several USEPA Superfund sites exist within this planning region, including the entire 17-mile Lower Passaic River (USEPA, 2016), Newark Bay and portions of the Hackensack River. Pathogenic microbial contamination, floatable debris, excessive levels of waterborne nutrients, and non-point source discharges further impair water quality. There are strict human consumption advisories for fish and crabs caught from this region. Habitat restoration plans have carefully considered the presence of contamination, the potential for the transport of contaminants, and attractive nuisance issues due to recontamination. In this planning region, the sequencing of restoration opportunities relative to remedial actions are coordinated through integration and partnership with the USEPA Superfund program.

Restoration complements and has been coordinated with ongoing activities within the planning region, specifically along the Hackensack River.

- Hackensack Mitigation Banks: Restoration complements the Richard P. Kane Wetland Mitigation Bank (restoration of 240 acres of tidal emergent marsh, streams, mudflats, freshwater forested wetlands and open water) and the MRI-3 Mitigation Bank (51 acres) parcel.
- Lincoln Park Wetlands Restoration Project involved the restoration of over 42 acres of tidal habitats from high marsh to open water and mud flats, provided beneficial reuse of dredge sands as the planting base of the marsh, provided for excavation of more than 250,000 cubic yards of illegally dumped materials to restore the correct marsh elevations, added more than 4,000 feet of new inter-tidal channels, reconnected a pond to the Hackensack River, restored tidal flushing to the pond, and provided walking trails and interpretive signs along the perimeter of the marsh.
- Hackensack Riverkeeper efforts: Restoration supports the Riverkeeper's efforts for environmental education (e.g., eco-tours, eco-cruises, canoeing/kayaking, etc), river cleanups and environmental restoration to protect, preserve and restore the various habitats in the region.
- Hackensack Meadowlands Initiative: Restoration supports municipalities' efforts to improve environmental stewardship and promote ecotourism.

7.2 Site Screening

Three rounds of screening occurred for restoration opportunities identified in the Hackensack River during the implementation of the "source" studies. The screening criteria and process to identify the final array of sites for further evaluation are presented below.

In 2004, the USACE, USFWS, and New Jersey Meadowlands Commission (now the NJSEA)—conducted the Meadowlands Environmental Site Investigation Compilation (MESIC) to identify and catalog existing data, assist in creating a strategy for future data collection, and eliminate the potential for duplicating data (USACE, 2004b). The information compiled in the MESIC report focused on 48 sites within the Meadowlands and also included data relevant to the Meadowlands as a whole (Table D7-3). The MCRIP (USACE, 2010) provided a menu of comprehensive, ecosystem-based actions that address the problems affecting the aquatic environs and associated habitats of the Hackensack Meadowlands. The 48 sites were screened three times using specific criteria described below.

7.2.1 First Round of Screening

Of the 48 sites identified in the MESIC Report, 20 of the sites were identified as "critical restoration opportunities." These 20 sites were selected by using criteria such as:

- Restoring hydrology or wetlands;

- Land ownership, with priority placed on sites owned only by the sponsor (New Jersey Meadowlands Commission); and
- Presence of contamination.

7.2.2 Second Round of Screening

The 20 critical restoration sites were screened further, with input from USFWS coordination that grouped the potential restoration sites into the following three categories (based on presence of contamination):

- Preferred sites (7 sites);
- Potential sites (4 sites); and
- Currently unsuitable sites (9 sites).

At this point, the nine currently unsuitable sites were screened out, leaving 11 sites to advance further.

7.2.3 Third Round of Screening

Of these "USFWS preferred or potential" critical restoration sites, the USACE and NJ Meadowlands Commission selected two restoration sites including Metromedia Tract and Meadowlark Marsh to evaluate further to recommend for near-term construction and are included in the Recommended Plan. These two sites were selected since they are owned by the NJSEA and provided significant ecological benefits. Sites including Richard Kane Natural Area/Empire Tract, Secaucus High School and Anderson Creek were implemented (or planned to be implemented) by others and were removed from further consideration. The other sites Bellman's Creek Marsh, Losen Slote Creek Park, Teterboro woods, Secaucus Tract, Petrillo Tract and Mehrhof Pond were not considered further since the sites were not owned by NJSEA.

Table D7- 3. Hackensack River Site Screening

#	(MCRIP #) Site Name	CRP #	First Screening	Second Screening	Third Screening	
			Critical Restoration Sites from MCRIP	USFWS PAR (Dec. 2004)	Implementation by Others	Sponsor Readiness/ Ownership
1	(22) Metromedia Tract	721				
2	(20) Meadowlark Marsh	719				
3	(14) Richard P. Kane Natural					

#	(MCRIP #) Site Name	CRP #	First Screening	Second Screening	Third Screening	
			Critical Restoration Sites from MCRIP	USFWS PAR (Dec. 2004)	Implementation by Others	Sponsor Readiness/ Ownership
	Area/Empire Tract					
4	(27) Secaucus High School					
5	(11) Anderson Creek	715				
6	(13) Bellman's Creek Marsh	42				
7	(18) Losen Slote Creek Park	522				
8	(30) Teterboro woods	729				
9	(28) Secaucus Tract	727				
10	(25) Petrillo Tract	724				
11	(21) Mehrhof Pond	720				
12	(19) Lyndhurst Riverside Marsh	718				
13	(23) Mori Tract	722				
14	(24) Oritani Marsh	723				
15	(26) Riverbend	725				

#	(MCRIP #) Site Name	CRP #	First Screening	Second Screening	Third Screening	
			Critical Restoration Sites from MCRIP	USFWS PAR (Dec. 2004)	Implementation by Others	Sponsor Readiness/ Ownership
	Wetland Preserve					
16	(29) Steiners Marsh	728				
17	(12) Berry's Creek Marsh	803				
18	(15) Kearny Brackish Marsh	843				
19	(16) Kearny Freshwater Marsh	39				
20	(17) Laurel Hill Park Wetlands	67				
21	(31) Bellman's Creek					
22	(33) Cromakill Creek					
23	(34) Eight Day Swamp					
24	(35) Hackensack River					
25	(36) Kingsland Impoundment					
26	(37) Losen Slote Creek					
27	(38) Mill Creek					

#	(MCRIP #) Site Name	CRP #	First Screening	Second Screening	Third Screening	
			Critical Restoration Sites from MCRIP	USFWS PAR (Dec. 2004)	Implementation by Others	Sponsor Readiness/ Ownership
28	(39) Moonachie Creek					
29	(40) NJSEA Sports Complex-Walden Marsh					
30	(42) Saw Mill Creek					
31	(1) Bellemeade Mitigation					
32	(2) Eastern Brackish Marsh					
33	(3) Harrier Meadow					
34	(4) Hess Mitigation Site					
35	(5) Marsh Resources Meadowlands Mitigation Bank					
36	(6) Mill Creek Marsh					
37	(7) Saw Mill Creek Wildlife Management Area					
38	(8) Skeetkill Creek Marsh					

#	(MCRIP #) Site Name	CRP #	First Screening	Second Screening	Third Screening	
			Critical Restoration Sites from MCRIP	USFWS PAR (Dec. 2004)	Implementation by Others	Sponsor Readiness/ Ownership
39	(9) Vince Lombardi Marsh					
40	(10) Western Brackish Marsh					
41	(43) 1-E Landfill					
42	(44) Avon Landfill					
43	(45) Erie Landfill					
44	(46) Keegan Landfill					
45	(47) Kingsland Landfill					
46	(48) Lyndhurst Landfill					
47	(49) Malanka Landfill					
48	(50) Rutherford Landfill					

A total of two (2) sites were included in the final array for restoration of the Hackensack River as a result of the screening process - Metromedia Tract and Meadowlark Marsh - were evaluated further in the HRE Feasibility Study. Existing conditions, alternatives development, quantification of benefits (Benefits Appendix), costs (Cost Appendix I) and Cost Effectiveness and Incremental Cost Analysis (CE/ICA) (Appendix J) were conducted for each site.

7.3 Site Specific Existing Conditions and Future Without Project Conditions

Section 6.1 provides background information on existing conditions within the Lower Passaic and Hackensack Rivers. The existing conditions of the seven (7) project sites, plus the additional reference sites, were assessed during field investigations in the summer of 2015. In addition to data gathered during the field studies, information on site geology, historic river geomorphology, and soils was also compiled and reviewed. Finally, desktop studies of potential uniqueness and heritage elements, as well as water quality classifications, were gathered. The baseline conditions were used as the basis for determining the appropriate restoration actions to be recommended for each site.

A request letter was sent to the New Jersey Natural Heritage Program (NJNHP) for known occurrences of threatened and endangered species within or near the project sites. Based on the correspondence with NJNHP (see Regulatory Appendix), there are recent records of rare species at or within the vicinity of two CRP sites: Meadowlark Marsh and Metromedia Tract as well as at other removed sites. Documented species at the projects sites include: short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), osprey (*Pandion haliaetus*), and yellow-crowned night-heron (*Nyctanassa violacea*). Several New Jersey state listed threatened and endangered avian species were observed during site investigations, including: black-crowned night heron (*Nycticorax nycticorax)* at Harrison Marsh and osprey (*Pandion haliaetus*) at Metromedia Tract.

7.3.1 Metromedia Tract

The Metromedia Tract project site is located in Carlstadt, Bergen County, New Jersey. The site is bordered by the Hackensack River to the east and south and by the Marsh Resources Meadowlands Mitigation Bank to the north. The site is underdeveloped and dominated by common reed. The property likely contains fill from unknown sources during construction of nearby radio towers.

It is bordered on the east and south by the Hackensack River and on the north by the Marsh Resources Meadowlands Mitigation Bank. The site is undeveloped and dominated by common reed. The site likely contains fill from unknown sources during the construction of the radio towers. The property was acquired by the New Jersey Meadowland Commission (now the New Jersey Sports and Exposition Authority) in July 2003.

Figure D7-1 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix). The site is primarily comprised of common reed-dominated emergent wetland due to restricted tidal flow. A number of small tidal channels connect this site to the Hackensack River. They are bounded by common reed and have gradually sloped mud banks and bottoms. Upland areas, which include tower maintenance roads, parking lots, and a dirt access road, will not be included in any restoration measures.

Figure D7- 1. Metromedia Tract – Existing Conditions

7.3.2 Meadowlark Marsh

The site is bounded to the south by Bellmans Creek, to the north and west by the New Jersey Turnpike – Eastern Spur, and to the east by 83rd street and active railroad tracks in Ridgefield, Bergen County, NJ. The upland area of the site is currently used as a dirt track for off-road vehicles, limiting the habitat available in upland areas. Pesticide overspray into a portion of the site from the utility right-of-way has been observed. The surrounding environment consists of a combination of commercial developments, roadways, New Jersey Turnpike service area, and common reed dominated emergent marshes. The site includes powerline and pipeline rights-of-way and associated access roads.

The site is primarily comprised of common reed-dominated emergent wetlands divided by utility access roads and other areas of fill. Historic fill material bisects the site. Several small emergent marsh areas within the common reed are dominated by sedges and ferns. Forested and scrub-shrub wetlands occur where the upland fill areas transition to emergent marsh. These wetlands are dominated by red maple, eastern cottonwood, and eastern baccharis. Mudflats are present in the bends of Bellmans Creek along the southern boundary of the site. Figure D7-2 provides the baseline conditions at the site as characterized by Evaluation of Planned Wetlands (see Benefits Appendix).

A mowed grass vegetated upland access road bisects the northern third of the site. A small, approximately 3 acre forested upland area is adjacent to the New Jersey Turnpike within the southern third of the site. This upland forested area is found above historic fill material and is dominated by black cherry, black locust and gray birch.

The site is primarily connected to the Hackensack River by Bellmans Creek. The banks along Bellmans Creek consist of mudflat and common reed stands and root mats. These banks appear to be stable. There are a few secondary channels connecting to Bellmans Creek. Several open water channels and ponded areas are interspersed among the northern sections of common reed marsh but their sources and connectivity are unclear. Runoff from development along Westside Avenue, the New Jersey Turnpike, and 83rd Street (Railroad Ave.) may be sources of freshwater hydrology supporting the onsite ponds.

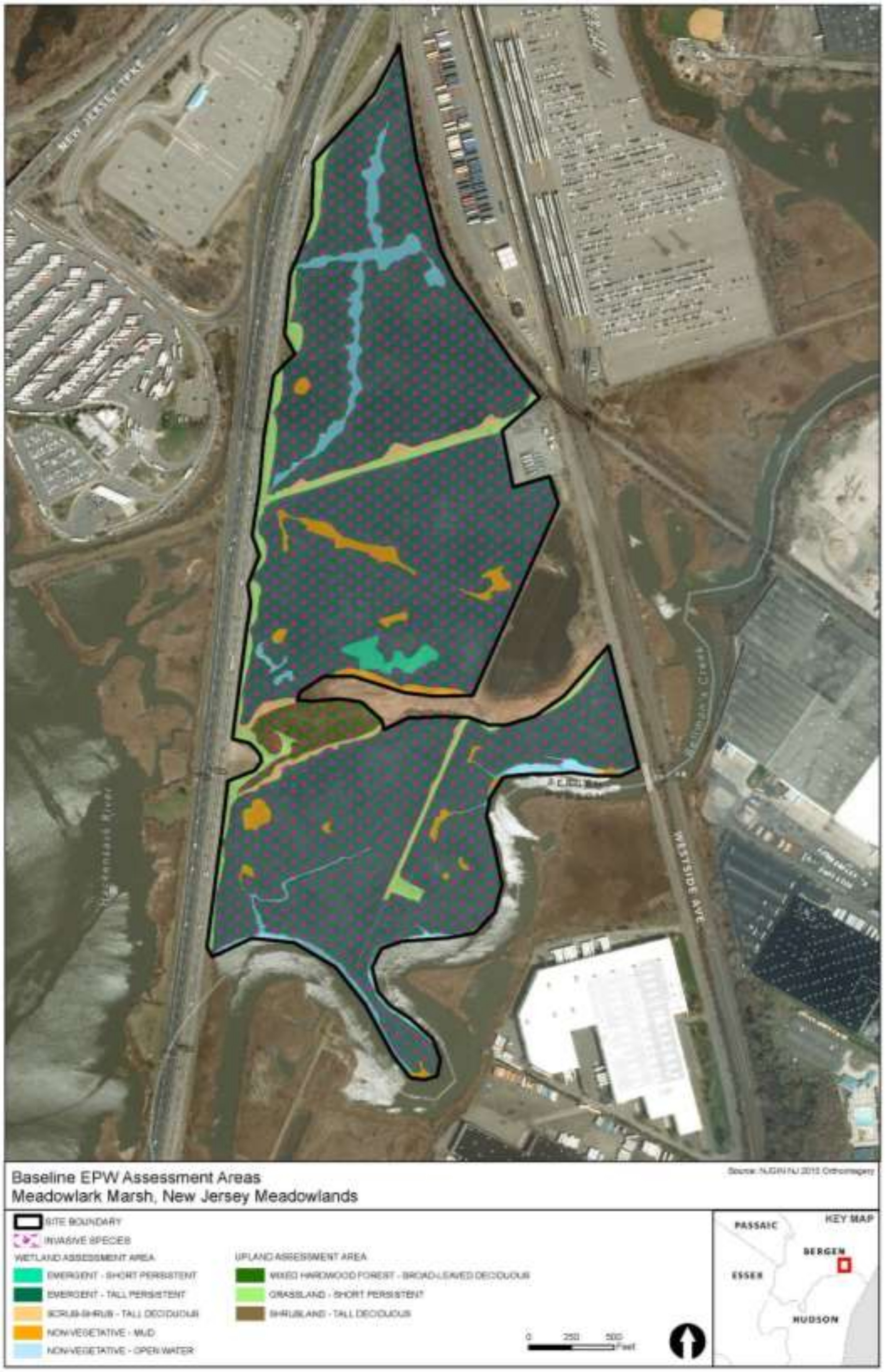

Figure D7- 2. Meadowlark Marsh – Existing Conditions

7.4 Proposed Alternatives

Both of the recommended sites had three (3) different alternatives, differing in functionality and ecological benefits. These sites had the potential for multiple design approaches (e.g. establishment of different upland buffers and/or wetland habitat types, multiple re-route locations of the stream, varying locations for wetland establishment) and varying restoration measures. Examples of variable measures include: a) type of streambank restoration structures (e.g. hard structure vs bioengineering vs plantings, b) acreage of invasive species removal or wetland restoration, or c) number of in-stream structures installed.

The restoration measures proposed for the site alternatives are based on the target ecosystem characteristics (TECs) presented in Chapter 1 of this Plan Formulation appendix. The restoration measures proposed were categorized into the TECs. There are different ecological restoration techniques associated with the proposed ecological restoration measures. Table D7-4 categorizes and explains each restoration habitat type or measure and techniques proposed for the Lower Passaic River and Hackensack River sites.

Shore softening is the removal of concrete, rock or debris and/or the addition of vegetation to an armored shoreline. Streambank restoration is a natural bank shoreline with no wetlands. It is assumed that restoration measures will include site specific actions that could increase various fish habitat and irregularity of stream bank. As part of shoreline softening and bank stabilization measures, wetland plants will be proposed at elevations near the ordinary high water mark, with the intent of restoring a narrow fringe wetland habitat at the site. Shoreline softening techniques include stacked rock wall with brush layers, select rock/concrete removal with native plant materials, and drilling with native plant materials. Streambank restoration techniques include stacked rock wall with brush layers, tired rock slope with native plant benches and pockets, and vegetated crib walls. In-stream structures that are associated with channel realignment and channel modification include cross vanes, skewed cross vanes, and j-hooks. The in-stream structures proposed should have little to no maintenance needed to maintain their functionality. One exception may be removal of fallen trees or large debris following major storm events.

Bed restoration techniques include thalweg restoration, bed material replacement, and restoration of riffle-pool complex. The sediment load reduction ecosystem restoration measure includes techniques such as vegetated swales, outlet protection, culvert replacement, sediment trap and emergent wetlands/bio-retention basins. Benches, wildlife view platform/designated area, boat/water access, proposed path, and education signage are all possible proposed public access techniques that could be added in the future and paid for by the non-federal sponsor.

Invasive plant species were identified by the team at every site during field investigations. For all alternatives in any area where existing invasive plant species were found, any measure that is proposed for that area will include the removal of invasive plant species. The alternative maps show ecological restoration measures such as shoreline softening and streambank restoration in areas where existing invasive plant species were observed. The implementation of these measures will include the removal of invasive plant species if present in the proposed measure locations. Based on the Planting Plan for Mamaroneck River Habitat Improvement provided by Westchester County, some large trees and wetland seed mix will be proposed for some sites. In the future, another invasive plant species survey should be conducted before implementation of restoration measures at the site. A tree survey should also be conducted at all of the sites in the future prior to any implementation of site restoration measures to account for type, size, and location of existing trees.

Table D7- 4. Ecological Restoration Measures.

TEC	Habitat Type/ Measure	Description	Techniques
Wetlands (Coastal Wetlands)	Emergent Wetland Restoration	Excavating and grading areas to restore an emergent wetland to replace upland invasive areas to provide a habitat that is less likely to become re-vegetated with the same upland invasive species.	• Excavation and Grading • Select Native Planting
	Forested and/or Scrub/Shrub Wetland Restoration	Excavating and filling areas to restore a forested and/or scrub/shrub wetland to provide continuous fringe habitat around and shade for fish habitat (from trees/shrubs).	• Excavation and Grading • Select Native Planting
	Invasive Species Removal with Native Plantings	Removal of non-native plants and replanting those areas with plants native to the ecosystem. Invasive species removal will be in coordination with other ecological restoration measures	• Invasive Species Removal with Native Plantings
Shorelines and Shallows	Shoreline Softening	The removal of existing structures and armoring and restoring a living shoreline to protect against erosion and to provide and preserve natural habitat.	• Stacked Rock Wall w-Brush Layers • Select Rock/Concrete Removal w-Native Materials • Drilling w-Native Plantings
	Streambank Restoration	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Stacked Rock Wall w-Brush Layers •Tiered Rock Slope w-Native Plant Benches/Pockets • Vegetated Crib Wall
	Riparian Buffer	Establishing and implementing measures to prevent and/or fix erosion and stabilize the embankment.	• Invasive Species Removal with Native Plantings

TEC	Habitat Type/ Measure	Description	Techniques
			• Select Native Planting
Habitat for Fish, Crab, & Lobsters	Realign Channel w-In-stream Structures	Changing the realignment of the channel and utilizing in-stream structures to modify the channel's hydrology and hydraulic characteristics.	• Cross Vane • Skewed Cross Vane • J-Hook
	Channel Plug with Select Native Plantings (Realign Channel w-In-stream Structures)	Block water from entering the secondary channel to restore a more adequate stream morphology in the main channel section.	• Excavation and Grading • Select Native Planting
	Channel Modification w-In-stream Structures	Modifications within the channel to steer, direct, and/or control the channel away from a specific area. The channel will remain within its current banks, but that sinuosity/more stable geometry will be achieved with the structures.	• Cross Vane • Skewed Cross Vane • J-Hook
	Bed Restoration	Modifications to the channel bed to restore a low flow channel.	• Thalweg Restoration • Bed Material Replacement • Restoration of Riffle-Pool Complex
	Debris Removal	The removal of substantial debris within the channel.	
	Sediment Dredging	Dredging of sediment laden areas within the channel to fix the hydraulic characteristics within the channel.	
	Forebay/ Sediment Basin	Restoration of forebay/sediment basin to capture sediment laden water and reduce the amount of sediment from settling in the channel.	
	Sediment Load Reduction	The reduction of sediment erosion in specified location.	• Vegetated Swale • Outlet Protection • Culvert Repair • Sediment Trap

TEC	Habitat Type/ Measure	Description	Techniques
			• Emergent Wetland/Bio-retention Basin
Tributary Connections	Fish Ladders	A structure that allows fish to migrate around obstacles like damns.	
	Weir Modification (Fish Passage)	Modifying the existing weir to modify the hydraulic characteristics of the weir.	

Restoration measures will follow floodway regulations as stated in FEMA's CFR 44 Chapter 60.3 regarding no net rise in floodway elevations. Restoration measures will take into consideration cut/fill requirements per site. Once the Feasibility level drawings are prepared, a more detailed cut/fill analyses will be completed to address potential flood inducement constraints per site.

Once the alternatives were developed, benefits were quantified (Appendix E) and first level costs were prepared (Appendix I) in order to conduct CE/ICA (Appendix J) to determine the Tentatively Selected Plan (TSP) alternative at each site. All TSP alternatives within the Planning Region were compared using a regional CE/ICA and resulted in the removal of sites from the Recommended National Ecosystem Restoration (NER) Plan. The alternative development is presented in the following sections for all sites. However, only the sites included in the Recommended NER Plan (Metromedia Tract and Meadowlark Marsh) present all alternatives and the recommended alternative that had been updated/optimized during feasibility detailed activities.

Each alternative (Metromedia Tract and Meadowlark Marsh) was evaluated for Relative Sea Level Change (RSLC) Analysis using the intermediate sea level rise curve. The Recommended NER Plan alternative was evaluated using the low, intermediate and high sea level rise curves. The RSLC analysis was conducted to ensure the restoration was sustainable and provided adequate ecological benefits over the 50 year planning horizon. These results are presented in the Engineering and Benefits Appendices.

SITES RECOMMENDED IN THE NER PLAN

7.4.1 Metromedia Tract

Alternatives A, B and C feature similar restoration measures but different acreages of each.

Metromedia Tract – Alternative A (Tentatively Selected Plan)

Alternative A proposes the restoration of approximately 38.0 acres of emergent low marsh wetland, 4.8 acres of native emergent high marsh wetland, approximately 5.3 acres of high marsh - scrub/shrub wetland transition and approximately 11.5 acres of scrub/shrub wetlands maritime upland (Figure D7-3). The restoration of maritime upland is a cost effective way to deal with the large quantities of All excavated material is placed on-site and also greatly increases site resiliency as it provides an area for marsh migration in response to sea level change.

Metromedia Tract – Alternative B

Alternative B features the restoration of approximately 43.1 acres of emergent low marsh wetland, approximately 4.5 acres of native emergent high marsh wetland and approximately 11.8 acres of scrub/shrub wetland (Figure D7-4). Alternative B does not include any conversion of wetlands to uplands. A higher volume of excavated materials are taken off-site resulting in considerably higher costs.

Metromedia Tract – Alternative C

Alternative C includes the restoration of approximately 50.6 acres emergent low marsh, approximately 4.1 acres of native emergent high marsh wetland and approximately 3.5 acres of high marsh - scrub/shrub wetland transition and 1.1 acres of scrub/shrub wetlands (Figure D7-5). Alternative C includes the conversion of highly degraded common reed dominated marsh to Alternative C also includes the conversion of emergent wetland to approximately 1.1 acres of maritime forest. This alternative includes the highest volume of off-site material placement.

Figure D7- 3. Metromedia Tract – Alternative A

Figure D7- 4. Metromedia Tract – Alternative B

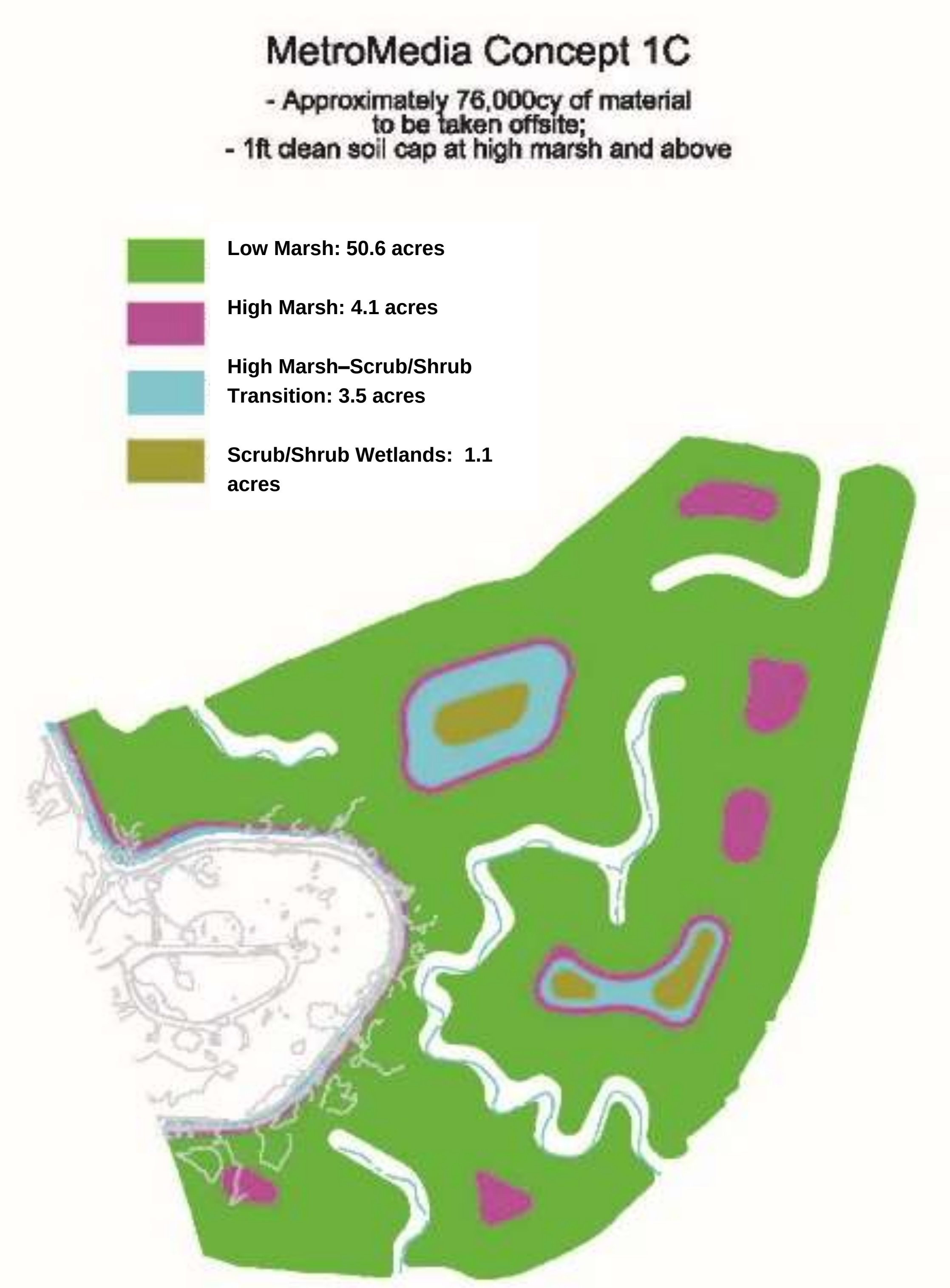

Figure D7- 5. Metromedia Tract -Alternative C

Metromedia Tract – Recommended Plan

The recommended plan is the optimized plan based on Alternative A and will increase diversity and improve fish and wildlife habitat as well as providing secondary benefits of improving flood storage and water quality. 38,000 CY of material will be excavated and replaced with 41,000 CY of clean growing media over an area of 67.3 acres (Figure D7-6).

This plan includes wetland restoration, including low marsh, high marsh and scrub/shrub habitats. In addition, the plan includes the restoration of tidal channels. The design includes the excavation of new tidal channels and the enhancement of existing tidal channels, totaling approximately 6,270 linear feet (2.79 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. Additionally, 6.51 acres of shallow water habitat will be restored along the tidal channels.

In total this design will restore 26.5 acres of low marsh, 11.7 acres of high marsh, and 13.8 acres of scrub/shrub wetlands. Grading and planting plans are included in the Engineering Appendix. Once the Metromedia Tract is restored, it will combine with an adjacent previously restored tract to restore a contiguous connected expanse of approximately 200 acres. Grading and planting plans are included in the Engineering Appendix.

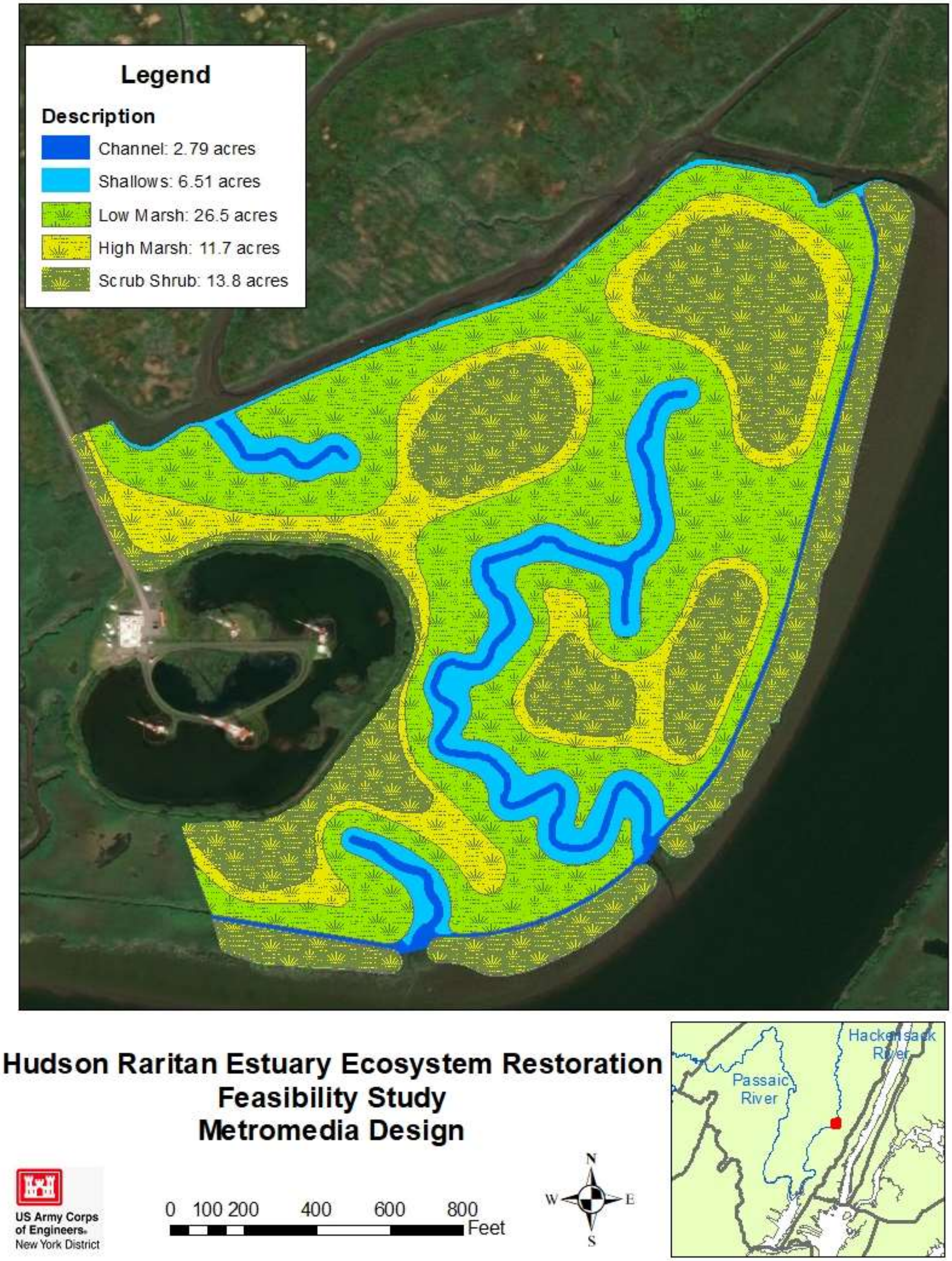

Figure D7- 6. Metromedia Tract – Recommended Plan

7.4.2 Meadowlark Marsh

Alternatives A, B and C feature similar restoration measures with different proposed acreages of each measure.

Meadowlark Marsh – Alternative A

Alternative A proposes the enhancement of approximately 55.04 acres of emergent low marsh wetland (Figure D7-7). This alternative includes the restoration of approximately 6.43 acres of emergent high marsh wetland and approximately 8.67 acres of forested wetland. Alternative A also restores and enhances approximately 2.31 acres of upland buffer forest habitat. Approximately 8,319 linear feet of tidal channels are proposed to be constructed in this alternative, restoring approximately 9.87 acres of fish habitat. This restoration measure includes the construction of two new open span bridges for an access road. Approximately 2.58 acres of existing fish habitat would be enhanced.

Meadowlark Marsh – Alternative B

Alternative B includes the enhancement of approximately 58.80 acres of emergent low marsh wetland (Figure D7-8). Alternative B proposes the restoration of approximately 5.04 acres of emergent high marsh wetland and 8.38 acres of forested wetland. This alternative would restore and enhance approximately 2.44 acres of upland buffer forest habitat. Approximately 7,086 linear feet of tidal channels are proposed to be constructed in this alternative, restoring approximately 7.12 acres of fish habitat. This restoration measure includes the replacement of two culvert structures. Approximately 3.28 acres of existing fish habitat would be enhanced.

Meadowlark Marsh – Alternative C (Tentatively Selected Plan)

Alternative C includes the enhancement of approximately 53.20 acres of emergent low marsh wetland (Figure D7-9). Alternative C also includes the restoration of approximately 4.94 acres of emergent high marsh and approximately 8.59 of forested wetland. This alternative would restore and enhance approximately 3.21 acres of upland buffer forest habitat. Alternative C does not include the restoration of any tidal channel or the restoration of fish habitat, but includes the enhancement of approximately 12.72 acres of existing fish habitat.

Figure D7- 7. Meadowlark Marsh – Alternative A

Figure D7- 8. Meadowlark Marsh – Alternative B

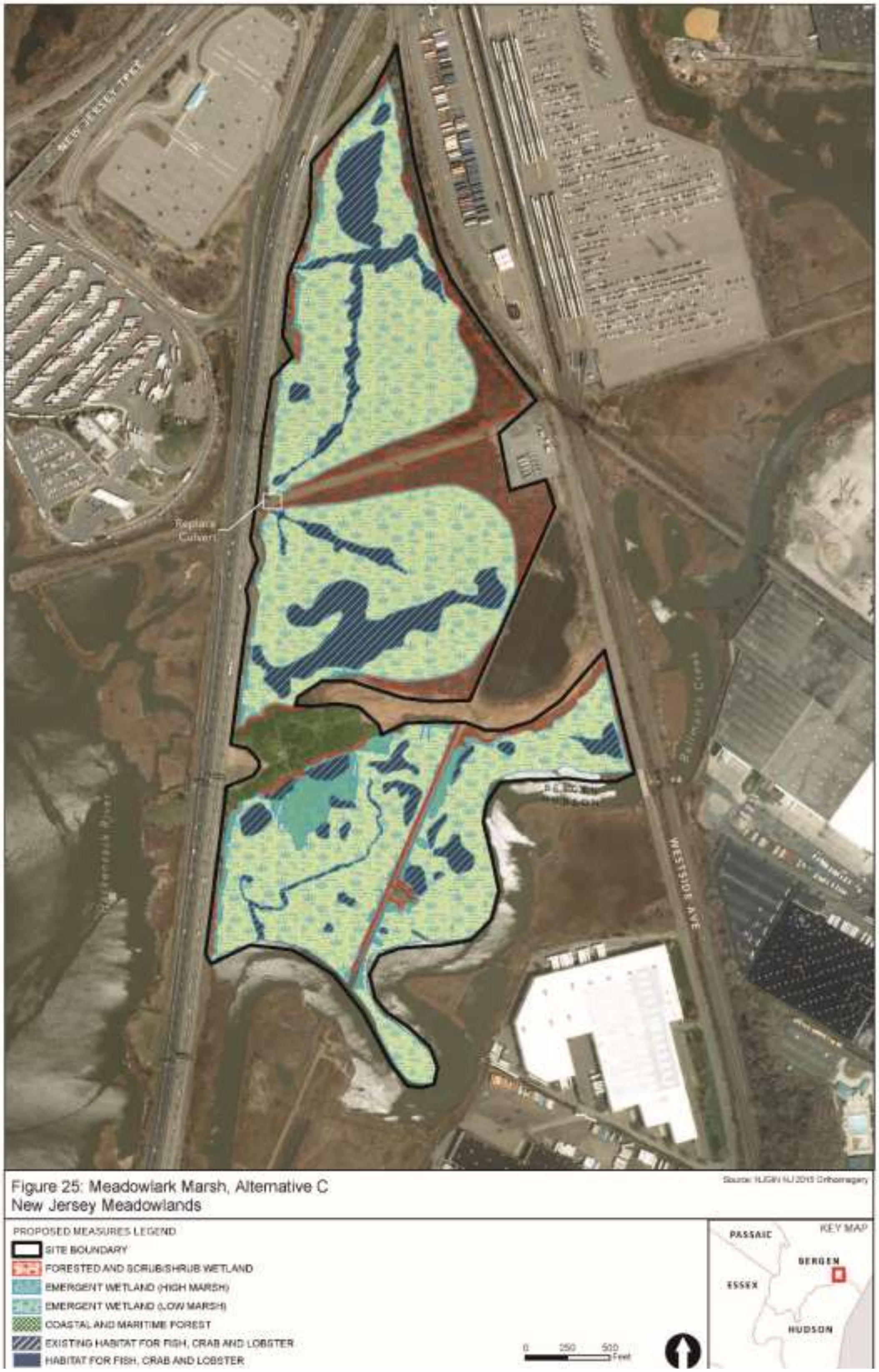

Figure D7- 9. Meadowlark Marsh – Alternative C

Meadowlark Marsh – Recommended Plan

This recommended plan is the optimized plan based on Alternative C. Restoration efforts at the site will improve fish and wildlife habitat as well as secondary benefits of flood storage and water quality improvements. The entire site (71.5 acres) will be graded, with 64,400 CY of excavated material taken off site, approximately 53,600 cubic yards resulting from clearing and grubbing operations (Figure 4-7-10).

A broken culvert at the western edge of the middle of the site is restricting tidal flow and will have to be replaced. It is assumed that the culvert will be a 6-foot concrete box culvert, approximately 50 feet long. Restoration of tidal channels are proposed and existing channels will be enhanced, totaling approximately 7,700 linear feet (4.6 acres), which will be extended into the site to enable tidal exchange within the sites, helping to sustain the planted wetlands and other vegetation communities. In total this restoration plan will restore 56.2 acres of low marsh, 6.5 acres of high marsh, 5.4 acres of scrub/shrub, and 4.6 acres of channels. Two (2) open-span bridges and a culvert would be installed to maintain gas pipeline access. Planting and grading plans are included in the Engineering Appendix.

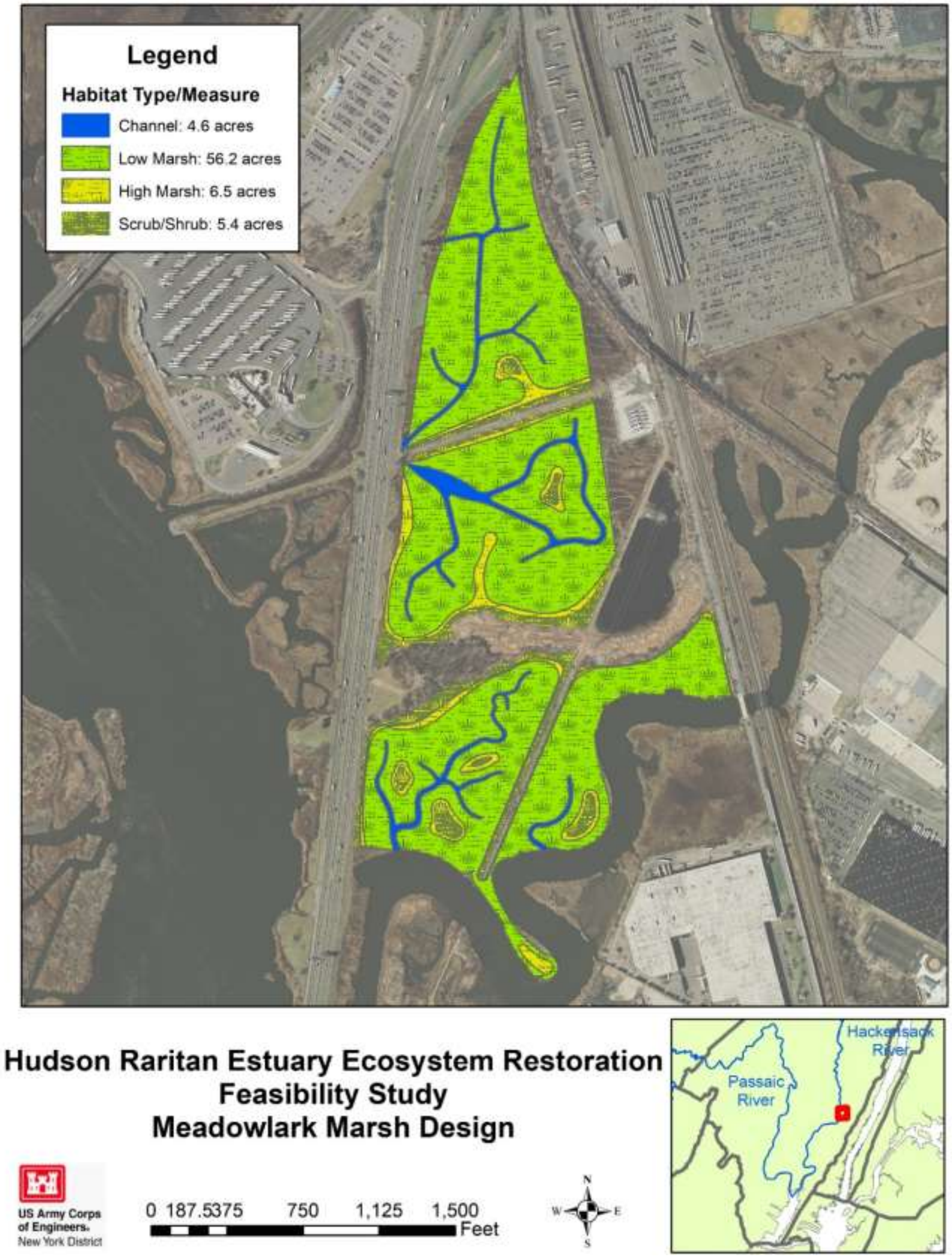

Figure D7- 10. Meadowlark Marsh – Recommended Plan

Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix D
Plan Formulation Appendix
Chapter 8: Oyster Reef Restoration

Final Integrated Feasibility Report
& Environmental Assessment

April 2020

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

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8. Oyster Reef Restoration Sites

Oyster reefs and their restoration were identified as a Target Ecosystem Characteristic (TEC) for the HRE with a target statement and overarching goal to "Establish sustainable oyster reefs at several locations" (USACE, 2016 and PANYNJ, 2014). The Oyster Reefs TEC was assigned a short-term objective of establishing 20 acres of reef habitat across several sites by 2020, and a long-term objective of establishing 2,000 acres of oyster reef habitat by 2050. These acreages were selected as the targets because they are fractions of the known historical oyster beds in the HRE and were a realistic achievable goal given the status of oyster reef restoration in the region. The oyster fishing industry in the estuary thrived in the mid-late 19th century and was estimated to cover approximately 200,000 acres (810 kilometers^2; Kennish 2002, Bain et al. 2007). The long-term goal of 2,000 acres is 1% of the historic oyster coverage, and the short-term goal is 0.01% of the historic coverage.

Conceptual plans were developed for small-scale restoration at five (5) sites in the draft feasibility report, which were subsequently refined to three (3) sites for this final report. See Appendix J for the Cost Effectiveness and Incremental Cost Analysis (CE/ICA) process to arrive at the sites included within the Recommended Plan.

The designs incorporate restoration techniques that have been tested during pilot programs implemented between 2010 and 2019, and include combinations of restoration techniques most suitable for the conditions, such as bathymetry, tidal currents, and substrate, at each site. The proposed small-scale oyster reef restoration restores over 50 acres of reef structure which, allowing for natural mortality associated with restoration, should meet and exceed the year 2020 objective. The Recommended Plan exceeds the goal for 2020 (20 acres), but is far below the goal for 2050 long term target of 2,000 acres. The restoration recommended in this interim FR/EA Report contributes significantly to the overall targets for the region work with partners. It was assumed that additional future oyster reef restoration would be recommended through future feasibility study spin-offs. It is envisioned that, between the HRE Feasibility Study oyster reef restoration projects and continuing restoration efforts by the sponsors and other entities in the HRE study area, there will be considerably more functioning oyster reef habitat by 2050.

This chapter presents background on the prior projects implemented at the locations within the Recommended Plan, measures and techniques for oyster reef restoration and alternative development at each site. These recommendations for near-term construction will be an important first step in oyster habitat restoration objectives and associated sub-objectives to incorporate diverse habitat to improve feeding, breeding and nursery grounds for fish and communities. Secondary benefits include incorporating habitat structure to provide secondary coastal storm risk management benefits (e.g., wave attenuation, shoreline stability, and shoreline resiliency) to serve as potential natural and nature-based features and improving water quality through filtration.

The small scale oyster reef restoration actions would advance improving shorelines throughout the HRE that currently are lined with bulkheads, piers, or rock revetments, by restoring oysters as living breakwaters where appropriate. In support of this purpose, the appendix summarizes the findings of evaluations of the following, culminating in the identification of recommended restoration techniques and sites, and presentation of conceptual plans for future small-scale oyster reef restoration efforts:

- Historic significance and decline of oysters in the HRE
- Recent and ongoing oyster reef restoration efforts of many organizations, including NY/NJ Baykeeper, New York City Department of Environmental Protection (NYCDEP), the Urban Assembly of the New York Harbor School (Harbor School), the Hudson River Foundation, and the Billion Oyster Project (BOP)
- Ecological benefits from oyster reef restoration
- Oyster reef restoration techniques/methods used throughout the HRE
- Candidate locations for future oyster reef restoration to be recommended for near-term construction in the HRE, specifically, Soundview Park, Bush Terminal, Governors Island, Jamaica Bay, and Naval Weapons Station Earle
- Oyster reef restoration methods and conceptual restoration plans recommended for the candidate oyster reef restoration locations

It is well documented that oyster reef restoration would provide significant ecological uplift to the HRE. Oysters are valuable organisms that can provide a multitude of ecological benefits including providing habitat for various aquatic species, filtering the water column, and, in some geographic areas, encouraging the growth of tidal shallows and salt marshes. Additionally, oysters can contribute to the reduction of climate change impacts by attenuating storm surges and sequestering carbon.

Previous oyster reef restoration activities, including the Oyster Restoration Research Project (ORRP) and other actions by the Harbor School/BOP, NY/NJ Baykeeper, the Hudson River Foundation and NYCDEP, have already provided encouraging results as oysters have been observed to survive for multiple years after placement on artificial substrate. The HRE Feasibility Study has taken the data provided by these restoration activities and has built upon them, serving as the foundation of recommendations for specific restoration techniques, site considerations, and management of existing reefs.

The restoration process begins by collecting wild oysters from New York Harbor. Wild oysters are used when possible to carry forward the genes that have made them successful in this challenging environment. These oysters become the broodstock for the next generation and are conditioned to spawn in the Harbor School Aquaculture classroom also known as the Harbor School Oyster Hatchery. After a three-week-long conditioning period, the oysters spawn and the resultant larvae are cultivated in the lab for another two (2) weeks. These larvae are introduced to clean shells that have been collected from restaurants. They will attach to the shells and metamorphose through the process of remote setting. The product of remote setting is the clusters of oysters that become the building blocks of our oyster reefs. These clusters are transferred to one of several nursery sites around the harbor where they are cultivated for an additional year. Year-old oysters are then installed at reef sites (USACE, 2016).

8.1 Project Area Context

Prior to European colonization, oysters and oyster reefs were key components of the estuarine habitat in the HRE. Today, although the vast majority of oyster reefs in the HRE have been degraded or destroyed by human activities, isolated populations do exist in a few areas of the HRE, where water quality, hydrodynamics, and substrate conditions combine to promote opportunities for limited reproduction, spatfall (i.e., settlement of spat) and growth.

The islands, bays, and waterbodies that comprise the HRE were largely shaped and formed during the last ice age. When the ice retreated, a series of shallow estuarine bays were left, which provide ideal habitat for oysters and the formation of oyster reefs.

The confluence of the Hudson River, Raritan River and Hackensack and Passaic Rivers; coupled with the tidal circulation provided by the Atlantic Ocean, East River and Long Island Sound; and sheltered by Sandy Hook and the Verrazano Narrows; the HRE provided ideal conditions for oysters to live and grow. In fact, it is estimated that during the time of European settlement in the 16th century, half of the oysters on earth could be found in the HRE (Kurlansky, 2007). It is believed that at that time approximately 350 square miles of oyster beds were present in the HRE. Principal concentrations were along the Brooklyn and Queens shorelines in the East River, in Jamaica Bay, and along the Manhattan shoreline of the Hudson and East Rivers. Oyster beds occurred in the Hudson River as far north as Stony Point, New York, and also along the Raritan Bay shoreline in the vicinity of Keyport, New Jersey. Oysters grew in the Keyport, Raritan and Hackensack Rivers, and on reefs surrounding Staten Island, City Island, Liberty Island, and Ellis Island (Mackenzie, 1996 as cited in HRE CRP OPG, 2012).

Accounts from early settlers at the time identified that great reefs of oysters were present along the shores of Brooklyn, Queens, Manhattan, and the other coastlines of the HRE. Large banks of oysters occurred in Raritan Bay, along the New Jersey coastline and as far north in the Hudson River as Ossining. In fact, several names of locations in New York Harbor are derived from oysters (e.g., Pearl Street in Manhattan, Oyster Island (now Liberty Island), etc. Early maps of the time reflect the shallow shoals and oyster banks in the HRE (Figure D8-1 and 8-2). Large oyster beds were present in the HRE until the early 20th century (Figure D8-3).

European colonization and the growth of the New York metropolis led to the removal of a good portion of the oyster reef habitat (e.g., shallow shoals along the coast). Local laws governing the over-exploitation and degradation of oyster beds were enacted in New York City during colonial times. In 1658, the then-Dutch colony of New Netherland enacted legislation regulating the taking of oysters on Manhattan Island and in the East River. In nearby Great South Bay limits on the number of vessels engaging in the harvest of oyster were set forth in 1679 (Kirby and Miller, 2005). By the mid-18th century raw sewage was entering the waters of NY/NJ Harbor adjacent to Manhattan Island. Shoreline modifications represented a direct impact to native oyster beds.

Overharvesting of natural oyster populations was so prevalent that by the early 19th century, the oyster industry of Jamaica Bay was primarily based on stock brought in from other estuaries to the north and south of New York City, including Delaware and Chesapeake Bays (Kirby and

Miller, 2005). Nonetheless, by 1880, New York City's oyster beds, whether farmed or native, were producing 700 million oysters each year (Kurlansky, 2006).

By the early 20th century, the relationship between oyster consumption in New York City and the periodic outbreak of diseases such as cholera and typhoid was apparent. Temporary closures of New York City oyster beds occurred in 1915 and in 1921. By 1925, the Jamaica Bay oyster fishery was closed permanently. Moreover, throughout the 20th century, oysters, pollution and reduced water quality contributed to sharp declines in oyster populations. However, with the passage of the Clean Water Act and improvements in water quality over the last few decades, oysters are now becoming reestablished in the HRE. Oysters and oyster reefs perform an important ecological function by filtering our waterways to providing important habitat for numerous marine species.

Today, the quantity of oysters in the HRE is a fraction of their former numbers. Large, dense beds and reefs are no longer present. Oysters now generally appear as isolated individuals along rocks and other hard substrates in the HRE. Oysters are sessile organisms. When enough oysters survive in a concentrated area for a numbers of years, the shells of former generations remain cemented together through a biogeochemical process. After decades and centuries, these oysters and oyster beds grow vertically and laterally to form what is called an oyster reef. These reefs can provide immense ecological benefits as compared to other habitats.

In order to address the historic significance of oysters in the HRE, and the oyster's decline, many organizations including the NY/NJ Baykeeper, the Urban Assembly of the New York Harbor School (Harbor School), the Hudson River Foundation and the New York City Department of Environmental Protection (NYCDEP), and others have advanced oyster reef restoration in the HRE.

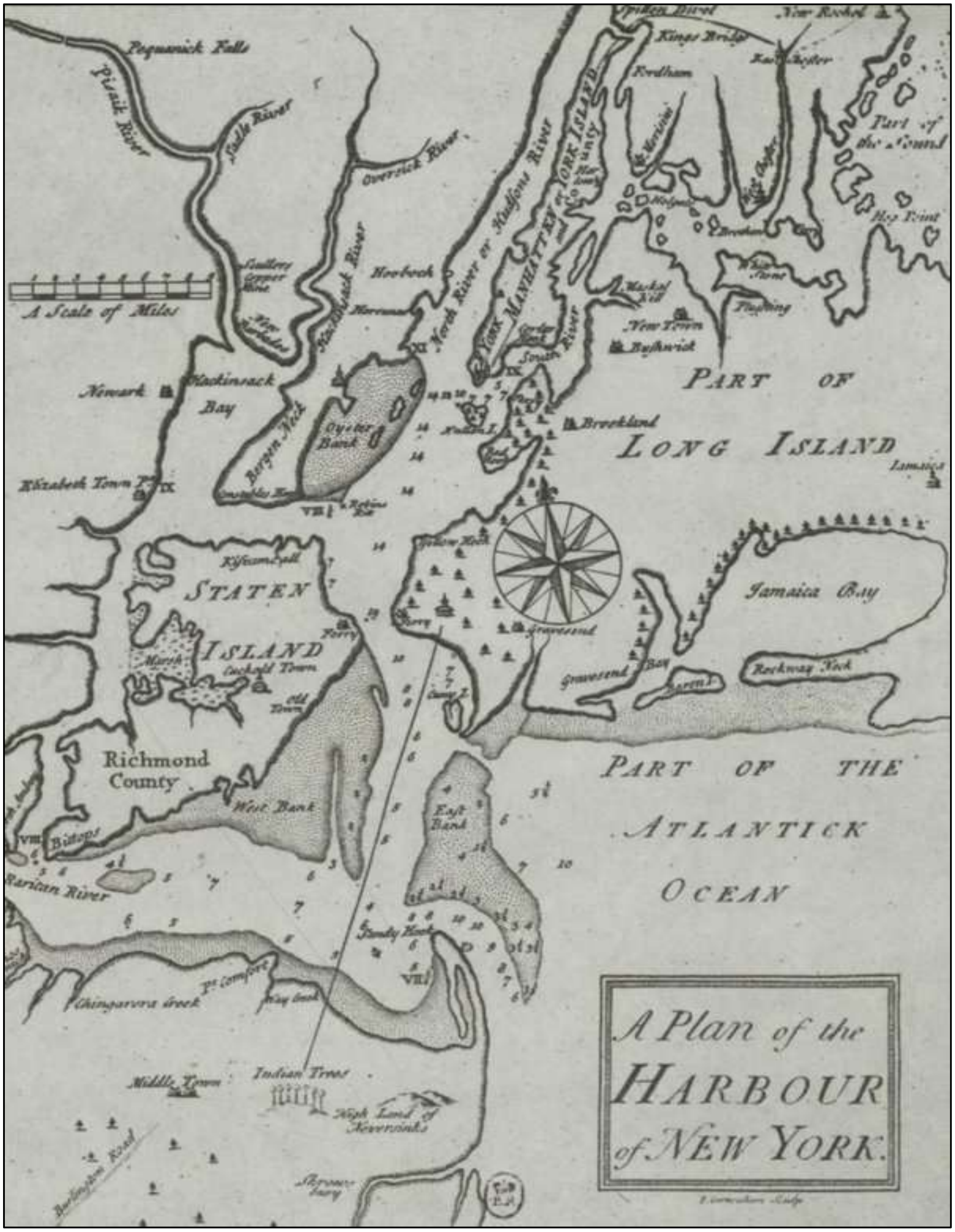

Figure D8- 1. The Carwitham Plan New York Harbor – 1735. Source: Cohen and Augustyn 2014.

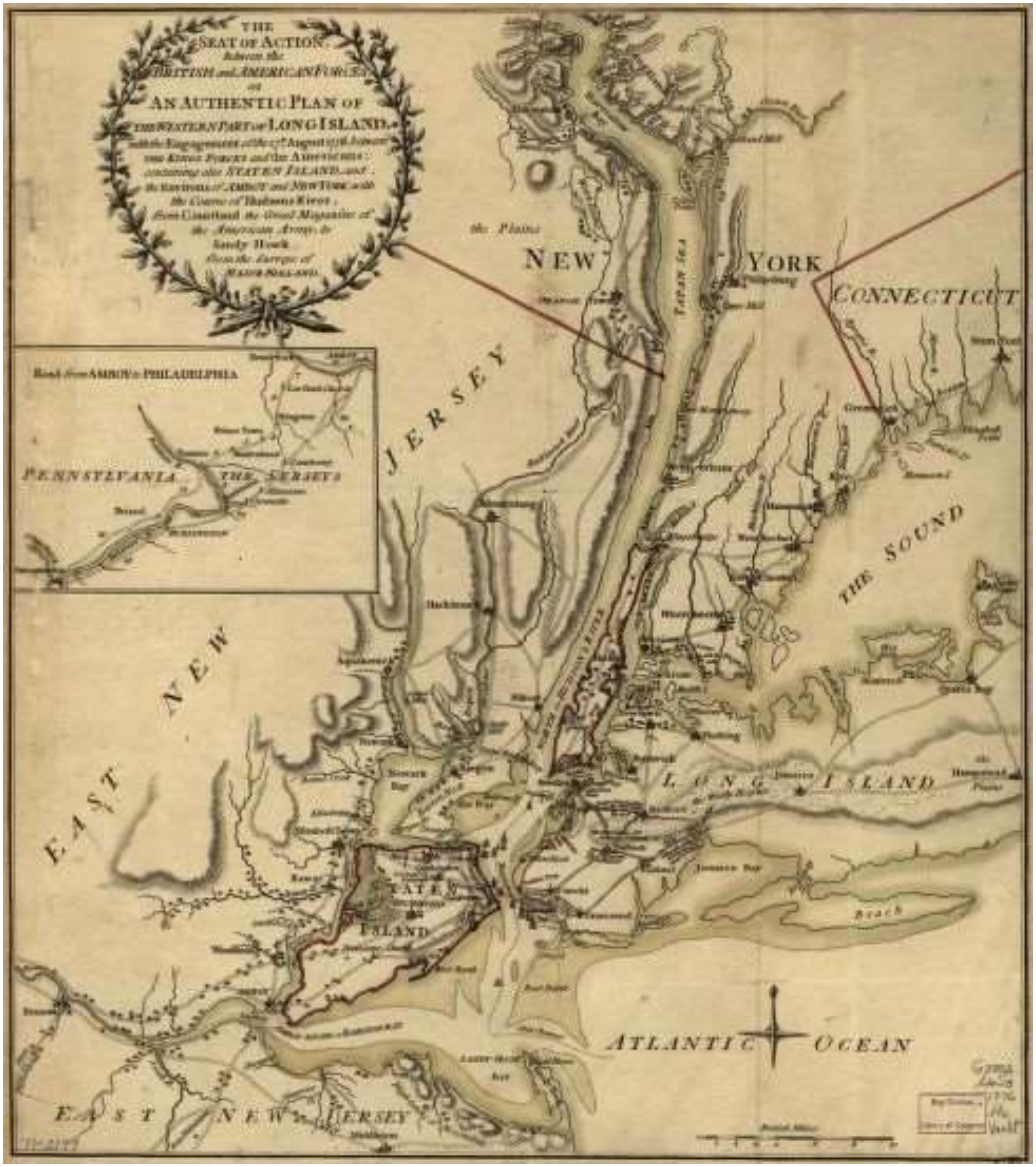

Figure D8- 2. New York Harbor 1776 (Adapted from Samuel Holland, The Seat of Action between British and American Forces). Source: Library of Congress, Geography and Map Division.

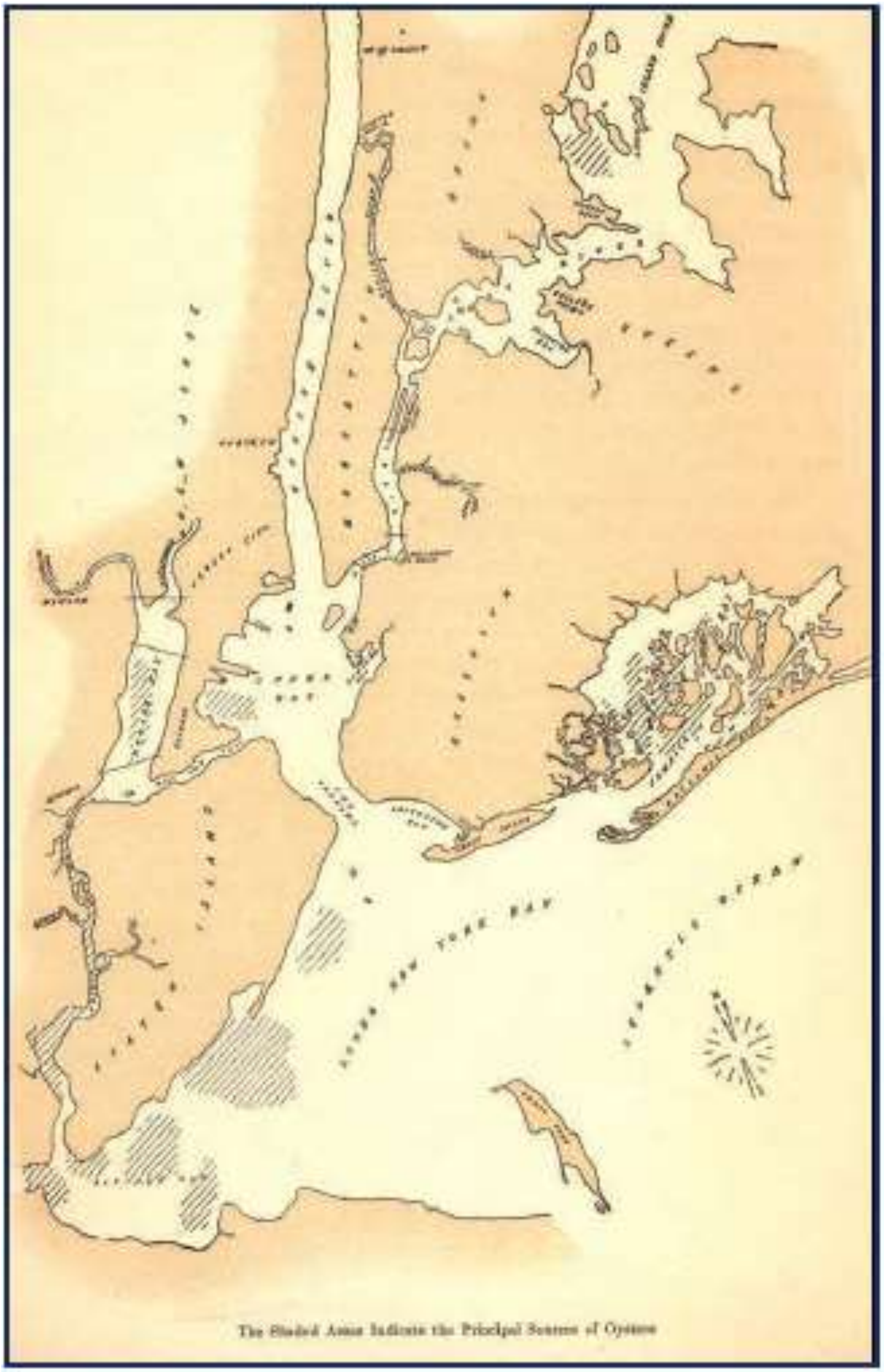

Figure D8- 3. Historic Presence of Oysters (dashed lines) in the HRE. Source: Metropolitan Sewage Commission.

8.2 The Billion Oyster Project

The Harbor School is a public high school located on Governors Island that has technical programs in a variety of marine fields (marine science, diving training, etc.). The Harbor School has been involved at some level in oyster reef restoration at all locations within the HRE. One program in particular, aquaculture, has played an important role in oyster reef restoration in New York Harbor. The laboratory and aquaculture facilities at the school can grow more than a million oysters per year and provide facilities, expertise, and dedicated students to support these large-scale oyster reef restoration efforts (BOP, 2015). The Billion Oyster Project (BOP) and Harbor School are creating new pilot projects at Bush Terminal Park and other sites throughout the Harbor.

The Harbor School serves as the production hub for the BOP, a long-term, large-scale plan to restore one (1) billion live oysters to New York Harbor over the next twenty years and in the process train thousands of young people in New York City to restore the ecology and economy of their local marine environment. A goal of the BOP is that by 2030, one (1) billion live oysters will be distributed around 100 acres of reefs, making the HRE once again the most productive waterbody in the North Atlantic and reclaiming its title as the oyster capital of the world (BOP, 2015).

The restoration process begins by collecting wild oysters from New York Harbor. Wild, or more likely, feral, oysters are used when possible to carry forward the genes that have made them successful in this challenging environment. These oysters become the broodstock for the next generation and are conditioned to spawn in the Harbor School Aquaculture classroom also known as the Harbor School Oyster Hatchery. After a three-week-long conditioning period, the oysters spawn and the resultant larvae are cultivated in the lab for another two (2) weeks. Remote setting begins when lab technicians introduce larvae to clean and cured shells that have been collected from restaurants. Larvae then begin metamorphosis, attaching to the shells; the resulting clusters of spat on shell are the building blocks of our oyster reefs. These clusters are transferred to one of several nursery sites around the harbor where they are cultivated for an additional year. Year-old oysters are then installed at reef sites.

Oyster reef construction is the shared responsibility of BOP staff and Harbor School's six (6) career and technical education (CTE) programs. Faculty and students from each program work together to prepare, install, and monitor oyster reefs and habitat restoration efforts. All of these activities, when conducted in New York Harbor, require a high level of skill. The water quality is compromised, currents are strong, visibility is limited and commercial traffic is constant. These added challenges require a great deal of expertise from Harbor School students.

Reef construction is a partnership effort. The BOP works directly with dozens of non-profit and government partners to advance oyster reef restoration in the harbor. Through the Oyster Restoration Research Project (ORRP) and Rebuild by Design, BOP has become a leader in the restoration world and the primary supplier of oysters for restoration. The six (6) CTE programs are described below:

- Aquaculture students, with support from BOP schools and volunteers, grow the oysters.

- Vessel operations students operate the boats needed to transport people, supplies, and equipment to reef sites, and provide surface support for diving installation and scientific monitoring.
- Marine Systems Technology students maintain the boats used by the school for oyster reef restoration, as well as construct metal and cement based artificial reefs infrastructure.
- Professional Diving students conduct underwater mapping once a site has been selected, and because most New York Harbor restoration sites are fully subtidal, they also play the key role in building, maintaining, and monitoring reef sites.
- Ocean Engineering students design and operate remotely operated underwater vehicles that can take video and monitor parameters in locations or conditions that are unsuitable for SCUBA divers.
- Marine Biology Research Program students have a direct role in monitoring, assessing new sites, gathering baseline data, and scientific research. They also operate in situ water monitoring instruments and conduct manual tests for nutrients and bacterial content, working closely with aquaculture students to better understand how water chemistry affects oyster growth in the hatchery and the harbor.

Through this work, the BOP currently produces between nine (9) and 11 million set oysters per year. With added hatchery equipment and a more advanced remote setting facility this will increase to 25 million set oysters per year.

8.3 Oyster Restoration Research Project

Oyster reef restoration has occurred sporadically throughout the HRE, with the most significant effort implemented under the ORRP. The ORRP, a partnership[1] of over 30 not-for-profit organizations, federal, state and city agencies, as well as citizens and scientists, has been restoring oysters and conducting research on oyster reefs in the HRE since the inception of the program in 2010, with the goal of furthering scientific understanding of oysters reintroduced into the estuary (Grizzle et al., 2012, 2013). The ORRP constructed experimental reefs at Bay Ridge Flats, Governors Island, Hastings, Soundview Park, and Staten Island in 2010 and 2011 (Grizzle et al., 2013). A key component of these restoration efforts were the contributions of the Harbor School and the BOP.

Beginning in 2010, the ORRP has been using the reefs to monitor and assess survival and growth of the oysters on the reefs; ecosystem services provided by the experimental reefs; and restoration techniques best suited for future oyster reef restoration efforts within the HRE (Grizzle et al., 2013). The objective of the ORRP is to determine where oysters will flourish in

[1] Hudson River Foundation, NY/NJ Baykeeper, the Urban Assembly New York Harbor School, U.S Army Corps of Engineers, The Port Authority of New York & New Jersey, New York Harbor Foundation, The Trust for Governors Island, The New York/New Jersey Harbor Estuary Program, The New England Interstate Water Pollution Control Commission, New York City Department of Parks and Recreation Natural Resources Group, New York City Department of Environmental Protection, U.S. Environmental Protection Agency, Region 2, New York State Department of Environmental Conservation -Hudson River Program, NOAA Restoration Center, Bay Ridge Flats Oyster Project, Rocking the Boat, Bronx River Alliance, University of New Hampshire, SUNY Stony Brook, Baruch College, CUNY, Loyola University Chicago, Brooklyn College, Wildlife Conservation Society, WCS-NOAA Lower Bronx River Partnership.

the HRE and develop methods best suited for scaling up to large-scale oyster reef restoration (USACE and PANYNJ, 2016). As such, this data should be consulted when planning for oyster reef restoration throughout the harbor.

Based in part on its experience restoring oysters in the HRE and on its research findings, the ORRP has provided recommendations for future oyster reef restoration within the HRE. The HRE Feasibility Study has taken the research provided by these pilot programs and has built upon them, serving as the foundation of recommendations for specific restoration techniques, site considerations, and management of existing reefs.

Some other oyster reef restoration efforts by other project partners, NY/NJ Baykeeper (Keyport Reef, the Navesink Reef, the Liberty Island Reef and Naval Weapon Station Earle) and NYCDEP, have carried out initial restoration studies in Sandy Hook Bay and Jamaica Bay, respectively. Although, the restored oyster reefs are relatively recent with data results, monitoring efforts have provided encouraging results as oysters have been observed to survive for four (4) seasons after placement on an artificial substrate. Efforts by the project sponsors in New York Harbor were evaluated at the feasibility level to support future restoration efforts as part of this HRE Feasibility Study.

8.4 HRE Objectives and Ecosystem Benefits

As part of HRE Feasibility Study, the USACE and the PANYNJ, in partnership with the New York-New Jersey Harbor Estuary Program, prepared the HRE Comprehensive Restoration Plan (CRP) Version 1.0 (USACE, 2016) as an interim document that serves as the foundation of the feasibility study and guides ecosystem restoration efforts throughout the estuary. The CRP was intended for use by restoration practitioners as a framework that guides work towards a series of shared restoration goals, providing ecological benefits to the estuary.

To achieve the CRP program goal, “to develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment”, the CRP identifies specific restoration targets that are collectively critical to the estuary’s ecological viability, termed target ecosystem characteristics (TECs). Each TEC defines specific goals for an important ecosystem property or feature that is of ecological and/or societal value. Based on the historical significance of oysters within the region, oyster reefs and their restoration were identified as a TEC for the HRE with a target statement and overarching goal to “establish sustainable oyster reefs at several locations.” The Oyster Reefs TEC was assigned a short-term objective of establishing 20 acres of reef habitat across several sites by 2020, and a long-term objective of establishing 2,000 acres of oyster reef habitat by 2050. The small-scale oyster reef restoration also meets the sub-objectives outlined in Table D8-1 and presented in Chapter 3 of the main report.

Table D8- 1. Oyster TEC Target Sub-Objectives and Secondary Benefits

TEC	Target Statement/Sub-Objectives/Secondary Benefits
Oyster Reefs	**Target Statement** Establish sustainable oyster reefs at several locations.
	Sub-Objectives

	• Incorporate diverse habitat structure to improve feeding, breeding, and nursery grounds for fish and benthic communities.
	Secondary Benefits • Incorporate habitat structure to provide secondary coastal storm risk management benefits (e.g., wave attenuation, shoreline stability, and shoreline resiliency), serving as potential natural and nature-based features. • Improve water quality through filtration.

As described in Chapter 2, oysters, oyster beds, and oyster reefs were once common throughout the HRE; however, the loss of oyster habitat due to development and the loss of oysters due to pollution have left the HRE with an abundance of silty and muddy substrates. Although these sediments do have ecological benefits, the restoration of oysters and oyster bed habitats, on the sediment substrates, would have increased ecological value per square meter and result in a marked ecological and functional uplift. Moreover, climate change is predicted to lead to increased storm activity. The presence of oysters, which could ultimately lead to the formation of oyster reefs, would attenuate wave velocities. Also, the oyster shells are carbonate and their establishment and growth would sequester carbon dioxide (CO_2), a greenhouse gas that is contributing to climate change. Finally, the benefits oysters, as filter feeders, provide to water quality is invaluable. One (1) adult oyster can filter up to 50 gallons of water a day. See Benefits appendix for quantification of ecological benefits used for Cost Effectiveness and Incremental Cost Analysis (CE/ICA) as well as more detailed information on ecological and functional uplift of any successful oyster reef restoration that is expected to:

- Improve habitat quality for vegetation, invertebrates, fish;
- Stabilize the shoreline to prevent erosion;
- Improve water quality through filtration of nutrients, water turbidity, nitrogen, phosphorous, organic carbon; and
- Sequester carbon.

8.5 Oyster Reef Restoration: Constraints and Techniques

8.5.1 Constraints

Conducting restoration projects in densely urbanized areas such as the HRE presents a unique set of challenges, including issues related to contaminated substrates, degraded water quality, land-use conflicts, and habitat trade-offs.

8.5.1.1 Water Quality Issues

Although water quality within the HRE has improved markedly in many areas, seasonal and localized water quality impairments still exist. These impairments may include, but are not limited to, seasonal stratification and episodic anoxia/hypoxia. Shallow, poorly flushed water bodies in densely populated areas may be subjected to eutrophication as a result of nutrient loading from wastewater treatment facilities and combined sewer outfalls. This often leads to seasonal phytoplankton and macroalgae (e.g., Ulva lactuca) blooms. As the phytoplankton/algal biomass decays, water column dissolved oxygen concentration is reduced, nitrogen and phosphorus is released, and anoxic, organic sediments accumulate in the affected areas.

8.5.1.2 Disease and Predation

American oysters are subject to a number of bacterial, viral and protozoan diseases, including the bacteria Vibrio and Pseudomonas, both of which have been shown to kill oysters under laboratory conditions (Stanley and Sellers, 1986). However, infection by two (2) protozoan parasites, Perkinsus marinus, also known as dermo, and Haplosporidium nelsoni, also known as multinucleated sphere unknown, (MSX), has caused widespread damage to oyster populations throughout much of the species' range along the Atlantic and Gulf coasts. Dermo was first documented in the 1940s in the Gulf of Mexico. Since 1991, this parasite has been found in oysters from Connecticut, New York, Massachusetts, and Maine (Ford and Tripp, 1996). Dermo is transmitted from dead and dying oysters releasing infective stages of the parasite back into the water column. The initial site of infection is the gill, but the parasite principally attacks the digestive system (Burreson and Calvo, 1996; Chu, 1996). Dermo is most prevalent in conditions of high temperature and high salinity, proliferating rapidly above 20°C and in salinities above 12 to 15 ppt. Dermo-infected oysters exhibit a reduction in growth and reduced reproductive capacity (Paynter, 1996; Paynter and Burreson, 1991).

MSX was first documented in 1957 in Delaware Bay and is now known to infect oysters from Maine to Florida (Ford and Tripp, 1996). At the time of its discovery, the specific disease agent was undescribed, but upon discovery of the spore-forming stage of the parasite in 1966 it was named Minchinia nelsoni, and subsequently re-named Haplosporidium nelsoni in 1980. The inability of oysters to transmit H. nelsoni under laboratory settings strongly suggests the possibility of an intermediate host. MSX first infects the gill, subsequently entering the blood stream to infect other tissues. MSX infection interferes with respiration and feeding, eventually resulting in death. Temperature and salinity play an important role in regulating MSX, with most infections acquired above 20°C and at salinities above 15 ppt (Ford, 1985; Ford and Haskin, 1982, 1987, 1988).

8.5.1.3 Contaminated Substrates

During the Industrial Era, the HRE was subject to the discharge of numerous contaminants that typically include heavy metals, polychlorinated biphenyls, polyaromatic hydrocarbons (PAHs), and dioxin. These contaminants can degrade an ecosystem by reducing available habitat, lowering biomass, and other factors. Contamination can also greatly reduce the biological and recreational value of the HRE study area through fish consumption advisories, human health risks, and economic impacts through restrictions of commercially harvested species.

The states of New York and New Jersey believe that oyster reef restoration in prohibited or specially restricted waters creates an attractive nuisance. Both states generally believe that the ecological benefits of having sustainable populations in these waters are outweighed by the potential health risks of consuming poached oysters. There are potential economic repercussions that the consumption of tainted oysters may affect the rest of the shellfish industry.

In the case of both oysters and lobsters, concerns exist that fishing could lead to consumption of shellfish that are not safe to eat. This could result in the need to restrict harvesting or fishing in these areas, which would lead to greater enforcement needs and increased costs to the regulatory agencies. Other potential policy issues stemming from restoration of reefs would be considered under both the habitat exchange and placement of fill sections. The New York State Department of Environmental Conservation (NYSDEC), NJDEP, NYSDOS, and USACE have jurisdiction in regulating these types of activities.

The NJDEP does not recommend restoration projects for commercially harvested shellfish in prohibited or restricted waters (i.e. closed to shellfishing). In 2010, the NJDEP banned research-related gardening of commercial shellfish species in waters classified as contaminated in order to minimize the risks of illegally harvested or poached shellfish (NY/NJ Baykeeper, 2016). Because they are concerned with illegal harvest of oysters and associated health risks, the NJDEP and NYSDEC recommend considering the restoration of shellfish species that have no commercial value in these waters. Presently efforts are being made to coordinate oyster reef restoration activities within the existing states' permitting framework. While the goals of the regulations are quite defensible (i.e., avoiding public harm with respect to navigation or the environment, protecting public health, etc.), alternative mechanisms for achieving them are being considered.

Contaminant concentrations measured at the specific sites were identified and outlined in the Engineering Appendix (Appendix C).

8.5.2 General Oyster Reef Restoration Considerations

As part of the CRP, key points were identified in the selection for restoration measures proposed at future candidate sites. These key points are used to evaluate the candidate sites in terms of whether oyster reef restoration at each of the sites is expected to be successful and, in concert with anticipated relative cost of the restoration techniques to be employed at each of the sites.

8.5.2.1 Site Selection

An important consideration of site selection was to choose sites that:

- Are compatible with local geography, land-use patterns, and navigation features within the study area.
- Avoid or minimize negative impacts to existing aquatic/terrestrial habitats in the vicinity of the restoration area, including plants and animals, and historic/cultural resources.
- Address the concerns and desires of the local community, including educational institutions, private advocacy groups, municipalities and local community boards. Cooperation with these and other stakeholder groups will be essential for the development of a positive public perception of oyster reef restoration in the HRE.
- Are consistent with federal, state and local regulatory agency requirements and policies.

After consideration of the information presented in the previous four (4) bullets, site selection should be a rigorous process. Key items to address in site selection are the following:

- Bathymetry: Existing bathymetric datasets can be used to identify areas that fall within the range suitable for oyster reef formation. Bathymetric design features for oyster reefs that have been constructed within the HRE recently place the height of constructed reefs at least one (1) foot below mean low water; within ranges to provide adequate tidal flow and sufficient water column dissolved oxygen, and at elevations that help to prevent poaching (i.e., as deep as possible but well within range of oyster life requirements).
- Salinity: Oysters are tolerant of a range of salinities; however growth is stunted at sustained salinities below 7.5 ppt. Oysters will not feed or grow in waters of less than five (5) ppt or above 32 ppt. Normal growth requires at least 10 ppt. An optimal salinity range of 12 to 27 ppt will ensure adequate production of gametes and promote rapid larval growth and settlement, while maintaining protection from oyster predators that are common in higher salinity waters, and disease. Autumn salinity measurements can be used to determine maximum values within a proposed reef construction area and spring measurements can be used to determine minimum values.

In addition, other criteria identified in the guide to consider for site selection are the following:

- Existing shellfish beds: Datasets of existing shellfish resources (e.g., clam beds, etc.) could be used to identify areas within the HRE that would benefit the most from oyster reef restoration.
- Existing navigation channels: Oyster reef restoration projects should not occur in the immediate proximity of navigation channels due to the disturbance from wake effects and sediment re-suspension.
- Tidal hydrodynamics: Tidal circulation patterns determine whether the area may act as a source or sink for larvae, help reduce or eliminate episodic hypoxia, and gently scour fine silt may foul an oyster reef in quiescent waters. Areas with higher current flows promote food delivery and waste removal. Hydrodynamic and/or particle transport models may be used to identify appropriate locations for constructed oyster reefs, particularly with regard to the potential movements and settlement patterns of oyster larvae.
- Attractive nuisance potential: Ideally, areas where illegal harvesting of oysters from constructed reefs can be deterred or prevented should be considered.
- Maintenance and monitoring: Constructed oyster reefs should be readily accessible to perform maintenance and monitoring activities, or to setup staging areas during initial reef construction activities or subsequent maintenance.
- Height: Optimal reef height will vary among geographic locations, as a function of tidal range and climate factors. It is generally believed that natural oyster reefs in the HRE did not achieve the considerable degree of vertical relief seen in estuaries to the south, such as Delaware Bay or Chesapeake Bay (K. Tammi, Roger Williams Univ., personal communication as cited in the 2009 CRP); rather, they formed beds of low to moderate relief. Thus, constructed reef designs in the HRE should take regional variability in height and growth form into consideration. Lenihan et al. (1999) found that oysters restricted to low-flow environment (e.g., at the base of reefs or in sheltered environments) were more susceptible to infection due to generally poor physiological conditions and recommended that restoration practitioners take flow speed and height into consideration in reef designs so as to elevate oysters above the low-flow benthic boundary layer. An added benefit of locating oysters above the benthic boundary layer is reduced sedimentation and greater food availability/quality.

- Sedimentation: Excess deposition of sediment, either gradually or in pulses due to stochastic natural or anthropogenic effects, is detrimental to the growth and survival of oyster reefs. The siting and design process for constructed oyster reefs should account for identification of local sediment sources, the probability of periodic sediment re-suspension events (e.g., deep draft vessel passage or maintenance dredging) in the vicinity of the proposed reef. Pre-construction analyses of the rate and magnitude of sediment deposition may be necessary to assure that the rate of sedimentation in the vicinity of a proposed oyster reef will be less than the anticipated rate of vertical accretion.

8.5.2.2 Stock and Substrate Selection

When selecting a broodstock for placement, it is important that the stock matches salinities and diseases present at specific geographical locations. Thus, having a local aquaculture and laboratory facilities that develop larval oysters for spat, and subsequent placement at local sites, would be an important component of future restoration efforts.

In order to reach maturity, spat need to attach to a solid surface. While rocks and other underwater debris are suitable for oyster growth, spat have higher success rates when attached to other oyster shells. Using carefully engineered aquaculture procedures, spat are cultured in specialized tanks and allowed to set onto oyster shells, or cultch. In a few months the spat, numbering about a dozen per shell, will have grown into tiny oysters no larger than a fingernail.

8.5.3 Restoration Techniques

Oyster reef restoration 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 sea bed and then planted with live oysters. The primary restoration techniques employed methods found to be effective in previous studies, including those conducted by the ORRP, the Harbor School, and BOP. This chapter identifies the various restoration techniques that will be considered for the development of alternatives at each site.

8.5.3.1 Spat on Shell

Spat on shell (SoS) (Figure D8-4) is produced through aquaculture using local broodstock (adult oysters) by the Harbor School. SoS is constructed by placing a base of eight (8)-to 12-inch sized rock/rubble on the bottom, followed by a veneer layer of approximately two (2) inches of mollusk shell on top of the base material. The top layer consists of the oyster spat settled on shell. SoS oyster beds constructed in deeper waters would require the use of a barge and crane. This type of construction can be accomplished from land; however, it requires an intensive amount of manpower. SoS is suitable for use in lower energy environments with firm substrate, or in combination with other restoration techniques that adequately shelter the SoS from strong currents and smothering by sediments, and prevent its sinking into loose substrate.

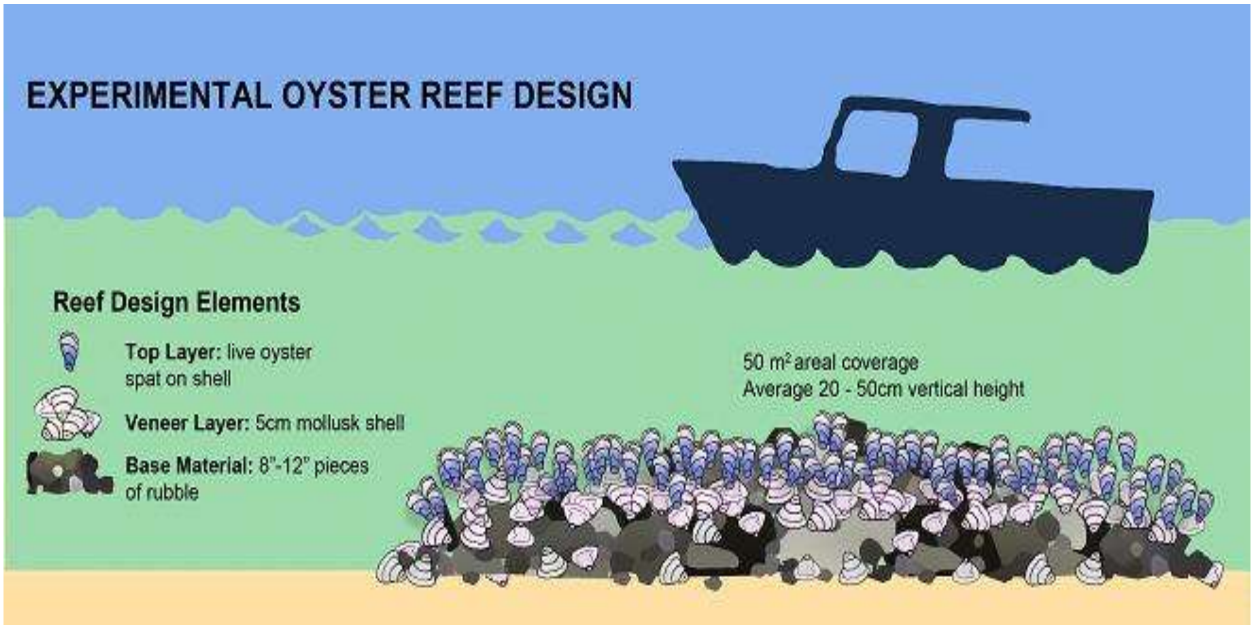

Figure D8- 4. Schematic Experimental Oyster Design – Spat on Shell

8.5.3.2 Reef Balls

A reef ball (Figure D8-5) is a half dome concrete structure. Within the top and surface of the structure, holes are placed allowing the water to flow through the structure and allows for fish and other aquatic creatures to inhabit the structures interior. Although used successfully to construct subtidal and intertidal reefs (USACE and PANYNJ, 2016), reef balls are better used in subtidal areas where the water depth is at least 10 feet above them to avoid damage from waves and currents (Hardy, 2011). 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 PANYNJ, 2016).

Figure D8- 5. Reef Ball

8.5.3.3 Oyster Condos

The Harbor School at Governors Island, New York, have designed an oyster condo (Figure D8-6) which are triangular structures constructed with welded rebar designed to hold gabion bags of oysters upright in the water column. Because oyster condos are stable structures, they are ideally suited for marine environments with strong currents. The triangular structure mimics the rugosity, or three dimensionality, of an oyster reef, providing additional habitat opportunities for marine fauna.

Figure D8- 6. Oyster Condo

8.5.3.4 Oyster Castles

Oyster castles (Figure D8-7) are constructed with interlocking concrete blocks usually about 30 pounds each. The blocks, which are partially hollow are interlocking and stacked like a brick wall. An oyster castle is designed to be instant habitat for oyster spat and growth. Oyster castle blocks are made of shell, limestone and concrete. The 12-inch by 8-inch square blocks are shaped in a tiered-structure that can interlock with each other to resist constant wave motion. It has been determined from previous studies that, in addition to providing immediate habitat for oyster growth, the placement of the castles fosters sedimentation behind them and encourages the regrowth of natural vegetation. This provides a shoreline erosion prevention benefit that is a mix of engineering and nature.

Figure D8- 7. Oyster Castle

Faherty (2011) restored an oyster reef on tidal flats off Lieutenant Island, in Wellfleet, Massachusetts. The study monitored the growth and survival of natural-set oysters to determine which of three (3) treatments — oyster castles, reef balls, and shell cultch (comprising surf clam and oyster shells) — worked best for catching and growing wild oysters. Oyster castles were the only substrate to maintain their structural integrity and to show a net increase in their oyster population each year (Faherty, 2011). Oyster castles also surpassed the other two (2) experimental treatments in terms of oyster abundance, density, and average size.

8.5.3.5 Wire Cages/Gabions

Wire cages (Figure D8-8 are filled with oyster shells pre-seeded with spat. The cages are then left on the bottom. In 2014, a gabion block restoration pilot effort was designed to address the erosion of SoS observed during the ORRP Phase 1 study and the first year data from the ORRP one-acre oyster reef restoration effort at the confluence of the East River and Bronx River, off Soundview Park (Lodge et al., 2015). In the later part of the Soundview effort, a new design was tested consisting of one (1) cubic-foot wire mesh blocks (small gabions), filled with oyster shell and secured together to form two (2) perimeter reefs, into which two-month age class SoS from the New York Harbor School was placed. In addition, half of the wire mesh blocks filled with oyster shell was also set with juvenile (two-year age class) oyster SoS, also produced by the Harbor School. Both studies were conducted in shallow waters, typically less than four (4) feet in depth.

Figure D8- 8. Wire Cages/Gabions

8.5.3.6 Super Trays

Super trays (Figure D8-9) 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, allowing water to circulate and flow through the trays and disperse veliger (larvae) to the water column and, ultimately, to nearby constructed reefs or beds, or other areas of hard substrate.

Figure D8- 9. Tray for Hanging Super Tray

8.5.3.7 Anchored Bags

Anchored bags (Figure D8-10) are mesh bag filled with oysters placed on the bottom historically used in aquaculture and shoreline stabilization efforts. In intertidal or shallow areas, the reef materials are deployed into patches and mounds in the estuarine waters and along shorelines. Reef materials are bagged and stacked to form a protective reef along the shoreline. In addition, the shell and marl can be deployed with shallow draft barges into mounds and interconnected patch reefs. NYCDEP, in collaboration with Cornell University's Cooperative Extension Service, constructed a 150-square-foot demonstration oyster reef from SoS over shell bags at Dubos Point, Jamaica Bay (USACE, PANYNJ 2016).

Figure D8- 10. Anchored Bags

8.5.3.8 Summary of Oyster Reef Restoration Techniques

Based on the information presented above, Table D8-2 identifies the best location, pros and cons, and installation effort of each restoration technique.

Table D8- 2. Summary of Oyster Reef Restoration Techniques.

Restoration Technique	Best Location for Installation	Pro	Con	Installation Effort
Spat on Shell Oyster Beds	Lower energy environments with firm substrate.	Oysters prefer to attach to other oyster shells. Best replicates normal settlement and growth most naturally.	Reef bases can be washed away or smothered in sediments or algae.	Placement off shore in large areas would require barges and cranes.
Reef Balls	Firm substrate that can support the 40-pound ball without sinking. Best used in water depths where wave action is less likely to damage structures.	Can be easily constructed with concrete or a mix of concrete and oyster shells. Less likely to be adversely affected by sedimentation and anoxic/hypoxic conditions.	Due to the hollow design with holes in the structure's surface, if poorly constructed could break apart.	Would likely require boats and divers as they should be placed well below the surf zone.

Restoration Technique	Best Location for Installation	Pro	Con	Installation Effort
Oyster Condos	Firm substrate that can support the 100-to 300-pound condos, without sinking.	Stable. Interlocking system that provides good vertical habitat.	Potential hazard to watercraft.	Requires boats and divers in waters over four (4) feet at low tide. Shallower areas could be accessed from land and wading to desired site.
Oyster Castles	Firm substrate that can support the approximately 30-pound blocks without sinking.	Stable. Interlocking system that provides good vertical habitat. Less likely to be adversely affected by sedimentation and anoxic/hypoxic conditions.	Potential hazard to watercraft.	Requires boats and divers in waters over four (4) feet at low tide. Shallower areas could be accessed from land and wading to desired site.
Wire Cages / Gabions	Anywhere except on anoxic mud and/or environments with substantial deposition.	Lightweight. Easy to make. Has good record of success so far in the limited installations in the HRE.		Would likely require boats and divers in waters over four (4) feet at low tide. Shallower areas could be accessed from land and wading to desired site.
Super Trays	Hanging from a fixed structure or float.	Allows oysters to live over a muddy bottom habitat without the need for expensive substrate alteration.	Requires suitable structure or float to be in place for tray installation.	Minimal.
Anchored Bags	Anywhere except on anoxic mud and/or environments	Lightweight. Easy to manipulate.	Durability. Bags made with non-toxic materials (e.g., hemp, etc.) have shown to be	Would require boats and divers in waters over

Restoration Technique	Best Location for Installation	Pro	Con	Installation Effort
	with substantial deposition.		less durable than plastic or other synthetic materials.	four (4) feet at low tide. Shallower areas could be accessed from land and wading to desired site.

8.6 Site Selection

Six sites throughout the HRE were evaluated for potential success as small-scale oyster reef restoration opportunities (Figure D8-11). The specific locations were determined based on the prior investigations within the region of principal investigators that have worked on advancing restoration in the HRE since 2010. Originally, the areas of highest probability of success were identified in the TEC maps presented in the 2009 draft version of the CRP based on physicochemical parameters. Pilots were advanced and past success was determined based on monitoring data collected at these pilot locations. These locations were the recommended sites by experts in this field in the NY/NJ Harbor Estuary.

8.6.1 First Screening

One site, the Tappan Zee Bridge was screened out due to lack of sponsor support. NYSDEC indicated they did not want to pursue oyster reef restoration at this time intending to wait multiple years evaluating data collected from the current project (Table D8-3).

8.6.2 Second Screening

Governors Island is the site of a 2010 pilot oyster reef from the ORRP. In 2010, as part of the ORRP, a 50-square-meter Spat on Shell (SoS) bed was installed at Governors Island. Although there was some documented survival of oysters, boat wakes and tidal currents in the area dismantled the SoS bed and prohibited substantial settlement or recruitment (Grizzle et al., 2013). Significant transport of SoS off the reef occurred during the winter months, which was addressed by re-seeding SoS in 2011. The fall 2011 monitoring events showed good retention and growth, as well as evidence of possible natural recruitment from wild oysters (Grizzle et al., 2013). Oyster condos were installed around most of the perimeter of the reef in 2014-2015 to address the issues with transport of spat on shell off of the reef. Conversations with BOP personnel indicate that this engineered solution, used as part of Harbor School curriculum, has increased documented oyster survival. Spat on shell oysters placed in 2016 grew an average of 0.1 millimeter per day between June and November of 2016 with a 7.3 percent survival rate. The low survival rate is likely due to predation by oyster drills. Continuing experiments planned for 2017 included placement of larger oysters and experimentation with copper tubing on the cage structures as a predator deterrent.

Unfortunately, the sponsor-led pilot oyster reef restoration project at Governors Island was ultimately unsuccessful, and ongoing data collection indicated that the proposed USACE action at Governor's Island may also be at high risk of failure. Due to this, the Governors Island Oyster site was screened out.

8.6.3 Third Screening

The Soundview Park Oysters were dropped because the sponsor recently received a grant for construction of the project and will advance the project independent of the HRE plan.

Site locations and alternatives were evaluated for each site using the information gathered from prior restoration efforts, analyzing site conditions based on readily available data (e.g., water quality, bathymetry, hydrodynamics, etc.), considerations and constraints for oysters and locations, and tested restoration techniques. The conceptual plans identify potential restoration techniques and constraints to oyster reef restoration at each site.

Figure D8- 11. Evaluated Proposed Restoration Sites

Table D8-3. Oyster Site Screening.

Site Name	1st Screening: Sponsor Support	2nd Screening: Unfeasible Conditions	3rd Screening: Advanced by Partners
Jamaica Bay, Head of Jamaica Bay			
Naval Weapons Station Earle			
Bush Terminal			
Soundview Park			
Governors Island			
Tappan Zee Bridge			

8.6.4 Lessons Learned from Prior Restoration Efforts

The following recommendations for future oyster reef restoration efforts in the HRE are based on the investigations of the ORRP experimental reefs at Bay Ridge Flats, Governors Island, Hastings, Soundview Park, and Staten Island (Mosher-Smith,2012); Grizzle et al., 2013); Lodge, undated; and Peterson and Kulp, 2013):

- Increase reef size: Larger reef footprints would aid in the assessment of reef development and performance, provide information more relevant to full-scale restoration, and increase the odds of recruitment from wild oysters.
- Develop mechanisms to limit erosion and transport of SoS off the reef: A large percentage of the planted SOS were hydraulically transported off the rip-rap and clam shell reef bases. Therefore, developing reef construction or reef maintenance techniques for retaining the planted SoS on the reefs is a critical obstacle to overcome when attempting to restore oyster reefs in the high energy areas typical of NY/NJ Harbor.
- Develop native broodstock: As oysters in the HRE may have developed a natural resistance tempered by adaptation to local environmental conditions (temperature, salinity, etc.) to the two (2) critical diseases, MSX and Dermo, development of broodstocks on a regional basis may be the most effective way to produce larvae for remote setting and production of SoS used to seed restored reefs. The long-term success of SoS used to seed restored reefs will likely be dependent on their disease resistance. At the Hastings site, where the oysters may be adapted to a wider range of salinities, restoration projects might be more successful if local broodstocks for larvae and SoS production were developed.
- Adopt monitoring protocols to new reef design: Quadrat-based monitoring methods are well suited for reefs that are accessible from shore, but proved difficult to consistently implement at sites in deeper water that required boats and the use of divers. The overall result was limited data from the deep-water reefs. For future projects that involve shallow and deep-water sites, monitoring methods should be developed that allow direct comparisons of the resulting data. The sampling devices do not have to be identical, but sample size and effectiveness should be similar.

- Adaptive approach: Future oyster reef restoration efforts must maintain an adaptive approach, reacting as necessary to findings that may emerge from monitoring.

8.7 Existing Conditions and Future without Project Conditions

The information for each site provided below summarizes readily available regulatory agency resource mapping, water quality data, prior oyster reef restoration efforts, published reports and journal articles, and site observations.

For over 100 years, NYCDEP has conducted a water quality monitoring program throughout New York Harbor. Water quality samples and measurements have been collected annually near Governors Island by NYCDEP. For 2011, the Inner Harbor region (water north of the Verrazano Bridge) was assigned a water classification of “I”. This score indicates that the waters of the Inner Harbor are suitable for fishing and boating, but not bathing. It also indicates that dissolved oxygen readings were never measured below 5.0 milligrams/liter (NYCDEP, 2012).

The water quality for the Inner Harbor region is based on the results for individual sampling stations. There are approximately 80 stations around the harbor (Figure D8-12). The 2011 site-specific data for the restoration locations are presented in Table D8-4. The water quality parameters measured at these locations are suitable for oysters.

Broadly speaking, oysters need the following water quality parameter ranges to survive:

- Salinity: Tolerable salinity range varies by life stage. Larvae need 10 to 27.5 parts per thousand (ppt)[2]. Adults can tolerate five (5) to 40 ppt, but optimum range is 14 to 28 ppt[1]. Adults have little growth below five (5) to 10 ppt[1] (NOAA, 2016).
- Temperature: Optimal temperature for larvae is 68 to 90.5 degrees Fahrenheit (°F) and for adults 68 to 86°F. Adults can tolerate 35.6 to 96.8°F and up to 120.2°F for short periods. Larvae can grow in water as cold as 63.5°F (NOAA, 2016).
- pH: Larvae are the most sensitive to pH. The tolerable pH range is 6.75 to 8.75 (NOAA, 2016).
- Dissolved oxygen: Oysters are more tolerant of low dissolved oxygen than are many bay animals. Preferred habitat is at >20 percent saturation, which corresponds to 2.3 milligrams/liter at 50°F and 1.5 milligrams/liter at 86°F (NOAA, 2016).

[2] ppt originally expressed as practical salinity units (psu). For purposes of consistency throughout the document, all salinities expressed as ppt.

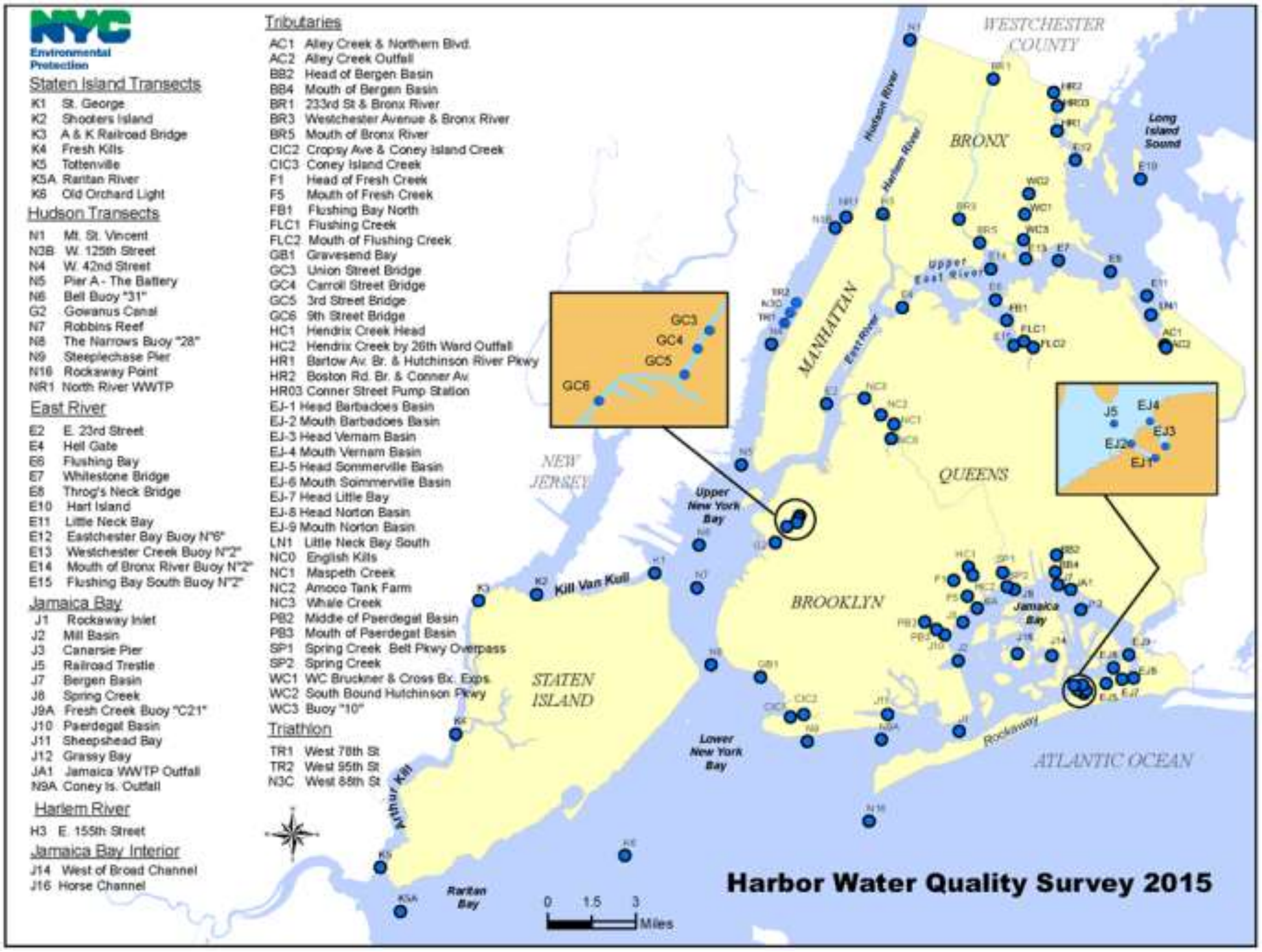

Figure D8- 12. NYCDEP Harbor Water Quality Monitoring Stations

Table D8- 4. NYCDEP 2011 Monitoring Results for Locations BR5, E14, G2, J5, J12, N5, and N6.

Restoration Site	Related NYSDEP Sampling Location	Date (2011)	Depth (ft)		Salinity (ppt)[3]		O_2 (mg/L)		pH		TSS (mg/L)		Chl a (ug/L)	
			Top	Bot	Top	Bot	Top	Bot	Top	Bot	Top	Bot	Top	Bot
Soundview	BR5	5/16 - 12/13	3.0 - 5.0	8.0 - 24.0	13.2 - 23.5	21.7 - 24.0	3.2 - 11.4	3.0 - 8.2	7.7 - 8.9	7.5 - 8.9	<2.0 - 22.0	4.0 - 16.0	1.1 - 141.0	NS
	E14	1/10 - 12/13	3.0 - 4.0	11.0 - 24.0	18.2 - 24.9	20.3 - 25.1	3.2 - 12.1	3.1 - 12.0	7.4 - 9.5	7.4 - 9.5	4.0 - 26.0	6.0 - 30.0	0.9 - 50.4	NS
Bush Terminal	G2	2/8 - 12/19	3.0 - 4.0	24.0 - 30.0	6.5 - 24.1	16.8 - 26.4	4.0 - 16.0	3.7 - 11.5	7.6 - 9.2	7.6 - 9.1	2.0 - 26.0	2.0 - 26.0	0.9 - 48.9	NS
Jamaica Bay	J5	1/11-10/5	3.0 - 3.0	16.0 - 23.0	21.0-26.7	21.0-27.5	4.5-14.3	2.8-14.92	7.8-9.6	7.8 - 9.7	2.0 - 28.0	4.0 - 30.0	1.7-129.0	NS
	J12	1/11 - 11/26	3.0 - 3.0	31.0 - 37.0	20.1 - 26.4	20.9 - 26.9	3.8 - 15.0	0.1 - 13.8	7.9 - 9.6	7.5 - 9.6	4.0 - 24.0	2.0 - 26.0	5.6 - 135.4	NS
Governors Island	N5	1/10 - 12/13	3.0 - 4.0	41.0 - 51.0	0.6 - 22.7	12.2 - 28.6	4.9 - 12.9	4.6 - 10.9	7.6 - 9.2	7.6 - 9.2	2.0 - 56.0	4.0 - 143.0	0.8 - 16.3	NS
	N6	2/8 -12/9	3.0 - 4.0	46.0 - 56.0	1.9 - 23.9	21.0 - 29.7	4.8 - 11.3	4.9 - 10.1	7.6 - 9.2	7.8 - 9.2	2.0 - 28.0	2.0 - 34.0	0.6 - 14.8	NS

[3] Data originally identified as psu, converted to ppt for consistency purposes for this report. All other salinities are identified as PPT.

8.7.1 Bush Terminal

The Bush Terminal site is defined by old eroding piers just south of the Gowanus Canal on the western shoreline of Brooklyn. Water depths near Bush Terminal Park are generally shallow, ranging from intertidal along the shoreline to approximately 16 feet, out to the ends of the remains of the old piers. Beyond the piers, the water depth rapidly plummets to over 30 feet (NOAA Office of Coast Survey, Chart 12334). Substrates identified by the NYSDEC include silt and silty sand (NYSDEC Benthic Mapper, 2015). Figure D8-13 depicts the location of the Bush Terminal proposed restoration site.

Tidal currents in the area of Bush Terminal range daily from a slack water condition to speeds up to 1.9 knots. The maximum current speeds in the area occur four (4) hours after high tide (Tidal Current Charts, New York Harbor; US Coast and Geodetic Survey). The water quality of this potential project area is likely similar to that of Governors Island. The nearest NYCDEP monitoring stations to the site are N6 and G2. The results of the monitoring are presented in Table D8-4. Based on the review of available current and tide data, it is anticipated that due to the strong tidal flushing action that the waters of the project area are similar to location N6. Water quality at both N6 and G2 are suitable for oyster growth.

The area is a former pier area used for shipping throughout the industrial era. Coupled with its close location to Gowanus Canal, there may be some level of contaminants in the sediments (See Appendix G [HTRW]). Prior to 1974, the Bush Terminal site was an active port. As of 2006, the car floats and Bush Terminal Rail Yard, 15 blocks south of the project site, are operated by New York New Jersey Rail, LLC, and used occasionally to deliver New York City Subway cars via the South Brooklyn Railway. Soil, groundwater, and sediment at and underneath the site became contaminated in the 1970s due to the unauthorized disposal of construction and demolition debris and liquid waste including oils, oil sledges, and wastewater (USACE, 2014).

The current NYC Park Bush Terminal Pier Park site was created by landfilling Piers 1-4 of the former Bush Terminal Warehouse Complex. Site investigations were conducted between 1999 and 2002, and site remediation was conducted between 2009 and 2014 (NYSDEC, 2017). The selected remedy for the ponded areas is described within the Environmental Restoration Record of Decision: “Excavation and covering of shallow pond area sediments, filling and covering of deeper pond area sediments, and shoreline stabilization to minimize potential ecological exposures to contaminated sediments” (ROD NY Site B00031-2). The site is listed on the NYSDEC Superfund Program database under Hazardous Water (HW) Site Code 58024 and HW Code 224011 with a classification of ‘3’: “Contamination does not presently constitute a significant threat to public health or the environment”. The site has a classification code of C (Completed) and under the Environmental Restoration Program now operates with an Environmental Easement with a Highest Allowable Future Use of Restricted Residential. The site is currently being managed under a Site Management Plan (NYSDEC, 2014).

Figure D8- 13. Bush Terminal Proposed Restoration Site Location

Multiple oyster studies have taken place at and near this location. The first was the Bay Ridge Flats Oyster Pilot Project (2009-2011) which showed extremely high growth rates but low success due to the dispersal of materials caused by fast currents across the barren flats. A larger, higher-relief reef was installed in 2010 as part of the ORRP, which suffered from high sand deposition on the reef and transport of oysters off the reef. While the high-energy environment is problematic, the strong growth rate was promising, so in 2016 efforts were shifted to the adjacent Bush Terminal Park lagoons where proximity to shore and to structures provide protection from strong currents which decreases the chances for loss due to transport. Within the protected lagoons, oysters have thrived, growing at a strong and steady rate and persisting in both wild and cultivated forms in multiple year classes. Ten welded steel gabions (10' x 2' x 2') containing live oysters were installed in the inner lagoon in 2016 and another five gabions were installed in 2017. In 2018, a 24 square-foot bagged-shell reef (approximately 5" in height) was installed in the inner lagoon. Three additional bagged-shell reefs are slated for install in 2020. Further addition of engineered structures to the areas around the outer edges of the park would provide excellent shielding from wave energy, habitat enhancements, and water quality benefits. In the future without project condition, the existing oyster reef at Bush Terminal Park will continue to thrive, but will not see the expansion it would if this project were to occur.

8.7.2 Head of Jamaica Bay

Water depths in the head of Jamaica Bay are fairly deep, up to 33 feet deep. Salt marsh habitat fringes much of the shoreline area. The bottom is steeply sloped close to the shoreline, as depths of over 25 feet are located within 100 feet of the shoreline in many areas. Substrate in the area is noted to be mud (NOAA Office of Coast Survey, Chart 12350). Based on the nearest tidal current station in Jamaica Bay (Grass Hassock Channel), the current speeds in the eastern portion of the bay rarely exceed one (1) knot. Figure D8-14 depicts the location of the Head of Jamaica Bay proposed restoration site in Jamaica Bay.

Water quality samples and measurements have been collected annually in Jamaica Bay by NYCDEP. The collection points J5 and J12 are relatively close to the head of the bay area and are considered part of the Jamaica Bay region. The open waters of the Jamaica Bay region were assigned a water classification of "SB" in 2012 based upon sampling results. The score indicates that the waters of the Inner Harbor are suitable for bathing and other recreational uses. It also indicates that dissolved oxygen readings were never measured below 5.0 mg/l (NYCDEP, 2012). The closest water quality monitoring station is J12 (Table D8-4). Review of the data collected at this location was within the tolerable ranges of oysters. Based on oyster modeling results, it is suggested the head of Jamaica Bay provides a greater potential degree of larva retention.

In 2011, NYCDEP conducted small-scale oyster demonstration projects at Dubos Point using a SoS method and at Gerritsen Creek using reef balls. The goals of the project were to demonstrate the effectiveness of water quality and ecological benefits and the effectiveness of safeguards to avoid "attractive nuisance" issues, and to develop information on how to restore a significant habitat type that once thrived in the region. Monitoring parameters included measuring growth, survival, reproduction and recruitment under natural conditions, and measuring exposure to predators. These demonstration projects revealed:

- Adequate conditions for survivability and function;
- Extensive predation;
- Low incidence of disease;
- Growth comparable to other east coast estuaries; and
- Gonadal development, but reproduction and recruitment of oyster larvae not directly observed.

Percent survival was greater on reef balls than on the SoS reef bed. The reef bed was found not to be stable, possibly due to boat activity and strong tidal currents. However, the number of macrobenthic species frequently observed near the oyster bed increased steadily over the life of the project.

As a companion to this effort, to test for the presence of oyster larvae within other areas of Jamaica Bay, NYCDEP also deployed 96 spat collectors at six (6) sites within Jamaica Bay from mid-June through the end of August 2016. As with the demonstration projects, no recruitment was observed in the spat collectors. However, the small scale of this and many other projects in the region may be contributing to the lack of observed recruitment. To date, many projects were only several hundred square feet in size and had limited buffering capacity.

Building upon the research already done at the Dubos Point and Gerritsen Creek sites, in 2016, the NYCDEP has implemented an expanded oyster demonstration project at Head of Jamaica Bay, Jamaica Bay to help address the scale question and determine if recruitment is a factor of the size of the project. A hydrodynamic model determined that the Head of Jamaica Bay site was among the highest sites for larvae retention of the 26 release points modeled. It is believed that the Idlewild salt marsh complex plays a substantial role in retaining oyster larvae prior to settlement (NYCDEP, 2015). The proximity of this site to John F. Kennedy International Airport and the mandatory exclusion zone within the waters of Head of Jamaica Bay provide excellent attractive nuisance controls.

The plan consisted of a spat donor bed and four (4) receiving beds to determine recruitment. Head of Jamaica Bay's relatively small width and proximity to the Idlewild salt marsh complex may increase the chance of recruitment on the test beds. In addition, the larger oyster beds would provide a greater degree of buffering capacity and greater resilience to disease and predation. NYCDEP is working with the New York Harbor Foundation, Cornell University and the Hudson River Foundation on the current ongoing oyster reef restoration effort at the head of Jamaica Bay.

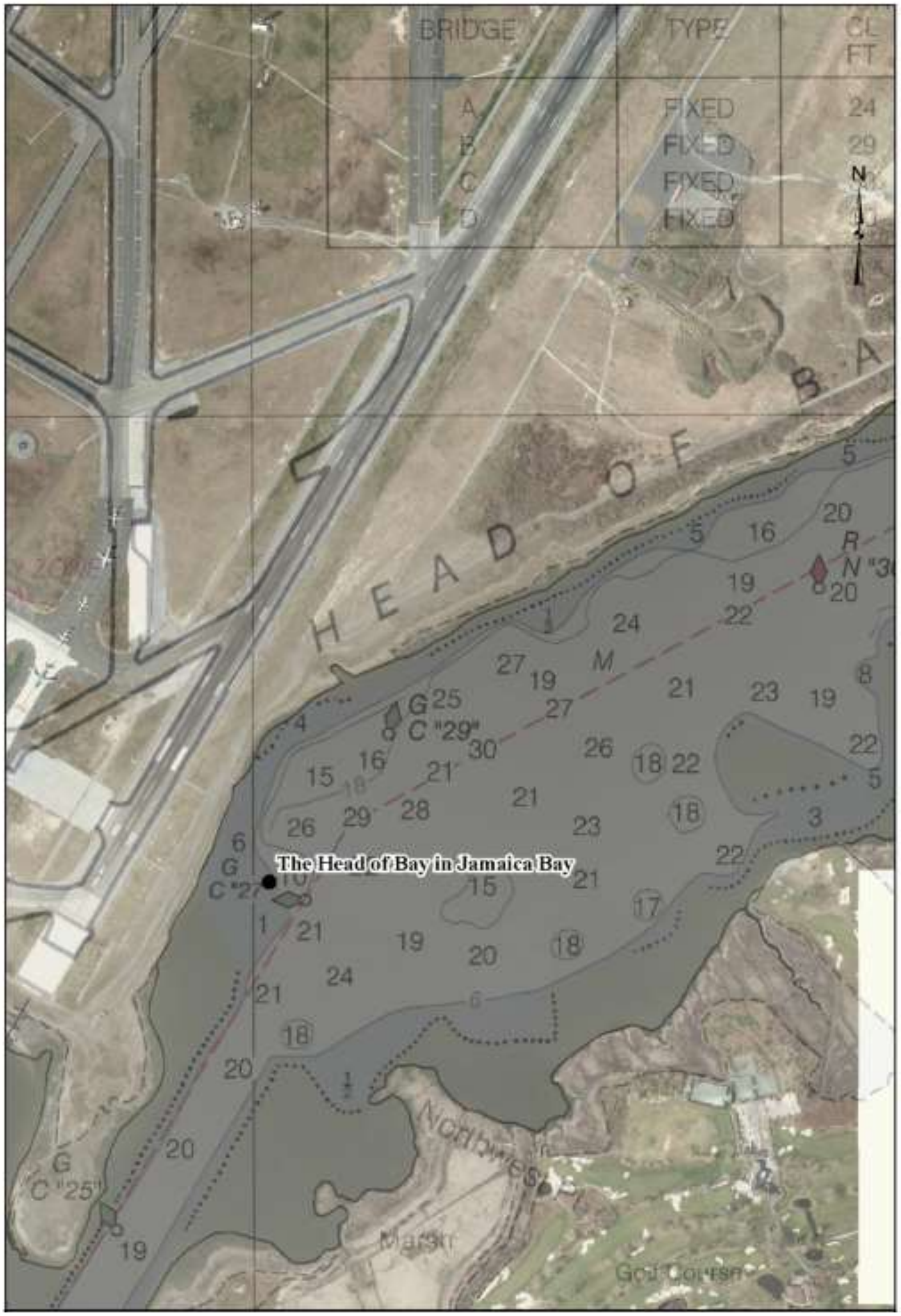

Figure D8- 14. Jamaica Bay Head of Jamaica Bay Proposed Restoration Site Location

In the future without project condition, it is not expected that wild oysters will establish on their own at this location. The lack of an oyster reef at the head of Jamaica Bay will mean that the benthic substrate will remain degraded lacking heterogeneity and optimal habitat for fish and invertebrates. In addition, water quality will not improve in this area due to oyster filtration.

8.7.3 Naval Weapons Station (NWS) Earle

Water depths at the NWS Earle vary from shallow waters of just one (1) to 12 feet out to approximately the midpoint of the pier located there. Beyond the midpoint of the pier to the end of the pier, the water depth goes from 12 to 16 feet. Out past the pier in the Terminal Channel area, water depths reach over 40 feet. Bottom substrates are noted near the pier and indicate substrates including mud and shell (NOAA Office of Coast Survey, Chart 12327). The United States Fish and Wildlife Service (USFWS) notes that the sediments of Raritan Bay and Sandy Hook Bay are predominantly sand, with some areas of gravelly sand overlaid with coarse to fine silt and fine to very fine sand, respectively (USFWS, 1997). Current speeds in the project area, based on NOAA current mapping, are usually less than one (1) knot. Figure D8-15 depicts the specific proposed location at NWS Earle.

Based on available NJDEP data collected near NWS Earle (Table D8-5), the water quality in the project area appears to be able to support the growth of oysters. Based on the 2016 New Jersey Shellfish Growing Water Classification Chart, the potential project area is identified as "restricted", due to potential issues with pollution. As per the NJDEP webpage, shellfish captured in this area must undergo further processing before sale or consumption. Depuration is used for 100 percent of hard clams harvested from the restricted waters of this growing area (NJDEP, 2016).

Oyster reef restoration in New Jersey waters is currently prohibited by the state; however, the naval facility is exempt from these regulations due to extensive security at the site. Over the last few years, a small scale oyster reef restoration has occurred along the naval ammunition piers under the auspices of the NY/NJ Baykeeper. An initial pilot study using lantern bags from the piers found very good rates of survival and growth; although, the durability of the news led Baykeeper to pursue other restoration methods (NY/NJ Baykeeper, 2014).

In July 2010 (NY/NJ Baykeeper 2016), NY/NJ Baykeeper's scientific work to test the viability of restoring oysters in the Raritan Bay was halted. With hope for restoring water quality and habitat in the Raritan Bay, NY/NJ Baykeeper approached the Navy about continuing oyster reef restoration research at NWS Earle, which is under 24/7 security, and therefore eliminates any poaching risk. Commanding Officer Captain Harrison and NWS Earle staff were excited about the idea and helped NY/NJ Baykeeper execute the project.

Figure D8- 15. NWS Earle Proposed Restoration Site Location

At NWS Earle, NY/NJ Baykeeper produces juvenile oysters for restoration projects at the Aquaculture Facility. There hatchery-raised oyster larvae attach, set, and grow on shell substrate, as well as reef balls and oyster castles. The larvae attach themselves to the shell and grow in this protected environment. Once the oysters have "set" on the shell, and grown for about one (1) month, they are ready for release onto newly established oyster beds, or reefs. During 2014 and 2015 three different structures-reef balls set with oysters, metal cages filled with spat on shell, and Reef Blocks filled with spat on shell-were tested over a ¼ acre at the NWSE site. Data showed that survivorship was best within the cages since these structures allow the oysters to be off the bottom alleviating pressure from oyster drills. The structures were placed in two (2) to three (3) feet of subtidal water, reducing the possibility of illegal poaching.

In 2015, monitoring of test structures at NWS Earle yielded the following results:

- Three (3) stages of Dermo (or perkinsosis) observed in tissue materials after addition of formalin preservative. Samples sent to Haskin Shellfish Research Lab in November 2015, to test for MSX and Dermo.
- High salinity around the bay in August led to a Dermo outbreak, which caused unusually high mortality.
- Oyster drill predation is a problem, which can be expected as water temperatures rise and salinity increases.
- During an October site visit oysters that had survived were hearty and had grown well. Juvenile oysters were 30 to 40 millimeters in November 2015, just four (4) months after they were set in the tanks at NWS Earle.

During summer 2016, Baykeeper installed the first phase of a living shoreline project at NWS Earle in summer. Oyster castles were set with juvenile oysters at the NY/NJ Baykeeper aquaculture facility and were placed parallel to the mouth of Ware Creek, on NWS Earle property. This project is part of a larger 200-acre plan involving the Navy and Middletown Township, and Monmouth County Planning to protect critical infrastructure at the naval base. NY/NJ Baykeeper expanded the living shoreline during the summers of 2017, 2018, and 2019 bringing the total number of castles at the living shoreline site to 600.

SCUBA and visual observations performed in 2019 found the installation to be intact. There was minimal shifting of castles, although a few pyramids from previous years have lost some of the top castles. This is encouraging, as the energy of the Raritan Bay due to fetch and storm energy is substantial. Monitoring showed excellent growth and survivorship. When deployed on 7/16/19, spat was an average of 3.0 mm. By 8/15/19, the average length was 18.8 mm and by 9/12/19, the average length was 26.3mm (Figure D8-16). Oyster survivorship varied among pyramids, with a high of 88.2% and a low of 0%. Those castles with low or no survivorship show evidence of the oysters being outcompeted by fouling organisms.

Figure D8- 16. Oyster growth and survivorship on 9/12/19. Photo courtesy of NY/NJ Baykeeper.

A handheld YSI Pro Plus probe was used daily to record water quality (temperature, dissolved oxygen, pH, and salinity) within the setting tanks and in the field.

Three rounds of sediment traps were deployed to determine sediment deposition within the living shoreline installation. All samples are currently being processed at the Rutgers University Soils Lab.

In 2019, Biohabitats performed an onsite baseline shoreline analysis consisting of assessment of vegetative community types and conditions, geolocating the extent of observed biological benchmarks, and photo documentation of site conditions.

Biodiversity observed on the oyster castles includes: crab species such as blue claw, spider, and mud; amphipod species; snail species such as mud and oyster drills; slipper shells; worm species such as hard tube, blood, and clam; sponge species such as red beard, yellow boring, and Bowerbank's*;* anemones; sea squirts; and other encrusting organisms such as lacy bryozoan, barnacles, and golden star tunicate. Larval/juvenile toadfish were present on the oyster castles, indicating utilization of the habitat restored by the oyster castles. Biodiversity was also surveyed using fish trap deployments and visual observations. Additionally, New Jersey City University (NJCU) assisted NY/NJ Baykeeper with fouling organism and invertebrate monitoring by identifying organisms on castles brought to the surface.

NY/NJ Baykeeper monitored the experimental plot between the Navy piers on in early fall 2019 and found recruitment within the Navy cages. These cages contain adult oysters planted as seed in 2015. There is remarkable oyster growth and natural recruitment (Figure D8-17).

In the future without project condition, the existing smaller oyster reef will continue to thrive, but it will not see the level of expansion it would if this restoration plan was executed. The adjacent benthic substrate will remain homogenous providing sub-optimal habitat for fish and invertebrates. In addition, water quality will not improve in this area due to oyster filtration.

Figure D8- 17. Oysters from 2015 and natural recruitment.
Photo courtesy of NY/NJ Baykeeper.

Table D8- 5. Water Quality Data – Raritan Bay Sampling Station 914.

STATION	Type	Temperature (C)	Dissolved Oxygen (mg/L)	Salinity (ppt)	Chlorophyll a (µg/L)
914	# Samples	40	39	40	24
914	Maximum	25	15	29	89
914	Average	14	9	24	14
914	Minimum	3	4	13	0

NJDEP 2015

8.8 Alternatives Development and Selection

Three (3) sites were selected for oyster reef restoration within the HRE. Three (3) alternatives were developed at each site and were evaluated based on ecological benefits (Benefits Appendix) and costs (Cost Appendix) in order to determine the Recommended National Ecosystem Restoration (NER) Plan through conduct of CE/ICA (Appendix J). The Recommended NER Plan for small-scale oyster reef restoration restores approximately 50 acres of oyster bed habitat in NY/NJ Harbor. The proposed actions at each site would provide immediate positive benefits to improve habitat, secondary water quality benefits, and functional uplift to the marine environment.

8.8.1 Naval Weapons Station (NWS) Earle

The NY/NJ Baykeeper has conducted oyster reef restoration at NWS Earle since 2010 on a small 0.25-acre plot in which oyster survival was documented. Being a naval facility with robust security, placement of oyster reef restoration in naval base water would eliminate the potential threat of poaching of oysters. Results (biodiversity, fouling studies, growth and mortality) from ongoing restoration efforts are currently being processed and appears encouraging. Three (3) alternatives were developed for future oyster reef restoration expanding the existing reef constructed by NY/NJ Baykeeper (Table D8-6).

8.8.1.1 NWS Earle – Alternative 1

Alternative 1 includes 32 gabions along the outer perimeter of the reef and 306 oyster pyramids on the interior covering 3 acres.

8.8.1.2 NWS Earle – Alternative 2

Alternative 2 includes 62 gabions along the outer perimeter of the reef and 612 oyster pyramids on the interior covering 6 acres.

8.8.1.3 NWS Earle – Alternative 3 (Tentatively Selected Plan in Draft Report)

Alternative 3 includes 102 gabions along the outer perimeter of the reef and 1,010 oyster pyramids on the interior covering 10 acres.

Table D8- 6. Naval Weapons Station Earle Alternatives

Naval Weapons Station Earle Oyster Reef Restoration	Total Area of Oyster Reef (acres)	Gabions	Pyramids
Alternative 1	3	32	306
Alternative 2	6	62	612
Alternative 3	10	102	1,010

8.8.1.4 NWS Earle – Recommended Plan

The recommended plan is optimized based on Alternative 3 (Figure D8-18). This plan restores a 10 acre oyster reef at the Naval Weapons Station Earle site. A total of 1,010 oyster pyramids, each consisting of 30 oyster castles, will be placed in groups of 30. Each group will consist of 5 staggered rows of 6 pyramids. 102 gabions will also be installed along the outer perimeter of the site totaling approximately 2,420 linear feet.

Figure D8- 18. Naval Weapons Station Earle – Recommended Plan

8.8.2 Bush Terminal

Bush Terminal would serve as a large anchor project for oyster reef restoration in New York Harbor as it demonstrates an innovative solution to reutilizing derelict shorelines and piers. The derelict piers and lagoons provide wave attenuation and the depths vary from shallow to deep allowing for good habitat diversity. This project would be partially located within NYC Parks' Bush Terminal Park. The site is close to the Harbor School, which would result in reduced transport costs for future placement of additional oysters. There is a positive synergistic effect with park visitors, staff, local community groups, and schools. Use of this site provides excellent public access, awareness, and opportunities for future scientific study. In the summer of 2016, BOP and the Harbor School constructed a pilot reef stocked with one million juvenile oysters within the protected lagoons of Bush Terminal Park. Between June and November, repeated monitoring from shore and by divers showed high oyster survivorship of 30 percent, and an average growth of 0.33 millimeter per day. Large wild oysters are present along the shoreline and during the first season of study, some wild oyster recruitment to the pilot reef was evident (BOP personal communication, 2017).

8.8.2.1 Bush Terminal – Alternative 1

Alternative 1 includes 3,760 feet of gabions and 11.0 acres of spat on shell (Figure D8-19) resulting in 376 individual gabions and 26,620 cubic yards of spat on shell.

8.8.2.2 Bush Terminal – Alternative 2

Alternative 2 includes 5,537 feet of gabions and 16.2 acres of spat on shell (Figure D8-20) resulting in 554 individual gabions and 39,204 cubic yards of spat on shell.

8.8.2.3 Bush Terminal – Alternative 3 (Tentatively Selected Plan in Draft Report)

Alternative 3 includes 10,938 feet of gabions and 32.0 acres of spat on shell (Figure D8-21) resulting in 1,094 individual gabions and 77,440 cubic yards of spat on shell.

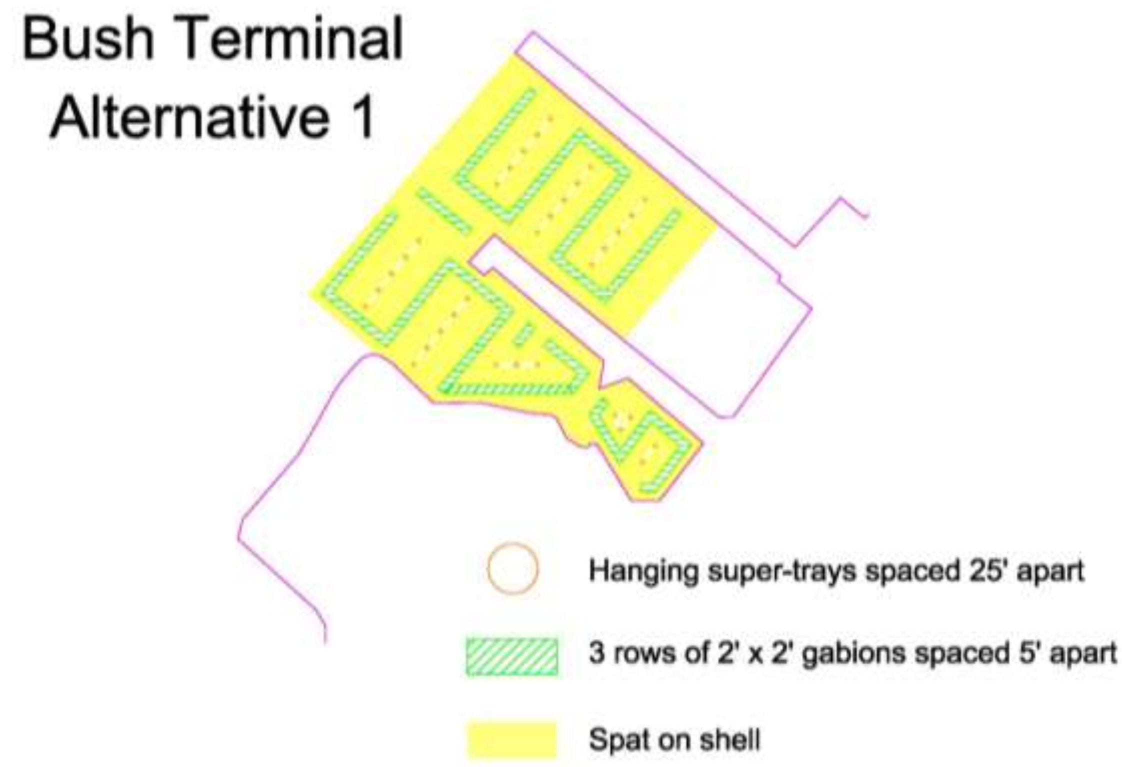

Figure D8- 19. Bush Terminal – Alternative 1

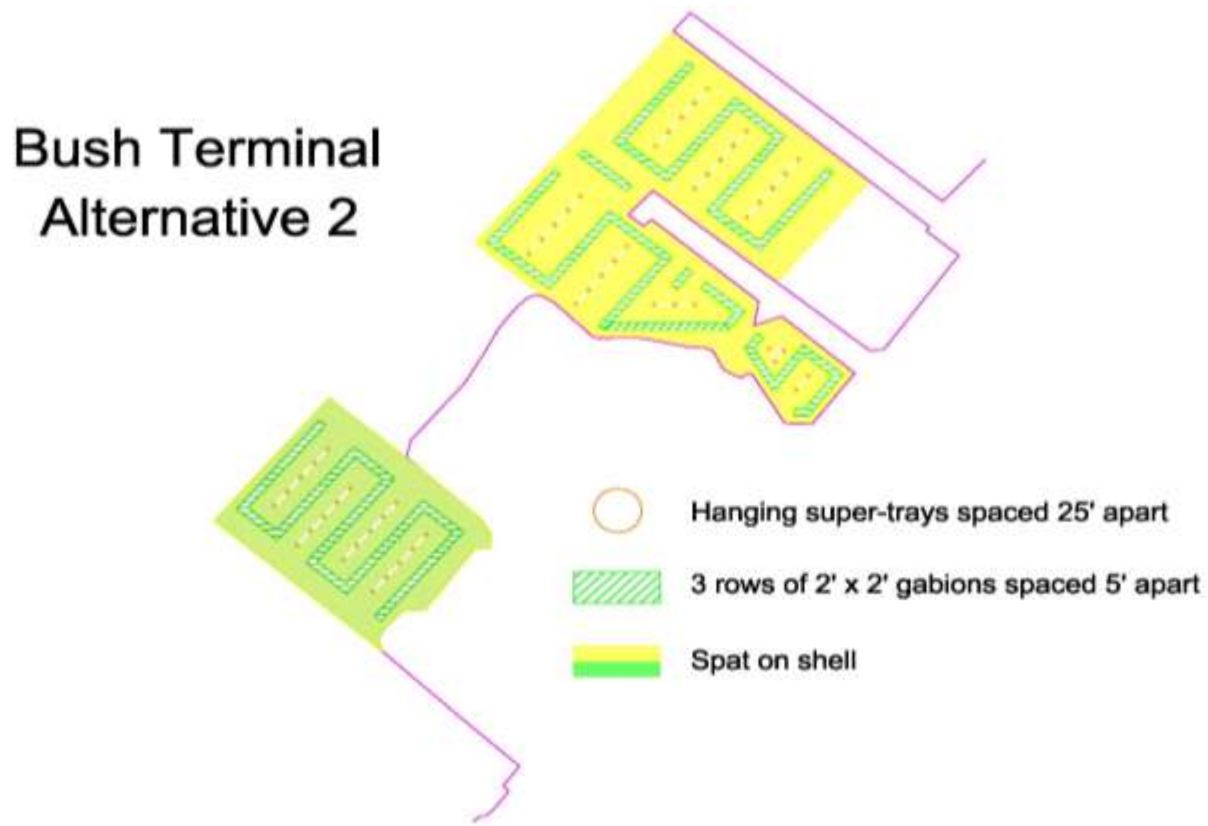

Figure D8- 20. Bush Terminal – Alternative 2

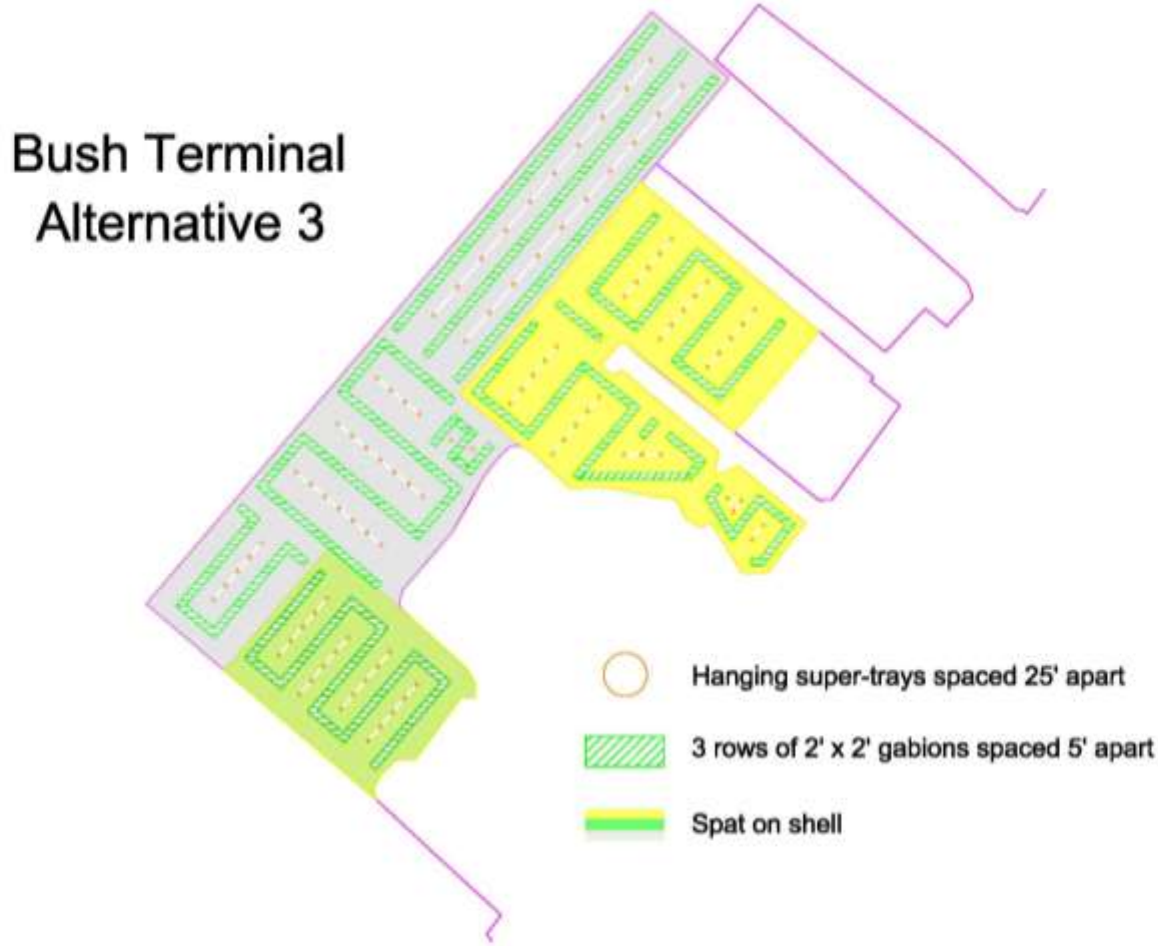

Figure D8- 21. Bush Terminal – Alternative 3

8.8.2.4 Bush Terminal – Recommended Plan

The recommended plan for Bush Terminal is optimized based on Alternative 3 (Figure D8-22). This plan would provide public access, awareness, and opportunities for future studies. The restoration measures for this site include 1,100 oyster gabions and 76,680 CY of spat-on-shell to restore a 31.9 acre oyster reef. The Recommended Plan would complement other restoration work by the NYC Parks at the adjacent Bush Terminal Piers Park and pilot studies for the Billion Oysters Project by the Harbor School.

Figure D8- 22. Bush Terminal Oysters – Recommended Plan

8.8.3 Head of Jamaica Bay

Hydrodynamic modeling showed that the water currents at this site are very conducive to oyster larvae transport and settlement. The proposed restoration site is located within the Head of Jamaica Bay, in somewhat quiescent waters of Jamaica Bay. As such, there is a high likelihood of larval resettlement and beginning of an oyster reef.

8.8.3.1 Head of Jamaica Bay – Alternative 1

Alternative 1 consists of 44 hanging oyster trays, 126 oyster castles, 112 gabions and 3.3 acres of spat on shell yielding 3.3 acres of oyster reef (Figure D8-23). The spat on shell would be 18 inches deep and have a volume of 7,986 cubic yards.

8.8.3.2 Head of Jamaica Bay – Alternative 2

Alternative 2 consists of 70 hanging oyster trays, 224 gabions, 220 oyster castles, and 6.6 acres of spat on shell yielding 6.6 acres of oyster reef (Figure D8-24). The spat on shell would be 18 inches deep and have a volume of 15,972.

8.8.3.3 Head of Jamaica Bay – Alternative 3 (Tentatively Selected Plan in Draft Report)

Alternative 3 includes 24 hanging oyster trays in two rows spaced 40-feet apart, 337 gabions, 150 oyster castles, and 9.85 acres of spat on shell yielding 10 acres of oyster reef (Figure D8-25). The spat on shell will be 12 inches thick and have a volume of 16,840 cubic yards.

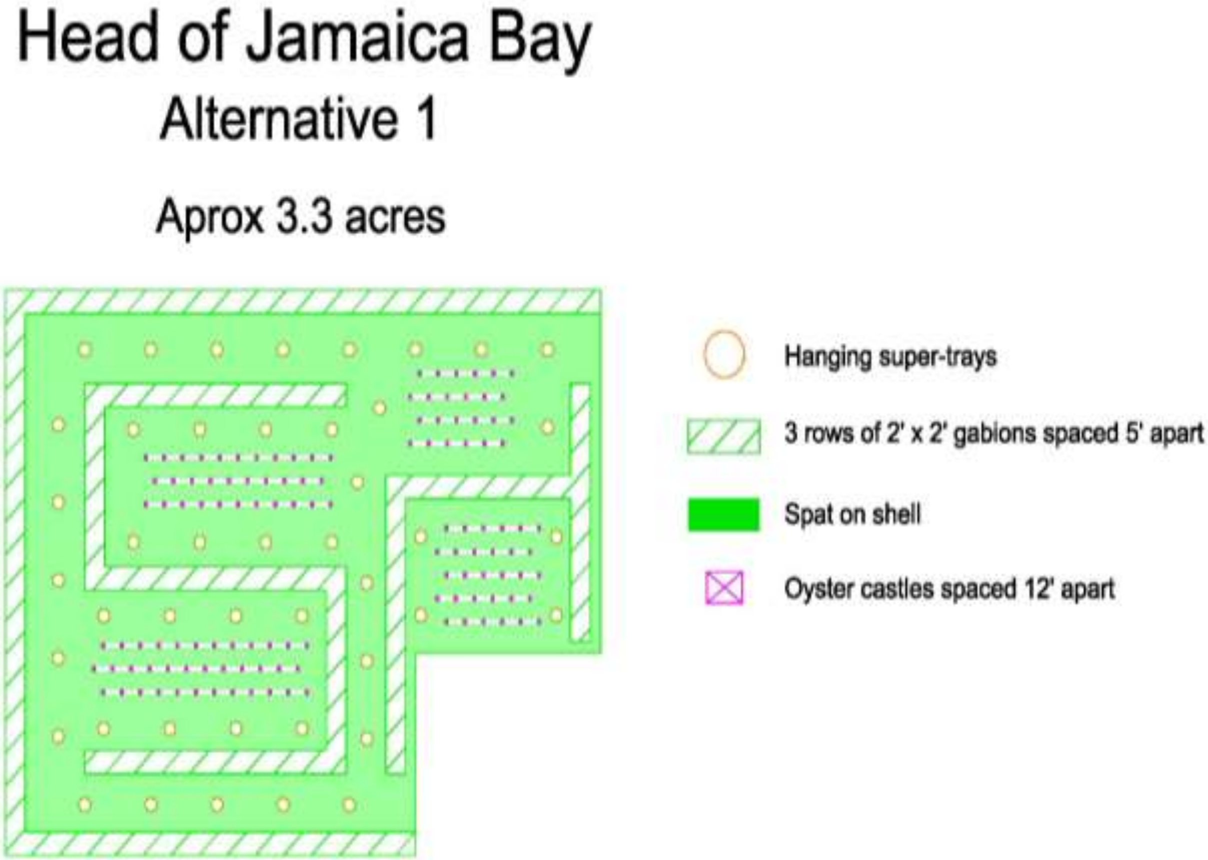

Figure D8- 23. Head of Jamaica Bay – Alternative 1

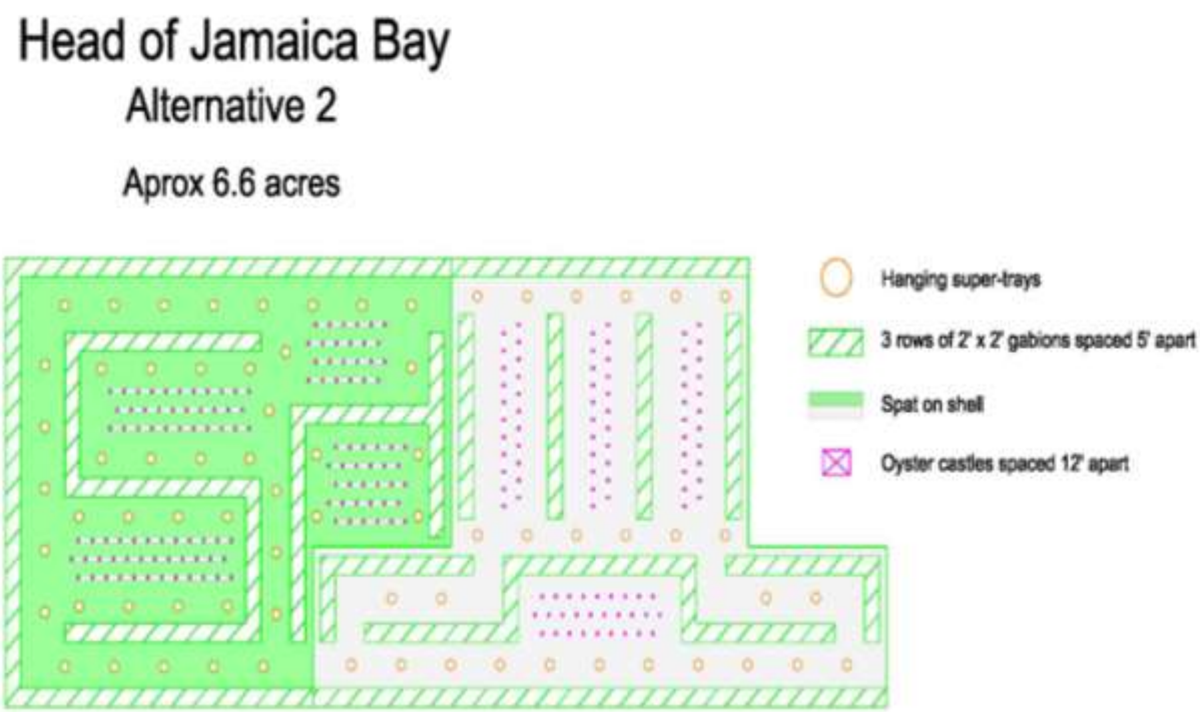

Figure D8- 24. Head of Jamaica Bay – Alternative 2

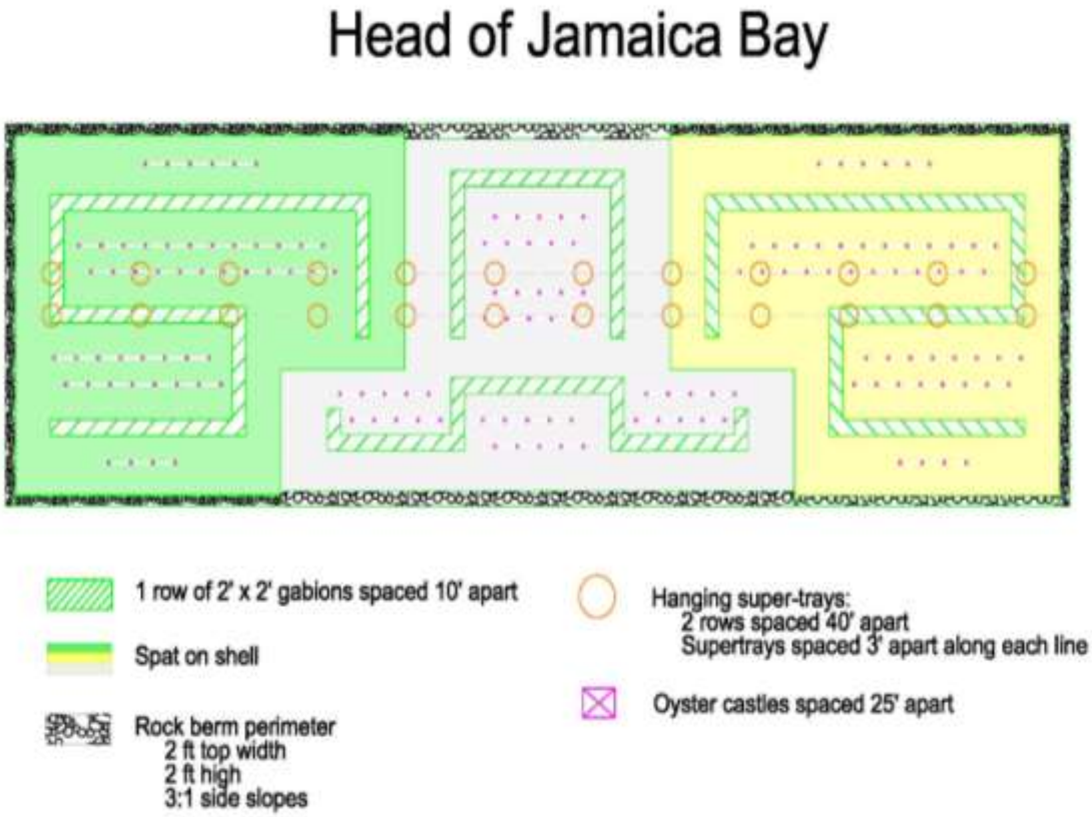

Figure D8- 25. Head of Jamaica Bay – Alternative 3

<u>Head of Jamaica Bay – Recommended Plan</u>

The recommended plan for Jamaica Bay is optimized based on Alternative 3 (Figure D8-26). The recommended plan will restore 10.1 acres of oyster reef through the placement of 9.85 acres of spat on shell placed on a substrate composed of shell and crushed porcelain. Structural complexity is restored through placement of 150 oyster pyramids, each consisting of 30 castles as well as 340 gabions. Gabions and pyramids will be spread among a bed of mixed shell, porcelain and spat-on-shell at a depth of 12-inches. Additionally, two rows of hanging supertrays (470 super trays total) will also be suspended by cables along the 1200-foot length of the proposed bed. The supertrays will be half-filled with spat-on-shell. Oyster reef restoration in Jamaica Bay will expand the reef that was recently constructed by the NYCDEP.

Figure D8- 26. Head of Jamaica Bay – Recommended Plan

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