the WATERS we SHARE

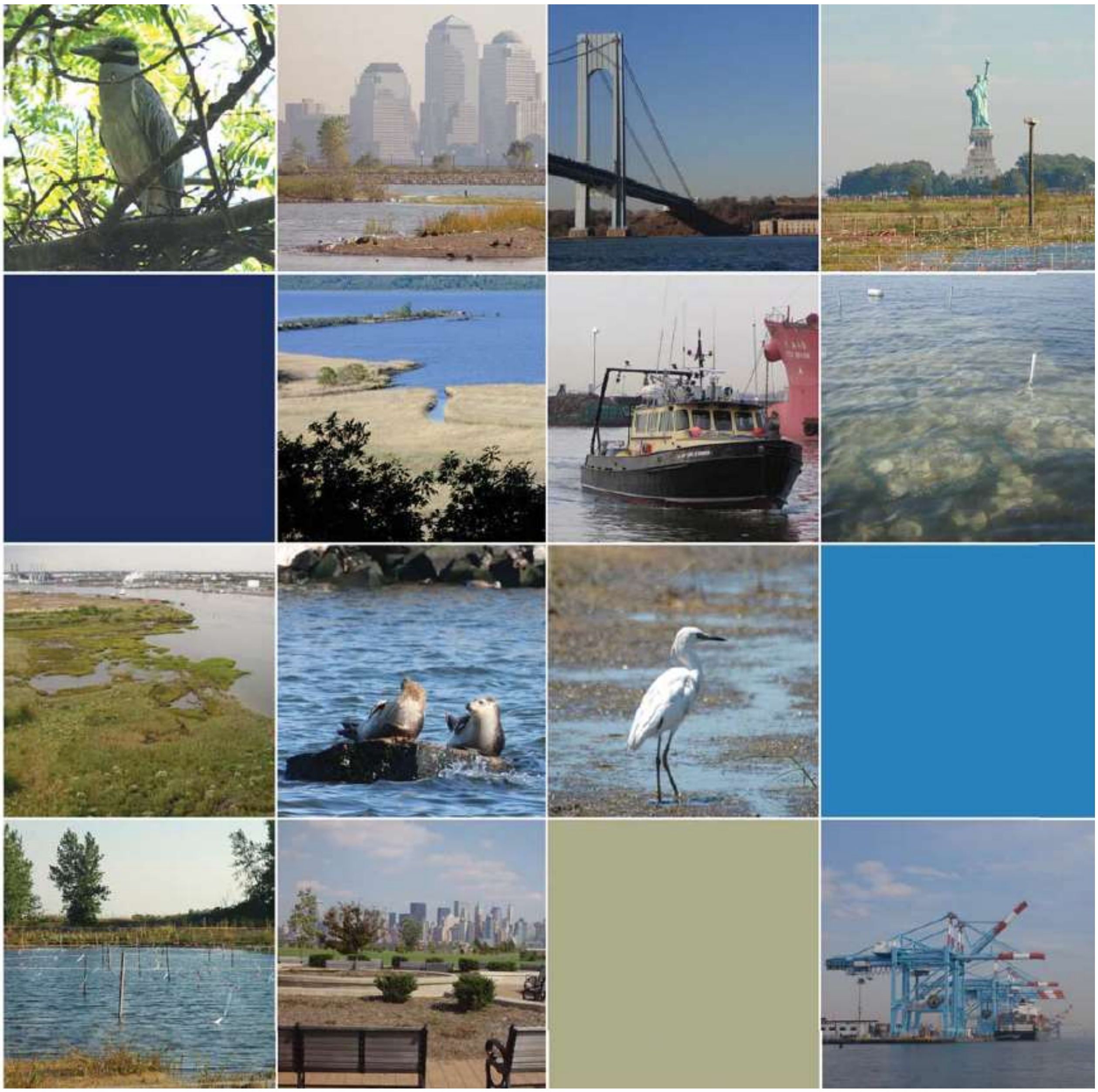
Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

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



Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study

Including:

Jamaica Bay, Marine Park, Plumb Beach Ecosystem Restoration Feasibility Study

Flushing Creek and Bay Ecosystem Restoration Feasibility Study

Bronx River Basin Ecosystem Restoration Feasibility Study

HRE-Lower Passaic River Ecosystem Restoration Feasibility Study

HRE-Hackensack Meadowlands Ecosystem Restoration Feasibility Study

This report was prepared by the New York District U.S. Army Corps of Engineers in partnership with the above sponsor agencies.

This page is left intentionally blank

Executive Summary

This Final Integrated Feasibility Report and Environmental Assessment for the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study was prepared by the United States Army Corps of Engineers (USACE) and provides an interim response to study authorities. The report includes recommendations for:

- Construction of twenty (20) restoration sites throughout the HRE; and
- Future feasibility studies carried out under the HRE study authority or the Continuing Authorities Programs, dependent upon availability of funding and willingness of non-federal sponsors to partner with the USACE.

The restoration opportunities recommended for construction are critical to address long-term and large-scale ecosystem degradation within the estuary. This document presents the potential alternatives for HRE restoration, analyzes the environmental impacts of those alternatives, describes the logic of recommended alternatives at each restoration site, and concludes with recommendations for project implementation. It also documents compliance with the National Environmental Policy Act of 1969 as amended, and includes input from the non-federal study sponsors, natural resource agencies, USACE offices, and the public.

The HRE is within the Port District of New York and New Jersey and is situated within a 25-mile radius of the Statue of Liberty National Monument. The HRE represents one of the most urbanized regions in the United States that has undergone centuries of industrial and residential development along with navigation and infrastructure improvements. Extensive degradation of aquatic and terrestrial ecosystems includes loss or transformation of wetlands, stream corridors, island rookeries, shellfish beds, and migratory bird habitat, all of which host federally-listed threatened and endangered species.

The study purpose is to evaluate the causes and effects of significant, widespread degradation in the estuary; to formulate and evaluate potential solutions to these challenges; to recommend a series of near-term construction projects with federal interest; and to identify potential opportunities for future study under the HRE authority. In partnership with multiple non-federal sponsors, six (6) concurrent USACE feasibility studies were initiated in the 1990s and early 2000s that focused on HRE restoration. Many of the original study sponsors have agreed to be local sponsors for construction of the recommended projects, and other agencies have also agreed to participate as local sponsors for construction and were included in the restoration planning as appropriate (Table ES-1). These “source” studies were integrated into the HRE Ecosystem Restoration Feasibility Study to streamline parallel efforts and maximize efficiencies, resources, and benefits. Analyses completed as part of these studies were incorporated into and informed the current planning effort. This HRE Feasibility Report and Environmental Assessment responds to all “source” study authorities.

Table ES-1: "Source" Feasibility Studies, Study Sponsors and Construction Sponsors

"Source" Feasibility Study	FCSA Execution	"Source" Study Sponsor(s)	Potential Construction Sponsor(s)
Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study	22 FEB 1996	New York City Department of Environmental Protection (NYCDEP)	NYCDEP, New York State Department of Environmental Conservation (NYSDEC), New York City Department of Parks and Recreation (NYC Parks)
Flushing Bay and Creek Ecosystem Restoration Feasibility Study	2 SEP 1999	NYCDEP and Port Authority of New York and New Jersey (PANYNJ)	NYCDEP
HRE Ecosystem Restoration Feasibility Study	12 JUL 2001	PANYNJ	All others and NY Harbor Foundation and NY/NJ Baykeeper for oyster restoration
Hackensack Meadowlands Ecosystem Restoration Feasibility Study	23 APR 2003	New Jersey Sports and Exposition Authority (Former Hackensack Meadowlands Commission)	New Jersey Sports and Exposition Authority and New Jersey Department of Environmental Protection (NJDEP)
Lower Passaic River Ecosystem Restoration Feasibility Study	30 JUN 2003	New Jersey Department of Transportation (NJDOT)	NJDEP
Bronx River Basin Ecosystem Restoration Feasibility Study	3 NOV 2003	NYCDEP and Westchester County	NYCDEP, NYC Parks, and Westchester County

As part of the overarching HRE Feasibility Study, the USACE and Port Authority of New York and New Jersey completed the Comprehensive Restoration Plan (CRP) in partnership with the New York-New Jersey Harbor & Estuary Program in 2009 and updated in 2016. During the preparation of the CRP, twelve Target Ecosystem Characteristics (TECs) were developed in partnership with federal, state, local agencies, academic institutions, and non-governmental organizations. Each TEC is an important ecosystem feature of ecological and/or societal value, which represent key components essential for successful restoration of healthy estuary. The TECs address problems affecting the estuary and describe critical habitats diminished over the past several centuries. Four TECs (Enclosed and Confined Waters, Contaminated Sediments, Public Access, Land Acquisition) were beyond the scope of the USACE's mission and the Eelgrass TEC (which requires additional local research prior to federal investment) were not included in the present ecosystem restoration planning activities. The remaining seven TECs were considered within the study process.

- Wetlands
- Habitat for Waterbirds
- Coastal and Maritime Forest
- Habitat for Fish, Crab and Lobsters
- Oyster Reefs
- Shorelines and Shallows
- Tributary Connections

Drawing from the CRP and "source" studies, overall planning objectives were identified based on problems, needs, opportunities, and existing physical and environmental constraints. Four broad planning objectives were used to guide formulation, screening, evaluation, and recommendation of alternatives. Table ES-2 presents project objectives and sub-objectives relative to the TECs and associated regional targets. Overall objectives include:

- **Objective-1**: Restore the structure, function, and connectivity, and increase the extent of estuarine habitat in the HRE;
- **Objective-2**: Restore the structure and function, and increase the extent of freshwater riverine habitat in the HRE;
- **Objective-3**: Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay; and
- **Objective-4**: Increase the extent of oyster reefs in the HRE.

Restoration opportunities were identified in the CRP, the "source" studies, and by the New York-New Jersey Harbor & Estuary Program Restoration Work Group. Sites were screened per the plan formulation strategy outlined in each "source" study to identify an initial array of 33 sites. Ecological benefits were quantified, costs were estimated, and site-specific cost effectiveness and incremental cost analysis was conducted to identify the Tentatively Selected Plan at each site (as presented in the Draft Feasibility Report and Environmental Assessment in February 2017). Each site was further evaluated to update costs and benefits, and site-scale and regional-scale Cost Effectiveness and Incremental Cost Analysis (CE/ICA) were then used to recommend a portfolio of sites within a Planning Region or habitat type. Thirteen sites were removed from the recommendation following regional-scale CE/ICA, a change in future without project conditions and advancement by others. Ultimately, twenty (20) restoration sites are recommended for execution based on ecological benefits, monetary costs, and secondary ecological, social, and economic factors. Figure ES-1 summarizes the screening, analysis, and recommendation of HRE restoration actions.

Table ES-2. CRP Regional Targets, Project Objectives and TEC Sub-Objectives in the HRE

Target Ecosystem Characteristics (TECs)	Pertinent Project Objectives and Associated TEC Sub-Objectives
Wetlands: Restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage.	**Relates to Study Objectives 1, 2, and 3** • Improve the quantity, quality, and complexity of wetland habitat. • Increase overall diversity and abundance of wetland habitat. • Increase connectivity of wetland habitats to reduce fragmentation. • Improve the hydrologic connectivity of the floodplain and the river/estuary. • Reduce shoreline erosion. • Reduce invasive monocultures, replace with natives • Restore tidal marsh systems to offset both historical and future losses.
Habitat for Waterbirds: Restore and protect roosting, nesting, and foraging habitat for long-legged wading birds.	**Relates to Study Objective 1, 2, and 3** • Improve roosting, nesting, and foraging habitat for long-legged wading birds. • Increase the number of nests and improve feeding habitat for target species.

Target Ecosystem Characteristics (TECs)	Pertinent Project Objectives and Associated TEC Sub-Objectives
Coastal and Maritime Forests: Restore a linkage of forests accessible to avian migrants and dependent plant communities.	**Relates to Study Objective 1 and 2** • Restore maritime forest and grassland habitat to ensure the sustainability of adjacent wetlands/aquatic habitat. • Restore maritime forest and grassland habitat to the system to provide vegetated buffer and transitional zone between aquatic habitat and urban environment. • Provide habitat and food sources for bird and wildlife species, stabilize shorelines, and provide soil retention.
Oyster Reefs: Establish sustainable oyster reefs at several locations.	**Relates to Study Objective 4** • Incorporate diverse habitat structure to improve feeding, breeding, and nursery grounds for fish and benthic communities.
Shorelines and Shallows: Restore shoreline and shallow sites with a vegetated riparian zone, an intertidal zone with a stable slope, and illuminated shallow water.	**Relates to Study Objectives 1, 2, 3, and 4** • Provide habitat and food, stabilize shoreline, retain soils • Soften hardened shorelines to restore transitional zones. • Restore buffer riparian zones, including littoral zones and intertidal areas, to support increased diversity and abundance of biological communities.
Habitat for Fish, Crab, and Lobsters: Restore functionally related habitats in each of the eight HRE planning regions.	**Relates to Study Objectives 1, 2, 3, and 4** • Develop mosaic of diverse quality habitats to sustain fish and invertebrate populations. • Restore natural stream geomorphology. • Reduce sediment loads to improve fish, shellfish, and benthic organism habitats.
Tributary Connections: Reconnect and restore freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms.	**Relates to Study Objectives 1 and 2** • Increase connectivity of riparian habitats to reduce fragmentation in migratory corridors. • Improve the hydrologic connectivity of the floodplain and the river/estuary to improve the function of riparian habitat, reduce velocities, increase infiltration, and improve natural sediment processes. • Enhance basin and tributary bathymetry configuration to promote optimal circulation. • Reduce shoreline erosion. • Remove invasive species and replace with natives • Increase habitat available for migratory fish through removal of fish passage impediment.

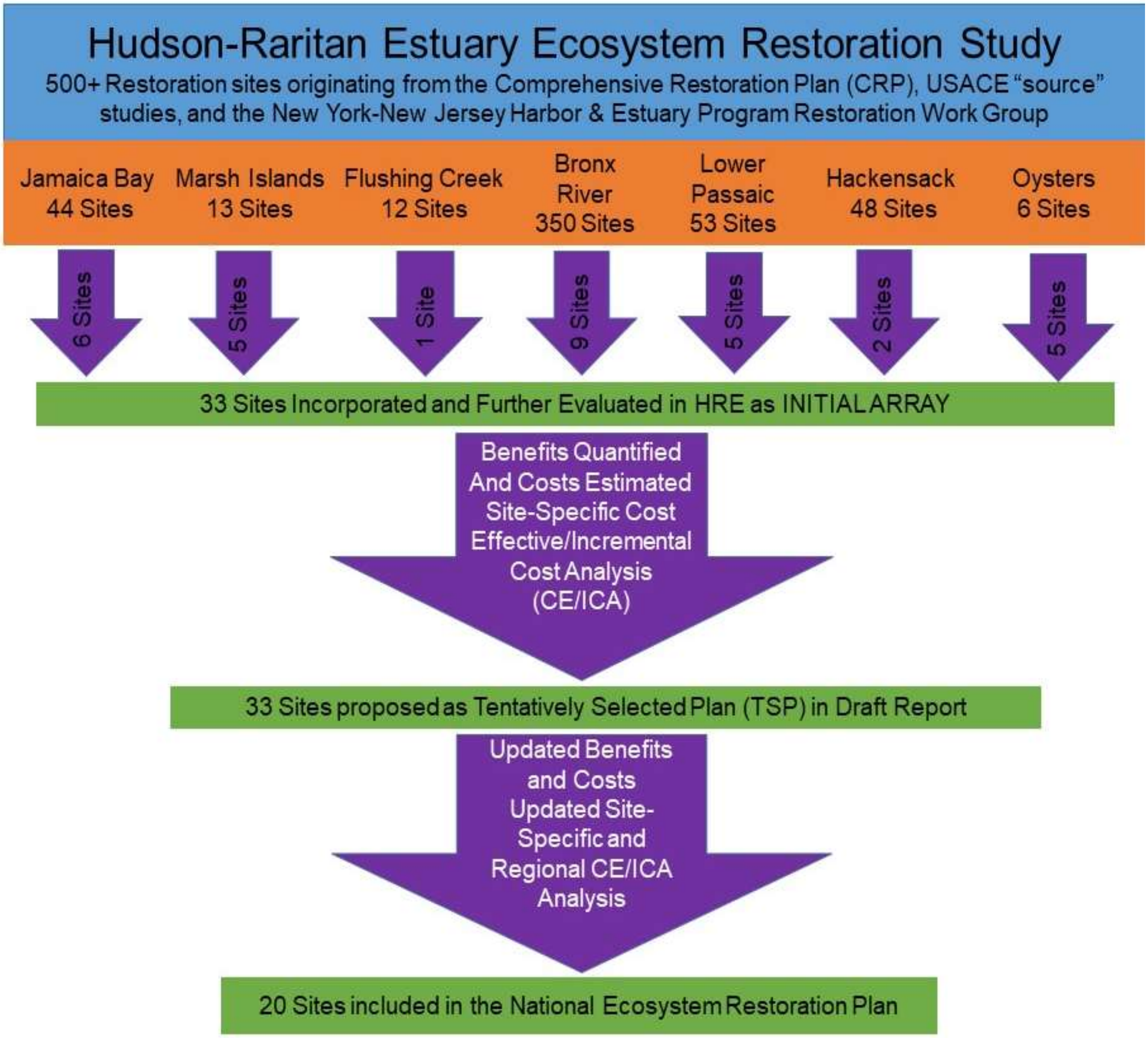


Figure ES- 1. Summary of site screening, benefit and cost analyses, and recommendation of HRE restoration actions.

The National Ecosystem Restoration (NER) Plan is a suite of restoration sites within the HRE that address long-term and large-scale degradation of aquatic habitat. The 20 recommended sites span five of eight planning regions (Figure ES-2) and would restore diverse ecosystems throughout the estuary in support of the CRP’s regional goal, "to develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment". The NER Plan will provide for the restoration of approximately 381 acres of estuarine wetlands including 16 acres/six (6) miles of tidal channels, 50 acres of freshwater riverine wetlands, 27 acres of coastal and maritime forest, 39 acres of shallow water habitat, and 52 acres of oyster habitat. Two fish ladders would be installed and three weirs would be modified to re-introduce or expand fish passage and control flow rate and water volume along the Bronx River.

Additionally, 1.6 miles of streambank restoration and 72 acres of bed and channel restoration is recommended. Tables ES-3 to Table ES-5 summarize the habitats restored by the NER Plan.

Ecological benefits were assessed with functional models, and the NER Plan provides 341 Average Annual Functional Capacity Units (AAFCUs) representing benefits related to estuarine and freshwater wetlands (287), fish passage connectivity (20) and oyster reef habitats (34). The estimated project first cost is $408,184,000 which includes monitoring costs of $2,977,000 and adaptive management costs of $12,359,000 (October 2019/FY2020 price levels). In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the estimated first cost is 65%, or $265,319,600, and the non-federal share is 35%, or $142,864,400. The non-federal costs include the value of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated to be $7,328,570. The fully funded costs will be the basis for the Project Partnership Agreements. The estimated total project cost, fully funded with escalation to the estimated midpoint of construction, is $587,661,000.Table ES-6 summarizes ecological benefits and costs of each site in the NER Plan.

The expected environmental effects of the NER Plan would be overwhelmingly beneficial to the flora, fauna, and people of the HRE. Restoration actions would restore ecosystem function in concert with the urban nature of the existing environment. It would provide the ability for anadromous and catadromous species to access the large segments of the Bronx River for the first time in centuries. Five marsh islands would be restored in Jamaica Bay. Construction of eastern oyster (*Crassostrea virginica*) reefs in the estuary would reintroduce the once-omnipresent keystone species.

As the proposed actions involve construction activities, implementation would result in some short-term, negative impacts to the environment; however, these impacts would be temporary and localized. All restoration measures would be implemented in accordance with regulatory agency stipulations and construction contractors would employ best management practices at all times. As the purpose of the proposed action is to restore degraded habitat and ecosystem function, USACE believes that proposed activities would result in positive significant cumulative effects, considering both the context and intensity of effects resulting from individual actions.

Significant support has been garnered as a result of coordination with long-term partners and stakeholders during the preparation of the Feasibility Study. The NER Plan would advance the region's highest environmental priorities. The Plan supports HRE study objectives and regional restoration goals, and additional non-federal construction sponsors are committed to advancing HRE restoration. Implementation of the NER Plan would complement past, ongoing, and planned restoration work by the USACE and other parties within the HRE in order to advance the region's vision of a "World Class Harbor Estuary".

Figure ES-2. 20 Sites included in the HRE National Ecosystem Restoration Plan

Table ES-3. Estuarine Habitat Restoration in the NER Plan

Restoration Site	Restoration Habitats						
	Low Marsh (acres)	High Marsh (acres)	Scrub/shrub Wetland (acres)	Maritime Forest	Tidal Channel/Pools (acres/linear feet)	Bed and Channel (acres)	Shallows (acres)
Jamaica Bay Planning Region – Perimeter Sites							
Dead Horse Bay	19.0	5.4	6.2	8	2.3 / 3,240		-
Fresh Creek	16.1	4.4	3.6	10.7		45.1	-
Jamaica Bay Planning Region – Marsh Islands							
Duck Point	24.9	5.6	8.1	-	1.0 / 2,730		7.6
Stony Creek	26.0	22.5	3.5	-	1.4 / 4,640		8.7
Pumpkin Patch West	13.7	8.61	0.9	-	0.7 / 2,040		3.9
Pumpkin Patch East	15.6	10.1	3.1	-	0.6 / 1,530		5.2
Elders Center	15.2	10.9	1.4	-	1.0 / 2,500		5.5
Harlem River, East River, Western Long Island Sound Planning Region							
Flushing Creek	9.8	2.5	1.8	3.9	-		1.4
Newark Bay, Hackensack River, Lower Passaic River Planning Region							
Oak Island Yards	5.3	0.9	0.4	2.85	1.4		-
Metromedia Track	26.5	11.7	13.8	-	2.8 / 6,270		6.5
Meadowlark Marsh	56.2	6.5	5.4	-	4.6 / 7,700		-
Total:	**228.3**	**89.0**	**48.23**	**25.45**	**16 / 30,650**	**45.1**	**38.7**

Table ES-4. Freshwater Habitat Restoration in the NER Plan

Restoration Site	Restoration Measures/Habitat Types (acres – except where specified)								
	Emergent Wetland	Wet Meadow	Forest Scrub/shrub	Invasive Removal and Native Planting	Bed and Channel	Streambank (linear feet)	Sediment Forebay	Fish Ladder Installation (miles opened)	Debris Removal
Harlem River, East River, Western Long Island Sound Planning Region									
Bronx Zoo and Dam	1.2	-	0.5	0.4	-	750	-	0.8	0.1
Stone Mill Dam	-	-	-	0.03	0.5	-	-	22.9	-
Shoelace Park	2.1	-	1.1	7.9	5.7	7,420	-	-	-
Bronxville Lake	0.9	-	2.5	1.4	0.7	-	0.3	-	-
Garth Woods/Harney Road	0.8	1.7	0.6	1.6	2.2	200	-	-	-
Newark Bay, Hackensack River, Lower Passaic River Planning Region									
Essex County Branch Brook Park	10.3	-	8.8	8.9	18.1	-	-	-	-
Total:	**15.2**	**1.7**	**13.4**	**20.2**	**27.1**	**8,370**	**0.3**	**23.7**	**0.1**

Table ES-5. Oyster Reef Restoration in the NER Plan

Restoration Site	Restoration Techniques				Total Restoration Area (acres)
	Spat-on-Shell (acres)	Oyster Gabions	Oyster Pyramids	Oyster Trays	
Lower Bay Planning Region					
Naval Weapons Station Earle	-	102	1,010	-	10
Upper Bay Planning Region					
Bush Terminal	31.9	1,100	-	-	31.9
Jamaica Bay Planning Region					
Head of Jamaica Bay	10.1	340	150	470	10.1
Total:					**52.0**

Table ES-6. Benefits and Costs of the Recommended Plan

Site	Net Benefits (AAFCU)	First Costs									Fully Funded Total ($)
		Monitoring Cost ($)	Adaptive Management Cost ($)	Average Annual Economic Cost ($)	Annual OMRR&R Cost ($)	Total[1] OMRR&R Cost ($)	Total First Costs ($)	Federal Share ($)	Non-Federal Total ($)		
									Non-Federal Total ($)	LERRD[2] Costs ($)	
Jamaica Bay Planning Region - Perimeter Sites											
Dead Horse Bay	30.3	$128,137	$285,853	$1,566,406	$4,541	$162,486	$40,750,432	$26,487,781	$14,262,651	$30,500	$68,645,000
Fresh Creek	36.9	$244,626	$273,065	$1,291,116	$5,086	$182,006	$33,914,507	$22,044,430	$11,870,077	$1,806,350	$44,377,000
Sub-Total	**67.2**	**$372,763**	**$558,918**	**$2,857,522**	**$9,627**	**$344,492**	**$74,664,939**	**$48,532,210**	**$26,132,729**	**$1,836,850**	**$113,022,000**
Jamaica Bay Planning Region - Marsh Islands											
Duck Point	28.4	$167,494	$392,470	$813,568	$4,734	$169,394	$21,401,095	$13,910,712	$7,490,383	$14,950	$27,271,000
Stony Creek	37.3	$167,494	$548,540	$887,316	$5,264	$188,380	$23,220,043	$15,093,028	$8,127,015	$14,950	$27,976,000
Pumpkin Patch West	18.4	$135,387	$272,670	$761,952	$4,326	$154,797	$20,124,334	$13,080,817	$7,043,517	$14,950	$31,897,000
Pumpkin Patch East	22.1	$135,387	$304,480	$818,662	$4,382	$156,827	$21,581,125	$14,027,731	$7,553,394	$14,950	$38,856,000
Elders Center	21.6	$135,387	$292,514	$741,493	$4,369	$156,333	$19,582,641	$12,728,717	$6,853,924	$14,950	$28,318,000
Sub-Total	**127.8**	**$741,149**	**$1,810,674**	**$4,022,991**	**$23,075**	**$825,731**	**$105,909,238**	**$68,841,005**	**$37,068,233**	**$74,750**	**$154,318,000**
Harlem River, East River and Western Long Island Sound Planning Region											
Flushing Creek	8.3	$129,188	$80,638	$615,187	$4,639	$166,006	$16,151,862	$10,498,710	$5,653,152	$114,075	$19,786,000
Bronx Zoo and Dam	1.9	$165,863	$718,045	$425,882	$15,653	$1,059,705	$10,993,425	$7,145,726	$3,847,699	$26,000	$13,020,000
Stonemill Dam	19.2	$104,696	$128,231	$182,857	$9,661	$665,011	$4,658,650	$3,028,123	$1,630,528	$26,000	$5,606,000
Shoelace Park	9.6	$165,863	$835,374	$796,204	$22,690	$1,504,484	$20,713,053	$13,463,484	$7,249,569	$39,000	$27,969,000
Bronxville Lake	3.8	$165,863	$863,094	$582,270	$5,044	$189,524	$15,400,018	$10,010,012	$5,390,006	$65,000	$22,389,000
Garth Woods/ Harney Road	4.3	$165,863	$741,432	$396,596	$12,871	$772,468	$10,322,520	$6,709,638	$3,612,882	$52,000	$13,134,000
Sub-Total	**47.1**	**$897,336**	**$3,366,814**	**$2,998,996**	**$70,558**	**$4,357,198**	**$78,239,528**	**$50,855,693**	**$27,383,835**	**$322,075**	**$101,904,000**

Site	Net Benefits (AAFCU)	First Costs									Fully Funded Total ($)
		Monitoring Cost ($)	Adaptive Management Cost ($)	Average Annual Economic Cost ($)	Annual OMRR&R Cost ($)	Total[1] OMRR&R Cost ($)	Total First Costs ($)	Federal Share ($)	Non-Federal Total ($)		
									Non-Federal Total ($)	LERRD[2] Costs ($)	
Newark Bay, Hackensack River, Lower Passaic River Planning Region											
Essex County Branch Brook Park	26.9	$190,965	$3,986,573	$1,976,173	$7,864	$317,423	$52,027,663	$33,817,981	$18,209,682	$62,400	$75,928,000
Oak Island Yards	2.8	$101,044	$102,760	$587,309	$4,308	$154,172	$15,440,769	$10,036,500	$5,404,269	$3,513,900	$25,906,000
Metromedia Tract	20.6	$184,854	$860,698	$1,181,233	$5,171	$185,055	$31,106,080	$20,218,952	$10,887,128	$521,775	$43,087,000
Meadowlark Marsh	14.6	$184,854	$444,980	$1,129,412	$5,066	$181,274	$29,668,449	$19,284,492	$10,383,957	$931,770	$46,351,000
Sub-Total	**64.9**	**$661,717**	**$5,395,011**	**$4,874,127**	**$22,409**	**$837,924**	**$128,242,961**	**$83,357,925**	**$44,885,036**	**$5,029,845**	**$191,272,000**
Oyster Reef Restoration											
Naval Weapons Station Earle	9.6	$78,278	$372,771	$328,007	$8,334	$298,238	$8,508,329	$5,530,414	$2,977,915	$13,000	$10,354,000
Bush Terminal	19.5	$147,972	$468,082	$267,098	$10,107	$361,673	$6,935,486	$4,508,066	$2,427,420	$39,000	$9,514,000
Head of Jamaica Bay	5.2	$78,278	$386,866	$221,761	$11,911	$426,253	$5,683,652	$3,694,374	$1,989,278	$13,000	$7,276,000
Sub-Total	**34.3**	**$304,528**	**$1,227,719**	**$816,866**	**$30,352**	**$1,086,164**	**$21,127,467**	**$13,732,854**	**$7,394,613**	**$65,000**	**$27,144,000**
Grand Total	**341.3**	**$2,977,493**	**$12,359,136**	**$15,570,502**	**$156,021**	**$7,451,509**	**$408,184,133**	**$265,319,686**	**$142,864,447**	**$7,328,520**	**$587,661,000**

[1] Total OMRR&R: Operation, Maintenance, Repair, Replacement and Rehabilitation is typically for a duration of 10 years for non-structural restoration. Sites including Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park include structural features that would be maintained for a 50 year period.

[2]LERRD Costs – The Lands, Easements, Rights-of-way, Relocations, and dredged or excavated material Disposal areas (LERRD) costs are a subset of the Total Non-Federal Costs.

Table of Contents

List of Figures

List of Tables

Appendices

Acronyms and Abbreviations

AAFCU	Average Annual Functional Capacity Unit
ACHP	Advisory Council on Historic Preservation
ALS	American Littoral Society
AOC	Administrative Order on Consent
AWOIS	Automated Wreck and Obstruction Information System
BMP	Best Management Practice
CAA	Clean Air Act
CAG	Community Advisory Group
CAP	Continuing Authorities Program
CARP	Contaminant Assessment and Reduction Project
CCPR	Committee on Climate Preparedness and Resilience
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPG	Cooperating Parties Group
CRP	Hudson-Raritan Estuary Comprehensive Restoration Plan
CSO	combined sewer outfall
CSRM	Coastal Storm Risk Management
CUNY	City University of New York
CWA	Clean Water Act
CWP	Comprehensive Waterfront Plan
CY	Cubic Yards
CZMA	Coastal Zone Management Act
DDT	Dichloro-diphenyl-trichloroethane
DDT	Dioxin and dichlorodiphenyl-trichloroethane
EE/CA	Engineering Evaluation/Cost Analysis
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EOP	Environmental Operating Principles
EPW	Evaluation of Planned Wetlands
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FCI	Functional Capacity Index
FCSA	Feasibility Cost Share Agreement
FCU	Functional Capacity Units
FR/EA	Integrated Feasibility Report and Environmental Assessment
FWCA	Fish and Wildlife Coordination Act
GHG	Greenhouse gas
GIS	Geographic Information System
GNRA	Gateway National Recreation Area
HARS	Historic Area Remediation Site
HDP	Harbor Deepening Project
HEP	New York-New Jersey Harbor & Estuary Program

HHMT	Howland Hook Marine Terminal
HRE	Hudson-Raritan Estuary
HTRW	Hazardous, Toxic, and Radioactive Wastes
ICA	Incremental Cost Analysis
ICC	Ironbound Community Corporation
IPaC	Information for Planning and Consultation
JFK	John F. Kennedy International Airport
LERRD	Lands, Easements, Right-of-way, and Disposal Sites
LF	Linear Feet
MESIC	Meadowlands Environmental Site Information Compilation
MFCMA	Mangnuson-Stevens Fishery Conservation and management Act
MLW	Mean Low Water
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organizations
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJMC	New Jersey Meadowlands Commission
NJSEC	New Jersey Sports and Exposition Authority
NJSHPO	New Jersey State Historic Preservation Office
NMFS	National Marine Fisheries Service
NNBF	Natural and Nature Based Features
NOAA	National Oceanic Atmospheric Administration
NRCS	National Resource Conservation Service
NYC Parks	New York City Department of Parks and Recreation
NYCDEP	New York City Department of Environmental Protection
NYCLPC	New York City Landmarks Preservation Commission
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OMRR&R	Operation Maintenance, Repair, Replacement, and Rehabilitation
PA	Programmatic Agreements
PAH	Polycyclic Aromatic Hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PCB	Polychlorinated Biphenyl
PED	Planning, Engineering and Design
ppt	parts per thousand
PRC	Passaic River Coalition
PRP	Potential Responsible Parties
PVSC	Passaic Valley Sewerage Commission
RI/FS	Remedial Investigation/Feasibility Study
RSE	Removal Site Evaluation
RM	River Mile
RWG	Restoration Work Group
SB	Shoreline Bank Erosion Control
SHPO	State Historic Preservation Office
SLR	Sea Level Rise

SNWA	Special Natural Waterfront Area
SRIJB	Science & Resilience Institute at Jamaica Bay
SS	Sediment Stabilization
SVAP	Stream Visual Assessment Protocol
TEC	Target Ecosystem Characteristic
TSP	Tentatively Selected Plan
UAO	Unilateral Administrative Order
URRI	Urban River Restoration Initiative
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UWFP	Urban Waters Federal Partnership
WL	Wildlife
WQ	Water Quality
WRDA	Water Resources Development Act

This page is left intentionally blank

Chapter 1: Introduction

The United States Army Corps of Engineers (USACE), New York District has prepared this Integrated Feasibility Report and Environmental Assessment (FR/EA) for the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study to provide an interim response to the study authorization. This FR/EA includes recommendations for:

- Construction of 20 restoration sites throughout the HRE (New York/New Jersey Port District).
- Future spin-off feasibility studies to be carried out under the HRE study authority or the Continuing Authorities Program, dependent upon the availability of federal and local funding, and the willingness of non-federal sponsors to partner with the USACE for such studies.

The restoration opportunities recommended for construction and future study are critical to address the ongoing long-term and large-scale ecosystem degradation within the estuary. This document presents the recommended alternatives for environmental restoration within the HRE, analyzes the environmental impacts of implementing those alternatives, outlines the process used for selecting the recommended alternative at each restoration site, and concludes with recommendations for project implementation. It also documents compliance with the National Environmental Policy Act (NEPA) of 1969, and includes input from the non-federal study sponsors, natural resource agencies, and the public.

- Chapter 1 Introduction*
- Chapter 2 Affected Environment*
- Chapter 3 Plan Formulation*
- Chapter 4 The Recommended Plan and Implementation
- Chapter 5 Environmental Consequences of the Alternatives*
- Chapter 6 Cumulative Effects*
- Chapter 7 Environmental Compliance with Environmental Statutes*
- Chapter 8 Summary of Coordination, Public Views, and Comments
- Chapter 9 Recommendations
- Chapter 10 References
- Chapter 11 Preparers*

The report sections marked with an asterisk (*) include required content for compliance with NEPA.

1.1 Study Purpose and Scope

The HRE is within the boundaries of the Port District of New York and New Jersey and is situated within a 25-mile radius of the Statue of Liberty National Monument. The HRE study area includes eight (8) planning regions: 1) Jamaica Bay; 2) Harlem River, East River and Western Long Island Sound; 3) Newark Bay, Hackensack River and Passaic River; 4) Upper Bay; 5) Lower Bay; 6) Lower Raritan River; 7) Arthur Kill/Kill Van Kull; and 8) Lower Hudson River. The HRE is located within one of the most urbanized regions in the United States, and has undergone centuries of industrial and residential development. Extensive navigation and infrastructure improvements, urbanization, and industrialization have resulted in extensive degradation of aquatic and terrestrial ecosystems, including wetlands, stream corridors, island rookeries, shellfish beds, migratory bird habitat, and resources used by federally-listed threatened and endangered species.

The purpose of the study is to evaluate the causes and effects of significant, widespread degradation in the estuary; to formulate, evaluate, and screen potential solutions to these problems; to recommend a series of projects for near-term construction that have a federal interest and are supported by a local entity willing to provide the necessary items of being a local sponsor (Appendix A); and to identify opportunities for potential future study under the HRE authority. The plan recommended for near-term construction furthers the goals of the HRE Comprehensive Restoration Plan (CRP), which was completed by the USACE in partnership with the New York-New Jersey Harbor & Estuary Program (HEP) in 2009 and updated in 2016. The CRP serves as the master plan for restoring the HRE. This study complements decades of restoration efforts by federal and state natural resource agencies, academic institutions, and non-governmental organizations.

The USACE and multiple non-federal sponsors commenced six (6) concurrent 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 HRE Ecosystem Restoration Feasibility Study effort. The studies, referred to as “source” studies include:

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

The analyses completed as part of these “source” studies were incorporated into and informed the current planning effort. This HRE FR/EA responds to all “source” studies’ authorities.

1.2 Study Authorities*

This FR/EA satisfies the multiple resolutions by the United States House of Representatives. Each of six (6) “source” feasibility studies was authorized by different Congressional resolutions, with three (3) “source” studies authorized by the same HRE resolution (Table 1-1). Because the “source” feasibility studies were integrated into the overall HRE study, all of the authorizations are pertinent to this effort.

Table 1-1. Study Authorities.

Planning Region	Authorization	"Source" Feasibility Study[1]
Jamaica Bay	August 1, 1990 Resolution by the United States House of Representatives Committee on Public Works and Transportation	Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study
East River, Harlem River, Western Long Island Sound	September 28, 1994 Resolution by the United States House of Representatives Committee on Public Works and Transportation	Flushing Bay and Creek Ecosystem Restoration Feasibility Study
	March 24, 1998 Resolution by the United States House of Representatives Committee on Transportation and Infrastructure	Bronx River Basin Ecosystem Restoration Feasibility Study
All	April 15, 1999 Resolution by the United States House of Representatives Committee on Transportation and Infrastructure	HRE Ecosystem Restoration Feasibility Study
Newark Bay, Hackensack River and Passaic River		Lower Passaic River Ecosystem Restoration Feasibility Study
		Hackensack Meadowlands Ecosystem Restoration Feasibility Study

[1]see section 1.6.3 for status of each "source" study

The Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study was authorized by a resolution adopted by the Committee on Public Works and Transportation on August 1, 1990 stating:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on the Atlantic Coast of New York City from East Rockaway Inlet and Jamaica Bay, New York published as House Document 215, Eighty-ninth Congress, First Session, and other pertinent reports, to determine whether modification of the recommendation contained therein are advisable at this time, to determine the feasibility of improvements for beach erosion control, hurricane protection and environmental improvements in Jamaica Bay including environmentally sensitive areas along Plumb Beach, Brooklyn, New York.*

The Flushing Creek and Bay Ecosystem Restoration Feasibility Study was authorized by a resolution of the Committee on Public Works and Transportation of the United States House of Representatives, dated September 28, 1994. The study authorization states:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Secretary of the Army, is requested to review the Report of the Chief of Engineers on Flushing Bay and Creek, New York, published as House Document 551, Eighty-seventh Congress, 2nd Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of water quality and other purposes, for Flushing Bay, New York.*

The Bronx River Basin Ecosystem Restoration Feasibility Study was authorized by a resolution of the Committee on Transportation and Infrastructure, dated March 24, 1998:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Bronx River, New York, published as House Document 897, 62nd Congress, 2nd Session, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time, in the interest of water resources development, including flood control, environmental restoration and protection and other related purposes.*

The HRE, Lower Passaic River, and Hackensack Meadowlands Ecosystem Restoration Feasibility Studies were authorized by a resolution of the Committee on Transportation and Infrastructure of the United States House of Representatives, dated April 15, 1999. The resolution provides USACE with broad authority to evaluate comprehensive ecosystem restoration opportunities within the entire Port of New York and New Jersey. The study authorization states:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the New York and New Jersey Channels, published as House Document 133, 74th Congress, 1st Session; the New York and New Jersey Harbor Entrance Channels and Anchorage Areas, published as Senate Document 45, 84th Congress, 1st Session; and the New York Harbor, NY Anchorage Channel, published as House Document 18, 71st Congress, 2nd Session, as well as other related reports with a view to determining the feasibility of environmental restoration and protection relating to water resources and sediment quality within the New York and New Jersey Port District, including but not limited to creation, enhancement, and restoration of aquatic, wetland, and adjacent upland habitats.*

A HRE Reconnaissance Report was completed in January 2001 under the April 15, 1999 United States House of Representatives authorization. The report detailed a federal interest in restoring the HRE. Additional reconnaissance reports were also prepared for:

- *Jamaica Bay* which demonstrated that there was a federal interest in addressing shore protection, storm damage reduction, hurricane protection and environmental restoration objectives (USACE, 1994).
- *Flushing Bay and Creek* which demonstrated that there is a federal interest in ecosystem restoration and related water quality improvements for Flushing Bay and Creek (USACE, 1996).
- *Bronx River* Basin established federal interest for potential ecosystem restoration measures in the Bronx River Basin (USACE, 1999).

This FR/EA is an interim response to the above study authorities. This report includes a recommendation for 1) the construction of a suite of restoration sites throughout the New York/New Jersey Port District, and 2) future spin-off feasibility studies to be carried out under the study authority, dependent upon the availability of federal and local funding, and the willingness of non-federal sponsors to partner with the USACE for such studies. The actions recommended for near-term construction are a critical step toward comprehensive restoration of the HRE by focusing on the immediate restoration of highly significant sites. Restoration alternatives for these sites were formulated in accord with the Principles and Guidelines (1983) criteria, for the Recommended Plan to be complete, effective, efficient, and acceptable. Sites not meeting these criteria (for instance, missing the criterion of completeness because some other action such as water quality improvements or remediation would be needed prior to the restoration action) are not included in this interim recommendation. Areas not included in the interim recommendation will continue to be in need of restoration, and could be included in new phase future spin-off studies.

1.3 Purpose and Need for Action*

The federal objective of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. The intent of ecosystem restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system.

Ecosystem restoration is to reverse the adverse impacts of human activity and restore ecological resources, including fish and wildlife habitat, to as close to previous levels of productivity as feasible, but not a higher level than would have existed under natural conditions in the absence of human activity.

The purpose of the proposed actions are to restore and sustain a mosaic of habitats within the human-dominated landscape important to the people of the region and the nation, in a cost-effective and socially-feasible manner, with minimal risks, and supported by monitoring and adaptive management to ensure meeting the restoration objectives. The recommendations use the best available science to advance the goals and objectives of the federally-supported HRE Comprehensive Restoration Plan (CRP), which is the regional roadmap for interagency restoration. The need for the proposed action comes from recognizing that valuable natural resources have declined to a point that the ecosystem may no longer be self-sustaining without immediate intervention to impede significant ecological degradation. Restoration of ecosystem structure, functions, and processes will benefit nationally significant resources in the study area.

As discussed below in Section 1.5, the HRE region is home to over 20 million people and is the economic hub of the northeastern United States. A healthy estuary is also essential to the regional economy. The prior efforts discussed above and detailed in the HRE CRP, documents the ecosystem problems that have given rise to the need for a comprehensive restoration effort requiring the assistance of the Federal Government.

The need for the proposed action comes from recognizing that the remaining critical natural resources within the urbanized setting of HRE have declined to a point that without immediate intervention, some resources, like the oysters will not continue to be self-sustaining. Continued anthropogenic stressors associated with development and urbanization have eliminated the mosaic of habitats that are associated with estuarine systems, which are the connection between terrestrial, freshwater, and marine ecosystems.

Aquatic, wetland and associated upland habitats have experienced significant water resources problems. Industrialization and development, including prior wetland filling, hydrologic and benthic changes and deterioration of sediment quality have contributed to creating conditions that do not support a productive ecosystem. Loss of rare, valuable and diverse habitats and increased vulnerability and susceptibility to the encroachment of invasive species are the primary aquatic, wetland and upland habitat problems. The study area is in need of improvements that will reestablish diverse habitat, based on indicator species, and measures that will set forth the conditions to allow the restored ecosystem to be sustainable.

The magnitude of restoring such a huge, highly urbanized area is considerable. As early as 2000, the HRE Reconnaissance Report identified the concept and need for “building blocks,” as an immediate and important ecological benefit to the estuary. The HRE CRP identified the “building blocks”, the Recommended National Ecosystem Restoration (NER) Plan in this report will be the initial foundation. As an example, see Figure 1-1 of the Lincoln Park Restoration, which was facilitated with the beneficial use of dredged material from the USACE’s New York/New Jersey Harbor Deepening Project.

The region’s local, state, and federal agencies, along with non-profit organizations have recognized the need to identify, evaluate and recommend actions that will maintain, protect and restore the essential and vital HRE. Because of the inherent complexities associated with the nearshore zone, such as varied ownership and mixed land use, action at many of the 296 CRP sites is beyond the resources of states, local governments, non-governmental organizations, or private entities. Federal agencies such as the USACE are better suited to taking the lead and playing a key role in large-scale restoration projects. As ecosystem restoration is one of the primary missions of the USACE Civil Works program, the USACE has the ability to use expertise in water-related resource problems to seek ecosystem construction authority within the estuary.

Figure 1-1. Lincoln Park Restoration – Hackensack River, New Jersey Before (2010) and After (2012)

1.4 Study and Construction Non-Federal Sponsors

The USACE and non-federal sponsors executed Feasibility Cost Share Agreements for each of the six (6) "source" feasibility studies. Many of the study sponsors have agreed to be local sponsors for construction of the recommended projects. In addition, other agencies have agreed to participate as a local sponsor for construction and were added to the restoration planning within the specific waterbody. The non-federal sponsors for each "source" study and potential construction sponsors are shown in Table 1-2. The sponsors have agreed that consolidation of planning efforts into the current study is the best, most efficient course of action for study completion. Letters of support are found in Appendix A.

Table 1-2. Non-Federal Study and Potential Construction Sponsors.

"Source" Feasibility Study	FCSA[1] Execution Date	Study Sponsor(s)	Potential Construction Sponsor(s)
Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study	February 22, 1996	New York City Department of Environmental Protection (NYCDEP)	NYCDEP, New York State Department of Environmental Conservation (NYSDEC), New York City Department of Parks and Recreation (NYC Parks)
Flushing Bay and Creek Ecosystem Restoration Feasibility Study	September 2, 1999	NYCDEP and Port Authority of New York and New Jersey (PANYNJ)	NYCDEP
HRE Ecosystem Restoration Feasibility Study	July 12, 2001	PANYNJ	All others and NY Harbor Foundation and NY/NJ Baykeeper for oyster restoration
Bronx River Basin Ecosystem Restoration Feasibility Study	November 3, 2003	NYCDEP and Westchester County	NYCDEP, NYC Parks, and Westchester County

"Source" Feasibility Study	FCSA[1] Execution Date	Study Sponsor(s)	Potential Construction Sponsor(s)
Hackensack Meadowlands Ecosystem Restoration Feasibility Study	April 23, 2003	New Jersey Sports and Exposition Authority (NJSEA, Former Hackensack Meadowlands Commission)	NJSEA and New Jersey Department of Environmental Protection (NJDEP)
Lower Passaic River Ecosystem Restoration Feasibility Study	June 30, 2003	New Jersey Department of Transportation (NJDOT) and NJDEP	NJDEP

[1] FCSA: Feasibility Cost Share Agreement

1.5 Study Area

The study area is located within one of the largest estuaries on the east coast of the United States, encompassing over 1,600 square miles and almost 1,600 linear miles of shoreline (USACE, 2006a, HEP 2016a). Watershed boundaries and physical landmarks were used to delineate the study area into eight (8) ecologically and historically distinct areas called planning regions (Figure 1-1). The study area includes all tidally influenced portions of rivers flowing into New York and New Jersey Harbor, including the Hudson, Raritan, Hackensack, Passaic, Shrewsbury, and Navesink Rivers, and the East River from the Battery to Hell Gate (USFWS, 1997). The 320-mile Hudson River dominates the hydrology of the system, with a watershed of 13,400 square miles, and an average flow of 21,000 cubic feet per second. The Hackensack, Passaic, Raritan, Shrewsbury, and Navesink rivers collectively account for about 13 percent of the flow into the harbor (USFWS, 1997).

The study area was delineated into the following eight (8) planning regions, which were developed using a watershed-ecosystem-scale approach to facilitate stakeholders' identification of restoration needs and opportunities specific to each region (Figure 1-2).

- **Jamaica Bay** – The Jamaica Bay Planning Region, located on the southwestern shore of Long Island, is enclosed by the Rockaway peninsula. This region includes portions of Brooklyn, Queens, and Nassau Counties, New York, as well as the John F. Kennedy International Airport. On the bay's western edge, Rockaway Inlet connects Jamaica Bay to Lower New York Bay.
- **Harlem River, East River and Western Long Island Sound** – The Harlem River, East River and Western Long Island Sound Planning Region contains sections of Manhattan and the Bronx to the north, and Brooklyn and Queens to the south. It extends east to include part of Long Island Sound, and portions of Westchester and Nassau Counties, New York.
- **Newark Bay, Hackensack River and Passaic River** – The Newark Bay, Hackensack River and Passaic River Planning Region encompasses portions of Bergen, Passaic,

Hudson, Essex, and Union Counties, New Jersey. A small portion of Rockland County, New York is also included in this planning region.

- **Upper Bay** – The Upper Bay Planning Region begins at the mouth of the Hudson River, is connected to Newark Bay and the Arthur Kill via the Kill Van Kull, and exchanges water with the East River and Long Island Sound.
- **Lower Bay** – The Lower Bay Planning Region includes Lower New York Bay, Raritan Bay, and Sandy Hook Bay. The planning region is bounded on the north by Staten Island and Brooklyn, New York, and on the south by Monmouth County, New Jersey, and on the ocean side by a transect between Sandy Hook, New Jersey and Rockaway Point, New York.
- **Lower Raritan River** – The Lower Raritan River Planning Region is the western-most planning region of the study area. This region contains the lower six (6) miles of the Raritan River before its confluence with Raritan Bay. Portions of the region extend into Union, Somerset, and Monmouth Counties, New Jersey.
- **Arthur Kill/Kill Van Kull** – The Arthur Kill/Kill Van Kull Planning Region lies between Newark Bay and the Lower Raritan River. The planning region connects to the Upper Bay via the Kill Van Kull and mixes those waters with Newark Bay. Important tributaries to the Arthur Kill include the Rahway and Elizabeth Rivers, Old Place Creek, Woodbridge Creek, and Fresh Kills Creek.
- **Lower Hudson River** – The Lower Hudson River Planning Region extends from the Upper New York Bay to the Tappan Zee Bridge, and includes portions of Bergen and Hudson Counties, New Jersey and New York City, Rockland, and Westchester Counties, New York.

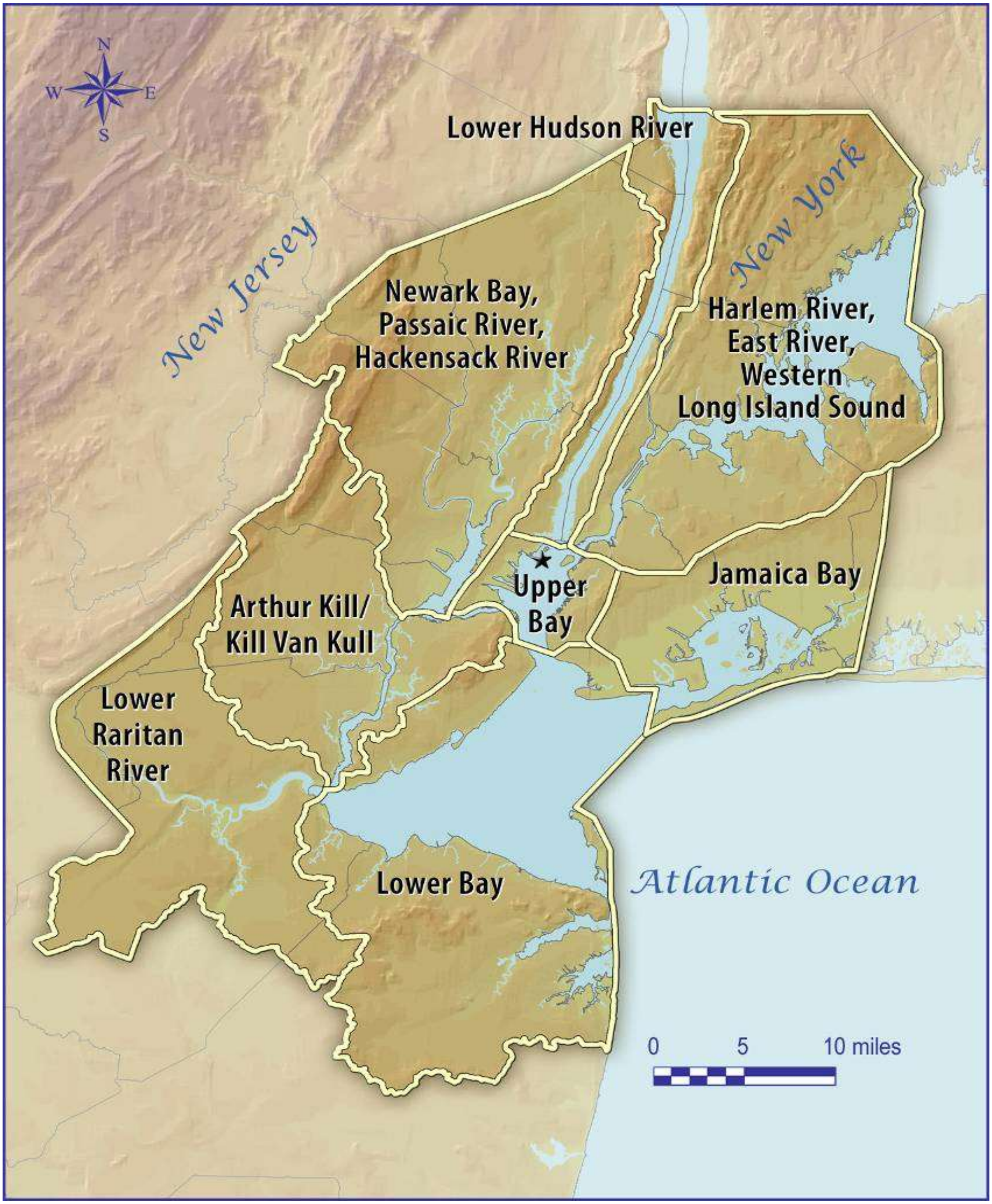


**Figure 1-2. HRE Study Area with Planning Regions.
The Statue of Liberty is denoted by a star.**

Source: U.S. Fish and Wildlife Service

Figure 1-3. Atlantic Flyway

The HRE study area is located where the east-west oriented shoreline of the New England and Long Island coasts meets the north-south oriented shorelines of the Mid-Atlantic coast. This concentrates those species of birds, insects, and fish that seasonally migrate along the coastline and funnels them into the region, leading to exceptional diversity and numbers (USFWS, 1997). The United States Fish and Wildlife Service (USFWS) lists approximately 400 plant, animal, and fish species of special emphasis as occurring within the HRE study area (USFWS, 1997). Additionally, the Atlantic Flyway (Figure 1-3), one (1) of four (4) major avian migratory routes in North America, passes directly through the HRE study area.

This estuary supports residents and migrants of almost 300 species of birds, over 100 species of fishes, over 2,000 vascular plant species, and many important terrestrial and aquatic invertebrates (Glenn, 2013; Steinberg et al., 2004; USFWS, 1997). In all, dozens of species of animals and plants currently on the federal threatened or endangered species lists depend on this estuary for one or more of their critical life stages, as do many others that are on state lists. In addition, the HRE contains approximately 400 plant and animal species of special emphasis and 25 percent of the nesting herons between Cape May, New Jersey and Rhode Island make their home in the harbor (USFWS, 1997).

The HRE is located within one of the most urbanized regions in the United States. Over 13 million people live within 25 miles of the Statue of Liberty, the approximate center of the estuary, including the highly urbanized cities of New York, and Jersey City, Newark, and Elizabeth, New Jersey. Urbanization and industrialization over the past 400 years has put stress on the estuary, resulting in significant loss of habitat. The estuary has a long history of industrial and residential development that began in the 1600s with the first European settlers and intensified as navigation and infrastructure improved. These alterations resulted in significant ecosystem-level changes due to residual, persistent impacts to numerous habitats, especially those linked to aquatic environments. Regional development of the watershed and massive physical changes to the estuary, including dredging and channeling, damming, and streambank restoration, led to marked hydrologic alterations, acute sediment contamination, pervasive reductions in water quality, and habitat fragmentation. The ecological integrity, health, and resiliency of the estuary have been severely compromised.

The extensive loss of shallow habitats and wetlands together with reductions in water quality has affected almost every aspect of the estuarine ecosystem. The abundance and diversity of fish, shellfish, and estuarine-dependent wildlife species have been severely reduced through the combined impacts of habitat loss and degradation, competition from invasive species, and resource exploitation. The HRE and its major tributaries have lost much of the natural capacity to buffer flood waters, as well as the capacity to sequester, transform, or degrade nutrients and contaminants. This decreased capacity to naturally maintain water and sediment quality is exacerbated by the region's high-density human population that produces enormous volumes of treated sewage effluent which, along with stormwater passing across impervious watershed surfaces, is discharged into the HRE.

The welfare of the human population surrounding the HRE, including health, economic prosperity, and aesthetics, is closely linked to vitality of the estuary. What began as beneficial use of the existing resources related to habitation and the growth of trade and industry eventually grew into overdevelopment, exploitation, and degradation of the HRE. Not only have these developmental changes directly impacted the estuary, but as part of the environment the regional human population has become a potential secondary receptor of these same impacts.

While a significant amount of the ecological value of the HRE and its watershed has been degraded or changed, it still provides habitat for diverse populations of resident and transient biological communities. Though certain irreversible changes to the estuary have occurred, many of the factors that have contributed to its decline can be better controlled or even eliminated. In addition, the implementation of environmental laws and regulations has led to significant recovery of the ecological resources over the past few decades. This recovery has coincided with an improvement in water quality and increased environmental awareness and stewardship of the ecological treasure that the estuary currently is and can still become.

The HRE can be viewed as an example of the resilience of natural systems, in which a mosaic of habitats within a human dominated landscape can actively be restored, and where there can be a balance between a healthy vibrant economy and a healthy vibrant estuary. This is the vision of the "World Class Harbor Estuary" that has been embraced by the numerous stakeholders within the region, representing shipping, economic development, and environmental restoration.

1.5.1 Significance of the Hudson-Raritan Estuary and Its Resources

The criteria for determining the significance of resources are provided in the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (United States Water Resources Council, 1983), Resource Significance Protocol for Environmental Project Planning, (IWR Report 97-R-4, July 1997) and in USACE planning guidance such as the Planning Guidance Notebook (Engineering Regulation 1105-2-100, April 22, 2000). The consideration of significant resources and significant effects is central to plan formulation and evaluation for any type of water resources development project. Significance of resources and effects are derived from institutional, public, and technical recognition of the ecological, cultural and aesthetic attributes of resources within the study area. As per the USACE Planning Guidance Notebook:

- **Institutional recognition** of a resource or effect means its importance is recognized and acknowledged in the laws, plans, and policies of government and private groups.

- **Technical recognition** of a resource or an effect is based upon scientific or other technical criteria that establish its significance.
- **Public recognition** means some segment of the general public considers the resource or effect to be important. Public recognition may be manifest in controversy, support, or opposition expressed in any number of formal or informal ways.

In ecosystem restoration planning, the concept of significance of outputs plays an especially important role because of the challenge of dealing with non-monetary outputs. The three (3) sources of significance - institutional, public, and technical recognition - and documentation on the relative scarcity of the resources helps determine the significance of the resources to be restored. The significance and the relative scarcity of the resources help to establish a federal interest in the project. The HRE includes resources that are technically, institutionally, and publicly significant as summarized below. In addition, the technical significance of the Recommended Plan is described in Chapter 4.

1.5.2 Institutional Significance

Numerous federal laws and executive orders establish National policy for and federal interest in the protection, restoration, conservation, and management of environmental resources. These provisions include compliance requirements with an emphasis on protecting environmental quality. They also endorse federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is given to the opportunities which projects afford to ecological resources. Water resources development authorizations have enhanced opportunities for USACE involvement in studies and projects to specifically address objectives related to the restoration of ecological resources and ecosystem management. They include the four (4) legislative actions authorizing the studies.

Wildlife resources are critical elements of the HRE ecosystem and important indicators of the health of aquatic habitats. Wildlife resources are important recreational and commercial resources, as well, and are regarded highly by the public for their aesthetic, recreational, and commercial value.

The HRE is designated as an Ecosystem of National Significance by a number of federal and state agencies, laws, and executive orders. Specific examples of institutional recognition of the significance of the resources in the estuary include the following:

- Endangered Species Act of 1973 - Twenty-seven (27) federally-listed species of special status, as well as two (2) additional species listed as candidate species, depend on habitat within and are found in the HRE.
- Migratory Bird Treaty Act (MBTA) of 1918 & Migratory Bird Conservation Act of 1929 - Many migratory birds protected under the MBTA breed, nest, forage, reside, and migrate through the study area.
- Urban Rivers Restoration Initiative (2003) - Joint pilot program between the EPA and USACE that included the Gowanus Canal (NY) and Passaic River (NJ) aimed to clean up polluted urban waterways.

- Urban Waters Federal Partnership (2011) - Supported by 14 Federal agencies and more than 28 non-governmental organization (NGO) partners working in 19 designated locations. Two locations are within HRE (Bronx and Harlem River Watersheds NY & Lower Passaic River/Newark NJ).
- The National Estuarine Research Reserve System (1982) - A partnership of the National Oceanic and Atmospheric Administration (NOAA) and coastal states, which was created to study and protect vital coastal and estuarine resources, designated four (4) distinct tidal wetland sites within the HRE as the Hudson River National Estuarine Research Reserve.
- National Estuary Program (Public Law 100-4, Public Law 92-500, 1987) - The New York and New Jersey Harbor Estuary was designated as an Estuary of National Importance and included in one of 28 such Nationally-important estuaries.
- Hudson River Valley National Heritage Area (1996) - Hudson River Valley was designated by Congress as one of 49 federally-recognized National Heritage Areas.
- American Heritage River by Executive Order 13061 Federal Support of Community Efforts Along American Heritage Rivers (1997).
- Hudson River Park Trust (1998 by NYS) within New York City - Planning, development and operation of the Hudson River Park as a public park will enhance and protect the natural, cultural and historic aspects of the Hudson River.
- Ecosystems of National Significance (2010) - The New York and New Jersey Harbor Estuary was designated by the Assistant Secretary of the Army for Civil Works among the Ecosystems of National Significance, recognizing its importance to our nation's history, the estuary's remarkable recovery over the past 20 years, and the clear vision and strong commitment by the regional stakeholders for continued restoration and conservation of this resource.
- National Recreation Trail by the National Park Service (2012 by NPS) - The Hudson River Greenway Water Trail was designated to connect communities and people to the Hudson River, promotes recreational access for all users, provides infrastructure for multi-day paddles, protects natural and cultural resources, and supports the health the river for future generations.
- The United States Fish and Wildlife Service (USFWS) has identified several regionally significant habitats within the harbor estuary, including Jamaica Bay and Breezy Point, Raritan and Sandy Hook Bays, the Hackensack Meadowlands, the Lower Hudson River, and the Narrows.

1.5.3 Technical Significance

The waters and nearshore habitats of the HRE once supported a diverse mosaic of ecological communities, but centuries of industrialization and urbanization have resulted in severe habitat loss and degradation, poor water quality, pervasive sediment contamination, and lack of public access to the estuary. These actions have significantly affected the ecological integrity, health, and public perception of the estuary and its resources. The HRE has a long history of physical and chemical habitat degradation associated with extensive industrial and residential development, along with vast navigation and infrastructure improvements. These alterations have resulted in ecosystem-level changes to the HRE, causing dramatic shifts in ecological community structure, and in the distribution and resiliency of open-water, nearshore, and coastal habitats.

With so much of the original habitat lost in the estuary, the small amount remaining is incredibly important to the health of the system. These few unhardened areas are sanctuaries for the flora and fauna of the estuary, so their preservation as such is integral for the continued resiliency of the ecosystem.

1.5.3.1 Habitat Scarcity

Since the 1600s, over half of the natural wetlands of the contiguous United States have been drained for conversion to other land uses. Within the HRE, over 85 percent of the coastal wetlands and 99 percent of the freshwater wetlands have been lost. Wetlands are threatened by pollution from chemicals, excess nutrients, and sediment. They are also sensitive to many of the effects of climate change, including higher temperatures, changes in rainfall, increased frequency and severity of storms, sea level rise, and higher levels of carbon dioxide in the atmosphere. When wetlands are lost, so are the benefits that they provide, including protection from flooding and drought, aesthetic and recreational services, and critical habitat for birds and other species. Coastal wetlands, like the salt marshes within the HRE, only make up 38 percent of the total wetland area in the lower 48 states; on the east coast, they are being lost at two (2) times the rate that they are being restored (Stedman and Dahl, 2008).

1.5.3.2 Connectivity

Habitat connectivity is the degree to which the landscape facilitates animal movement and other ecological flows. Mobility is the key to survival for many wildlife species. Terrestrial species must navigate a habitat landscape that meets their needs for breeding, feeding, and shelter. Natural and semi-natural components of the landscape must be large enough and connected enough to meet the needs of all species that use them. As habitat conditions change in the face of habitat loss and climate change, some species ranges are already shifting and wildlife must be provided greater opportunities for movement, migration, and changes in distribution. In addition, aquatic connectivity is critical for anadromous and catadromous fish that encounter many potential barriers as they migrate upstream and downstream. Since most of the habitat within the HRE has been severely degraded or destroyed, the habitat that remains is significantly fragmented. It is important to enhance and restore the remaining habitat in order to maintain important spatial areas and restore greater habitat connectivity within the HRE.

1.5.3.3 Migratory Flyways

The routes followed by migratory birds are numerous, and while some of them are simple and easily traced, others are extremely complicated. The Atlantic Flyway (Figure 1-2) is a major migratory route used by millions of waterfowl. It extends from the offshore waters of the Atlantic Coast west to the Allegheny Mountains, where, curving northwestward across northern West Virginia and northeastern Ohio, it continues in that direction across the prairie provinces of Canada and the Northwest Territories to the Arctic Coast of Alaska. The coastal route of the Atlantic Flyway, which in general follows the shoreline, has its northern origin in the eastern

Arctic islands and the coast of Greenland. The flyway embraces several primary migration routes and many more that are important as tributaries, some of the latter being branches from primary routes of other flyways.

The Atlantic Flyway route is of great importance to over 500 avian species, many of which use the HRE as stopover and breeding grounds. They include many species of sparrows, warblers, thrashers, crows, herons, and urban birds. Many of the species are listed as threatened and endangered by the USFWS, including the threatened piping plover (*Charadrius melodus*) and red knot (*Calidris canutus rufa).*

1.5.3.4 Habitat for Special Status Species

Twenty-seven (27) federally-listed species of special status (threatened or endangered), as well as two (2) additional species listed as candidate species, depend on habitat within and are found in the HRE. Raritan Bay and Sandy Hook Bay support the greatest variety of federal threatened and endangered species in the study area (USFWS, 1997). Urban areas, such as Manhattan, support the least amount of these species. The HRE also contains 400 plant and animal species of special emphasis, and 25 percent of the nesting herons between Cape May, New Jersey, and Rhode Island make their home in the harbor.

1.5.3.5 Ecosystem Services

Ecosystem services are the benefits[1] people obtain from ecosystems. Overall, the cumulative impacts of urban coastal development on aquatic and upland habitats have greatly reduced the quantity and quality of coastal habitats, and the environmental benefits and ecosystem services those habitats provide to the nation. Given the overarching potential threats to human health and future sustainability of ecosystem services, the major water resources problems and affected ecosystem services are:

- Loss of quality, quantity, and connectivity of aquatic, wetland, and related coastal habitats (pollination, biological control, food production, raw materials, and genetic resources ecosystem services).
- Imbalance of ecosystem functions and values (gas regulation, climate regulation, disturbance regulation, water regulation, soil formation, and disturbance regulation ecosystem services).
- Degradation of sediment quality (nutrient recycling, erosion control, and sediment retention ecosystem services).
- Degradation of water quality impacting ecosystem function/habitat (water regulation, water supply, and climate regulation ecosystem services).
- Limited recreational opportunities and adversely impacted aesthetic and social issues (cultural and recreation ecosystem services).

Restoration of the HRE to a more natural state would reduce threats to human health and repair the ability of the ecosystem to filter water and provide natural resources.

[1] Benefits associated for ecosystem services were not quantified in the ecosystem benefits evaluated for this study.

1.5.3.6 Summary of Technical Significance for Specific Habitats

Although significant portions of the HRE have been degraded, the estuary still supports highly diverse biological communities and contains patches of relatively stable, high quality habitat. Based on the study's planning objectives, the recommended plan targets the restoration of degraded areas that increase the connections between habitat patches and create corridors that increase the overall function, structure and dynamic processes within the estuary.

Estuarine marsh habitat is historically scarce in the HRE (>85% lost). Restoration within Jamaica Bay, Flushing Creek, and the Newark Bay, Passaic River and Hackensack River Planning Region will contribute to this scarce resource. Restoring the estuarine marshes within the Meadowlands will restore critical ecosystem functions (e.g., biogeochemical cycling of nutrients, flood storage) and provide the needed habitat that supports a large amount of the State of New Jersey's biodiversity (e.g., 75 percent of New Jersey's avifaunal species and over 25 State-listed species are within the Meadowlands). Similarly, restoration actions in Jamaica Bay will increase biodiversity and estuarine fish and wildlife habitat in the regionally significant Jamaica Bay Wildlife Refuge. Since much of the habitat that remains in Jamaica Bay and the Meadowlands are severely degraded, the habitat that remains is significantly fragmented. Restoration of the these habitats provide critical habitat connectivity for spawning and nursery habitat for more than eighty anadromous and estuarine fish species; over 300 species of birds that reside and visit the bay every year along the Atlantic Flyway migration route; and nursery & spawning habitat for horseshoe crabs, roseate terns, common tern, least tern, and waterfowl (mallard, canvasback, lesser scaup, wood duck); and wading birds (cattle egret, snowy egret, great egret). These areas function as critical habitat for horseshoe crabs and diamondback terrapins that use unvegetated open shorelines to lay their eggs.

Jamaica Bay is one of the largest and most productive coastal ecosystems in the northeastern United States and includes the largest tidal wetland complex in the New York metropolitan area and the last remaining marsh island complex in the HRE. The wetlands in Jamaica Bay have had significant loss from the combined effects of subsidence, sea level rise, and lack of sediment distribution within the bay (partially attributed to the increased depth of Jamaica Bay from dredging of the navigation channels). These marsh islands have been disappearing and a loss of more than 2000 acres have been documented since 1924 and will continue to be lost at an alarming rate. Without these marsh islands, the stability and health of Jamaica Bay is severely threatened. These saltwater marshes not only serve as nursery, feeding, spawning and refuge sites for the many species listed above, the interior marsh islands provide an important food source for adult transient fishes. In addition to the 100s of fish and wildlife species, endangered and threatened species like peregrine falcons, piping plovers, and the Atlantic Ridley sea turtle reside in or visit the bay. The bay's wildlife depends on the wetlands for survival. The marsh islands and perimeter wetlands also naturally mitigate flooding and serve as coastline buffers from waves, tides, winds, and floods, and can help reduce coastline erosion and property damage during storm events for more than five hundred thousand New Yorkers.

Freshwater wetlands are a resource that is extremely scarce (~99% lost) in the HRE. Restoration of freshwater and forested wetlands, streambanks, and natural streambed geometry in the Bronx River and Passaic River tributaries will reestablish natural processes and reduce sources of erosion and sedimentation. These actions advance the planning objective through the formation of spawning and feeding habitats for diadromous fish and restoration of essential habitat for native fish, birds, reptiles, amphibians, mammals, and waterbirds.

In the past, the Bronx River had a complex ecosystem, but due to industrialization, damming of rivers, channel modification, filling of wetlands, runoff from roadways and other anthropogenic perturbations, the river ecosystem has degraded over time diminishing the diversity of aquatic life and water quality. Restoration of habitat connectivity is exemplified in the Bronx River, where freshwater wetland restoration creates valuable connections to the less degraded headwater habitat in the north; and where fish ladders allows anadromous fish (e.g., American shad, striped bass, alewife, blueback herring) to reach nursery grounds for larval and juvenile life stages and catadromous fish (e.g., American eel) to live out adult life stages.

Oyster reefs represents a habitat type of both ecological and historical importance to the HRE watershed. In the mid-late 19th century oyster reefs were estimated to cover approximately 200,000 acres (810 $kilometers^2$; Kennish 2002, Bain et al. 2007), providing important habitat for hundreds of marine species while simultaneously filtering and cleaning the surrounding waters. Currently, oyster reefs are one of the most scarce habitat resource in the HRE. Each site recommended for construction contributes to the overall goal of developing a mosaic of habitats throughout this highly urbanized study area. Oyster reefs provide three dimensional structure for spawning, foraging, nursery and refugia habitat as well as improve the connectivity of adjacent habitats for fish and invertebrates communities. In the long-term, larval juvenile and adult oysters would also provide a prey resource for many fish.

1.5.4 Public Significance

Public recognition of the significance of a resource may involve memberships in a conservation organization, financial contributions to resource-related efforts, volunteer labor, and correspondence regarding the importance of the resource. Public concerns with the health of the ecosystem have been evident for centuries. The HRE area has approximately 13 million people in a highly urbanized environment who would receive increase access to natural wetland communities as well as enhances recreational and commercial fishing. A large number of non-profit organizations have formed or organized around improving conditions in the study area. These organizations include:

- American Littoral Society
- Bayonne Oyster Gardeners
- Bergen County Audubon
- Brooklyn Botanic Garden
- Clean Air Campaign Inc.
- Clean Ocean Action
- Clifton Environmental Commission
- Concerned Citizens of Bensonhurst
- Crossroads of the American Revolution
- Downtown Boathouse
- East Coast Greenway
- National Parks of New York Harbor Conservancy
- National Resources Protective Association
- New Jersey Audubon Society
- New York/New Jersey Baykeeper
- New York City Audubon
- New York State Museum
- Outside New York
- Passaic River Boat Club
- Passaic River Coalition

- Edison Wetlands
- Environmental Defense Fund
- Friends of Liberty State Park
- Gateway Bike & Boathouse
- Going Coastal
- Gowanus Canal Conservancy
- Hackensack Riverkeeper
- Hoboken Cove Community
- Hudson River Park Trust
- Interstate Environmental Commission
- Ironbound Community Corporation
- Jamaica Bay Eco Watchers
- Jamaica Bay Task Force
- Jamaica Bay Watershed Protection
- Plan Advisory Committee.
- Lower Passaic River Watershed Alliance
- National Fish and Wildlife Federation
- National Parks Conservation Association
- Passaic Valley Sewerage Commission
- Raritan Baywatcher
- Raritan River Initiative
- Raritan Riverkeeper
- Red Hook Boaters
- Regional Plan Association
- Rockaway Waterfront Alliance
- Sebago Canoe Club
- Sheepshead Bay/Plumb Beach Civic Association
- The Gaia Institute
- The Natural Areas Conservancy
- The Nature Conservancy
- Trust for Public Land
- Urban Divers Estuary Conservancy
- Washington Park Association
- Waterfront Alliance
- Wildlife Conservation
- Wildlife Trust
- Working Harbor

Over 120 federal and state agencies, academic institutions, and nonprofit and community organizations collaborated to draft the 2009 and 2016 HRE CRP (USACE and PANYNJ, 2009a, 2009b, 2016) to address the need for a comprehensive master plan for restoration of the HRE.

1.6 A History of Collaborative Restoration Planning

Regional, comprehensive restoration planning to restore the HRE began in 1988 following the estuary's recognition by the United States Congress as an estuary of national importance and its subsequent induction into the National Estuary Program. In conjunction with this designation was the formation of the HEP, which established a formal partnership of federal, state, and local governments; scientists; civic and environmental advocates; the fishing community; business and labor leaders; and educators. The HEP provides an open forum for discussion, planning, and action on environmental issues facing the estuary. Technical and advisory committees and work groups made up of government, academic, private, non-profit groups, and citizens inform the Policy and Management Committees. From its beginning, the USACE has been a federal leader of the HEP, serving on or coordinating with all committees and work groups since 1988.

In 1996, the HEP completed the Comprehensive Conservation and Management Plan, which documents the degraded condition of the estuary's important environmental resources and proposes a series of critical actions to address the significant threats (HEP, 1996). Included among its recommendations was the development of a comprehensive regional plan to restore and protect ecological resources. This recommendation received support from the region's stakeholders, including state and municipal regulators and policy makers, federal agencies, non-governmental organizations, and the general public. In response to this broad support, Congress authorized the USACE to investigate and identify opportunities to restore the estuary that are in the federal interest. A 2000 Reconnaissance Report detailed that there is a federal interest in restoring the HRE (USACE, 2000).

In response to the 2000 HRE Reconnaissance Report (as well as Reconnaissance Reports for Jamaica Bay [USACE, 1994], Flushing Creek and Bay [USACE, 1996], and Bronx River Basin [USACE, 1999]), the USACE and a number of non-federal sponsors began six (6) complementary feasibility studies in the 1990s and early 2000s that focused on the restoration of priority sites; these are the six (6) "source" studies that were integrated into the HRE Ecosystem Restoration Feasibility Study. Each study was in a different planning phase, as discussed in Section 1.5.3. The studies focused on the needs and opportunities unique to one or more planning regions (Table 1-1).

1.6.1 Needs and Opportunities

The first step of what was called a "stakeholder based planning process" for this study was initiated in 2001 to develop a "needs and opportunities" report to initiate restoration of the HRE as a whole. The USACE, PANYNJ, and the Regional Plan Association completed the Needs and Opportunities Report (USACE, 2003), which established a collaborative planning process with stakeholders, identified the water resource problems and needs of the estuary, highlighted the need to build upon partner restoration efforts of the past 20 years and stressed the need for a Comprehensive Restoration Plan. The Needs and Opportunities Report also included a list of candidate restoration sites that could address the needs of each waterbody. Subsequently, study area reports that document the history of degradation, restoration needs, existing restoration efforts and potential restoration opportunities within each planning region were prepared (USACE, 2004a-h).

1.6.2 HRE Comprehensive Restoration Plan

The Draft and Version 1.0 of the CRP (USACE and PANYNJ, 2009 and 2016) was the culmination of years of collaborative planning amongst the regions stakeholders and estuarine scientists providing regional consensus on ecosystem goals, objectives, targets, restoration opportunities and implementation strategies for ecosystem restoration in the estuary. The Hudson River Foundation and the Center for the Environment at Cornell University provided support to the USACE and PANYNJ since 2005 to develop this unifying framework for harbor-wide restoration goals and targets (Target Ecosystem Characteristics), and a shared vision of a restored future state. The HRE CRP presents an overarching program goal:

> *To develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment.*

In December 2009 following release of the CRP, the HEP, including all regional partners and stakeholders within the New York-New Jersey Harbor & Estuary, adopted the CRP as their future restoration plan for the region. Dozens of public outreach meetings occurred in each planning region to obtain comments and input on the draft plan to ensure the consensus vision.

The HEP Restoration Work Group, chaired by the USACE, was formed in 2010 assuming the function of the Habitat Work Group, and charged with steering the coordination and implementation of the HRE CRP. The Restoration Work Group also steers the Program's research and actions relevant to HEP priorities that concern restoration, acquisition, species, or habitat identified in the New York-New Jersey Harbor & Estuary Program Action Plan, Comprehensive Conservation and Management Plan, and Comprehensive Restoration Plan. Members of the group include non-governmental, city, state, and federal representatives with expertise in habitat restoration and preservation. The Restoration Work Group is responsible for developing strategy, providing direction to, and tracking habitat restoration, public access, and acquisition efforts of the program and its participants as they relate to the CRP.

The CRP, prepared for the HRE study, serves as the foundation for all restoration efforts in the study area and highlights ongoing partner ecosystem and coastal restoration efforts in the HRE (see Section 2.6; USACE and PANYNJ, 2016). The CRP presents 296 sites following evaluation of the restoration opportunities identified in the needs and opportunities report, sites nominated by the HEP Habitat Work Group, and sites identified by geographic information system efforts that were deemed as high-value restoration areas that will best help meet the HRE CRP program goal (http://www.harborestuary.org/watersweshare).

1.6.3 Past and Ongoing Restoration Efforts

The HRE feasibility study and “source” studies were built upon the extensive studies undertaken by the USACE and regional federal, state and local partners coordinated within the HEP. In addition, other collaborative frameworks and committees (e.g., New York/New Jersey Federal Leadership Resiliency Collaborative) have been established to coordinate regional efforts to restore, protect and improve the resiliency of the shoreline following Hurricane Sandy. Figure 1-4 illustrates federal efforts to better coordinate and leverage resources and future opportunities. Those shown demonstrate planned federal projects that influence and/or are more effective in combination with the recommendations in this report.

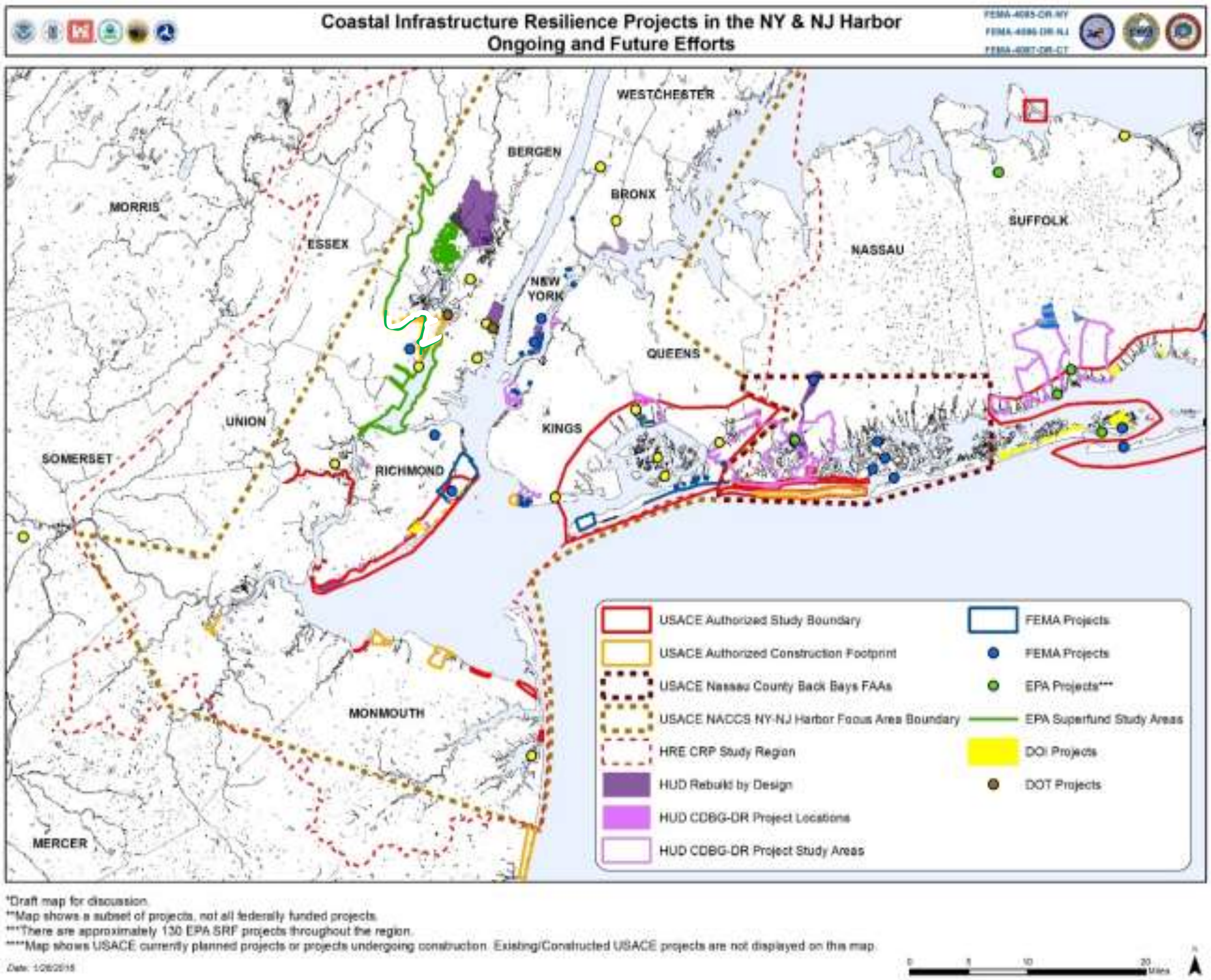


Figure 1-4. Ongoing and Future Coastal Infrastructure Resilience Projects in the HRE Study Area

More detailed coordination within a planning region is ongoing for activities in the Newark Bay, Hackensack River and Lower Passaic River Planning Region (Figure 1-5) and Jamaica Bay Planning Region (Figure 1-6) through leadership committees like the Federal Resilience Collaborative and the Science and Resilience Institute at Jamaica Bay.

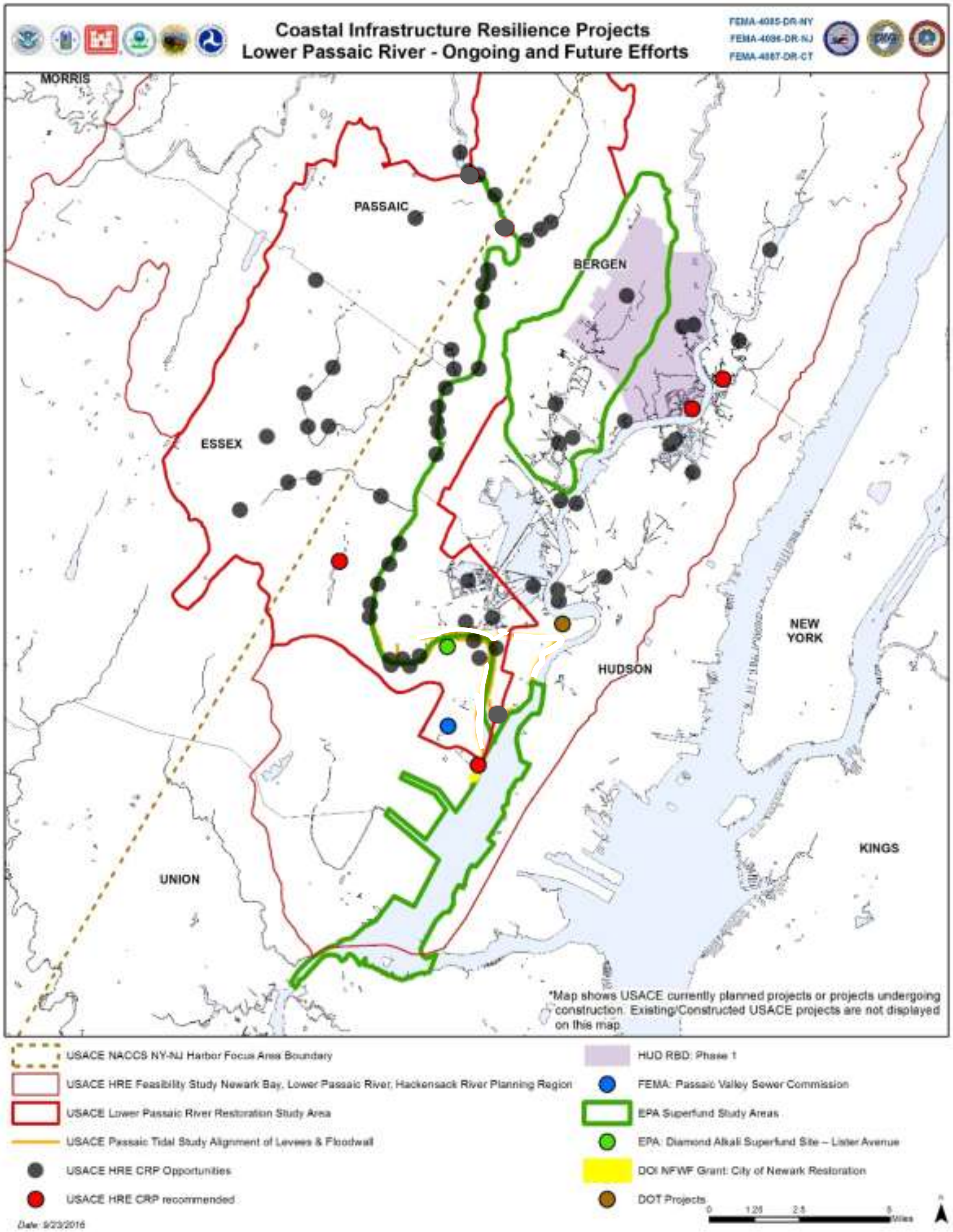


Figure 1-5. Ongoing and Future Coastal Infrastructure Resilience Efforts in the Newark Bay, Hackensack River and Lower Passaic River Planning Region

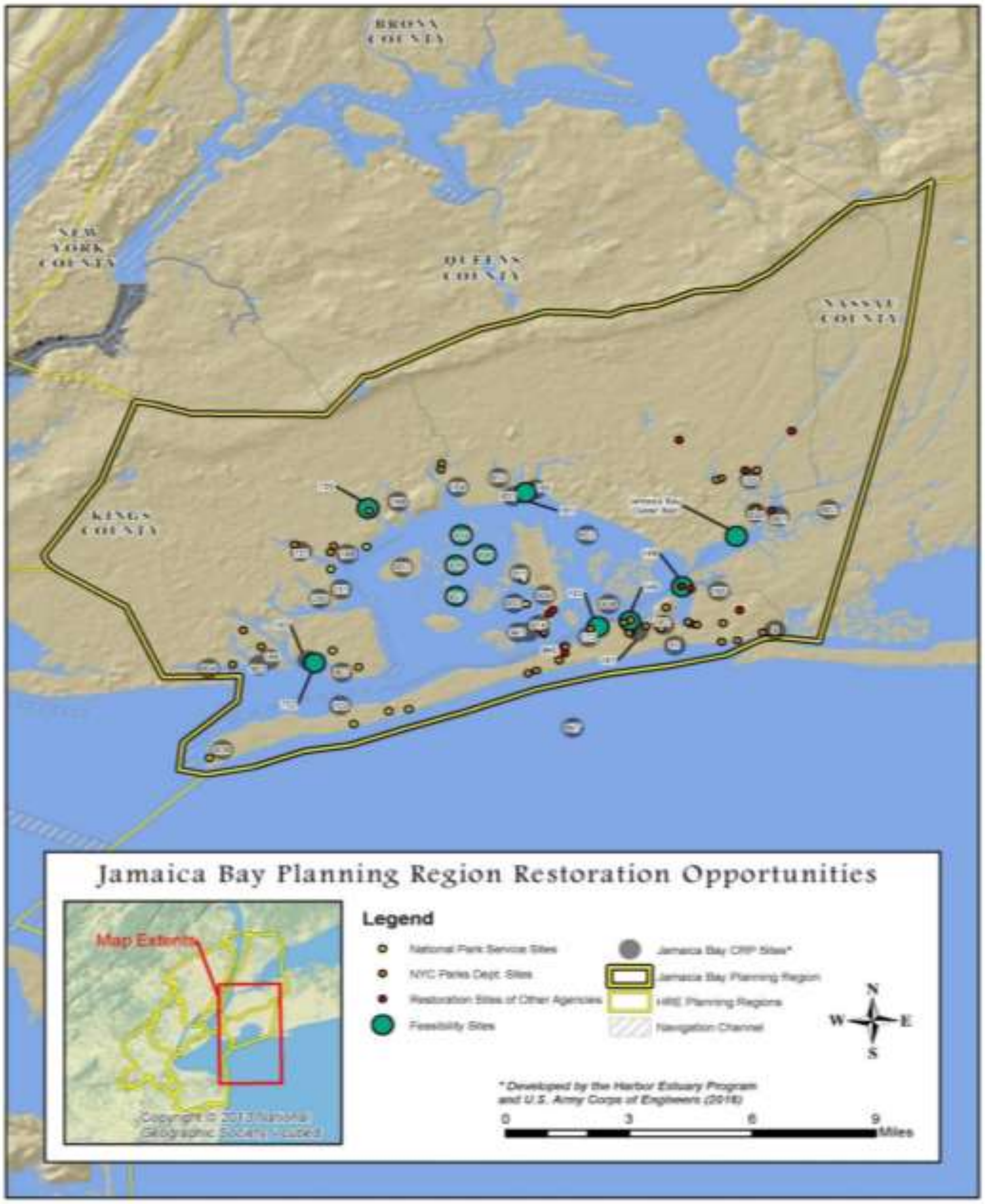


Figure 1-6. Ongoing and Future Coastal Infrastructure Resilience Efforts in Jamaica Bay Planning Region

Prior reports and studies utilized during the restoration planning in the HRE are outlined in Appendix B. In addition, the HEP Restoration Work Group has prepared progress reports highlighting restoration efforts and progress in the harbor estuary through 2014 (HEP, 2014), between 2014 through 2016 (HEP, 2016) and between 2017 through 2019 (HEP, 2019).

Significant advancement had been made during the restoration planning efforts for each USACE "source" study. Each feasibility study was at a different stage prior to their consolidation into the HRE Feasibility Study in early 2015:

- **Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study** was initiated in 1996 with the NYCDEP. During the early stages of the Feasibility Study, significant data collection efforts and planning were conducted in conjunction with National Park Service (NPS) including:

  - ✓ Cultural resource Section 106 National Historic Preservation Act surveys (2000);
  - ✓ Water levels/tide gauges (2001) and Evaluation of Planned Wetlands (EPW) assessment (2001);
  - ✓ Hazardous toxicity radioactive waste (HTRW) contamination (2001);
  - ✓ Biological communities: bird, fish, benthic invertebrates, vegetation, mammals, reptiles and amphibians (2002);
  - ✓ Water quality: Physical (meteorological, tidal, temp, turbidity), chemical (pH, nitrite/nitrates, phosphates, salinity, dissolved oxygen, chlorine), biological (chlorophyll-a, bacteriological) (2002);
  - ✓ Water quality modeling (2003);
  - ✓ Topography/bathymetry (2002) and NPS bathymetry project (pre-Sandy-http://irma.nps.gov/App/Reference/Profile/2204762);
  - ✓ Shoreline change analysis, slope stability, wave analysis, hydrodynamic modeling (2003); and
  - ✓ Bio-benchmarks (2004).

  Based on the above data collection efforts and partner coordination, a total of 44 restoration opportunities were identified and evaluated, resulting in the recommendation of eight (8) perimeter (shoreline) sites, along the periphery of Jamaica Bay, as the tentatively selected plan (TSP) in 2010. Meanwhile, initial steps to address the vanishing marsh islands were advanced using the USACE Continuing Authorities Program (CAP). Based on the success of CAP projects in Jamaica Bay, recommendations for additional marsh island restoration are also included in the HRE Feasibility Study.

  A preliminary draft integrated feasibility report and environmental assessment was prepared in 2010, but never finalized. Following Hurricane Sandy, which severely impacted portions of New York and New Jersey in October 2012, the perimeter sites were evaluated further in the East Rockaway to Rockaway Inlet and Jamaica Bay Reformulation Study as potential natural/nature based features. Recommendations for ecosystem restoration within the Jamaica Bay Study Area, also the Jamaica Bay Planning Region, were integrated into the HRE Feasibility Study in 2014.

- **Flushing Bay and Creek Ecosystem Restoration Feasibility Study** was initiated in 1999 with the NYCDEP and the PANYNJ. Data collected for the Flushing Bay and Creek Ecosystem Restoration Study included:

  - ✓ Phase 1 environmental site assessment (2001);
  - ✓ Tidal and current measurement program (2001);
  - ✓ Water quality sampling program (2001);
  - ✓ Finfish community surveys (2002);

- ✓ Benthic community surveys (2002);
- ✓ NYCDEP Erosion Analysis- Hydrodynamic and Sediment Transport (2011);
- ✓ NYCDEP Benthic and fisheries surveys (2012-2013);
- ✓ NYCDEP Bathymetric (2012) and land surveys (2013);
- ✓ NYCDEP Wetland and Upland Habitat Characterization (2013);
- ✓ NYCDEP Sediment Coring in Flushing Creek (2013);
- ✓ NYCDEP Geotechnical Study (shear stress) (2013); and
- ✓ NYCDEP Sustainability and Hydrodynamic Assessment (2014).

Twelve (12) sites were evaluated and a draft FR/EA was prepared in 2007, but was not released to the public. The recommended restoration alternative was not supported by NYCDEP, and required further coordination with the department's combined sewer outfall (CSO) discharge long term control plans for Flushing Bay and Flushing Creek and with future environmental dredging in the bay and creek. Progress was suspended due to lack of funding and the study was inactivated. Recommendation for ecosystem restoration within Flushing Creek was identified as a priority within the Flushing Creek and Bay Study Area within the Harlem River, East River and Western Long Island Sound Planning Region and was subsequently integrated into the study in 2013.

- **HRE-Lower Passaic River Ecosystem Restoration Feasibility Study** was a unique joint coordinated effort to comprehensively remediate and restore 17 miles of the Lower Passaic River and associated tributaries, Third River, Second River, and Saddle River. The study was initiated in 2003 through a governmental partnership with the USEPA, NOAA, USFWS, NJDOT, and NJDEP. The NJDOT was the official local sponsor for the feasibility study, with subsequent transfer in 2007 to NJDEP for technical oversight of completion of the study.

Significant amounts of data were collected for the USEPA's Remedial Investigation and Feasibility Study (RI/FS) and USACE restoration planning efforts and are available on www.ourpassaic.org. Much of the data collected for this multi-agency project on baseline conditions has been summarized in the Final Remedial Investigation and Focused Feasibility Study Report for the lower 8.3 miles of the Lower Passaic River (USEPA, April 2014). Project sampling efforts included:

- ✓ GIS Mapping Overview (2004);
- ✓ Bathymetry and Geophysical Surveys (2004, 2005, 2007, 2008, 2010, 2011);
- ✓ Field reconnaissance of restoration opportunities (2004/2005);
- ✓ Literature review of historic biological community data – in river (2004);
- ✓ Hydrodynamic Surveys (2004-2005; 2008-2009);
- ✓ Benthic Invertebrate Survey (2005; 2009-2010);
- ✓ Low and/or High Resolution Sediment Coring (2005-2010; 2012-2013);
- ✓ Sediment profile imaging survey of sediment and benthic habitat characteristics – in river (2005);
- ✓ Side scan sonar (2005);
- ✓ Municipality Surveys for Regional Visioning (2006-2007);
- ✓ Restoration opportunities report (2006);

- ✓ Hydrodynamic surveys (2005-2006 and 2008-2009);
- ✓ Kingfisher investigation – along shorelines (2007);
- ✓ Master plan review and municipality surveys regional visioning (2006-2007);
- ✓ Reconnaissance of potential restoration sites on tributaries to Passaic River (2008);
- ✓ Identification of Lower Passaic River restoration plant resources (2008);
- ✓ Vegetation sampling, wetland delineation and bio-benchmarks- subset of restoration sites (2008);
- ✓ Bioaccumulation testing- fish, crabs and bivalves- in river (2009-2010);
- ✓ Visioning: 3-D flyover for future conditions (2011);
- ✓ Avian community surveys (2010);
- ✓ Combined sewer overflow (CSO) stormwater outfall chemistry (2011);
- ✓ Surface water chemistry – in river (2012-2013);
- ✓ Background sediments- above Dundee Dam (2012-2013);
- ✓ Soil sampling at several upland locations for chemistry (2013); and
- ✓ Bathymetry – in river (1989-2011).

Although significant amounts of data have been collected to characterize baseline conditions in the 17-mile stretch of the Passaic River main stem, limited data is available for the specific restoration opportunities.

Fifty-three restoration opportunities were identified and were dependent upon the outcome of the USEPA's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (42 United States Code 9601 et seq.) Superfund Program. The remedial action decisions have influenced the sequence and type of recommendations for restoration—i.e., near-term construction, near-term construction following remedial actions, or future feasibility study. The study area was also a pilot project to coordinate remediation and restoration of degraded urban rivers under the Urban River Restoration Initiative and was selected as a location in the Urban Waters Federal Partnership Initiative Program. The study was re-scoped pursuant Civil Works Transformation in February 2013 and subsequently integrated into this study in 2015.

- **HRE-Hackensack Meadowlands Ecosystem Restoration Feasibility Study** was initiated in 2003 with the New Jersey Meadowlands Commission (NJMC), now the New Jersey Sports and Exposition Authority (NJSEA). While a vast amount of data exists for the Hackensack Meadowlands, the information compilation focused on data that could be useful in accomplishing the ecological restoration of the Meadowlands. Data collection included:

  - ✓ Fisheries Surveys (2001-2003);
  - ✓ Hydro-geomorphic Evaluation (2004);
  - ✓ Geotechnical and HTRW contamination data collection (2004-2005);
  - ✓ Cultural investigations (2006);
  - ✓ Topographic surveys;
  - ✓ Benthic community investigation (2007);
  - ✓ Avian Surveys (2007); and

✓ Geophysical investigation (2008).

In 2004, the USACE, USFWS, and NJMC conducted the Meadowlands Environmental Site Information 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 compilation focused on 48 sites within the Meadowlands and also included data relevant to the Meadowlands as a whole.

The Meadowlands Comprehensive Restoration Implementation Plan (USACE, 2005) provided a menu of comprehensive, ecosystem-based actions that address the problems affecting the aquatic environs and associated habitats of the Hackensack Meadowlands. A draft programmatic environmental impact statement was prepared and used to support this Environmental Assessment.

A total of 48 restoration opportunities were identified, with 18 of the sites identified as “critical restoration opportunities” for restoration in the future. Progress was suspended in 2012, when funds were no longer available. The study was inactivated and subsequently integrated into the HRE Feasibility Study in 2013. A subset of these “critical restoration opportunities” was then advanced.

- **Bronx River Basin Ecosystem Restoration Feasibility Study** was initiated in 2003 with NYCDEP and the Westchester County Department of Planning. Baseline data collected for the Bronx River Basin Ecosystem Restoration Feasibility Study included:

✓ Water Quality Assessment (2003);
✓ Cultural Investigations (2006);
✓ Water Quality and Baseline Data Collection (2006);
✓ Phase 1 Environmental Assessment (2006);
✓ Existing Conditions Hydrology: HEC-1 Modeling (2006-2007);
✓ Geomorphic Assessment (2006-2007);
✓ Ichthyofaunal Survey (2007);
✓ Wetland Field Assessment (2007); and
✓ Microbial Source Tracking Study (2007).

A restoration opportunities report was prepared identifying 350 opportunities within the Bronx River Basin (USACE, 2010). Sites were ranked using habitat and water quality parameters resulting in the prioritization of 23 sites to be evaluated further. The study was re-scoped in July 2012 and subsequently integrated into the study in 2015.

Given the consistent restoration planning approach for all sites to be recommended for authorization within the HRE planning regions, (in conjunction with the improved efficiency and cost effective strategy) the recommendations from these studies are included likewise in this interim HRE Integrated FR/EA.

Chapter 2: Affected Environment

This chapter identifies the historic, existing and future without project conditions within the eight (8) Hudson Raritan Estuary (HRE) planning regions. The existing conditions include a discussion of each planning region's physical land and water bodies, flora and fauna, cultural resources, and socioeconomic character. Although all planning regions within the HRE study area are in need of restoration, detailed discussion of existing conditions are only presented for planning regions with proposed restoration projects recommended in this Feasibility Report and Environmental Assessment (FR/EA). Only general background information is included for the Arthur Kill/Kill Van Kull, Lower Raritan River and Lower Hudson River Planning Regions since detailed existing conditions can be found in the HRE Comprehensive Restoration Plan (CRP) (USACE, 2016b) and will be documented in future "spin-off" feasibility studies since restoration is not recommended at this point in time.

2.1 History of Degradation and Historic Loss

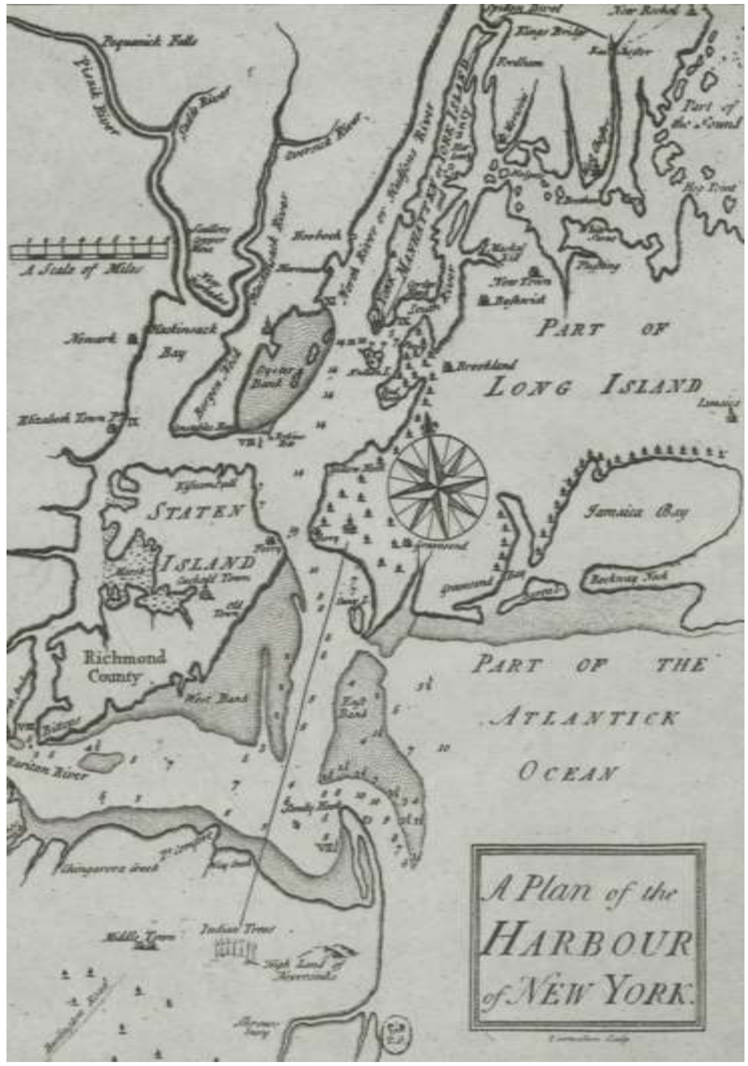
The HRE is located within one of the most densely populated estuary and urbanized regions in the United States. Over 20 million people live within 25 miles of the Statue of Liberty, the approximate center of the estuary, including the highly urbanized cities of New York, and Jersey City, Newark, and Elizabeth, New Jersey. Urbanization and industrialization over the past 400 years has put stress on the estuary, resulting in significant loss of habitat. The estuary has a long history of industrial and residential development that began in the 1600s with the first European settlers and intensified as navigation and infrastructure improved. These alterations resulted in significant ecosystem-level changes due to residual, persistent impacts to numerous habitats, especially those linked to aquatic environments. Regional development of the watershed and massive physical changes to the estuary, including dredging and channeling, damming, and streambank restoration, led to marked hydrologic alterations, acute sediment contamination, pervasive reductions in water quality, and habitat fragmentation. The ecological integrity, health, and resiliency of the estuary have been severely compromised.

Some of the aforementioned habitats have been preserved or restored in the HRE; however, many of these remaining environmental assets represent isolated sites that are typically surrounded by industrialized or densely populated urban areas and are vulnerable to degradation from surrounding land uses. Although currently they support some fish and wildlife, many of these open areas are severely degraded and would benefit significantly from habitat improvements.

Degradation and destruction of habitats in the HRE study area have been the result of human modifications to natural systems, as well as natural forces. Historically, the types of degradation commonly identified in the HRE study area were classified as bathymetric alterations, shoreline modifications, hydrodynamic and hydraulic changes, and changes to water and sediment quality. In addition to human modifications, sea level rise and natural forces such as Hurricane Sandy have also resulted in habitat loss and degradation. Sea level rise results in a direct loss of land and habitat due to inundation in the costal environments within the HRE.

2.1.1 Bathymetric Alterations

Before colonial settlement, the HRE study area was a relatively shallow system, with most of the waters less than 20 feet in depth at mean low water (Figure 2-1). The completion of the Erie Canal in 1825 along the Mohawk River made passage between the Great Lakes Region and the Atlantic Ocean possible. This eventually required deepening the natural channel of the Hudson River and its estuary. While the lower Hudson River and estuary were naturally deep enough to accommodate most vessels in 1825, as the need for more goods grew and wooden boats were replaced with larger steel ships, a series of navigation improvement projects was initiated in New York Bay to accommodate these vessels. In 1891, a 30-foot deep passage was dredged through the Lower Bay, followed by an extensive deepening to 40 feet completed in 1914 (Parkman, 1983). During World War II, the network of channels and supporting berthing areas were deepened to almost 45 feet and expanded into the Upper, Raritan, and Newark Bays (Parkman, 1983). Since then, navigation channels have been maintained or deepened throughout the HRE's rivers and bays, resulting in over 250 miles of established channels and associated berthing areas. In 2000, Congress authorized the deepening of the main shipping channels within the HRE to 50 feet to meet shipping needs and ensure New York-New Jersey Harbor's long-term economic viability (§101(a)(2) of Water Resources Development Act 2000, Public Law 106–541), which was recently completed in September 2016.



Source: Cohen and Augustyn, 2014

Figure 2-1. New York Harbor 1735

Approximately 300,000 acres of underwater lands have been filled and dredged for these shipping channels in New Jersey and almost 9,000 acres in New York (Bokuniewicz, 1988; Squires, 1992). Additionally, the Lower Bay of New York Harbor has been a major source of sand and gravel for construction aggregate and fill. For one study period of 1967 to 1978, the rate of removal averaged about 5.5 million cubic yards per year (Kastens, et al., 1978).

Extensive dredging of the Passaic and Hackensack rivers from the late 1800s onward further altered the waters of the Hackensack Meadowlands. The dredging allowed larger amounts of seawater to flow north from Newark Bay into the rivers' deepened channels (Marshall, 2004). Between 1897 and 1936, New York City (NYC) adopted a plan under which the main basin, tributaries and marshes of Jamaica Bay were to be substantially altered by the creation of two (2) large industrial islands bordered by numerous piers and wharves. This plan was never fully implemented but the substantial portion of the work that was executed significantly changed the northwest portion of Jamaica Bay, filling in large portions of salt marshes and straightening, widening, deepening, truncating and even eliminating tidal creeks that feed the vast marsh complexes along the outer boundaries of the bay.

Flushing Creek was impacted by the land development associated with the New York World's Fair of 1939-1940. Site hydrology was altered with the creation of Willow and Meadow Lakes and also the channelization of Flushing Creek. Bathymetric changes in support of navigation or from aggregate mining can influence estuarine systems and their outer beaches. These impacts include alterations of water circulation (Malhadas et al., 2009; Meyers et al., 2014; Valle-Levinson and Lwiza, 1995) and near shore tidal range (Wong and Wilson, 1979), offshore sediment transport processes (Kelley et al., 2004; Kortkaas et al., 2010), deprivation of littoral replenishment material (Kraus and Galgano, 2001), and alteration of biological communities (Byrnes et al., 2004).

2.1.2 Shoreline Modifications

Shortly after European settlement, colonists began developing the shoreline in the HRE study area. By filling and stabilizing nearshore habitat with soil, rocks, and refuse, colonists protected their homes and industries from flooding, erosion, and ice, as well as creating fast lands. Today, approximately 36 percent of shoreline in the HRE study area has been hardened, according to the 2006 NOAA National Geodetic Survey (Bain et al., 2007). Three (3) HRE planning regions with the highest percentage of hardened shorelines are the Harlem River/East River/Western Long Island Sound (46 percent), Lower Hudson River (66 percent), and Upper Bay (87 percent). Most of Manhattan's southern shorelines were hardened and approximately 279 acres of new land was added onto the island in an effort to expand the city. At the expense of the shoreline and shallow waters, riprap revetments and bulkheads stabilized shorelines and allowed for larger vessels to navigate the bays and rivers. By the early 1800s, ship traffic increased and solid-filled pier bases replaced the more basic stone embankment and timber piling designs. By 1853, there were 112 piers in the East and Lower Hudson Rivers, some of them extending 600 feet into the river (Wise et al., 1997).

Continued population growth and technological improvements called for improved transportation infrastructure. Railroad causeways were built, fragmenting many wetlands in the Hackensack Meadowlands and surrounding areas. The present-day LaGuardia, John F. Kennedy, Newark International Airports, and Floyd Bennett Field were constructed on filled wetlands. Major shipping terminals were established in the HRE which occupied a total of 755 miles of shoreline between New York and New Jersey, with 460 miles and 295 miles, respectively (USFWS, 1997).

Urban and industrial uses currently dominate nearshore areas in the HRE study area, and these activities have eliminated natural shoreline habitat from much of the estuary. New York-New Jersey Harbor has close to 1,000 miles of shoreline (576 miles in New York City alone), 75 percent of which consists of man-made structures, such as bulkheads, rip-rap, and piers (HEP, 1996). These hardened and often deepened shorelines have replaced the gently sloping and vegetated natural shorelines. The construction of bulkheads, piers, and placement of shoreline fill have greatly reduced the physically diverse near-shore zone of shallow, soft-bottom habitats, rocky outcroppings, wetlands, and sand beaches.

The littoral zone historically found in the estuary was structurally complex with diverse physical characteristics, supporting resident fish populations as well as attracting large populations of migratory and transient fish for spawning and feeding. These complex and productive waters were ideal nursery areas for young fish, particularly where benthic structure and/or plant communities existed.

The construction of piers slowed near-shore waters and promoted extensive sediment accumulation, which, in concert with other forms of shoreline hardening, contributed to the loss of physically complex habitat, greatly reducing quality of spawning and nursery areas. Remaining stretches of unhardened inner shorelines within the HRE study area are typically littered with debris, such as dilapidated piers or abandoned buildings, which obstruct aquatic and terrestrial growth. A 1992 survey of the Hudson River Estuary reported that the New York Harbor segment of the estuary lost approximately 56,000 acres of emergent marsh, resulting an approximate 80% reduction of the original wetland area in the harbor. In some cases human activity resulted in an increase of wetlands, with the area of the Hudson River between the Federal Dam in Troy, NY to the Tappan Zee Bridge estimated to have gained a net of approximately 1900 acres of tidal freshwater wetlands, resulting principally from shoreline railroad construction (Squires, 1992). Along the Lower Passaic River nearly all of the wetland and tidal-creek habitats once present have been destroyed by land-reclamation activities (Iannuzzi and Ludwig, 2004).

The HRE also includes outer sandy shorelines. While the morphology of outer sandy beaches is chiefly determined by gradual and continuous littoral processes affecting beach mobility (beach accretion or erosion), they can also be altered by punctuated extreme storm events (Bird, 2008; Hapke et al., 2013; Williams, 2013). The main natural controls affecting coastal morphology around tidal estuaries include fetch distance, shoreline orientation, tidal range, slope and width of the low tide terrace, wind and wave orientation and intensity, rates of submergence, vegetation on the foreshore, and sediment supply (Jackson, 1995; Jackson and Nordstrom, 1992). In the HRE, the outer sandy beaches and their nearby waters have also undergone extensive anthropogenic alterations. These activities have included beach nourishment, groin and jetty construction, dredging for navigation, and borrow area excavation. Cumulatively, these actions can alter natural littoral processes and subsequent coastal morphology and ecology (Bulleri and Chapman, 2010; Byrnes et al., 2004; Hall and Pilkey, 1991; Kraus and Galgano, 2001; Valverde et al., 1999; Williams, 2013; Wong and Wilson, 1979).

Long term outer-shoreline changes for the Jamaica Bay Planning Region show low accretion levels with the highest at the East Rockaway Inlet and Breezy Point areas. Recent investigation suggests that Jamaica Bay was historically much more open, without the marsh islands, and there has been an east-to-west progression of the Rockaway Peninsula that in turn led to salt marsh formation in the interior of the bay approximately 200 to 230 years ago (Hapke et al., 2010; Sanderson, 2016). Long term outer-shoreline changes for the Lower Bay Planning Region generally have shown slight erosion in many areas with the exception of Sandy Hook which has migrated considerably northward and quadrupled in size over the past 300 years. The rate of littoral sediment transport along Sandy Hook is the highest within the entire HRE and it has a current accretion rate of almost 19 feet per year due primarily to a suite of hydrographic feature which influence the transport of sediment throughout the system (Chrysler, 1930; Gorman and Reed, 1989; Hapke et al., 2010; Nordstrom et al., 1990; USACE, 2015c Yasso and Hartman, 1975).

2.1.3 Hydrodynamic and Hydraulic Changes

Within the estuary, most streams and creeks have either been eliminated by filling, redirected through storm sewers, or have been altered by stormwater runoff or channelization. These modifications have also altered the estuarine salinity gradient in many of the HRE's tidal tributaries. Wastewater treatment plants and CSOs increase freshwater inputs to localized areas. Stormwater runoff into the estuary also brings debris and sediment that can alter nearshore areas by filling or scouring, depending on the magnitude of flow. Bridges, piers, and roadways have constricted or restricted flow in many locations (USACE 2004a). Bathymetric alterations in support of navigation have also influenced water circulation and flow patterns. An increase in ship traffic by larger vessels produces waves and wakes, and large, deep-draft vessels navigating in shallow side channels results in scoured areas.

In addition to factors within the HRE study area that caused hydrodynamic and hydraulic changes, changes occurring outside of the study area have also directly affected the estuary. One of the most substantial has been the decrease in freshwater flow to the estuary. The Hudson River, the primary source of freshwater to the HRE study area, has reduced natural flow to the estuary due to more than 13,000 barriers including culverts, almost 800 dams of significance, and dozens of reservoirs in its watershed. Much fewer dams were found in the East River, Harlem River and Western Long Island Sound Planning Region where only 60 dams were identified in the USACE National Inventory of Dams and the New York State Inventory of Dams datasets ranging significantly in age (20 to 201 years), height (four [4] to 40 feet) and width (50 to 7,000 feet) (McKay et al., 2017). Impoundments alter stream flow patterns and encourage upstream siltation that can alter channel structure, benthic substrate, and bank stability in downstream river reaches. By physically blocking the river, storing excess runoff, or releasing water according to human needs, dams alter natural flow regimes (Poff et al., 1997). This decrease in freshwater flow to the estuary is exacerbated during low flow periods as flood tides bring a greater volume of saline water up the Hudson River, influencing community composition and habitat use by migratory and transient species preventing the spawning of anadromous fishes (e.g. American shad [*Alosa sapidissima*], alewife [*Alosa pseudoharengus*], hickory shad [*Alosa mediocris*], striped bass [*Morone saxatilis*], and blueback herring [*Alosa aestivalis*).

Likewise, the acceleration of human-engineered alterations of water flow to the Hackensack Meadows rapidly and drastically altered the salinity of its waters (Montalto and Steenhuis, 2004). Construction of dams to create millponds along the Passaic and Hackensack Rivers and their tributaries began diminishing the rivers' flow during the late 1600s and 1700s. In the 1830s, construction of the Morris Canal, the eastern half of which drew water from the tributaries of the

Passaic River, further decreased the flow along the Lower Passaic. Newark and Jersey City started pumping water from the Passaic River in the mid-1800s for their municipal water supplies. During the late 1800s, new and larger dams were constructed on the tributaries of the upper Passaic River to create large reservoirs for municipal use (Marshall, 2004).

Within the New York City boroughs, the majority of streams and creeks have either been eliminated by filling, redirected through storm sewers, or have been altered by stormwater runoff or channelization. Reduced freshwater flow regimes can significantly alter downstream ecosystems (Nilsson et al., 1991; Simenstad et al., 1992; Drinkwater and Frank, 1994; Jay and Simenstad, 1994). The decrease in natural freshwater flow can also increase salinity intrusions into an estuary (Liu et al., 2001; Parsa and Etemad-Shahidi, 2009). Salinity intrusions not only affect ecosystems and native species compositions (Marshall, 2004; Xiao et al., 2014) but can also facilitate the introduction of invasive species (Cordell and Morrison, 1996).

The HRE study area has suffered extensive losses in wetland habitat and aquatic vegetation communities, such as eelgrass beds. Approximately 300,000 acres of tidal wetlands and sub-tidal waters have been filled in the study area and only about 5 percent (15,500 acres) of historic tidal wetlands remain. Without aquatic vegetation, which functions as storage areas for flood runoff, most of the current overland runoff and leachate enters directly into open water. The loss of shoreline aquatic vegetation has resulted in increased turbidity, shoreline erosion, and reductions in wildlife breeding and wintering grounds. Moreover, alterations in tidal exchange have transformed much of the remaining shallow water and salt marsh habitat from the originally diverse wetland plant assemblages to monocultures of invasive species. Almost all of the approximately 224,000 acres of freshwater wetlands that existed in New York City prior to the American Revolution have been filled or otherwise eliminated.

2.1.4 Water Quality and Sediment Degradation

Four (4) centuries of human impacts adversely affected water and sediment quality in the HRE study area (Ayres and Rod, 1986; Bopp et al., 1998; Connell, 1982; Wolfe et al., 1996). Water and sediment quality had been demonstrably degraded in the Hudson River (Rohman, 1988), Lower Passaic River-Hackensack River-Newark Bay system (United States Environmental Protection Agency [USEPA], 2013; 2014a, b, c; 2016; Crawford et al., 1994; Iannuzzi et al., 1997; Iannuzzi and Ludwig, 2004; Shin et al., 2013), the Raritan River-Raritan Bay system (Anderson and Faust, 1974; Bokuniewicz, 1988; Foreman and Johns, 1940; Pearce, 1979) and the Bronx River (USACE, 2010). Unchecked and untreated discharges of human and industrial wastes and debris entered the estuary and its sediments from the time of European settlement to the establishment of environmental regulations in the 1970s.

Although the establishment of water quality regulations such as the Clean Water Act (CWA) has led to gradual improvements to water quality, the surface waters are impaired in areas where bathymetry and/or shoreline alterations have affected the natural flows and flushing. In addition, during large rain events, untreated wastewater enters the estuary through the hundreds of combined sewer overflows (CSOs) that remain in the HRE. The wastewater contains floatable debris, as well as chemical and biological pollutants that include pesticides, fertilizers, nutrients, metals, organochlorines, pharmaceuticals, and pathogens (disease causing microorganisms). Nitrogen inputs to estuaries on the Atlantic Coast of the United States are still two (2) to 20 times greater than during pre-industrialized time. Chronic nitrogen additions to nitrogen-limited estuaries can accelerate primary production and eutrophication, leading to many undesirable responses, such as increased frequency of harmful algal blooms, hypoxic (<4 milligrams) and anoxic bottom waters, loss of aquatic plants (Latimer and Rego, 2010; Orth et al., 2010; Short and Burdick, 1996), reduced fish stocks, and noxious odors (Castro et al., 2003; Lambert and Davy, 2011; Steinberg et al., 2004; Yozzo et al., 2001). Dissolved oxygen levels can be particularly low in some bays and confined waterways with limited circulation and where sewage treatment plants are the main source of fresh water, such as the tributaries of Jamaica Bay and the Hackensack and Lower Passaic Rivers (HEP, 2012). Deficits in dissolved oxygen are also common in dead-end tributaries like Flushing Bay and near CSO outfalls (Stinnette et al., 2018).

Urbanization also causes less conspicuous impairments to water quality. Increased paved and impervious surfaces restrict the amount of water that can be absorbed by the ground surface and increases the amount of stormwater entering surface waters. During extreme rain events, stormwater entering drainage systems may exceed the storage capacity of municipal wastewater treatment plants, and a mixture of predominantly stormwater and diluted sewage is discharged, untreated, into the HRE's waterways. The prevalence of impervious surfaces in the HRE study area generates large volumes of stormwater, and even relatively minor storms may result in CSO discharges. Urban runoff can also decrease clarity and alter circulation patterns in surface waters, affecting sensitive aquatic habitats. Reduced water clarity can also affect foraging by zooplankton or larval fish, and larger, predatory species.

Many point sources and historic discharges of contaminants of concern have also contributed to the legacy contamination within the sediments and soils of the HRE study area. Restoration hinges on removal of Hazardous, Toxic, and Radioactive Waste (HTRW) contamination from within or near ecosystem restoration sites, and is paramount to successful long-term restoration (USACE 2014). An HTRW assessment was conducted by USACE in 2014 to identify, investigate, and assess potential HTRW sites that may influence current and potential restoration opportunities within the HRE. Per the assessment, 1,386 HTRW sites are located within a 0.5 mile buffer of a CRP restoration opportunity sites. There are 50 USEPA Superfund sites, 62 New York State Department of Environmental Conservation (NYSDEC) environmental remediation sites, and 1,274 New Jersey Known Contaminated Sites (KCS) near CRP sites (USACE, 2014). Most notably, the Lower Passaic River and the Hudson River Superfund sites have contributed significant levels of contamination that have been transported throughout the HRE study area. Sediment quality is critical to the estuarine ecosystem, the success of restoration, human health and safety, and the port's economic viability. Any restoration initiative undertaken in or along a water source draining to the harbor and any restoration within the HRE is susceptible to impacts from contaminated sediment (USACE, 2014).

The presence of contaminated sediment from discharges or spills in portions of the HRE study area has decreased the quality of benthic habitat and has led to increased levels of contaminants in many aquatic and terrestrial species. Sediment and mussel samples from the estuary rank the highest overall in heavy metal, polyaromatic hydrocarbon (PAH), polychlorinated biphenyl (PCB), pesticide, and dioxin concentrations among the estuaries sampled by the National Status and Trends Program (NOAA, 1995). Major sources of contaminated sediments include, but are not limited to, industrial discharges, wastewater treatment plant discharges, CSOs, stormwater runoff, non-point source discharges, atmospheric deposition, and chemical and oil spills (USFWS, 1997). Other active sources of contamination to water and sediment quality include leachate (i.e., water percolating through landfills), as well as persistent sediment contaminants that are vestiges from before the CWA (HEP, 1996). The Contaminant Assessment and Reduction Project (CARP), which completed the most comprehensive data sampling and laboratory analysis program of sediments, ambient water, external sources, and biota for the harbor, determined that these legacy contaminants are expected to continue influencing sediments throughout the HRE. In general, CARP model simulations indicate that levels of contaminants will continue to decline even if ongoing loads remain constant. Ultimately, sediment remediation will likely be the most significant future method of source control (Lodge et al., 2015b).

Other significant indirect economic impacts of sediment and surface water contamination are associated with fisheries resources. Although the HRE study area has historically supported significant fisheries resources, these benefits are currently unclaimed due to fish consumption advisories relating to high concentrations of mercury, PCBs, dioxin, and dichlorodiphenyl-trichloroethane (DDT) in fish and shellfish (HEP, 2012). While concentrations of many toxic contaminants like PCBs in key fish species have been declining, other contaminants like mercury still remain persistent and pose a risk to marine species and in human consumption (Stinnette et al., 2018). Much of the harbor is closed to commercial fishing and recreational fishing is primarily limited to anglers that practice catch-and-release techniques; however, significant subsistence consumption of locally caught fish remains despite health warnings. Contamination issues have limited the economic benefits that could be achieved through a viable fishery that includes both commercial and recreational fishing industries.

Physical and chemical habitat alteration has led to changes in the populations of organisms that use the HRE study area. For example, the historically abundant eastern oyster (*Crassostrea virginica*) has all but disappeared over their once expansive range. Sedimentation likely smothered some oyster beds, killing them directly and buried hard benthic substrates on which oysters colonize, reducing available habitat. These high sedimentation rates were the combined effect of increased overland runoff, dredging, shoreline structure, and poor land management in the HRE study area. Overharvesting and poor water quality also contributed to the population decline of oysters (HEP, 2018). Other community changes resulted from the disappearance of oyster beds, which provide benthic structure over a range of depths and habitats for many aquatic species.

Contamination of the HRE's surface waters and sediments has also led to significant indirect economic impacts to the region through increased costs of port operation. Maintaining the economic viability of the region requires navigational access to the Port of New York and New Jersey by container ships and vessels. Navigational channels require periodic maintenance and deepening, and the costs associated with the placement of dredged materials vary with the concentration of contaminants contained therein. Dredged materials with low concentrations of contaminants can be transported by barge for placement at the Historic Area Remediation Site (HARS). However, fine-grained, and often contaminated sediments tend to settle in the navigation channels and when dredged, appropriate placement sites must be identified. Expensive processing of sediments (e.g., solidification and stabilization) is often required to bind the contaminants prior to the overland transport and ultimate upland disposal or beneficial use. These processes can exponentially increase the costs associated with navigation channel maintenance and decrease the overall efficiency of navigation programs (USACE, 2008b; Lodge et al., 2015b).

2.2 Hudson-Raritan Estuary Planning Regions Existing Conditions

The ecological integrity, health and resiliency of the estuary have been severely compromised as a result of development and industrialization in the HRE. It is estimated that approximately 80 percent of wetlands no longer exist and over 2,000 acres of tidal salt marshes in Jamaica Bay alone have been lost since 1924 (USACE, 2016b). The extensive loss of shallow habitats and wetlands, coupled with competition from invasive species and resource exploitation, have severely reduced the abundance and diversity of fish, shellfish, and estuarine-dependent wildlife species within the HRE. Major tributaries within the HRE have also lost much of the natural capacity to buffer floodwaters, as well as the capacity to sequester, transform, or degrade nutrients and contaminants. This decreased capacity to naturally maintain water and sediment quality is exacerbated by the region's high-density human population that produces enormous volumes of treated sewage effluent that, along with stormwater passing across impervious watershed surfaces, are discharged into the HRE.

Since 1974, regulations preventing the dredging and filling of coastal wetlands in New York State helped curtail the rampant acreage losses observed in the early and middle part of the century. Despite this, since the 1990s severe losses of interior wetlands have alarmed stakeholders. Detailed research studies have investigated the potential causes for the losses and these efforts continue today. Potential causes and contributing factors range from climate change, SLR, and erosive losses to invasive species, increased nutrients, and an unbalanced sediment budget.

Changes in the Clean Water Act (CWA) have led to substantial water quality improvements to date, but there remains significant room for improvement. Legacy chemicals in the sediments, including mercury, PCBs, DDT, and dioxin, still exceed acceptable levels (Steinberg et al., 2004). Many of these chemicals, which are readily absorbed in the fat cells of animals, can accumulate to dangerous levels. Currently, all regions of the HRE study area have consumption advisories in some fish and shellfish species (New York State Department of Health, 2015; New Jersey Department of Health, 2016). Moreover, the recent rates of decline in contaminants will be difficult to match in the future since current non-point sources of these chemicals and metals (e.g., overland runoff, atmospheric deposition) will not be as easy to control as point sources (Steinberg et al., 2004).

Within the HRE study area, each of the eight (8) planning regions consists of different habitats that contribute to the overall health of the ecosystem. In the absence of federal action, it is anticipated that the degraded conditions described above will continue and likely worsen in the future. The following sections describe the existing conditions of the HRE planning regions, identifying the primary resource problems within each region. Additional information is presented in the Engineering (C), Plan Formulation (D), Benefits (E), Regulatory Compliance (F), Hazardous, Toxic, Radioactive Waste (G), and Cultural Resources Documentation (H) appendices.

2.2.1 Jamaica Bay Planning Region

The Jamaica Bay Planning Region, located on the southwestern shore of Long Island, is enclosed by the Rockaway Peninsula (Figure 2-2). This region includes portions of Brooklyn, Queens, and Nassau Counties, New York, as well as the John F. Kennedy (JFK) International Airport. On its western edge, Rockaway Inlet connects Jamaica Bay to Lower Bay. Most of the watershed is urbanized and the shorelines are flanked by heavily developed lands, including the Belt Parkway, JFK Airport, and several landfills.

Figure 2-2. Jamaica Bay Planning Region

This planning region contains one of the last large contiguous blocks of habitat in the HRE study area. The Jamaica Bay Wildlife Refuge, established as part of the Gateway National Recreation Area, was the country's first national park and remains a dominant feature of this planning region (NPS, 2014a) (Figure 2-3). The refuge includes over 12,600 acres of aquatic habitat, salt marshes, freshwater and brackish water ponds, upland fields and woods, and open bay and islands (NPS, 2014). The wildlife refuge is centered around an artificial impoundment created to replicate the historically abundant freshwater habitats of the region. The Jamaica Bay Wildlife Refuge and surrounding parkland is dominated by an open water/tidal wetland complex that serves as an island of habitat within the urbanized estuary. These wetlands are visited by over 300 bird species annually, and are home to shellfish, invertebrates, and nearly 100 fish species (NPS, 2014a).

Figure 2-3. Photo of the Jamaica Bay. Marshes and osprey nest in foreground. Housing in background. (Source NPS)

Jamaica Bay is threatened by poor water and sediment quality, and habitat losses. CSOs, landfill leaching, municipal waste discharge, and runoff from the roads and developed areas diminish water quality (USFWS, 1997). Chronic erosion in the bay has sloughed off shorelines and deteriorated the interior islands. Substantial marsh losses were first identified by the Jamaica Bay Ecowatchers and brought to the attention of federal and state agencies in 1999. An estimated 2,000 acres of tidal salt marsh have been lost from the marsh islands since 1924, with the system-wide loss rate rapidly increasing in recent years. From 1994 to 1999, an estimated 220 acres of salt marsh were lost at a rate of 47 acres per year (Figure 2-4). Left alone, the marshes were projected to vanish by 2025, destroying wildlife habitat and threatening the bay's shorelines (NYSDEC, 2001).

Figure 2-4. Jamaica Bay Marsh Island Loss

The Jamaica Bay Planning Region experienced extensive damages resulting from the storm surge associated with Hurricane Sandy. Hardest hit areas in the planning region were the Atlantic shoreline of the Rockaway Peninsula and Breezy Point and the Howard Beach community (GOSR, 2014) within Jamaica Bay. The Atlantic shorefront suffered severe beach erosion resulting in shoreline retreat of up to 100 feet and lowering dune and berm elevations up to five (5) feet (USACE, 2012). Storm surge induced inundation of up to five (5) feet over the entire inland area. In addition, storm waves induced runup, overtopping, overwash, and damaged waterfront structures including boardwalks, concrete walls, residential buildings, roads, and other infrastructure. Within the interior of Jamaica Bay, coastal wetlands were littered with debris following the storm and wrack deposits were visible in many marsh areas. Initial reports and damage assessments may have underestimated the amount of wrack deposited, especially where obscured by dense reed stands or maritime woody vegetation (ALS, 2012). The Jamaica Bay marsh islands, restored prior to Hurricane Sandy by the USACE in partnership with NYSDEC, New York City Department of Environmental Protection (NYCDEP), Port Authority of New York and New Jersey (PANYNJ), and National Park Service (NPS), accumulated significant amounts of debris, but experienced relatively little damage to existing plantings; repairs to vegetation originally planted at Yellow Bar Hassock island in the summer of 2012 were required in the spring of 2014. The sand placed on Rulers Bar and Black Wall islands did not experience any damage as a result of the storm. Black Wall and Rulers Bar were subsequently vegetated through a community based planting effort led by American Littoral Society (ALS), Jamaica Bay Ecowatchers, and the Jamaica Bay Guardian funded by NYCDEP in July 2013.

The freshwater East and West Ponds of the Jamaica Bay Wildlife Refuge were breached by the storm surge during Hurricane Sandy and were inundated with saltwater. Storm waves washed away portions of the berm that separated the ponds from Jamaica Bay, transforming them into saltwater inlets. The ponds were well known for their abundance of waterfowl and shorebirds, including snow geese (*Chen caerulescens*), lesser and greater scaup (*Aythya affinis* and *A. marila*), ruddy duck (*Oxyura jamaicensis*), ring-necked duck (*Aythya collaris*), green winged teal (*Anas carolinensis*), northern pintail (*Anas acuta*), American wigeon (*Anas americana*), and gadwall (*Anas strepera*). The sudden rise in salinity created an unsuitable environment for brackish water species, which may ultimately alter foraging habitats (ALS, 2012). Proposed repairs to the primary and secondary breaches include replacement of the wetlands water control structure and installation of a groundwater well to provide freshwater, which will allow NPS to return West Pond to a more freshwater and resilient condition that supports a diversity of Jamaica Bay habitats and wildlife (NPS, 2016).

Wastewater treatment plants within the Jamaica Bay Planning Region were flooded during Hurricane Sandy, resulting in the release of partially treated or untreated sewage into the surrounding waterbodies. The Coney Island Wastewater Treatment Plant on Sheepshead Bay was inundated and released 213 million gallons of raw sewage, and an additional 284 million gallons of partially treated sewage. The 26th Ward Wastewater Treatment Plant also bypassed 89 million gallons of partially treated sewage into Jamaica Bay via Hendrix Creek (Kenward et al., 2013). Significant investments by the partner agencies to identify solutions to future coastal flooding and restoration of the ecosystem have transpired since Hurricane Sandy devastated the Jamaica Bay Planning Region. Major studies and resiliency efforts include the Atlantic Coast of New York City, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Coastal Storm Risk Management Reformulation Study (USACE, 2015a), Howard Beach – New York Rising Reconstruction Plan (GOSR, 2014), NPS Sandy Resilience Projects, and the formation of the Science and Resiliency Institute at Jamaica Bay, coordinated through a General Management Agreement with the City University of New York (CUNY) and the NPS as part of the NPS Sandy Resilience Projects. Many of the efforts are collecting significant amounts of baseline information, advancing the state of the science, and enhancing coordination among partners and stakeholders in order to develop comprehensive strategies for coastal restoration in the planning region.

2.2.1.1 Geomorphology and Sediment Transport

Jamaica Bay is in the Atlantic Coastal Plain physiographic province. The center of the bay is dominated by subtidal open water and extensive low-lying islands with areas of salt marsh, intertidal flats, and uplands. The bay and barrier beach sediments are composed predominantly of sand and gravel derived from glacial outwash and marine sources. Surficial deposits on Long Island are glacial in origin with morainal deposits to the north and outwash deposits to the south. Extensive dredging, filling, and development have altered the landscape. Losses of upland and wetland buffers continue to threaten the estuary. Salt marsh islands that were once prevalent have subsided/eroded and are disappearing.

The sediment in Jamaica Bay is composed of a relatively even ratio of mud and sand. Jamaica Bay is threatened by poor sediment quality derived from a combination of sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed areas (USFWS, 1997). Erosion results in slumping, undercutting, and inward retreat of peat from bank ledges along island peripheries and tidal creeks, and widens tidal channels. Remnant borrow pits and channels in the Bay, some as deep as 60 feet, are sometimes oxygen-deficient (hypoxic), affecting habitat suitability for fish and wildlife. These depressions may act as sediment sinks, trapping fine, organic sediment that otherwise may have been deposited on the surrounding wetlands, and may alter the hydrodynamics of Jamaica Bay by increasing the residence time of water as much as three-fold (Hartig et al., 2002; USFWS, 1997).

Additional details on Jamaica Bay's geology, bathymetry, topography, shoreline stability and geotechnical characteristics of Jamaica Bay are found in more detail in the Engineering Appendix (Appendix C).

2.2.1.2 Water Resources

Jamaica Bay lies within the Southern Long Island watershed (United States Geological Survey Hydrologic Unit 2030202), which has a drainage area of approximately 1,960 square miles and includes Kings, Queens, Nassau, and Suffolk counties of New York State. Within Kings and Queens Counties, the aquifer is not utilized as the sole or principal source of drinking water; however, these areas do contribute to the recharge zone for aquifers underlying the southeastern portion of Queens County. The watershed has 625 miles of waterways, consisting mainly of small rivers and streams, including the Peconic River (USACE, 2003). There are no documented freshwater springs in the area (USACE, 2003).

Jamaica Bay itself drains an area of approximately 132 square miles (USFWS, 1997) within the larger Southern Long Island watershed. The bay is a saline to brackish, nutrient-rich estuary covering almost 40 square miles. The bay has a mean depth of 13 feet, a tidal range averaging five (5) feet, and a residence time of about 33 days (USFWS, 1997). The bay opens into Lower New York Bay and the Atlantic Ocean via the Rockaway Inlet. Rockaway Inlet is a high current area that is 0.63 miles wide at its narrowest point, with an average depth of 23 feet (USFWS, 1997).

Jamaica Bay was once a shallow, sandy system with channels networking through extensive salt marsh islands and surrounded by fringing wetlands. Fresh waters entered the bay through an array of tributary creeks that broadened and became more saline as they flowed downstream. Made of glacial till left behind during the last ice age and shaped by erosion and wave action (NPS 2004), the open water and wetlands portion of Jamaica Bay is approximately eight (8) miles long, four (4) miles wide and covers 26,645 acres (Swanson et al., 1992). Three-fourths of Jamaica Bay is water, marsh, and meadowland; the remaining upland areas include beaches, dunes, and forests (Swanson et al., 1992). Coastal portions of Jamaica Bay lie within the 100-year floodplain.

Because of landfilling and sewer diversions, the freshwater wetlands of Jamaica Bay comprise less than one (1) percent of their historic coverage (NYCDEP, 2007). The bay's original network of freshwater and brackish creeks have been shortened, straightened, bulkheaded, and channelized, with two-thirds of the freshwater runoff diverted through four (4) water pollution control plants. The waters within Jamaica Bay are classified by the NYSDEC as Class SB (suitable for primary and secondary contract recreation such as swimming, kayaking and fishing), but may be deferred pending development, implementation, or evaluation of other restoration measures. Jamaica Bay was approved for delisting in 2012 by the USEPA as Category 4b waters, where required control measures other than a total maximum daily load are expected to result in attainment of water quality standards within a reasonable period of time (NYSDEC, 2016).

2.2.1.3 Vegetation

The Jamaica Bay Planning Region contains one of the last large contiguous blocks of habitat in the HRE study area. The center of the bay is dominated by subtidal open water and extensive low-lying islands with areas of salt marsh, and intertidal flats. The average mean low tide exposes mudflats and low salt marshes dominated by smooth cordgrass (*Spartina alterniflora*), and high marsh dominated by saltmeadow cordgrass (*S. patens*). Macroalgae growth in the extensive intertidal areas is dominated by sea lettuce (*Ulva latuca*) (Hartig et al., 2002; Holmes and Milligan, 2013; Mack and Feller, 1990).

Aquatic vegetation and habitat of the Jamaica Bay Planning Region has been disturbed by extensive dredging and dredged material placement, and infrastructure development. About two-thirds of wetlands in the bay have been filled in, mostly around the perimeter of the bay, resulting in large expanses of dense non-native common reed (*Phragmites australis*) reeds interspersed with smaller patches of native vegetation. There are two subspecies of *Phragmites* found in New York State. The native subspecies (*Phragmites austrailis* americanus) is now rare throughout its range while the non-native *Phragmites* is an aggressive invasive species that can rapidly form dense stands of stems which crowd out or shade native vegetation, turn habitats into monocultures, and alter marsh hydrology by decreasing salinity in brackish wetlands (NYIS, 2019; Saltonstall et al. 2004). Despite this, Jamaica Bay is an estuary with diverse habitats, including open water (littoral zone), coastal shoals, bars, mudflats, intertidal zones (low and high marshes), and upland areas (Hartig et al., 2002). Upland communities are predominantly grasslands, scrub-shrub, developing woodland, and beachgrass dune. Despite the predominance of urban habitats in the region, the overall vascular plant variety is fairly rich with 456 species in 270 genera recorded in one study (Stalter and Lamont, 2002).

2.2.1.4 Finfish

Jamaica Bay continues to be a significant nursery ground for commercially and recreationally important fish, such as the winter flounder (*Pseudopleuronectes americanus*) and striped bass. In 2002, of all the finfish species, the majority caught in the bay during a Jamaica Bay Ecosystem Research and Restoration Team (2002) study were juveniles. Overall, the most abundant finfish caught during seining in the study was the juvenile Atlantic silverside (*Menidia menidia*), comprising 61 percent of all species. This fish consistently remains one of the most abundant juvenile fish in the bay and also throughout the Middle Atlantic Bight. *Fundulus* species, including the striped killifish (*Menidia beryllina*) and spotfin killifish (*Fundulus luciae*), were the second most prevalent taxa. The third most prevalent taxa caught seining was the Atlantic menhaden (*Brevoortia tyrannus*), followed by the striped mullet (*Mugil cephalus*) and the winter flounder (Jamaica Bay Ecosystem Research and Restoration Team, 2002). Under the Magnuson-Stevens Fishery Conservation and Management Act (16 United States Code 1801 et seq.), Jamaica Bay has been designated by the National Marine Fisheries Service (NMFS) as essential fish habitat (EFH) for numerous species and life stages of commercially or ecologically important fish.

Other common fish species that inhabit this area include bay anchovy (*Anchoa mitchilli*), mummichog (*Fundulus heteroclitus*), scup (*Stenotomus chrysops*), bluefish (*Pomatomus saltatrix*), windowpane (*Scophthalmus aquosus*), tautog (*Tautoga onitis*), weakfish (*Cynoscoin regalis*), black sea bass (*Centropristis striata*), summer flounder (*Paralichthys dentatus*), and American eel (*Anguilla rostratal*). Anadromous species that use the area include blueback herring, Atlantic sturgeon (*Acipenser oxyrhynchus*), alewife, American shad, and striped bass (USFWS, 1997).

2.2.1.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from the National Oceanic and Atmospheric Administration (NOAA) NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate EFH for all managed species, to minimize to the extent practicable adverse effects on EFH, and to identify other actions to encourage the conservation and enhancement of EFH. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (NOAA, 2004). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining “waters” to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties: “substrate” to include sediment, hard bottom, and structures underlying the water; areas used for “spawning, breeding, feeding, and growth to maturity” to cover a species’ full life cycle; and “prey species” as being a food source for one or more designated fish species (NOAA, 2004).

NOAA’s Guide to EFH Designations in the Northeastern United States provides the species and life stages that have EFH. Table 2-1 lists the EFH designations in the Jamaica Bay Planning Region. The planning region falls within two (2) 10-minute grids; however, because these grids extend beyond the bay to also cover a large portion of oceanic area, some of the designated species are oceanic pelagic species that would not occur in the planning region habitat (NOAA, 2016). EFH is discussed further in Appendix F.

Table 2-1. Summary of EFH Designation for Jamaica Bay Planning Region

Managed Species	Eggs	Larvae	Juveniles	Adults
Atlantic salmon (*Salmo salar*)				X

Managed Species	Eggs	Larvae	Juveniles	Adults
Pollock (*Pollachius virens*)			X	
Silver hake (*Merluccius bilinearis*)	X	X	X	
Red hake (*Urophycis chuss*)	X	X	X	
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X
Windowpane flounder (*Scophthalmus aquosus*)	X	X	X	X
Atlantic sea herring (*Clupea harengus*)			X	X
Monkfish (*Lophius americanus*)	X	X		X
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triacanthus*)	X	X	X	X
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X
Summer flounder (*Paralichthys dentatus*)		X	X	X
Scup (*Stenotomus chrysops*)	X	X	X	X
Black sea bass (*Centropristis striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Sand tiger shark (*Carcharhinus taurus*)		X		
Blue shark (*Prionace glauca*)				X
Dusky shark (*Carcharhinus obscurus*)		X		
Sandbar shark (*Carcharhinus plumbeus*)		X	X	X
Tiger shark (*Galeocerdo cuvieri*)		X		
Source: NOAA, 2016. 10'x10' square coordinates: 40° 40.0'N, 73° 40.0'W, 40° 30.0'N, 73° 50.0'W 40° 40.0'N, 73° 50.0'W, 40° 30.0'N, 74° 00.0'W				

2.2.1.6 Shellfish and Benthic Resources

Areas of existing salt marsh in the Jamaica Bay Planning Region provide reproductive areas for invertebrates, such as mussels and crabs. Mudflats in the planning region are important habitat for horseshoe crabs (*Limulus polyphemus*) and shorebirds. Each spring, horseshoe crabs congregate on these mudflats to breed. Migratory shorebirds that winter in the Geotropic and breed in the Artic stop during their migration to rest and replenish their fat reserves by feeding on the horseshoe crab eggs. Shorebird species such as ruddy turnstones (*Arenaria interpres*) and red knots (*Calidris canutus*) rely on the horseshoe crabs for their survival. Favorable habitat is generally limited to small, isolated patches on the beaches of Jamaica Bay.

Jamaica Bay once supported significant shellfisheries including eastern oyster, hard clam or northern quahog (*Mercenaria mercenaria*), softshell clam (*Mya arenaria*), and blue crab

(*Callinectes sapidus*). However, as a result of pollution, decreased habitat, and overharvesting, the industry collapsed. The New York City Health Department closed harvest of the Bay's shellfish in 1921 due to contamination, a threat which persists today. Current shellfisheries in the Bay are limited to reduced recreational harvest of a few species.

2.2.1.7 Wildlife

Widely recognized as a uniquely valuable habitat complex within the HRE, New York City designated Jamaica Bay as a Special Natural Waterfront Area (SNWA) in response to recommendations in the 1992 Comprehensive Waterfront Plan (NYC, 2011). The habitat of the Jamaica Bay estuary serves important functions for fish, birds, and other wildlife populations. The geographic location of Jamaica Bay at the turning point of the Atlantic coastline creates a convergence point for migratory marine and estuarine species. Shorebirds, raptors, waterfowl, and landbirds are concentrated by the coastlines in both directions. Areas of existing saltmarsh serve as nursery grounds for larval and juvenile fish, as well as reproductive areas for invertebrates such as mussels and crabs. Areas of sandy beach provide critical habitat to breeding horseshoe crabs and various shorebirds, including several federal and state endangered or threatened species. The Jamaica Bay Planning Region is within the Atlantic Flyway and natural areas within the planning region are heavily used by migrant birds. The harbor seal (*Phoca vitulina*) has been observed on the islands of Jamaica Bay, as well as the grey seal (*Halichoerus grypus*), although less frequently (USFWS, 1997).

Islands scattered through the marshes and mudflats support important nesting habitat for colonial waterbirds (USACE, 2004a). Upland meadows and shrublands provide habitat for terrestrial species and are important buffer areas that provide protections from noise and human encroachment. The planning region includes the Jamaica Bay and Breezy Point complex, which has been designated by the USFWS as a significant habitat complex of the New York Bight watershed. Although fish and wildlife species use the remaining habitat within the planning region, the wetland habitat within Jamaica Bay is eroding rapidly and the surrounding land use further diminishes the quality of the habitat (NYSDEC, 2001).

2.2.1.8 Rare, Threatened, and Endangered Species

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species, and species of special concern within the project sites and their vicinities. The USFWS and NMFS were contacted regarding federally listed threatened and endangered species, while the NYSDEC Division of Fish, Wildlife, and Marine Resources gave comments regarding state listed species. Numerous endangered, threatened, or rare plant and animal species exist within the boundaries of the bay.

Some species found in or near several Jamaica Bay restoration sites are the northern harrier (*Circus hudsonius*), peregrine falcon (*Falco pereginus*), piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii*), and seabeach amaranth (*Amaranthus pumilu*). Four (4) different species of protected marine turtles have been found in the bay, as well as a number of marine mammals. Breezy Point, on the western tip of the Rockaway Barrier Beach, sustains large populations of beach-nesting colonies of piping plovers in the New York Bight coastal region (USFWS, 1997).

USFWS

The USFWS Information for Planning and Consultation (IPaC) website was consulted to determine potential threatened and endangered species or critical habitats that occur in Jamaica Bay (Appendix F). No critical habitats were identified in Jamaica Bay; however, several protected species were identified as being in the habitats of Jamaica Bay. Two (2) endangered species were identified: roseate tern and sandplain gerardia (*Agalinis acuta).* Also four (4) threatened species were identified: piping plover; red knot, seabeach amaranth, and the northern long-eared bat (*Myotis septentrionalis*)

NMFS

Listed by the NOAA NMFS, four (4) species of Endangered Species Act (ESA) sea turtles have been seasonally present in the bay, including:

- Threatened Northwest Atlantic Ocean distinct population segment (DPS) of loggerhead (*Caretta*);
- Threatened North Atlantic DPS of green (*Chelonia mydas*);
- Endangered Kemp's ridley (*Lepidochelys kempii*); and
- Endangered leatherback sea turtle (*Dermochelys coriacea*).

These threatened and endangered sea turtles can be present in the Jamaica Bay area from May to mid-November. Adult and sub-adult Atlantic sturgeon can be found in the Jamaica Bay Planning Area. The New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPSs are endangered, and the Gulf of Maine DPS is threatened in the area. Atlantic sturgeon eggs, larvae, or juvenile life stages will not be found in the waters of the Jamaica Bay Planning Area. Additionally, the shortnose sturgeons (*Acipenser brevirostrum*), of the adult and subadult life stages are also present in these waters.

NYSDEC

Through correspondence with NYSDEC, and their review of the New York Natural Heritage Program database, the following list of endangered, threatened, or species of special concern for any animal species that are listed federally, or are candidates for federal listings in the Jamaica Bay area include:

- Short-eared owl (*Asio flammeus*) – Endangered;
- Peregrine falcon – Endangered;
- Northern harrier – Threatened;
- Common tern (*Sterna hirundo*) – Threatened;
- Black skimmer (*Rynchops niger*) – Special Concern;
- Upland sandpiper (*Bartramia longicauda*) – Threatened;
- Laughing gull (*Leucophaeus atricilla*) – Protected Bird - Critically Imperiled in NYS;
- Barn owl (*Tyto alba*) – Protected Bird – Critically Imperiled in NYS;
- White-m hairstreak (*Parrhasium m-album*) – Unlisted – Status Uncertain; and
- Red-banned hairstreak (*Calycopis cecrops*) – Unlisted – Status Uncertain.

The following list of endangered, threatened, or species of special concern for any plant species that are listed federally, or are candidates for federal listings in the area includes:

- Scirpus-like rush (*Juncus scirpoides*) – Endangered – Critically Imperiled in NYS;
- Northern gamma grass (*Tripsacum dactyloides*) – Threatened – Imperiled in NYS;
- Fringed boneset (*Eupatorium torreyanum*) – Threatened – Imperiled in NYS;
- Roland's sea-blite (*Suaeda rolandii*) – Endangered – Critically Imperiled in NYS and Globally Rare;
- Narrow-leaf sea-blite (*Suaeda linearis*) – Endangered – Critically Imperiled in NYS;
- Cut-leaved evening primrose (*Oenothera laciniata*) – Endangered – Critically Imperiled in NYS;
- Willow oak (*Quercus phellos*) – Endangered - Critically Imperiled in NYS;
- Seaside bulrush (*Bolboschoenus maritimus ssp. Paludosus*) – Threatened – Imperiled in NYS; and
- Schweinitz's flatsedge (*Cyperus schweinitzii*) – Rare – Vulnerable in NYS.

In addition, the New York Natural Heritage Program deems the Low Salt Marsh, present throughout Jamaica Bay, to be a significant natural community from a statewide perspective having a high ecological and conservation value.

Threatened and endangered species may be present at any of the Jamaica Bay sites as either residents or transients. It is assumed that prior to construction activities a resource inventory would be conducted to determine if these species are present. Chapter 5 discusses these inventories in greater detail.

2.2.1.9 Land Use

Jamaica Bay is a highly urbanized estuary in southern Brooklyn and Queens that contains the Jamaica Bay Wildlife Refuge, established as part of Gateway National Recreation Area. The recreation area was the country's first national urban park and remains a dominant feature of this planning region (RPA, 2003). Predominant land uses on the northern shore of Jamaica Bay are developed commercial, industrial, and residential. The shorelines of Jamaica Bay are flanked by heavily developed lands, including the Belt Parkway, JFK International Airport, and several landfills. Along the waterfront, land and water uses include marinas, marine parks, parkland, vacant disturbed land (wetlands and uplands), tidal wetlands, and residential land. Public parks and open space present in the study area include Floyd Bennett Field, Prospect Park and Spring Creek Park. Rockaway Peninsula, in the southern part of the Jamaica Bay Planning Region, is distinct from the northern shores of the planning region. Developed as a summer resort in the 1830s, Rockaway Peninsula is predominantly a residential area from its border with Nassau County on the east to Rockaway Point on the west.

2.2.1.10 Hazardous, Toxic, and Radioactive Waste

All of eastern Jamaica Bay and its tributaries have been designated by NYSDEC as impaired, due to nitrogen levels, oxygen demand, and presence of pathogens (NYSDEC, 2016). Six (6) sewage treatment plants occur in the planning region; four (4) are owned and operated by the NYCDEP; one (1) is owned and operated by the Village of Cedarhurst, NY; and one (1) is owned and operated by the Nassau County Department of Public Works. Major investments in New York City's sewage treatment plants over the past three (3) decades have dramatically improved the bay's water quality, but significant problems remain. The primary culprits are CSOs and discharges of treated wastewater from the six (6) city sewage treatment plants that encircle the bay. While there is considerable variability in residence time estimates, it is clear that many locations within the bay are prone to retain pollutants for long periods of time, while pollutants can be removed from other locations rather rapidly (NYCDEP, 2007). Jamaica Bay's tributaries and dead-end canals are also prone to reduced water quality due to direct surface runoff and poor flushing (NYCDEP, 2011). Dissolved trace metals, including lead, have also been detected in the water column of Jamaica Bay (Beck et al., 2009).

An HTRW sampling report (USACE, 2002) was completed for potential restoration sites in the Jamaica Bay Planning Region. Soils encountered at the sites under investigation consist primarily of fill materials comprised of disturbed soils and/or placement of dredged material, building demolition debris, domestic refuse, and coal combustion residues (i.e., coal and coal ash). Details of the compounds found in soil samples that exceeded the limits set by the NYSDEC recommended soil cleanup objective and cleanup levels can be found in Appendix G.

2.2.1.11 Noise

Noise is generally defined as unwanted sound and its loudness is measured by amplitude, which is expressed in decibels. Noise levels can be approximated based on land use and can range from 30 decibels in wilderness areas to 90 decibels in urban areas (USEPA, 1978). Ambient noise levels within the Jamaica Bay Planning Region would be highly variable due to its combination of developed urban land and the less-developed bay and marsh islands. The primary sources of noise in the planning region include air traffic from JFK International Airport, automobile traffic on the Belt Parkway or other local roads, and boat traffic in Jamaica Bay. Receptors in the planning region include residential areas and wildlife habitats. Noise criteria and the descriptors used to evaluate project noise will depend on the type of land use in the vicinity of the proposed project areas.

2.2.1.12 Navigation

A federal navigation channel is within Jamaica Bay, along the west and south shores, with an entrance channel connecting two (2) interior channels to the Atlantic Ocean at Rockaway Inlet. North Channel is the interior channel from the Marine Parkway Bridge along the west shore of the bay and is authorized to be 18 feet deep at mean low water (MLW) and 300 feet wide to Mill Basin, with a turning basin 1000 feet wide and 1000 feet long at that point. North of Mill Basin the channel continues with an authorized depth of 12 feet MLW and 200 feet wide to Fresh Creek Basin. Beach Channel, authorized to 15 feet deep MLW and 200 feet wide, is the interior channel from the Marine Parkway Bridge along the south shore and continues to Head of Bay. At the entrance to Head of Bay, the channel branches, going north into the Head of Bay and south, forking into Mott Basin and Inwood Creek. The entrance channel, Rockaway Inlet, is authorized to 18 feet deep MLW and 500 feet wide from the Marine Parkway Bridge to Rockaway Point, where it expands to an authorized 20 feet deep MLW and 1000 feet wide to the ocean.

The Rockaway Inlet entrance channel is generally dredged on a two (2) to three (3) year maintenance cycle. The five (5) year average annual commercial tonnage at Jamaica Bay federal navigation channel is 678,400 tons.

2.2.1.13 Recreation

The Jamaica Bay Planning Region has 61 public access points lining the waterfront around the bay. The majority are found at the entrance of the bay around Dead Horse Bay, Gerritsen Creek, and Mill Basin; however, they are not limited to this area and others can be found along the Rockaway Peninsula and the islands of the bay and the Jamaica Bay Wildlife Refuge. Public swimming beaches line Rockaway Peninsula through Fort Tilden and Jacob Riis Parks (New York City Department of Parks and Recreation [NYC Parks], 2012).

In the Jamaica Bay Planning Region, recreational fishing from the shorelines occurs in New York City or state parks and in areas of Gateway National Recreation Area (parts of Floyd Bennett Field, Breezy point, Canarsie Pier, Dead Horse Bay, Fort Tilden, and Jacob Riis Park) (NYCDEP, 2007). Recreational species that occur in the Jamaica Bay Planning Region include bluefish, tautog, weakfish, black sea bass, winter flounder, summer flounder, and striped bass.

2.2.1.14 Cultural Resources

The Jamaica Bay region has a long history of occupation, first by Native American groups from as early as 12,000 before present until the arrival of European explorers in the fifteenth century. Early colonial settlements appear in the 1600s and evolve slowly from agricultural to industrial in character followed by urbanization in the last century. Potential for prehistoric and historic archaeological sites exists throughout the region. Archaeological sites and above ground historic properties can be found in upland, lowland, marsh, and submerged environments. Architectural and archaeological investigations are required to determine the presence or absence of such resources in most of the study area due to lack of existing data.

In 2014, the USACE completed a cultural resources survey titled *Cultural Resources Overview of the Hudson-Raritan Estuary Comprehensive Restoration Plan* (Harris et al., 2014) that aimed at inventorying all existing cultural resources data relevant to the candidate restoration sites in the HRE study area. The survey was not a comprehensive survey but an overview that compiled general cultural resources data for the entire Jamaica Bay region and resource data solely for individual restoration sites. There were 44 restorations sites investigated in the Jamaica Bay Planning Region. More than 120 cultural resources, historic districts, and surveys were recorded within the study area. Of the 120 items, 42 are Automated Wreck and Obstruction Information System (AWOIS) objects, 36 are archaeological sites, and 28 are historic properties.

Three (3) historic districts were recorded within the study area: Floyd Bennett Field, Jacob Riis Park, and Fort Tilden. Eleven (11) cultural resources surveys were documented for these areas within the Jamaica Bay Planning Region. Among the surveys and most relevant to the current study are those that were carried out by the USACE in Jamaica Bay as part of the Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study (Panamerican Consultants Inc., 2003, 2004, and 2006). All documentation related to Cultural Resources are presented in Appendix H.

2.2.1.15 Social and Economic Resources

The Jamaica Bay Planning Region is predominantly in Kings and Queens Counties with Nassau County covering a small portion to the east. The population in the Jamaica Bay Planning Region is over 3.7 million people according to the 2018 population estimates (United States Census Bureau). The five (5) Jamaica Bay Marsh Islands, as well as the two (2) Jamaica Bay Perimeter sites are located in in Kings County. The Jamaica Bay Oyster Restoration site at Head of Bay is located between JFK Airport in Queens County and Inwood, New York located in Nassau County. The demographic makeup of the Jamaica Bay Planning Region can be found in Table 2-2. Median household income (in 2018 dollars) for Kings, Queens and Nassau County can also be found in Table 2-2.

Table 2-2. Jamaica Bay Planning Region Socioeconomic Data*

	Kings County	Queens County	Nassau County
White	49.5%	47.9%	74.0%
Black or African American	34.1%	20.7%	13.0%
Asian	12.7%	26.8%	10.5%
Other Races	3.7%	4.6%	2.5%
Hispanic or Latino^	19.1%	28.1%	17.2%
Owner-Occupied Homes	30%	44.5%	80.6%
Median Household Income	$52,782	$62,008	$105,744
Households Below the Poverty Level	18.9%	11.6%	5.8%

*All socioeconomic data is based on the United States Census Bureau Population Estimates Program (PEP) and the American Community Survey (ACS), which are updated annually.

^Those identifying as Hispanic or Latino may be of any race, and are included in applicable race categories.

2.2.1.16 Aesthetics and Scenic Resources

The east portion of Jamaica Bay is bordered by JFK International Airport (USACE, 2002). Jamaica Bay is enclosed by Rockaway Peninsula. The bayside of the peninsula is urbanized and bulkheaded in most areas east of the Breezy Point Cooperative, while the seaside is made up almost entirely of sandy beaches from Breezy Point to Far Rockaway.

Vistas of the remaining marsh islands and other natural areas in Gateway National Recreation Area provide for picturesque views of the bay. The Jamaica Bay Wildlife Refuge also provides a unique landscape containing a variety of native habitats including salt marsh, coastal dunes, upland fields and woods, and both fresh and brackish water ponds.

2.2.1.17 Coastal Zone Management

The Coastal Zone Management Act of 1972 (16 United States Code 1451-1464) was enacted by Congress to balance the demands for growth and development with the competing demands for protection of coastal resources. This act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. This act is regulated in New York by the New York State Department of State, Division of Coastal Resources.

Local governments can participate in the New York State Coastal Management Program through the Waterfront Revitalization of Coastal Areas and Inland Waterways Act, by preparing and adopting local waterfront revitalization programs. The programs provide more detailed implementation of the New York Coastal Management Program through use of existing broad powers such as zoning and site plan review. New York City, Piermont, Dobbs Ferry, Mamaroneck, Port Chester, and Rye have approved local waterfront revitalization programs in the HRE study area. The local program only advises on the New York State Coastal Management Program, and as such, the New York State Department of State makes the final determination on coastal zone consistency.

The Jamaica Bay Planning Region includes portions within the coastal boundary of New York. Restoration activities within the region will be reviewed by the New York State Department of State for consistency with the policies of the New York State Coastal Management Program and the applicable local New York City program, The New Waterfront Revitalization Program. All information related to the USACE coastal consistency review is presented in Appendix F.

2.2.2 Harlem River, East River and Western Long Island Sound Planning Region

The Harlem River, East River and Western Long Island Sound planning region contains sections of Manhattan and the Bronx to the north, and Brooklyn and Queens to the south (Figure 2-5). It extends east to include part of Long Island Sound and portions of Westchester and Nassau Counties, New York. The East River is an important tidal strait connecting Long Island Sound and Upper Bay. This system connects to the brackish Lower Hudson River via the Harlem River. A portion of this planning region has been

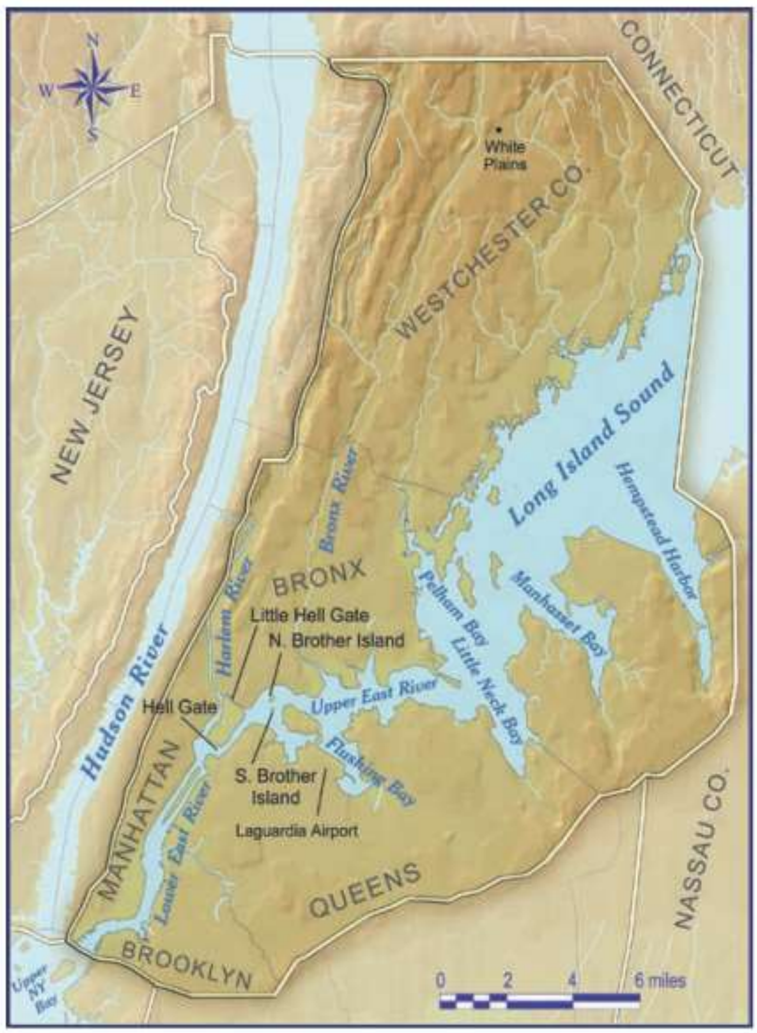


Figure 2-5. Harlem River, East River and Western Long Island Sound Planning Region

designated as the Upper East River-Long Island Sound SNWA by New York City due to the extensive marsh systems in the area, such as those in Alley Pond Park, and islands that support significant populations of nesting shorebirds (NYC, 2011).

These areas are stressed by numerous factors that threaten water quality and habitat integrity (Yozzo et al., 2001), such as shoreline development, persistent contamination, and pollutant discharges (USFWS, 1997). Like all areas in the HRE study area, the shores are heavily urbanized, lessening much of the ecological benefit provided by its beaches, decreasing transitional littoral habitat, and fragmenting important shorebird feeding and waterfowl wintering areas. Water and sediment quality are degraded due to numerous point sources, including landfills and CSOs (USACE, 2000).

Water quality in the tributaries of this planning region has been severely degraded by industrial discharge and wastewater inputs, limiting the waterways to primarily transportation-related uses. With the exception of Tibbets Brook and Little Hell Gate, the Harlem River's tributaries are completely enclosed in culverts and are often redirected several city blocks from their historic route to allow for building or road construction. In the lower East River, most shorelines have been bulkheaded and filled, creating a deep, narrow passage. Natural river features that created topographic relief, including rock reefs, mudflats and sandbars, were dredged or blasted in the late-19th century to create a continuous, navigable channel through Hell Gate (USACE, 1999).

In 2012, Hurricane Sandy caused extensive flooding, damage from wave action, beach erosion, loss of beach nesting habitat, wind damage, and water advisories in the Harlem River, East River and Western Long Island Sound Planning Region. Beach erosion and reductions in beach elevations were observed along Long Island's north shore beaches, specifically at Manursing Lake and the Edith G. Read Wildlife Sanctuary in Rye, New York. Beach erosion impacted shorebird nesting areas, leaving these sites vulnerable to repeated flooding, overwash, and high or neap flooding, as well as storm surges and wave action from future storms. Impacted species include piping plover, American oystercatcher (*Haematopus palliatus*), least tern (*Sternula antillarum*), and common tern; these species breed and nest on beaches, dunes, and overwash fans. Migratory shorebirds such as sanderling (*Calidris alba*), semipalmated sandpiper (*C. pusilla*), ruddy turnstone, black-bellied plover (*Pluvialis squatarola*), and red knot were also impacted as they are all beach foragers.

Manursing Lake in Rye, New York was the subject of a major two-part restoration project completed in 2012. Impacts to this area from Sandy were significant. Sand dunes and vegetation situated between the sound and the lake were destroyed, with only 200 feet of field and road remaining to prevent further inundation to the salt marsh and lake. A large quantity of sand and rock was pushed onto fields and access roads, and sections of the salt marsh were buried by sand and debris. Portions of the lakeshore were eroded, along with cliffs at the north end of the beach.

Wind damage was another impact from Hurricane Sandy reported within this planning region. The New York Botanical Gardens reported more than 200 trees downed. Soundview Park, located in the Bronx, New York, suffered wind damage and loss of trees in the Bronx River Forest canopy, providing an opportunity for an influx of invasive species. However, fallen tree branches created potential habitat in the Bronx River for American eels and other estuarine-dependent fish species (ALS, 2012).

Elevated fecal coliform levels were observed in the waters within the planning region following Sandy, potentially due to the discharge of untreated and partially treated sewage from nearby wastewater treatment plants. The storm surge caused the Newtown Creek Wastewater Treatment Plant to discharge 143 million gallons of untreated sewage into the creek, and the Hunts Point Wastewater Treatment Plant discharged 153.8 million gallons of diluted, untreated sewage into the East River (Kenward et al., 2013).

2.2.2.1 Geomorphology and Sediment Transport

The Harlem River, East River and Western Long Island Sound Planning Region lies with the Atlantic Coastal Plain physiographic province. Sediments vary depending upon location as a result of the complex flow patterns existing in the Long Island Sound, and overall HRE. Surficial sediments include both glacial and postglacial deposits, with the most recent glaciation period ending about 21,000 years ago. Surficial glacial deposits include till and stratified drift. Postglacial deposits consist of sand, marsh deposits, and estuarine silt.

Appendix C includes all detailed information regarding the geology, geomorphology, hydrology and sediment transport, including a Sediment Impact Assessment Model, for the Bronx River and Flushing Creek.

2.2.2.2 Water Resources

The Harlem River, East River and Western Long Island Sound Planning Region is made up of the Bronx River watershed and a portion of the Northern Long Island watershed, which drain into the East River. The East River is a tidal strait driven by the differences in tide between its two (2) ends, and tidal currents are strong throughout most of the East River with maximum current exceeding five (5) knots in the west channel between Manhattan and Roosevelt Island. Many tributaries of the East and Harlem Rivers have been channelized and redirected through culverts. The upper East River still has bays and creek mouths, but with sparse remnants of tidal wetland and upland habitats (RPA, 2003; USACE, 2004a). With the exception of Tibbets Brook and Little Hell Gate, the Harlem River tributaries are completely enclosed in culverts and are often redirected several city blocks from their historic route to allow for building or road construction. In the lower East River, most of its shorelines have been bulkheaded and filled, creating a deep, narrow passage. River obstructions that created topographic relief, like reefs, shallows, and rocks, were dredged or blasted to create a continuous, navigable channel through Hell Gate (USACE, 1999).

The Bronx River basin is a highly built up urban area within the greater New York City metropolitan area. The drainage area is approximately 56 square miles, through which the Bronx River traverses approximately 23 miles. A series of low head dams along the river form small impoundments or lakes, with the largest pools located near Tuckahoe and Bronxville in Crestwood Lake and Bronxville Lake, respectively. A total of 49 dams were identified within the planning region (Figure 2-6; Appendix C).

Due to a high percentage of impervious surfaces in the watershed, stormwater is collected primarily as runoff and, in many cases, piped directly into the river. Five (5) CSOs also discharge to the Bronx River.

Flushing Bay is an embayment of the East River consisting of approximately 6,200-acres of open water and is a moderately stratified and partially mixed estuary. Flushing Bay exchanges water with the East River which is in contact with both the Atlantic Ocean and Long Island Sound. Flushing Bay is considered a dynamic and well-mixed system. However, the mixing is significantly reduced in the inner bay. The flushing half-life varies from one (1) tidal cycle at mid-bay to six (6) tidal cycles in Flushing Creek. The flushing effectiveness was found to be 99.9 percent. The salinity of the Bay ranges from 22 to 24 parts per thousand.

Tidal range in Flushing Bay is approximately seven (7) feet. Mean tide ranges within Flushing Creek at the Northern Boulevard Bridge are reported to be 6.8 feet at mean tide and 8.0 feet at spring tide. The system receives freshwater (non-saline) flow from CSO discharges, direct rainfall runoff, and discharge through the tide gate from Meadow and Willow lakes. The bay and creek are Class I waters per the NYSDEC. The best intended usages for this classification are secondary contact recreation and fishing. The Flushing Bay and Creek watershed is highly urbanized with a dense mixture of residential, transportation, commercial, industrial and institutional development. Fourteen (14) CSOs discharge a combination of raw sewage and storm water during periods of heavy rainfall into the bay and creek.

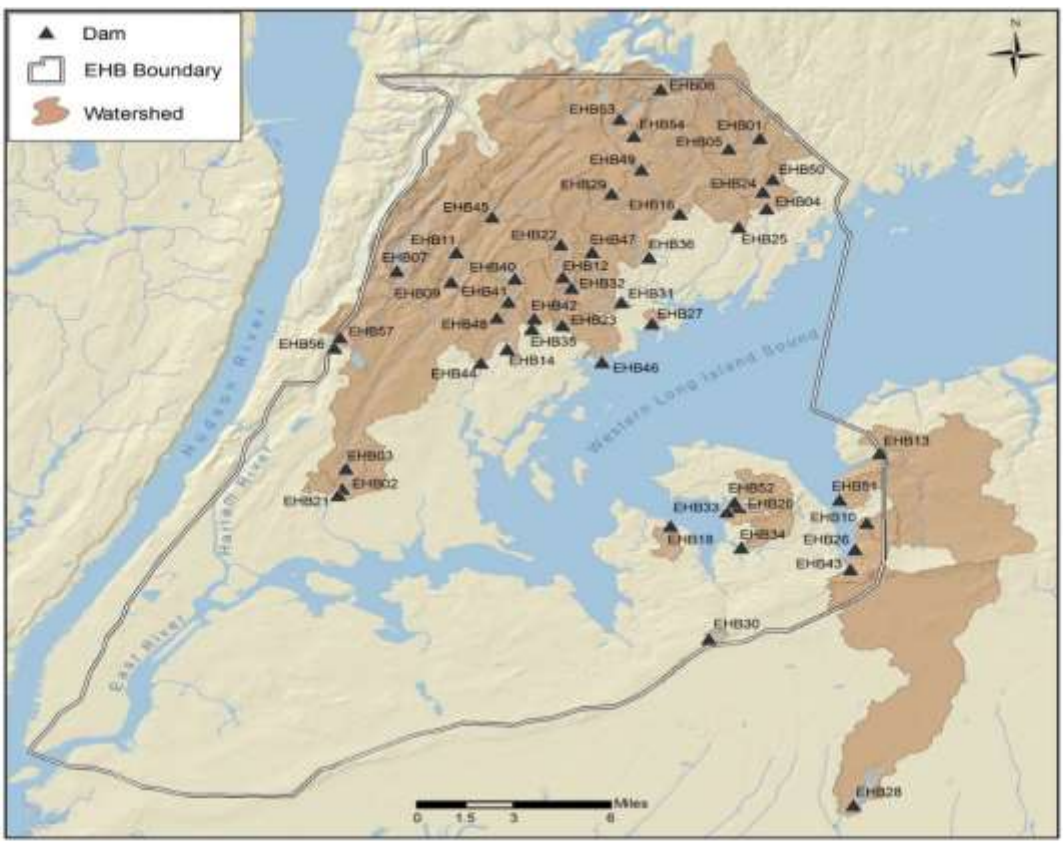


Figure 2-6. Barriers (only dams) Identified in the Harlem River, East River and Western Long Island Sound Planning Region

2.2.2.3 Vegetation

Many of the shorelines, tidal river inlets and embayments within the Harlem River, East River, Western Long Island Sound Planning Region are densely urbanized or disturbed, often with sparse remnants of tidal wetlands, sandy/gravelly beaches, and upland habitats (RPA, 2003; USACE, 2004a). Areas of open space contain maritime salt marsh, mixed hardwood woodland, grassland/meadow, mixed deciduous forests, swamps, marshes, open fields, and fresh water ponds. The numerous islands are mostly covered with grassland, shrub land or deciduous forest, or are highly urbanized.

The estuarine environment of Flushing Bay and Creek include tidal habitats, adjacent tidal marsh wetlands, and mudflats. The low marsh area is dominated by smooth cordgrass. The tidal zone from mean high tide to the spring tide elevation is dominated by spike grass and saltmeadow cordgrass. The invasive common reed is the dominant species in much of these marsh areas. Inter-tidal emergent marshlands persist along the western bank of Flushing Creek and are dominated by invasive species (Appendix D-4).

The Bronx River basin includes estuarine and palustrine wetlands. Estuarine wetlands are located in the southern portion of the watershed. Limited to the tidal portion of the watershed, these wetlands are dominated with native salt grasses such as smooth cordgrass, saltmeadow cordgrass, and spike grass (*Distichlis spicata*), as well as invasive common reed. Soundview Park located at the delta of the Bronx River, is one of the few remaining estuarine, salt marsh wetlands. Palustrine wetlands are located throughout the Bronx River basin and include emergent, scrub-shrub, and forested wetlands (Appendix D-5).

2.2.2.4 Finfish

Complex tidal flow patterns prevail in this region. The tidal influences in the East River from Upper Bay and Long Island Sound interact with the generally southern movement of water from the Hudson River through the Harlem River (USACE 1999). The result is a region influenced by the tidal patterns of three (3) estuarine bodies that serve as a significant route for migratory fishes (RPA 2003, USACE 2004a). The bays are also productive nurseries and feeding areas for marine shellfish and finfish, including striped bass, scup, bluefish, Atlantic silverside, Atlantic menhaden, winter flounder, and blackfish, and contain important hard clam beds (USFWS, 1997). However, the size of many of these fish populations, such as American eel, winter flounder, and especially the Atlantic and shortnose sturgeons, are fractions of their historic population levels, likely due to historic harvest, impoundments, and/or habitat degradation within this planning region as well as the entire HRE study area (Mayo et al. 2006).

The fisheries resources of Flushing Bay and creek are limited as confirmed during 2012 and 2013 surveys conducted by NYCDEP (Appendix F). The species diversity and abundance of fish species was limited compared to larger and more complex East River and Hudson River estuaries. During the fall and spring 2013 surveys, 477 finfish representing 12 different species and 31 blue crabs were collected including mummichog (62.5 percent), Atlantic silverside (14.9 percent), gizzard shad (*Dorosoma cepedianum*) (10.7 percent) and Atlantic menhaden (8.6 percent).

2.2.2.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from NOAA NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate EFH for all managed species, to minimize to the extent practicable adverse effects on EFH, and to identify other actions to encourage the conservation and enhancement of EFH. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (NOAA, 2004). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining “waters” to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties: “substrate” to include sediment, hard bottom, and structures underlying the water; areas used for “spawning, breeding, feeding, and growth to maturity” to cover a species’ full life cycle; “prey species” as being a food source for one or more designated fish species (NOAA, 2004). NOAA’s Guide to EFH Designations in the Northeastern United States provides the species and life stages with EFH. Table 2-2 lists the EFH designations in the Harlem River, East River and Western Long Island Sound Planning Region. The planning region falls within three (3) 10-minute grids (NOAA, 2016). EFH is discussed further in Appendix F.

Table 2-3. Summary of EFH Designation for Harlem River, East River and Western Long Island Sound Planning Region

Managed Species	Eggs	Larvae	Juveniles	Adults
Atlantic cod (*Gadus morhua)*			X	X
Pollock (*Pollachius virens*)			X	X
Red hake (*Urophycis chuss*)		X	X	X
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X
Windowpane flounder (*Scophthalmus aquosus*)	X	X	X	X
Atlantic sea herring (*Clupea harengus*)		X	X	X
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triacanthus*)		X	X	X
Atlantic mackerel (*Scomber scombrus*)			X	X
Summer flounder (*Paralichthys dentatus*)		X	X	X
Scup (*Stenotomus chrysops*)	X	X	X	X
Black sea bass (*Centropristis striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Sand tiger shark (*Carcharhinus taurus*)		X		
Dusky shark (*Carcharhinus obscurus*)		X		
Sandbar shark (*Carcharhinus plumbeus*)		X	X	X

Source: NOAA, 2016.
10’x10’ square coordinates: 40° 50.0’N, 73° 50.0’W, 40° 40.0’N, 74° 00.0’W
40° 50.0’N, 73° 40.0’W, 40° 40.0’N, 73° 50.0’W
41° 00.0’N, 73° 40.0’W, 40° 50.0’N, 73° 50.0’W

2.2.2.6 Shellfish and Benthic Resources

Within the Harlem River, East River and Western Long Island Sound Planning Region, Little Neck Bay, Manhasset Bay, and Hempstead Bay are productive nurseries and feeding areas for marine shellfish and finfish. Concentrations of northern quahogs (hard clams) and soft-shelled clams (*Mya arenaria*) are locally important (USFWS, 1997).

Benthic macroinvertebrate community assessment in the Bronx River indicates moderately impacted water quality conditions (Bode et al., 1999, 2003). The benthic biological communities in and around Flushing Bay are subject to significant anthropogenic influences. These influences come in the form of a variety of pollutants with some originating locally while others are transported in from various drainage pipes or from drainage into Flushing Creek. The NYCDEP surveyed benthic communities of the New York-New Jersey Harbor and concluded that the benthic habitat of Flushing Bay was grossly degraded and was not able to support the species typically found in local healthy estuarine bottom sediments (NYCDEP, 2000). NYCDEP further confirmed the benthic communities in fall 2012 and spring 2013 between the intertidal and subtidal habitats and revealed the invertebrate communities were dominated by common, widely-distributed, pollution-tolerant marine annelids (Appendix F).

2.2.2.7 Wildlife

Several islands in this region support large populations of wading birds, most notably South Brother Island, which was estimated to support almost 500 breeding pairs of wading birds and over 300 cormorant (*Phalacrocoracidae*) nests (Bernick, 2006; Blanchard et al., 2001). Further east into Long Island Sound, the southern shore contains some of the most significant waterfowl wintering areas in the HRE, Little Neck Bay, Manhasset Bay, and Hempstead Harbor (USACE, 2000; USACE, 2004a). The wetlands along the mainland in this planning region provide important nesting habitat for several species of special emphasis, including green-backed heron (*Butorides striata*), yellow-crowned night-heron (*Nyctanassa violacea*), American bittern (*Botaurus lentiginosus*), Canada goose (*Branta canadensis*), American black duck (*Anas rubripes*), and clapper rail (*Rallus crepitans*). However, displacement of herons and destruction of heron nesting habitat by cormorants or human disturbances in the form of intrusions into bird nesting area is a major threat to the herons in this area (USFWS, 1997).

2.2.2.8 Rare, Threatened, and Endangered Species

The USFWS, NMFS, and NYSDEC agencies were consulted regarding the documentation of rare, threatened, and endangered species and species of special concern within the planning region. Correspondence with these agencies is located in Appendix F.

USFWS

According to the USFWS (USFWS, 1997), listed species in the region include:

- Piping plover – federally listed threatened;
- Northern diamondback terrapin (*Maclemys t. terrapin*) – federal species of concern;
- Least tern – state-listed endangered;
- Common loon (*Gavia imme*r) – state-listed special concern; and
- Common barn owl – state-listed special concern.

NMFS

Listed by the NOAA NMFS, four (4) species of ESA sea turtles have been seasonally present in the East River and adjacent bays:

- Threatened Northwest Atlantic Ocean DPS of loggerhead;
- Threatened North Atlantic DPS of green;
- Endangered Kemp's ridley; and
- Endangered leatherback sea turtle.

Also two (2) protected fish species, Atlantic sturgeon and shortnose sturgeons, were identified by NMFS as being potentially present in the East River and adjacent bays (Appendix F).

New York Natural Heritage Program

In correspondence with the New York Natural Heritage Program, the agencies indicated they have no records of threatened species within the planning region where restoration activities would be likely to occur.

2.2.2.9 Land Use

The Harlem River, East River and Western Long Island Sound Planning Region is the most densely populated of the eight (8) HRE planning regions. Shorelines along the Harlem and East rivers are lined with urban residential, commercial, and industrial development. Commercial ferry terminals, marinas, and parkland are also found along the shorelines of this planning region. The waterways are used for commercial navigation as well as recreational boating, fishing, and water/jet skiing. Public and private beaches, found in the Upper East River and Western Long Island Sound, are open for bathing except when total coliform concentrations exceed water quality criteria. This planning region receives treated effluent from six (6) sewage treatment plants, and water is withdrawn from the East River by four (4) power plants as well as industrial/commercial interests (USACE, 2004a).

2.2.2.10 Hazardous, Toxic, and Radioactive Waste

The majority of the Harlem River, East River and Western Long Island Sound Planning Region is highly urbanized. Water quality in the tributaries of this planning region has been severely degraded by industrial and CSO inputs, limiting the waterways to primarily transportation related uses. Historic inputs of toxic substances have degraded water quality and contaminated bottom sediments of freshwater tributaries. The primary contaminants of concern in the planning region are heavy metals, PCBs, and oil by-products. In addition, sewage and storm water discharges have degraded water quality to the extent that portions of the Western Long Island Sound become hypoxic or anoxic at certain times of the year. Anoxic and hypoxic events in the planning region are believed to occur from sewage effluent that, when discharged into the waters, causes algal blooms and subsequent oxygen depletion due to bacterial decomposition. Leachate, containing toxic substances, particularly ammonia, from the Pelham Bay landfill has also contributed to historic water quality degradation in the planning region (USACE, 2004a).

Water quality throughout Flushing Bay and Creek typically exhibit low levels of dissolved oxygen and anoxia, and high levels of bio-chemical oxygen demand. Sediments are organics-rich with a low level of benthic community diversity. Exposed intertidal mudflats generate hydrogen sulfide gas. Elevated concentrations of metals have also been detected in Flushing Bay and Creek, which likely result from the long term presence of industrial activities along streambanks, and other non-point sources of pollution such as CSOs. NYCDEP investments in CSO abatement and Long Term Control Plan since 2007 have improved water quality within this basin (Appendix D-4).

Water quality problems in the Bronx River are largely caused by infringements in the riparian corridor, loss of wetlands, reduced base flow, sedimentation, channel aggradation, floatable garbage, diffuse waterfowl and pet waste, stream bank erosion, and runoff from impervious surfaces and other point and non-point sources of pollution, including CSOs (USACE, 1999). Throughout the river’s 21.5 mile-long freshwater section (including Westchester), storm water from parking lots, sidewalks, roads and roofs flow directly into the Bronx River through more than 100 discharge pipes (USACE, 2010). Water quality in the estuary section of the river is influenced by upstream and tidal waters from the Hudson River estuary, New York Harbor and Long Island Sound. Low dissolved oxygen levels are of special concern in the Bronx River, where four (4) CSOs are located. In the Bronx, most storm water, which is normally directed to water treatment plants, can during heavy rains overload the carrying capacity of the system. When this happens, the combined storm water and sewage flow is directed to the river through CSOs, discharging raw human waste and many other untreated pollutants (USACE, 2010). Additional information on the presence of HTRW within the planning region is presented in Appendix G.

2.2.2.11 Noise

Ambient noise levels within the Harlem River, East River, Long Island Sound Planning Region would likely be in the mid-to high-range in the highly developed southwestern portion, and in the low-to mid-range as the planning region moves north and west away from the city. The primary sources of noise in the planning region include air traffic from LaGuardia Airport, Interstate and local automobile traffic, and boat traffic in Long Island Sound and the East River. Receptors in the planning region include residential areas and wildlife habitats. Noise criteria and the descriptors used to evaluate project noise will depend on the type of land use in the vicinity of the proposed project areas.

2.2.2.12 Navigation

For about 2.5 miles upstream from its confluence with the East River, the Bronx River is a federally designated navigable waterway and is used frequently by commercial barges. This channel is maintained from the East River to East 172nd Street, a distance of approximately 2.6 navigable miles. It is a shallow draft low-usage channel which had commercial tonnage of approximately 269,000 tons in 2006 and a 10-year average of about 133,500 tons per year. It was last dredged in 1991, at which time 64,158 cubic yards of sediment was removed and placed at the Mud Dump Site or Historic Area Remediation Site in the New York Bight. The maintained navigation channel, which was originally authorized by the River and Harbors Act of 1913, is 10 feet deep and 100 feet wide and runs from the East River to East 172nd Street at the downstream end of the River.

A federal navigation channel spans Flushing Bay and Flushing Creek with a designed channel depth of 15 feet mean low water.

2.2.2.13 Recreation

The Harlem River, East River, Long Island Sound Planning Region contains 99 public access points with many being located along the Lower East River in Manhattan and Queens. Elsewhere in the planning region a significant amount of public access points are spread along the Harlem River, the Upper East River (Flushing and Bowery Bays), and along the Western Long Island Sound (Pelham and Little Neck Bays). Beaches in Nassau County and Westchester County also offer water access to the public for recreation. Rye Playland Beach is a beach that is part of an amusement park. Glen Island Park in New Rochelle is the second most widely used park in the Westchester County Parks system and offers a swimming beach, boat launch, picnic areas, and restaurants. Orchard Beach is a public area for swimming and boating in Pelham Bay Park, New York (Westchester County Department of Parks and Recreation, 2012; NYC Parks, 2012). In Nassau County, Bay Park offers boating and recreation activities to the public (Nassau County Parks Department, 2012).

Fishing also occurs from vessels and the shorelines of the Harlem River, East River and Western Long Island Sound Planning Region. In Western Long Island, bays such as Little Neck, Flushing, Manhasset, and Hempstead bays are important recreational fishing areas (USACE, 2000). Species sought include striped bass, bluefish, weakfish, scup, black sea bass, tautog, summer flounder and winter flounder.

2.2.2.14 Cultural Resources

The Harlem River, East River and Western Long Island Sound Planning Region has a long history of occupation, first by Native American groups from as early as 12,000 before present until the arrival of European explorers in the fifteenth century. Early colonial settlements appear in the 1600s which evolved slowly from agricultural to industrial in character followed by urbanization and development of suburbs in the last century. Potential for prehistoric and historic archaeological sites exists throughout the region. Archaeological sites and above-ground historic properties can be found in upland, lowland, marsh, and submerged environments. Architectural and archaeological investigations are required to determine the presence or absence of such resources in most of the study area due to lack of existing data.

In 2014 the USACE completed a cultural resources survey titled *Cultural Resources Overview of the Hudson-Raritan Estuary Comprehensive Restoration Plan* (Harris et al., 2014) that aimed at inventorying all existing cultural resources data relevant to the candidate restoration sites in the HRE study. General background information about the region was collected to provide a historical and cultural context. Cultural resources data was not compiled for the entire region but for each individual restoration site and a one-mile buffer area that was applied to the site for the survey. There were 48 restorations sites investigated in the Harlem River, East River and Western Long Island Sound Planning Region.

The Harlem River, East River and Western Long Island Sound Planning Region survey area contains more than 1,710 cultural resources, historic districts, or surveys documented, 625 of which are historic properties. The majority of these resources are located in the densely populated portions of Manhattan and Brooklyn. Many additional resources are found in Kings, Queens, and Bronx counties of the city and along the Bronx River Parkway of Westchester County. Similarly distributed are the 46 historic districts in the survey area. The survey found 238 recorded AWOIS objects, mainly in the East River, Western Long Island Sound, and Eastchester Bay near Hart and City islands. A total of 201 recorded archaeological sites are found throughout the survey area, but more densely along the shores and inlets of East River, Western Long Island Sound, and Eastchester Bay; especially around the Pelham Bay area. The 61 cultural resources surveys in the survey area are located mainly in the areas of Manhattan and Brooklyn along the East River and near Pelham Manor in Westchester County. The Stone Mill Dam HRE restoration site is located within two National Historic Landmarks (NHL): The New York Botanical Gardens NHL and the Lorillard Snuff Mill NHL.

In the south portion of this planning region, in Flushing, Queens, numerous cultural resources can be found with many still in operation today. Flushing is host to world-class sporting events. Citi Field is home to the New York Mets, and the United States Tennis Association National Tennis Center is home to the United States Open tennis tournament. The Queens Botanical Garden is located on Main Street and has been in operation continuously since its opening as an exhibit at the 1939 World's Fair. Other attractions and remnants from the World's Fairs in Flushing Meadows-Corona Park include the Queens Museum, featuring a scale model of New York City (the largest architectural model ever built), the New York Hall of Science, and the Queens Zoo. In addition to the Unisphere, the park contains a variety of sculptures and markers from the fairs. Appendix H includes additional documentation of cultural resources within this planning region.

2.2.2.15 Social and Economic Resources

The Harlem River, East River and Western Long Island Sound Planning Region is in Westchester, Bronx, New York, Kings, Queens and Nassau counties. Within this planning region, one (1) recommended site is found in Queens County, three (3) recommended sites are found in Bronx County, and two (2) are found in Westchester County. The population of these counties is over 4.6 million people according to the 2010 Census (United States Census Bureau, 2010). The demographic makeup of these counties can be found in Table 2-4. Median household income (in 2018 dollars) for Queens, Bronx and Westchester County can also be found in Table 2-4.

Table 2-4. Harlem River, East River and Western Long Island Sound Planning Region Planning Region Socioeconomic Data*

	Queens County	Bronx County	Westchester County
White	47.9%	44.9%	73.4%
Black or African American	20.7%	43.6%	16.6%
Asian	26.8%	4.5%	6.4%
Other Races	4.6%	7.0%	3.6%
Hispanic or Latino^	28.1%	56.4%	25.1%
Owner-Occupied Homes	44.5%	19.7%	61.5%
Median Household Income	$62,008	$36,593	$89,968
Households Below the Poverty Level	11.6%	27.3%	8.3%

*All socioeconomic data is based on the United States Census Bureau, Population Estimates Program (PEP) and the American Community Survey (ACS), which are updated annually (2017).

^Those identifying as Hispanic or Latino may be of any race, and are included in applicable race categories.

Downtown Flushing is the largest urban center in the borough of Queens, the busiest shopping district in Queens, and a financial center that is corporate home to 47 financial institutions. In 2003, the City of New York designated downtown Flushing as a regional economic center, and has unveiled a $2 billion redevelopment plan that features a revitalized waterfront, high quality mixed-use development projects, street enhancements, open and green spaces, new transportation links and parking strategies. The historic neighborhood core is the largest urban center in the borough, and it is the wealthiest and the largest Chinatown in New York City, surpassing even Manhattan’s Chinatown.

Low-income and communities of color along the Bronx River's downstream reaches have received the fewest resources to reclaim, restore and redevelop what is the most polluted and ecologically abused portions of Bronx River and its watershed (Bronx River Alliance, 2006). Based upon the fact that the proposed projects focus on ecological restoration, disproportionately high and adverse human health or environmental effects on minority and low-income populations are not anticipated from the construction of these projects. Rather, the recommended projects will enhance the quality of life for communities located in the planning region by: linking disparate communities in the Bronx and Westchester Counties through shared resources; increasing availability of local water resources; improving water quality; protecting and restoring native habitats; strengthening local economies; and expanding recreation opportunities.

As discussed in the Cultural Resources section, Flushing, Queens is host to world-class sporting events such as New York Mets major league baseball at Citi Field and the National Tennis Center United States Open tennis tournament. Other local tourist attractions in the south portion of the planning region include Queens Botanical Garden, remnants from the 1939 and 1964 World's Fairs, the New York Hall of Science, and the Queens Zoo.

2.2.2.16 Aesthetics and Scenic Resources

The shorelines along the Harlem and East rivers are lined with urban residential, commercial, and industrial development. Commercial ferry terminals, marinas, and parkland are also found along the shorelines of this planning region. Public and private beaches can be found in the Upper East River and Western Long Island Sound. Pelham, Little Neck, Manhasset, and Hempstead bays are regionally distinct, pairing rocky outcroppings characteristic of the New England coast with broad intertidal mudflats.

The planning region contains many access points, parks and esplanades that allow the public to view the water and skylines. The Manhattan Waterfront Greenway is a 32-mile route that circumnavigates Manhattan Island and builds on recent efforts to transform a long-neglected waterfront into a green attraction for recreational and commuting use. Construction on the South Bronx Greenway commenced in November 2006 and encompasses 1.5 miles of waterfront greenway, 8.5 miles of inland green streets, and nearly 12 acres of new waterfront open space throughout Hunts Point and Port Morris. These greenways will link existing parks through a network of waterfront and on-street routes which will provide the community with recreational opportunities such as walking and bike paths contributing to public health (New York City Department of City Planning, 2012; New York City Economic Development Corporation, 2012).

2.2.2.17 Coastal Zone Management

The Coastal Zone Management Act of 1972 (16 United States Code 1451-1464) was enacted by Congress to balance the demands for growth and development with the competing demands for protection of coastal resources. This act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. This act is regulated in New York by the New York State Department of State, Division of Coastal Resources and in New Jersey by the New Jersey Department of Environmental Protection (NJDEP).

Local governments can participate in the New York Coastal Management Program through the Waterfront Revitalization of Coastal Areas and Inland Waterways Act, by preparing and adopting local waterfront revitalization programs. The programs provide more detailed implementation of the New York Coastal Management Program through use of existing broad powers such as zoning and site plan review. New York City, Piermont, Dobbs Ferry, Mamaroneck, Port Chester, and Rye have approved local waterfront revitalization programs in the HRE Study Area. The local program only advises on the New York State Coastal Management Program, and as such, the New York State Department of State makes the final determination on coastal zone consistency.

The Harlem River, East River and Western Long Island Sound Planning Region includes portions within the coastal boundary of New York. Restoration activities within the region will be reviewed by the New York State Department of State for consistency with the policies of the New York State Coastal Management Program and the applicable local New York City program, The New Waterfront Revitalization Program. All information related to the USACE coastal consistency review is presented in Appendix F.

2.2.3 Newark Bay, Hackensack River and Passaic River Planning Region

The Hackensack and Passaic River basins create the upper boundary of this HRE planning region, with the lower boundary encompassing Newark Bay (Figure 2-7). This watershed is indirectly connected to Upper Bay and Lower Bay through Kill Van Kull and Arthur Kill, respectively. The Hackensack and Passaic Rivers drain portions of the densely populated Bergen, Passaic, Hudson, Essex, and Union Counties, New Jersey, including the cities of Newark and Paterson. A small portion of Rockland County, New York is also included in this planning region.

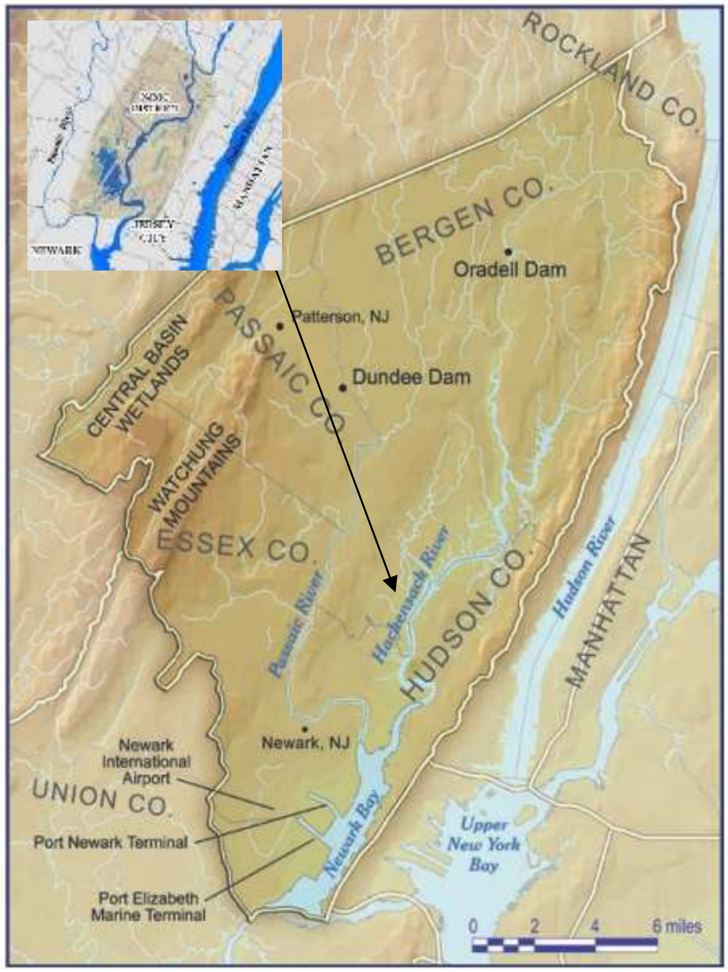


Figure 2-7. Newark Bay, Hackensack River and Passaic River Planning Region

Two (2) large habitat complexes of regional importance and ecological value in this region are the New Jersey Hackensack Meadowlands and a portion of the Central Basin Wetlands. Within the Hackensack Meadowlands District exists the largest remaining brackish wetland complex in the HRE study area, measuring approximately 8,400 acres (USACE, 2004b) (Figure 2-7). Originally a large, 21,000-acre marshland complex, the Meadowlands have diverse habitat types and over 100 species of nesting birds, fish and shellfish, many of which are state- or federally-protected (RPA, 2003). Although degraded, the Meadowlands and surrounding areas in this region represent significant open spaces that continue to provide ecosystem functions, including flood storage and fish/wildlife habitat, and offer a variety of potential restoration opportunities (USFWS, 1997).

Development in this region has contributed to extensive habitat losses. Historic wetland losses and hydrologic modifications have transformed the Hackensack Meadowlands from a rich combination of freshwater and saltwater marshland into a less diverse, brackish tidal marsh with a 60 percent loss in area (RPA, 2003; USACE, 2004b). Even at this reduced size, the

Meadowlands still represents, after Jamaica Bay, the largest remaining tracts of habitat in the HRE study area.

In the fall of 2012, the Newark Bay, Hackensack River and Passaic River Planning Region sustained damage from Hurricane Sandy leading to saltwater intrusion, debris, and water use advisories. In the Hackensack Meadowlands, a series of naturally occurring and man-made earthen berms prevent tidal waters from entering developed areas and freshwater habitats in the surrounding townships. Most of these berms are at an elevation of less than six (6) feet above sea level, and were not able to prevent Sandy's nine-foot storm surge from reaching developed lands and freshwater habitats (MERI, 2013). Some areas along the Hackensack River experienced episodic fish kills potentially due to increases in salinity, with reports of numerous carp washed up along shorelines. Data collected by the Meadowlands Environmental Research Institute (MERI) showed a sharp increase in salinity in various areas of the Meadowlands as the storm hit (MERI, 2013). Kearny Marsh, an important breeding site for least bittern (*Ixobrychus exilis*) was affected by floating islands of common reed stands pushed inland by the storm surge.

Following Hurricane Sandy, sewage releases prompted state officials to issue water use advisories for several surface waters within the planning region, including the Passaic and Hackensack Rivers, and Newark Bay. Damage to the Passaic Valley Sewerage Commission (PVSC) treatment plant in Newark led to the discharge of 840 million gallons of untreated sewage into Newark Bay in the first few days following Hurricane Sandy, and approximately three (3) billion gallons of partially treated wastewater was released over the next few weeks following the restoration of secondary wastewater treatment (Kenward, et al. 2013). In 2013, PVSC installed a "muscle wall" barricade system around key infrastructure, providing temporary protection against floodwaters. PVSC has several mitigation projects on the horizon including a more permanent floodwall, equipment upgrades, and enhanced emergency response systems (PVSC, 2014). Other natural areas of this planning region sustained little to no impacts during Hurricane Sandy (ALS, 2012).

The level of contamination in this region has been of great concern to stakeholders for decades. Many of these contaminants pose risks to human and ecological health. Several USEPA Superfund sites exist within this planning region, including the 17-mile tidal portion of the Lower Passaic River (Figure 2-8), Newark Bay, and portions of the Hackensack River

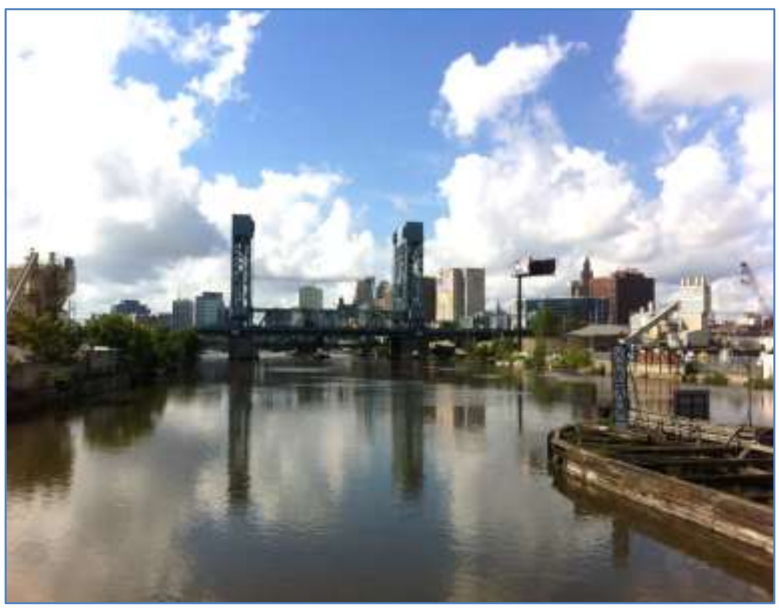


Figure 2-8. Photo of the Lower Passaic River (Newark Skyline in Background). (Source AECOM)

The Lower Passaic River was designated a location for Urban Waters Federal Partnership (UWFP) in February 2013, a program coordinated by the White House Domestic Policy

Council to improve our nation's water systems and promote their economic, environmental, and social benefits (www.urbanwaters.gov). USEPA and USACE serve as co-leads with the intent to reconnect overburdened or economically distressed urban communities with their waterways by improving coordination among Federal agencies and collaborating with community led revitalization efforts. Specifically, the UWFP program will enhance the coordination of USEPA's Superfund program, USACE's Ecosystem Restoration and Flood Risk Management/Coastal Restoration Programs, other Federal and state programs, as well as work with the City of Newark, other interested municipalities, Ironbound Community Corporation (ICC), and other local non-governmental organizations (NGOs).

2.2.3.1 Geomorphology and Sediment Transport

The Newark Bay, Hackensack River and Passaic River Planning Region lies on the Piedmont Lowlands physiographic province. The Piedmont Lowlands are a moderately low-lying area of wide valleys and small hills. The soils in the Piedmont are very fertile and arable, combined with easily developable terrain, makes the area suitable for agricultural and industrial needs. The region is also characterized by ridges of igneous rock and traprock interrupting the rolling sedimentary sandstones, shales, and deep red soils (USFWS, 1997). Newark Bay sediments tend to be a fine-grained combination of silts, clays, and sands, reflecting the deposition of sediments from river input at the northern end and tidal input at the southern end (USACE, 1999).

The Passaic River, along with the Hackensack River and Newark Bay, is one of the most complex estuarine systems in the United States. The hydrodynamics of the Passaic-Hackensack-Newark Bay system is predominantly controlled by three (3) forcing mechanisms, freshwater flows (buoyancy sources), tides, and winds. Two (2) major sources of freshwater inflows, the Passaic and Hackensack Rivers, contribute to the salinity gradients in the system. Flow over the Dundee Dam is the primary source of freshwater to the Lower Passaic River, with a long-term average flow of approximately 1,100 cubic feet per second (cfs). The mouth of the river at Newark Bay experiences a semidiurnal (i.e. twice daily) tidal fluctuation in surface elevation, with a range of approximately five (5) feet. This tidal elevation influence may propagate upstream as far as the physical barrier at Dundee Dam under low freshwater (Upper Passaic River) flow conditions.

Salinity in Newark Bay, especially near the bottom of the water column, is high relative to the freshwater inflow to the Lower Passaic River at Dundee Dam, but it varies in response to freshwater flow and wind (Chant and Wilson, 2004; Chant, 2005). During low flow periods, the salinity in Newark Bay is over 20 parts per thousand (ppt), whereas the salinities at the mouth of the Lower Passaic River are typically five (5) ppt lower than Newark Bay. The salinity drops significantly as the freshwater river flow increases, i.e. during periods of higher flow.

Within the Lower Passaic River, the density contrast between the freshwater river flow and more saline water in Newark Bay interacts with the tidal input to form a partially stratified estuary. Denser saline water from Newark Bay extends upstream underneath the less dense freshwater surface layer. The tidally-averaged velocity profile near River Mile (RM) 5 showed a clear residual upstream velocity near the bottom and a strong downstream velocity near the top, which is characteristic of estuarine circulation. Relatively strong tidal currents generate vertical turbulent mixing that partially mixes the water column along the interface between the two (2) layers. The upstream edge of the interface is called the salt front.

The position of the salt front within the Lower Passaic River is controlled by the force balance among riverine discharge, tidal flow, the magnitude of the salinity difference between Upper Passaic River water and Newark Bay water, turbulent mixing of the opposing momentum in the surface and bottom density layers, and frictional effects of the riverbed. For example, under low-flow conditions of approximately 35 cfs, measured salinity and turbidity data place the salt front between RM10 and RM12. Under high-flow conditions of approximately 11,654 cfs, measured data found the salt front pushed well downstream into Newark Bay. Under typical flow conditions, the salt front is usually located between RM2 and RM10, and moves back and forth about four (4) miles each tidal cycle (twice a day).

Since the magnitude of estuarine circulation in the Lower Passaic River is controlled, in part, by the salinity contrast between freshwater inflow at Dundee Dam and salinity at the head of Newark Bay, a complete understanding of the hydrodynamics requires knowledge of the physical processes and morphological features controlling salinity in Newark Bay. Thus, the spatial scale of the hydrodynamic characterization must encompass the Lower Passaic River, the Hackensack River, and Newark Bay. This combination forms one of the most complex estuarine systems in the United States. The confluence of the Passaic River and Hackensack River is located at the northern end of Newark Bay. Newark Bay is connected at its southern end to Upper New York Bay and Raritan Bay through two (2) narrow tidal straits, the Kill van Kull and Arthur Kill, respectively. Relatively deep (35 to 50 feet) shipping channels run along the centerlines of both Kills and extend northward along the western side of Newark Bay, supporting shipping at Port Elizabeth and Port Newark. These shipping channels play an important role in transporting saline water from the coastal ocean into the Passaic River-Hackensack River-Newark Bay system.

The estuarine circulation pattern described above affects the resuspension, deposition and transport of solids in the Lower Passaic River. The stratification and the tidal currents work together to move sediment and associated contaminants both upstream and downstream within the estuary, transporting contaminants multiple miles downstream and upstream of their original discharge points while tending to smooth out contaminant concentration gradients along the Lower Passaic River. While the net transport of sediment at any given time is highly dependent on the balance of fresh water and tidal flows, over the long-term, there is a net transport of sediment from the Lower Passaic River to Newark Bay (Appendix C).

2.2.3.2 Water Resources

The Hackensack and Passaic Rivers receive water from tributaries in Bergen, Passaic, Hudson, Essex, and Union Counties and discharge to Newark Bay. The watershed is indirectly connected to Upper New York Bay and Lower New York Bay through Kill Van Kull and Arthur Kill, respectively.

A significant portion of the low-lying areas around Newark Bay and the Hackensack and Passaic Rivers are within the 100-year floodplain. Most of the Hackensack Meadowlands are designated floodplains. Near the Watchung Mountains, the Central Basin Wetlands support large swamp areas and forested wetlands that are fed by several important tributaries. Newark Bay's shorelines and river channels have been greatly modified by bulkheads and riprap. Unfortunately, the hydrology of open river areas was altered by numerous flood risk management structures, dams and debris, which reduce connectivity and freshwater flow to Newark Bay, and block upstream passage by fishes (USFWS, 1997).

Many streams feeding into the Hackensack and Passaic Rivers have been converted to storm sewer drainages. Surrounding wetlands were filled or ditched in order to control mosquito populations. These actions have resulted in water quality degradation and have altered native floral and faunal assemblages (USACE, 2004b, Yozzo et al., 2001). Shorelines and river channels have been greatly modified by bulkheads and riprap. Dams and debris reduce connectivity and freshwater flow to Newark Bay and block upstream and downstream fish passage. The Lower Passaic River and its shorelines have been subject to continued degradation from historical industrial and commercial activities, along with urban development, resulting in significant losses of floodplains and valuable aquatic and terrestrial habitat areas. In the lower seven (7) miles of the Lower Passaic River, the riverbanks consisted of 70 to 80 percent bulkhead and riprap, 10 to 30 percent riprap or bulkhead with overhanging vegetation and five (5) percent aquatic vegetation (Windward, 2011).

2.2.3.3 Vegetation

Habitat complexes of regional importance and ecological value in the Newark Bay, Hackensack River and Passaic River Planning Region are the Hackensack Meadowlands, a portion of the Central Basin Wetlands, and a portion of Preakness Mountain.

Over 400 vascular plants have been historically reported from the Hackensack Meadowlands including New Jersey rare species: floating marsh-pennywort (*Hydrocotyle ranunculoides*), wild calla (*Calla palustris*), rough cotton-grass (*Eriophorum tenellum*), bunchberry (*Cornus canadensis*), and crested yellow orchid (*Platanthera cristata*). Presently the floral assemblage is much less diverse with the non-native common reed dominate. Uplands within the Hackensack Meadowlands are mostly artificial (including closed landfills) and include grassland, shrubland, and early successional forest. Small undeveloped, uplands are also scattered around the edge of the Meadowlands (Kiviat and MacDonald, 2004; Sipple, 1971).

The Central Basin Wetlands, also referred to the Passaic Meadows, is a remnant of Lake Passaic, an extinct glacial lake (Salisbury and Kümmel, 1895). This 34-square mile wetland area is one of the largest freshwater wetland complexes in the region (USFWS, 1997). Specific wetlands are the Great Swamp, which includes swamp woodland, hardwood ridges, cattail marsh, and grassland; Troy Meadows, half of which is a large emergent marsh composed of cattails (*Typha*), common reed, and sedges (*Carex* spp.) and the remainder a mix of forested and scrub-shrub swamps, ephemeral ponds, floodplain, and grasslands; and Great Piece Meadows, a mainly forested wetland with some scrub-shrub and emergent marsh areas.

Preakness Mountain is located west of Paterson, New Jersey on the border of the Bergen and Passaic counties. Preakness Mountain is vegetated with open woodland and dense forest. Six (6) upland ecological communities have been identified and mapped, including talus slope community, traprock glade/outcrop community, hickory-ash-red cedar woodland, dry-mesic inland mixed oak forest, mesic hemlock-hardwood forest, and successional old field. The traprock glade/outcrop community is a globally imperiled community type (USFWS, 1997).

Surveys conducted in 2010 as part of the Remedial Investigation for the Lower Passaic River found plant communities were less diverse than other areas and mostly composed of scrub-shrub vegetation, with individual or small stands of trees occasionally present. Sites with emergent vegetation were located primarily below RM3.5 and were associated with intertidal mudflats and occupied by smooth cordgrass or common reed. Areas of mixed forest and urban green spaces and parks became more prevalent upriver of RM4. No extant submerged aquatic vegetation has been documented for the Lower Passaic River (Earth Tech, 2004) and only remnants of the formerly extensive emergent tidal marsh that was contiguous with the Meadowlands complex exist (USEPA, 2014).

Vegetation communities that were identified at the Lower Passaic and Hackensack River restoration sites are found in Appendices D-6 and D-7.

2.2.3.4 Finfish

Lower reaches of the Passaic and Hackensack Rivers provide habitat for marine and estuarine fish and invertebrates, while farther upstream, the rivers support a mix of estuarine and freshwater species (USACE 2004b). Newark Bay's open water is used by many fish as nursery habitat, although its shorelines and river channels have been greatly modified by bulkheads and riprap. The bay supports some 50 species of finfish including bay anchovy, juvenile red hake, weakfish, alewife, striped bass, and blueback herring (Woodhead *et al.*, 1992; Berg and Levinton, 1985). Urbanization and damming of the rivers upstream stopped the movement of migratory fish beyond certain points in the Hackensack and Passaic Rivers while also threatening resident freshwater fish species. Conditions began improving after the 1972 CWA and there is now a more diverse fish species assemblage than before the act was passed (USEPA, 2011).

The hydrology of open river areas has been altered by numerous flood risk management structures, dams and debris, which reduce connectivity and freshwater flow to Newark Bay, and block upstream passage by fishes (USEPA, 2011). Anadromous fishes make annual spawning runs up the 17-mile tidal stretch of the Passaic River to the Dundee Dam, but are blocked from going further. The Oradell Reservoir Dam, on the Hackensack River, blocks passage of American shad, alewife, and blueback herring from reaching upstream segments of the watershed (USACE, 2004b; USEPA, 2011). Other smaller dams and inoperable tide gates in the planning region degrade habitat and impair passage for anadromous species (Durkas, 1993). Furthermore, catadromous species, like the American eel, may also be negatively affected by these impediments.

Several fish surveys in 2009 and 2010 on the Lower Passaic River indicated the majority of fish occurring throughout the estuarine reaches included white perch (*Morone americana*), inland silverside (*Menidia beryllina*), mummichog, alewife, striped bass, Atlantic tomcod (*Microgadus tomcod*), and Atlantic menhaden. The freshwater reaches of the Lower Passaic River found freshwater fish habitat for warm water assemblages of carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*), black crappie (*Pomixis nigromaculatus*), and other species (USEPA, 2014).

2.2.3.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from NOAA NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate EFH for all managed species, to minimize to the extent practicable adverse effects on EFH, and to identify other actions to encourage the conservation and enhancement of EFH. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" (NOAA, 2004). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining "waters" to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties: "substrate" to include sediment, hard bottom, and structures underlying the water; areas used for "spawning, breeding, feeding, and growth to maturity" to cover a species' full life cycle; "prey species" as being a food source for one or more designated fish species (NOAA, 2004).

NOAA's Guide to EFH Designations in the Northeastern United States provides the species and life stages with EFH. Table 2-5 lists the EFH designations for the Newark Bay, Hackensack River and Passaic River Planning Region. Because the planning region is outside the ten-minute squares for marine waters, the designations are based on the Hudson River/Raritan/Sandy Hook Bays, New York/New Jersey estuarine area (NOAA, 2016). EFH is discussed further in Appendix F.

Table 2-5. Summary of EFH Designation for Newark Bay, Hackensack River and Passaic River Planning Region

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Red hake (*Urophycis chuss*)		M,S	M,S	M,S	
Winter flounder (*Pseudopleuronectes americanus*)	M,S	M,S	M,S	M,S	M,S
Windowpane flounder (*Scophthalmus aquosus*)	M,S	M,S	M,S	M,S	M,S
Atlantic sea herring (*Clupea harengus*)		M,S	M,S	M,S	
Bluefish (*Pomatomus saltatrix*)			M,S	M,S	
Atlantic butterfish (*Peprilus triacanthus*)		M	M,S	M,S	
Atlantic mackerel (*Scomber scombrus*)			S	S	
Summer flounder (*Paralichthys dentatus*)		F,M,S	M,S	M,S	

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Scup (*Stenotomus chrysops*)	S	S	S	S	
Black sea bass (*Centropristis striata*)			M,S	M,S	
King mackerel (*Scomberomorus cavalla*)	X	X	X	X	
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X	
Cobia (*Rachycentron canadum*)	X	X	X	X	
Source: NOAA, 2016. S = includes the seawater salinity zone; M = includes the mixing water/brackish salinity zone; F = includes the tidal freshwater salinity zone					

2.2.3.6 Shellfish and Benthic Resources

Within the Newark Bay, Hackensack River and Passaic River Planning Region, the Hackensack Meadowlands supports an active recreational fishery with target species that include blue crab. However, consumption advisories are in effect throughout the HRE study area.

Shellfish (bivalves and macrocrustaceans) are a critical wildlife resource in the Newark Bay/Lower Passaic River/Hackensack River Planning Area, although the condition of this resource is impaired due to habitat loss and water quality and sediment degradation. No commercial or recreational shellfishing is permitted within the waters of the Newark Bay/Lower Passaic River/Hackensack River Planning Area, due to the legacy of sediment and water quality degradation. This prohibition includes bivalves (clams, mussels, oysters) (NJDEP, 2015) and blue crabs (New Jersey Department of Health, 2016). If the no action alternative is implemented, shellfish habitat in the region would continue to degrade from the effects of water pollution and loss of habitat.

Benthic community surveys conducted in the Lower Passaic River found that dominant species observed were pollution-tolerant organisms such as tubificid worms, heavily influenced by the urban and industrial surroundings (Iannuzzi and Ludwig 2005, USEPA 2014).

2.2.3.7 Wildlife

The Newark Bay, Hackensack, and Passaic River Planning Region supports many species that tolerate a wide range of conditions and disturbances in their physical environment allowing them to utilize urban and developed areas for shelter and forage.

The Hackensack Meadowlands provide important habitat for thousands of shorebirds, both in spring and fall migrations, and for wintering and summering waterfowl (USFWS, 1997). Bats that migrate through the area include the little brown bat (*Myotis lucifugus*), silver-haired bat (*Lasionycteris noctivans*), red bat (*Lasiurus borealis*), and hoary bat (*Lasiurus cinereus*). Whitetailed deer (*Odocoileus virginianus*) are abundant in the suburban outskirts of the study area (USFWS, 1997). Additionally, owls and hawks, such as northern harrier, rough-legged hawk (*Buteo lagopus*), red-tailed hawk (*Buteo jamaicensis)*, American kestrel (*Falco sparverius*), short-eared owl, and long-eared owl (*Asio otus*), forage on small mammals that inhabit landfills occurring in this planning region.

A variety of urban-adapted small mammals are likely to occur in the this planning region including the meadow vole (*Microtus pennsylvanicus*), cottontail rabbit (*Sylvilagus floridanus*), gray squirrel (*Sciurus carolenensis*), raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), white-footed mouse (*Peromyscus leucopus*), short-tail shrew (*Blarina blevicauda*), and eastern chipmunk (*Tamias striatus*). Small mammals introduced by humans include house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and feral dogs (*Canis familiaris*) and cats (*Felis catus*).

Avian surveys conducted in 1999, 2000, 2010 and 2011 identified a total of 41 aquatic and semi-aquatic species identified within the Lower Passaic River corridor. Common species included Canada geese, mallard ducks (*Anas platyrhynchos*), ring-billed gulls (*Larus delawarensis*), terns, sandpipers, killdeer (*Charadrius vociferous*), sanderlings, swans, belted kingfishers (*Megaceryle alcyon*), double-crested cormorant (*Phalacrocorax auritus*), and red-winged black birds (*Agelaius phoeniceus*) (Windward Environmental, 2011). Mammals including squirrels, chipmunks, groundhogs, and rats were periodically observed along the river banks, and mink tracks were identified along the bank near Dundee Dam (USEPA, 2014).

2.2.3.8 Rare, Threatened, and Endangered Species

Listed sea turtles occur seasonally in the coastal waters of New Jersey and New York, and occasionally occur in the temperate waters of New York-New Jersey Harbor; however, they are not likely to occur in the rivers and estuaries in the planning region. The planning region includes areas mapped as accessible habitat for Atlantic sturgeon. However, Atlantic sturgeons are not likely to be present in the intertidal and shallow water depths where restoration activities would likely occur.

The United States Fish and Wildlife Service (USFWS) and New Jersey Natural Heritage Program were contacted regarding federally and state listed threatened and endangered species for the project sites within this planning region. Correspondence with the referenced agencies can be found in Appendix F.

United States Fish and Wildlife Service (USFWS)

USFWS official species lists (included in Appendix F) indicate that there are no endangered or threatened species or critical habitats under USFWS jurisdiction in the planning region where restoration activities would be likely to occur.

National Marine Fisheries Service (NMFS)

NMFS listed species are not likely to occur within the planning region. According to NMFS ESA maps (included in Appendix F) there is no critical habitat for any NMFS ESA species within the waters of the planning region. The planning region is not within the range of Atlantic salmon, shortnose sturgeon, or any of the listed marine mammals in the Greater Atlantic Region.

New Jersey Department of Environmental Protection (NJDEP)

The New Jersey Natural Heritage Program correspondence (included in Appendix F) indicates that there are no records of federally endangered or threatened species in the planning region where restoration activities would be likely to occur. However, there are recent records of state endangered and/or threatened species within the planning region. Through correspondence with NJDEP, and their review of the Natural Heritage Program database, the following list includes endangered, threatened, or species of special concern within the planning region:

- Bald eagle (*Haliaeetus leucocephalus*) – state endangered.
- Black-crowned night heron (*Nycticorax nycticorax*) – state threatened.
- Cattle egret (*Bubulcus ibis*) – state threatened.
- Glossy ibis (*Plegadis falcinellus*) – special concern.
- Little blue heron (*Egretta caerulea*) – special concern.
- Northern harrier – state endangered.
- Osprey (*Pandion haliaetus*) – state threatened.
- Peregrine falcon – state endangered.
- Snowy egret (*Egretta thula*) – special concern.
- Yellow-crowned night heron – state threatened.
- Red-headed woodpecker (*Melanerpes erythrocephalus*) – state threatened.
- Tricolored heron (*Egretta tricolor*) – special concern.

It is assumed that prior to construction activities a resource inventory would be conducted to determine if these species are present. Chapter 5 discusses these inventories in greater detail.

2.2.3.9 Land Use

Predominant land uses in the Hackensack River, Passaic River, and Newark Bay Planning Region include commercial, industrial, and residential development. Surface waters are withdrawn from the Hackensack and Passaic Rivers by three (3) power plants. Three (3) sewage treatment plants are also located in this region (USACE, 2004b). The lower 1.7 miles of the Lower Passaic River is dominated by commercial petroleum facilities. The upstream reaches of the lower Passaic River predominantly support recreational uses (USACE, 2008a). Along the western shoreline of Newark Bay are Port Newark and the Elizabeth-Port Authority Marine Terminal. Collectively, these ports are the largest maritime cargo handling facilities on the East Coast of North America, and operate primarily as a container ship facility.

The Hackensack Meadowlands are a dominant feature within this region, measuring approximately 19,730 acres. The New Jersey Meadowlands District contains residential, commercial, industrial, and landfill areas, as well as large expanses of tidal wetlands and open space. Water use in the Hackensack and Passaic Rivers includes municipal drinking water supplies (NYCDEP, 2012). For example, Lake Deforest and the Oradell, Tappan, and Woodcliff

Lake Reservoirs supply drinking water to much of Rockland County, New York and northern New Jersey. Similar impoundments at the headwaters of the Passaic River (e.g., Point View Reservoir) also aid in contributing to drinking water in New Jersey (NJDEP, 2012).

2.2.3.10 Hazardous, Toxic, and Radioactive Waste

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. Unregulated discharges from these facilities have caused severe contamination of sediments in the rivers. Pathogenic microbial contamination, floatable debris, excessive levels of waterborne nutrients, and non-point source discharges further impair water quality (Appendix G).

Strict consumption advisories are currently in effect for fish and crabs caught from this region. Although several petroleum refineries and chemical manufacturing plants continue to operate, the majority of the industrial facilities in the planning region have been shut down, but their legacy of contaminants still remain in the sediments. Primary contaminants of concern in the study area include dioxins (2,3,7,8-tetrachlordibenzo-p-dioxin), mercury, lead, polychlorinated dibenzofurans, PCBs, PAHs, and DDT. Many of these contaminants pose severe threats to human and ecological health. Several USEPA Superfund sites exist within this planning region, including the 17-mile tidal portion of the Lower Passaic River, Newark Bay, and portions of the Hackensack River.

Contaminants in the Lower Passaic River are largely the result of discharges from the Diamond Alkali Superfund site, which was listed on the National Priorities List in 1984. For approximately 30 years during the mid-20th century, various companies manufactured pesticides and herbicides at facilities in Newark. In addition, there are more than 100 Potential Responsible Parties (PRPs) that have released contaminants of concern into the Lower Passaic River. These PRPs have formed a Cooperating Parties Group (CPG), which is currently completing the remedial investigation and feasibility study (RI/FS) for the 17-miles of the Lower Passaic River, from Newark Bay to the Dundee Dam on behalf of USEPA. As stated in Chapter 1, the USACE's Reconnaissance Study identified the Lower Passaic River as one of the priority restoration areas within the estuary. In recognition of the coincidental study areas and related roles and responsibilities of USEPA and USACE, along with the project sponsor (New Jersey Department of Transportation [NJDOT]), the agencies integrated the USEPA Superfund RI/FS and USACE Feasibility Study into a comprehensive cooperative effort (www.ourpassaic.org). This coordinated effort was also a pilot project to coordinate remediation and restoration of degraded urban rivers in the U.S. under the Urban River Restoration Initiative (URRI). The Governmental Partnership (including USEPA, USACE, NOAA, USFWS, NJDOT, and the NJDEP) was established for the Lower Passaic River Feasibility "Source" Study in order to assist in recommending a comprehensive solution for the Lower Passaic River Basin.

While the RI/FS was advancing, USEPA signed an agreement with Occidental Chemical and Tierra Solutions to remove 200,000 cubic yards (CY) of contaminated sediment from the portion of the Lower Passaic River adjacent to the former Diamond Alkali facility in Newark. The first phase of the removal (40,000 CY) was completed in 2012. In 2013, USEPA and the CPG implemented a Time-Critical Removal Action (removal of 16,000 CY with cap) to address highly contaminated surface sediments in Lyndhurst, which was completed in 2014. A Focused Feasibility Study and Proposed Plan were released by USEPA in April 2014 (USEPA, 2014a). USEPA issued the Record of Decision on the final cleanup plan for the lower 8.3 miles of the Passaic River in March 2016 that includes bank to bank dredging and removal of 3.5 million CY of sediment and subsequent capping (USEPA, 2016). Additional information is available at www.ourpassaic.org.

The USEPA has also been studying Newark Bay since 2004 to determine the nature and extent of sediment contamination, determine potential risks of contamination, and to determine the significant, on-going sources of pollution (USEPA, 2014b) (www.ournewarkbay.org).

Berry's Creek is a tidal tributary to the Hackensack River located within the Meadowlands in Bergen County, New Jersey. The creek is located in a highly industrial area, and contaminants and discharges from surrounding properties have led to sediment mercury concentrations greater than what is considered to be protective of wildlife. Berry's Creek has historically been associated with mercury contamination originating from the Ventron/Velsicol Superfund site. However, two (2) other USEPA Superfund sites, the Universal Oil Products site and the Scientific Chemical Processing site, as well as several hazardous waste sites are located in the Berry's Creek watershed. The USEPA Berry's Creek study area includes the 6.5-mile Berry's Creek, its tributaries, the Berry's Creek canal, and adjacent wetlands. The Berry's Creek study area has been the subject of an RI/FS since 2006. The trustees (USFWS and NOAA) completed a pre-assessment screening to determine the extent of impacts to the watershed in 2014 and they are currently planning for a full Natural Resource Damage Assessment (NRDA).

USEPA is currently conducting sediment sampling after a recently released preliminary assessment report on the Lower Hackensack River in Bergen and Hudson Counties outlined potential threats to public health and/or the environment posed by the site, identified the potential for release of hazardous constituents into the environment, and recommended possible placement of the site on the National Priorities List (USEPA, 2015).

2.2.3.11 Noise

As much of the planning region is highly developed, ambient noise levels within the Newark Bay, Hackensack River and Passaic River Bay Planning Region would likely be in the mid-to high-range. The primary sources of noise in the planning region include air traffic from Newark and Teterboro airports, truck and automobile traffic, and boat traffic in Newark Bay and on the Passaic and Hackensack Rivers. Receptors in the planning region include residential areas and wildlife habitats. Noise criteria and the descriptors used to evaluate project noise will depend on the type of land use in the vicinity of the proposed project areas.

2.2.3.12 Navigation

Although originally a shallow tidal estuary, deep navigational channels are maintained in Newark Bay to provide ocean-going container ship access to the Port Newark-Elizabeth Marine Terminal along the bay's western side. Collectively, these ports are the largest maritime cargo handling facilities on the East Coast of North America, and operate primarily as a container ship facility.

The New York and New Jersey Harbor Deepening Project was recently completed in September 2016 dredging the navigation channel to 50-feet in Newark Bay.

These navigational channels originally extended northward from Newark Bay into the Lower Passaic River and the Hackensack River, but the channels in the rivers have not been maintained for decades (USEPA, 2014). The Lower Passaic River is used for commercial navigation, although that navigation is constrained by substantially shallower channel and horizontal and vertical clearances of bridge structures (USACE, 2010). The federal navigation channel is 300 feet at its widest location, which restricts the turning radius of larger vessels (which can be up to 350 feet long). Despite these constraints, the lower two (2) miles of the river are a corridor for transportation of petroleum products to or from major facilities.

2.2.3.13 Recreation

There are 33 public access points that exist in the Newark Bay, Hackensack River and Passaic River Planning Region. The majority of these public access points are found along the Hackensack and Passaic River and in the Hackensack Meadowlands overlooking the wetlands. A few access points are scattered around the east waterfront of Newark Bay in Bayonne and Jersey City.

The Hackensack Meadowlands supports an active recreational fishery. Target species include blue crab, striped bass, American eel, white catfish (*Ameiurus catus*), white perch, carp, pumpkinseed (*Lepomis gibbosus*), and brown bullhead (*Ictalurus nebulosus*) (Weis, 2004).

2.2.3.14 Cultural Resources

The Newark Bay, Hackensack River and Passaic River Planning Region has a long history of occupation, first by Native American groups from as early as 12,000 before present until the arrival of European explorers in the fifteenth century. Early colonial settlements appear in the 1600s which evolved slowly from agricultural to industrial in character followed by urbanization and development of suburbs in the last century. Potential for prehistoric and historic archaeological sites exists throughout the region. Archaeological sites and above-ground historic properties can be found in upland, lowland, marsh, and submerged environments. Architectural and archaeological investigations are required to determine the presence or absence of such resources in most of the study area due to lack of existing data.

In 2014 the USACE completed a cultural resources survey titled *Cultural Resources Overview of the Hudson-Raritan Estuary Comprehensive Restoration Plan* (Harris et al., 2014) that aimed at inventorying all existing cultural resources data relevant to the CRP candidate restoration sites in the HRE study. General background information about the region was collected to provide a historical and cultural context. Cultural resources data was not compiled for the entire region but for each individual restoration site and a one-mile buffer area that was applied to the site for the survey. There were 78 restorations sites investigated in the Newark Bay, Hackensack River and Passaic River Planning Region.

The Newark Bay, Hackensack River and Passaic River Planning Region has more than 6,300 cultural resources, historic districts, or surveys documented in its boundaries. There are 5,655 historic properties documented within New Jersey and one property that is recorded in New York, but crosses state lines; the Palisades Interstate Parkway. In New Jersey, historic structures are heavily concentrated in Glen Ridge Borough, East Orange, Newark, and the western portion of Union City. The 93 historic districts in the region are all recorded in New Jersey and reflect the distribution of historic resources with the addition of linear transportation related districts throughout. The 466 recorded cultural surveys in the region follow the same pattern as above. The southern two-thirds of the region, from Elizabeth to Paterson, are densely covered with survey areas. However, the northern portion, north of Paramus, there are relatively few surveys. A single cultural resources survey is the document for New York and crosses the region across the mouth of Newark Bay. All of the 87 archaeological sites recorded in this region are recorded in New Jersey. These sites are distributed throughout the region with one notable cluster along the Passaic River just south of Paterson. Finally, there are nine (9) AWOIS objects of the region and all are located in Newark Bay.

2.2.3.15 Social and Economic Resources

The Newark Bay, Passaic River and Hackensack River Planning Region lies within Bergen, Passaic, Hudson, Essex, and Union counties in New Jersey. Within this planning region, two (2) recommended sites are found in Essex County and two (2) are found in Bergen County. The population of these counties is over 1.7 million people according to the 2010 Census (United States Census Bureau, 2010). The demographic makeup of these counties can be found in Table 2-6.

Table 2-6. Newark Bay, Hackensack River and Passaic River Planning Region Planning Region Socioeconomic Data*

	Essex County	Bergen County
White	49.0%	73.0%
Black or African American	41.9%	7.3%
Asian	5.8%	16.9%
Other Races	3.3%	2.8%
Hispanic or Latino^	23.5%	20.6%
Owner-Occupied Homes	44.5%	64.6%
Median Household Income	$57,365	$91,572
Persons Below the Poverty Level	14.9%	6.8%

*All socioeconomic data is based on the United States Census Bureau, Population Estimates Program (PEP) and the American Community Survey (ACS), which are updated annually (2017).

^Those identifying as Hispanic or Latino may be of any race, and are included in applicable race categories.

The City of Newark, where both Essex County sites are found, have an average median household income (in 2018 dollars) lower than the county average at $34,826 and has a higher percentage of persons below the poverty line at 28.3%.

2.2.3.16 Aesthetics and Scenic Resources

The Hackensack River winds south from the Oradell Reservoir in northern Bergen County and terminates in Newark Bay. Along the way, multiple bridges and crossings extend across the waterway, including Portal Bridge (NJ Transit), the New Jersey Turnpike, Route 3, and Route 46. *Phragmites* marshes, industrial and commercial facilities, and major highways can be viewed as the river nears Newark Bay. The Passaic River flows from central New Jersey, growing wider as tributaries flow into it along the way (Ramapo River, Rockaway River, Saddle River), before it terminates in Newark Bay. Extensive *Phragmites* marshes and industrial and commercial facilities can be found surrounding the river and major highways cross the river (e.g., New Jersey Turnpike, Interstate 280).

Commercial and residential structures are the primary feature of the eastern shoreline of Newark Bay, which is protected by structures. The marine terminals at Elizabeth and Port Newark occupy a large portion of the western shoreline of the Bay. The Elizabeth Port Authority Marine Terminal is a large expanse of containers, storage facilities, and cargo/container cranes. Looking east from the pierhead line and marine terminal areas, the Bayonne shoreline is visible across Newark Bay. To the north is a view of the Newark Bay Bridge. The viewshed from the Newark Bay Terminal includes industrial activities, automobile processing, and warehousing facilities. Newark Bay and the surrounding area are visible from the Newark Bay Bridge (USACE, 1999). South of the Newark Bay Bridge, Richard A. Rutkowski Park provides a contrast to the industrial development with preserved wetlands and a bird sanctuary along the eastern shoreline of Newark Bay (City of Bayonne, 2012).

2.2.3.17 Coastal Zone Management

The Coastal Zone Management Act of 1972 (16 United States Code 1451-1464) was enacted by Congress to balance the demands for growth and development with the competing demands for protection of coastal resources. This act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. This act is regulated in New Jersey by the NJDEP.

New Jersey's coastal zone management program primarily derives its authority from three (3) state statutes: The Waterfront and Harbor Facilities Act of 1914 (New Jersey Statutes Annotated 12:5-3), the Wetlands Act of 1970 (New Jersey Statutes Annotated 13:9A), and the Coastal Area Facility Review Act (New Jersey Statutes Annotated 13:19). The Hackensack Meadowlands Reclamation and Development Act (New Jersey Statutes Annotated 13:17), Freshwater Wetlands Protection Act (New Jersey Statutes Annotated 13:9B), the Law concerning the transportation of dredged materials containing PCBs (New Jersey Statutes Annotated 13:19-33) and the Department's dredging technical manual titled, “The Management and Regulation of Dredging Activities and Dredged Material Disposal in New Jersey's Tidal Waters” are additional laws governing New Jersey’s enforceable coastal zone policies.

The Newark Bay, Passaic River and Hackensack River Planning Region includes portions within the inland, seaward, and interstate coastal zone boundaries for New Jersey. Restoration activities within the region will be reviewed by the NJDEP for consistency with the policies of their respective coastal management programs. All information related to the USACE coastal consistency review is presented in Appendix F.

2.2.4 Upper Bay Planning Region

The Upper Bay Planning Region is centrally located within the HRE study area, connecting five (5) other HRE regions (Figure 2-9). The Upper Bay begins at the mouth of the Hudson River as it empties into Lower New York Bay, is connected to Newark Bay and the Arthur Kill via the Kill Van Kull, and exchanges water with the East River and Long Island Sound. The Upper Bay, surrounding the Statue of Liberty, and Ellis and Governors Islands, is closely tied to portions of Manhattan, Brooklyn, and Staten Island, New York as well as Hudson County, New Jersey.

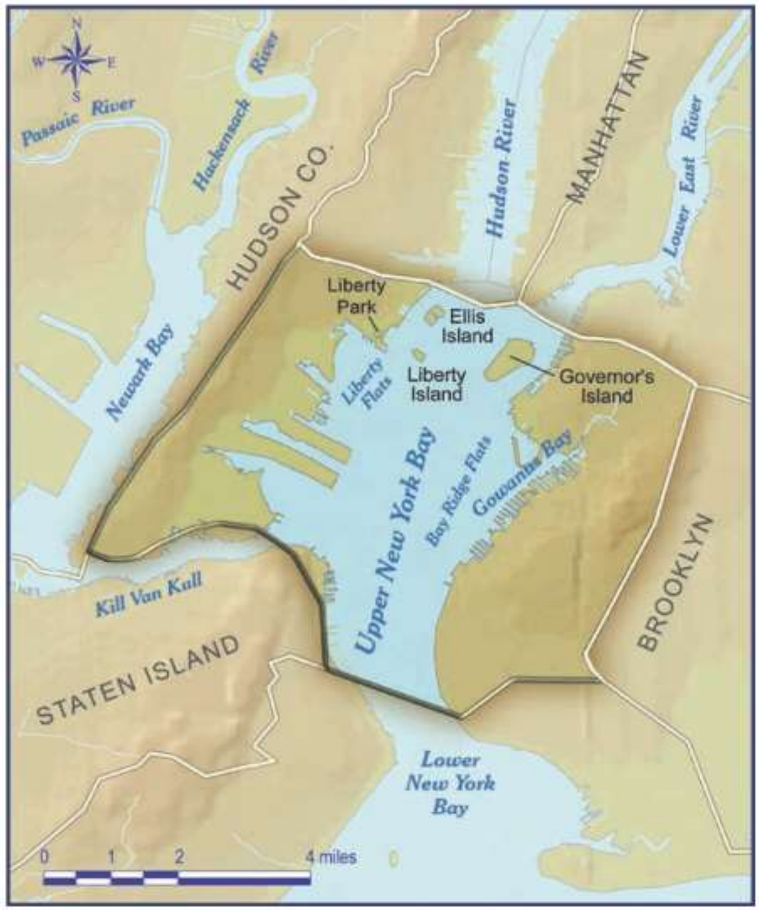


Figure 2-9. Upper Bay Planning Region

Unhardened shoreline habitat and valuable aquatic habitat in the Upper Bay are limited. Shoreline habitat can be found in the form of wetlands on the west side of Liberty Island. Remnant mudflats are located along the New Jersey coastline (USACE, 2000; USACE, 1999). Sandy shallows within the Bay Ridge Flats that have been significantly reduced in size over time by dredging are located along the eastern edge of the bay. These flats provide some habitat to many species of young fishes. The Upper Bay is still a critical component of the HRE study area because it serves as a migratory pathway for many fish species, providing access to important feeding, overwintering, and nursery areas (USACE, 2004a).

In the HRE study area, the Upper Bay is a vital link among the other regions; both influencing them and being influenced by their hydrology, biology, and impairments. Even the open water is crowded with ship traffic and large channels that must be maintained. Sediment contaminants occur in several waterfront areas of the Upper Bay, due in part to historic industrial uses, local runoff, and CSO inputs. Shallow sheltered areas and littoral habitats are almost nonexistent, and heavy commercial boat traffic erodes unprotected shorelines (USACE, 2004a).

Hurricane Sandy impacted the Upper Bay Planning Region with flooding and elevated levels of bacteria in surface waters. Newtown Creek and the Gowanus Canal contained “unacceptable” water levels of Enterococcus bacteria three (3) days after the storm. Enterococcus levels in the

Gowanus Canal were 230 times greater than what is considered acceptable for swimming (ALS, 2012).

2.2.4.1 Geomorphology and Sediment Transport

The Upper Bay Planning Region is in the Atlantic Coastal Plain physiographic province. Upper Bay currents vary substantially and, therefore, this area has the most complex distribution of sediments. The Upper Bay sediment varies from coarse sands and gravels in high energy areas to fine-grained silts and clays in low energy areas. This region is heavily urbanized along its perimeter, made possible through shoreline filling and hardening. Additional available information regarding geology, bathymetry, topography and hydrology is found in Appendix C.

2.2.4.2 Water Resources

The Upper Bay represents the confluence of oceanic waters and the East River tidal strait, Kill Van Kull, and mouth of the Hudson River. Tidal ranges are approximately five (5) feet. Waters in the planning area are over 55 feet in depth; although, shallow areas (six [6] feet) are common along the New Jersey Coast and near Ellis Island. The shorelines have been significantly altered in the planning area, much of the shallows once present along the Brooklyn coastline have been filled and expanded. The Gowanus Canal is a prominent site within the Upper Bay Planning Region. Its watershed is a highly developed urban area located in the Borough of Brooklyn. There are approximately 60 acres of open water along the canal. Coastal portions of lower Manhattan, Brooklyn, and Staten Island lie within the 100-year floodplain.

Gowanus Canal is impacted by poor water quality. The Gowanus Canal was added to the USEPA Superfund List in 2010, and issued its final cleanup plan for the Gowanus Canal Superfund site on September 27, 2013 (USEPA, 2016). Consumption advisories are in effect for any fish caught in the Harbor, including Upper New York Bay. Two (2) sewage treatment plants discharge effluent into the Upper Bay (USACE, 2004a). Upgrades of existing and construction of new water pollution control infrastructure has led to gradual improvements, as measured by some standards, to surface water quality in the Upper Bay (NYCDEP, 2011).

2.2.4.3 Vegetation

Land in the Upper Bay Planning Region is almost entirely developed. Most of the shorefront land use within the Upper Bay is commercial and industrial, with a few public parks and open spaces. However, parks (e.g., Liberty State Park, etc.) do not constitute “natural” areas but are predominantly recreational grasslands. Liberty State Park is comprised of 1,100 acres including a salt marsh of about 40 acres. The vascular plant assemblage is surprising robust considering the heavily disturbed history.

The Upper Bay perimeter is heavily urbanized dominated by bulkheads, piers, and the placement of shoreline fill which have greatly reduced the abundance of natural nearshore habitats including rocky outcroppings, wetlands, and sand beaches (Sanderson, 2005). Aquatic habitat and shoreline that is not hardened are limited in the Upper Bay with some persisting wetlands on the west side of Liberty Island, beaches on the eastern edge of Staten Island, and remnant mudflats located along the New Jersey shoreline (USACE, 2000; USACE, 1999).

Upland habitat consists of old-field and scrub-shrub/woodland habitats. Many of these upland communities occur on former wetlands that were filled with material that is contaminated. Other upland communities have grown on abandoned or vacant properties that are former developed sites (USACE, 2004).

2.2.4.4 Finfish

The Upper Bay Planning Region is a critical component of the HRE study area because it serves as a migratory pathway for many fish species, providing access to important feeding, overwintering, and nursery areas (USACE, 2004a). Of the 32 species of fish that have been reported in the Upper Bay, characteristic fish species of this area include bay anchovy, winter flounder, American shad, Atlantic tomcod, and alewife (NJDEP, 1984). Consumption advisories are in effect for any fish caught in the Harbor, including Upper New York Bay (NYSDEC, 2011).

2.2.4.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from NOAA NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate EFH for all managed species, to minimize to the extent practicable adverse effects on EFH, and to identify other actions to encourage the conservation and enhancement of EFH. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" (NOAA, 2004). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining "waters" to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties: "substrate" to include sediment, hard bottom, and structures underlying the water; areas used for "spawning, breeding, feeding, and growth to maturity" to cover a species' full life cycle; "prey species" as being a food source for one or more designated fish species (NOAA, 2004).

NOAA's Guide to EFH Designations in the Northeastern United States provides the species and life stages with EFH. Table 2-7 lists the EFH designations in the Upper Bay Planning Region. The Upper Bay Planning Region falls within two (2) 10-minute grids, one of which also covers a portion of the Lower Bay Planning Region (NOAA, 2016). EFH is discussed further in Appendix F.

Table 2-7. Summary of EFH Designation for Upper Bay Planning Region

Managed Species	Eggs	Larvae	Juveniles	Adults
Red hake (*Urophycis chuss*)	X	X	X	X
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X
Windowpane flounder (*Scophthalmus aquosus*)	X	X	X	X
Atlantic sea herring (*Clupea harengus*)		X	X	X
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triacanthus*)		X	X	X
Atlantic mackerel (*Scomber scombrus*)			X	X
Summer flounder (*Paralichthys dentatus*)		X	X	X

Managed Species	Eggs	Larvae	Juveniles	Adults
Scup (*Stenotomus chrysops*)	X	X	X	X
Black sea bass (*Centropristis striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Sand tiger shark (*Carcharhinus taurus*)		X		
Dusky shark (*Carcharhinus obscurus*)		X	X	
Sandbar shark (*Carcharhinus plumbeus*)		X		X
Source: NOAA, 2016. 10'x10' square coordinates: 40° 50.0'N, 74° 00.0'W, 40° 40.0'N, 74° 10.0'W 40° 40.0'N, 74° 00.0'W, 40° 30.0'N, 74° 10.0'W				

2.2.4.6 Shellfish and Benthic Resources

The Upper Bay is closer to the urban and industrial areas of the harbor, and the benthic habitats consist of shellfish beds and areas of silty sediment. Opportunistic infauna associated with disturbed and polluted habitats dominate the benthos. Northern quahog, softshell clams, American oyster, surf clam (*Spisula solidissima*) and blue mussel (*Mytulis edulis*) beds occur in the Upper Bay Planning Region (USFWS, 1997). Additional information available on existing shellfish/oyster populations is found in Appendix D-8.

2.2.4.7 Wildlife

The terrestrial ecosystems of the Upper Bay include a high degree of urban and industrial development that influence the distribution and abundance of terrestrial wildlife. Unhardened shoreline habitat and valuable aquatic habitat in the Upper Bay are limited. Flora and fauna includes many species that tolerate the wide range of conditions and disturbances in their physical environment, allowing them to utilize urban and developed areas for shelter and forage.

2.2.4.8 Rare, Threatened, and Endangered Species

Atlantic sturgeon (various life stages) and shortnose sturgeons (adults and sub-adults) may be present in the Upper Bay as the species transit through the region to the Hudson River. It is unlikely these species would be present in the intertidal and shallow water depths where proposed restoration activities would occur.

Restoration sites proposed in the Upper Bay Planning Region are limited to marine oyster restoration. As such, federal agency correspondence is limited to NOAA NMFS. The New York Natural Heritage Program was also consulted in regards to state listed species. Agency correspondence is located in Appendix F.

National Marine Fisheries Service (NMFS)

Listed by the NOAA NMFS, four (4) species of ESA sea turtles have been seasonally present in the bay, including:

- Threatened Northwest Atlantic Ocean DPS of loggerhead;
- Threatened North Atlantic DPS of green;
- Endangered Kemp's ridley; and
- Endangered leatherback sea turtle.

These threatened and endangered sea turtles can be present in the Upper Bay area from May to mid-November. Adult and subadult Atlantic sturgeon can be found in the Lower Bay Planning Area. The New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPSs are endangered, and the Gulf of Maine DPS is threatened in the area. Atlantic sturgeon eggs, larvae, or juvenile life stages will not be found in the waters of the Upper Bay Planning Area. Additionally, the shortnose sturgeons, of the adult and subadult life stages are also present in these waters.

New York Natural Heritage Program

In correspondence with the New York Natural Heritage Program, the agency indicated that the state threatened common tern may be present at one of the project sites. It is assumed that prior to construction activities a resource inventory would be conducted to determine if these species are present. Chapter 5 discusses these inventories in greater detail.

2.2.4.9 Land Use

Land use along the shoreline of the Upper Bay Planning Region is primarily commercial and industrial, with few non-industrial uses. Degraded water quality limits the waterways to primarily transportation-related uses. Scattered among the shipping terminals and marinas are parklands or public promenades, some vacant disturbed land, and small residential areas. Waterfront parks, including Liberty State Park, provide recreational areas and open spaces but are mostly lined by bulkheaded shorelines.

2.2.4.10 Hazardous, Toxic, and Radioactive Waste

Industrial and CSO inputs into tributaries to the Upper Bay, such as the Gowanus Canal and Newtown Creek, have severely degraded water and sediment quality. Historic uses in and around the Gowanus Canal have caused a significant deposition of hazardous materials on the canal bottom. The canal is impacted by poor water quality, contaminated sediments, such as heavy metals, PCBs, and PAHs, deteriorating bulkheads, a poor benthic community structure, extensive filling, little or no buffers, and odors, all resulting from more than a century of heavy industrial use. In 2010, the Gowanus Canal was included on the USEPA Superfund sites National Priorities List, as it has become one of the nation's most extensively contaminated water bodies. In September 2013, the USEPA finalized the cleanup plan for the Gowanus Canal Superfund site. The plan included dredging contaminated sediments, capping the dredged areas, and reducing sewage flows and other land based discharges into the canal. USEPA issued a Unilateral Administrative Order (UAO) to National Grid and 29 other parties in March 2014 to prepare the remedial design and issued an UAO in May 2014 to New York City (NYC) relating to the CSO portion of the remedy (NYCDEP, 2016). Newtown Creek was also added to the Superfund site National Priorities List in 2010. The Phase I Remedial Investigation for Newtown Creek Superfund site was completed in 2013 (USEPA, 2013).

Commercial shipping terminals throughout Upper Bay Planning Region allow for the constant risk of spill from passing commercial vessels as well as vehicles on land. The dense confluence of both land based and aquatic traffic, as well as existing commercial and industrial uses present the potential for environmental risk. The Upper Bay Planning Region also includes Governors Island, a 172-acre island in the New York Harbor that served as a U.S Army base and then a Coast Guard Station for over 200 years. It has been listed as a superfund site and is in the process of a remediation and revitalization effort since the announcement of the closure of the Coast Guard Station.

Consumption advisories are in effect for any fish caught in the Harbor, including Upper New York Bay. Two (2) sewage treatment plants discharge effluent into the Upper Bay (USACE, 2004a). Upgrades of existing and construction of new water pollution control infrastructure have led to gradual improvements, as measured by some standards, to surface water quality in the Upper Bay (NYCDEP, 2011).

2.2.4.11 Noise

As much of the planning region is highly developed, ambient noise levels within the Upper Bay Planning Region would likely be in the mid-to high-range. The primary sources of noise in the planning region include automobile traffic, truck traffic on the highways and piers, and boat traffic in Upper Bay. Receptors in the planning region include residential areas and wildlife habitats. Noise criteria and the descriptors used to evaluate project noise will depend on the type of land use in the vicinity of the proposed project areas.

2.2.4.12 Navigation

The Upper Bay Planning Region is a major navigational hub in the region, with connections to the Hudson River, East River, Kill van Kull, and the Narrows. In addition to commercial vessels that frequent shipping terminals along most of the shoreline, many public and private ferry operations cross the bay daily. Ellis Island, Liberty Island, and Governors Island are also busy destinations for boat traffic in Upper Bay. Shallow sheltered areas and littoral habitats are almost non-existent, and heavy commercial boat traffic erodes unprotected shorelines (USACE, 2004a).

2.2.4.13 Recreation

The Upper Bay Planning Region contains 21 public access points mostly found along the waterfront of South Brooklyn and Bayonne and Jersey City. Some are located on the waterfront of northern Staten Island. Recreational fishing in the Upper Bay Planning Region occurs from private vessels, party/charter boats, and from piers. Target species include bluefish, weakfish, black sea bass, winter flounder, summer flounder, and striped bass.

2.2.4.14 Cultural Resources

The Upper Bay Planning Region has a long history of occupation, first by Native American groups from as early as 12,000 before present until the arrival of European explorers in the fifteenth century. Early colonial settlements appear in the 1600s which evolved slowly from agricultural to industrial in character followed by urbanization and development of suburbs in the last century. Potential for prehistoric and historic archaeological sites exists throughout the region. Archaeological sites and above-ground historic properties can be found in upland, lowland, marsh, and submerged environments. Architectural and archaeological investigations are required to determine the presence or absence of such resources in most of the study area due to lack of existing data.

In 2014 the USACE completed a cultural resources survey titled *Cultural Resources Overview of the Hudson-Raritan Estuary Comprehensive Restoration Plan* (Harris et al., 2014) that aimed at inventorying all existing cultural resources data relevant to the CRP candidate restoration sites in the HRE study. General background information about the region was collected to provide a historical and cultural context. Cultural resources data was not compiled for the entire region but for each individual restoration site and a one-mile buffer area that was applied to the site for the survey. This area is referred to below as the study area to differentiate it from the entire region. There were seven (7) restorations sites investigated in the Upper Bay Planning Region.

The Upper Bay Planning Region has more than 270 cultural resources, historic districts, or surveys documented in its study area. The most commonly recorded resource type in this study area are historic properties; including 69 in the New York portion and 43 in the New Jersey portion. Most of these resources are located on Ellis and Liberty Islands, with additional resources recorded on Governors Island, the northernmost point of Staten Island, and throughout Brooklyn. Of the 14 historic districts in this region, five (5) are in New Jersey and nine (9) are in New York. The 51 total AWOIS objects in the study area are spread throughout the Upper Bay Planning Region, increasing in density in the waters around Ellis, Liberty, and Governors islands.

Archaeological sites in the study area are found mainly on the islands of New York, with 20 sites, and to a lesser degree in Bayonne, New Jersey with four (4) sites. Finally, this region is densely covered with a total of 74 cultural resources surveys; 28 in New York and 46 in New Jersey. However, as with many of these resources, Ellis and Liberty Islands are the location of many of these surveys and they are recorded by both state’s repositories. Additional surveys in New Jersey cover a high percentage of the Bayonne area and the mouth of the Kill Van Kull, as well as the New York side of the Upper Bay Planning Region. Documentation related to cultural resources is located in Appendix H.

2.2.4.15 Social and Economic Resources

The Upper Bay Planning Region is predominantly in Hudson County, New Jersey and Kings County, New York with small portions of New York and Richmond counties in the north and south, respectively. The site that is recommended located in the Upper Bay Planning Region is located in Kings County, New York. The population of Kings County is more than 2.5 million people according to the 2010 Census (United States Census Bureau, 2010). The demographic makeup of Kings County can be found in Table 2-8. Median household income for Kings County where the recommended site is located is $52,782 (in 2018 dollars).

Table 2-8. Upper Bay Planning Region Socioeconomic Data*

	Kings County
White	49.5%
Black or African American	34.1%
Asian	12.7%
Other Races	3.7%
Hispanic or Latino^	19.1%
Owner-Occupied Homes	30%
Median Household Income	$52,782
Households Below the Poverty Level	18.9%

*All socioeconomic data is based on the United States Census Bureau Population Estimates Program (PEP) and the American Community Survey (ACS), which are updated annually.

^Those identifying as Hispanic or Latino may be of any race, and are included in applicable race categories.

2.2.4.16 Aesthetics and Scenic Resources

The New Jersey shoreline of Upper New York Bay is dominated by commercial industrial facilities. Riprap and bulkheads predominate along the shore in this area to accommodate these facilities. Very little natural shoreline remains in this area, with the exception of wetlands to the west of Liberty Island, some interpier areas, and a small area north of Caven Point. Mudflats are found along the New Jersey shoreline of Upper New York Bay. A large mudflat is located between the Military Ocean Terminal at Bayonne and Constable Hook (USACE, 1999).

The northern section of the Brooklyn shoreline from the Brooklyn Bridge to Owls Head Park is dominated by the Brooklyn Marine Terminal and the Red Hook Container Terminal. Common shoreline characteristics include a mixture of maintained piers, rock riprap and sheet pile bulkheads, boat launches, residential buildings, and warehouses. The central portion of the Brooklyn shoreline consists of the Shore Parkway about 10 feet above the high-water mark, a landfill, and a small-boat marina. The Upper Bay Planning Region provides many opportunities to view the waters of the area, mostly found along the waterfront of South Brooklyn, Bayonne, Jersey City, and a few on the waterfront of northern Staten Island. The entire shoreline of Governors Island is publicly accessible, providing additional views of the region.

2.2.4.17 Coastal Zone Management

The Coastal Zone Management Act of 1972 (16 United States Code 1451-1464) was enacted by Congress to balance the demands for growth and development with the competing demands for protection of coastal resources. This act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. This act is regulated in New York by the New York State Department of State, Division of Coastal Resources and in New Jersey by the NJDEP.

Local governments can participate in the New York Coastal Management Program through the Waterfront Revitalization of Coastal Areas and Inland Waterways Act, by preparing and adopting local waterfront revitalization programs. The programs provide more detailed implementation of the New York Coastal Management Program through use of existing broad powers such as zoning and site plan review. New York City, Piermont, Dobbs Ferry, Mamaroneck, Port Chester, and Rye have approved local waterfront revitalization programs in the HRE study area. The local program only advises on the New York State Coastal Management Program, and as such the New York State Department of State makes the final determination on coastal zone consistency.

New Jersey's coastal zone management program primarily derives its authority from three (3) state statutes: The Waterfront and Harbor Facilities Act of 1914 (New Jersey Statutes Annotated 12:5-3), the Wetlands Act of 1970 (New Jersey Statutes Annotated 13:9A), and the Coastal Area Facility Review Act (New Jersey Statutes Annotated 13:19). The Hackensack Meadowlands Reclamation and Development Act (New Jersey Statutes Annotated 13:17), Freshwater Wetlands Protection Act (New Jersey Statutes Annotated 13:9B), the law concerning the transportation of dredged materials containing PCBs (New Jersey Statutes Annotated 13:19-33) and the Department's dredging technical manual titled, “The Management and Regulation of Dredging Activities and Dredged Material Disposal in New Jersey's Tidal Waters” are additional laws governing New Jersey’s enforceable coastal zone policies.

The Upper Bay Planning Region includes portions within the inland, seaward, and interstate coastal zone boundaries for New Jersey as well as within the coastal boundary of New York. Restoration activities within the region will be reviewed by the NJDEP and New York State Department of State for consistency with the policies of their respective coastal management programs. All information related to the USACE coastal consistency review is presented in Appendix F.

2.2.5 Lower Bay Planning Region

The Lower Bay Planning Region contains an expanse of both deep and shallow open water habitat, including Lower Bay, Raritan Bay, and Sandy Hook Bay (Figure 2-10). The planning region is bounded on the north by Staten Island and Brooklyn, on the south by Monmouth County, New Jersey. An artificial transect between Sandy Hook, New Jersey and Rockaway Point, New York separates Lower Bay from the New York Bight.

Sandy Hook peninsula, and Hoffman and Swinburne Islands just off Staten Island, are part of the Gateway National Recreation Area. In comparison to other planning regions in the HRE study area, the Lower Bay’s shoreline retains a more natural configuration, with salt marshes, extensive mudflats, and sandy beaches providing valuable fish and shellfish habitat, primarily in Raritan and Sandy Hook Bays (RPA, 2003). The USFWS National Wetlands Inventory depicts over 4,800 acres of intertidal and subtidal sand flats and mudflats off the shorelines of the bays and western Staten Island (USFWS, 1997). Sandy Hook is a nine-mile narrow sand spit that has a fairly extensive vegetated dune system and two (2) distinct maritime forest communities that encompass 285 acres. Soft shoreline habitat, primarily sandy bank, also surrounds Coney Island, with occasional riprap and seawalls (USACE, 1999). Beach habitat provides foraging areas for waterfowl and shorebirds (RPA, 2003). Riparian forests of the Atlantic Highlands occur along the upper reaches of the Navesink and Shrewsbury Rivers (RPA, 2003; USACE, 2004a; USACE, 1999). Raritan Bay and Sandy Hook Bay also support the greatest variety of state and federally listed threatened and endangered species in the HRE study area (USFWS, 1997).

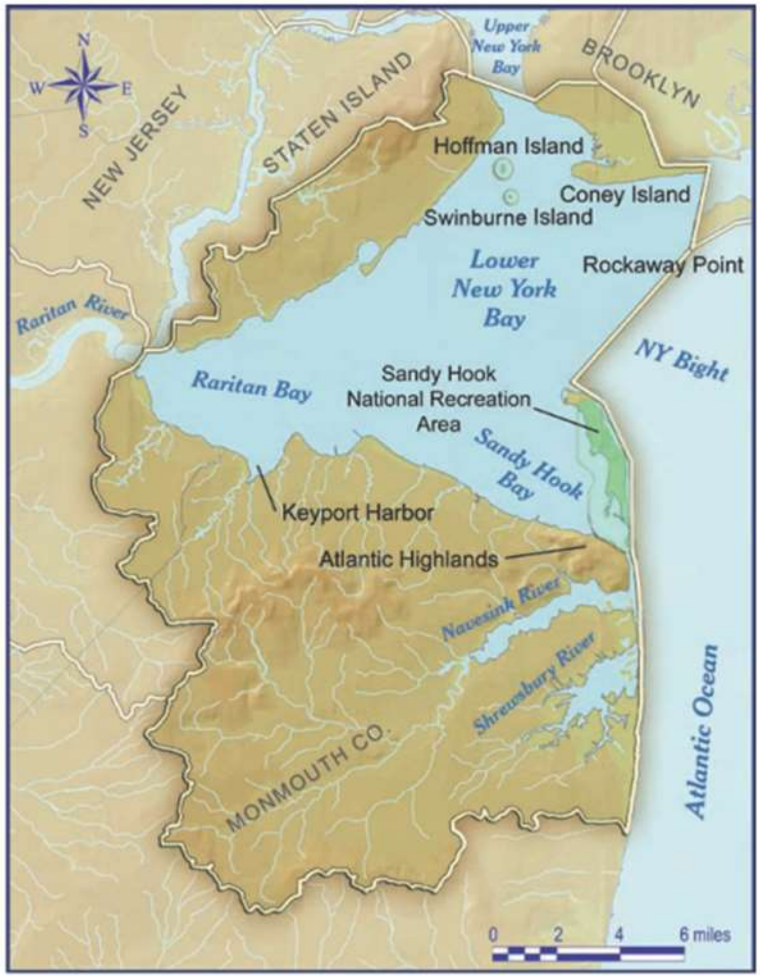


Figure 2-10. Lower Bay Planning Region.

2.2.5.1 Geomorphology and Sediment Transport

The Lower Bay Planning Region lies on the Inner Coastal Plain, within the Atlantic Coastal Plain physiographic province. Most of the sediment in this area are marine deposited sedimentary sands, gravels, and clays. The sedimentary deposits of the Inner Coastal Plains that were deposited during the Cretaceous Period are separate from the Outer Coastal Plain to its southeast by a belt of hills called Cuestas (USFWS, 1997). The Lower Bay area of the HRE has sediments made up mostly of sand varying in grain size. Lower New York Bay sediments in the area just south of the Narrows are characterized by gravelly sands underlying the main channel, with finer-grained sands, clays, and silts to the east and west. Extensive deposits of sand characterize the northern part of the Lower New York Bay (USACE, 1999). Additional available information can be found in the Engineering Appendix C.

2.2.5.2 Water Resources

Major waterbodies in this planning region provide a combination of marine and estuarine habitats that support diverse ecological communities (USACE, 2004a); Lower Bay generally provides deeper, marine habitat, while the Raritan Bay–Sandy Hook Bay complex is generally shallow with much of the bay's 69,188 acre-area at less than 20 feet deep (USFWS, 1997). Lower Bay is influenced by Jamaica Bay, Upper Bay, the Atlantic Ocean, and dozens of freshwater tributaries. Raritan Bay receives inputs from the Raritan River and Newark Bay and its tributaries via the Arthur Kill. Sandy Hook Bay receives inputs from the Navesink and Shrewsbury Rivers, which are separated from the Atlantic Ocean by a barrier beach.

The Lower Bay Planning Region is within the Sandy Hook-Staten Island watershed and contains an expanse of both deep and shallow open water, including Lower New York Bay, Raritan Bay, and Sandy Hook Bay. The watershed includes Kings and Richmond counties in New York, and portions of Essex, Union, Middlesex, and Monmouth counties in New Jersey. The watershed occupies 354,963 acres and ranges in elevation from negative seven (7) to 646 feet above sea level (NRCS, 2011). Raritan Bay receives inputs from the Raritan River and Newark Bay and its tributaries via the Arthur Kill. Sandy Hook Bay receives inputs from the Navesink and Shrewsbury Rivers, which are wide tidal rivers with a few dredged material and salt marsh islands at the confluence of the two (2) rivers, surrounded by mostly residential development and separated from the Atlantic Ocean by developed barrier beaches (USFWS, 1997).

Flooding events associated with only excessive rainfall are rare in the study area due to the system of stormwater conveyances and outfall. Flooding of low-lying areas is more likely to occur from storm surges from tropical storms or “nor’easters” that can surcharge water back into catchment systems combined with heavy precipitation. Coastal flooding in the region is likely to occur less than once every 10 years and is typically restricted to one tidal cycle (a half day).
Hurricane Sandy caused extensive damage along the Atlantic shoreline, within coastal wetlands and freshwater surface waters in the Lower Bay Planning Region. The Atlantic shoreline, including Coney Island in New York, Sandy Hook, and areas south to Manasquan Inlet in New Jersey, experienced changes to the shore profile and loss of beach fill and erosion, with an estimated average drop in beach elevation of five (5) to 10 feet. Locations which previously supported dunes prior to the storm lost up to 100 percent of existing dunes (including dune vegetation), which is critical habitat for nesting seabirds, and feeding and roosting migratory shorebirds (USACE, 2012). Where sand was pushed 60 to 150 feet inland, significant amounts overwashed into the streets of many coastal residential areas including the Borough of Atlantic Highlands, New Jersey (HRF, 2012), the private community of Sea Gate, New York, and Staten Island Borough (USACE, 2012). Sandy Hook was exposed to the full power of the tidal surge and the worst of the storm’s winds. The shore profile was completely changed and sand dunes along the peninsula were pushed up to several hundred feet west. Many dunes were completely flattened, uprooting and dispersing the beach grass normally found on them and likely affecting the bird species that use them for breeding. In addition to the overwash of sand and beach erosion, many coastal areas, such as Coney Island, were inundated and sustained damages to residential buildings and waterfront structures including boardwalks, concrete walls, roads, and other coastal infrastructure. In the private community of Sea Gate, the waterfront bulkhead and the first row of residential buildings were severely damaged by storm waves (USACE, 2012).

Coastal wetlands within Raritan Bay and on Staten Island experienced damage caused by the tidal surge and debris. Reportedly, small mammal populations were eliminated in many areas, creating a food shortage for northern harriers, a New York State threatened species, and New Jersey State endangered hawk species. Wrack deposits were visible in many back-bay marsh areas, often at the marsh/upland forest edge. Approximately 100,000 tons of debris was deposited in Cheesequake State Park. This debris layer, composed mostly of reeds and other vegetation, combined with tires, duck blinds, and other manmade structures is expected to inhibit vegetation growth, impacting invertebrate communities (e.g., fiddler and marsh crabs) as well as kingfishers, herons, gulls, and other marsh-dependent birds that feed upon them (ALS, 2012). More information is required to assess the impacts to invertebrates, which could be devastating to marsh-dependent birds. The need for further impact assessment was noted as an important source of concern by resource managers throughout the planning region (ALS, 2012). In addition to coastal wetlands, Hurricane Sandy's tidal surge caused saltwater intrusions in freshwater lakes and wetlands throughout the Lower Bay Planning Region. Several vernal pools in the lowland forest were also destroyed by the storm surge. Affected species include frogs, toads, and salamanders (ALS, 2012). At Hooks Creek Lake in Cheesequake State Park, The saltwater intrusion was exacerbated by a dam/culvert structure damaged by the storm. Potentially impacted species include black bass, catfish, sunfish, carp, and crappie (ALS, 2012). Brown's Pond, located on Staten Island, experienced episodic fish kills as a result of saltwater inundation; impacted species included fish, primarily carp, ducks, and freshwater dependent shorebirds.

Maritime holly (*Illex opaca*) and red cedar *(Juniperus virginiana*) forests in Sandy Hook survived the storm. However, there was extensive damage to Atlantic white cedar (*Chamaecyparis thyoides*) swamp forests in Cheesequake State Park, including saltwater intrusion, blow-down trees, and the creation of canopy gaps. More than 300 trees were lost, including 100-year old oaks and numerous Atlantic white cedars.

Hurricane Sandy caused extensive damage to sewage treatment plants in waters surrounding the Lower Bay Planning Region. State officials issued water use advisories for surface waters within the Lower Bay Planning Region (ALS, 2012).

2.2.5.3 Vegetation

The Lower Bay Planning Region has a diversity of plant communities including numerous marine, estuarine and upland terrestrial habitats scattered throughout. Major waterbodies in the Lower Bay Planning Region provide a combination of marine and estuarine habitats that support diverse ecological communities (USACE, 2004a).

The south shore of Raritan Bay to Sandy Hook Bay is characterized by a narrow strip of high and low salt marsh and creeks with intertidal and shallow subtidal mudflats and sandflats extending from these habitats. The salt marshes along this shoreline consist of high and low marsh cordgrass with some black grass, marsh elder (*Iva frutescens*), and groundsel bush (*Baccharis halimifolia*) in the high tide zone, as well as invasive common reed. Riparian forests of the Atlantic Highlands line the freshwater tributaries that feed into Sandy Hook Bay, the Navesink and Shrewsbury Rivers (RPA, 2003; USACE, 2004a; USACE, 1999).

Sandy Hook is a nine-mile narrow sand spit that has a fairly extensive vegetated dune system and two (2) distinct maritime forest communities that encompass 285 acres. Extensive areas of back dune habitat occur toward the northern end, with dry sandy soils supporting shrubby vegetation. The west side of the Sandy Hook spit consists of extensive tidal mud and sandflats and salt marsh dominated by low marsh cordgrass, with a few small inland marsh areas dominated by common reed (USFWS, 1997).

Eastern Staten Island comprises the northwestern boundary of the Lower Bay Planning Region. Beach, maritime shrub and grassland, and forest communities, as well as highly urbanized areas, are located along the eastern Staten Island shoreline from the Verrazano Narrows to Tottenville.

2.2.5.4 Finfish

The waters of the Lower Bay represent the nexus between the nearshore shallow waters of western Brooklyn, eastern Staten Island, the mouth of Jamaica Bay, the greater Raritan Bay and the oceanic waters of the Atlantic Ocean. Fish that migrate into New York Harbor typically will at some point travel through the Lower Bay. Raritan and Sandy Hook Bays are characterized by saltmarshes, extensive mudflats, and sandy beaches with valuable fish and shellfish habitat (RPA, 2003).

Characteristic fish species of the Lower Bay Planning Region include bay anchovy, winter flounder, American shad, Atlantic tomcod, and alewife (NJDEP, 1984). Thirty-two (32) species of fish have been reported in the upper and lower bays; the most abundant estuarine species include mummichog, bay anchovy, Atlantic silverside, white perch, and hogchoker (*Trinectes maculatus*). Weakfish, bluefish, winter flounder, summer flounder, striped bass, black sea bass, tautog, and scup support recreational fisheries (USFWS, 1997).

2.2.5.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from NOAA NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate EFH for all managed species, to minimize to the extent practicable adverse effects on EFH, and to identify other actions to encourage the conservation and enhancement of EFH. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (NOAA, 2004). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining “waters” to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties: “substrate” to include sediment, hard bottom, and structures underlying the water; areas used for “spawning, breeding, feeding, and growth to maturity” to cover a species’ full life cycle; “prey species” as being a food source for one or more designated fish species (NOAA, 2004).

NOAA’s Guide to EFH Designations in the Northeastern United States provides the species and life stages with EFH. Table 2-5 lists the EFH designations in the Lower Bay Planning Region. The Lower Bay Planning Region falls within two (2) 10-minute grids, one of which also covers a portion of the Upper Bay Planning Region (NOAA, 2016b). EFH is discussed further in Appendix F.

Table 2-9. Summary of EFH Designation for Lower Bay Planning Region

Managed Species	Eggs	Larvae	Juveniles	Adults
Red hake (*Urophycis chuss*)	X	X	X	
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X
Windowpane flounder (*Scophthalmus aquosus*)	X	X	X	X
Atlantic sea herring (*Clupea harengus*)		X	X	X

Managed Species	Eggs	Larvae	Juveniles	Adults
Bluefish (*Pomatomus saltatrix*)			X	X
Atlantic butterfish (*Peprilus triacanthus*)		X	X	X
Atlantic mackerel (*Scomber scombrus*)			X	X
Summer flounder (*Paralichthys dentatus*)		X	X	X
Scup (*Stenotomus chrysops*)			X	X
Black sea bass (*Centropristis striata*)			X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Sand tiger shark (*Carcharias taurus)*				
Dusky shark (*Carcharhinus obscurus*)		X	X	
Sandbar shark (*Carcharhinus plumbeus*)		X	X	X
Source: NOAA, 2016. 10’x10’ square coordinates: 40° 30.0’N, 74° 00.0’W, 40° 20.0’N, 74° 10.0’W 40° 40.0’N, 74° 00.0’W, 40° 30.0’N, 74° 10.0’W				

2.2.5.6 Shellfish and Benthic Resources

Benthic habitats within New York Harbor have been studied extensively as part of the USACE New York District Harbor Deepening Project. The findings indicate that extensive shellfish beds and ampeliscid mats are found in the sandy sediments of the Lower Bay, which is the least disturbed by urban and industrial influences. The Lower Bay was least susceptible to pollution and degradation and typically has better water quality than other areas of the harbor. Species identified in the Lower Bay include hard and softshell clams, eastern oyster, surf clam and blue mussel.

As a result of the poor water quality in the Raritan and Sandy Hook Bays, shellfish that are harvested must undergo a purification process before they can be sold for consumption. Areas are assigned for shellfish areas, and harvesting outside of these areas is illegal (NJDEP, 2008). Additional information regarding shellfish/oyster habitat within the planning region is found in the Engineering and Plan Formulation Appendices (C and D-8, respectively).

2.2.5.7 Wildlife

The Raritan Bay-Sandy Hook Bay complex is one of the USFWS Significant Habitats and Habitat Complexes of the New York Bight Watershed (USFWS, 1997). The combination of geographic location and configuration coupled with productive bay wetlands, flats, and waters in Raritan Bay make it an important migratory staging area for many species of waterfowl on the Atlantic Flyway. Beach habitat provides foraging areas for waterfowl and shorebirds (RPA, 2003). Additionally, Sandy Hook is an important migratory corridor for raptors, including northern harrier, osprey, common barn owl, red-tail hawk, Cooper’s hawk (*Accipiter cooperii*), sharp-shinned hawk

(*Accipiter striatus*), American kestrel, and peregrine falcon. Overwintering raptors include northern harrier, rough-legged hawk, American kestrel, common barn owl, short-eared Owl, long-eared owl, and peregrine falcon. The small mammal and songbird populations of the urban core provide a rich food resource for resident and migratory raptor populations (USFWS, 1997).

2.2.5.8 Rare, Threatened, and Endangered Species

Raritan Bay and Sandy Hook Bay support the greatest variety of state- and federally-listed threatened and endangered species in the HRE study area (USFWS, 1997). The undeveloped condition of Sandy Hook makes it a favorable nesting habitat for several protected species, including the federally listed threatened piping plover and the state-listed endangered least tern (USFWS, 1997).

Since the only proposed restoration site in Lower Bay is a marine oyster restoration site, federal agency correspondence was limited to NOAA NMFS. NJDEP Landscape Project version 3.1 data was also reviewed. Agency correspondence is located in Appendix F.

National Marine Fisheries Service (NMFS)

Four (4) species of ESA sea turtles that have been seasonally present in the Lower Bay Planning Region are listed by the NMFS, including:

- Threatened Northwest Atlantic Ocean DPS of loggerhead;
- Threatened North Atlantic DPS of green;
- Endangered Kemp's ridley; and,
- Endangered leatherback sea turtle.

These threatened and endangered sea turtles can be present in the Lower Bay area from May to mid-November. Adult and sub-adult Atlantic sturgeon can be found in the Lower Bay Planning Area. The New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPS are endangered, and the Gulf of Maine DPS is threatened in the area. Atlantic sturgeon eggs, larvae, or juvenile life stages will not be found in the waters of the Lower Bay Planning Area. Additionally, the shortnose sturgeons, of the adult and sub-adult life stages are also present in these waters.

New Jersey Department of Environmental Protection (NJDEP)

NJDEP Landscape Project 3.1 has also identified foraging habitat within the project area for the special concern species common tern.

It is assumed that prior to construction activities a resource inventory would be conducted to determine if these species are present. Chapter 5 discusses these inventories in greater detail.

2.2.5.9 Land Use

The Lower Bay Planning Region is predominantly developed with industrial, commercial, and residential land uses. Sandy Hook's shoreline is interspersed with public and private marinas, sandy beaches, and riprap shorelines (USACE, 1999). Private and public beaches are scattered throughout the region, located in Monmouth County, New Jersey, and on Coney Island and Staten Island, New York. The surface waters in this planning region are used for commercial shipping, recreational boating, and fishing/shellfishing (USACE, 2004a).

2.2.5.10 Hazardous, Toxic, and Radioactive Waste

As a result of industrial activities in and near the Lower Bay Planning Region, toxic contaminants such as heavy metals, hydrocarbons, PCBs, and PAHs, are present in the sediments. Shellfisheries in this area have been closed and fish consumption advisories have been issued due to high sediment contamination in the planning region. Sediment contamination in Raritan Bay is generally the result of the outflow from the Arthur Kill and the Raritan River. The highest toxicity levels are found in western Raritan Bay. Previous studies within the Lower Bay have identified areas with slightly elevated levels of arsenic, copper, and mercury and moderate to high levels of nickel, silver, zinc, and chromium. The Lower Bay also has localized “hotspots” of aldrin and hexachlorobenzene (USACE, 2004a).

An April 2016 Environmental Data Resources, Inc. database search was conducted within one (1) mile of the Naval Weapons Station Earle, located in Sandy Hook Bay (Figure 2-11). According to the Environmental Data Resources, Inc. database search, *Naval Weapons Station Earle* has operated since the 1940s as a base for renovation, storage, and maintenance of ammunition, including small arms, missile components, and explosives. Twenty-seven (27) areas of concern have been identified at the station under the Superfund program, and three (3) areas are permitted under the Resource Conservation and Recovery Act. Contamination was first detected in the 1980s, and has since come to include contaminants from paint and ammunition chips, PCBs, lead, volatile organic compounds, and hydrocarbon compounds. In addition a 2-mile long naval service pier that includes fuel lines and transports munitions extends above the proposed restoration site.

Figure 2-11. Naval Weapon Station Earle. (Source US Navy)

Leonardo State Marina is a state run marina located to the east of the NWS Earle site, which features a boat launch and 176 berths. The marina has several records, including the removal and ongoing remediation of a fuel tank, and a sunken vessel, which resulted in release of fuel and other contaminants. Additional details on potential HTRW in the Lower Bay Planning Region can be found in Appendix G.

2.2.5.11 Noise

Ambient noise levels within the Lower Bay Planning Region would likely be in the lower to mid-range, as much of the planning region encompasses residential communities, open water or open space. The primary sources of noise in the planning region include boat traffic in Raritan and Sandy Hook Bays, automobile traffic on local roads, and periodic explosions from demolition training at Naval Weapons Station Earle. Receptors in the Lower Bay Planning Region include residential areas and wildlife habitats. Noise criteria and the descriptors used to evaluate project noise will depend on the type of land use in the vicinity of the proposed project areas.

2.2.5.12 Navigation

The Ambrose Channel, providing 50-foot water access, is the main shipping channel in and out of the Port of New York and New Jersey. The Ambrose Channel is part of the Lower Bay located several miles off the coasts of Sandy Hook, New Jersey and Breezy Point, Queens, New York. The Ambrose Channel connects to the Anchorage Channel at the Narrows which connects to channels leading to main container terminals within the Port to accommodate the fleet of larger and deeper draft container ships. The Ambrose Channel terminates at Ambrose Anchorage, just south of the Verrazano Narrows Bridge.

Sandy Hook Channel has a project depth of 35 feet and provides a secondary route from the sea to deep water in Lower Bay; it connects with Raritan Bay Channel to the westward, Chapel Hill Channel to the north, and Terminal Channel to the south. Chapel Hill Channel has a project depth of 30 feet. Swash Channel, a natural buoyed passage between Ambrose Channel and Sandy Hook Channel, has a controlling depth of 18 feet. Terminal Channel, entered from Sandy Hook Channel about one (1) mile west-southwest of the northern tip of Sandy Hook, leads to a turning basin, and two deepwater ammunition handling piers of the U.S. Naval Ammunition Depot at Earle/Leonardo. Federal project depth is 35 feet in the channel and turning basin. The deepwater piers and barge pier are connected to the shore by a trestle that extends nearly two (2) miles across the mud flats from Earle/Leonardo. This area is restricted to authorized craft or vessels only (NOAA, 2017).

Raritan Bay is full of shoals with depths of seven (7) to 18 feet. Great Kills Harbor, a shallow bight on the south side of Staten Island, is used as an anchorage by small craft. The harbor is entered through a dredged channel that leads from deep water in the Lower Bay along the southwesterly side of Crookes Point, thence along the westerly side of the harbor to the head of bay. Coney Island Channel is a buoyed passage along the south side of Coney Island that leads from deep water in Lower Bay to Rockaway Inlet. In January-April 2000, the controlling depth was 12 feet. It is used principally by vessels going to Jamaica Bay and Coney Island (NOAA, 2017).

2.2.5.13 Recreation

The Lower Bay Planning Region has 120 public access points. These public access points are distributed fairly evenly around the planning region along the beaches of the Sandy Hook Peninsula, up the Navesink and Shrewsbury Rivers, the Raritan Bay shoreline of New Jersey to Perth Amboy, and the waterfront area of Staten Island.

Numerous public and private beaches are located in the Lower Bay region. Point Comfort beach, located in Keansburg, New Jersey, includes an amusement park/waterpark with a walkway along the beach. The south shore of Sandy Hook Bay features maintained beaches. The recently renovated South Beach, located on Staten Island just south of the Verrazano Narrows Bridge, offers views of the bridge and Lower New York Bay. Other beaches on the eastern shore of Staten Island include Midland Beach (part of Franklin D. Roosevelt Beach and Boardwalk), New Dorp Beach, Oakwood Beach, Fox Beach, Cedar Grove Beach (in Great Kills Park), Annandale Beach (Blue Heron Park Preserve), and Huguenot Beach (Bunker Ponds Park) (NYC Parks, 2012). The beach at Coney Island, on the south shore of Long Island in Brooklyn, features an amusement park, a boardwalk, and swimming beaches. Moving west, Manhattan Beach Park contains public swimming beaches, sports recreation areas, and play areas for children.

In the Lower Bay Planning Region many offshore coastal areas have been designated by New Jersey and New York as sport fishing grounds, including the intersection of the Chapel Hill South Channel, Raritan Bay Channel, Sandy Hook Bay, Old Orchard Shoal, Flynn’s Knoll, and Romer Shoal. A number of charter companies provide sport fishing opportunities in the New York and New Jersey Harbor. Many of these “party boats” can accommodate dozens of anglers and are based in Sheepshead Bay Brooklyn, and on City Island in the Bronx. Common recreational species caught by boat in the Lower Bay Planning Region include silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), striped bass, black sea bass, scup, weakfish, bluefish, summer flounder, and tautog (NJDEP, 1982).

Some fishing areas in the Lower Bay Planning Region can be accessed from piers and beaches (USACE, 2000). Recreational fishing areas have been designated in Gateway National Recreation Area, where waters are calm. At the Sandy Hook unit, a fishing beach is found just north of the ranger station, although surf fishing is permitted at any unguarded beach (USACE, 1999). Recreational species caught from shore include, weakfish, bluefish, winter flounder, summer flounder, and striped bass.

2.2.5.14 Cultural Resources

The Lower Bay Planning Region has a long history of occupation, first by Native American groups from as early as 12,000 before present until the arrival of European explorers in the fifteenth century. Early colonial settlements appear in the 1600s which evolve slowly from agricultural to industrial in character followed by urbanization in the last century. Potential for prehistoric and historic archaeological sites exists throughout the region. Archaeological sites and above ground historic properties can be found in upland, lowland, marsh, and submerged environments. Architectural and archaeological investigations are required to determine the presence or absence of such resources in most of the study area due to lack of existing data.

In 2014 the USACE completed a cultural resources survey titled *Cultural Resources Overview of the Hudson-Raritan Estuary Comprehensive Restoration Plan* (Harris et al., 2014) that aimed at inventorying all existing cultural resources data relevant to the 301 candidate restoration sites in the HRE study. General background information about the region was collected to provide a historical and cultural context. Cultural resources data was not compiled for the entire Lower Bay Planning Region but for each potential restoration site and a one-mile buffer area that was applied to the site for the survey. There were seven (7) restoration sites investigated in the Lower Bay Planning Region.

More than 1,000 historic properties, archaeological sites, historic districts, and surveys were compiled for the Lower Bay Planning Region. There are 597 historic properties; 542 of which are in the New Jersey portion of the region. In New Jersey, the recorded historic properties are concentrated in Keyport, Middletown Township, Red Bank, and Matawan. The 55 New York resources are found throughout eastern Staten Island and Gravesend, Brooklyn. Of the 19 historic districts in this region, 17 are located in New Jersey and two (2) in New York. Notable districts include the Naval Weapons Station Earle Historic District, Fort Hancock and Sandy Hook Proving Ground Historic District, and Garden State Parkway Historic District (Monmouth), all in New Jersey, and Fort Wadsworth Historic District on Staten Island, New York.

A total of 168 archaeological sites are recorded in this planning region; 103 in New York and 65 in New Jersey. These sites are found most densely along the eastern shoreline of Staten Island, but also along the near shore areas of the Raritan Bay in New Jersey. A total of 78 AWOIS objects are documented all around Raritan Bay, but found in concentration in Gravesend Bay, Brooklyn and off of Belford Harbor in Monmouth County, New Jersey. Finally, a total of 166 cultural resources surveys have been carried out in the region; 141 in New Jersey and 25 in New York. Many of the surveys in the New York portion of the region are large marine surveys in the Raritan Bay, while in New Jersey many surveys area found along the southern shore of the Raritan Bay, in the Matawan Creek drainage, and in Sandy Hook.

2.2.5.15 Social and Economic Resources

The Lower Bay Planning Region lies mostly within Monmouth County, New Jersey, with small portions falling within Middlesex County, New Jersey and Kings and Richmond counties in New York. The recommended site located in the Lower Bay Planning Region is found in Monmouth County. The population of Monmouth County is over 600,000 according to the 2010 Census (United States Census Bureau, 2010). The demographic makeup of Monmouth County can be found in Table 2-10. Median household income for Monmouth County where the recommended site is located is $91,807 (in 2018 dollars).

Table 2-10. Lower Bay Planning Region Socioeconomic Data*

	Monmouth County
White	84.6%
Black or African American	7.6%
Asian	5.7%
Other Races	2.1%
Hispanic or Latino^	11.1%
Owner-Occupied Homes	73.8%
Median Household Income	$91,807
Households Below the Poverty Level	6.7%

*All socioeconomic data is based on the United States Census Bureau Population Estimates Program (PEP) and the American Community Survey (ACS), which are updated annually.

^Those identifying as Hispanic or Latino may be of any race, and are included in applicable race categories.

2.2.5.16 Aesthetics and Scenic Resources

Salt marshes, beaches, and riprap- and bulkhead-protected shorelines characterize the New Jersey shoreline from Sandy Hook to Perth Amboy. Sandy beaches cover most of the shore on Sandy Hook, while the Perth Amboy shoreline is predominantly bulkheaded (USACE, 1999). The southern section of the Brooklyn shoreline is characterized by private dwellings, the Norton Point Coney Island Light House, a wide sand beach at Coney Island, and the Coney Island Amusement Park (USACE, 1999).

The view of the southeast shoreline of Staten Island from the Verrazano Narrows bridge southwestward to Tottenville is predominantly of sandy beaches, most of which are maintained and groomed (USACE, 1999). Looking east from Fort Wadsworth across the Narrows towards Fort Hamilton in Brooklyn, the Belt Parkway can be seen running along the bulkheaded shoreline. Coney Island Amusement Park and its associated beaches and boardwalk are also visible providing a scenic view of the Brooklyn shoreline.

2.2.5.17 Coastal Zone Management

The Coastal Zone Management Act of 1972 (16 United States Code 1451-1464) was enacted by Congress to balance the demands for growth and development with the competing demands for protection of coastal resources. This act requires that federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally approved state coastal zone management plans. This act is regulated in New York by the New York State Department of State, Division of Coastal Resources and in New Jersey by the NJDEP.

New Jersey's coastal zone management program primarily derives its authority from three (3) state statutes: The Waterfront and Harbor Facilities Act of 1914 (New Jersey Statutes Annotated 12:5-3), the Wetlands Act of 1970 (New Jersey Statutes Annotated 13:9A), and the Coastal Area Facility Review Act (New Jersey Statutes Annotated 13:19). The Hackensack Meadowlands Reclamation and Development Act (New Jersey Statutes Annotated 13:17), Freshwater Wetlands Protection Act (New Jersey Statutes Annotated 13:9B), the law concerning the transportation of dredged materials containing PCBs (New Jersey Statutes Annotated 13:19-33) and the Department's dredging technical manual titled, “The Management and Regulation of Dredging Activities and Dredged Material Disposal in New Jersey's Tidal Waters” are additional laws governing New Jersey’s enforceable coastal zone policies.

The Lower Bay Planning Region includes portions within the inland, seaward, and interstate coastal zone boundaries for New Jersey as well as within the coastal boundary of New York. Restoration activities within the region will be reviewed by the NJDEP and/or New York State Department of State for consistency with the policies of their respective coastal management programs. All information related to the USACE coastal consistency review is presented in Appendix F.

2.2.6 Lower Raritan River, Arthur Kill/Kill Van Kull, and Lower Hudson River Planning Regions

All planning regions in the HRE study area are in need of and have opportunities for restoration. The Lower Raritan River, Arthur Kill/Kill Van Kull, and Lower Hudson River Planning Regions do not include sites that are being recommended in this FR/EA, thus only general background information is included for these planning regions. More information about the existing conditions of these planning regions can be found in in the HRE Comprehensive Restoration Plan (CRP) (USACE, 2016b) and will be documented in future "spin-off" feasibility studies since restoration is not recommended at this point in time due to sponsor readiness and funding limitations.

2.2.6.1 Lower Raritan River Planning Region

Primarily located in Middlesex County, New Jersey, the Lower Raritan River is the western-most planning region of the HRE study area (Figure 2-12). This region contains the lower six (6) miles of the Raritan River before its confluence with Raritan Bay (USACE, 2004a). Portions of the planning region stretch into Union, Somerset, and Monmouth Counties, New Jersey. The shoreline of the Lower Raritan River is flanked with residential or industrial development. Land use changes from predominantly industrial development with bulk-headed shorelines and piers at the river's mouth to a mix of industrial, commercial, and residential development farther upstream (USACE, 2004a; USACE, 1999). Agricultural lands are located along the upstream boundary of the planning region (USACE, 2004a). Isolated pockets of tidal wetlands occur along the shore (USACE, 2004a; USACE, 1999). An unremediated landfill, the former Raritan Arsenal, and the Sayreville and Werner generating stations are also located along the shoreline. Although there are no public bathing areas in the region,

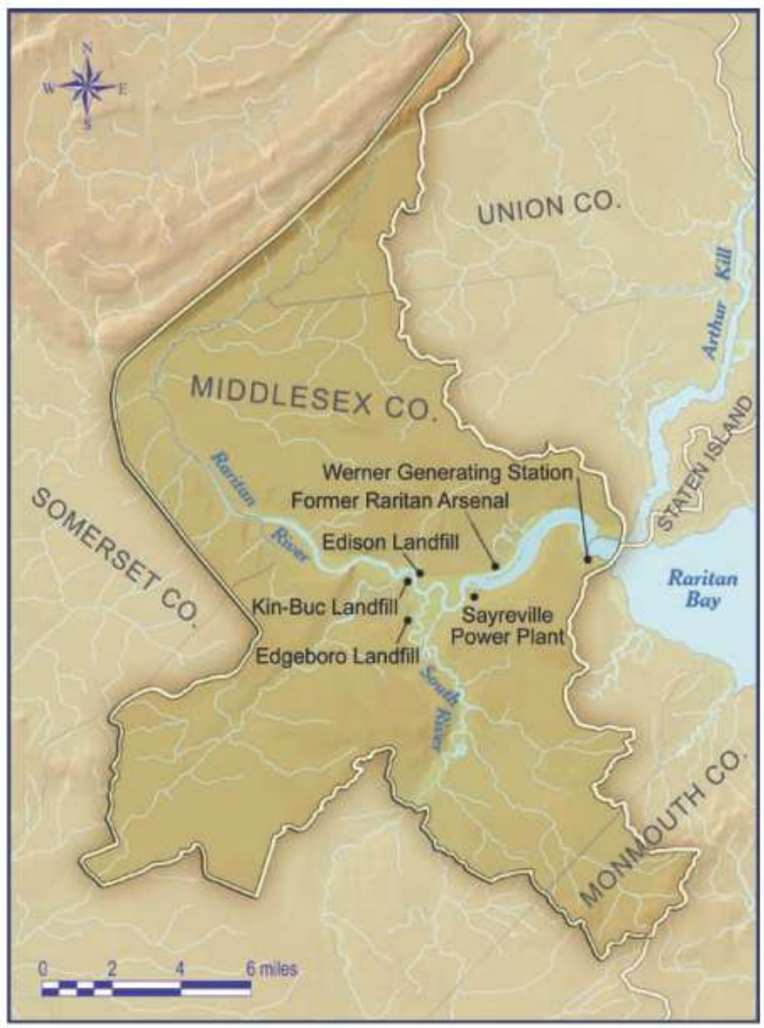


Figure 2-12. Lower Raritan River Planning Region.

waterbodies are used for recreational navigation and secondary contact recreation including water/jet skiing and fishing (USACE, 2004a).

This tidally influenced river features some regionally important floral and faunal assemblages (RPA, 2003; USACE, 2004a). A large wetland complex of 1,000 acres, located in Edison Township, provides habitat for waterfowl, wading birds, mammals, and fish (USACE, 2004a). Saltwater intrusion occurs throughout the length of the Lower Raritan River, with sensitive estuarine resources such as tidal wetlands, submerged aquatic vegetation, and intertidal mud flats occurring in shallow, nearshore areas (USACE, 1999). Some fallow or abandoned agricultural lands afford open spaces for upland wildlife (USACE, 2004a). However, these habitats are isolated and somewhat degraded due to the industrial land uses in the region.

The landscape of the Lower Raritan River Planning Region has changed tremendously over the past few centuries. Wetland losses due to filling have been estimated at 93 percent of their former area, and remaining wetlands are generally a degraded mix of non-native or invasive plants (USACE, 2004a).

In addition, 12 dams are located on the Lower Raritan River and its tributaries, impeding the movement of diadromous fish that travel upriver or downriver to spawn.

Hurricane Sandy affected the Lower Raritan River Planning Region with sustained flooding from the storm surge. The flooding rendered several major sewage treatment plants inoperable due to power outages, which resulted in the release of raw or partially treated sewage into local waterways. The Middlesex County Utilities Authority pump stations in Sayreville and Edison, New Jersey were severely damaged during Hurricane Sandy, causing the release of more than 1.1 billion gallons of sewage over a three (3) month period (Kenward et al., 2013). State officials issued water use advisories for several water bodies and described the event as an “ecological catastrophe.” The releases posed several threats, including hypoxic zones caused by waste-fed algal blooms, high concentrations of E. coli bacteria and

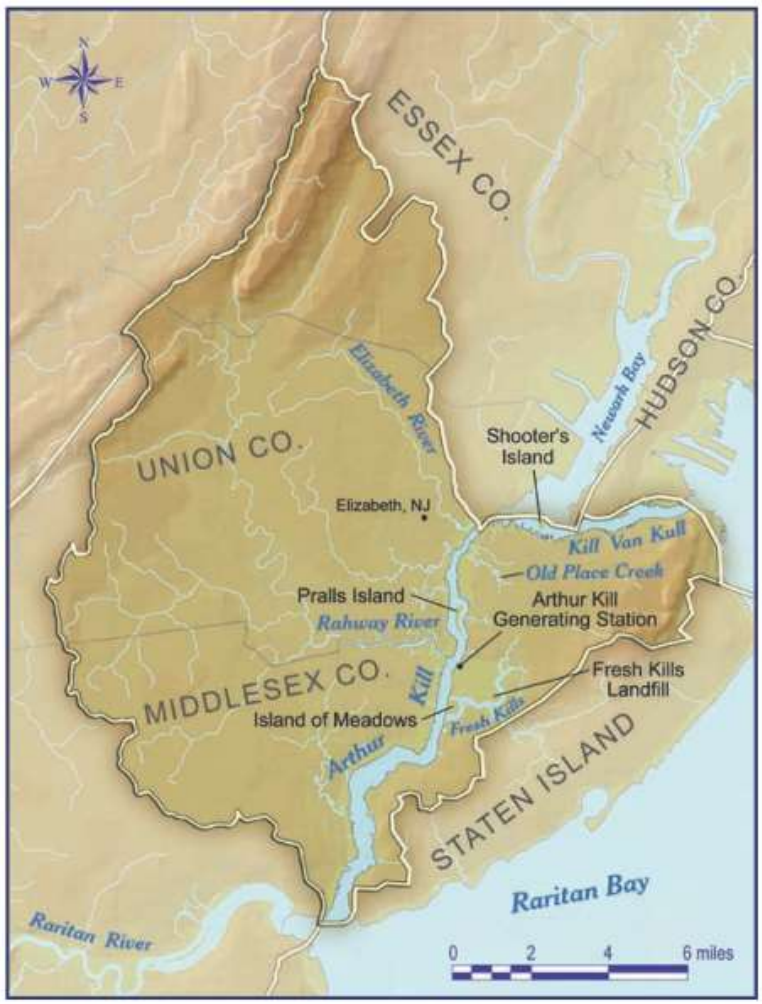


Figure 2-13. Arthur Kill/Kill Van Kull Planning Region.

other pathogens, and a general degradation of water quality. Impacted resources included fish, invertebrates, small mammals, wading birds, and amphibians (ALS, 2012).

2.2.6.2 Arthur Kill/ Kill Van Kull Planning Region

The Arthur Kill/Kill Van Kull Planning Region lies between Newark Bay and the Lower Raritan River (Figure 2-13). The Arthur Kill is a tidal strait that connects to Upper Bay via the Kill Van Kull (another tidal strait) and mixes waters with Newark Bay. The Arthur Kill also connects Newark Bay with Raritan Bay. Important tributaries to the Arthur Kill include the Rahway and Elizabeth Rivers, Old Place Creek, Woodbridge Creek, and Fresh Kills Creek (USACE, 2004a). The Arthur Kill/Kill Van Kull Planning Region has a dynamic hydrology due to the variation in tidal velocity, amount of freshwater flow, and bathymetry among the three (3) connecting bays (i.e., Upper, Newark, and Raritan Bays; USACE, 1999).

These waterways exist within a heavily industrialized and developed corridor, with an average population density of almost 5,000 people per square mile. The New Jersey side of the Arthur Kill is industrialized; large areas of wetlands are intermingled with industrial facilities on the New York side. On Staten Island, wetlands are located adjacent to the world's largest landfill (Fresh Kills) and the Arthur Kill Generating Station. In the southern section, many abandoned industrial facilities exist along the shoreline (USACE, 2004a). The industries of the Arthur Kill and Kill Van Kull waterways process petroleum and non-petrol chemicals along their shorelines, and occasional oil spills occur (Yozzo, et al. 2001, Steinberg et al. 2004). At least 30 closed landfills and dozens of contaminated brownfields once discharged leachate into the groundwater in this planning region (USACE, 2004a). Although leachate collection systems are now in place on most of the closed landfills, many contaminants persist in estuarine sediments (USACE, 2004a).

The Arthur Kill and Kill Van Kull also have deepwater navigation channels that allow transport of cargo into and out of the Ports of New York and New Jersey. Howland Hook Marine Terminal (HHMT) is located on Staten Island's northwestern waterfront along the Arthur Kill, approximately one mile west of Arlington, New York. The area between Arlington and HHMT is sparsely populated, with large industrial sites and a few local roadways. Much of the area is undeveloped and vacant. Prominent land uses around HHMT include transportation facilities and industrial sites. Industrial properties south of HHMT include the PANYNJ's Gulfport, Visy Paper Plant, R.T. Baker & Sons (defunct salvage operation), and the former GATX Staten Island Terminal Property. The extensive tributary system of the Arthur Kill supports a mosaic of tidal and freshwater wetlands, mudflats, and riparian forest. Deeper, open-water habitats in this planning region support over 60 migratory and resident fish species including species of commercial or recreational importance such as winter flounder (*Pseudopleuronectes americanus*) and black sea bass (*Centropristis striata*; RPA, 2003; USACE, 2004a). Northwest Staten Island and the islands along the Arthur Kill and Kill Van Kull were designated as a SNWA by NYC due to the diverse landscape of habitats (NYC, 2011). Arlington Marsh and Graniteville Swamp are examples of important habitats within this planning region. Three (3) islands are located in the Arthur Kill and Kill Van Kull Planning Region. Pralls Island and the Isle of Meadows are located adjacent to the western shoreline of Staten Island on the Arthur Kill, and Shooters Island is located on the Kill Van Kull.

Large breeding populations of herons, egrets, and ibises have used these uninhabited islands as nesting sites, and the nearby marshlands and mudflats as foraging areas. From the late 1970s through the early 1990s, the islands supported the largest heron rookery in New York State. It was estimated that the entire rookery in the HRE study area accounted for almost 25 percent of the wading birds that nested in coastal waters within New York, New Jersey, and Connecticut (USFWS, 1997). Although none of the islands in the Arthur Kill region currently support active wading bird rookeries, these islands provide habitat for other bird species and may be recolonized by wading birds in the future (Bernick, 2006). Many of the coastal sections in this planning region are fragmented or degraded and monotypic stands of common reed (*Phragmites australis*) dominate wetland parcels (USACE, 2000). Several spillways and cement riverbeds exist on tributaries on both sides of the Arthur Kill, creating ponds for urban parks (Durkas, 1992). Unfortunately, these structures often deter movement of anadromous fish (USACE, 2000; Durkas, 1993; Durkas, 1992; USFWS, 1997). This region has had long-term issues with poor water quality and high contaminant levels (USACE, 1999). However, because this HRE planning region contains More than 30,000 acres of open space, these sites have the potential to be important for future habitat restoration programs (RPA, 2003).

Damage from Hurricane Sandy within the Arthur Kill and Kill Van Kull Planning Region included shoreline erosion, loss of colonial bird nesting habitat, oil spill contamination, and sewage releases. The western shore of Staten Island experienced flooding, but relatively little wind damage. Coastal areas experienced some erosion, with sizable sections of shoreline eroded away by waves in some locations (HRF, 2012). Pralls Island sustained a complete overwash from Hurricane Sandy’s storm surge, as well as damage to trees and other plants from both the surge and high winds. Debris previously scattered along Pralls Island’s edges was piled in the middle; deer fencing established to protect potential heron nesting areas was knocked own (ALS, 2012).

Oil spill contamination resulting from Hurricane Sandy impacted areas along the Arthur Kill, adjacent marshes and tributaries. As the storm surge flooded the banks of the Arthur Kill, several bulk fuel tanks were damaged, releasing nearly 378,000 gallons of diesel fuel into the water (ALS, 2012). Oil contamination in the area was far reaching, and oil coated marshes along the Arthur Kill shorelines of Staten Island and New Jersey, including Pralls Island and tidal tributaries such as Woodbridge Creek, Rum Creek, and Smith Creek. Impacted resources included fish, invertebrates, small mammals, wading birds, and a recently discovered species of leopard frog (*Rana kauffeldi*) documented to inhabit freshwater wetlands along the western shoreline of Staten Island (ALS, 2012). In addition to the release of oil, raw and partially treated sewage was spilled into the waters within the planning region. State officials issued water use advisories for several waterways including the Arthur Kill and the Kill Van Kull (ALS and NFWF, 2012).

2.2.6.3 Lower Hudson River Planning Region

The Lower Hudson River Planning Region extends from the Upper Bay to the Tappan Zee Bridge and includes portions of Bergen and Hudson Counties in New Jersey, NYC, Rockland, and Westchester Counties in New York (Figure 2-14). The western Manhattan, west Bronx, and lower Westchester County shoreline is densely populated. Areas in northeastern New Jersey along the Hudson River coastline are among the most populated in the state (USACE, 2006a).

The Palisades Interstate Park runs along the western shoreline of the Lower Hudson River from Bergen County, New Jersey to Rockland County, New York. Recreational and commercial boating is prevalent in the Lower Hudson River.

Figure 2-14. Lower Hudson River Planning Region.

Land use along the shoreline consists of residential areas, marinas, marine parks, some vacant disturbed lands, and scattered commercial and industrial facilities, especially in areas below the George Washington Bridge. Several commercial/industrial facilities (including the World Financial Center) draw cooling water from the Lower Hudson River; nine (9) wastewater treatment plants are also located in this region (USACE, 2004a). Power plants and industrial facilities draw cooling water from the Lower Hudson River and discharge heated water back into the river.

Strong semi-diurnal tides make the Lower Hudson River one of the few major tidal rivers of the North Atlantic coast (USFWS, 1997). This stretch of river is naturally turbid, with limited primary productivity and moderate to high salinity levels. The Lower Hudson River includes a wide range of riverine and estuarine habitats that function as overwintering habitat and significant nursery areas for many fish and invertebrate species (USACE, 2004a; USFWS, 1997; USACE, 2000). The Lower Hudson River is the primary nursery and overwintering area for striped bass (*Morone saxatilis*) in the Hudson River estuary. Two (2) federally listed endangered species, shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*A. oxyrhynchus*), also spawn in the Lower Hudson. At the northern reach of the region, Piermont Marsh, a brackish intertidal wetland supports a variety of aquatic and terrestrial species. Shallowwater habitat of the Lower Hudson River, including shoals and inter-pier areas, may be important foraging sites for young fish before they move into deeper harbor waters (USACE, 2004a).

Like most major rivers in the U.S., the Lower Hudson River is maintained for navigation and has been affected by centuries of human use. Shorelines and wetlands were extensively altered, relocated, and eliminated between 1800 and 1972. Hundreds of dams have been built in tributaries leading to the Hudson, fragmenting habitats, degrading water quality, and preventing migratory fish movement, while simultaneously welcoming invasive plant and animal species in the estuary (Miller, 2013). Consumptive water use has altered the natural salinity range, resulting in secondary effects on species diversity and habitat function, particularly of wetlands such as Piermont Marsh, which are currently dominated by monotypic common reed stands (USFWS, 1997). Maintenance of the shipping channel and bulkhead construction have progressively narrowed and deepened the river. The western shore runs along the Palisades (a geologic feature dominated by steep, rocky shorelines); therefore, littoral (e.g., shallow water) habitat is naturally sparse. Bulkhead and pier construction on the eastern shore eliminated any remaining natural shoreline and littoral habitats (USACE, 2000).

The Lower Hudson River is also contaminated with persistent chemicals. Between 1946 and 1977, about 1.3 million pounds of PCBs were released from two (2) General Electric Company plants located in the Upper Hudson River, upstream from the HRE study area (NYSDEC, 2015). The USEPA designated a 200-mile stretch of the Hudson River, from Hudson Falls to the Battery in NYC, as a Superfund site due to this contamination. PCBs from the discharge points were transported to the Lower Hudson River, causing bioaccumulation and contamination of fishery resources throughout the river. A cleanup called for targeted environmental dredging of approximately 2.65 million CY from a 40-mile section of the Upper Hudson. In 2009, the USEPA and General Electric initiated the first phase of dredging a 14-mile stretch of the Upper Hudson River in an effort to remove PCBs that were discharged north of the Federal Troy Lock and Dam (USEPA, 2014c). The second phase of dredging began in 2011 dredging to remove PCBs from a 40-mile stretch of the upper Hudson River between Fort Edward and Troy, New York was completed in the fall 2015. The Operation, Maintenance & Monitoring phase of the project is underway and will continue. During this phase, monitoring is conducted to track the ongoing recovery of the river and the effectiveness of the cleanup over time. The five-year review period will be completed by April 23, 2017 (USEPA, 2016; http://www.epa.gov/hudson).

In 1976, the contamination of benthic habitat and fish tissue in the Hudson River led New York State to close the commercial striped bass fishery throughout the river and to issue consumption warnings for many other important species of the Hudson River (USEPA, 2008; NYSDOH, 2014). The New York State Department of Health (NYSDOH) recommends that children and women under 50 should not eat any fish from the Lower Hudson River, and men over 15 and women over 50 should consume no more than one meal per month of striped bass collected from the Lower Hudson (NYSDOH, 2014).

During Hurricane Sandy, the Yonkers Joint Wastewater Treatment Plant released 1.2 billion gallons of partially treated sewage into the Lower Hudson River; the North River Wastewater Treatment Plant on the west side of Manhattan released 83 million gallons of raw sewage into the river in the first few days following the storm (Kenward, et al. 2013). The impact of Hurricane Sandy in the Lower Hudson River region was felt by all counties along the New Jersey shoreline of the Hudson, and in New York, north of the HRE study area, as far as Albany and Rensselaer Counties (USACE, 2015a).

In order to minimize similar impacts in the face of future storm events along the Upper Hudson River, the NYSDEC Hudson River Estuary Program released a restoration plan in 2013 and the

Action Agenda 2015-2020 (Miller, 2013; NYSDEC, 2014). These reports, in conjunction with the future Hudson River Comprehensive Restoration Plan and Hudson River Habitat Restoration Feasibility Study, will complement the HRE CRP for the Hudson River north of the Tappan Zee Bridge.

2.3 Air Quality

The HRE encompasses a highly urbanized and industrialized setting, including many major transportation corridors servicing the New York City Metropolitan Area. As required by the Clean Air Act of 1970, National Ambient Air Quality Standards have been established for six (6) major air pollutants identified by USEPA as being of nationwide concern: carbon monoxide, nitrogen oxides, ozone, particulates, sulfur oxides, and lead. In the HRE study area, ambient concentrations of carbon monoxide, ozone, and lead are predominantly influenced by vehicle emissions, nitrogen oxides and particulates are emitted from both motor vehicle and stationary sources (e.g., power generation, industrial), and emissions of sulfur oxides and sulfates are mainly from stationary sources. These standards have also been established as the ambient air quality standards for New York and New Jersey. Primary standards are intended to protect public health, while secondary standards are intended to protect public welfare (e.g., physical damage to structures, ecological damage).

The NJDEP and the NYSDEC operate a network of air monitoring stations to evaluate pollutants and compare them to the National Ambient Air Quality Standards (NJDEP, 2014; NYSDEC, 2014). Additionally, NJDEP has established a Pollutant Standards Index, which is based on concentrations of individual pollutants including carbon monoxide, nitrogen oxides, suspended particulates as "smoke shade," sulfur dioxide, ozone, non-methane organic compounds, and inhalable particulates. Ambient air in the region is similar to that of other highly urbanized areas. Placing emission controls on automobiles and industrial sources and limiting sulfur content of fuels have helped to improve the regional air quality in the HRE over the last 30 years.

With respect to the National Ambient Air Quality Standards (NAAQS, 40CFR§81.333), the counties in which project elements are located (Kings, Queens, Bronx, and Westchester Counties, NY and Bergen County, NJ) are currently classified as in 'moderate' nonattainment of the 2015 8-hour ozone standard, "serious" nonattainment of the 2008 8-hour ozone standard, and 'maintenance' for the 2006 particulate matter less than 2.5 microns ($PM_{2.5}$) standard. These counties are part of the Ozone Transport Region. Ozone levels are controlled through the regulation of ozone precursor emissions, which include oxides of nitrogen (NO_x) and volatile organic compounds (VOC). Sulfur dioxide (SO_2) is a precursor of $PM_{2.5}$ (USACE 2014).

2.4 Environmental Justice

In 1990, the EPA established the Environmental Equity Workgroup to investigate the alleged inequity of environmental protection services in the communities of racial minority and low-income populations. As a result of the workgroup's final report and recommendations, the Office of Environmental Equity was established; this office was later renamed the Office of Environmental Justice (USEPA, 2004).

Environmental justice requires the fair treatment and meaningful involvement of all people with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. No group of people (including racial, ethnic, or socioeconomic groups) should experience a disproportionate share of negative environmental impacts from any private, state, or federal action, program, or policy (USEPA, 2004). In order to prevent such a situation, potentially affected communities should have every opportunity to participate in decisions about a proposed activity that will affect their environment and/or health. The potentially affected community should also be afforded the opportunity to influence the final decision of the regulatory agency involved through the consideration of that community's concerns (USEPA, 2004).

The NYSDEC identifies "Potential Environmental Justice Areas (PEJAs)" as census block groups meeting one or more of the following NYSDEC criteria in the 2000 U.S. Census (NYSDEC, 2016):

- 51.1% or more of the population are members of minority groups in an urban area;
- 33.8% or more of the population are members of minority groups in a rural area; or
- 23.59% or more of the population in an urban or rural area have incomes below the federal poverty level.

The NYSDEC publishes county maps identifying PEJAs, including Kings, Queens, and Nassau, Bronx, and Westchester counties (NYSDEC, 2016). Upon review, the recommended projects at Dead Horse Bay, Fresh Creek, Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park, and Flushing Creek are all within PEJA areas. Using this same criteria for the recommended sites in New Jersey, the team has determined that Oak Island Yards and Essex County Branch Brook Park are located in PEJAs.

No comments were received from the community during the public comment period for the draft Feasibility Report and Environmental Assessment. Additional public comment periods will occur during permitting and/or if design changes take place. The District is committed to receiving input from the communities identified as PEJAs and will update and engage the stakeholders during future phases of this study.

Chapter 3: Plan Formulation

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. U.S. Army Corps of Engineers (USACE) guidance for planning studies requires the systematic formulation of alternative plans that contribute to the federal objective. To ensure that sound decisions are made with respect to development of alternatives and ultimately with respect to plan selection, the plan formulation process requires a systematic approach to the formulation, comparison, and selection of plans. This chapter presents the results of the plan formulation process.

This study was conducted in accordance with the requirements of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983); Planning Guidance Notebook (Engineer Regulation [ER] 1105-2-100; USACE 2000a); Civil Works Ecosystem Restoration Policy (ER 1165-2-501); and Ecosystem Restoration Supporting Policy Information (Engineer Pamphlet 1165-2-502). The plan formulation framework incorporated an analytical screening process to develop alternative plans, based on existing information from prior plan formulation efforts and more recent data collection conducted for each site. The strategy involves the formulation of interdependent management measures and components that serve to meet the planning objectives while avoiding planning constraints.

3.1 Problems and Opportunities

This section documents the identification of problems and opportunities within the Hudson-Raritan Estuary (HRE), which is the first step in the USACE six (6)-step planning process (USACE 2000a). From the planning perspective, a problem can be thought of as an undesirable condition, while an opportunity offers a chance for progress or improvement. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives.

Plan Formulation General Terms

Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints.

Alternative plans are sets of one or more management measures functioning together to address one or more planning objectives.

Management measures are features or activities that can be implemented at a specific geographic site to address one or more planning objectives.

Features are structural elements that require construction or assembly on site. **Activities** are nonstructural actions.

3.1.1 Problems

As described in Chapter 2, the major environmental problems in the HRE are extensive habitat loss and degradation, which have reduced the quantity and diversity of habitats, and the functional and structural integrity of the overall HRE ecosystem and its ability to provide valuable and sustainable services. These acute environmental problems are due to the direct and indirect impacts of urban coastal development in New York and New Jersey. Development-induced impacts on the environment include the following degradation factors throughout the HRE Study Area over the centuries:

- Modifications to the natural hydrologic regime;
- Creation of fast land (upland) in former aquatic/wetland habitats;
- Shoreline hardening and modification;
- Blockage of anadromous fish passage by dams and culverts;
- Contaminant inputs to water and sediment; and
- Overall increase in impervious area throughout the watershed.

Figure 3-1. Historical Extent of Wetlands in the HRE Study Area (1778)

As a result of these (and other) stressors, populations of fish, shellfish, and fish-eating birds have been severely reduced through the combined impacts of habitat loss and system-wide degradation. Long-term habitat loss has been dramatic relative to historic extent (Figure 3-1) resulting in scarce habitat, for instance:

- Loss of > 99% of freshwater wetlands;
- Loss of > 85% of estuarine wetlands;
- Loss of 100% of oyster reefs (>200,000 acres);
- Loss of >95% of eelgrass beds; and
- Loss of ~2,000 acres of marsh islands in Jamaica Bay since 1924 (half of bay's vegetated marsh islands have disappeared between 1924 and 1999 [NYSDEC, 2001]).

Figure 3-2 illustrates this transformation depicting the past as seen by Henry Hudson in 1609 and the current city-scape of the Manhattan region. Site-specific problems at each of the sites in the initial array evaluated are presented in Section 3.7.

All regional partners are working together to implement the HRE Comprehensive Restoration Plan towards the overall restoration goals and targets for the future. Although partners are advancing restoration projects in the region, it is known that their efforts will only accomplish a small percentage of the restoration needed in the harbor. A large investment by the Federal Government and significant acreage that is recommended as part of the Recommended National Ecosystem Restoration (NER) Plan is needed to achieve significant progress for many of the Target Ecosystem Characteristic (TEC) goals.

Figure 3-2. Mannahatta (Sanderson, 2009)

Historically, the USACE has been the entity that has the technical experience to implement large scale restoration projects in the region.

Future Without Project (FWOP) conditions for each site will be further detailed based on any other partner activities that would be required as a precursor (EPA remediation or water quality improvements by NYCDEP) and those activities that will be completed in adjacent areas that will enhance connectivity of habitat and provide additional benefits to the area. The intent of the restoration plan is to coordinate all activities and leverage programs. Each of the activities proposed by the USACE will be within our aquatic ecosystem restoration mission. All measures proposed for each site will be confirmed within USACE mission and if measures are deemed more suitable for partners (additional terrestrial habitat, storm water measures), the non-federal sponsor will pay 100% of the costs.

3.1.2 Future Without Project Conditions

A planning horizon of 100 years comes into play with large scale civil works projects, like storm surge barriers and floodwalls. HRE, while collectively large, is composed of mostly medium- to small-sized restoration projects. Performance beyond 50-years was deemed challenging to assess given the resolution of ecological and economic models. While benefits are expected to accrue beyond 50-years, the economic period of analysis and planning horizon were both set at 50-years, from 2025 (for the first project), when the first construction season is assumed to end, to 2075. The terms are used synonymously throughout the report. The future-without project condition describes how conditions in the study area will change over the period of analysis if no federal action is taken as a result of this study. The future-without project condition is the baseline to which the effects of alternative plans are compared.

The quality and area of some habitats in the HRE ecosystem are expected to improve slightly over the 50-year planning horizon. Ongoing, planned, and ad-hoc restoration and conservation projects, including small-scale projects in the watershed, by government agencies, municipalities, and non-governmental organizations, will result in small habitat gains. Additionally, sediment cleanups including planned remedial actions in the Lower Passaic River, Gowanus Canal and Newtown Creek will continue to improve sediment quality in the estuary.

The degradation of the HRE ecosystem as a whole is expected to continue, with losses to the area and quality of riparian, wetland, and aquatic habitats. Development, channel dredging and continued shoreline erosion will negatively affect water quality, increasing turbidity and temperature and altering water depths in littoral zones, wetlands, and streams. Additionally, the range of invasive species already present in the HRE is expected to continue to expand within many of the HRE ecosystem's habitats. This will negatively affect the diversity and abundance of native plant, vertebrate, and invertebrate species in the HRE's ecosystem, with marsh-nesting birds disproportionately affected.

In Jamaica Bay, wetlands and marshes along the periphery of the bay will decrease in acreage due to erosion, subsidence, sea level rise, and invasive species interference. Without restoration, the remaining marsh islands could be lost to continued erosional forces and rising sea levels (Gornitz et al., 2002). The loss of Jamaica Bay marsh islands could, in turn unleash accelerated erosional forces upon the shoreline along the perimenter of the bay (Gedan et al., 2011). Similarly, the Harlem River, East River, and Western Long Island Sound region will experience further loss and degradation of existing estuarine and riverine habitats due to continuing natural erosive forces and anthropogenic stressors. Although local green initiatives will help to reduce the propensity of flash flooding in the Bronx River, these actions are expected to only partially address the flash flooding issue. The need to modify impoundments to improve water flow and fish passage along the river is unlikely to occur in the absence of federal action.

Despite the cleanup of legacy sediments in the Lower Passaic River proper, the environmental health of the Newark Bay, Hackensack River, and Passaic River planning region is still expected to decline or remain a continuation of the existing condition in the absence of ecosystem restoration; due to climate change and Sea Level Rise, sedimentation from non-point source water quality inputs, erosion, and invasive species expansion. The environmental health in both the Upper and Lower Bay Planning Regions is expected to decline with continued losses of low lying coastal habitats from erosion and sedimentation expected in the without project condition. Although oyster populations do exist in isolated areas, much of the reefs in the Upper Bay have been degraded or destroyed by human activities.

Another important consideration for the characterization of future without-project conditions in the HRE is the projected sea level change. Warming global temperatures are considered extremely likely over the coming decades and through the course of the next century. It is anticipated that this warming will be at a faster rate than past trends, which will have the effect of increasing the rate of global sea level rise (SLR). Given the long-term nature of SLR effects and the variables intrinsic to predicting global carbon emissions, global climate conditions, and the resulting effects on sea level, there are ranges in SLR projections that take into account various scenarios (New York City Panel on Climate Change, 2009).

A 2015 report prepared by the New York City Panel on Climate Change (2015) presents SLR projections that take into account the predicted ranges of both global climate change and local land subsidence. The central range of these projections are sea level increases in New York City of 4-8 inches by the 2020s, 11-21 inches by the 2050s, and 18-39 inches by the 2080s (New York City Panel on Climate Change, 2015). Extreme ranges presented in the report that assume rapid ice melt yielded projections of sea level increases of 5-10 inches by the 2020s, 19-29 inches by the 2050s, and 41-55 inches by the 2080s. The USACE Sea-Level Change Curve Calculator, using the NOAA Sandy Hook Gauge (Station ID #8531680), indicates an increase in sea levels of 0.7 feet (8.4 inches), 1.1 feet (13.2 inches), and 2.6 feet (31.2 inches) over 50 years for the low, medium and high rates, respectively. These rates are consistent with the New York City Panel Climate Change report referenced above.

Rising sea levels will negatively impact the existing wetland within the HRE study area. The future-without project condition, characterized by extensive reaches of hardened shorelines, reduced shallow water environments, diminished connectivity, and degraded sediment distribution processes will lack the resiliency to adequately adapt to such changes. The urban character of the study area exacerbates these trends as areas of wetlands will often be unable to migrate due to space constraints. Sediment accretion rates in these wetlands will not be able to keep pace with rising water elevations and shallow waters will deepen, resulting in further habitat loss.

3.1.3 Opportunities: Target Ecosystem Characteristics

TECs were developed to focus restoration goals on distinct actions. Each TEC is an important ecosystem property or feature that is of ecological and/or societal value. The TECs are key components essential for successful restoration of a healthy estuary. The TECs defined for the HRE Comprehensive Restoration Plan (CRP) address the problems affecting the HRE and describe critical habitats and habitat complexes that have become diminished within the HRE over the past several centuries. Some TECs focus on specific habitats, others on the interconnectedness of the habitats, while still others address support structures for the estuary, contamination issues, and societal values.

The process of establishing the TECs began with a two (2)-day workshop in October 2005, led by the Hudson River Foundation and Cornell University to review existing restoration plans and solicit candidate restoration goals and actions (Bain et al., 2006). The process of selecting the TECs successfully demonstrated an effective framework for building consensus and defining broad restoration objectives. The multidisciplinary group was comprised of approximately 45 people from various federal, state, and local agencies, non-governmental organizations, and national and regional estuarine scientists. Eleven (11) TECs were developed at the 2005 workshop, with a twelfth TEC (Land Acquisition) added in 2012 in response to public comments (Table 3-1). Of the 12 TECs, the following eight (8) are within the purview of the USACE's aquatic ecosystem restoration mission:

- Wetlands
- Habitat for Waterbirds
- Coastal and Maritime Forests
- Oyster Reefs
- Eelgrass Beds
- Shorelines and Shallows
- Habitat for Fish, Crab, and Lobsters
- Tributary Connections

Sub-objectives were developed for each TEC and incorporated into the planning process (Table 3-1).

Each planning region is distinct in its combination and distribution of TECs, and contributes in a unique way to the character of the HRE ecosystem. Therefore, the restoration of one (1) site, or all sites within one (1) planning region, cannot meet all objectives, but a plan that includes the restoration of a variety of sites throughout the study area would contribute to developing a mosaic of habitats. Each TEC represents a unique habitat type or complex, ecological service, or value, as described below. Together, the TECs cumulatively define habitat and societal needs that will promote increased biotic diversity, sustainable ecosystem functions, and public enjoyment.

3.1.3.1 Wetlands

Wetlands are a primary habitat type included in the HRE plan formulation to advance aquatic ecosystem restoration and restore lost and degraded wetland habitat in the region. Wetlands are established in the estuary's brackish to saline waters of the intertidal zone where there is sufficient substrate stability and nutrient supply. Coastal wetlands, defined as tidally influenced wetlands connected to the open waters of the HRE, historically represented a significant regional habitat complex. Non-tidal freshwater wetlands, including riparian forested and emergent wetlands along watercourses, fringing wetlands along lakes and ponds, and isolated wetlands maintained by groundwater or precipitation, were also historically abundant. Today, almost 99% of freshwater wetlands have been lost in the HRE.

Coastal and freshwater wetlands provide valuable habitat for a variety of organisms. Juvenile fish and crustaceans gain refuge from predators and benefit from abundant prey resources in tidal marshes. Deep pools and channels in non-tidal freshwater wetlands also support a characteristic fish community, typically comprised of warm-water species. Wetlands are critical habitat for waterbirds. Wading birds prey upon resident fishes and invertebrates in wetlands. Migratory waterfowl use wetlands as stopovers during their winter and summer migrations. A variety of mammals use wetlands for foraging, breeding, and refuge. Coastal and freshwater wetlands can also be important areas for recreational boating and fishing, and offer numerous public access and educational opportunities. Coastal and freshwater wetlands also perform a variety of functions including shoreline stabilization, storage of floodwaters, groundwater recharge, sediment retention and improvement of surface water quality which is important for chemical detoxification, nutrient retention and recycling, and decomposition processes (Seneca and Broome, 1992). The ability of coastal and freshwater wetlands to retain high levels of nitrogen has important implications for eutrophication and nitrogen-loading to the HRE study area; they also have a role in denitrification, by converting stored mineralized nitrogen and returning it to the atmosphere as gas.

Table 3-1. Target Ecosystem Characteristics, Sub-Objectives, Regional CRP Target Statements and Short-Term (2020) and Long-Term (2050) Target Goals (USACE, 2016) in the Hudson-Raritan Estuary Study Area.

TEC	CRP Target Statement/Sub-Objectives/Secondary Benefits	CRP Short-Term Goal	CRP Long-Term Goal
Wetlands 	**CRP Target Statement** • Restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage. **Sub-Objectives** • Improve the quantity, quality, and complexity of wetland habitat. • Increase overall diversity and abundance of wetland habitat. • Increase connectivity of wetland habitats to reduce fragmentation. • Improve the hydrologic connectivity of the floodplain and the river/estuary. • Reduce shoreline erosion. • Reduce invasive species monocultures and replace with diverse native vegetation. • Restore tidal marsh systems to offset both historical and future losses. **Secondary Benefits** • 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 and storage of floodwaters.	Restore a total of 1,000 total acres of wetlands	Continue restoring an average of 125 acres per year for a total system gain of 5,000 acres
Habitat for Waterbirds 	**CRP Target Statement** • Restore and protect roosting, nesting, and foraging habitat (i.e., inland trees, wetlands, shallow shorelines) for long-legged wading birds. **Sub-Objectives** • Improve roosting, nesting, and foraging habitat for long-legged wading birds. • Increase the number of nests and improve feeding habitat for target species.	Enhance at least one island without an existing waterbird population in HRE regions containing islands and restore or enhance at least one foraging habitat	All islands provide roosting and nesting sites and have nearby foraging habitat

TEC	CRP Target Statement/Sub-Objectives/Secondary Benefits	CRP Short-Term Goal	CRP Long-Term Goal
Coastal and Maritime Forests 	**CRP Target Statement** • Restore a linkage of forests accessible to avian migrants and dependent plant communities. **Sub-Objectives** • Restore maritime forest and grassland habitat to ensure the sustainability of adjacent wetlands/aquatic habitat. • Restore maritime forest and grassland habitat to the system to provide vegetated buffer and transitional zone between aquatic habitat and urban environment. • Provide habitat and food sources for bird and wildlife species, stabilize shorelines, and provide soil retention. **Secondary Benefits** • Provide secondary coastal storm risk management benefits (e.g., wave attenuation, shoreline stability, and shoreline resiliency), serving as potential natural and nature-based features.	Establish one new maritime forest of at least 50 acres and restore at least 200 acres among several coastal forests/upland habitat types	500 acres of maritime forest community among at least three sites and 500 acres of restored coastal forest/upland habitat.
Oyster Reefs 	**CRP 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.	20 acres of self-sustaining, naturally expanding reef habitat across several sites	2,000 acres of established oyster reef habitat

TEC	CRP Target Statement/Sub-Objectives/Secondary Benefits	CRP Short-Term Goal	CRP Long-Term Goal
Shorelines and Shallows	**CRP Target Statement** • Restore shoreline and shallow sites with a vegetated riparian zone, an intertidal zone with a stable slope, and illuminated shallow water. **Sub-Objectives** • Soften hardened shorelines to restore transitional zones. • Restore buffer riparian zones, including littoral zones and intertidal areas, to support increased diversity and abundance of biological communities.	Develop new shorelines in two HRE regions	Restore all available shoreline habitat in three HRE regions
Habitat for Fish, Crab, and Lobsters	**CRP Target Statement** • Restore functionally related habitats in each of the eight (8) regions of the HRE. **Sub-Objectives** • Develop mosaic of diverse quality habitats to sustain fish and invertebrate populations. • Restore natural stream geomorphology. • Reduce sediment loads to improve fish, shellfish, and benthic organism habitats.	Complete a set of two related habitats in each HRE region	Complete four sets of at least two habitats in each HRE region
Tributary Connections	**CRP Target Statement** • Reconnect and restore freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms. **Sub-Objectives** • Increase connectivity of riparian habitats to reduce fragmentation in migratory corridors. • Improve the hydrologic connectivity of the floodplain and the river/estuary to improve the function of riparian habitat, reduce velocities, increase infiltration, and improve natural sediment processes. • Enhance basin and tributary bathymetry configuration to promote optimal circulation. • Reduce shoreline erosion. • Remove invasive species and replace with diverse native vegetation. • Increase habitat available for migratory fish through removal of fish passage impediment.	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas

3.1.3.2 Habitat for Waterbirds

Although waterbirds include a variety of species that are adapted to life in coastal habitats, including seabirds, shorebirds, waterfowl, and long-legged wading birds, the long-legged waders are the primary focus of this TEC. Nine (9) species of egrets, ibises and herons collectively known as the “Harbor Herons” are known to have inhabited coastal islands of the Arthur Kill, Kill Van Kull, East River and Jamaica Bay since the 1970s (Steinberg et. al., 2004; Winston, 2015, 2007).

Waterbirds function as important species in estuarine systems, are indicators of ecosystem integrity, and are intrinsically valuable to the public (Bain et al., 2007). Waterbirds consume fish and crustaceans within coastal wetlands and other littoral areas, and, in their natural setting, are sought after by members of the birding community, members of which are often active supporters of ecological restoration initiatives, especially in urban locales. In addition to the important ecological role and the recreational opportunities waterbirds offer, they also function as indicators of ecological health. Through bioaccumulation of contaminants in the food web, bird reproduction can be impaired, leading to diminished or extirpated populations. Species bioaccumulate and biotransform chemicals differently; therefore, contaminants may have different effects on species as they pass throughout the food web (Rand, 1995). In some cases, high concentrations of single contaminants can be as lethal as low concentrations of a mixture of contaminants. Most effects are sub-lethal, in that the effects may manifest themselves singly or as a combination of behavioral (e.g., swimming, feeding, predator-prey interactions), physiological (e.g., growth, reproduction, development), biochemical (e.g., enzymatic, ion levels), or histological (e.g., immune system, genetic, carcinogenic) modifications (Bain et al., 2007).

Populations are native, but were nearly extirpated by centuries of hunting, pollution, and habitat loss. With improved water and habitat quality, herons experienced a dramatic comeback.

3.1.3.3 Coastal and Maritime Forests

Coastal and maritime forests are regionally rare, ecologically significant plant communities that provide habitat and food resources to support many bird and wildlife species, as well as attenuate waves, stabilize shorelines, and provide soil retention. These systems have become vulnerable to extirpation within the HRE study area and globally. Restoration proposed in the HRE study area contribute to this TEC; however, alternatives were not formulated directly to restore this habitat. Coastal and Maritime forests are included as an important component of aquatic restoration providing buffer protection and improving sustainability of the adjacent wetland in this densely populated urban environment. In addition, coastal and maritime forest restoration result from cost effective on-site soil/sediment placement.

Maritime plant communities are dynamic systems that occur across a range of fringe seacoast habitats in narrow, discontinuous bands (National Biological Service, 1995). These forests, often described as “strand forests”, are influenced by strong salt spray, high winds, unstable substrates (e.g., dune deposition/shifting), and have characteristically stunted and contorted trees (National Biological Service, 1995, Yozzo et al., 2003, Edinger et al., 2014). Maritime communities are perpetually shifting complexes that interchange in response to the dynamics of the substrate. Beach and dune habitats are the most dynamic of the maritime vegetative communities, being modified by winds and waves, and stabilized by vegetation. When the dunes are altered, this changes the inland shrub and forested lands, bringing them closer to shore, pushing them further inland or even periodically eliminating them. Herbaceous and shrub layers thrive on the outskirts of the forest and in bog areas, behind the dune and swale communities (Bain et al., 2007). Both evergreen and deciduous trees, such as American holly (*Ilex opaca*), oaks (*Quercus spp*.), sassafras (*Sassafras albidum*), shadbush (*Amelanchier canadensis*), black tupelo (*Nyssa sylvatica*), American beech (*Fagus grandifolia*), Eastern red cedar (*Juniperus virginiana*), northern bayberry (*Myrica pensylvanica*), and beach plum (*Prunus maritima*), commonly dominate the forest community (Bain et al., 2007). The species composition can depend upon how connected these communities are to nearby forests on the coastal plain (Bain et al., 2007).

Coastal forests are non-maritime communities found within the coastal plain, but are not exposed to the same intensity of salt spray, wind, and substrate shifting as maritime communities. This results in trees that are of normal stature and not contorted or “salt-pruned”, despite the minor salt spray from severe storms like hurricanes (Edinger et al., 2014). Coastal forests occur on dry, well-drained, low-nutrient soils, do not have dense, vine undergrowth, and have low species diversity typically dominated by few tree species. These communities include oak, hickory (*Carya* spp.), beech, holly, red maple, and pitch pine (*Pinus rigida*) forests (Edinger et al., 2014).

Barrens (i.e., pine barrens) occur on shallow, low-nutrient soils, comprised of stunted or dwarfed trees that are generally adapted to a high frequency of fire (Olsvig et al., 1998). These communities occur on stabilized dunes, glacial till, outwash plains, and rocky soils, and include species such as pitch pine, scrub oak (*Quercus ilicifolia*), post oak (*Quercus stellata*), and blueberry (*Vaccinium corymbo*sum), and huckleberry (*Gaylussacia baccata*) shrubs. Pine-dominated forests blend with pine-oak forests as soil composition changes, but species composition generally stays the same, with only abundance changing. Representative examples outside of the HRE study area include the southern New Jersey Pine Barrens, and the Long Island Pine Barrens, which occur along the glacial outwash plain of the Ronkonkoma Moraine and along the Peconic River. Some pitch pine communities do not require fire regimes to persist and would be viable for restoration in the HRE.

Coastal and maritime forest communities provide a variety of valuable functions to human and natural communities. When overlying coastal aquifers, they typically function as groundwater recharge areas. By providing a vegetated buffer between human development and the water, these forests attenuate runoff from developed areas and provide protection from storm surges and coastal flooding. Coastal areas within the HRE study area are especially vulnerable to threats posed by coastal surges associated with sea level change and coastal storms. In the aftermath of Hurricane Sandy, federal, state, and municipal assessment and planning documents emphasized the need for Natural and Nature-Based Features (NNBFs) that would protect the coastline of the HRE from future storms. The NNBFs (wetlands and dunes) such as those found in coastal and maritime forest communities could reduce coastal risk (USACE, 2013). Coastal and maritime forest restoration opportunities would contribute to coastal storm risk reduction through wave attenuation, sediment stabilization, and dense vegetation that could slow the advance of storm surge, enhancing shoreline resiliency and sustainability, and providing coastal risk management benefits for surrounding communities (USACE, 2015).

3.1.3.4 Oyster Reefs

Oyster Reef restoration is a primary habitat type and TEC included in the HRE plan formulation to advance aquatic ecosystem restoration. Oysters were once prevalent throughout the study area. At the time of European settlement, approximately 350 square miles of oyster beds were present in the estuary (Mackenzie, 1996). By the early 19th century, overharvesting of natural oyster populations was so prevalent that the fishery was primarily based on stock brought in from other estuaries to the north and south of New York City (Kirby and Miller, 2005). 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, where water quality, hydrodynamics, and substrate conditions combine to promote opportunities for limited reproduction, settlement of spat, and growth.

American oyster (*Crassostrea virginica*) reefs, or beds, provide spatially complex substrate and benthic structure that is important for many estuarine organisms. A well-developed oyster reef will typically consist of intricately layered formations of live oysters on the exterior and layers of old oyster shell forming the base and reef interior. Deep crevices created by the oyster shell provide refuge for numerous species of small aquatic organisms. Oyster reefs are also feeding, breeding, and nursery grounds for finfish and large crustaceans, where multi-species congregations occur (Harding and Mann, 1999). Oyster reefs provide attachment sites for the eggs of many small fishes, such as gobies and blennies, as well as the oyster toadfish (*Opsanus tau*). Juvenile and adult oysters are important prey for gastropods, whelks, sea stars, crabs, and boring sponges. Intertidal oyster reefs provide rich feeding grounds for many shorebird species.

Oysters are valuable organisms that can actually promote the growth and viability of other habitats. By filtering particulate material from the water column, oysters form an important link between the pelagic (i.e., open water) and benthic food webs (Yozzo et al., 2001). Through water clarity improvements, oysters can enhance other subtidal habitats like eelgrass by increasing the amount of light that can penetrate the water (Cerco and Noel, 2007). Investigators have documented measureable water quality effects of reefs soon after construction, including removal of nitrogen, particulate phosphorus, and seston (Dame et al., 1989, Grizzle et al., 2006). In some geographic areas, oyster reefs may develop substantial vertical relief off the sea floor, altering patterns of current flow and possibly creating or expanding shallow water habitat by trapping sediments. Oyster reefs can encourage the growth and expansion of salt marshes located inshore of the reefs by functioning as natural breakwaters (Coen and Luckenbach, 2000).

Historical accounts from colonial times document flourishing oyster populations in the estuary. Large expanses of oysters in upper Raritan Bay stretched a mile in diameter and were referred to as the “Great Beds.” Populations also existed in the Hudson River and tributaries of Staten Island, although the upstream extent to which they occurred is uncertain (MacKenzie, 1992). Historically, oysters were a keystone species in the HRE study area, providing both ecological functions and an economic role 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 (Kennish, 2002, Bain et al. 2007). By the early 20th century, poor water quality conditions and incidence of human-transferable diseases resulted in declining harvest and, by 1925, the oyster industry in the estuary was abandoned (MacKenzie 1992). The loss of historic oyster beds permanently altered the structure and functions of the estuary's benthic ecosystem, and eliminated a significant habitat resource for estuarine fish and invertebrate species that rely on spatially complex submerged structures.

3.1.3.5 Eelgrass Beds

Eelgrass beds are believed to have historically represented a significant habitat complex in the region, but were eliminated as a result of disease, shoreline modification, dredge and fill activities, and water quality degradation by the mid-20th century. During the 1930s, wasting disease, a widespread infection by the slime mold (*Labryinthula zosterae*), decimated Atlantic coast eelgrass populations, including those in the HRE and adjacent waters (Short et al., 1986, 1988).

Eelgrass beds were highlighted as an important habitat type for restoration in the HRE Comprehensive Restoration Plan (CRP). However, the HRE CRP also documented that eelgrass restoration pilots have not yielded successful results and organizations including Cornell University and NYCDEP continue to study this type of restoration in the study area. Due to this, it was agreed between USACE and the non-federal sponsors that eelgrass restoration would be recommended at a later date. Thus, none of the recommended restoration sites in the HRE contain eelgrass beds.

3.1.3.6 Shorelines and Shallows

Plan formulation within the HRE considered the restoration of shorelines and shallows within estuarine and freshwater systems. Many natural shorelines have been replaced with bulkheads, revetments, riprap, and dock/pier infrastructure. These structures have eliminated transitional intertidal and littoral areas. Hardened shorelines dissipate but also redirect wave energy, which can increase erosion and deepen nearshore waters, affecting water quality and clarity, and habitat availability. Pier construction has reduced channel width, reduced current velocities, and increased sedimentation. Increased sedimentation reduces available water column habitat and buries existing, natural hard substrates. Shading impacts of shoreline structures on aquatic flora and fauna are increasingly being recognized in aquatic resource assessments, and recent research conducted within the HRE study area has documented fewer species, lower abundances, and fewer feeding opportunities underneath large over-water structures in comparison to open water, pile fields, or edge habitat (Able and Duffy-Anderson, 2006).

3.1.3.7 Habitat for Fish, Crab, and Lobsters

All aquatic restoration in the HRE provides habitat for fish, crab and lobsters. Physical and chemical habitat alteration has led to changes in the populations of organisms that use the HRE study area. The construction of bulkheads, piers, and placement of shoreline fill have greatly diminished the extent and function of shallow, soft-bottom habitats, rocky outcroppings, wetlands, and sand beaches (Sanderson, 2005). Historically, the littoral zone in the estuary was structurally complex with diverse physical characteristics, supporting resident fish populations as well as attracting large populations of migratory and transient fish for spawning and feeding (Levinton and Waldman, 2006). These complex and productive waters were ideal nursery areas for young fish, particularly where benthic structure and/or plant communities existed. The construction of piers slowed near-shore waters and promoted extensive sediment accumulation, which in concert with other forms of shoreline hardening, contributed to the loss of physically complex habitat, greatly reducing the quality of spawning and nursery areas.

This TEC focuses on the spatial arrangement of aquatic and intertidal habitats like oyster reefs, eelgrass beds, and tidal marshes, which are components of other TECs, as well as non-TEC habitats like soft-bottom, unvegetated mudflats or hard-bottom substrates. Each fish and crustacean species has specific habitat needs, especially during spawning or early development, for specific substrates or structural elements. For instance, vegetated or structurally complex habitats provide refuge from predators, whereas broad, sandy flats may be ideal foraging areas (Bain et al., 2007). The most effective way to sustain or increase fish and macroinvertebrate populations in the HRE may be to restore mosaics of critical habitats, to provide what habitat was historically lost, as well as expand upon existing habitats (e.g., subtidal shallows, rocky intertidal).

3.1.3.8 Tributary Connections

Streams and rivers are important parts of the landscape providing water, sediment, and nutrients from higher elevations to the estuary influencing water quality and functioning downstream habitats. Land use changes in the watershed, channel straightening, culverts, removal of streambank vegetation, impoundments, and other activities lead to stream instability and adjustments in channel form (Harman et al., 2012). Stream degradation (scour) has resulted from increased streamflow volume and frequency and stream aggradation has resulted from land use practices that have caused increased sediment loads. Restoration of stream functions increases the likelihood of stream stability, thus allowing the watershed and its tributaries to function to transport water, sediment, and nutrients to ensure and maintain connections between various habitats.

Tidally influenced streams and creeks provide thruways for fish to access habitats across a gradient of abiotic factors (i.e., salinity, depth, temperature, dissolved oxygen, and sediment type). The estuary historically has provided passage for migratory fish populations that would move up the tributaries to spawn. Many migratory or highly mobile fish species require access to upstream areas to spawn because eggs or larvae have specific life history requirements that are very different from juvenile or adult life stages. In addition to benefiting native migratory species, such as American shad, alewife, blueback herring, striped bass, and American eel, re-establishing tributary connections may also benefit resident fish and invertebrate populations by providing greater access to feeding, spawning, and refuge habitats. Several freshwater mussel species (i.e., Family Unionidae) may also benefit from improved fish passage, as they are dependent upon fish movement for dispersal (Peckarsky et al., 1990).

3.1.3.9 Other Regional TECs

Restoration within the HRE may also contribute to four (4) other TECs outlined in the HRE CRP including Enclosed and Confined Waters, Sediment Contamination, Public Access and

Acquisition. Plan formulation was not guided by these targets and the resulting restoration may have provided secondary benefits to improve hydrology in tidal creeks and enclosed basins, improve sediment quality and provide public access for the surrounding communities to enjoy local scenic, natural, cultural, historic, and recreational resources.

3.2 Planning Objectives

Planning objectives were identified based on problems, needs, and opportunities, as well as on existing physical and environmental constraints, present in the study area. Four (4) broad planning objectives with associated sub-objectives (Table 3-1) for relevant TECs were used to guide the formulation and screening of alternatives. All objectives are for a 50-year period of analysis ending in 2075. The period of analysis is the period of time the alternative would have significant beneficial effects; however, effects are expected go beyond the 50 year period of analysis.

3.2.1 Objective #1: Restore the structure, function, and connectivity, and increase the extent of estuarine habitat in the HRE.

This objective to restore estuarine habitats contributes to the TECs of wetlands, habitat for waterbirds, coastal and maritime forests, eelgrass beds, shorelines and shallows, habitat for fish, crab, and lobsters, and tributary connections in estuarine systems. This objective contributes to the regional 2050 long-term CRP goals to:

- Restore 5,000 acres of wetlands;
- Restore habitat for waterbirds that all islands that provide roosting and nesting sites have nearby foraging habitat;
- Restore at least 500 acres of coastal and maritime forest community habitat;
- Restore all available shoreline and shallow habitat in three HRE regions;
- Restore habitat for fish, crab, and lobsters to complete four sets of at least two habitats in each HRE region; and
- Restore connectivity or habitat within one tributary each year.

3.2.2 Objective #2: Restore the structure and function, and increase the extent of freshwater riverine habitat in the HRE.

This objective to restore riparian habitats contributes to the TECs of wetlands, habitat for waterbirds, shorelines and shallows, habitat for fish, crab, and lobsters, and tributary connections in freshwater riverine systems. This objective also contributes to the many 2050 long-term regional CRP goals listed for estuarine habitat for Objective #1.

3.2.3 Objective #3: Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay.

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 (GNRA), the first urban national park, which was established in 1972. The marsh islands complex is an integral part of the Jamaica

Bay ecosystem and has been targeted for restoration by numerous stakeholders. More than 2,036 acres of marsh islands have been lost in Jamaica Bay between 1924 through 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. Restoration of the marsh islands is an overarching priority with an overall goal of restoring as much marsh islands as feasible. This objective contributes to the TECs of wetlands, habitat for waterbirds, shorelines and shallows, habitat for fish, crab, and lobsters and each of the TECs 2050 long-term goal outlined in Objective #1.

3.2.4 Objective #4: Increase the extent of oyster reefs in the HRE.

This objective to increase the extent of oyster beds contributes to the TECs of oyster reefs, shorelines and shallows, and habitat for fish, crab, and lobsters. This objectives contributes to the 2050 CRP goal to restore 2,000 acres of oyster beds by 2050. This acreage was selected as the target because it is a fraction of the extent of known historical oyster beds in the HRE and was considered a realistic goal based on ongoing projects. 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 2050 long-term goal of 2,000 acres is 1% of the historic oyster coverage.

Each objective relates to *specific habitats and geographic regions* – habitats and regions being simply the place where organisms live (Odum, 1971). The structure and function of a habitat greatly influences what types of organisms will live there, how they will live, and if a community will thrive. Table 3-2 illustrates the TECs and TEC Sub-Objectives within the USACE’s aquatic ecosystem restoration mission that apply to each planning objective.

Table 3-2. Target Ecosystem Characteristics and Sub-Objectives Applicable to Each Planning Objective.

TECs	TEC Sub-Objectives	Planning Objectives			
		#1 Restore Estuarine Habitat	**#2 Restore Freshwater Riverine Habitat**	**#3 Restore Jamaica Bay Marsh Islands**	**#4 Increase Oyster Reefs**
Wetlands (low marsh, high marsh, emergent, forested, scrub/shrub) 	• Improve wetland habitat • Increase diversity and abundance • Increase wetland connectivity • Improve hydrologic connectivity • Reduce shoreline erosion • Reduce invasive monocultures, replace with natives • Restore tidal marsh systems to offset losses	●	●	●	
Habitat for Waterbirds 	• Improve roosting, nesting, and foraging habitat • Increase nests and improve feeding habitat	●	●	●	
Coastal and Maritime Forests 	• Ensure sustainability of adjacent habitats • Provide vegetated buffer and transitional zone • Develop mosaic of diverse habitats	●	●		
Oyster Reefs 	• Incorporate diverse habitat structure				●

TECs	TEC Sub-Objectives	Planning Objectives			
		#1 Restore Estuarine Habitat	**#2 Restore Freshwater Riverine Habitat**	**#3 Restore Jamaica Bay Marsh Islands**	**#4 Increase Oyster Reefs**
Shorelines and Shallows 	• Provide habitat and food, stabilize shoreline, retain soils • Soften hardened shorelines • Restore buffer riparian zones	●	●	●	●
Habitat for Fish, Crab, and Lobsters 	• Develop mosaic of diverse quality habitats to sustain fish and invertebrate populations • Restore natural stream geomorphology • Reduce sediment loads to improve fish, shellfish, and benthic organism habitats	●	●	●	●
Tributary Connections 	• Increase riparian habitat connectivity • Improve hydrologic connectivity • Enhance basin and tributary bathymetry configuration • Reduce shoreline erosion • Remove invasive species and replace with natives • Increase migratory fish habitat	●	●		

3.3 Planning Constraints and Considerations

Planning constraints and considerations guide the plan formulation and selection process. The planning team identified a number of constraints and considerations that are unique to the study and study area.

3.3.1 Constraints

Constraints are significant barriers or restrictions that limit the extent of the planning process. Constraints are designed to avoid undesirable changes between without-and with-plan conditions. A number of constraints unique to the study were considered during plan formulation.

3.3.1.1 Physical Constraints

The most obvious constraint on restoration within the HRE is physical. The study area contains many locations where permitted land uses and infrastructure, such as combined sewer outfalls (CSOs), landfills, port terminals, and hardened shorelines, are necessary to society and the economy and cannot be removed without significant secondary costs.

3.3.1.2 Induced Flooding

Restoration should not contribute to or induce flooding. For example, in some cases, restoration of the hydrologic regime of a degraded wetland may not be feasible through removal of existing barriers such as dams or floodwalls that functions to protect the public from potential storm surges.

3.3.1.3 Limitations by Policy and Law

Because the TEC sub-objectives reflect the collective interest of the regional restoration community, some restoration actions are limited within the authority of USACE to implement as a cost-sharing partner under current law. For example, coastal and maritime forest communities are located within many tidally-influenced areas, but also far inland of the shore and beyond lakes and rivers. The USACE is limited in its authority to participate only in the restoration of aquatic habitat. However, the coastal and maritime forest habitat included in the proposed restoration has been associated with the least-cost on-site disposal option for excavated soil/sediment or necessary important habitat for transitional zones.

USACE also has policy limitations to implement restoration on other federal land as specified in ER 1105-2-100 for the Continuing Authorities Program (CAP). This policy would influence restoration activities in the Jamaica Bay Planning Region under the jurisdiction of the National Park Service, Gateway National Recreation Area if carried out under the CAP authority. Since this restoration is being carried out through the General Investigation (GI) program and will obtain Congressional authorization in a Water Resource Development Act (WRDA), restoration of the marsh islands and sites within Jamaica Bay are considered policy compliant.

3.3.1.4 Remediation Actions

Due to the urban nature of the estuary, some sites may contain Hazardous, Toxic, and Radioactive Waste (HTRW) - contaminated material. USACE will follow the requirements of ER 1165-2-132, which provides guidance on HTRW for civil works projects.

To the extent practicable during the study, contamination has been considered during plan formulation. Areas with known HTRW contamination will require clean-up action by the non-federal sponsors, USEPA, or the responsible state before construction on the ecosystem restoration project can begin. The sequencing of the HRE project has been carefully designed in order to allow for the remediation of HTRW contamination in the Lower Passaic River (e.g., Oak Island Yard) and Dead Horse Bay before any ecosystem restoration construction would begin.

In 2019, NPS conducted response actions under the authority of the CERCLA and determined that a removal action to evaluate appropriate options to minimize human exposure to and migration of hazardous substances from the landfill that are potentially being released from the banks along the southern shoreline of the Site into Jamaica Bay (Dead Horse Bay South). NPS further determined that a site-wide Remedial Investigation/Feasibility Study (RI/FS) to fully characterize site contamination and evaluate the need for remedial action is also required. If determined no actions are needed at Dead Horse Bay North, the restoration would still be timed in coordination with the NPS removal action on South given clean excavated soil from the restoration project is planned as clean cap material for the NPS remedial action.

Oak Island Yards and (most recently) Dead Horse Bay are known as “Tier 2” Sites given the timing/sequencing of their implementation is dependent upon the completion of the CERCLA remedial actions on or adjacent these sites. For all sites, additional HTRW sampling will occur during the Preconstruction Engineering and Design (PED) phase. If unacceptable levels of contamination/HTRW is identified, necessary remediation would take place prior to restoration actions. HTRW remediation is the responsibility of the non-federal sponsor, and will be carried out at 100 percent non-federal expense. The HRE study sponsors recognize and accept this responsibility.

3.3.2 Considerations

Considerations are those issues or matters that should be taken into account during the planning process, but do not necessarily limit the extent of the process as do constraints. A number of considerations unique to the study were considered during plan formulation.

3.3.2.1 Attractive Nuisances

Coastal wetland restoration can become an attractive nuisance in areas where tidal waters have a legacy of contamination. These waters carry suspended sediments and contaminants downstream that eventually settle out of the water column. Any uplands or areas newly opened to tidal exchange would be exposed to these contaminants, which would then accumulate in the restored tidal wetland. The accumulation of contaminated sediments opens exposure pathways for vegetation and wildlife initially through direct exposure and eventually through consumption.

Human exposure pathways are unlikely, as entry into restoration areas and harvesting food sources is prohibited.

In the states of New York and New Jersey, restoration of both oyster reefs and artificial reefs for lobsters (i.e., fish, crab, and lobster habitat) has regulatory implications, as Oyster Reef restoration in prohibited or specially restricted waters creates an attractive nuisance that can lead to human exposure pathways. While New York has regulatory policies that reflect an understanding that the ecological benefits of having sustainable populations in these waters outweighs the potential health risks of consuming poached oysters, Oyster Reef restoration in New Jersey is currently permitted only in closed waters with continuous security to prevent poaching (e.g., Naval Weapons Station Earle). Concerns about the potential for economic repercussions may affect the rest of the shellfish industry if tainted oysters were to be consumed. With regard to oysters and lobsters, there is concern that fishing could lead to consumption of shellfish that are unsafe to eat. This would result in the need to restrict harvesting or fishing in these areas and lead to greater enforcement needs and increased costs to the regulatory agencies. However, the ban may be lifted in the near future, as bill S2617 was signed in early 2016. The bill requires the New Jersey Department of Environmental Protection (NJDEP) to adopt new Shellfish Rules to provide improved and expanded research and restoration opportunities.

Attracting wildlife to areas where it may create hazards for public safety is another serious concern. For example, migratory and nesting birds in the region are a concern to airport operators, particularly within a five-mile radius of airports (FAA, 2007). Increasing the amount of habitat near airports could attract birds and other animals that are particularly hazardous to aircraft, resulting in an increased number of strikes by planes. Bird and animal strikes are a serious economic and public safety issue in the aviation industry. These concerns are often addressed through cooperative interagency policies, such as Wildlife Hazard Management Plans, that detail preventive measures to reduce wildlife attractants, minimize hazards, and identify responsible parties. This guidance should be an integral component of community land use planning within a five-mile radius of airports and any restoration actions should be planned with full realization and compliance with these plans to maximize the safety of the flying public.

3.3.2.2 Consistency with Current Master Plans

Restoration planning should consider and be complementary to the many municipal, site, and park master plans. Potential for conflicting objectives exists with respect to zoning and land use. Restoration projects should be sited and designed in coordination with stakeholders to also meet local planning objectives.

3.3.2.3 Synergy with Other USACE Studies and Projects

Recommended actions have been planned in coordination with other USACE studies and projects. Additionally, the purpose of the HRE CRP was to identify potential conflicts and to bring meaningful dialogue to the table with all regulatory agencies and stakeholders, in an effort to make the process run more smoothly and be more transparent from the onset of the process.

3.3.2.4 Coordination with Operation & Maintenance Dredging Projects

The plan should coordinate with Operation and Maintenance Dredging Projects in order to beneficially use dredged material in order to minimize cost of restoration.

3.3.2.5 Adverse Effects to Historic Properties

The plan should avoid causing adverse effects to historic resources and significant archaeological sites.

3.4 Overall Plan Formulation Strategy

As described in Chapter 1, the overall plan formulation strategy was to integrate the individual "source" studies in order to capture efficiencies, leverage programs and capitalize on the similarities of restoration planning within the HRE Study Area. The study formulation strategy was to choose the most cost effective alternative at each restoration site that meets planning objectives, avoids, constraints, and supports the HRE Comprehensive Restoration Plan (CRP) program goal to restore a mosaic of habitats. Most sites within each planning region have similar attributes, problems, needs, opportunities, constraints, considerations, and trade-offs. The formulation strategy revolves around the fact that, generally, discrete habitat types are found in differing ranges and density within each planning region, and thus, most restoration opportunities and management measures are similar within a planning region. The site screening process is described in detail in the Plan Formulation Appendix D for each watershed and "source" study (Section 3.5) resulting in the final array of sites (Section 3.6) that were further evaluated (Sections 3.7, 3.8, 3.9, 3.10, 3.11) to identify the recommended plan. This plan formulation screening and evaluation process is illustrated in Figure 3-3.

3.5 Restoration Opportunities and Site Screening (Initial Array of Sites)

The initial array of 33 sites originated from two places: 23 of them originated from the "source studies" (Jamaica Bay, Flushing Creek, Bronx River, Lower Passaic River and Hackensack River), and 10 sites (the marsh islands and oyster sites) were developed by HRE to fulfill Objectives 3 and 4; which are to restore marsh islands and oyster reefs (Figure 3-3). These sites were selected using various screening criteria identified during the studies and are further described in Appendix D. A summary of the screening process resulting in the initial array of sites for each feasibility "source" study is presented below.

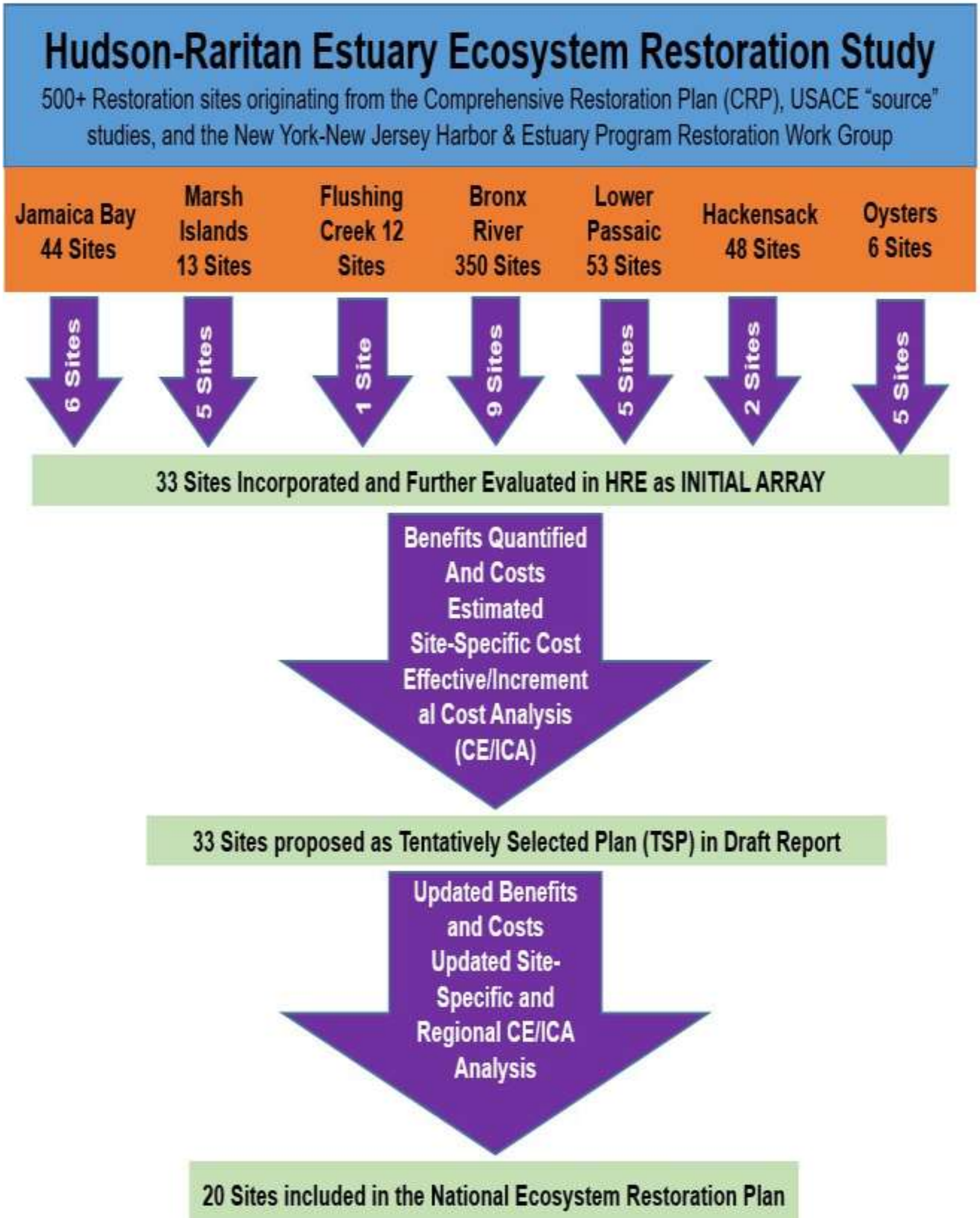


Figure 3-3. Site Screening and Development of Initial Array of Sites

3.5.1 Jamaica Bay "Source" Study

All of the Jamaica Bay Perimeter sites were identified in the Jamaica Bay "source" study. The "source" study initially identified 44 restoration opportunities. Through four rounds of screening, six (6) sites were brought forward for further evaluation included in HRE. The first round of screening removed sites that had characteristics that were expected to greatly increase costs. The second round ranked the sites as high and low priority sites. The third round took the high priority sites and screened out those that showed poor water quality results in data collected by the non-federal sponsor and those sites that had been already moved forward by other authorities. The fourth round of screening again removed sites that had been advanced through other authorities. The six sites brought forward to HRE included: Dead Horse Bay (Tier 2), Fresh Creek, Brant Point, Bayswater Point State Park, Hawtree Point, and Dubos Point (Figure 3-4).

Figure 3-4. Initial Array of Jamaica Bay Perimeter restoration sites

3.5.2 Jamaica Bay Marsh Islands

The Jamaica Bay Marsh Island sites were developed as part of the HRE Study to fulfill Objective 3, to restore more marsh islands in Jamaica Bay. 13 sites were evaluated and went through two rounds of screenings. The first screening removed sites that were too close to JFK airport (east of Cross Bay Boulevard) and would cause problems with avian-airplane strikes. The second screening removed sites that were too shallow to allow a dredge to approach them (see plan formulation appendix section 3.2 for more information). The site screening resulted in identifying five (5) sites as the initial array of sites including: Duck Point, Stony Creek, Pumpkin Patch West, Pumpkin Patch East and Elders Center (Figure 3-5).

Figure 3-5. Initial Array of Jamaica Bay Marsh Island restoration sites

3.5.3 Flushing Creek "Source" Study

The Flushing Creek site comes from the Flushing Bay and Creek Ecosystem Restoration Feasibility "source" study. This source study evaluated 12 sites resulting in the focus of one (1) location in Flushing Creek between the Long Island Railroad (LIRR) and Roosevelt Avenue (Flushing Creek) that was brought forward to HRE. The Flushing Creek site was then integrated into the HRE and three new alternatives were developed following NYCDEP's decision to conduct environmental dredging in the creek as part of their Long Term Control Plan. Once NYCDEP determined they would no longer dredge the creek, the FWOP conditions had changed and the alternatives were reformulated. Three additional alternatives were developed assuming no dredging in the creek as the existing and FWOP condition (Figure 3-6).

Figure 3-6. Initial Array of Sites in Flushing Creek and Bronx River

3.5.4 Bronx River "Source" Study

The Bronx River "source" study contributed nine (9) sites to the HRE study. The Bronx River sites came from the Bronx River "source" study that had been evaluated and prioritized 23 sites to meet habitat restoration goals. HRE then investigated the 23 sites and identified those sites that NYCDEP, Westchester County and NYC Parks identified their wiliness to support and cost share implementation. Based on sponsor readiness, 23 sites were screened down to 10 sites (see plan formulation appendix section 6.2 for detailed history of the origin of these sites). Two (2) physically contiguous sites, Harney Road and Garth Woods, were combined resulting in a total of nine (9) sites. These nine sites include: Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park, Bronxville Lake, Garth Woods/Harney Road, Muskrat Cove, River Park/West Farm Rapids Park, Crestwood Lake, and Westchester County Center (Figure 3-6).

3.5.5 Lower Passaic "Source" Study

The Lower Passaic River sites were identified as the initial array of sites as part of the Lower Passaic River "source" study. The project goal of the HRE-Lower Passaic River Ecosystem Restoration Feasibility Study was to coordinate with the USEPA, USFWS, NOAA, and the State of New Jersey, to remediate and restore 17 miles of the Lower Passaic River and its tributaries (i.e., Third River, Second River, and Saddle River). The study was a unique joint program with the USEPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund program in order to develop a comprehensive solution for remediation and restoration in the watershed. 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.

Figure 3-7. Selected Hackensack River and Lower Passaic River Restoration Sites

Since 2004, restoration opportunities were identified through public outreach, baseline surveys conducted as part of the coordinated USEPA and USACE Remedial Investigation/Feasibility Study, three (3) Restoration Opportunities Reports (USACE, 2006), and visioning efforts with municipalities within the tributaries and the 17-mile lower river. 53 sites were identified and were screened through three rounds of screening. The first round removed sites that needed remediation from the Superfund Program (see plan formulation appendix D-6 for history on source study screening). The second round of screening removed sites for a variety of reasons including: lack of sponsor interest, located in potential remediation area (located in river miles 9-14), land ownership and/or future development, fish passage concerns associated with the Superfund Site, and limited ecosystem benefits. The third and final round of screening removed sites that provided decreased benefits associated with NJDEP's Natural Resource Damage Assessment program. The five initial array of sites to be further evaluated included: Oak Island Yards (Tier 2), Kearny Point (Tier 2), Essex County Branch Brook Park, Dundee Island Park, and Clifton Dundee Canal Green Acres (Figure 3-7). Although most sites that would require remediation were screened out for further analysis, it was decided to include Oak Island Yards and Kearny Point given their significant restoration benefit potential and the ability to showcase coordination with USEPA within the Urban Waters Federal Partnership (UWFP) program.

3.5.6 Hackensack "Source" Study

The restoration opportunities and initial array of sites within the Hackensack River were identified in the Hackensack River "source" study. This "source" study examined 48 sites, 2 of which were evaluated in HRE following three rounds of screening. The first round of screening used results from the Meadowlands Environmental Site Information Compilation (MESIC) report. The MESIC report was written in 2004 as a joint effort between USACE, USFWS, and New Jersey

Meadowlands Commission -now the New Jersey Sports and Exposition Authority (NJSEA). Its purpose was to identify and catalog existing data and restoration opportunities, assist in creating a strategy for future data collection, and eliminate the potential for duplicating data (USACE, 2004b). The information compiled focused on 48 sites within the Meadowlands and also included data relevant to the Meadowlands as a whole. In the first round of screening, sites that were determined to be “critical restoration opportunities” moved forward. A critical restoration opportunity was defined as a site that would restore hydrology or wetlands, was owned by the New Jersey Meadowlands Commission, and did not have HTRW concerns (see plan formulation Appendix D-7 for history on Hackensack source study screening). The second round of screening was based on the USFWS Planning Assistance (PAR) letter which prioritized sites based on known presence of contamination. The third round of screening removed sites that the non-federal sponsor did not own. In addition, the USACE, with the NJSEA, prepared the Meadowlands Comprehensive Restoration Implementation Plan (USACE, 2005). The plan provided a menu of comprehensive, ecosystem-based actions that address the problems affecting the aquatic environs and associated habitats of the Hackensack Meadowlands. The two sites that were identified as the initial array of sites for further evaluation in HRE included Meadowlark Marsh and Metromedia Tract (Figure 3-7).

3.5.7 Oyster Sites

The oyster sites were developed in the HRE Study to fulfill objective #4: increase the extent of oyster beds. A number of agencies and non-profit and academic organizations have constructed successful oyster reefs within the region. The HRE Feasibility Study builds upon lessons learned from these projects to design and recommend individual plans at a number of restoration sites identified in coordination with potential construction sponsors. The site locations were selected to maximize oyster productivity, based on best available science. In addition, seasonally- and spatially-variable water quality parameters were mapped to identify restoration opportunities and to ensure that the locations of restoration would yield greatest success (USACE and PANY/NJ, 2009a, 2016). The analysis was based on physical-chemical properties (salinity range, dissolved oxygen, and total suspended solids) and bathymetry of the waterbody in comparison with oyster life-cycle needs and habitat characteristics. Six sites were originally evaluated by HRE in order to build upon original pilot study locations currently being advanced by local partners. These oyster sites went through three rounds of screening. The first round

Figure 3-8. Initial Array of Oyster Sites

of screening removed sites that were not supported by the non-federal sponsor including the reef near the Tappan Zee Bridge. This screening resulted in five sites to be further evaluated by the HRE Study including Governors Island, Soundview Park, Naval Weapons Station Earle, Bush Terminal and Head of Jamaica Bay (Figure 3-8).

3.5.8 Initial Array of Sites for Feasibility Evaluation

A total of 33 sites identified above were included in the Initial Array of Sites as documented above resulting from each 'source" study (Figure 3-9 and Table 3-3).

Figure 3-9. Initial Array of Sites

Table 3-3. Locations of the 33 Sites

Jamaica Bay Planning Region		Oyster Reefs (Multiple Planning Regions)
Perimeter Sites	**Marsh Islands**	
Dead Horse Bay Fresh Creek Hawtree Point Bayswater Point State Park Dubos Point Brant Point	Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	Naval Weapons Station Earle Bush Terminal Jamaica Bay, Head of Bay Governors Island Soundview Park
Harlem River, East River and Western Long Island Sound Planning Region		**Newark Bay, Hackensack River and Passaic River Planning Region**
Flushing Creek 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		Oak Island Yards Kearny Point Essex County Branch Brook Park Dundee Island Park Clifton Dundee Canal Green Acres Metromedia Tract Meadowlark Marsh

3.5.9 Future Spin-Off Studies

This report is considered an interim response to the HRE Study authorization allowing for restoration opportunities via “spin-off” studies within each planning region under the same study authority to contribute further to the region’s restoration goals. A total of 304 restoration opportunities have been identified (296 were outlined in the 2016 HRE Comprehensive Restoration Plan, but some sites have been split following subsequent investigation and additional sites have been added). The site selection process outlined in the following sections identified a total of 33 sites which would be evaluated further as part of the overall HRE Feasibility Study to characterize water resource problems, select measures (Section 3.7), develop restoration alternatives (Section 3.8) and evaluate alternatives (Section 3.9) at each site. In addition, 20 sites are being advanced by regional partners. The remaining 253 restoration opportunities could be advanced as part of future “spin-off” feasibility studies that could result in subsequent requests for construction authorization in the future (Appendix K).

3.6 Site-Specific Problems

This section includes a brief description of the site-specific ecological problems, existing conditions and future without project (FWOP) conditions at each of the 33 sites that were further evaluated as the initial array of sites. See the Plan Formulation Appendix D for additional information.

Jamaica Bay Planning Region – Perimeter

3.6.1 Dead Horse Bay (Tier 2)

The Dead Horse Bay site (Figure 3-10) is adjacent to Floyd Bennett Field and includes tidal wetlands, sandy beach, upland scrub/shrub and a small tidal pond. The entire area was filled, covering the historic marsh with dredged material in the north and solid waste landfill on the south. Vast areas that were once wetlands were converted into upland by adding this fill. Currently, erosion is exposing the landfill on the south. As stated in Section 3.3.1.4, NPS is conducting a removal action in the South and site-wide RI/FS to determine if any additional remedial actions are required. If needed, any required remediation in the north must be completed before construction of the restoration project. HTRW remediation is the responsibility of the non-federal sponsor (or Potential Responsible Party), and must be carried out at 100 percent non-federal expense. The project non-federal sponsor recognizes and accepts full financial responsibility for HTRW remediation. Restoration of this site will be coordinated with NPS.

Figure 3-10. Dead Horse Bay

3.6.2 Fresh Creek

The Fresh Creek site (Figure 3-11) is located in and along the tidal wetlands and adjacent upland bordering Fresh Creek, a tributary to Jamaica Bay. It includes beach, mudflat, salt marsh, coastal scrub/shrub forest, mature woodlands, and invasive plant species. The site is surrounded by dense urban development and subject to combined sewer overflow (CSO) and stormwater outfalls. The Fresh Creek site has poor benthic habitat from past dredging, along with the extensive historic loss of wetland due to filling. Water quality improvements to address poor water quality from CSOs and stormwater runoff is being addressed by NYCDEP's Long Term Control Plan and green infrastructure projects allowing

Figure 3-11. Fresh Creek

Figure 3-12. Hawtree Point

the future restoration to be successful and sustainable. The habitat and hydrology at the site will continue to be impacted in the future.

3.6.3 Hawtree Point

The Hawtree Point site (Figure 3-12) is located in the northern portion of the bay and includes Charles Memorial Park, a developed area with recreational facilities and a large mowed area. Hawtree Point was filled during the development of the communities of Howard Beach and Hamilton Beach. It contains monotypic stands of nonnative invasive plant species and is continually disturbed by the use of all-terrain vehicles along the shoreline.

3.6.4 Bayswater Point State Park

Bayswater Point State Park (Figure 3-13) is comprised of grassland, small tidal marshes, monocultures of invasive species, and native and opportunistic woody vegetation. The site contains the last patch of a mature native oak forest on Jamaica Bay. A deteriorating seawall contributes to severe shoreline erosion and loss of habitat. The site is also dominated by nonnative, invasive plant species, which is a threat to existing desirable wetland habitat.

Figure 3-13. Bayswater Point State Park

3.6.5 Dubos Point

Dubos Point (Figure 3-14) is home to a native flora and cover types ranging from tidal marsh to upland scrub/shrub. The site has been disturbed by dumped trash and debris, fill material in the marsh, and the proliferation of nonnative, invasive plant species. A high energy littoral zone along western and northern shorelines contributes to severe shoreline erosion.

Figure 3-14. Dubos Point

3.6.6 Brant Point

Brant Point (Figure 3-15) is located in the southern portion of Jamaica Bay. A grounded barge located offshore has acted as an erosion

Figure 3-15. Brant Point

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, nonnative 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.

Jamaica Bay Planning Region: Marsh Islands

The historic loss of marsh islands is illustrated in Figure 3-16 for the five (5) marsh islands from 1951 to 2003. Marsh loss will continue into the future and will completely disappear without intervention. See Engineering Appendix for the Regional Sea Level Change (RSLC) analysis.

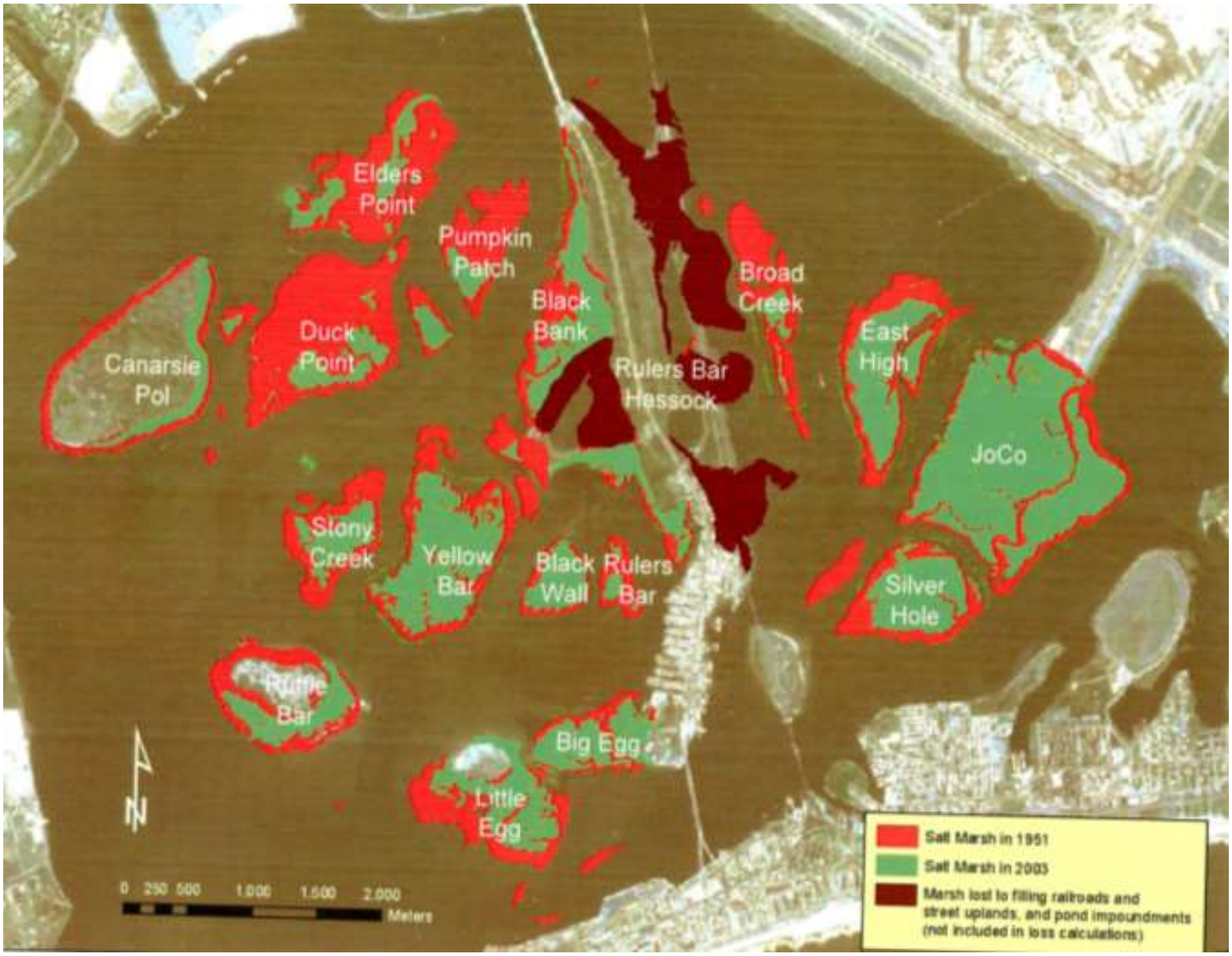


Figure 3-16. Historic Loss of Jamaica Bay Marsh Islands

3.6.7 Duck Point

The existing elevations at Duck Point represent 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: approximately 2.8 acres per year between 1974 and 1994.

3.6.8 Stony Creek

The existing condition remnant marsh found at Stony Creek Marsh Island is well defined and characterized by relatively high elevations. Almost 60 percent of the marsh island has been lost in the past 42 years.

3.6.9 Pumpkin Patch West

Pumpkin Patch West is currently approximately four (4) acres. The average loss rate for Pumpkin Patch as a whole is approximately 1.3 acres/year between 1974 and 1994, with variation up to 2.5 acres/year between 2003 and 2005.

3.6.10 Pumpkin Patch East

Pumpkin Patch East is currently approximately eight (8) acres. The average loss rate for Pumpkin Patch as a whole is approximately 1.3 acres/year between 1974 and 1994, with variation up to 2.5 acres/year between 2003 and 2005.

3.6.11 Elders Center

Elders Point Marsh was historically one (1) island but marsh loss in the center of the island created two (2) distinct islands separated by a mud flat (USACE, 2006). When the restoration of Elders Point East and Elders Point West were planned and implemented, it was infeasible to restore Elders Center based on the depth of the substrate in that area. Presently, no marsh island exists above water between the two (2) islands (Figure 3-17).

Figure 3-17. Aerial of Jamaica Bay Marsh Islands

Harlem River, East River and Western Long Island Sound Planning Region

3.6.12 Flushing Creek

The Flushing Creek restoration site (Figure 3-18) comprises approximately 15.4 acres of shoreline and the tidally influenced Flushing Creek and is roughly two (2) miles upstream from the East River. Previously a sinuous tidal creek in an extensive tidal wetland system, the site suffers from significant straightening of the stream, filled and degraded wetlands, and eroded shorelines dominated by invasive species. Poor water quality limits the diversity of fish and benthic communities. NYCDEP has improved water quality as part of their Long Term Control Plan which will ensure the sustainability of future restoration of the site. Adjacent waterfront development is planned to revitalize the area and will improve public access to the site. The site would continue to be degraded and characterized by invasives species in the future.

Figure 3-18. Flushing Creek

3.6.13 River Park/West Farm Rapids Park

The River Park/West Farm Rapids Park site (Figure 3-19) surrounds the Bronx River in a developed, urban area interspersed with small fragmented woodlots and sparsely vegetated wetlands dominated by invasive species. The site is impaired by garbage and stormwater runoff. The stream channel is mostly armored and the benthic substrate largely consists of construction debris and boulders.

Figure 3-19. River Park/ West Farm Rapids Park

3.6.14 Bronx Zoo and Dam

The Bronx Zoo and Dam restoration site (Figure 3-20) is generally flat and occupied with roadways, parking lots, and the installations of the Bronx Zoo. Flow from the Bronx River is affected by a dam system consisting of two (2) dams abreast of each other separated by a mid-stream island. The site suffers from limited in-stream habitat, invasive species, barriers to

Figure 3-20. Bronx Zoo and Dam

fish movement and poor water quality. NYCDEP's Long Term Control Plan will continue to improve water quality over time. However, the presence of the dam will continue to impede fish passage upstream.

3.6.15 Stone Mill Dam

The Stone Mill Dam restoration site (Figure 3-21) is situated in a steep valley within the New York Botanical Garden. Wetlands consist only of a few, very small, discontinuous pockets of emergent vegetation adjacent to the shoreline and uplands consist of wooded slopes with large rock outcrops. This dam serves as a barrier to fish migration upstream for diadromous fish. This dam will continue to be an impediment to fish passage in the future.

Figure 3-21. Stone Mill Dam

3.6.16 Shoelace Park

The Shoelace Park restoration site (Figure 3-22) is located along the Bronx River and is surrounded by dense, urban development. The site is characterized by an over-widened channel with steep vertical banks and eroded shoreline. Stream banks are sparsely vegetated and wetlands are limited to very narrow, dispersed strips of emergent vegetation. The wetlands and large portions of the upland riverine corridor provide low quality upland buffer and are dominated by invasive species. Stream habitat is also degraded by poor water quality and increased sediment load. Although habitat will remain degraded and characterized by invasive species, NYCDEP has invested in improving water quality within the Bronx River. In addition, NYC Parks has implemented restoration activities (including invasives species removal and native plantings) in localized areas within Shoelace Park.

Figure 3-22. Shoelace Park

3.6.17 Muskrat Cove

The Muskrat Cove restoration site (Figure 3-23) surrounds the Bronx River where it flows

Figure 3-23. Muskrat Cove

through a small, narrow valley. The river and aquatic environment were highly engineered with armored banks with the goal of conveying water past large arterials (e.g., rail lines, roads, etc.) which resulted in impacts on the local ecology. Due to the past and ongoing disturbances at the site, habitats are small fragmented limited fish and wildlife habitat value and often dominated with large stands of invasive species.

3.6.18 Bronxville Lake

The Bronxville Lake restoration site (Figure 3-24) is a suburban park that surrounds a portion of the Bronx River that uses a weir to form a lake. Most of the site consists of maintained lawn, with patches of natural vegetation interspersed. Small pockets of mowed wetlands form in shallow depressions and around the lake and contain little ecological value. The lack of shaded cover, shallowness of the lake, and lack of submerged aquatic vegetation or in-stream cover limit the habitat value of the lake for aquatic species. Degraded conditions will continue into the future.

Figure 3-24. Bronxville Lake

3.6.19 Crestwood Lake

At the southern end of the Crestwood Lake restoration site (Figure 3-25), the Bronx River is dammed, forming the broad shallow lake which is subject to nutrient enriched runoff from surrounding lawns. Fringing wetlands and surrounding uplands are dominated by nonnative invasive species. Sediment bars are formed within the stream at the confluence of Troublesome Creek tributary.

Figure 3-25. Crestwood Lake

3.6.20 Garth Woods/ Harney Road

Garth Woods and Harney Road are two (2) adjacent restoration sites (Figure 3-26) surrounding the Bronx River in Westchester County. Within the site, the stream channel is over-widened and shallow, and the banks show signs of moderate erosion. Vegetation is sparse

Figure 3-26. Garth Woods/Harney Road

and dominated by nonnative invasive species, except for a large forested area within the Garth Woods site. Westchester County will conduct improvements in adjacent areas at Garth Woods. Other areas would continue to be degraded in the future.

3.6.21 Westchester County Center

The Westchester County Center restoration site (Figure 3-27) is traversed by the Bronx River and includes the confluence of two (2) tributaries, the Manhattan Brook and Fulton Brook. Undisturbed wetland and upland habitats are sparse and dispersed across the largely maintained park. Much of the park consists of right-of-way lawns and largely of nonnative, invasive species. The stream is subject to strong and high flows during storm events causing active erosion on the banks, sediment deposits, and collection of garbage and debris.

Figure 3-27. Westchester County Center

<u>Newark Bay, Hackensack River and Passaic River Planning Region</u>

3.6.22 Oak Island Yards (Tier 2 Site)

Figure 3-28. Oak Island Yards

The Oak Island Yards restoration site (Figure 3-28) contains Newark's largest extent of tidal marsh, tidal creeks, and palustrine emergent wetland in the Passaic River. This estuarine ecosystem is documented to have historic fill, vacant structural elements, debris in the tidal channel, and unused pipelines running throughout. The site is dominated by non-native invasive vegetation, limiting ecological value. USEPA will be conducting the remedial action in the lower 8.3 miles of the Lower Passaic and may also conduct a remedial action in Newark Bay pursuant the RI/FS improving sediment quality adjacent the site in the future. Any required remediation must be completed before construction of the Oak Island Yards restoration project. HTRW remediation is the responsibility of the non-federal sponsor (or Potential Responsible Party), and must be carried out at 100 percent non-federal expense. The project non-federal sponsor recognizes and accepts full financial responsibility for HTRW remediation.

3.6.23 Kearny Point

The Kearny Point restoration site (Figure 3-29) is a decommissioned industrial facility built entirely of historic fill and dominated by invasive species in the Lower Passaic River. It contains a forested area on the eastern half of the site which is the location of an active bald eagle nest. The Kearny Point site was a Tier 2 site awaiting remediation of the lower 8.2 miles of the Lower Passaic River. However the Kearny Point upland portion of the site was remediated in 2015 which was found to prevent future restoration on-site.

Figure 3-30. Kearny Point

3.6.24 Essex County Branch Brook Park

The Essex County Branch Brook Park (Figure 3-30) restoration site contains approximately 4,200 linear feet of Branch Brook and adjacent parkland in Newark, New Jersey. The stream and adjacent forest areas experience considerable amounts of anthropogenic trash and are characterized by the presence of invasive vegetation. Three (3) ponds, created by weirs, suffer from algal blooms and eutrophication indicative of excess nutrient inputs. Degradation of the site will continue in the future.

Figure 3-31. Essex County Branch Brook Park

3.6.25 Dundee Island Park

The Dundee Island Park (Figure 3-31) restoration site consists of approximately 2,370 linear feet of the western shoreline of the Lower Passaic River approximately 1.3 miles downstream of the Dundee Dam in Passaic, NJ. The site includes a park with a soccer field, benches, a playground, a boat launch and fish consumption advisory signage. Within the boundary of the site the stream bank is very steep and stabilized with rip-rap and concrete. Flood-driven woody debris and floatable trash have been deposited along the shore. Large ash trees were removed from the shoreline and bank is now dominated by invasive Japanese

Figure 3-29. Dundee Island Park

knotweed. The site has since been restored by NJDEP, the Trust for Public Land and Passaic County.

3.6.26 Clifton Dundee Canal Green Acres

The Clifton Dundee Canal Green Acres site (Figure 3-32) consists of approximately 1,800 linear feet of the western shoreline of the Lower Passaic River downstream of the Dundee Dam in Clifton, NJ. Within the site is Dundee Island Preserve, which includes a trail network, benches, interpretive signage, trash and recycling bins, and fish consumption advisory signage. The site also includes property which is subject to a NJDEP environmental investigation/cleanup. Large volumes of flood-driven woody debris and floatable trash have been deposited along the shore of the central portion of the site and nonnative invasive plant species are found throughout.

3.6.27 Metromedia Tract

Bordered on the east and south by the Hackensack River, and on the north by Marsh Resources Meadowlands Mitigation Bank, the Metromedia Tract restoration site (Figure 3-33) surrounds the Metromedia Broadcast site and towers. This restoration site is undeveloped and characterized as generally poor habitat, largely dominated by invasive common reed (*Phragmites australis*). The site would continue to be degraded in the future.

3.6.28 Meadowlark Marsh

The Meadowlark Marsh restoration site (Figure 3-34) is located north of Bellman's Creek within the Hackensack Meadowlands District. The site is primarily comprised of *Phragmites*-dominated (monoculture) emergent wetlands divided by utility access roads and other areas of historic fill material. Upland areas on the site are currently being used as an all-terrain vehicle course or a utility access road, and consist of relatively low quality habitat.

Figure 3-33. Clifton Dundee Canal Green Acres

Figure 3-32. Metromedia Tract

Figure 3-34. Meadowlark Marsh

Oyster Reef Restoration – Multiple Planning Regions

As described in Section 3.1.3.4, oysters were once prevalent throughout the study area covering approximately 200,000 acres (Kennish, 2002, Bain et al. 2007). By the early 20th century, poor water quality conditions and incidence of human-transferable diseases resulted in declining harvest and, by 1925, the oyster industry in the estuary was abandoned (MacKenzie 1992). The five sites evaluated were historically populated by oyster reefs and are now only populated by small-scale reefs implemented by non-federal sponsors. In addition, the surrounding areas are characterized by uniform degraded non-complex benthic habitat.

3.6.29 Naval Weapons Station Earle

The Naval Weapons Station Earle site is located along the northern New Jersey shore in the south end of Sandy Hook Bay and features a 2.9-mile pier. The naval facility is considered an ideal restoration area and the presence of naval security forces and exclusion areas would likely result in a low disturbance of the restoration area. Restoration activities would occur under the pier at a location closer to land away from naval ship activity. The restoration would build on previous successful Oyster Reef restoration by the NY/NJ Baykeeper at Naval Weapons Station Earle.

3.6.30 Bush Terminal

Oyster Reef restoration at Bush Terminal would complement other restoration work by NYC Parks at the adjacent Bush Terminal Piers Park and pilot studies implemented by the Harbor School's Billion Oyster Project.

3.6.31 Head of Jamaica Bay

Oyster Reef restoration in Jamaica Bay will expand the small reef that was recently constructed by the NYCDEP.

3.6.32 Governors Island

The Harbor School on Governors Island conducts numerous oyster studies and restoration efforts at Governors Island would maximize efforts of the Billion Oyster Project and benefit the students through expanded scientific study opportunities. Results from pilot studies conducted by the Harbor School indicated that the reef would not be successful and should not be evaluated further in the HRE study and was removed from further consideration.

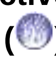
3.6.33 Soundview Park

Oyster Reef restoration at the Soundview Park site would build on previous successful oyster reef restoration under the direction of the Harbor School and Billion Oyster Project. This site was subsequently removed from the HRE Study given the Harbor School is advancing the project through grant from New York State.

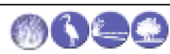
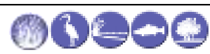
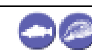
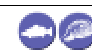
3.7 Management Measures

Management measures are features or activities that can be implemented at a specific geographic site to address one or more planning objectives to restore structure, function, connectivity and extent of the focal habitat types. Measures revolved around the planning objectives and TECs and sources for management measures included the "source" study reconnaissance reports, Needs and Opportunities Report (RPA, 2003), prior public meetings and the U.S. Army Engineer Institute of Water Resources (IWR) Management Measures Digital Library for Ecosystem Restoration. Table 3-4 provides a sample of the management measures that were used alone or in combination to develop alternatives for the sites associated with the planning objectives. Generally, discrete habitat types are found in differing ranges and densities within each planning region. Thus, most restoration opportunities, and therefore most management measures are similar within a planning region. The study team identified and evaluated cost-effective and site-appropriate measures, scales, and combinations of feature and activity types at each restoration site to improve the native habitats within the site. This supports an intent to develop a mosaic of habitats within each site proper, given the limited opportunities and available habitat within the highly urbanized environment.

Table 3-4 identifies the measures that could restore the TECs and meet the planning objectives. The team combined these measures to generate conceptual plans at each of the sites within the study area, and bundled the conceptual plans for each site to form planning alternatives for the feasibility study.

Table 1-4. Management Measures to Achieve Planning Objectives and Associated Target Ecosystem Characteristics (TECs). TECs include: wetlands (), habitat for waterbirds (), fish, crab and lobster habitat (), oyster reefs (), shorelines and shallows (), tributary connections (), and coastal and maritime forest ().

Management Measures	***#1*: Restore the structure, function, and connectivity, and increase the extent of estuarine habitat**	***#2*: Restore the structure and function, and increase the extent of freshwater riverine habitat**	***#3*: Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay**	***#4*: Increase the extent of oyster reefs**
Excavation and regrading				
Invasive species removal				
Native vegetation planting				
Fill removal				
Sediment placement				

Management Measures	***#1*: *Restore the structure, function, and connectivity, and increase the extent of estuarine habitat***	***#2*: *Restore the structure and function, and increase the extent of freshwater riverine habitat***	***#3*: *Restore the structure and function, and increase the extent of marsh island habitat in Jamaica Bay***	***#4*: *Increase the extent of oyster reefs***
Fish ladders				
Berm or dike removal				
Shoreline restoration				
Shoreline softening				
Bank stabilization				
Hydrologic improvements (deepening, in-stream structures)				
Channel modification				
Sediment control best management practices				
Deploying live shellfish				
Submarine reef placement				

A strategy was developed to rapidly assess and screen management measures for each major habitat type: estuarine habitat, freshwater riverine habitat, marsh islands, and oyster reefs. Most sites within each planning region have similar attributes, problems, needs, opportunities, constraints, considerations, and trade-offs, and the formulation strategy seizes on similarities within a planning region and ecosystem type. Measures and alternatives were also built directly from prior recommendations in the "source" studies. This streamlined approach to restoration planning was considered consistent with SMART Planning principles and deemed appropriate to maximize efficiencies, resources, and benefits (IPR, January 2015).

Details about each measure for each TEC are included in the Plan Formulation appendix (Appendix D) and the Engineering Appendix (Appendix C).

3.7.1 Screening of Management Measures

Several evaluation criteria were used to screen measures for consideration at each restoration site identified in Section 3.5 and 3.6 (with the exception of oyster reefs at Governors Island and Soundview Park). A measure was considered for use at a site providing it met the following qualitative criteria:

> **Screening**
>
> **Screening** is the ongoing process of eliminating from further consideration, based on planning criteria, what is no longer important. Criteria are derived for the specific planning study, based on the planning objectives, constraints, and the opportunities and problems of the study or project area.

- Meets the planning objectives;
- Avoids planning constraints;
- Observes planning considerations;
- Contributes to achieving TEC objectives within the watershed, as well as in the overall HRE as the primary goal was to develop a mosaic of habitats;
- Accounts for technical and institutional significance of resources as components of an estuary of importance under the National Estuary Program in a highly urbanized context;
- Size or scale is conducive to implementation;
- Operations and maintenance would be relatively minor, making restoration as self-sustaining as possible;
- Complements adjacent measures and/or future actions proposed by the project sponsors;
- Can be implemented without requiring impractical engineering controls or causing a burden or intolerable hardship on the local community (e.g., without requiring extensive grading or relocation of structures such as highway bridge piers);
- Increases ecological uplift either alone or in concert with other measures; and
- Performs well with respect to climate change (i.e., sea level change), as some sites are spatially constrained to a narrow strip along a water interface and may lose acreage as the sea level rises.

3.8 Development of Site-Specific Alternatives

Alternatives were developed for each of the 31 sites (Section 3.6). Site appropriate measures (Section 3.7) were chosen based on existing conditions, and site-specific problems, opportunities, objectives, constraints, and considerations. Topographic surveys, hydraulic and hydrology analyses, and ecological functional assessments—Evaluation of Planned Wetlands (EPW) rapid assessment procedure for wetlands were performed to establish, quantify, and evaluate existing baseline conditions.

Conceptual plans were developed for each potential restoration site (Appendix D) and are summarized in Tables 3-5 through 3-8. In most cases, measures have been designed to build upon each other, meaning that increased functionality is a product of the interactions of all measures proposed at a given site. At each of the sites in the final array of site plans, each of the recommended measures is needed to fully meet the objectives that will be addressed at that site.

3.8.1 Estuarine and Freshwater Restoration Sites (Objectives #1 and #2)

Alternatives were developed through the following multi-step, iterative process in which the sponsors and stakeholders were closely involved. As a benchmark, all restoration alternatives addressed, at a minimum, the most serious environmental stressors at the specific site. The alternatives prepared for each restoration site were developed by varying and combining site-appropriate measures (e.g., wetland restoration, streambank restoration, bed restoration) aimed at meeting region-and site-specific objectives. In selecting measures, the feasibility study team considered the following:

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

For the Jamaica Bay Perimeter sites, a range of one (1) to six (6) alternatives were developed for each site. These alternatives were all taken from the Jamaica Bay “source” study (Table 3-5).

For the Flushing Creek site, which was included in the Flushing Creek and Bay “source” study, HRE developed three new alternatives with the assumption that NYCDEP would conduct environmental dredging adjacent the site. Three (3) reformulated alternatives were then developed in 2019 due to a change in future without project conditions when NYCDEP indicated they were not planning on conducting the adjacent dredging. The three (3) alternatives were variations of area footprint, acreage of various habitat types while considering the existing bathymetry to minimize costs (Table 3-5).

For the Bronx River, Lower Passaic River, and Hackensack river sites, a minimum of three alternatives were developed by the HRE PDT for each site. Typically, three (3) restoration alternatives or concept plans were developed, varying the type and magnitude of TECs achievable within the site. The three (3) alternatives comprised the following (Table 3-5 and Table 3-6):

- Alternative A or 1 maximizes the restoration potential for each site through the placement of a mosaic of habitats, or TECs, and solutions for stressors of water resources. Typically, this alternative has the highest anticipated restoration benefits and the greatest ecological lift through a range of benefits.
- Alternative B or 2 focuses largely on correcting the most significant environmental stressors and restoring targeted habitats and ecological functions for a particular site. The alternative removes key stressors and has moderate to high ecological lift.

- Alternative C or 3 focuses on correcting the most significant environmental stressors for a particular site. The alternative has moderate ecological lift, achieved only through removing key stressors.

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

Table 3-4. Alternatives Developed for the Estuarine Sites

Restoration Site	Restoration Measure/Habitat Type (acres)						
	Alt	Low Marsh	High Marsh	Scrub/ shrub or Forested Wetland	Maritime/ Buffer Forest*	Tidal Channel	Other
Jamaica Bay Planning Region – Perimeter Sites							
Dead Horse Bay	1	10	3	0	87	0	-
	2	10	3	0	87	0	DHB South: Excavation and Reuse of Landfill and Dune Creation
	3	31	7	0	60	4	-
	4	31	7	0	61	4	DHB South: NPS -Excavation and Reuse of Landfill and Dune Creation
Fresh Creek	1	6.3	1.7	9.7	4.5	0	-
	2	6.3	1.7	9.7	4.5	0	Half of Creek Re-contoured
	3	13	2.4	11	4.5	2.1	Head of Creek Re-contoured
	4	6.3	1.7	9.7	4.5	0	Full Creek Re-contoured
	5	13	2.4	11	4.5	2.1	Full Creek Re-contoured
Hawtree Point	1	0	0	1.7	0	0	Salt Marsh Hay Planting
Bayswater Point State Park	1	2	0.4	0	0	0.21	Dune Creation
	2	2.6	0.3	0	0	0.8	Dune Creation and additional Hard Structures

Restoration Site	Restoration Measure/Habitat Type (acres)						
	Alt	Low Marsh	High Marsh	Scrub/ shrub or Forested Wetland	Maritime/ Buffer Forest*	Tidal Channel	Other
	3	2.5	0.4	0	0	0.21	Dune Creation and Shallow Water Habitat
Dubos Point	1	3.5	0.6	0	2	0.7	-
	2	3.5	0.6	0	2	0.7	Toe Protection
	3	3.5	0.6	0	2	0.7	Maximum Toe Protection
Brant Point	1	1.9	0.7	0	2.4	0	Meadow
	2	1.9	0.7	0	2.4	0	Meadow and Rubble Mounds
Harlem River, East River and Western Long Island Sound Planning Region – Flushing Creek Site							
Flushing Creek	1	5.53	2.28	1.1	1.02	0	-
	2	8.74	4.01	1.5	2.43	0	-
	3	10.53	4.1	2.1	4.5	0	-
Newark Bay, Hackensack River and Lower Passaic River Planning Region – Lower Passaic River Sites							
Oak Island Yards	A	5.85	1.31	1.68	1.86	1,526 LF	Streambank Restoration
	B	5.05	2.34	0.99	1.86	1,873 LF	Streambank Restoration
	C	4.7	2.04	2.21	1.86	1369 LF	Streambank Restoration
Kearny Point	A	17.83	2.53	6.61	6.95	3,404 LF	Debris Removal and Streambank Restoration
	B	17.17	2.11	3.87	18.23	3,391 LF	Streambank Restoration and Shoreline Softening
	C	8..77	1.68	11.73	13.49	1,750 LF	Streambank Restoration and Shoreline Softening

Restoration Site	Restoration Measure/Habitat Type (acres)						
	Alt	Low Marsh	High Marsh	Scrub/ shrub or Forested Wetland	Maritime/ Buffer Forest*	Tidal Channel	Other
Newark Bay, Hackensack River and Lower Passaic River Planning Region – Hackensack River Sites							
Metromedia Tract	A	38.0	4.8	5.3	11.5	-	-
	B	43.1	4.5	11.8	0	-	-
	C	50.6	4.1	3.5	1.1	-	-
Meadowlark Marsh	A	55.04	6.43	8.67	2.31	8,319 LF	-
	B	58.8	5.04	8.38	2.44	7,086 LF	-
	C	53.2	4.94	8.59	3.21	0	-

*Maritime Forest Restoration resulted from on-site placement of excavated material which was the least cost option. In addition, alternatives developed as part of the Jamaica Bay “source” study planned to restore dunes resulting from on-site placement of excavated material as well.

Table 3-5. Alternatives Developed for the Freshwater Sites

Restoration Site	Restoration Measures /Habitat Type							
	Alt	Emergent Wetland (acres)	Forest Scrub/shrub (acres)	Invasives Removal/ Native Planting (acres)	Bed Restoration and Channel Modification (acres)	Fish Ladder (acres/miles opened)	Streambank Restoration and Shoreline Softening (acres)	Other
Harlem River, East River and Western Long Island Sound Planning Region – Bronx River Sites								
River Park/ West Farm Rapids Park	A	0.04	-	0.87	0.6	-	0.34	Debris Removal
	B	0.04	-	0.87	0.47	-	0.34	Debris Removal
	C	-	-	0.98	0.36	-	0.06	Debris Removal
Bronx Zoo and Dam	A	0.99	0.29	0.35	0.35	0.04 / 0.8	0.05	Debris Removal
	B	0.71	-	0.64	0.35	0.04 / 0.8	0.05	Debris Removal
	C	0.56	-	0.79	-	0.04 / 0.8	-	Debris Removal
Stone Mill Dam	A	-	-	0.037	-	0.02 / 22.9	-	Fish Attractants
	B	-	-	0.027	-	0.02 / 22.9	-	
	C	-	-	-	0.09	-	-	
Shoelace Park	A	2.07	2.95	9.56	5.44	-	0.73	
	B	2.07	-	10.2	5.59	-	2.06	
	C	2.01	-	5.87	-	-	2.07	
Muskrat Cove	A	-	-	11.4	0.37	-	0.94	Debris Removal

Restoration Site	Restoration Measures /Habitat Type							
	Alt	Emergent Wetland (acres)	Forest Scrub/shrub (acres)	Invasives Removal/ Native Planting (acres)	Bed Restoration and Channel Modification (acres)	Fish Ladder (acres/miles opened)	Streambank Restoration and Shoreline Softening (acres)	Other
	B	-	-	11.4	0.37	-	0.94	Debris Removal
	C	-	-	11.4	-	-	0.36	Debris Removal
Bronxville Lake	A	4.0	1.0	0.02	1.32	-	-	Sediment Forebay and Weir Modification
	B	0.86	2.96	1.38	1.30	-	-	Sediment Forebay and Weir Modification
	C	0.65	0.56	0.02	3.51	-	-	Sediment Forebay, Fish Passage and Weir Modification
Crestwood Lake	A	4.79	-	1.3	1.24	-	-	Riprap Forebays and Weir Modification
	B	0.94	-	1.31	1.24	-	-	Riprap Forebays and Weir Modification

Restoration Site	Restoration Measures /Habitat Type							
	Alt	Emergent Wetland (acres)	Forest Scrub/shrub (acres)	Invasives Removal/ Native Planting (acres)	Bed Restoration and Channel Modification (acres)	Fish Ladder (acres/miles opened)	Streambank Restoration and Shoreline Softening (acres)	Other
	C	0.32	-	1.31	1.21	<0.01		Riprap Forebay
Garth Woods/ Harney Road	GW[1]: A-2	-	0.04	0.17	-	-	-	-
	A	3.1	-	0.34	0.86	-	0.01	Weir Modification and Culverts
	B	0.76	-	1.47	1.34	-		Weir Modification
	C	0.24	0.53	1.47	-	<0.01	-	-
Westchester County Center	A	4.88	-	3.83	2.0	-	-	-
	B	2.7	-	4.45	0.99	-	0.07	-
	C	2.76	-	4.39	-	-	0.07	Debris Removal
Newark Bay, Hackensack River and Lower Passaic River Planning Region – Lower Passaic River Sites								
Essex County Branch Brook Park	A	3.8	26.3	5.23	25.56	-	8.25 + 10,320 lf	Upland Buffer Forest
	B	28.22	-	5.23	17.07	-	8.25 + 15,007 lf	-
	C	-	-	5.23	23.52	-	10,320 lf	-
	D	10.25	8.8	8.91	18.09		0.99	
Dundee Island Park	A	-	-	1.79	-	-	0.71	-

Restoration Site	Restoration Measures /Habitat Type							
	Alt	Emergent Wetland (acres)	Forest Scrub/shrub (acres)	Invasives Removal/ Native Planting (acres)	Bed Restoration and Channel Modification (acres)	Fish Ladder (acres/miles opened)	Streambank Restoration and Shoreline Softening (acres)	Other
Clifton Dundee Canal Green Acres	A	0.21	2.84	5.5	-	-	-	Debris Removal and Buffer Forest Enhancement
	B	0.21	-	7.86	-	-	-	Debris Removal and Buffer Forest Enhancement
	C	-	-	7.93	-	-	-	Debris Removal and Buffer Forest Enhancement

[1] GW**:** Garth Woods site only had one alternative (A-2) that was evaluated with each Harney Road Site Alternative.

3.8.2 Jamaica Bay Marsh Islands (Objective #3)

Three (3) alternatives were developed at the five (5) marsh island locations (Table 3-7). The alternatives were based on lessons learned and cost-effectiveness evaluations to develop the optimal marsh island size and design. 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 the National Park Service (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.
- Coordination with New York State Department of Environmental Conservation (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. In certain instances, alternatives were designed beyond the 1974 footprint where the existing condition elevations were relatively high.
- The minimum size of the marsh island is driven by cost constraints of mobilization and demobilization of dredging and placement of sand.
- The maximum area/acreage of the marsh island may be described by the existing depth, or contour, 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 and monitoring indicated success of hummock replanting and use of tri-plugs (*Spartina alterniflora*, *Spartina pattens*, and *Distichlis spicata*) with optimal spacing (18-inches on center).
- Plans were developed based on minimum sand volumes for maximum wetland acreage and sustainability.
- Marsh islands also have potential to serve as NNBFs providing secondary coastal storm risk management benefits as suggested by the Structures of Coastal Resilience; http://structuresofcoastalresilience.org/locations/jamaica-bay-ny/.

Given the fact that ecological output for an acre of marsh island is constant, cost effectiveness analysis of prior marsh restoration efforts clearly 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 Recommended 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 alternative 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 (3) alternatives informed by the constraints. Three alternatives were developed for each marsh island based upon the above lessons learned from prior marsh island restoration efforts.

Table 3-6. Alternatives Developed for the Marsh Island sites

Restoration Site	Habitat Restoration Type (acres)				CYD of Sand
	Alternative	Low Marsh	High Marsh	Scrub/Shrub	
Duck Point	1	15.4	12.5	-	96,100
	2	22.5	13.9	2.2	213,776
	3	25.9	15.7	2.9	284,989
Stony Creek	1	26.0	25.3	0.7	151,360
	2	28.3	11.3	-	88,614
	3	22.9	8.40	-	65,258
Pumpkin Patch West	1	10.8	5.50	-	206,810
	2	13.7	8.60	0.9	327,686
	3	18.7	10.3	1.2	435,493
Pumpkin Patch East	1	18.5	16.8	-	432,790
	2	12.4	7.70	1.2	255,123
	3	15.6	10.1	3.1	351,952
Elders Center	1	8.50	7.50	-	236,410
	2	9.50	6.90	1.9	217,163
	3	15.2	10.9	1.4	284,891

3.8.3 Oyster Reef Restoration (Objective #4)

The Oyster Reef restoration recommendations build upon pilot programs that were conducted by regional partners. Initial pilot programs to restore oysters -such as the Oyster Reef restoration Research Project, a partnership of over 30 not-for-profit organizations, federal agencies, including USACE, state and city agencies, scientists, and citizens -began in the early 2000s. Among the objectives of the Oyster Reef Restoration Research Project is determining the best sites and methods to use in scaling up to large-scale oyster reef restoration in the New York/New Jersey Harbor Estuary (USACE, 2016).

The partnership’s initial pilot programs, along with those undertaken by NYCDEP, NY/NJ Baykeeper, The Urban Assembly New York Harbor School, and others, have determined that restored oysters and created oyster beds can survive in the HRE. However, oysters are sessile organisms and offspring are often dispersed into the current with little chance of resettlement. Thus, a more targeted Oyster Reef restoration effort in the HRE, as proposed, would advance oyster recovery in key areas of the HRE.

Based in part on its experience restoring oysters in the HRE and on its research findings, the Oyster Reef Restoration Research Project has provided recommendations for future Oyster Reef restoration within the HRE. The HRE Feasibility Study builds upon the research provided by these pilot programs, serving as the foundation of recommendations for specific restoration techniques, site considerations, and management of existing reefs. Initially, alternatives were developed for five (5) Oyster Reef restoration sites within the HRE study area. However, two (2) of the sites including Governors Island and Soundview Park were deleted from further consideration. Three (3) feasibility-level conceptual plans were developed for small-scale restoration at the three (3) sites in the HRE, incorporating restoration techniques that have been tested during pilot programs implemented between 2010 and 2015. Based on a literature review, information gathered from pilots, and sponsors' recommendations, the designs include combinations of restoration techniques most suitable for the conditions, such as bathymetry, tidal currents, and substrate, at each site. Three alternatives were developed per oyster site (Table 3-8).

The proposed Oyster Reef restoration sites would restore in total over 50 acres of reef structure. 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 in the future.

Table 3-7. Alternatives Developed for the Oyster Reef Restoration sites

Restoration Site	Alternative	Restoration Techniques				
		Spat-on-Shell (acres)	Oyster Gabions	Oyster Pyramids	Oyster Castles	Oyster Trays
Lower Bay Planning Region						
Naval Weapons Station Earle	1	-	32	306	-	-
	2	-	62	612	-	-
	3	-	102	1,010	-	-
Upper Bay Planning Region						
Bush Terminal	1	11	376	-	-	-
	2	16.2	554	-	-	-
	3	32	1,094	-	-	-
Jamaica Bay Planning Region						
Head of Jamaica Bay	1	3.3	112	-	126	44
	2	3.3	224	-	220	70
	3	9.85	337	-	150	24

3.9 Evaluation of Restoration Alternatives

Site-scale alternatives were evaluated and compared based on four steps: forecasting of environmental benefits of restoration actions, estimation of restoration cost, analysis of cost-effectiveness and incremental cost analysis (CE/ICA), and consideration of these analyses in light of other decision factors (e.g., constraints, return on investment, secondary objectives). The following sections review these steps at the site and regional scales.

The basic logic of decision-making proceeded by selecting the “best buy” alternative with an incremental analysis that efficiently provides benefits on an incremental unit cost basis.. Using this alternative as a starting point, other best buy and cost-effective alternatives were compared relative to the policy guidance and secondary factors discussed above. However, as described in ER 1105-2-100 (E-156), “neither analysis [CE/ICA] dictates what choice to make,” and decisions may be guided by a variety of factors including (E-158): curve anomalies such as breakpoints in the incremental cost curve, output targets and thresholds for an ecological resource, cost affordability, and unintended effects including other secondary decision factors. In addition to CE/ICA, the following factors also influenced alternative comparisons:

Best buy plans produce the greatest increase in value at the lowest cost. These plans are typically considered candidates for recommendation in a feasibility study.

- Contribution to the planning objectives,
- Avoidance of project constraints,
- Completeness, effectiveness, efficiency, and acceptability of an alternative,
- Other Social Effects (OSE) consisting of institutional, public, and technical significance of ecological resources at the site, and
- Support of the regional restoration goals defined by the TECs.

3.9.1 Forecasting Environmental Benefits

Ecosystem restoration projects provide benefits to people and the environment, some of which are not easily quantified. For example, healthy ecosystems can support diverse habitats, biodiversity, food web stability, and materials cycling. In planning ecosystem restoration projects, USACE uses non-monetary indicators of ecological benefits rather than traditional economic benefit-cost analysis. The diversity of HRE’s ecosystems types required three models for assessing ecological benefits. Detailed descriptions of the environmental benefits analysis are presented in Appendices E and J (Benefits Analysis and CE/ICA, respectively).

Evaluation of Planned Wetlands (EPW) was used to quantify benefits for estuarine and freshwater wetland restoration sites. EPW is a rapid assessment procedure, certified for regional use in July 2016, which provides a method for determining the capacity of an ecosystem to perform certain ecological and watershed functions. EPW evaluates five functional categories: shoreline bank erosion, sediment stabilization, water quality, wildlife, and fish (Bartoldus 1994, Bartoldus et al. 1994). EPW scores were calculated for existing conditions at each site. From this baseline, each alternative was assessed relative to anticipated increases in each functional outcome as a result of implementing the proposed action. The five functional categories were averaged to obtain a functional capacity index (FCI), which was subsequently multiplied by project area (in acres) to obtain a quality-weighted area metric (functional capacity units [FCUs]).

The Watershed-Scale Upstream Connectivity Toolkit (WUCT) was used to assess watershed connectivity benefits associated with fish passage measures at Bronx Zoo and Dam and Stone Mill Dam. WUCT was developed by the Engineer Research and Development Center (ERDC) and certified for National use on 29 October 2018 (McKay et al. 2017, McKay et al. 2018). The model focuses on upstream movement of migratory organisms and combines three data sources (habitat quantity, habitat quality, and structural passability) to estimate quality-weighted, accessible habitat at the watershed scale.

Oyster Suitability Habitat Index Model (OHSIM) was used to determine overall habitat suitability for Eastern Oysters (*Crassostrea virginica*) at Naval Weapons Station Earle, Bush Terminal and Head of Jamaica Bay. The OHSIM uses a series of linear equations to calculate habitat suitability for *C. virginica* under different restoration scenarios and was certified for national use (Swannack et al. 2012). For the HRE, a spatially-implicit model version was applied to each site separately. The overarching assumption of the OHSIM is that variables, substrate and salinity can be used to quantitatively estimate suitable oyster habitat. An overall Habitat Suitability Index (HSI) value is calculated as the geometric mean of all substrate and salinity metrics.

All models were applied at four time intervals for all alternatives including future without project (FWOP): Year 0 (TY0 – baseline conditions), Year-2 (TY2 – as built/post construction period reflecting initial ecological response), Year 20 (TY20 – incorporates 19 full growing seasons and estimates long term outcomes), and Year-50 (TY50 – end of the planning horizon). Habitat acreage (low marsh, high marsh, and floodplain) was projected 50 years beyond the design year (based on the annual elevation datum) for the intermediate sea level change scenario, and all benefits include the effects of sea level rise. Ecological benefits were annualized by computing the time-averaged benefits distributed over the entire planning horizon (known as average annual functional capacity units, AAFCUs). Alternatives were compared using the net benefits (or "ecological lift") over the future without project condition (i.e., Lift = $AAFCU_{Alt}$ – $AAFCU_{FWOP}$). Multiple models were applied at two sites (Bronx Zoo and Dam and Stone Mill Dam), and average annual outputs were combined by summation at these sites. While multiple models were used, this report shows all benefits as AAFCUs for simplicity of presentation.

3.9.1 Development of Costs Estimates

Preliminary project first cost estimates were developed for the 31 proposed sites with the following assumptions (See Appendix I for details):

- Construction costs were developed in MCACES, Second Generation (MII) using the appropriate Work Breakdown Structure (WBS) and based on current estimated quantities provided by the Hydraulics & Hydrology Engineers. The cost estimate was developed from these quantities using cost resources such as RSMeans, historical data from similar construction features, and MII Cost Libraries.
- Project contingencies were developed through an Abbreviated Risk Analysis (ARA) tool provided by the Cost MCX, ranging from 30% to 40%.
- Site-specific real estate costs (Account 01) were developed for each site. Fee title and temporary easements will be acquired per ER 1105-2-100 Sec. 3-5(b)(9) and ER 405-1-12. Real estate costs are based on the following assumptions. Estimates include land acquisition and incidental costs (i.e., appraisals, land surveys, title services, etc.). Most sites are owned by non-federal sponsors and do not require land acquisition. For Lower Passaic River sites, private land owners were considered part of the Cooperating Parties Group (CPG) within the Superfund program and will be donating their property to the

State of New Jersey for restoration as part of their settlement. Therefore, land acquisition costs were not developed for Kearny Point and Oak Island Yards. To minimize real estate costs, small private parcels that bordered the restoration were avoided without affecting restoration benefits.

- Pre-construction Engineering and Design (PED) (Account 30) and Construction Management (Account 31) were included as a percentage of the construction costs at 20.50% and 9.00% respectively except for Jamaica Bay Marsh Islands where the account 30 cost range from 9% to 15.50%.
- Monitoring cost was initially assumed to be 1% of construction cost. However, a minimum lump sum of $50,000 was included for lower cost alternatives, and oyster sites included higher monitoring costs due to site access challenges.
- Adaptive management cost was initially assumed to be 3% of construction cost. However, a minimum lump sum of $100,000 was included for lower cost alternatives.

Average annual economic costs were developed from first costs, interest during construction, monitoring, adaptive management, and Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) as follows. All alternative costs were amortized at FY2018 interest rate of 2.75% (EGM 18-01) over a 50 year period of analysis.

- Interest during construction was computed based on estimated construction duration (See Appendix J).
- Monitoring and adaptive management costs were amortized over a five-year horizon.
- Annualized OMRR&R costs were estimated over the economic period of analysis (50 years). For all oyster sites, an OMRR&R cost of $10,000 was used. For all other sites, OMRR&R was estimated from first cost as follows:
    - If first cost was $0 to $10,000,000, then OMRR&R cost was $20,000.
    - If first cost was $10,000,000 to $30,000,000, then OMRR&R cost was $50,000.
    - If first cost was greater than $30,000,000, then OMRR&R cost was $80,000.

3.9.2 Relative Sea Level Change Analysis

<u>All Alternatives</u>
An RSLC analysis was conducted consistent with EP 1100-2-1 (June 2019) and ER-1100-2-8162 (Dec 2013) for each site within the Maximum Vertical Datum of Concern in order to adequately project ecosystem benefits in the future and ensure the restoration action will be sustainable. Of the 33 HRE sites, 16 were found to be within the Maximum Vertical Datum of Concern and were analyzed with regard to sea level change. The remaining 17 sites were either freshwater sites (predominantly but not exclusively within the Bronx River) or Oyster Reef sites, which were judged to not be sensitive to changes in sea level.

In accordance with the tenets of SMART Planning, many of the designs for the 16 sites that were analyzed were designed to a relatively low level of detail; a grading plan, which is needed to effectively analyze sea level change, had not been prepared at that point. Conceptual level grading plans for each of the alternatives were therefore developed to proceed with the sea level change analysis.

For the present SLC analysis, the National Oceanic Atmospheric Administration (NOAA) tide gauge at Sandy Hook was referenced and the level of SLC for the period of analysis was derived using the Corps' Online Sea Level Change Curve Calculator. For this analysis, only the intermediate curve results were used. The absolute magnitude of sea level (MSL) change for years 20 and 50 were then applied to the local tidal data used as the basis of design for each site. For each site, the project base year used in the SLC analysis was taken to be the year that site specific tidal data was collected, as this corresponds to the time the designs were developed. It is acknowledged that this is a departure from guidance that sets the base year as a date in the future (the planned construction date).

The analyses and performance of the Recommended Plan or RSLC discussed in Chapter 4.6.

3.10 Summary of Site Benefits and Costs

Table 3-9 presents a summary of all benefits and costs for each site and alternative. Additional detail may be found in Appendix E (Benefits), Appendix I (Costs), and Appendix J (Annualization and CE/ICA).

Table 3-8. Ecological Benefits and Costs of Each Alternative for Estuarine and Freshwater Riparian Habitat Site.

Site	Alt	Net Ecological Benefits (AAFCU)	Sub-Total Project First Cost ($)	Monitoring and Adaptive Management Cost ($)	Project First Cost ($)	Annualized OMRR&R Cost ($)	Average Annual Economic Cost ($)
Jamaica Bay Planning Region – Perimeter Sites							
Dead Horse Bay	4	35.8	$82,697,602	$1,848,360	$84,545,962	$80,000	$3,330,851
Fresh Creek	5	36.8	$33,148,455	$737,068	$33,885,522	$80,000	$1,382,939
Brant Point	2	3.4	$6,425,941	$155,406	$6,581,347	$20,000	$273,007
Hawtree Point	1	0	$1,981,636	$150,000	$2,131,636	$20,000	$101,510
Bayswater Point State Park	2	1.1	$5,766,391	$150,000	$5,916,391	$20,000	$247,399
Dubos Point	3	1.9	$9,585,028	$214,028	$9,799,056	$20,000	$396,781
Jamaica Bay Planning Region – Marsh Islands							
Duck Point	1	14.8	$20,847,701	$473,882	$21,321,583	$50,000	$869,796
	2	22.3	$23,408,019	$532,104	$23,940,123	$50,000	$970,476
	3	26.3	$28,182,992	$640,688	$28,823,679	$50,000	$1,158,245
Stony Creek	1	29.3	$22,218,071	$515,297	$22,733,369	$50,000	$924,034
	2	18.9	$17,973,727	$416,821	$18,390,547	$50,000	$757,065
	3	14.9	$15,770,046	$365,691	$16,135,738	$50,000	$670,374
Pumpkin Patch West	1	9.9	$14,027,060	$333,372	$14,360,432	$50,000	$614,934
	2	12.7	$20,504,279	$487,409	$20,991,688	$50,000	$875,808
	3	18.1	$26,710,462	$634,999	$27,345,461	$50,000	$1,125,766

Site	Alt	Net Ecological Benefits (AAFCU)	Sub-Total Project First Cost ($)	Monitoring and Adaptive Management Cost ($)	Project First Cost ($)	Annualized OMRR&R Cost ($)	Average Annual Economic Cost ($)
Pumpkin Patch East	1	21.8	$30,400,272	$693,870	$31,094,142	$50,000	$1,245,530
	2	13.5	$17,068,819	$389,499	$17,458,318	$50,000	$721,250
	3	17.5	$23,653,276	$539,829	$24,193,105	$50,000	$980,194
Elders Center	1	9.9	$14,516,762	$347,914	$14,864,676	$50,000	$621,457
	2	12	$14,303,695	$342,804	$14,646,500	$50,000	$613,069
	3	20.2	$20,411,448	$489,273	$20,900,721	$50,000	$853,506
Harlem River, East River and Western Long Island Sound Planning Region							
Flushing Creek	1	5.1	$8,399,122	$150,000	$8,549,122	$80,000	$404,470
	2	7.3	$13,204,697	$309,022	$13,513,719	$80,000	$592,618
	3	7.6	$16,113,674	$378,139	$16,491,813	$80,000	$705,583
Bronx Zoo and Dam	A	1.7	$6,161,341	$150,000	$6,311,341	$20,000	$255,948
	B	1.4	$4,784,598	$150,000	$4,934,598	$20,000	$204,371
	C	1.1	$3,691,719	$150,000	$3,841,719	$20,000	$163,428
Stone Mill Dam	A	19	$779,827	$150,000	$929,827	$20,000	$54,241
	B	17.4	$708,351	$150,000	$858,351	$20,000	$51,572
	C	17.4	$540,223	$150,000	$690,223	$20,000	$45,295
Shoelace Park	A	5.7	$24,961,173	$545,406	$25,506,579	$20,000	$1,006,948
	B	5	$18,530,516	$404,768	$18,935,284	$20,000	$760,408

Site	Alt	Net Ecological Benefits (AAFCU)	Sub-Total Project First Cost ($)	Monitoring and Adaptive Management Cost ($)	Project First Cost ($)	Annualized OMRR&R Cost ($)	Average Annual Economic Cost ($)
	C	1.7	$8,920,217	$195,935	$9,116,152	$20,000	$362,013
Bronxville Lake	A	4.5	$21,281,995	$464,614	$21,746,610	$50,000	$864,975
	B	3.8	$14,381,709	$313,706	$14,695,415	$50,000	$600,726
	C	2.7	$14,302,390	$311,971	$14,614,361	$50,000	$597,688
Garth Woods/Harney Road	A	2.5	$7,336,979	$312,399	$7,649,378	$20,000	$305,228
	B	1.2	$6,547,824	$300,000	$6,847,824	$20,000	$275,274
	C	0.3	$3,917,834	$300,000	$4,217,834	$20,000	$176,858
River Park/ West Farm Rapids Park	A	0.5	$4,114,139	$150,000	$4,264,139	$20,000	$179,079
	B	0.4	$4,056,461	$150,000	$4,206,461	$20,000	$176,920
	C	0.2	$2,670,590	$150,000	$2,820,590	$20,000	$125,060
Muskrat Cove	A	0.6	$7,942,235	$179,193	$8,121,428	$20,000	$348,155
	B	0.7	$8,143,118	$182,495	$8,325,614	$20,000	$356,245
	C	0.2	$4,186,585	$150,000	$4,336,585	$20,000	$202,470
Crestwood Lake	A	4.9	$27,452,116	$599,718	$28,051,834	$50,000	$1,123,787
	B	1.4	$13,666,095	$298,869	$13,964,964	$50,000	$584,571
	C	1	$12,807,222	$279,436	$13,086,658	$50,000	$550,928
Westchester County Center	A	4.4	$24,707,587	$540,188	$25,247,775	$50,000	$996,182
	B	1.9	$14,692,572	$321,161	$15,013,732	$50,000	$612,653

Site	Alt	Net Ecological Benefits (AAFCU)	Sub-Total Project First Cost ($)	Monitoring and Adaptive Management Cost ($)	Project First Cost ($)	Annualized OMRR&R Cost ($)	Average Annual Economic Cost ($)
	C	0.9	$13,695,728	$299,360	$13,995,088	$50,000	$574,478
Newark Bay, Hackensack River and Passaic River Planning Region							
Oak Island Yards	A	4.8	$18,173,963	$397,189	$18,571,152	$50,000	$753,781
	B	3.5	$18,739,873	$409,811	$19,149,684	$50,000	$775,704
	C	4.4	$17,702,790	$387,130	$18,089,921	$50,000	$735,543
Essex County Branch Brook Park	A	47.2	$71,649,492	$1,566,145	$73,215,637	$80,000	$2,857,716
	B	37.5	$71,714,594	$1,567,569	$73,282,163	$80,000	$2,860,240
	C	14.2	$22,130,218	$483,165	$22,613,383	$80,000	$937,928
	D	22.3	$46,399,651	$1,013,934	$47,413,586	$80,000	$1,855,027
Clifton Dundee Canal Green Acres	A	1.2	$8,881,501	$171,710	$9,053,210	$20,000	$363,553
	B	0.1	$8,270,796	$161,671	$8,432,467	$20,000	$339,990
	C	0	$7,238,061	$150,000	$7,388,061	$20,000	$300,325
Dundee Island Park	A	0.4	$2,621,005	$150,000	$2,771,005	$20,000	$124,161
Kearny Point	A	10	$50,998,310	$1,113,686	$52,111,997	$80,000	$2,057,073
	B	6	$46,128,926	$1,007,194	$47,136,120	$80,000	$1,868,294
	C	5.2	$39,470,487	$861,574	$40,332,061	$80,000	$1,610,156
Metromedia Tract	A	13.5	$27,733,012	$605,205	$28,338,217	$50,000	$1,137,241
	B	13.7	$45,413,789	$991,882	$46,405,671	$80,000	$1,860,425

Site	Alt	Net Ecological Benefits (AAFCU)	Sub-Total Project First Cost ($)	Monitoring and Adaptive Management Cost ($)	Project First Cost ($)	Annualized OMRR&R Cost ($)	Average Annual Economic Cost ($)
	C	13.4	$30,991,135	$676,460	$31,667,595	$80,000	$1,294,977
Meadowlark Marsh	A	9.1	$63,974,334	$1,398,947	$65,373,280	$80,000	$2,588,139
	B	10.6	$58,407,208	$1,277,194	$59,684,403	$80,000	$2,369,877
	C	15.5	$46,725,473	$1,021,716	$47,747,190	$80,000	$1,911,889
Oyster Reefs – Multiple Planning Regions							
Naval Weapons Station Earle	1	2.9	$1,075,750	$150,000	$1,225,750	$10,000	$55,108
	2	5.8	$2,099,310	$150,000	$2,249,310	$10,000	$93,239
	3	9.6	$3,438,265	$81,652	$3,519,917	$10,000	$141,160
Bush Terminal	1	6.7	$3,105,071	$118,328	$3,223,398	$10,000	$129,449
	2	9.9	$4,555,260	$126,994	$4,682,254	$10,000	$183,836
	3	19.5	$8,960,603	$153,319	$9,113,921	$10,000	$350,169
Head of Jamaica Bay	1	1.7	$1,098,250	$150,000	$1,248,250	$10,000	$55,898
	2	3.5	$2,115,129	$150,000	$2,265,129	$10,000	$93,738
	3	5.2	$3,175,638	$118,758	$3,294,396	$10,000	$132,220

[1]The Jamaica Bay Perimeter sites were originally assessed via CE/ICA, recommended, and approved at a 2010 USACE Alternative Formulation Briefing. In 2010, 32 restoration alternatives (including no action) for the original eight Jamaica Bay perimeter sites were analyzed. Details of the original benefits analysis and CE/ICA can be found in Appendices E and J, respectively. The recommended sites and alternatives were subsequently updated with respect to benefits and costs for consistent comparison with other regions.

3.11 Cost Effectiveness/Incremental Cost Analysis (CE/ICA)

Cost-effectiveness and incremental cost analyses (CE/ICA) are analytical tools for assessing the relative benefits and costs of ecosystem restoration actions and informing decisions. Benefits and costs (Table 3-9) are assessed prior to these analyses using ecological models and cost engineering methods, respectively. CE/ICA may then be conducted at the site scale to compare alternatives at a single location (e.g., no action vs. riparian planting vs. channel manipulation) or at the system scale to compare relative merits of multiple sites (e.g., no sites vs. Site-A only vs. Site-B only vs. Site-A and Site-B).

Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the greatest return-on-investment (i.e., the most environmental benefits for a given level of cost or the least cost for a given level of environmental benefit). An "efficiency frontier" identifies all plans that efficiently provide benefits on a per cost basis. Incremental cost analysis sequentially compares each cost-effective plan to all higher cost cost-effective plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide benefits on an incremental unit cost basis. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish objectives relative to unit costs and are typically referred to as "best buys."

This section presents two analyses, which together informed the recommendation of the Tentatively Selected Plan. First, CE/ICA was applied to develop site-scale recommendations for all 31 sites independently. Ultimately, this analysis results in a single recommended alternative at each site (e.g., Alternative-B for Shoelace Park). Second, combinations of sites were examined to develop system-scale “plans” for each of the five planning regions (i.e., Jamaica Bay Perimeter, Jamaica Bay Marsh Islands, The Harlem River, East River and Western Long Island Sound, Newark Bay, Hackensack River and Passaic River Planning Region, and Oyster Reefs). CE/ICA was then applied to each combination of sites to inform system-scale decision-making in each region.

USACE policy instructs teams to recommend a restoration plan that cost-effectively delivers ecological benefits. In particular, the Planning Guidance Notebook (ER 1105-2-100) directs teams to consider all monetary and non-monetary costs and benefits and recommend a plan that “reasonably maximize[s] overall project benefits” (ER 1105-2-100, Appendix C, Page C-5). Furthermore, “the results of incremental analysis must be synthesized with other decision-making criteria (for example, significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, reasonableness of costs) to help the planning team select and recommend a particular plan” (ER 1105-2-100, Appendix E, Page E-153). In light of this directive, three primary decision rules were applied when identifying recommended alternatives at both the site- and system-scales:

- Does this alternative/plan meet the planning objectives?
- Which best buy alternative/plan has the lowest incremental unit cost (i.e., $/AAFCU or $/AAHU)?

- Which alternative reasonably maximizes environmental benefits in light of non-linearity in cost-benefit data, incremental cost associated with additional investment, cost affordability, and benefits not adequately captured by models (as directed by Appendix E of ER 1105-2-100)?

3.11.1 Site-Level CE/ICA

At each site, multiple alternatives were developed varying in both their costs and benefits (See Table 3-9). Cost-effectiveness and incremental cost analysis were then applied to compare alternatives at each site to identify both cost-effective and best buy alternatives. From this array, other decision rules were applied to identify the tentatively selected plan at each site. As described in Appendix J, the Jamaica Bay Perimeter sites were previously assessed in a system-wide context, where a portfolio of sites was recommended across the region. The most efficient combination of sites was investigated during the initial plan formulation of the source study and approved at the 2010 Alternative Formulation Briefing. As such, only the future without project (FWOP) and the recommended alternative are carried through this analysis with updated costs and benefits. Table 3-10 summarizes the selected alternative each site based on the site level CE/ICA and includes the benefits (AAFCU), annualized costs ($) and unit costs ($/AAFCU) for each site. Appendix J presents detailed site-by-site justification for the alternatives.

Table 3-9. Summary of site-scale recommendations prior to system-scale analysis and plan optimization

Site	Alt	Lift (AAFCU)	Avg Ann Cost ($)	Unit Cost ($/AAFCU)
Jamaica Bay Planning Region – Perimeter Sites				
Dead Horse Bay	4	35.84	3,330,851	92,936
Fresh Creek	4	36.78	1,382,939	37,600
Brant Point	2	3.45	273,007	79,195
Hawtree Point	1	0.05	101,510	2,242,038
Bayswater Point State Park	2	1.14	247,399	217,429
Dubos Point	3	1.9	396,781	209,024
Jamaica Bay Planning Region – Marsh Islands				
Duck Point	2	22.31	970,476	43,490
Stony Creek	1	29.26	924,034	31,582
Pumpkin Patch West	2	12.68	875,808	69,071
Pumpkin Patch East	3	17.49	980,194	56,041
Elders Center	3	20.23	853,506	42,192
Harlem River, East River and Western Long Island Sound Planning Region				
Flushing Creek	2	7.26	592,618	81,631
Bronx Zoo and Dam	A	1.69	255,948	151,275
Stone Mill Dam	A	19	54,241	2,855
Shoelace Park	B	4.97	760,408	152,923
Bronxville Lake	B	3.82	600,726	157,057
Garth Woods/Harney Road	A	2.46	305,228	124,046
River Park/West Farm Rapids Park	A	0.48	179,079	370,502

Site	Alt	Lift (AAFCU)	Avg Ann Cost ($)	Unit Cost ($/AAFCU)
Muskrat Cove	A	0.65	348,155	535,806
Crestwood Lake	A	4.92	1,123,787	228,336
Westchester County Center	A	4.41	996,182	226,107
Newark Bay, Hackensack River and Passaic River Planning Region				
Oak Island Yards	A	4.8	753,781	157,019
Essex County Branch Brook Park	D	22.34	1,855,027	83,028
Clifton Dundee Canal Green Acres	A	1.25	363,553	290,902
Dundee Island Park	A	0.43	124,161	286,974
Kearny Point	A	10.04	2,057,073	204,899
Metromedia Tract	A	13.45	1,137,241	84,525
Meadowlark Marsh	C	15.47	1,911,889	123,589
Oyster Reefs– Multiple Planning Regions				
Naval Weapons Station Earle	3	9.58	141,160	14,731
Bush Terminal	3	19.5	350,169	17,956
Head of Jamaica Bay	3	5.25	132,220	25,201

3.11.2 Regional CE/ICA

Preceding analyses focused on site-scale outcomes of restoration with minimal consideration of system-wide effects of actions at multiple sites. This section analyzes system-wide restoration outcomes for each planning region. All combinations of restoration sites are considered for each of the five regions or habitat types (e.g., Jamaica Bay Marsh Islands, oyster reefs). The following sections describe the regional CE/ICA methods in greater detail, and then provide a region-by-region assessment of the recommended restoration plan. In general, four elements are presented for each region, all of which intend to clarify the agency's recommendation and explain the logic behind the challenging issue of "How much ecosystem restoration is worth the Federal investment?" Appendix J presents detailed review of these methods[1] and additional decision logic.

- System-scale CE/ICA: Plans are developed and analyzed for each Planning Region/Habitat Type relative to ecological benefits and costs.
- Secondary decision factors: Secondary criteria are then presented to quantify the value of individual sites relative to other decision factors (primarily Other Social Effects).
- Decision matrices: Data are synthesized and summarized to inform decision-making.
- Decision justification: The logic of the recommended restoration plan is explicitly documented based on the information presented above.

[1] Methods are also described in McKay, Kohtio, Scarpa, Tommaso, Weppler, and Baron. Incorporating multiple lines of evidence in urban stream restoration decision-making. In revision for *Anthropocene*.

3.11.2.1 Methods for Regional CE/ICA

System-wide plans were developed for five logical groupings of sites: Jamaica Bay Perimeter, Jamaica Bay Marsh Islands, Harlem River, East River and Western Long Island Sound Planning Region, the Newark Bay, Hackensack River and Passaic River Planning Region, and Oyster Reefs appearing in multiple planning regions. Site-level recommendations (Table 3-10) are combined into regional plans each representing a different combination of sites (e.g., No sites vs. A-only vs. B-only vs. A+B). All possible site combinations were computed for each planning set; however, some planning sets have more sites and thus many more combinations of sites (e.g., 9 Bronx River sites and 1 site at Flushing Creek can be combined into 1,024 unique plans). CE/ICA was subsequently conducted for all regional plans. All ecological benefits include the effects of sea level change, where appropriate. The following five issues are highlighted by policy to help teams interpret CE/ICA outputs and justify recommendations (ER 1105-2-100, Appendix E, Page E-157):

- Curve Anomalies – Inflection points in the response of benefits and costs (from CE/ICA) can indicate non-linear changes in a project's return on investment.
- Output Targets – Some studies have quantitative goals including a specific amount of habitat restoration agreed to as part of a broader, multi-stakeholder planning agreement.
- Output Thresholds – Some ecosystems exhibit well-defined threshold responses (e.g., minimum patch size for a focal taxa), which can serve as a basis for plan selection.
- Cost Affordability – Implementation funding can be a constraint from either a legislative threshold (e.g., maximum investment under a particular authority) or practical threshold (e.g., maximum investment affordable to both USACE and cost-share sponsors).
- Unintended Effects – "Decisions to recommend a particular cost effective or best buy plan are not made in isolation. Other factors that matter in terms of selecting one alternative over another could include, for example, land ownership, effects on other outputs, and effects on nearby stakeholders. It is possible that the unintended consequences could be just as important as the primary project purpose of ecosystem restoration. The importance and magnitude of these unintended effects will of course vary from study to study."

The first four of these factors are largely derived from close examination of CE/ICA and contextual knowledge of the decision (e.g., local ecological knowledge, collaboration with non-Federal sponsors). However, unintended effects are more challenging to capture and are often addressed narratively in the discussion of what level of investment is appropriate. In this analysis, we take a more quantitative view of this concept. Urban ecosystems often produce important social and economic outcomes, which may be important considerations for decision-making. While not the focal point of plan formulation, these other social effects relate to secondary goals, provide context regarding unintended, positive consequences of restoration, and assist in making judgments about whether a larger restoration plan is "worth the investment." Four key factors were identified as important context for HRE decision-making:

- Environmental Justice (Executive Order 12898): The study area is one of the most demographically diverse regions in the United States, and equitability of access to restoration benefits is an important secondary factor. We computed two proxies for social equity issues at each restoration site using 2010 Census data: total population and classification as environmental justice communities. First, total population was assessed as any census block wholly or partially contained within a one-mile “halo” surrounding the project area. Second, we identified these communities as Potential Environmental Justice Areas (PEJAs) based on NYSDEC’s (2018) criteria.

- Ecosystem Services: Citizens and cost-share sponsors are often interested in the “benefits people obtain from ecosystems” (i.e., ecosystem services, MEA 2005). However, complex interrelationships between ecological resources and marketable ecosystem goods and services often limit the application of this concept. Furthermore, the environmental outputs considered in USACE project evaluation are typically not monetized. As a proxy for ecosystem service provision, a semi-quantitative scoring system was developed for five locally-relevant ecosystems services related to flood risk, navigation, recreation, thermal regulation, and water quality.
- Stakeholder Support: The study area has a large community of engaged and interested parties, including nine cost-share sponsors, numerous coordinating entities (e.g., Federal permitting agencies), and dozens of stakeholder groups. All proposed restoration sites have significant local and regional support, but some sites have more formal institutional support (e.g., participation in the Urban Waters Federal Partnership). Two proxy metrics were applied as a gage of interest in a given site: (1) the number of cost-share sponsors for the site and (2) a modified form of the USACE “plan recognition” scoring system used in budget prioritization (EC-11-2-206).
- Technical significance: USACE defines the significance of an ecosystem relative to institutional, public, and technical dimensions. The former two categories are partially addressed by criteria related to ecosystem services, environmental justice, and stakeholder support. However, technical significance is also a crucial factor in determining the competitiveness of a USACE project in the budgeting process. We adapted the USACE technical significance scoring system used in budget prioritization (EC-11-2-206) as a semi-quantitative metric with six factors: habitat scarcity, special status species, connectivity, hydrologic character, geomorphic condition, and self-sustaining. Notably, the scale of each metric was adapted from the budget criteria to reflect equal weighting among the six criteria (i.e., all scales are 0-20 with a maximum score of 120).

Many ecosystem management problems produce multiple lines of evidence and ask decision-makers to synthesize diverse data and information to make informed choices regarding complex issues (Linkov et al. 2011). A variety of decision support tools are growing in prominence in the restoration and conservation communities, and we applied three different methods of summarizing results for decision-makers. The positive and negative consequences of different restoration plans are presented relative to these summaries. First, CE/ICA was visually summarized with only the primary objectives included (i.e., ecological benefits and costs) at the system-scale. Second, secondary criteria described above are presented to quantify the value of individual sites relative to other decision factors (primarily Other Social Effects). Third, primary and secondary outcomes are then collected in a decision matrix summarizing a final array of management options at the system-scale. Decision matrices provide an opportunity for deep exploration of the relative merits of a plan (Gregory and Keeney 2002, Gregory et al. 2012), and these tables often include not only raw data, but summary values more indicative of decision-making. Finally, these lines of evidence are synthesized and rationale is provided for the recommended plan in each region.

3.11.2.2 Results for Regional CE/ICA[2]

Jamaica Bay Planning Region – Perimeter Sites

Six Jamaica Bay Perimeter sites were combined into 64 potential plans, which were examined with CE/ICA (Figure 3-35) and assessed relative to secondary criteria (Figure 3-36). Table 3-11 provides a summary of these analyses. Three plans were considered for the final decision array. Smaller plans would not meet the planning objectives and would likely be unacceptable to stakeholders and sponsors.

- *Base Plan (Fresh Creek + Brant Point + Dead Horse Bay)* -**Recommendation**: When considering only benefits/outputs (increases in the net quantity and/or quality of desired ecosystem resources), a plan reasonably maximizes the restoration of the Planning Region would include all sites up to Dead Horse Bay (i.e., Fresh Creek, Brant Point, Dead Horse Bay). This plan costs $125.0M and produces 76.1 average annual functional capacity units (AAFCU). The plan also generally occurs at a “break point” in incremental cost as recommended in ER 1105-2-100. While smaller plans have lower incremental cost per incremental unit, this plan is deemed “worth it” due to the relatively small incremental cost of this step (i.e., $93,000/AAFCU) and the low unit cost of the plan as a whole (i.e., $66,000/AAFCU). The plan includes 2 of 4 PEJAs and captures more than half of the potential benefits related to ecosystem services, plan recognition, and technical significance.
- *Moderate Plan (Base Plan + Dubos Point)*: This plan incorporates Fresh Creek, Brant Point, Dead Horse Bay, and Dubos Point. The plan has a total first cost of $134.8M and produces 78.0 AAFCUs. This plan incorporates the PEJA around Dubos Point, but also leads to a substantial increase in the unit cost. The OSE benefits associated with wetland restoration at Dubos Point include providing the local PEJA community with increased passive recreation opportunities, enjoyment of improved resources and natural flood risk management measures.
- *Save the Bay Plan (Base Plan + Dubos Point + Bayswater Point State Park)*: This plan reasonably maximizes benefits to the ecologically unique Jamaica Bay ecosystem by including all sites except Hawtree Point (i.e., Fresh Creek, Brant Point, Dead Horse Bay, Dubos Point, Bayswater Point State Park). This plan addresses the significant ecological degradation that has occurred in the unique Jamaica Bay system, while avoiding the costly Hawtree Point site. This plan costs $140.7M, produces 79.1 AAFCUs, and includes all PEJAs. The Bayswater Point site is a high visibility public park and represents an important contribution to public education and patronage opportunities. Bayswater Point State Park is a pivotal link and plays an important role due to its key location ensuring connectivity to adjacent critical habitat between Jamaica Bay City Park and Rockaway Community Park and Dubos Point. In addition, this restoration would be integrated with planned public access improvements implemented by NYS Department of Parks. While higher cost, the plan is deemed “worth it” given the distinctiveness of the Bay ecosystem, the need for connectivity of critical habitat, the unique role the USACE plays in the Bay, and the effect of these projects on system-wide functionality in other business lines.

[2] Appendix J provides detailed interpretation of analyses and supporting rationale for recommendations.

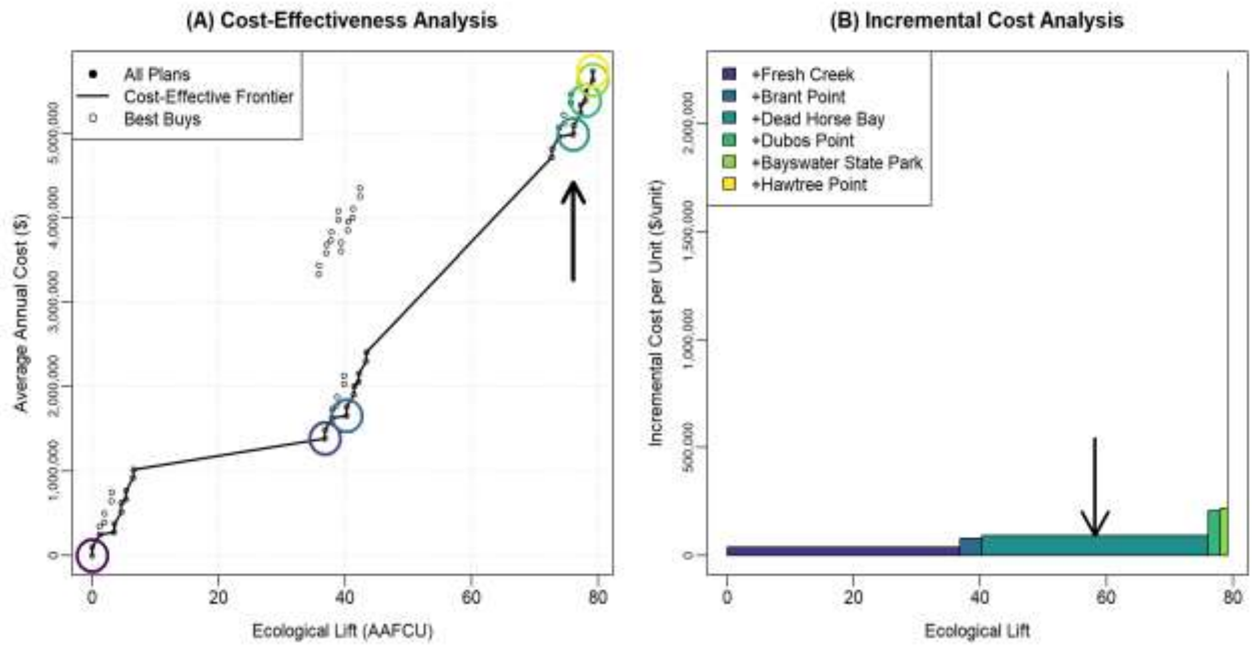


Figure 3-35. Cost-effectiveness and incremental cost analyses for the Jamaica Bay Planning Region - Perimeter Sites. Arrows indicate the recommended plan.

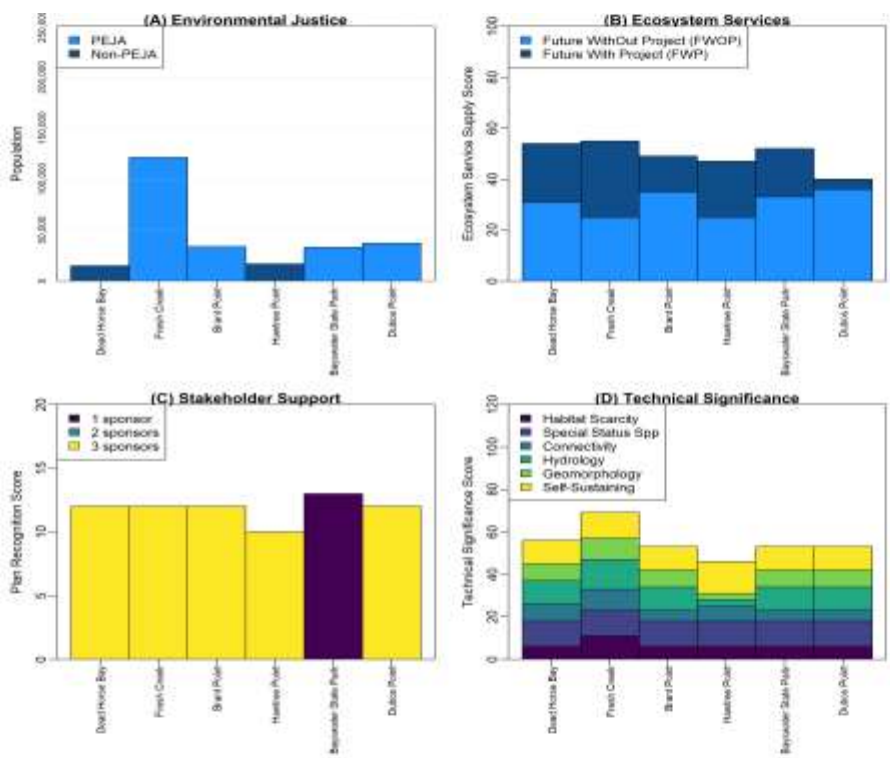


Figure 3-36. Secondary decision factors for the Jamaica Bay Planning Region - Perimeter Sites.

Table 3-10. Array of best buy plans for the Jamaica Bay Planning Region -Perimeter Sites. All plans indicated cumulative quantities inclusive of prior plans (e.g., "+Dead Horse Bay" includes restoration actions at Fresh Creek, Brant Point, and Dead Horse Bay).

Plan	Ecological Lift (AAFCU)	Annualized Cost ($)	Incremental Cost ($/AAFCU)	Unit Cost ($/AAFCU)	Total Cost ($)	Total Population	Number of PEJAs	Net Ecosystem Services Score (sum)	Plan Recognition Score (sum)	USACE Technical Significance (sum)
FWOP	0	0	0	0	0	0	0	0	0	0
+Fresh Creek	36.8	1,382,939	37,600	37,600	33,885,522	121,308	1	30	12	69
+Brant Point	40.2	1,655,946	79,195	41,164	40,466,869	154,941	2	44	24	122
+Dead Horse Bay	76.1	4,986,797	92,936	65,557	125,012,831	169,704	2	67	36	178
+Dubos Point	78	5,383,579	209,024	69,050	134,811,887	206,727	3	71	48	231
+Bayswater Point State Park	79.1	5,630,978	217,429	71,184	140,728,278	239,702	4	90	61	284
+Hawtree Point	79.1	5,732,488	2,242,038	72,426	142,859,915	256,504	4	112	71	330

Jamaica Bay Planning Region - Marsh Islands

Five Jamaica Bay marsh islands were combined into 32 potential plans, which were examined with CE/ICA (Figure 3-37) and assessed relative to secondary criteria (Figure 3-38). Table 3-12 provides a summary of these analyses. Only the largest plan was preserved for the final decision array. Smaller plans would not meet the planning objectives and would likely be unacceptable to stakeholders and sponsors.

- *Base Plan (Stony Creek + Elders Center + Duck Point + Pumpkin Patch -East + Pumpkin Patch -West)* -**Recommendation**: The plan that reasonably maximizes environmental benefits includes all the marsh island sites evaluated (i.e., Stony Creek, Elders Center, Duck Point, Pumpkin Patch -East, Pumpkin Patch -West). This plan costs $112.8M and produces 102.0 AAFCUs. Marsh Islands function as a system of projects, and there are significant synergies to including all five islands in the recommendation. This plan also directly addresses the loss of an ecosystem that only the USACE is capable of addressing, given the agency's role in coastal resiliency and regional sediment management through its Civil Works Mission. These sites provide an enormous array of ecosystem services and directly address the USACE technical significance criteria as well as contribute to a primary objective to restore this critical marsh island habitat that has been significantly lost. A resilient marsh ecosystem provides coastal storm risk management services to adjacent communities through wind fetch reduction and wave attenuation. The collection of sites are also recommended because of their systemic functioning and larger-scale effect on Bay-wide hydrodynamics (not accounted for in the purely ecological benefits presented here). Furthermore, the relatively low unit cost (less than $50,000 / unit) and high visibility of these sites (e.g., by every passenger to John F. Kennedy airport and visitor to the National Park) make these sites an efficient investment.

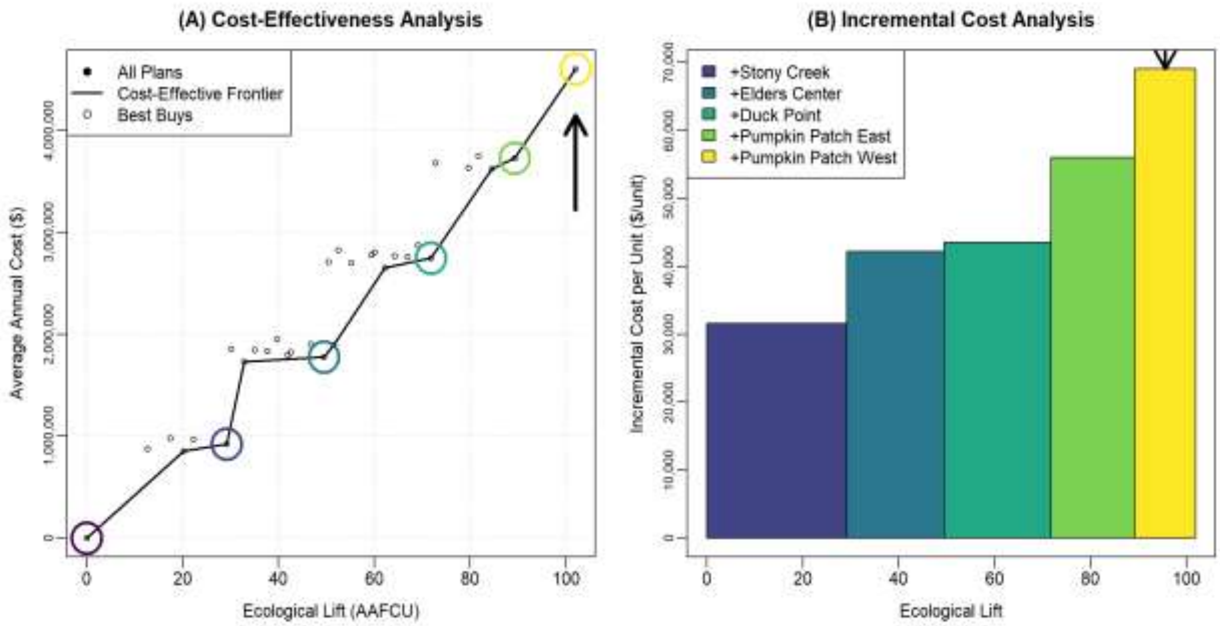


Figure 3-37. Cost-effectiveness and incremental cost analyses for Jamaica Bay Planning Region - Marsh Islands. Arrows indicate the recommended plan.

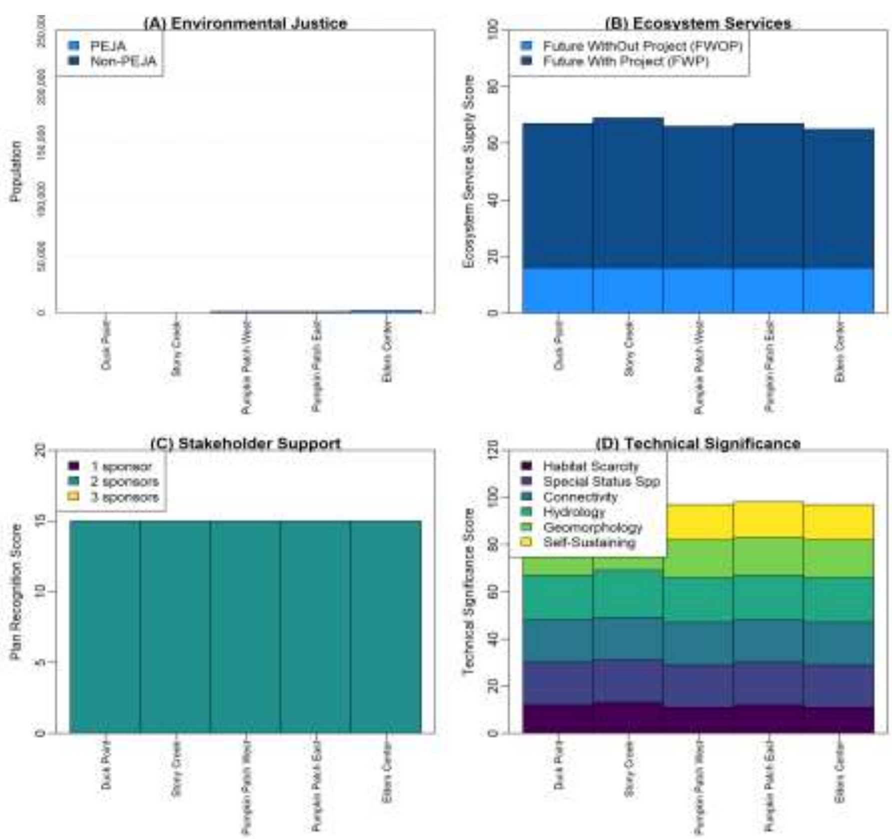


Figure 3-38. Secondary decision factors for the Jamaica Bay Planning Region - Marsh Islands

Table 3-11. Array of best buy plans for the Jamaica Bay Planning Region - Marsh Islands. All plans indicated cumulative quantities inclusive of prior plans (e.g., "+Duck Point" includes restoration actions at Stony Creek, Elders Center, and Duck Point).

Plan	Ecological Lift (AAFCU)	Annualized Cost ($)	Incremental Cost ($/AAFCU)	Unit Cost ($/AAFCU)	Total Cost ($)	Total Population	Number of PEJAs	Net Ecosystem Services Score (sum)	Plan Recognition Score (sum)	USACE Technical Significance (sum)
FWOP	0	0	0	0	0	0	0	0	0	0
+Stony Creek	29.3	924,034	31,582	31,582	22,733,369	19	1	53	15	100
+Elders Center	49.5	1,777,540	42,192	35,919	43,634,090	2,480	2	102	30	197
+Duck Point	71.8	2,748,016	43,490	38,272	67,574,213	2,499	3	153	45	295
+Pumpkin Patch East	89.3	3,728,210	56,041	41,753	91,767,318	3,836	3	204	60	393
+Pumpkin Patch West	102	4,604,018	69,071	45,150	112,759,006	5,173	3	254	75	490

Harlem River, East River and Western Long Island Sound Planning Region

Nine (9) Bronx River sites and one (1) site at Flushing Creek were combined into 1,024 potential plans, which were examined with CE/ICA (Figure 3-39) and assessed relative to secondary criteria (Figure 3-40). Table 3-13 provides a summary of these analyses. Based on these analyses, three plans were considered for the final decision array. Smaller plans would not meet the planning objectives and would likely be unacceptable to stakeholders and sponsors.

- *Base Plan (Stone Mill Dam + Flushing Creek + Garth Woods/Harney Road + Bronx Zoo and Dam + Shoelace Park + Bronxville Lake)* -**Recommendation**: When considering only environmental outputs, a plan that reasonably maximizes benefits would include all sites up to Bronxville Lake. This plan costs $62.0M and produces 39.2 habitat units, and the plan generally occurs at a “break point” in incremental cost as recommended in ER 1105-2-100. This plan is extremely efficient and obtains 79% of the total potential benefits at 48% of the total potential cost. The plan also captures a large portion of secondary benefits (i.e., 4 of 6 PEJAs, 827,000 nearby residents, 58% of the net ecosystem services score, multiple top priority sites). Bronxville Lake is cost-shared with Westchester County and also represents a second site for this sponsor.
- *Basin-Wide Restoration Plan (Base Plan + Westchester County Center)*: This plan provides a larger restoration contribution to the highly degraded Bronx River ecosystem and includes all sites up to Westchester County Center. This plan costs $87.3M and produces 43.6 habitat units. Westchester County Center is a public facility, which would provide key educational opportunities and demonstrate the USACE’s commitment to urban ecosystem restoration. This site is also a major contribution to ecosystem services and technical significance.
- *Urban Waters Federal Partnership Plan (Base Plan + Westchester County Center + Crestwood Lake)*: This plan maximizes benefits to the Bronx River ecosystem by including all sites up to Crestwood Lake. The plan has a total first cost of $115.3M and produces 48.5 habitat units. Crestwood Lake is a key provider of ecosystem services in the Bronx River, given its large floodplain habitat and key role in restoring hydrologic processes at all subsequent sites downstream in general and Bronxville Lake in particular. The Bronx River is a focal site in the Urban Waters Federal Partnership, and the inclusion of this site provides another high visibility ecosystem restoration project in a basin where natural systems are extremely scarce.

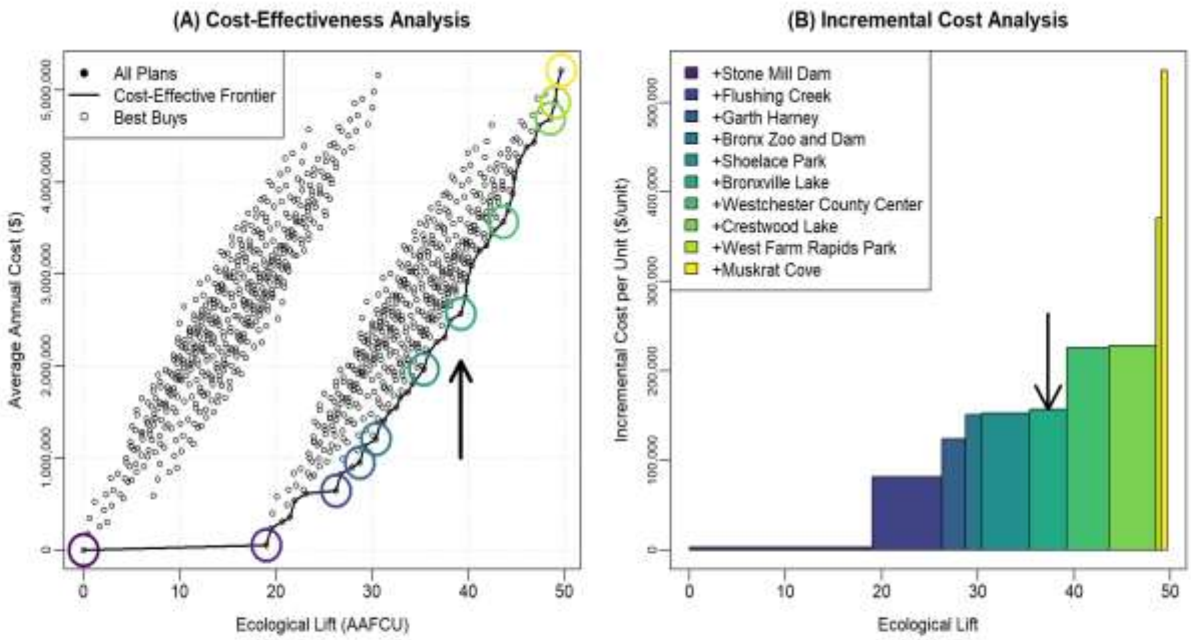


Figure 3-39. Cost-effectiveness and incremental cost analyses for the Harlem River, East River and Western Long Island Sound Planning Region. Arrows indicate the recommended plan.

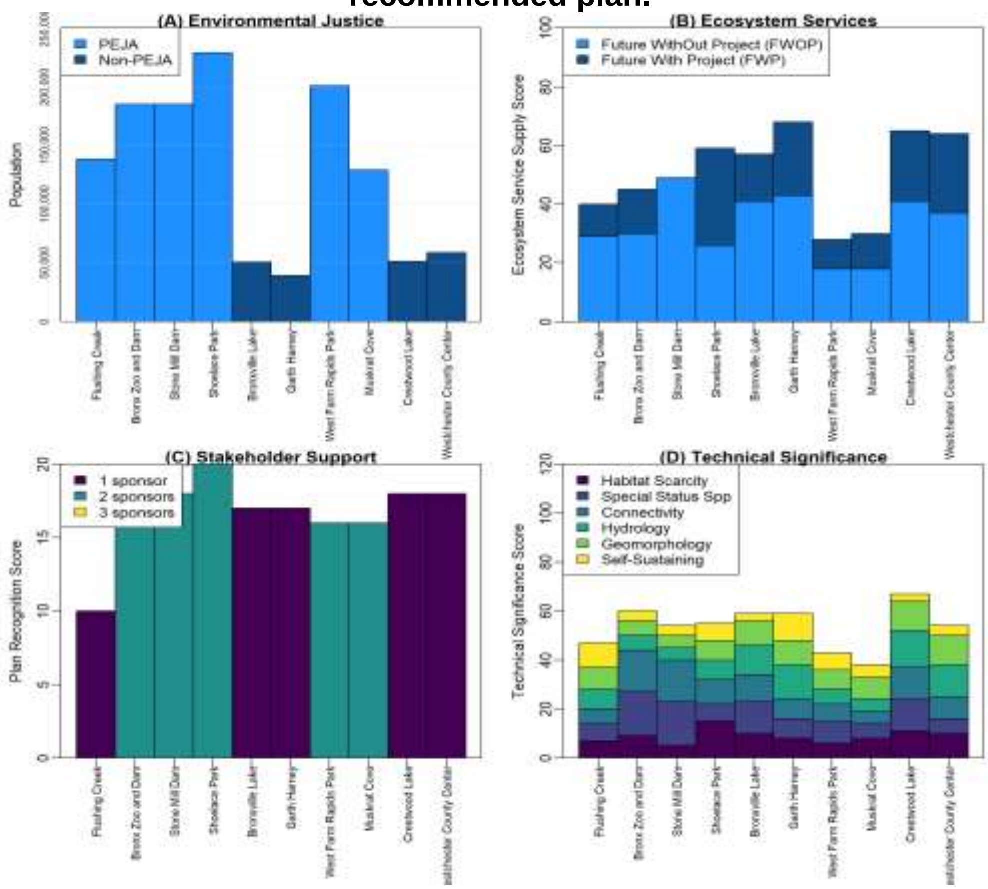


Figure 3-40. Secondary decision factors for Harlem River, East River and Western Long Island Sound Planning Region.

Table 3-12. Array of best buy plans for the Harlem River, East River and Western Long Island Sound Planning Region. All plans indicated cumulative quantities inclusive of prior plans (e.g., "+Garth Woods/Harney Road" includes restoration actions at Stone Mill Dam, Flushing Creek and Garth Woods/Harney Road).

Plan	Ecological Lift (AAFCU)	Annualized Cost ($)	Incremental Cost ($/AAFCU)	Unit Cost ($/AAFCU)	Total Cost ($)	Total Population	Number of PEJAs	Net Ecosystem Services Score (sum)	Plan Recognition Score (sum)	USACE Technical Significance (sum)
FWOP	0	0	0	0	0	0	0	0	0	0
+Stone Mill Dam	19	54,241	2,855	2,855	929,827	185,029	1	0	18	54
+Flushing Creek	26.3	646,859	81,631	24,634	14,443,546	323,440	2	11	28	101
+Garth Woods/Harney Road	28.7	952,087	124,046	33,151	22,092,924	362,759	2	36	45	160
+Bronx Zoo and Dam	30.4	1,208,035	151,275	39,723	28,404,265	547,821	3	51	63	220
+Shoelace Park	35.4	1,968,443	152,923	55,631	47,339,549	776,691	4	84	83	275
+Bronxville Lake	39.2	2,569,169	157,057	65,525	62,034,964	827,429	4	100	100	334
+Westchester County Center	43.6	3,565,351	226,107	81,747	87,282,739	886,260	4	127	118	388
+Crestwood Lake	48.5	4,689,137	228,336	96,611	115,334,573	937,570	4	151	136	455
+ River Park/ West Farm Rapids Park	49	4,868,216	370,502	99,312	119,598,713	1,138,402	5	161	152	498
+Muskrat Cove	49.7	5,216,371	535,806	105,022	127,720,140	1,267,513	6	173	168	536

Newark Bay, Hackensack River and Passaic River Planning Region

Seven (7) Hackensack and Lower Passaic sites were combined into 128 potential plans, which were examined with CE/ICA (Figure 3-41) and assessed relative to secondary criteria (Figure 3-42). Table 3-14 provides a summary of these analyses. Based on these analyses, four plans were considered for the final decision array. Smaller plans would not meet the planning objectives and would likely be unacceptable to stakeholders and sponsors.

- *Minimal Plan (Essex County Branch Brook Park + Metromedia Tract)*: When considering only environmental outputs and costs, a plan including Essex County Branch Brook Park and Metromedia Tract emerges. The plan has total first cost of $75.8M and produces 35.8 AAFCUs. This plan is very efficient by producing 53% of potential benefit in the region at 37% of the cost. However, a single action in the Passaic and Hackensack Watersheds would likely be unacceptable to stakeholders and cost-share sponsors.
- *Base Plan (Essex County Branch Brook Park + Metromedia Tract + Meadowlark Marsh)*: The minimally acceptable base plan would include Essex County Branch Brook Park, Metromedia Tract, and Meadowlark Marsh. The plan has total first cost of $123.5M and produces 51.3 AAFCUs. Metromedia Tract and Meadowlark Marsh are both ecologically important to the Meadowlands wetland ecosystem. These sites leverage prior restoration efforts by connecting high functioning habitat thus restoring a contiguous expanse of wetlands in the region. Local, state, and federal partners have previously identified this site as a key multi-agency priority. By including Meadowlark Marsh, this plan incorporates all sites making major contributions to ecosystem services.
- *Multi-Watershed Restoration Plan (Essex County Branch Brook Park + Metromedia Tract + Meadowlark Marsh + Oak Island Yards)*: This plan reasonably maximizes ecological benefits (56.1 AAFCU, total first costs $142.1M). Oak Island Yards contains Newark's largest extent of tidal marsh, tidal creeks, and emergent wetland, and this project would return this site to a less degraded, more natural condition. This site is near the confluence of the largest concentration of wetlands in the region, which make it important for ecological connectivity. Oak Island Yards also contains a unique habitat type (salt panne), which is undervalued by EPW. Oak Island Yards is a Tier 2 site and would be deferred until the lower 8.2 miles of the Lower Passaic River is remediated. Including this site is important to demonstrate the joint program and governmental partnership with EPA's Superfund program sequencing restoration following the remedial action for the Lower Passaic River. This site is also important for the Urban Waters Federal Partnership showcasing our coordination with USEPA as Co-Lead Agency. This plan includes two of four PEJAs.
- *Urban Waters Federal Partnership Plan (Essex County Branch Brook Park + Metromedia Tract + Meadowlark Marsh+ Oak Island Yards + Kearny Point)* -**Recommendation**: This plan includes all sites up to Kearny Point. The plan addresses the significant ecological degradation that has occurred in the Newark Bay, Hackensack River and Passaic River Planning Region system, while avoiding extremely costly sites (i.e., Dundee Island Park, Clifton Dundee Canal Green Acres). This plan includes three of four PEJAs, and makes a strong contribution to the Passaic River focal site of the Urban Waters Federal Partnership. This plan costs $215.1M, produces 66.1 AAFCUs. This plan includes three of four PEJAs, and makes a strong contribution to the Passaic River focal site of the

Urban Waters Federal Partnership. Kearny Point would be deferred for implementation until the lower 8.2 mile cleanup of the Passaic River was completed by EPA.

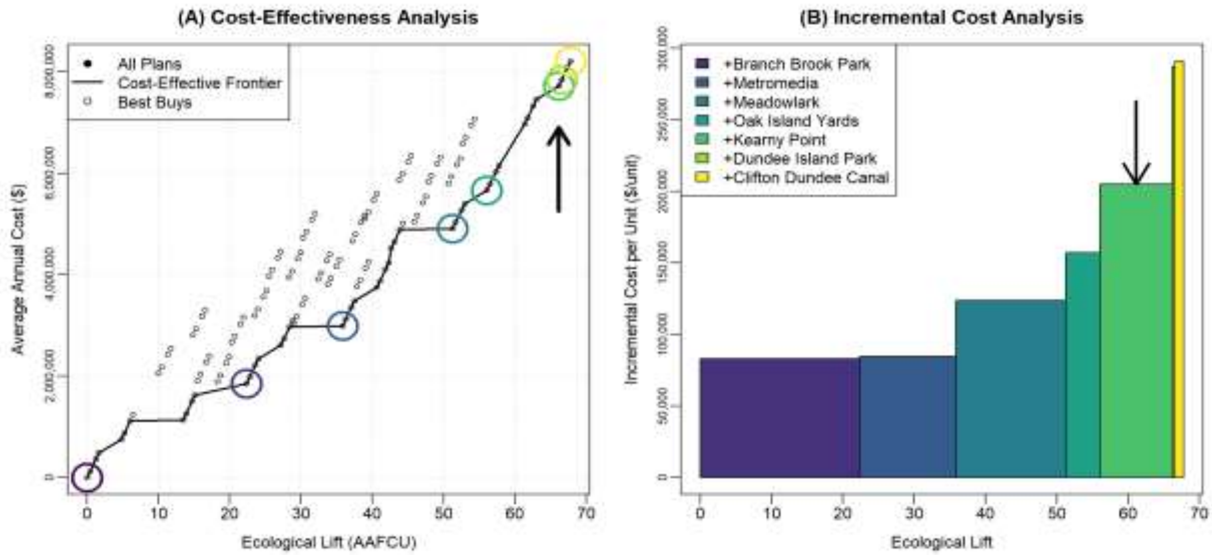


Figure 3-41. Cost-effectiveness and incremental cost analyses for the Newark Bay, Hackensack River and Passaic River Planning Region. Arrows indicate the recommended plan.

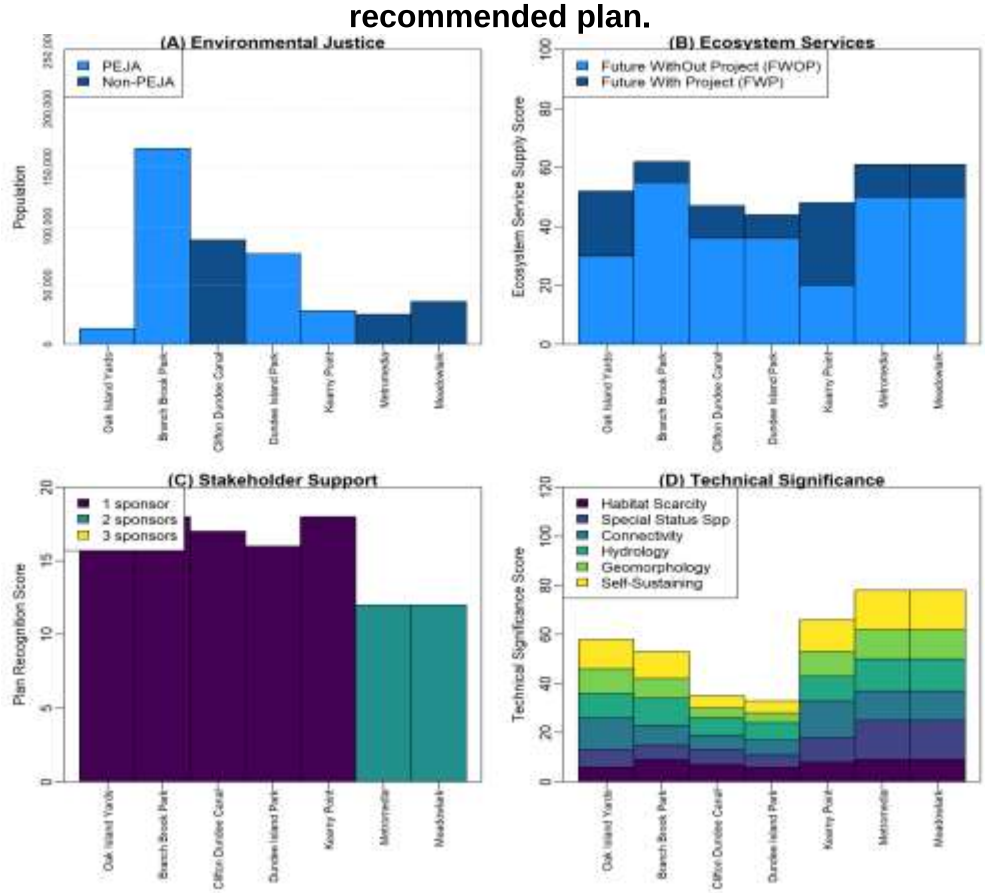


Figure 3-42. Secondary decision factors for the Newark Bay, Hackensack River and Passaic River Planning Region

Table 3-13. Array of best buy plans for the Newark Bay, Hackensack River and Passaic River Planning Region. All plans indicated cumulative quantities inclusive of prior plans (e.g., "+Meadowlark Marsh" includes restoration actions at Essex County Branch Brook Park, Metromedia Tract and Meadowlark Marsh).

Plan	Ecological Lift (AAFCU)	Annualized Cost ($)	Incremental Cost ($/AAFCU)	Unit Cost ($/AAFCU)	Total Cost ($)	Total Population	Number of PEJAs	Net Ecosystem Services Score (sum)	Plan Recognition Score (sum)	USACE Technical Significance (sum)
FWOP	0	0	0	0	0	0	0	0	0	0
+Essex County Branch Brook Park	22.3	1,855,027	83,028	83,028	47,413,586	166,302	1	7	18	53
+Metromedia Tract	35.8	2,992,268	84,525	83,591	75,751,803	191,559	1	18	30	131
+Meadowlark Marsh	51.3	4,904,157	123,589	95,661	123,498,993	227,920	1	29	42	209
+Oak Island Yards	56.1	5,657,938	157,019	100,914	142,070,145	241,171	2	51	60	267
+Kearny Point	66.1	7,715,010	204,899	116,706	194,182,142	269,789	3	79	78	333
+Dundee Island Park	66.5	7,839,171	286,974	117,813	196,953,146	346,424	4	87	94	366
+ Clifton Dundee Canal Green Acres	67.8	8,202,724	290,902	121,004	206,006,357	434,928	4	98	111	401

Oyster Reef Restoration

Three oyster reefs were combined into 8 potential plans, which were examined with CE/ICA (Figure 3-43) and assessed relative to secondary criteria (Figure 3-44). Table 3-15 provides a summary of these analyses. Based on these analyses, one plan was considered for the final decision array. Smaller plans would not meet the planning objectives and would likely be unacceptable to stakeholders and sponsors.

- *Base Plan* -**Recommendation**: In light of only environmental outcomes, a reasonable plan would include all oyster reef sites (i.e., Naval Weapons Station Earle, Bush Terminal and Head of Jamaica Bay). This plan costs $15.9M and produces 34.3 habitat units. This plan directly addresses the loss of an ecosystem that has declined to less than 1% of its historical range. Furthermore, the relatively low unit cost (less than $20,000 / unit) and high visibility of these sites (e.g., the Billion Oyster Project) make these sites an efficient investment. This recommendation also significantly contributes to the regional Comprehensive Restoration Plan targets of 2,000 acres by 2050.

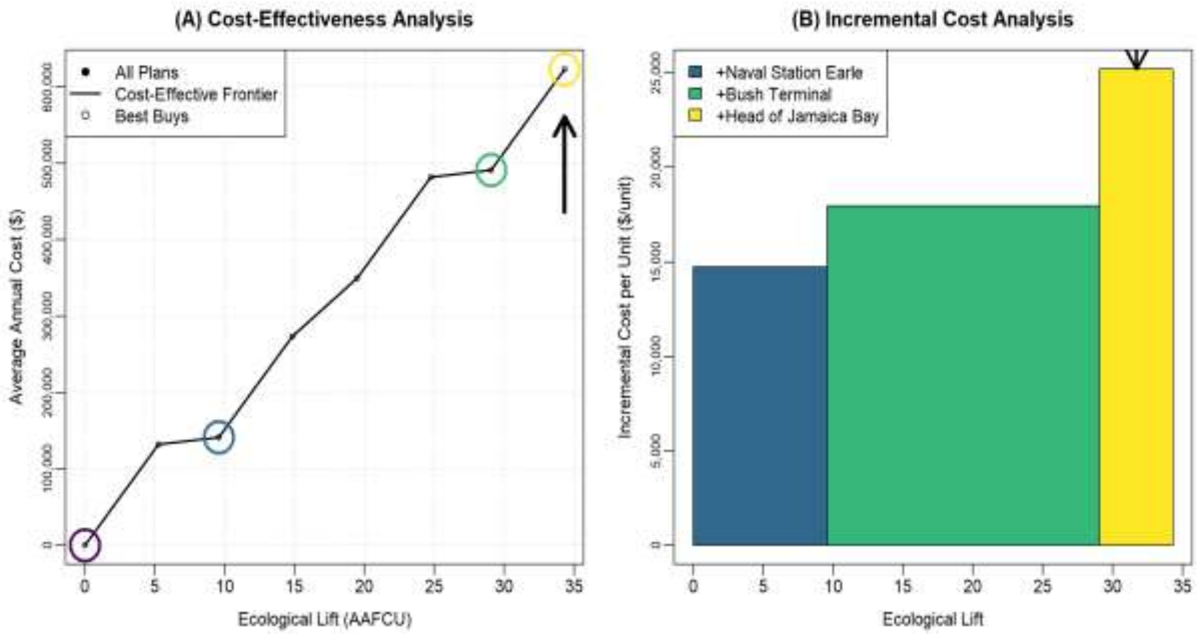


Figure 3-43. Cost-effectiveness and incremental cost analyses for Oyster Reefs. Arrows indicate the recommended plan.

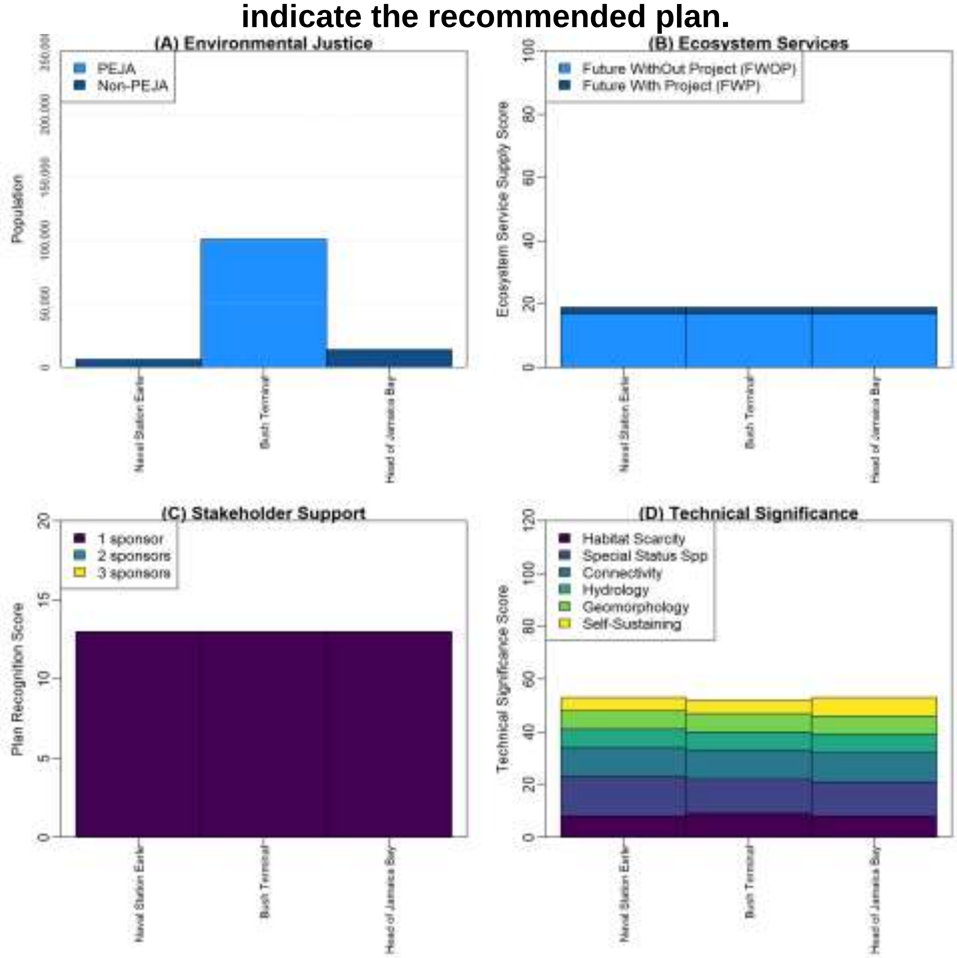


Figure 3-44. Secondary decision factors for Oyster Reefs.

Table 3-14. Array of best buy plans for oyster reefs. All plans indicated cumulative quantities inclusive of prior plans (e.g., "+Bush Terminal" includes restoration actions at Naval Weapons Station Earle and Bush Terminal).

Plan	Ecological Lift (AAFCU)	Annualized Cost ($)	Incremental Cost ($/AAFCU)	Unit Cost ($/AAFCU)	Total Cost ($)	Total Population	Number of PEJAs	Net Ecosystem Services Score (sum)	Plan Recognition Score (sum)	USACE Technical Significance (sum)
FWOP	0	0	0	0	0	0	0	0	0	0
+Naval Weapons Station Earle	9.6	141,160	14,731	14,731	3,519,917	6,131	0	2	13	53
+Bush Terminal	29.1	491,329	17,956	16,893	12,633,838	107,202	1	4	26	105
+Head of Jamaica Bay	34.3	623,549	25,201	18,163	15,928,235	121,184	1	6	39	158

3.12 Recommended Plan Summary

The regional CE/ICA recommended 22 sites for execution based on ecological benefits, monetary costs, and secondary decision factors as well as other issues described in the Planning Guidance Notebook (ER 1105-2-100, Appendix E). Two sites were subsequently removed from the recommendation due to changes in the future without project conditions, specifically:

- Brant Point: Jamaica Bay Perimeter planning activities initially assumed independence from other USACE projects without final approvals (i.e., Chief's Reports). However, Brant Point is a natural and nature-based feature included in the Chief's Report for the Atlantic Coast of New York East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study which was approved during final stages of HRE planning (August 2019). Restoration plans will be folded into designs for this ongoing project and not recommended for HRE.
- Kearny Point: During the planning process, remedial actions were conducted at the site by other agencies which preclude USACE actions at the site, and thus, this site is not recommended for further action.

Ultimately, 20 sites are included in the Recommended Plan as shown in Tables 3-16, 3-17, and 3-18. Sites that were removed from the TSP were color coded based on the outcome of the **regional CE/ICA** and **changes in future without project condition**. Additional analyses (including optimization of the designs, update of benefits, cost estimates and RSLC analysis) were conducted on the 20 sites in the recommend plan, which are presented in Chapter 4.

Table 3-15. Sites Removed and Sites Included in the Recommended Plan

Jamaica Bay		**Oyster Reefs**
Perimeter	**Marsh Islands**	
Dead Horse Bay Fresh Creek ~~Brant Point~~ ~~**Hawtree Point**~~ ~~**Bayswater Point State Park**~~ ~~**Dubos Point**~~	Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	Naval Weapons Station Earle Bush Terminal Head of Jamaica Bay
Harlem River, East River and Western Long Island Sound		**Newark Bay, Hackensack River and Passaic River**
Flushing Creek ~~**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**~~	Oak Island Yards Essex County Branch Brook Park ~~**Dundee Island Park**~~ ~~**Clifton Dundee Canal Green Acres**~~ ~~**Kearny Point**~~ Metromedia Tract Meadowlark Marsh

Table 3-16. Summary of Site-Scale Recommendations BEFORE Plan Optimization

System	Site	Alt	Lift (AAFCU)	Avg Ann Cost ($)	Unit Cost ($/AAFCU)	Total Cost ($)
Jamaica Bay - Perimeter	Dead Horse Bay	4	35.84	3,330,851	92,936	84,545,962
	Fresh Creek	4	36.78	1,382,939	37,600	33,885,522
Jamaica Bay - Marsh Islands	Duck Point	2	22.31	970,476	43,490	23,940,123
	Stony Creek	1	29.26	924,034	31,582	22,733,369
	Pumpkin Patch West	2	12.68	875,808	69,071	20,991,688
	Pumpkin Patch East	3	17.49	980,194	56,041	24,193,105
	Elders Center	3	20.23	853,506	42,192	20,900,721
Harlem River, East River and Western Long Island Sound	Flushing Creek	2	7.26	592,618	81,631	13,513,719
	Bronx Zoo and Dam	A	1.69	255,948	151,275	6,311,341
	Stone Mill Dam	A	19	54,241	2,855	929,827
	Shoelace Park	B	4.97	760,408	152,923	18,935,284
	Bronxville Lake	B	3.82	600,726	157,057	14,695,415
	Garth Woods/ Harney Road	A	2.46	305,228	124,046	7,649,378
Newark Bay, Hackensack River and Passaic River	Oak Island Yards	A	4.8	753,781	157,019	18,571,152
	Essex County Branch Brook Park	D	22.34	1,855,027	83,028	47,413,586
	Metromedia Tract	A	13.45	1,137,241	84,525	28,338,217
	Meadowlark Marsh	C	15.47	1,911,889	123,589	47,747,190
Oyster Reefs	Naval Weapons Station Earle	3	9.58	141,160	14,731	3,519,917
	Bush Terminal	3	19.5	350,169	17,956	9,113,921
	Head of Jamaica Bay	3	5.25	132,220	25,201	3,294,396

Table 3-17. Summary of System-Scale Recommendations BEFORE Plan Optimization

Region	Ecological Lift (AAFCU)	Annualized Cost ($)	Unit Cost ($/AAFCU)	Total Cost ($)	OMRR&R Cost ($)	Total Population	Number of PEJAs
Jamaica Bay - Perimeter	73	4,713,790	64,910	118,431,484	160,000	136,071	2
Jamaica Bay -Marsh Islands	102	4,604,018	45,151	112,759,006	250,000	5,173	3
Harlem River, East River and Western Long Island Sound	39	2,569,169	65,540	62,034,964	210,000	827,429	4
Newark Bay, Hackensack River and Passaic River	56	5,657,938	100,926	142,070,145	260,000	241,171	2
Oyster Reefs	34	623,549	18,163	15,928,234	30,000	121,184	1
TOTAL	**304**	**18,168,464**	**59,729**	**451,223,833**	**910,000**	**1,331,028**	**12**

Chapter 4: Recommended Plan and Implementation

This chapter describes the restoration and sites included in the Recommended National Ecosystem Restoration (NER) Plan, the plan's benefits and costs, and its implementation. The Recommended NER Plan is a suite of ecosystem restoration sites within the Hudson Raritan Estuary (HRE) that address long-term and large-scale degradation of aquatic habitat that support the overall HRE program goal, "*to develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment*".

The HRE Comprehensive Restoration Plan (CRP) identified 296 sites for restoration. Of these sites, 20 are recommended for construction authorization in this decision document, and are presented as the Recommended Plan in this chapter. The Recommended Plan also includes additional restoration opportunities which may be investigated by the USACE through "new phase" future "spin-off" feasibility studies, as described in "Recommended Restoration Opportunities for Future Study" (Section 4.11) and Appendix K.

The Recommended NER Plan would provide for the restoration of over 381 acres of estuarine wetland habitat including 16 acres/six (6) miles of tidal channels, 50 acres of freshwater riverine wetland habitat, 27 acres of maritime forest/upland habitat, 38 acres of shallow water habitat and 52 acres of oyster habitat. Two (2) fish ladders would be installed and three (3) weirs would be modified to re-introduce or expand fish passage and control flow rate and water volume along the Bronx River. Additionally, 1.6 miles of streambank restoration and 72 acres of channel and bed restoration is recommended. The plan would provide an increase of 341 average annual functional capacity units (AAFCUs) and many other ecosystem benefits distributed at the 20 sites throughout the region. The total first project cost is $408,184,134 and total fully funded cost is $587,661,000.

Figure 4-1 summarizes the sites and selected plans in the Recommended Plan. The Recommended Plan alternative designs for each site are presented in Figures 4-2 through 4-21. Additional detailed supporting information including baseline conditions, alternative development and designs for each site are presented in Appendix D (Plan Formulation).

Figure 4-1.The Recommended NER Plan: Restoration Sites Recommended for Construction

4.1 Restoration Sites Included in the Recommended NER Plan

Proposed actions will combat the ongoing habitat loss occurring within the HRE by providing the unique feeding and nesting habitat for the multiple species of migratory birds, wildlife, aquatic plants, and the commercially important species of fish and shellfish.

This section includes a description of recommended restoration actions at each site, organized by planning region. Figure 4-1 shows the locations of the proposed sites within the study area. See the Engineering Appendix for the grading and planting plans and the Relative Sea Level Change (RSLC) analysis for each recommended plan.

4.1.1 Jamaica Bay Planning Region

4.1.1.1 Estuarine Habitat Restoration- Jamaica Bay Perimeter Sites (Objective #1)

Table 4-1 summarizes the areal extent of the principal habitats and restoration measures that would be implemented as part of the Recommended Plan at the estuarine habitat restoration sites in the Jamaica Bay Planning Region. The Recommended Plan includes estuarine habitat restoration at two (2) shoreline sites along the perimeter of Jamaica Bay.

Table 4-1. Recommended Plan - Estuarine Habitat in Jamaica Bay

Restoration Site	Restoration Measure/Habitat Type					
	Low Marsh (acres)	High Marsh (acres)	Scrub/ shrub Wetland (acres)	Maritime Forest/Upland (acres)	Tidal Channel/Basin/Pool (acres/linear feet)	Bed and Channel Restoration
Dead Horse Bay	19.0	5.4	6.2	8.0	2.31 / 3,240	-
Fresh Creek	16.1	4.4	3.6	10.7	-	45.08
Total:	**35.1**	**9.8**	**9.8**	**18.7**	**2.31 / 3,240**	**45.08**

<u>Dead Horse Bay</u>

The Recommended Plan at Dead Horse Bay has optimized Alternative 4 (the TSP) following National Park Service (NPS) decision to conduct a Remedial Investigation/Feasibility Study pursuant to CERCLA (Figure 4-2). The restoration at this site will be restored in coordination with NPS. The Southern portion of the site, which is the focus of a future remedial action, is no longer 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 and 8 acres of upland, and 2.31 acres of tidal creek. In the absence of restoration, the north parcel would remain heavily dominated by invasive species and considerably degraded from its past ecological values. Restoration will provide habitat that supports both black-crowned (*Nycticorax nycticorax*) and yellow-crowned night herons (*Nyctanassa violacea*).

Restoration at Dead Horse Bay is an important part of the collaboration with USEPA Trash Free Waters Program, NPS Gateway National Recreation Area General Management Plan, and other partner initiatives including New York State Department of Conservation (NYSDEC), New York State Department of State (NYSDOS), NYCDEP, NYC Parks, New York City Department of Sanitation. The partners have formed an Advisory Committee in July 2016 to coordinate efforts on the site.

<u>Fresh Creek</u>

The recommended plan (Figure 2-21) 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.). The restoration will restore the patchy eroding marsh to allow for native *Spartina alternaflora* and ribbed mussels which will also provide streambank restoration and wave attenuation for the area.

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 Mean Tide Level (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.

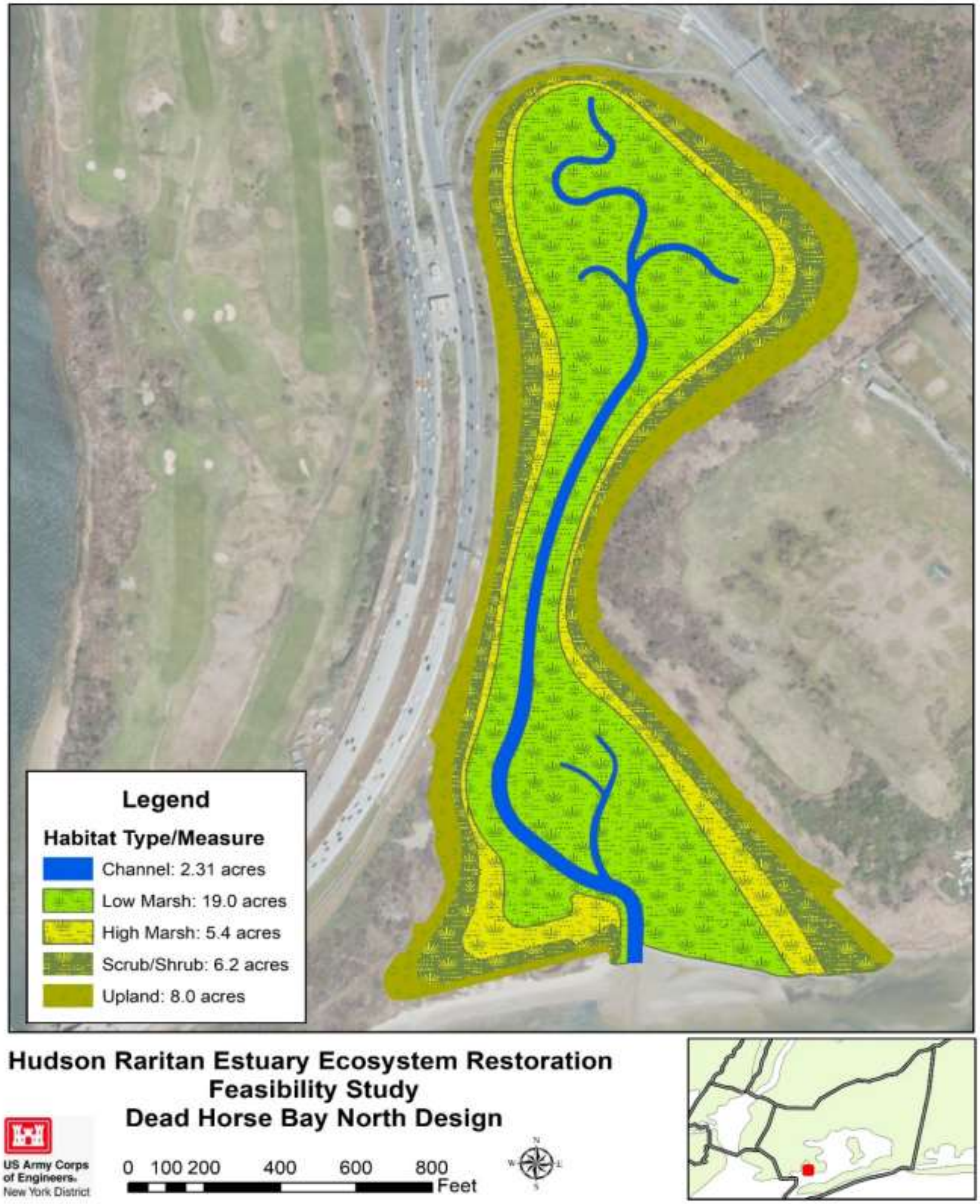


Figure 4-2. Dead Horse Bay – Recommended Plan

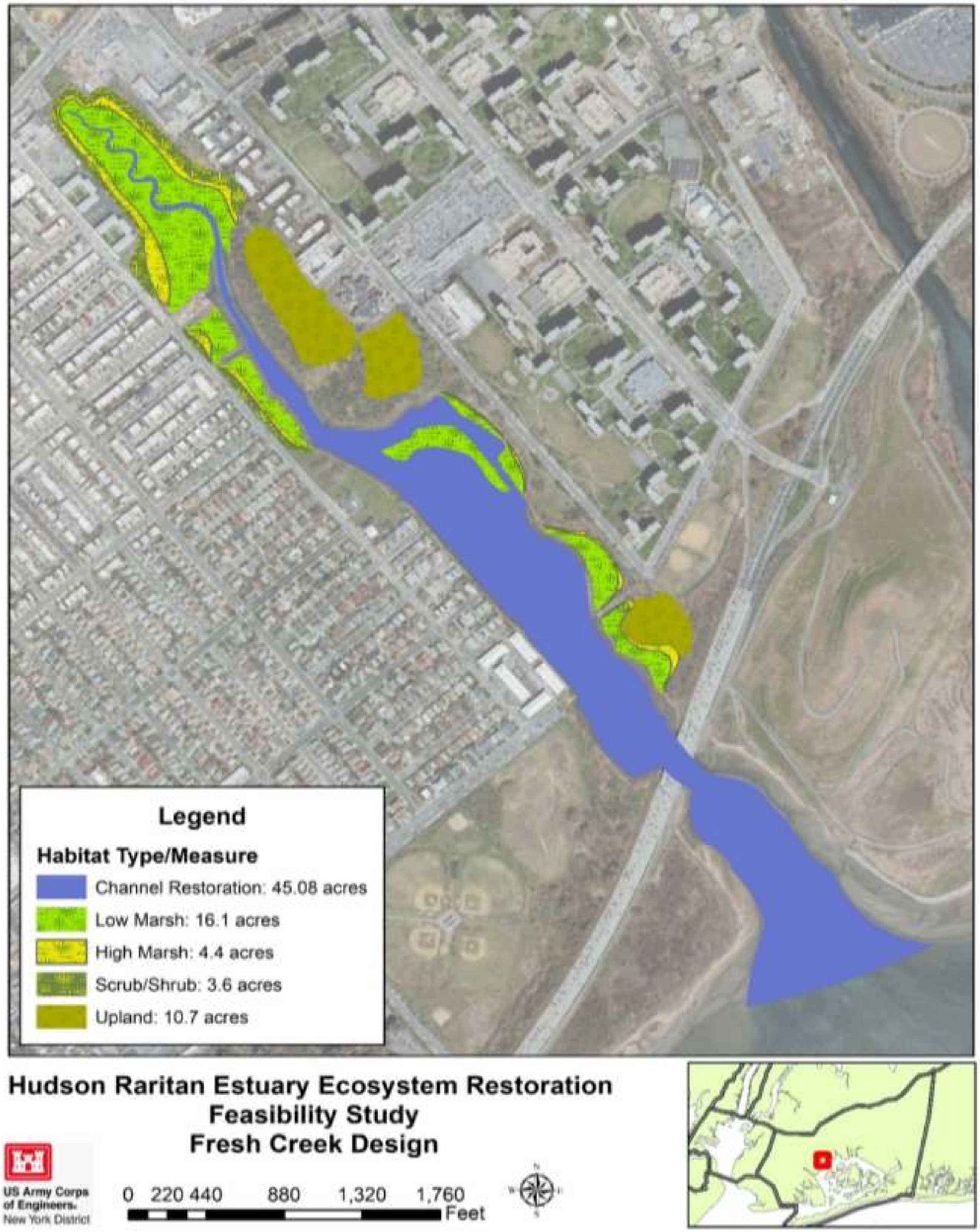


Figure 4-3. Fresh Creek – Recommended Plan

4.1.1.2 Jamaica Bay Marsh Islands (Objective #3)

Restoration actions will increase biodiversity and estuarine fish and wildlife habitat. It should be noted that the acreage involved in the proposed restoration at Jamaica Bay Marsh Islands is only a fraction of the acreage that historically existed in the area. The effect of its restoration on the ecological resources of the stressed and degraded Jamaica Bay system will be compounded and complemented by the eventual implementation of other restoration sites in Jamaica Bay.

Each of the Marsh Island projects below will utilize clean sand (>95%) from the USACE Operation and Maintenance (O&M) of the Jamaica Bay or Ambrose Federal Navigation Channel projects. The marsh island project construction schedules have been coordinated with USACE Operations Division to align with the dredging cycles for these projects. The quantities needed for restoration can be accommodated by these navigation projects.

Table 4-2 summarizes the areal extent of the principal restoration measures/habitat types that would be implemented by restoring five (5) Marsh Islands included in the Recommended Plan.

Table 4-2. Recommended Plan- Jamaica Bay Marsh Islands

Restoration Site	Restoration Measures/Habitat Types					
	Low Marsh (acres)	High Marsh (acres)	Scrub/shrub Wetland (acres)	Tidal Channel (acres/linear feet)	Shallows (acres)	Quantity of Dredged Material (CYD)
Duck Point	24.9	5.6	8.10	1.03 / 2,730	7.57	213,776
Stony Creek	26.0	22.5	3.49	1.43 / 4,640	8.67	151,360
Pumpkin Patch West	13.7	8.61	0.9	0.74 / 2,040	3.88	351,952
Pumpkin Patch East	15.6	10.1	3.1	0.58 / 1,530	5.22	327,686
Elders Center	15.2	10.9	1.4	0.95 / 2,500	5.49	284,891
Total:	**95.4**	**57.71**	**16.99**	**4.73 / 13,440**	**30.83**	**1,329,665**

<u>Duck Point</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. It was assumed that the marsh island 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.

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 4-4).

Stony Creek

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, 22.5 acres of high marsh and 3.49 acres of scrub/shrub (Figure 4-5).

Pumpkin Patch West

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 4-6).

Pumpkin Patch East

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 4-7).

Elders Center

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 4-8). The restoration at Elders Center and other marsh islands would complement adjacent restoration in planned for Spring Creek and provide secondary coastal storm risk management benefits for the Howard Beach Community.

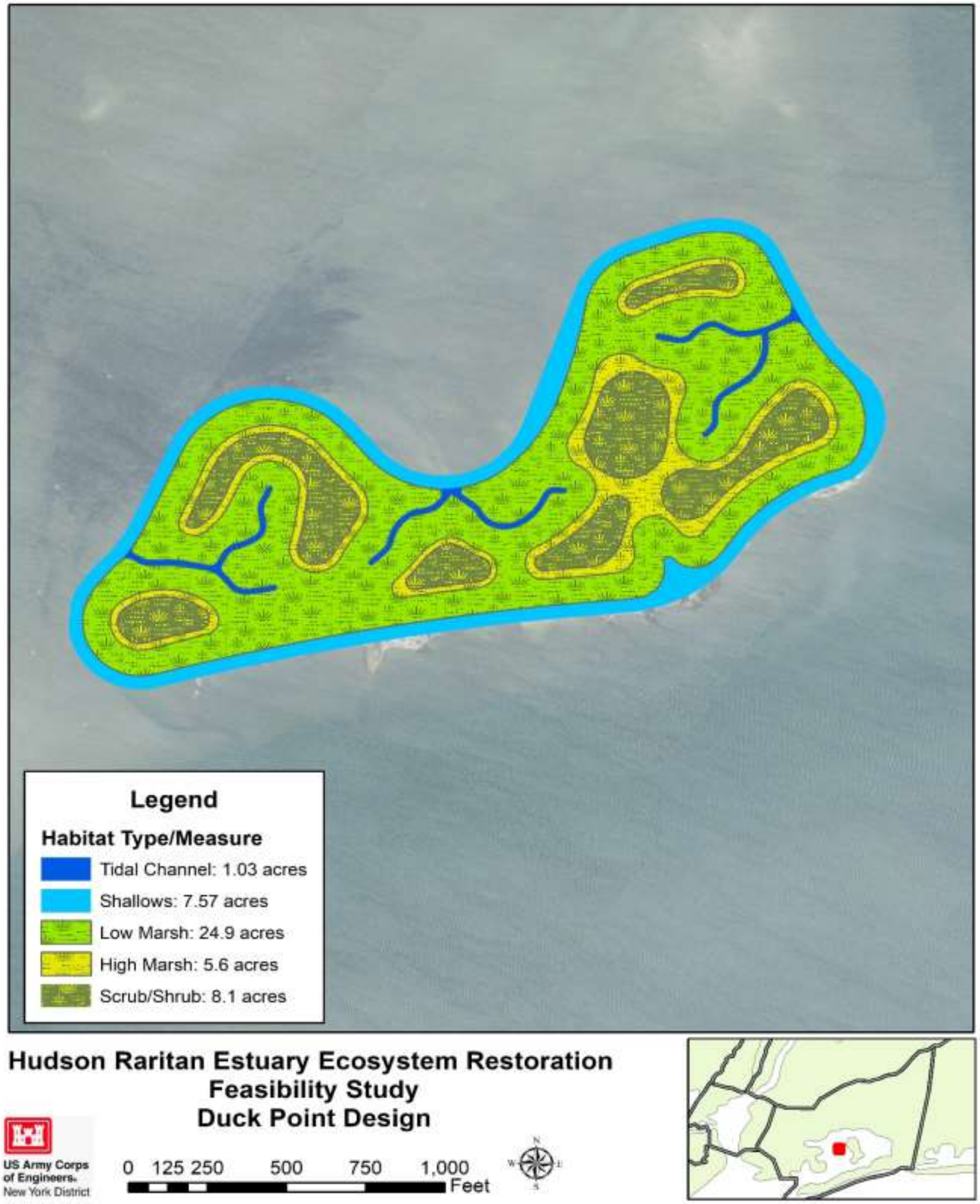


Figure 4-4. Duck Point - Recommended Plan

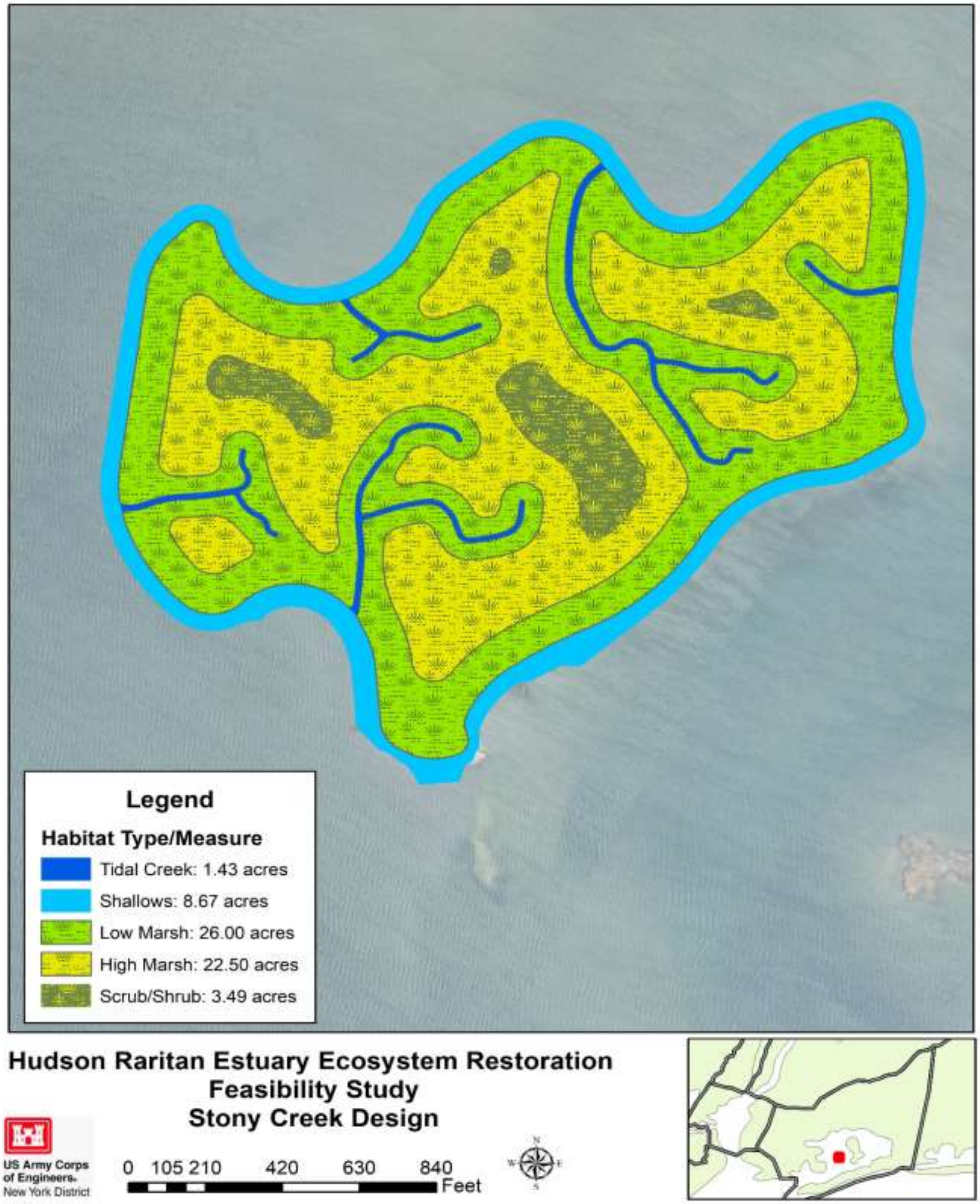


Figure 4-5. Stony Creek – Recommended Plan

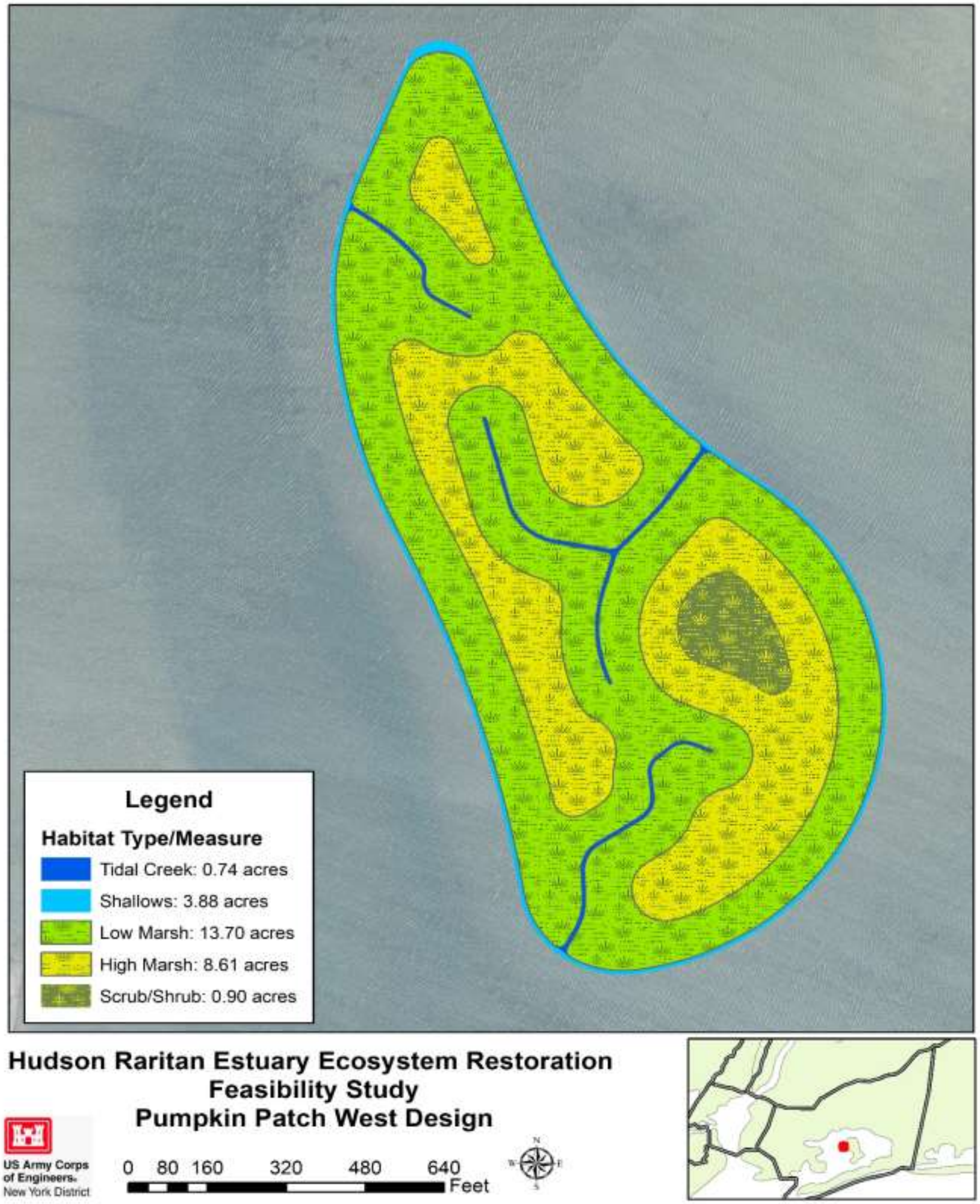


Figure 4-6. Pumpkin Patch West – Recommended Plan

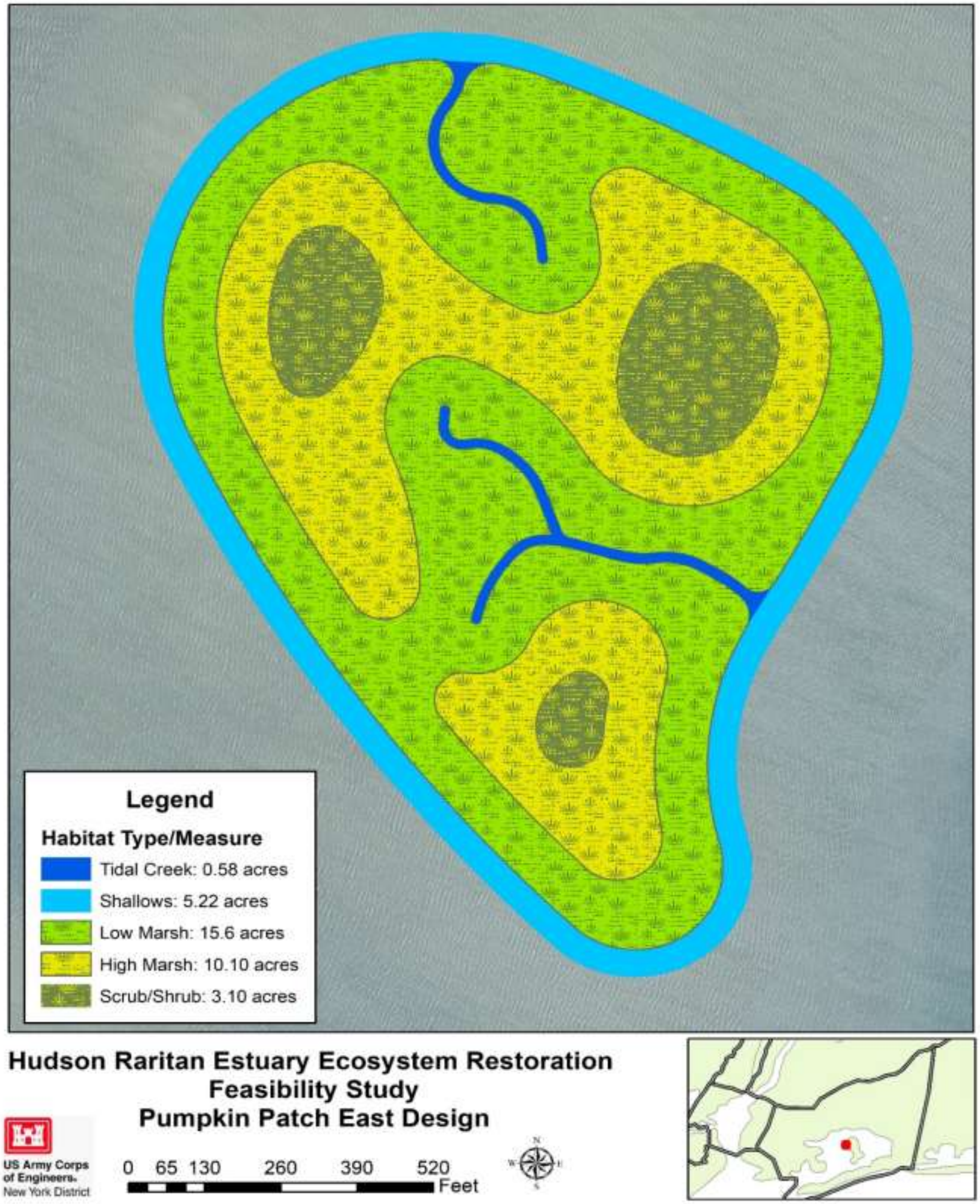


Figure 4-7. Pumpkin Patch East- Recommended Plan

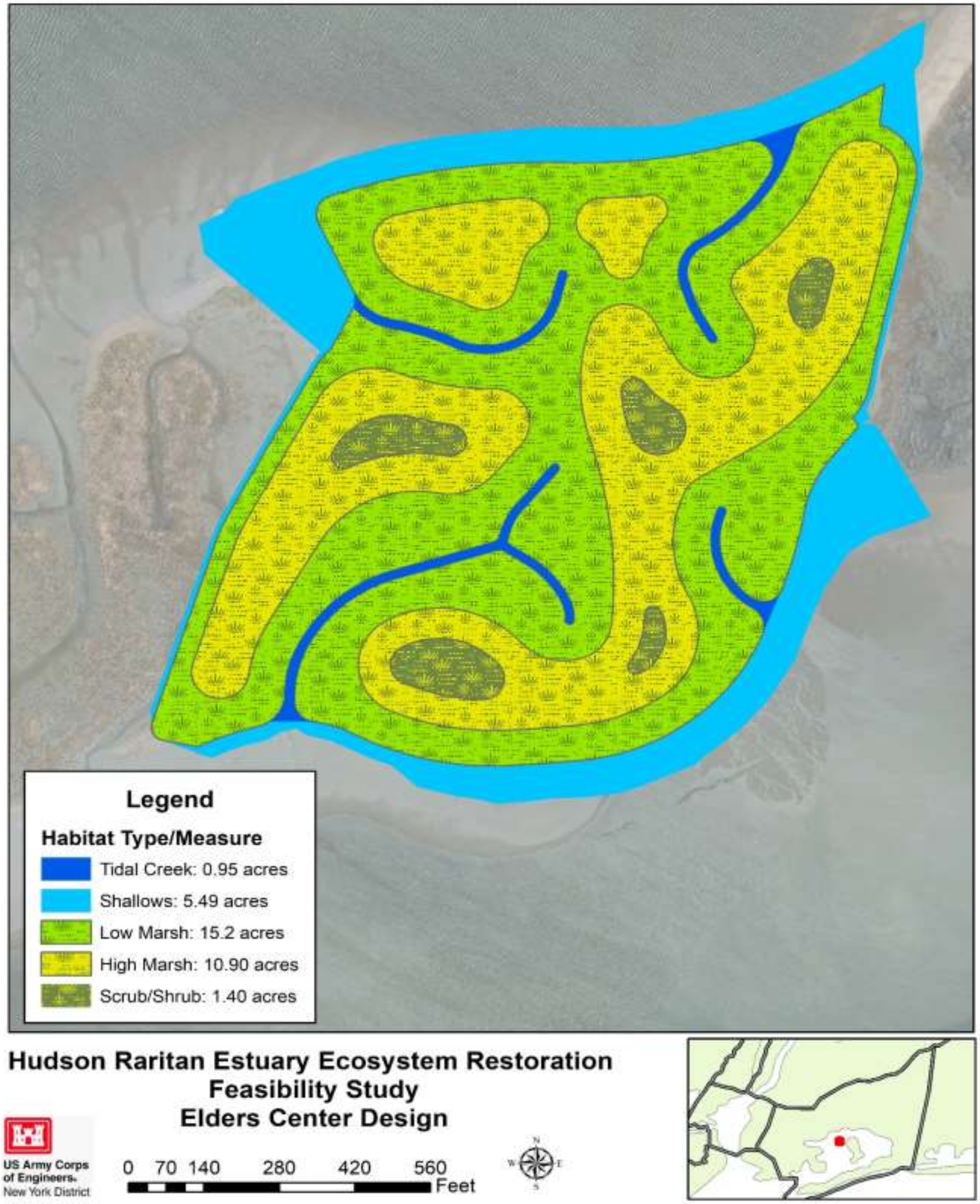


Figure 4-8. Elders Center – Recommended Plan

4.1.2 Harlem River, East River and Western Long Island Sound Planning Region

4.1.2.1 Estuarine Habitat Restoration (Objective #1)

Table 4-3 summarizes the areal extent of the principal restoration measures and habitat types that would be implemented as part of the Recommended Plan at the estuarine habitat restoration site in the Harlem River, East River and Western Long Island Sound Planning Region. The Recommended Plan includes estuarine habitat restoration at one (1) shoreline site along Flushing Creek:

Table 4-3. Recommemded Plan – Estuarine Habitat at Flushing Creek

Restoration Site	Restoration Measures / Habitat Type (acres)				
	Low Marsh	High Marsh	Scrub/shrub Wetland	Maritime Forest	Shallows
Flushing Creek	9.76	2.47	1.8	3.89	1.37

<u>Flushing Creek</u>

The restoration of Flushing Creek will provide habitat for waterfowl (mallard, canvasback, lesser scaup, wood duck) and wading birds (cattle egret, snowy egret, great egret) observed using the degraded habitat. The recommend plan is the optimized design based on Alternative 2 (Figure 4-9). 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 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. Restoration at Flushing Creek is an important complement to the NYCDEP surface water improvements in Flushing Creek and Bay resulting from the implementation of NYCDEP's Long Term Control Plan and CSO Abatement efforts.

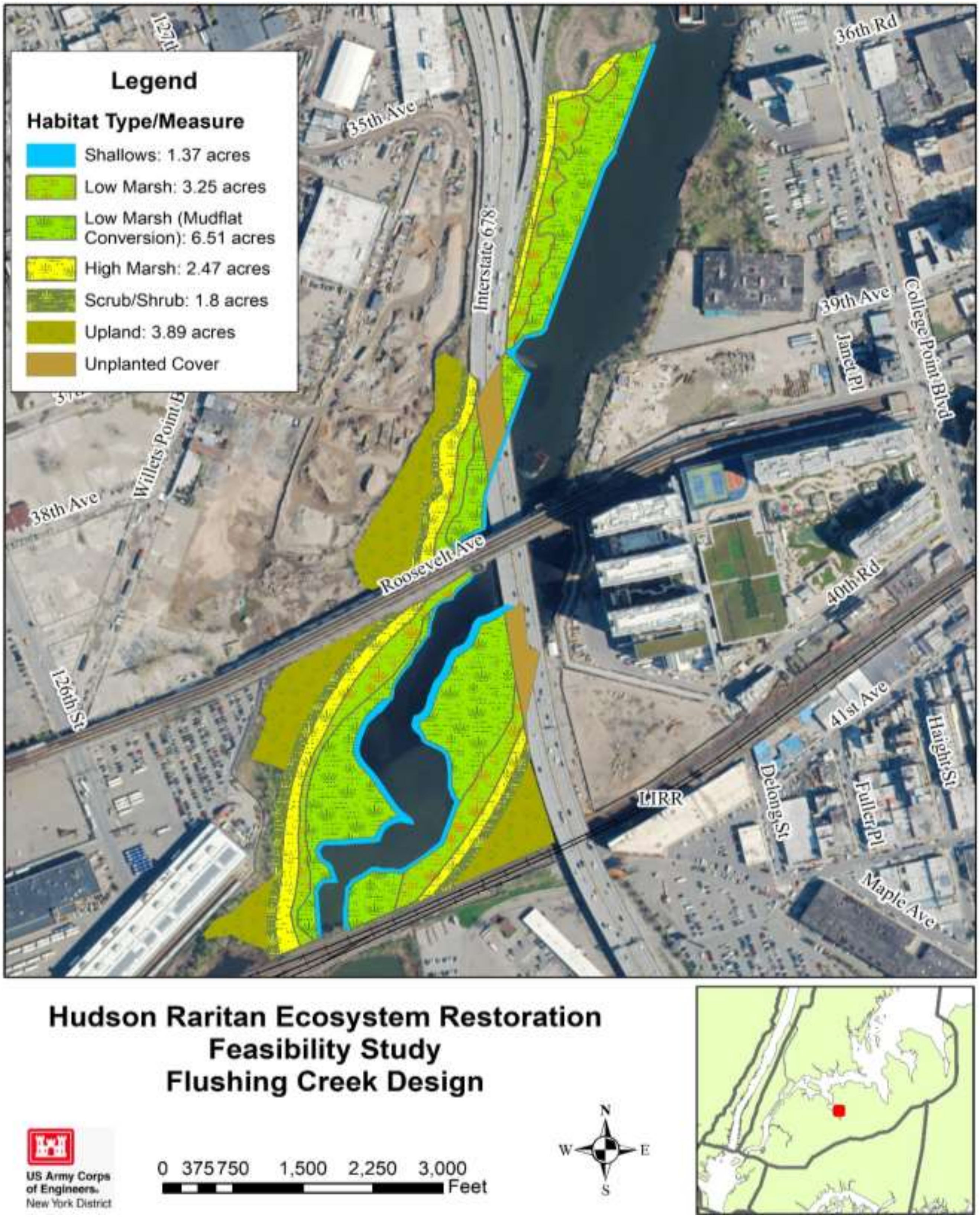


Figure 4-9. Flushing Creek – Recommended Plan

4.1.2.2 Freshwater Riverine Habitat Restoration (Objective #2)

New York City has only 1% of its historic freshwater wetlands (emergent, scrub-shrub and forested wetlands, freshwater marshes, wet meadows, vernal pools and seasonally inundated floodplains). Freshwater wetlands have been filled to an even greater extent for residential, commercial, industrial, and transportation development. Only an estimated 2,000 of 224,000 acres of freshwater wetland that once existed in New York City remain, a loss of over 99%. The proposed fish ladders at Bronx Zoo and Dam and Stone Mill Dam will open up 23.7 river miles of the Bronx River that were previously inaccessible to fish. The modification of these barriers will allow anadromous fish (e.g., American shad, striped bass, alewife, blueback herring) to reach nursery grounds for larval and juvenile life stages and catadromous fish (e.g., American eel) to live out adult life stages. Installing fish ladders at Bronx Zoo and Dam and Stone Mill Dam will open up 23.7 river miles of the Bronx River that were previously inaccessible to fish. The installation of these fish ladders will open a significant amount of habitat to important migratory fish species at all life stages.

Table 4-4 summarizes the areal extent of the principal restoration measures that would be implemented in the Recommended Plan at the freshwater riverine habitat restoration sites in the Harlem River, East River and Western Long Island Sound Planning Region. The Recommended Plan includes freshwater riverine habitat restoration at five (5) sites along the Bronx River.

Table 4-4. Recommended Plan- Freshwater Habitat Along the Bronx River

Restoration Site	Restoration Measures/Habitat Type (acres – except where specified)								
	Emergent Wetland Restoration	Wet Meadow Restoration	Forested Scrub/ shrub Restoration	Invasive Removal and Native Planting	Bed and Channel Restoration	Streambank Restoration (linear feet)	Sediment Forebay Restoration	Fish Ladder Installation (miles opened)	Debris Removal
Bronx Zoo and Dam	1.16	-	0.48	0.42	-	750	-	0.8	0.09
Stone Mill Dam	-	-	-	0.032	0.5	-	-	22.9	-
Shoelace Park	2.07	-	1.1	7.9	5.7	7,415	-	-	-
Bronxville Lake	0.86	-	2.49	1.39	0.65	-	0.3	-	-
Garth Woods/ Harney Road	0.82	1.67	0.57	1.63	2.19	200	-	-	-
Total:	**4.91**	**1.67**	**4.64**	**11.372**	**9.04**	**8,365**	**0.3**	**23.7**	**0.09**

Bronx Zoo and Dam

The recommended plan is the optimized design based on Alternative A (Figure 4-10). The optimized recommended plan for the Bronx Zoo and Dam site will improve aquatic habitat and 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 miles 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 restored 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.

Stone Mill Dam

The recommended plan is the optimized design based on Alternative A and has been largely designed by the NYC Parks Department (Figure 4-11). 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 miles 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.

Shoelace Park

The recommended plan is the optimized design based on Alternative B (Figure 4-12). 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 emergent wetlands/bio-retention basins along the east bank to reduce sediment loads reaching the river. This plan will improve aquatic habitat and water quality 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. The restoration at Shoelace Park has been coordinated with and complements NYC Parks' efforts within the park to conduct invasive species removal and native plantings and NYCDEP's CSO Abatement Program to improve habitat.

<u>Bronxville Lake</u>

The recommended plan is the optimized plan based on Alternative B (Figure 4-13). The recommended plan will improve aquatic habitat, water quality and flow regime. 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 wetlands 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.

Garth Woods/Harney Road

The recommended plan has been optimized based on Harney Road Alternative A and Garth Woods Alternative A-2 (Figure 4-14). 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. Approximately 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, 0.57 acres of forested 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 and water quality, 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 and improved aquatic habitat and water quality. 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.

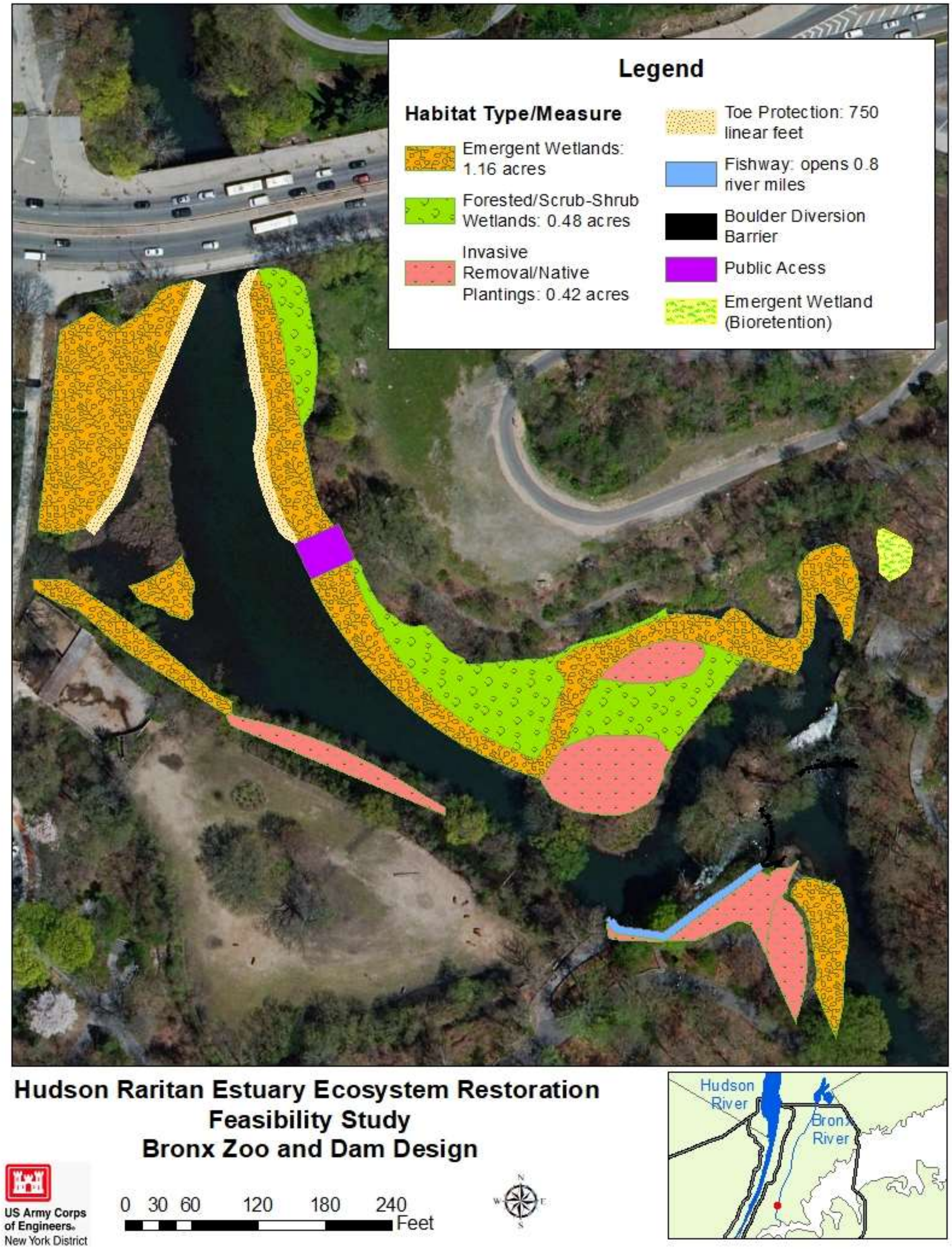


Figure 4-10. Bronx Zoo and Dam – Recommended Plan

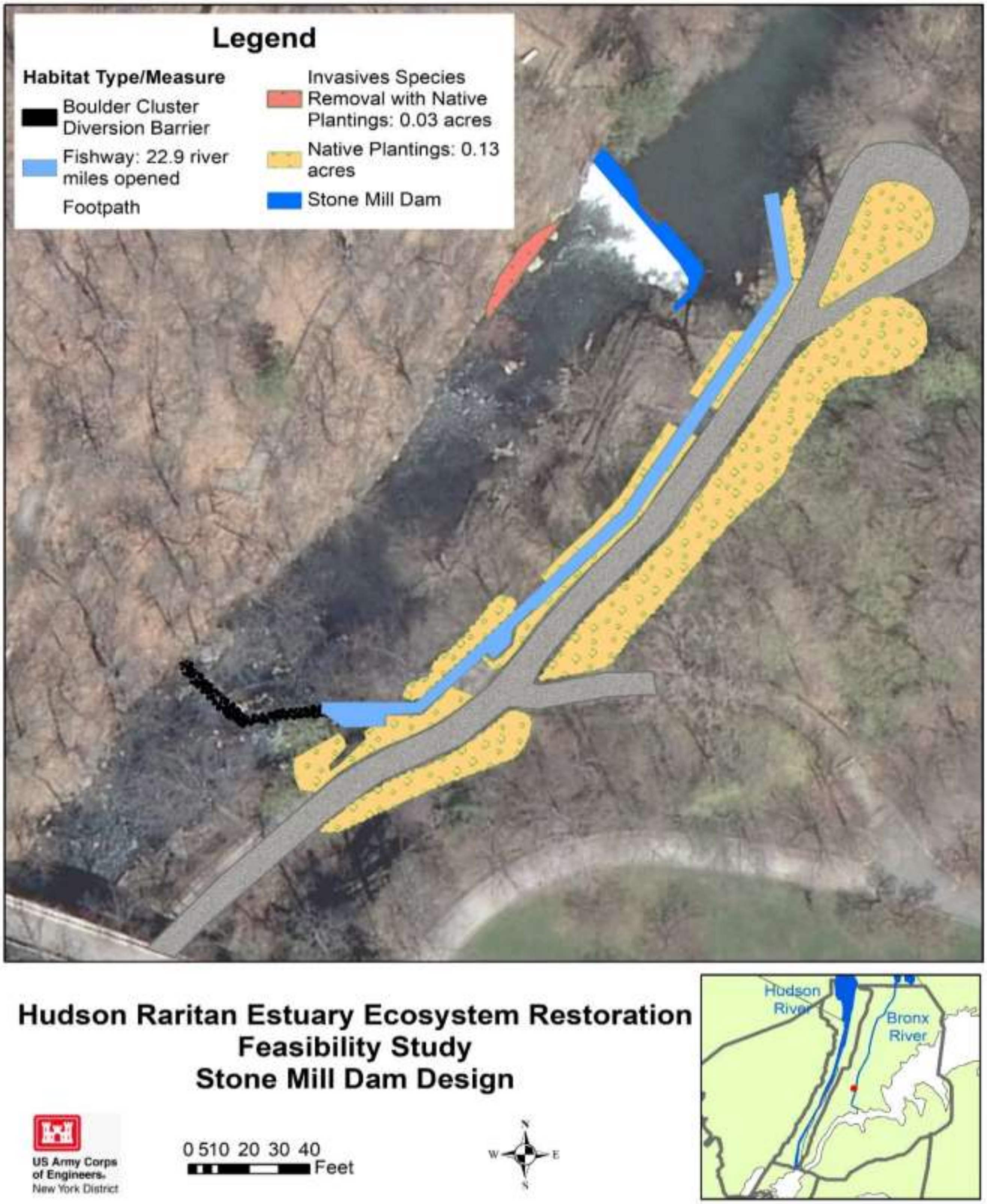


Figure 4-11. Stone Mill Dam – Recommended Plan

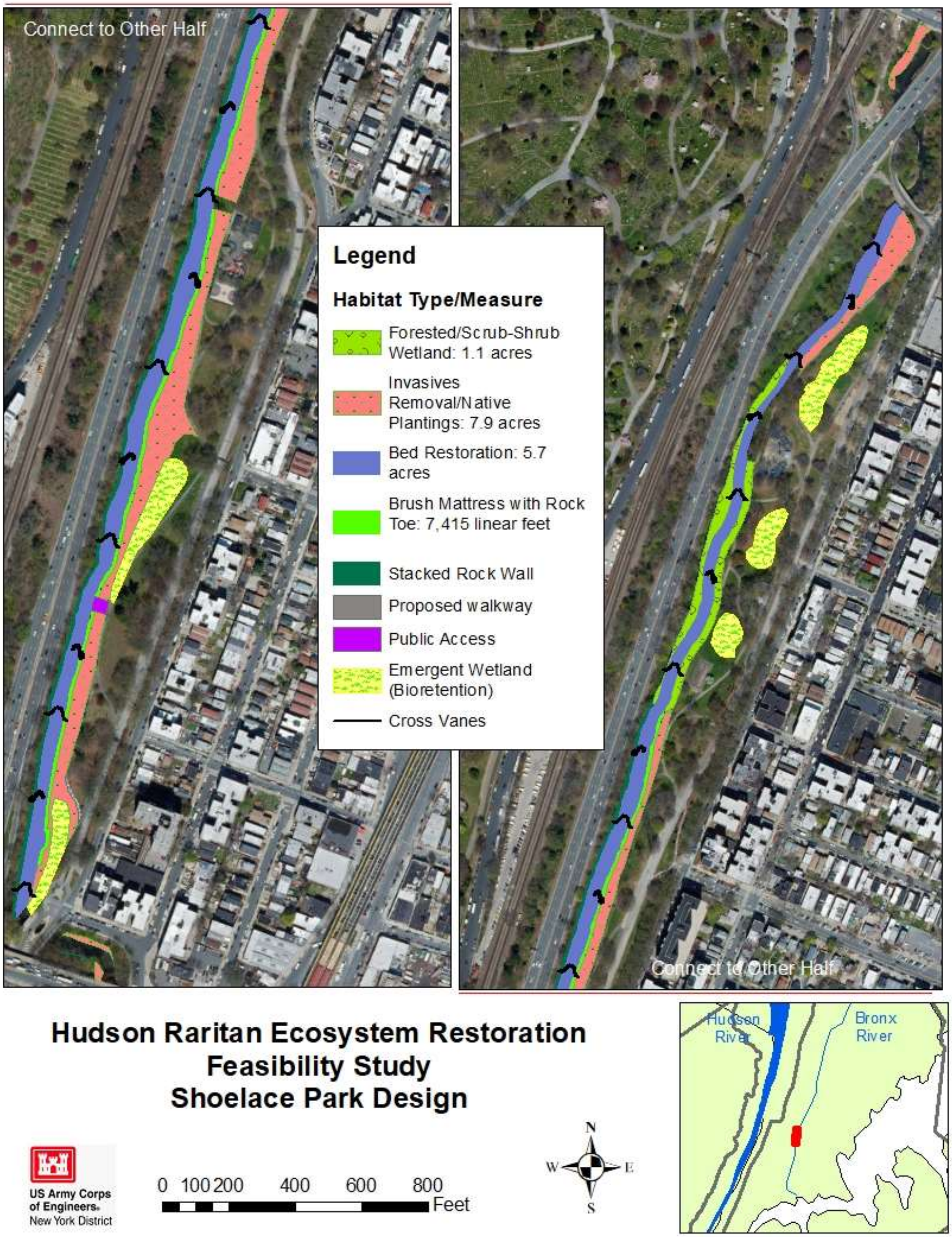


Figure 4-12. Shoelace Park- Recommended Plan

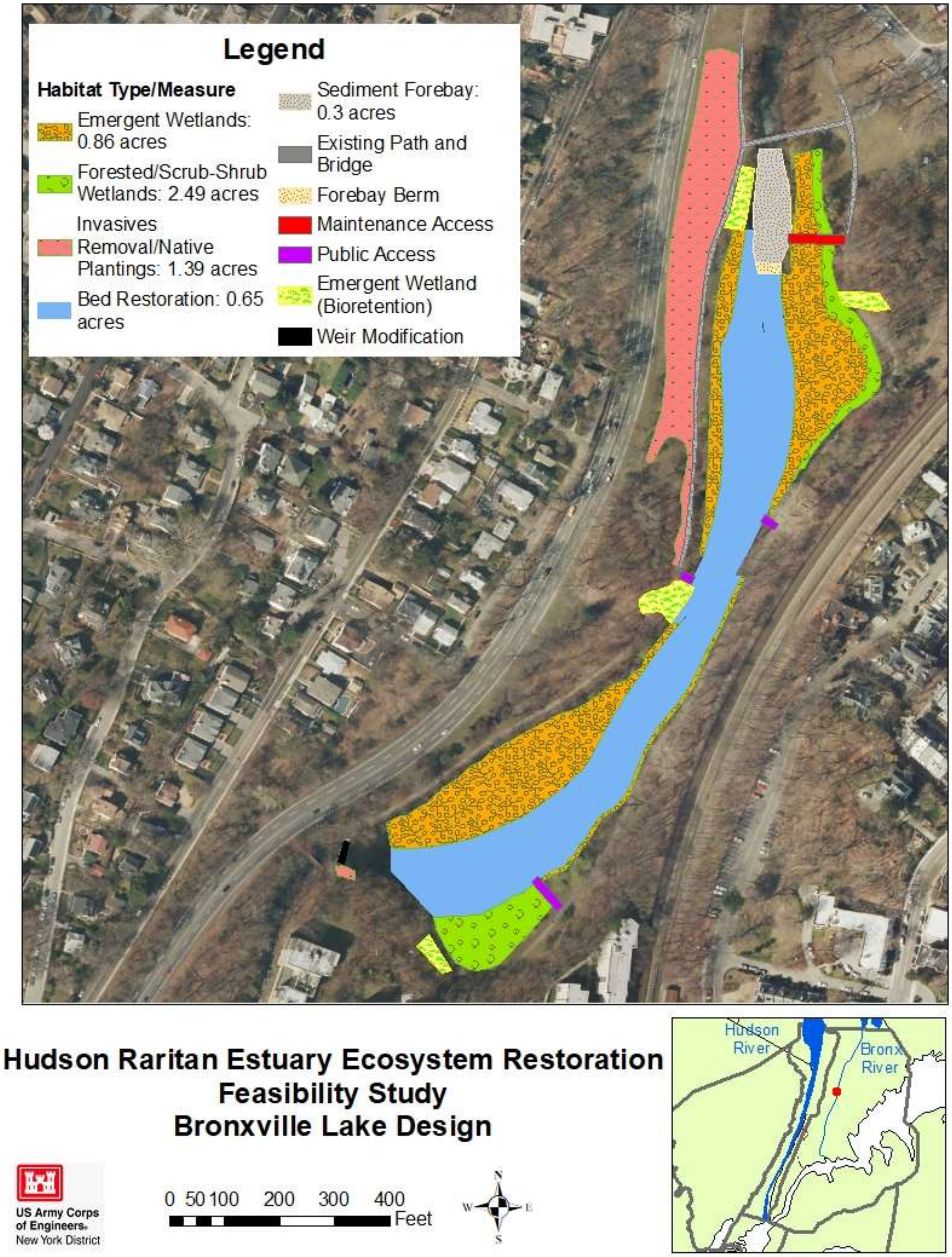


Figure 4-13. Bronxville Lake- Recommended Plan

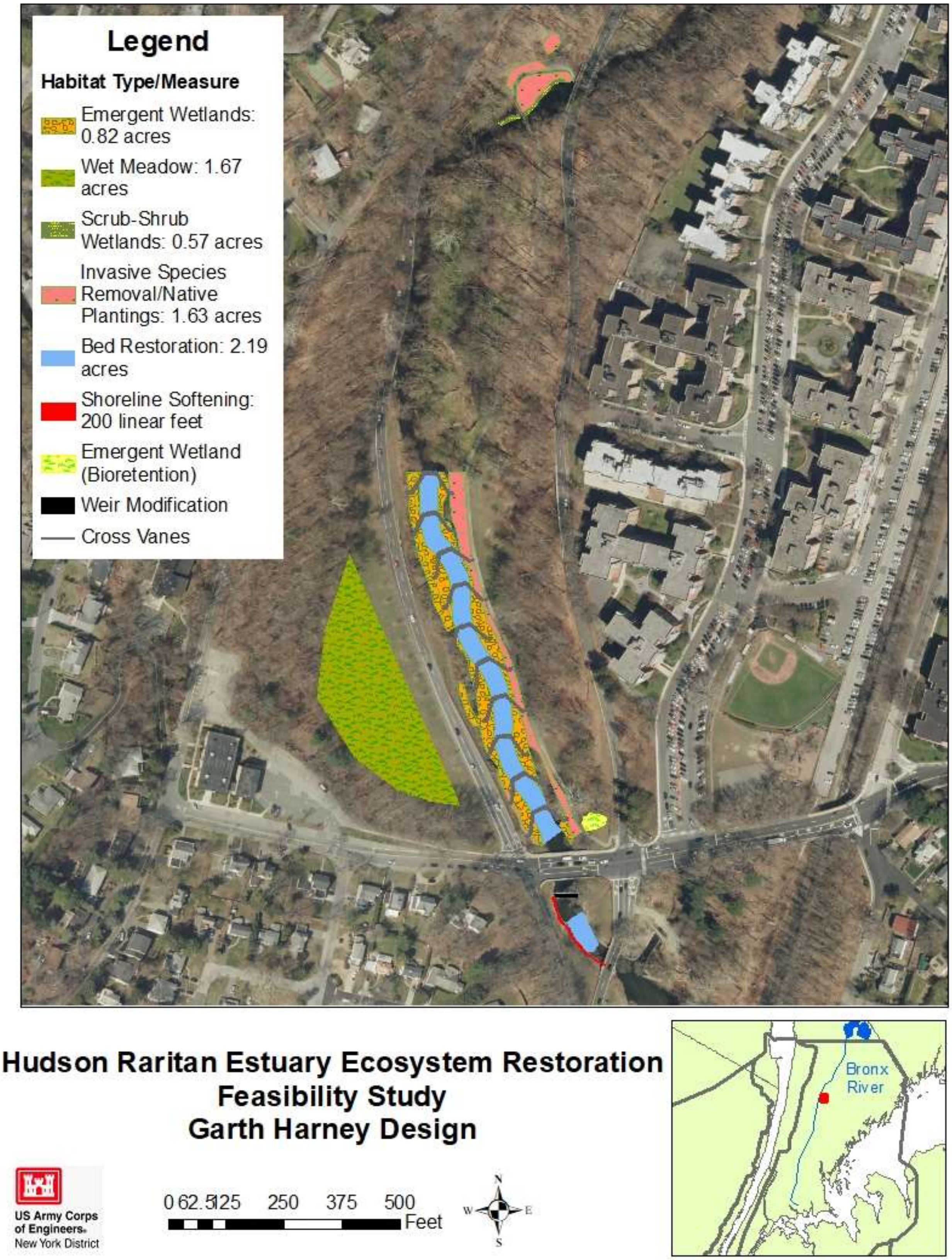


Figure 4-14. Garth Woods/Harney Road – Recommended Plan

4.1.3 Newark Bay, Hackensack River and Passaic River Planning Region

4.1.3.1 Estuarine Habitat Restoration (Objective #1)

Restoring the marshes within the Meadowlands will restore the critical ecosystem functions (e.g., biogeochemical cycling of nutrients, flood storage) and provide the needed habitat that supports a large amount of the State of New Jersey's biodiversity (e.g., 75 percent of New Jersey's avifaunal species and over 25 State-listed species are within the Meadowlands). Table 4-5 summarizes the areal extent of the principal restoration measures and habitat types that would be implemented in the Recommended Plan at the estuarine habitat restoration sites in the Newark Bay, Hackensack River and Passaic River Planning Region. The Recommended Plan includes estuarine habitat restoration at two (2) shoreline sites along the Hackensack River and one (1) Tier 2 site (following USEPA remedial actions) along the mainstem of the Lower Passaic River. Two sites: Metromedia Tract and Meadowlark Marsh have generally poor habitat characterized by *Phragmities*. Management options for the removal of *Phragmites* may include one or a combination of the following:

1. Herbicide - Effectiveness: Herbicide use is a 2 year, 2 step process because the plants may need a touch-up application, especially in dense stands since sub-dominant plants are protected by thick canopy and may not receive adequate herbicide in the first application;
2. Plastic - Effectiveness: Tarping can be effective in small stands i.e., <100 plants, low to medium density (1-75%area). Plants die off within 3-10 days, depending on sun exposure;
3. Cutting - Effectiveness: Can be effective in small stands i.e., <100 plants, low to medium density (1-75%area) and <3 acres;
4. Pulling - Effectiveness: Can be effective in small stands i.e., <100 plants. This method is very labor intensive and best with sandy soils; or
5. Excavation - Effectiveness: Can be effective for patches up to 2 acre. Cost is the limiting factor.

Table 4-5. Recommended Plan - Estuarine Habitat Along the Lower Passaic River and Hackensack River

Restoration Site	Restoration Measures/Habitat Types					
	Low Marsh (acres)	High Marsh (acres)	Scrub/shrub Wetland (acres)	Maritime Forest (acres)	Tidal Channel/Basin/ Pool (acres/linear feet)	Shallows (acres)
Oak Island Yards	5.32	0.85	0.44	2.85	1.36	-
Metromedia Track	26.5	11.7	13.8	-	2.79 / 6,270	6.51
Meadowlark Marsh	56.2	6.5	5.4	-	4.60 / 7,700	-
Total:	**88.02**	**19.05**	**19.64**	**2.85**	**8.75 / 13,970**	**6.51**

<u>Oak Island Yards, Tier 2</u>

The recommended plan is the optimized plan based on Alternative A (Figure 4-15). This plan wouldrestore 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.

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.

<u>Metromedia Tract</u>

The recommended plan 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 4-16).

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. 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.

<u>Meadowlark Marsh</u>

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 4-17).

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.

Figure 4-15. Oak Island Yards- Recommended Plan

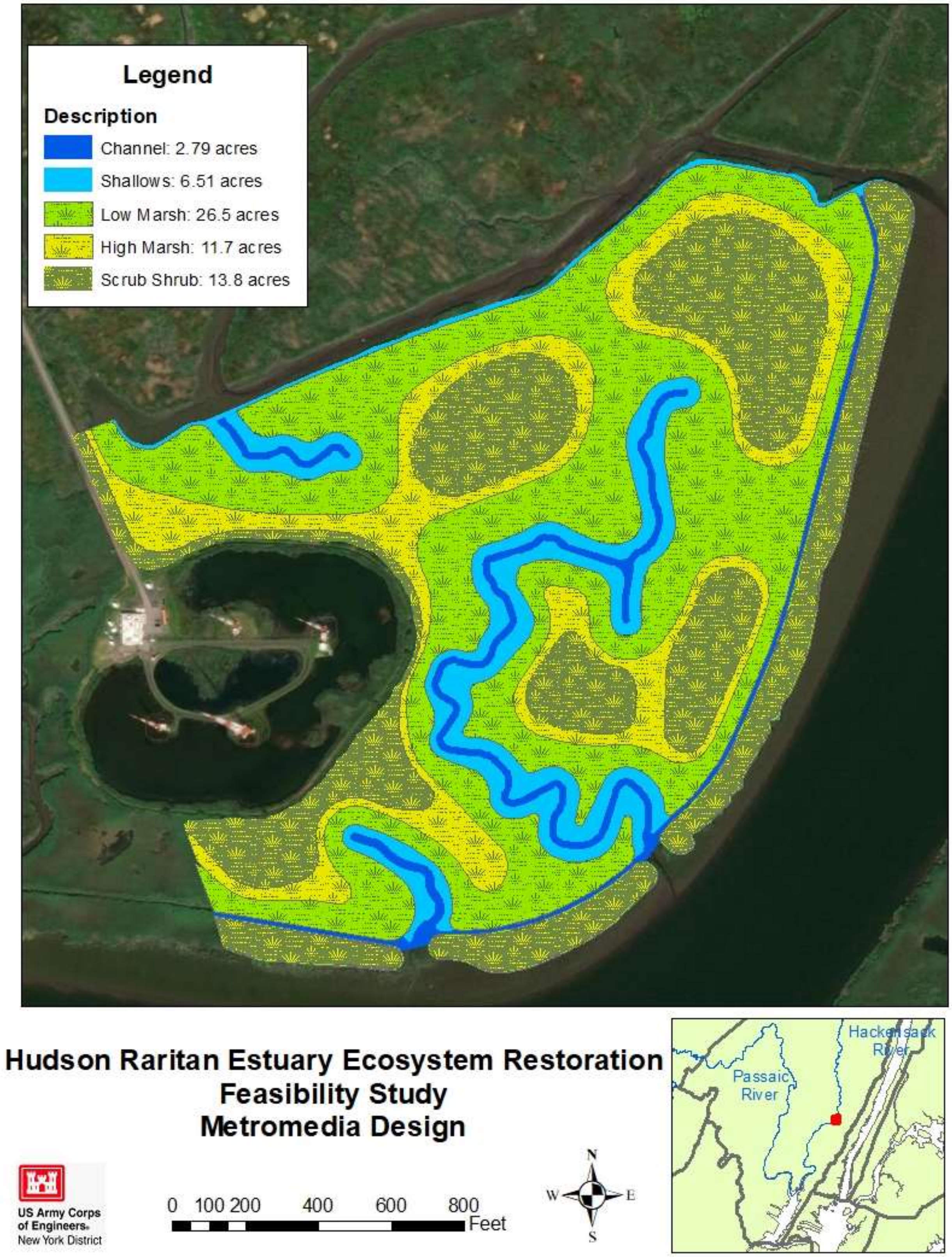


Figure 4-16. Metromedia Tract – Recommended Plan

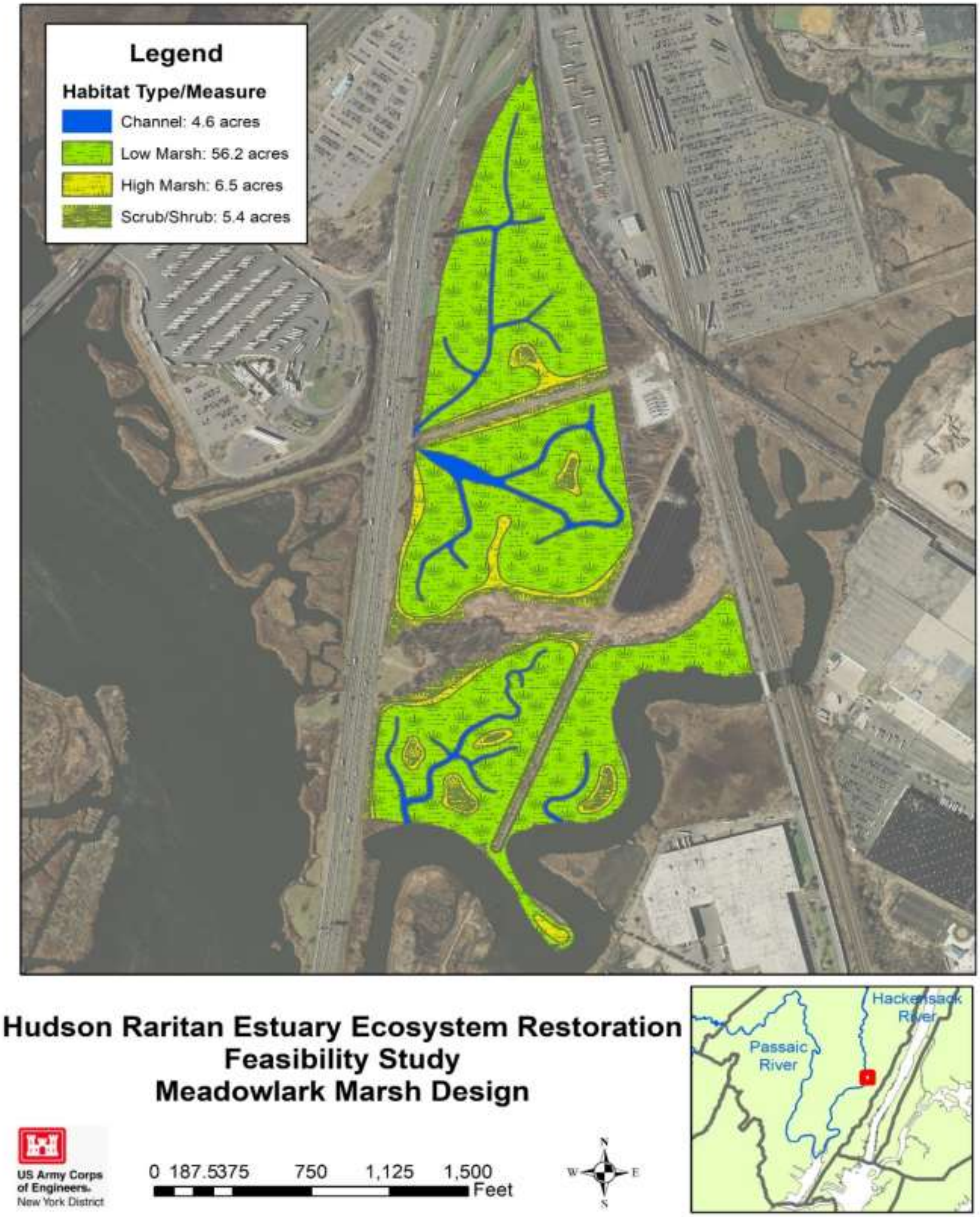


Figure 4-17. Meadowlark Marsh – Recommended Plan

4.1.3.2 Freshwater Riverine Habitat Restoration (Objective #2)

Restoration activities will improve habitat for reptiles and amphibians (herpetofauna) as well as waterbirds. Table 4-6 summarizes the areal extent of the principal restoration measures and habitat types that would be included in the Recommended Plan at freshwater riverine habitat restoration sites in the Newark Bay, Hackensack River and Passaic River Planning Region. The Recommended Plan includes freshwater riverine habitat restoration at one (1) site on Branch Brook, a tributary to the Lower Passaic River.

Table 4-6. Recommended Plan- Freshwater Habitat within Lower Passaic River Watershed

Restoration Site	Restoration Measures (acres)			
	Emergent Wetland Restoration	Forested Scrub/shrub Wetland Restoration	Invasive Removal and Native Planting	Bed and Channel Restoration
Essex County Branch Brook Park	10.25	8.8	8.9	18.09

<u>Essex County Branch Brook Park</u>

The recommended plan for Essex County Branch Brook Park will enhance 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 scrub/shrub wetland restoration, and 10.25 acres of emergent wetlands. 3,170 CY will be excavated during stream naturalization and 55,020 CY will be excavated for channel deepening (Figure 4-18).

The selected alternative will also provide shoreline softening and 8.9 acres of invasive plant species removal and planting of native vegetation. Restoration measures incorporated into this design would additionally provide enhanced fish habitat.

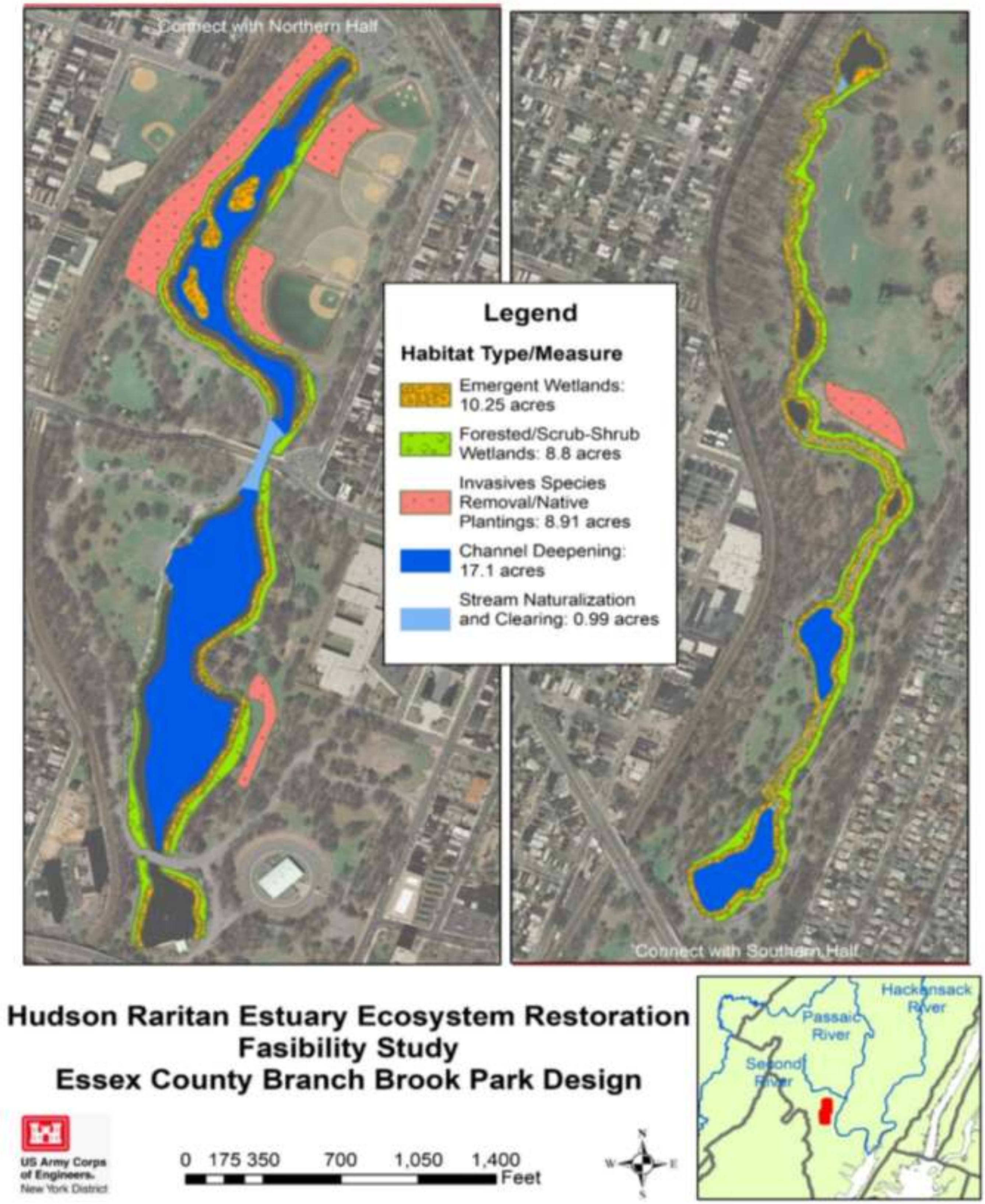


Figure 4-18. Essex County Branch Brook Park – Recommended Plan

4.1.4 Small-Scale Oyster Reef Restoration

4.1.4.1 Lower Bay, Upper Bay and Jamaica Bay Oyster Reef Restoration (Objective #4)

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. Restoration actions that promote small reef development will increase biodiversity, improve sediment stability, and provide habitat for local species of fish and crabs while also improving the local water quality by removing nitrogen, phosphorous and, organic carbon.

Table 4-7 summarizes the areal extent of the oyster reef restoration measures and techniques that are included in the Recommended Plan within three Planning Regions – Jamaica Bay, Upper Bay and Lower Bay.

Table 4-7. Recommended Plan for Oyster Reef Restoration

Planning Region	Restoration Site	Restoration Techniques				Total Restoration Area
		Spat-on-Shell	Oyster Gabions	Oyster Pyramids	Oyster Trays	
Lower Bay	Naval Weapons Station Earle	-	102	1,010	-	10 acres
Upper Bay	Bush Terminal	31.9 acres	1,100	-	-	31.9 acres
Jamaica Bay	Head of Jamaica Bay	10.1 acres	340	150	470	10.1 acres

<u>Naval Weapons Station Earle</u>

This site is located along the northern New Jersey shore in the south end of Sandy Hook Bay and features a 2.9-mile pier. The naval facility is considered an ideal restoration area and the presence of naval security forces and exclusion areas would likely result in a low disturbance of the restoration area. Restoration activities would occur under the pier at a location closer to land away from naval ship activity. The recommended plan is optimized based on Alternative 3 (Figure 4-21). This plan restores a 10 acre oyster reef at the Naval Weapons Station Earle site. A total of 1010 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. The Recommended Plan would build on previous successful oyster reef restoration by the NY/NJ Baykeeper at Naval Weapons Station Earle.

<u>Head of Jamaica Bay</u>

The recommended plan for Jamaica Bay is optimized based on Alternative 3 (Figure 4-19). 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.

Bush Terminal

The recommended plan for Bush Terminal is optimized based on Alternative 3 (Figure 4-20). 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 4-19. Naval Weapons Station Earle Oyster Reef – Recommended Plan

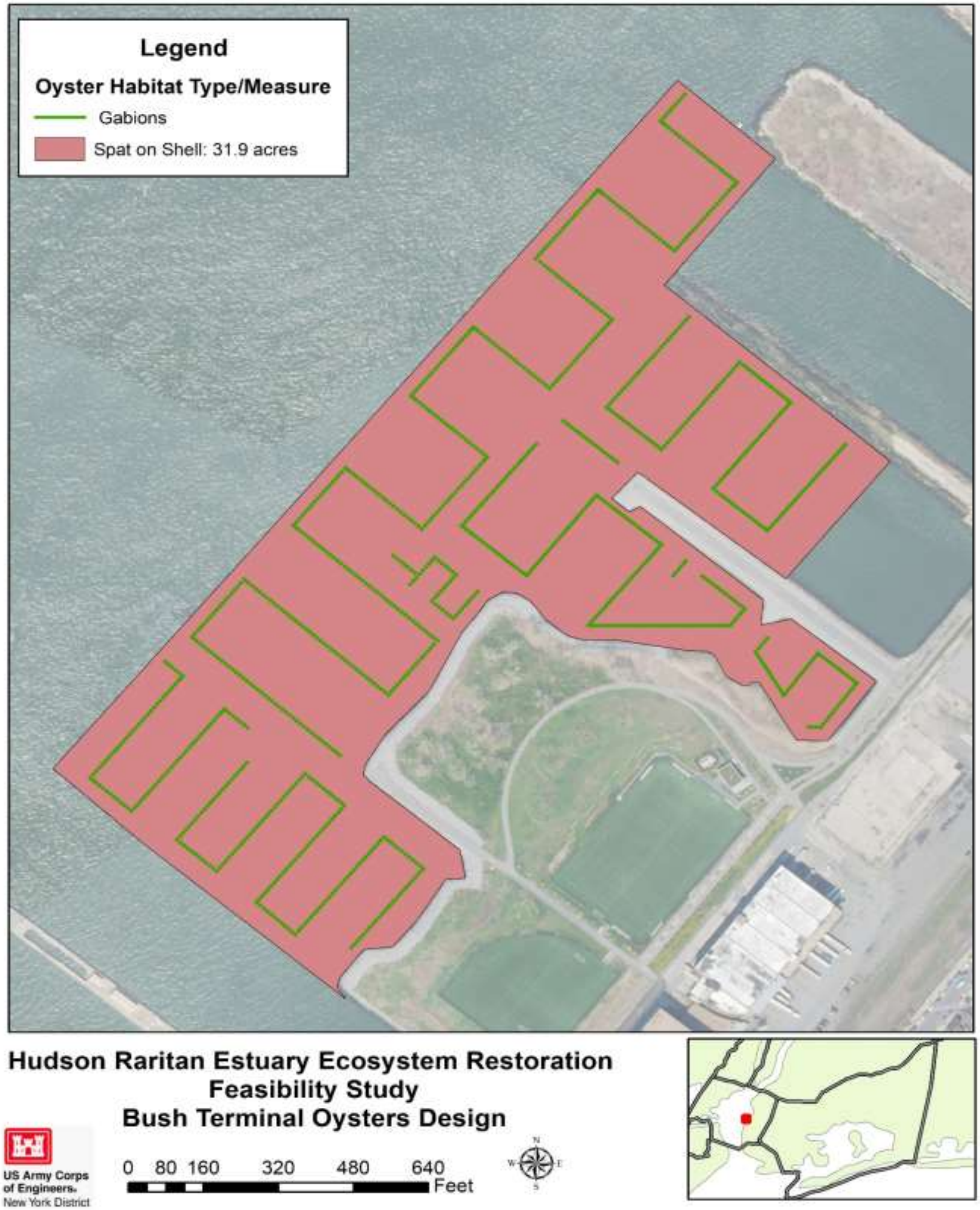


Figure 4-20. Bush Terminal Oyster Reef - Recommended Plan

Figure 4-21. Head of Jamaica Bay Oyster Reef - Recommended Plan

4.2 Plan Costs and Benefits

Costs (Appendix I) and benefits (Appendix E) were updated for the Recommended Plan following optimization. Updated costs were developed using the FY2020 interest rate of 2.75% (EGM 20-01) with contingencies ranging from 21% to 37% for each site using a Cost Schedule Risk Analysis (CSRA) tool provided by the Cost MCX. Real estate (01 Account) costs were updated (Section 4.9.1; Appendix M) and site-specific monitoring and adaptive management costs were developed for each site (Section 4.9.2; Appendix L).

Planning, Engineering and Design (30 Account) includes costs for the Pre-construction Engineering and Design (PED) Phase (Section 4.9.4) and were developed for all activities associated with the planning, engineering and design effort. The costs were developed for each site including costs related to regulatory compliance, field data collection, and preparation of design plans, documentation, and specifications for all sites. It includes all the in-house labor based upon work-hour requirements, material and facility costs, travel and overhead.

Construction Management (Account 31) costs were developed for all construction management activities from pre-award requirements through final contract closeout. This cost includes in-house labor based upon work-hour requirements, materials, facility costs, support contracts, travel, and overhead. The cost was developed based on input from the construction division in accordance with Civil Works Breakdown Structure (CWBS) and includes, but is not limited to, anticipated items such as the salaries of the resident engineer and staff, surveyors, inspectors, drafters, clerical, and custodial personnel; operation, maintenance and fixed charges for transportation and for other field equipment; field supplies; construction management, general construction supervision; and project office administration, distributive cost of area office, and general overhead charged to the project. This account also includes engineering support during construction through project completion.

Total fully funded project costs were then developed with escalation to the mid-point of construction for each project sequenced over a 20 year period (Section 4.9.5). The estimated total first cost for the Recommended NER Plan is $408,184,000 (October 2019, FY20 Price Level) and the total fully funded project costs is $587,661,000.

The Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs for each project were updated based on similar activities and estimates identified in the Monitoring and Adaptive Management Plan (Appendix L, Section 5.0) and MII files (Appendix I). Average annual OMRR&R costs are estimated to be approximately $156,021. The total OMRR&R costs are estimated to be $7,451,509 (Table 4-8).

- Total OMRR&R costs for projects in Jamaica Bay, Lower Passaic River, Hackensack River and Flushing Creek represent Operation and Maintenance (O&M) of non-structural features for 10 years. Costs include activities for a site survey; an invasive assessment and treatment for an estimated percentage of each habitat type within each site; debris removal; and bed restoration repairs. These activities are estimated to occur once per year in years 6-15.

- Total OMRR&R costs for oyster restoration sites represent O&M for 10 years. Costs include activities for a site survey every year and stock and substrate installation over an estimated percentage of the total reef footprint five times in years 6-15.

- Total OMRR&R costs for projects in the Bronx River include O&M of non-structural features for up to 10 years (years 6-15) and repair and replacement of structural features (fishways, instream structures, toe protection/stacked rock wall) for up to 50 years (years 6-56). O&M activities include a site survey; an invasive assessment and treatment for an estimated percentage of each habitat type within each site; debris removal; bed restoration repairs; and sediment forebay maintenance estimated to occur once per year. Repair and replacement activities for an estimated percentage of instream structures were estimated to occur one time with surveys/minor adjustments occurring annually between years 6-56; toe protection/stacked rock wall one time; and fishways repair and debris removal every year during fish migration in years 6-56.

The total quantitative benefits for the Recommended Plan are 341 Average Annual Functional Capacity Units (AAFCUs) (Table 4-8) [Note: the Recommended NER Plan increased benefits by 23 AAFCUs compared to the selected alternatives prior to optimization.] The estuarine and freshwater habitat benefits were quantified using Evaluation of Planned Wetlands (EPW) with 287 AAFCUs over a fifty year period considering relative sea level change (RSLC) analysis using the intermediate sea level rise curve. The benefits for fish passage measures at Bronx Zoo and Dam and Stone Mill Dam were quantified as 20 AAFCUs using the Watershed Scale Toolkit and 34 AAFCUs using the Oyster Habitat Suitability Index for oysters.

Table 4-8. Benefits and Costs of the Recommended Plan

Site	Alt	Construction Duration (months)	Net Benefits (AAFCU)	First Costs					Fully Funded Total Cost ($)
				Monitoring Cost ($)	Adaptive Management Cost ($)	Project First Cost ($)	Average Annual Economic Cost ($)	Total OMRR&R Cost ($)	
Dead Horse Bay	4	32	30.3	128,137	285,853	40,750,432	1,566,406	162,486	68,645,000
Fresh Creek	5	23	36.9	244,626	273,065	33,914,507	1,291,116	182,006	44,377,000
Duck Point	2	21	28.4	167,494	392,470	21,401,095	813,568	169,394	27,271,000
Stony Creek	1	26	37.3	167,494	548,540	23,220,043	887,316	188,380	27,976,000
Pumpkin Patch West	2	17	18.4	135,387	272,670	20,124,334	761,952	154,797	31,897,000
Pumpkin Patch East	3	19	22.1	135,387	304,480	21,581,125	818,662	156,827	38,856,000
Elders Center	3	17	21.6	135,387	292,514	19,582,641	741,493	156,333	28,318,000
Flushing Creek	B	20	8.3	129,188	80,638	16,151,862	615,187	166,006	19,786,000
Bronx Zoo and Dam	A	14	1.9	165,863	718,045	10,993,425	425,882	1,059,705	13,020,000
Stone Mill Dam	A	8	19.2	104,696	128,231	4,658,650	182,857	665,011	5,606,000
Shoelace Park	B	12	9.6	165,863	835,374	20,713,053	796,204	1,504,484	27,969,000
Bronxville Lake	B	17	3.8	165,863	863,094	15,400,018	582,270	189,524	22,389,000

Site	Alt	Construction Duration (months)	Net Benefits (AAFCU)	First Costs					Fully Funded Total Cost ($)
				Monitoring Cost ($)	Adaptive Management Cost ($)	Project First Cost ($)	Average Annual Economic Cost ($)	Total OMRR&R Cost ($)	
Garth Woods/ Harney Road	A	11	4.3	165,863	741,432	10,322,520	396,596	772,468	13,134,000
Oak Island Yards	A	19	2.8	101,044	102,760	15,440,769	587,309	154,172	25,906,000
Metromedia Tract	A	22	20.6	190,965	3,986,573	52,027,663	1,976,173	317,423	75,928,000
Meadowlark Marsh	C	23	14.6	184,854	860,698	31,106,080	1,181,233	185,055	43,087,000
Essex County Branch Brook Park	D	27	26.9	184,854	444,980	29,668,449	1,129,412	181,274	46,351,000
Naval Weapons Station Earle	C	18	9.6	78,278	372,771	8,508,329	328,007	298,238	10,354,000
Bush Terminal	C	8	19.5	147,972	468,082	6,935,486	267,098	361,673	9,514,000
Head of Jamaica Bay	C	4	5.2	78,278	386,866	5,683,652	221,761	426,253	7,276,000
Total		**NA**	**341**	2,977,494	12,359,136	408,184,134	15,570,502	7,451,508	587,661,000

4.3 Contribution to Study Objectives

Chapter 3 outlined the four primary study objectives and the relevant TECs and the TEC sub-objectives to achieve our study goals to restore a mosaic of habitats throughout the HRE. Each site within the Recommended NER Plan contributes to specific study objectives and meets a variety of the sub-objectives depending on the actions and site. Tables 4-9 through 4-12 present whether each site meets the TEC sub-objectives contributing to the four study objectives (★Indicates site restoration would contribute to meeting the sub-objective.)

Restoration recommended at sites in Jamaica Bay, Flushing Creek, Lower Passaic River and Hackensack River sites contribute to Planning Objective #1 which is to *restore the structure, function, and connectivity, and increase the extent of estuarine habitat* in the HRE (Table 4-9).

Table 4-9: Restoration at Sites Meeting Objective #1 (Estuarine Habitat) and Relevant TEC Sub-Objectives

		Planning Region					
		Jamaica Bay		Harlem River, East River & W. Long Island Sound	Newark Bay, Hackensack River and Passaic River		
		Sites					
TEC	**TEC Sub-Objective**	**Dead Horse Bay**	**Fresh Creek**	**Flushing Creek**	**Metromedia Tract**	**Meadowlark Marsh**	**Oak Island Yards**
Wetlands	Improve wetland habitat	★	★	★	★	★	★
	Increase diversity and abundance	★	★	★	★	★	★
	Increase wetland connectivity	★	★	★	★	★	★
	Improve hydrologic connectivity	★	★	★	★	★	★
	Reduce shoreline erosion	★	★				
	Reduce invasive monocultures, replace with natives	★	★	★	★	★	★
	Restore tidal marsh systems to offset loss	★	★	★	★	★	★
	Improve roosting, nesting, and foraging habitat	★	★	★	★	★	★

TEC	TEC Sub-Objective	Dead Horse Bay	Fresh Creek	Flushing Creek	Metromedia Tract	Meadowlark Marsh	Oak Island Yards
		Planning Region					
		Jamaica Bay		**Harlem River, East River & W. Long Island Sound**	**Newark Bay, Hackensack River and Passaic River**		
		Sites					
Habitat for Waterbirds	Increase nests and improve feeding habitat	★	★	★	★	★	★
Maritime Forests	Ensure sustainability of adjacent habitat	★	★	★	★	★	★
	Provide vegetated buffer and transitional zone	★	★	★	★	★	★
	Develop mosaic of diverse habitats	★	★	★	★	★	★
Shorelines & Shallows	Provide habitat and food, stabilize shoreline, retain soils	★	★	★	★	★	★
	Soften hardened shorelines						
	Restore buffer riparian zones						
Fish, Crab and Lobster	Develop mosaic of diverse habitats	★	★	★	★	★	★
	Restore natural stream geomorphology	★	★	★	★	★	★
	Reduce sediment loads	★	★	★	★	★	★
Tributary Connections	Increase riparian habitat connectivity	★	★	★	★	★	★
	Improve hydrologic connectivity	★	★	★	★	★	★
	Enhance basin and tributary bathymetry configuration	★	★	★	★	★	★
	Reduce shoreline erosion	★	★	★	★	★	★
	Remove invasive species and replace with natives	★	★	★	★	★	★
	Increase migratory fish habitat	★	★		★	★	★

Restoration recommended at sites in the Bronx River and Branch Brook a tributary to the Lower Passaic River contribute to Planning Objective # 2 which is to *restore the structure, function, and increase the extent of freshwater riverine habitat in the HRE* (Table 4-10).

Table 4-9. Restoration at Sites Meeting Objective #2 (Freshwater Habitat) and Relevant TEC Sub-Objectives

		Planning Region					
		Harlem River, East River and Western Long Island Sound					**Newark Bay, Hackensack River & Passaic River**
		Site					
TEC	**TEC Sub-Objective**	**Bronx Zoo and Dam**	**Stone Mill Dam**	**Shoelace Park**	**Bronxville Lake**	**Gath Woods / Harney Road**	**Essex County Branch Brook Park**
Wetlands	Improve wetland habitat	★	★	★	★	★	★
	Increase diversity and abundance	★	★	★	★	★	★
	Increase wetland connectivity	★	★	★	★	★	★
	Improve hydrologic connectivity	★	★	★	★	★	★
	Reduce shoreline erosion	★		★	★	★	★
	Reduce invasive monocultures, replace with natives	★	★	★	★	★	★
	Restore tidal marsh systems to offset loss						
Habitat for Waterbirds	Improve roosting, nesting, and foraging habitat	★	★	★	★	★	★
	Increase nests and improve feeding habitat	★	★	★	★	★	★
Maritime Forest	Ensure sustainability of adjacent habitat	★		★	★		★
	Provide vegetated buffer and transitional zone	★		★	★	★	★

		Planning Region					
		Harlem River, East River and Western Long Island Sound					Newark Bay, Hackensack River & Passaic River
		Site					
TEC	**TEC Sub-Objective**	**Bronx Zoo and Dam**	**Stone Mill Dam**	**Shoelace Park**	**Bronxville Lake**	**Gath Woods / Harney Road**	**Essex County Branch Brook Park**
	Develop mosaic of diverse habitats	★	★	★	★	★	★
Shorelines & Shallows	Provide habitat and food, stabilize shoreline, retain soils	★	★	★	★	★	★
	Soften hardened shorelines					★	
	Restore buffer riparian zones	★	★	★	★	★	★
Fish, Crab & Lobster	Develop mosaic of diverse habitats	★	★	★	★	★	★
	Restore natural stream geomorphology	★	★	★	★	★	★
	Reduce sediment loads	★	★	★	★	★	★
Tributary Connections	Increase riparian habitat connectivity	★	★	★	★	★	★
	Improve hydrologic connectivity	★	★	★	★	★	★
	Enhance basin and tributary bathymetry configuration	★		★	★	★	★
	Reduce shoreline erosion	★		★	★	★	
	Remove invasive species and replace with natives	★	★	★	★	★	★
	Increase migratory fish habitat	★	★	★	★	★	★

Restoration recommended at the five Jamaica Bay Marsh Island sites contribute to Planning Objective #3 which *restores the structure and function, and increase the extent of marsh island habitat in Jamaica Bay* (Table 4-11).

Table 4-11: Restoration at Sites Meeting Objective #3 (Jamaica Bay Marsh Islands) and Relevant TEC Sub-Objectives

		Planning Region				
		Jamaica Bay				
		Site				
TEC	**TEC Sub-Objective**	**Stony Creek**	**Duck Point**	**Elders Center**	**Pumpkin Patch West**	**Pumpkin Patch East**
Wetlands	Improve wetland habitat	★	★	★	★	★
	Increase diversity and abundance	★	★	★	★	★
	Increase wetland connectivity	★	★	★	★	★
	Improve hydrologic connectivity	★	★	★	★	★
	Reduce shoreline erosion	★	★	★		
	Reduce invasive monocultures, replace with natives	★	★	★	★	★
	Restore tidal marsh systems to offset loss	★	★	★	★	★
Habitat for Waterbirds	Improve roosting, nesting, and foraging habitat	★	★	★	★	★
	Increase nests and improve feeding habitat	★	★	★	★	★
Shorelines & Shallows	Provide habitat and food, stabilize shoreline, retain soils	★	★	★	★	★
	Soften hardened shorelines					
	Restore buffer riparian zones					
Fish, Crab & Lobster	Develop mosaic of diverse habitats	★	★	★	★	★
	Restore natural stream geomorphology	★	★	★	★	★
	Reduce sediment loads	★	★	★	★	★
Tributary Connections	Increase riparian habitat connectivity					
	Improve hydrologic connectivity	★	★	★	★	★
	Enhance basin and tributary bathymetry configuration	★	★	★	★	★
	Reduce shoreline erosion	★	★	★		
	Remove invasive species and replace with natives	★	★	★	★	★
	Increase migratory fish habitat					

Restoration recommended at the three oyster reef sites contribute to Planning Objective #4 which increases the extent of oyster reefs in the HRE (Table 4-12).

Table 4-12: Restoration at Sites Meeting Objective #4 (Oyster Reefs) and Relevant TEC Sub-Objectives

		Planning Region		
		Jamaica Bay	Upper Bay	Lower Bay
		Site		
TEC	TEC Sub-Objective	Head of Jamaica Bay	Bush Terminal	Naval Weapons Station Earle
Oysters	Incorporate diverse habitat structure	★	★	★
Shorelines & Shallows	Provide habitat and food, stabilize shoreline, retain soils	★	★	★
	Soften hardened shorelines			
	Restore buffer riparian zones			
Fish, Crab & Lobster	Develop mosaic of diverse habitats	★	★	★
	Restore natural stream geomorphology			
	Reduce sediment loads	★	★	★

4.4 Synergy with the HRE Comprehensive Restoration Plan & Contribution to Regional Targets

As described in Chapters 1 and 3, the HRE CRP was the foundation of plan formulation for this FR/EA. The HRE CRP was developed in collaboration with more than 129 federal, state and local agencies; non-governmental organizations; stakeholder groups; academic institutions; research groups; and private consulting firms to restore the NY/NJ Harbor Estuary. The HRE CRP was developed to address the objectives of regional stakeholders first expressed in the New York-New Jersey Harbor Estuary Program (HEP) Comprehensive Conservation and Management Plan (CCMP) (HEP, 1996) to develop a comprehensive regional master plan for restoration within the HRE and outlines a system for coordinating restoration efforts on local, state, and federal levels. All partners are working together and coordinating efforts to achieve the overall goal of advancing the TEC targets through participation in the NY/NJ HEP Restoration Work Group.

Each site recommended for construction contributes to the overall goal of developing a mosaic of habitats throughout this highly urbanized study area. Each project contributes to the TECs and the overall planning objectives and sub-objectives outlined in Section 3.1 and 4.3. Table 4-13 summarizes those TECs that are within the USACE's aquatic ecosystem restoration mission and are addressed by the Recommended Plan for construction. Restoration actions for most

TECs are included in the plan. Restoration of TECs not included in the Plan may be included in plans for sites investigated in future feasibility studies.

The regional partners of the HEP Restoration Work Group will continue to coordinate and advance the remaining restoration opportunities that are outlined in the HRE CRP. To date, the HEP RWG has tracked progress of restoration in the region since the release of the 2009 Draft CRP. Progress reports (2009-2014; 2014-2016; 2016-2019) in Appendix B illustrates the success of partners towards achieving the region's restoration goals. However, the reports also demonstrate the need to implement the Recommended Plan – the next phase of top priority restoration projects in the region. Construction of the Recommended Plan will advance the regional TEC target statements and short-term (2020) and long-term (2050) restoration targets as discussed in Chapter 3, which are critical to achieve the regional goals in the HRE CRP (USACE, 2016).

Table 4-10. Contribution of Recommended Plan to Regional TEC Targets

TEC	Recommended Plan	CRP Goal		HRE Contribution	
		2020	2050	2020	2050
Wetlands	381 acres of estuarine wetlands and 50 acres of freshwater riverine wetlands Total wetland: 431 acres	Restore 1,000 acres	Restore 5,000 acres	43% of total 2020 goal	8.6% of 2050 goal
Habitat for Waterbirds	5 marsh islands restored	Enhance 1 island and restore or enhance one foraging habitat	All islands provide roosting and nesting with nearby foraging	Five more marsh islands will be restored	A subset of islands has been contributed to restoring habitat and nearby foraging
Coastal and Maritime Forests	27 acres restored	Restore 50 new acres and restore 200 acres	500 acres of new forest and 500 acres of restored forest	54% of new goal, 0% of restore goal	5.4% of new goal, 0% of restore goal
Oyster Reefs	52 acres	20 acres	2,000 acres	260% of 2020 goal	2.6% of 2050 goal
Shorelines and Shallows	Streambank restoration in Bronx Planning Region; 39 acres of shallow water habitat restored in Jamaica	Develop new shorelines in two HRE regions	Restore all available shoreline habitat in three regions	New shorelines restored in 3 planning regions	Restore a portion of available shoreline habitat in three HRE

TEC	Recommended Plan	CRP Goal		HRE Contribution	
		2020	2050	2020	2050
	Bay Marsh Islands, Flushing, and Lower Passaic				planning regions
Habitat for Fish, Crab, and Lobsters	Low marsh and shallows connected in Marsh Islands, Flushing, Passaic; Emergent wetland and bed restoration connected in Bronx and Passaic/ Hackensack; Oyster reefs restored in Jamaica Bay, Lower Bay, and Upper Bay	Make a set of two related habitats in each region	Complete four sets of at least two habitats in each region	Sets restored in 5 planning regions: 62.5% of 2020 goal	14 sets restored in 5 planning regions: 43.8% of 2050 goal
Tributary Connections	Two fish ladders installed in Bronx River	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas	200% of 2020 goal	7% of 2050 goal

4.5 Systems/Watershed Context

As stated in Section 1.5.3 and Appendix B, regional partners are working together to achieve the overall goals and targets of the HRE CRP. The restoration projects that are proposed in this FR/EA were high priorities for the region and have been coordinated and integrated with ongoing efforts to restore the New York-New Jersey (NY/NJ) Harbor and specific planning regions. These restoration projects provide ecosystem benefits and can also serve as NNBFs providing secondary benefits for coastal storm risk management, improving the resiliency and sustainability of the region's shorelines.

A brief synopsis of the integration of the Recommended Plan at the watershed level for the various study areas is provided below.

4.5.1 Jamaica Bay

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. 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 (JFK) International Airport. 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 bay itself is composed of salt marsh islands, mudflats, tidal creeks, navigational channels, and open water.

Jamaica Bay hosts large and diverse fish, shellfish, invertebrate, and bird populations, though they are not as rich as they were historically. Approximately 50 species of fish live in its waters, and the area is designated as essential fish habitat for 22 of those species (NOAA, 2016). Many of these fish use the bay as a nursery, particularly winter flounder and striped bass (RPA, 2003). There were once also thriving shellfish fisheries in the area, but pollution, habitat loss, and overharvesting led to the collapse of the oyster, clam, and crab industries in the area. Jamaica Bay currently serves as an essential stopping point along the Atlantic Flyway for migratory birds (USACE, 2006), a role that is linked closely to the population of horseshoe crabs in the area and at the marsh islands in particular (JBERRT, 2002). Over 300 species of birds inhabit or migrate through Jamaica Bay annually (RPA, 2003). However, existing species in the area are at risk from the reduction in available habitat. There has been a 75 percent loss of historic marsh island habitat in Jamaica Bay. Further analysis indicates that the marsh islands are disappearing at an accelerating rate and could vanish entirely without intervention (RPA 2003, NPS 2007). Just one (1) percent of historic freshwater wetlands remain along the perimeter of the bay due to filling and sewer diversions (NYCDEP, 2007). Other ecological challenges facing Jamaica Bay include CSO, landfill leaching, municipal waste discharge, runoff, the establishment of invasive species, and sea level rise.

USACE has already restored several marsh islands in the Jamaica Bay Planning Region: Elders Point East, Elders Point West, Yellow Bar Hassock, Black Wall, and Rulers Bar. Together, these islands amount to over 160 acres, which provide habitat for finfish, shellfish, birds, plants, and other wildlife in the Jamaica Bay region. USACE and other organizations have also been involved with restoring perimeter wetland sites, such as Gerritsen Creek. The two (2) proposed shoreline projects and the five (5) proposed marsh islands are considered key critical components to restoring Jamaica Bay as part of the NYCDEP Jamaica Bay Watershed Protection Plan, the NYC Waterfront Development Plan, NYC Special Initiative for Rebuilding and Resiliency and the Science and Resilience Institute of Jamaica Bay efforts. Together, these actions would restore over 325 acres of habitat. Restoration activities at each site recommended within Jamaica Bay work in concert with one another and with previously constructed projects to provide increased habitats for wildlife throughout the bay. See Figure 1-4 for ongoing and future restoration efforts in the Jamaica Bay Planning Region.

In addition to the ecological benefits, the recommendations complement actions that are advancing by others resulting from Sandy Recovery grants and NY Rising Reconstruction efforts provided to improve the resilience of the shoreline. The five (5) proposed marsh island restorations and the perimeter sites will build upon the lessons learned from previous marsh island restoration to advance the ecological integrity of Jamaica Bay.

4.5.2 Bronx River

The Bronx River is 23 miles long, flowing through both suburban and highly urban communities in the Bronx and Westchester Counties. For much of its length, the river runs through numerous parks and parallels and intersects the Bronx River Parkway and the Metro North Harlem commuter rail line. 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. 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.

Habitat degradation and poor water quality are notable environmental stressors for the Bronx River. The Recommended Plan for each site results in the reduction of these stressors through the restoration of wetlands and strengthening shorelines to reduce erosion. When appropriate, the Recommended Plan also increases tributary connections at sites with dams by placing fish ladders or modifying weirs to allow for anadromous and catadromous fish movement to and from the upper reaches of the river. The restoration projects recommended improve habitat connectivity and quality for wildlife in this highly urbanized environment. These activities are important components and complements to NYCDEP's Long Term Control Plan improving water quality in the Bronx River, and the NYC Parks plan to improve habitat along the shoreline and prevent erosion in NYC Parks' property (including restoration activities at Shoelace Park and Muskrat Cove), Bronx River Alliance, and the Bronx River/Harlem River Urban Waters Federal Partnership.

4.5.3 Hackensack River and Lower Passaic River

Habitat reduction and significant loss, primarily freshwater and tidal wetlands, and poor water quality are notable environmental stressors for the Passaic and Hackensack. The Recommended Plan for each site recommended works to reduce these stressors and increase native habitat through the restoration of wetlands and the strengthening and softening of shorelines to reduce erosion. Many of the restoration activities at each site contribute to provide increased and improved habitats for wildlife throughout the rivers and reduce the sediment load entering the rivers.

The Lower Passaic River site alternatives were designed with the NJDEP Natural Resource Damage Division, and will be coordinated with NJDEP's program and Natural Resource Damage Assessment settlement with Diamond Alkali. The Essex County Branch Brook Park site also was coordinated with the Essex County Department of Parks, Recreation, and Cultural Affairs and the Branch Brook Park Alliance, transitioning towards Care of the Park Movement. The Lower Passaic River recommendations are initial steps to advance restoration in the Lower Passaic River in advance of large-scale remedial actions planned by USEPA for the lower 8.3 miles of the river. The remaining 47 restoration opportunities, and more specifically 27 restoration sites requiring EPA remediation, will be needed to realize comprehensive restoration of the watershed. In order to illustrate this point, this FR/EA includes recommendations for habitat restoration at Oak Island Yards to be implemented following USEPA cleanup actions. These sites symbolize the leveraging of federal, state and private (potential responsible parties) resources to remediate and restore the river advancing the goals of the Urban Waters Federal

Partnership. See Figure 1-4 for ongoing and future resilience efforts in the Newark Bay, Hackensack River and Passaic River Planning Region.

4.5.4 Oyster Reef Restoration

Small-scale oyster reef restoration is proposed in order to expand existing, ongoing oyster reef restoration efforts conducted by NYCDEP, New York Harbor School, NY/NJ Baykeeper and the Hudson River Foundation. This recommendation would provide significant contributions to the regional efforts of the Harbor School and the Billion Oyster Project providing improved habitat for fish and benthic communities. The USACE seeks to accomplish the Oyster Reefs TEC objective of establishing 20 acres of oyster reef habitat by 2020 (will be met later in decade). The restoration plans, developed with significant input from regional technical expertise, would restore over 50 acres of oyster reef habitat throughout New York Harbor. The restoration of over 50 acres allows for mortality or damage to occur from unforeseen events while still attaining the short term goal of 20 acres. 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.

4.6 Resilience & Sustainability

As part of plan formulation, USACE considers how the Recommended Plan contributes to resiliency of affected ecological communities and affects the sustainability of environmental conditions in the affected area. Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions, and withstand and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue, in existence or a certain state, or in force or intensity, without interruption or diminution.

The Recommended Plan is a resilient, sustainable ecosystem solution that integrates multiple habitat features that can adapt to changes, and can recover after a major disturbance naturally. The 20 sites included in the Recommended Plan were identified as important restoration opportunities in the HRE CRP that should be restored to address long-term regional ecosystem degradation trends. The Recommended Plan addresses the most feasible and highest priority sites for USACE participation in the near-term. It complements ongoing and future restoration work in support of the goals of the HRE CRP, the region's framework for restoration. The Recommended Plan will work in concert with completed restoration work by USACE and others, in addition to ongoing and future projects to improve the sustainability of the HRE. USACE will continue to work with the non-federal sponsors and stakeholders to ensure the sustainability of restoration actions, especially for those parks and public lands for which there are master plans.

The increase in spatial extent and biodiversity encourages resiliency with the implementation of the Recommended Plan. The addition of diverse native species, novel physical features, and functional redundancy into the ecosystem will allow restored areas to better adapt to changing conditions, and withstand and rapidly recover from disruption. This is important as climate change, sea level change, water quality degradation, the introduction and proliferation of invasive species, and other stressors continue to influence the region.

Recognizing the federal government's commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, the implemented Recommended Plan will ensure that development at each site within the floodplain of these site will not occur. The non-federal sponsor's ownership and acquisition (if required) of the restoration sites will result in the protection from the threat of development on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features or interfere with the project's proper function.

4.6.1 Relative Sea Level Change

The design and implementation of coastal habitat restoration projects requires consideration of the effects of climate change, including global sea level rise. The foundation for coordinated action on climate change preparedness and resilience across the Federal government was established by Executive Order 13514 of October 5, 2009, and the Interagency Climate Change Adaptation Task Force led by the Council on Environmental Quality (CEQ). In October 2011, the Task Force developed a National Action Plan that provided an overview of the challenges a changing climate presents for the management of the nation's freshwater resources. Climate preparedness and resilience actions have also been established by the USACE, as demonstrated by the annual release of the Climate Change Adaptation Plan, prepared under the direction of the USACE Committee on Climate Preparedness and Resilience (CCPR) (USACE, 2015a). USACE established an overarching USACE Climate Change Adaptation Policy Statement and a governance structure to support mainstreaming adaptation in 2011, following the release of the Executive Order (USACE, 2015a). Per Engineer Regulation 1100-2-8162, Incorporating Sea Level Change in Civil Works Program, released in December 2013, followed by Engineer Pamphlet 1100-2-1 (USACE, 2019a), Procedures to Evaluate Sea Level Change: Impacts, Responses and Adaptation in July 2014, USACE plans and incorporates climate change into Civil Works projects.

NYC's Comprehensive Waterfront Plan (NYC CWP; a component of the city's "Vision 2020") lists coastal wetland restoration as one option for the City for increasing resiliency of natural and man-made systems in the face of rising sea level (NYC, 2011). Research is underway to better understand sediment accretion rates in coastal wetlands throughout NYC in comparison to wetlands in adjacent regions. Remote sensing (e.g., LiDAR) datasets are being evaluated to identify potential areas where migration of wetlands inland can be accommodated or where historic fill can be removed, creating opportunities for migration and or creation of new wetlands (NYC, 2011). Recognizing the success of the Marsh Island Restoration Project in Jamaica Bay, the City recognizes that the beneficial use of dredged material can be undertaken in other HRE planning regions to increase the resilience of coastal communities. The approach could be used to restore and reinforce eroding wetlands, maintain wetlands under threat of submergence due to sea level rise, or create new wetlands in areas that could benefit from enhanced wave attenuation.

For the HRE restoration sites, restoration activities were targeted to confront and remedy immediate environmental stressors, namely coastal and shoreline erosion, habitat loss, and restoration of previous habitats, and to complement existing and ongoing restoration efforts by other agencies. Fourteen of the 20 recommended sites are within the maximum vertical datum of concern. A sea level change analysis of eleven of these sites was conducted to better understand the impacts of rising sea levels on the proposed designs. An SLC analysis was not conducted for the remaining three sites which are oyster reef restoration sites as research indicates that the vertical growth of oyster reefs generally outpaces changes in sea level.

Prior to the SLC analysis of the proposed designs discussed here, an analysis of all alternatives for those sites within the maximum vertical datum of concern was conducted. This preliminary analysis was conducted using intermediate rates of SLC only, as opposed to the analysis of detailed designs, which analyzed project performance under all three curves. The use of the intermediate curve only for the analysis of alternatives was deemed sufficient given the fact that 1) prior experience indicates excellent project performance for the duration of the project life cycle under the low curve and 2) project performance under the high curve is very much dependent on detailed design decisions that simply had not been developed at that stage of the study.

For the recommended plan, both the designs and the SLC analysis of those designs were updated using all three SLC curves to reflect a future planned construction date and planting elevation ranges that incorporate projected MTL for that date. Designs were developed in accordance with Engineer Construction Bulletin (ECB)-2018-2. For each tidal site analyzed, an accretion level of 3.75 mm/yr. was used to project future conditions (Year 20 and Year 50.) for the intermediate and high curve. An accretion level of 2.8 mm/yr was used for the low curve. The accretion rates are based on studies that have been conducted in the HRE area and field data collected by the NPS in Jamaica Bay. The rates were chosen using engineering judgment and considered to be reasonable and conservative. Both rates are less than the annualized SLC rates and become increasingly less as time goes forward as the rates are treated as static while the rate of SLC change is increasing.

The results of the SLC impact analysis are discussed in Appendix C (Engineering Appendix) and are summarized here. Project designs, which were informed by the screening stage SLC analysis, successfully incorporated resiliency into the proposed designs by providing a measure of elevation capital at each site and by maximizing the ability of salt marsh habitats to migrate landward and vertically. Elevation capital simply refers to the vertical distance between estimated MTL (at the time of construction) and the lower edge of the low marsh planting range. This distance, generally between 0.75 to 1 foot (depending on site specific constraints), essentially delays the onset of SLC-driven salt marsh deterioration for many years, depending on the rate of SLC.

All sites perform excellently under the low curve, with salt marsh acreages of 97% to 121% of the original design acreage at year 50. (It should be noted that the total restored area will have decreased as a result of rising sea level, as upland converts to scrub-shrub habitat and scrub/shrub habitat converts to high marsh). Most sites perform excellently under the intermediate curve as well with salt marsh acreages of 103% to 129% of the original design acreage at year 50 for ten out of eleven sites. A single site, Meadowlark, is projected to have 50% of its original design acreage at year 50 but it is believed that further optimization can significantly increase performance at this single site.

While the sites do not perform as well under the high curve, the results as a whole reflect the high degree of resiliency that is intrinsic to the designs. Four sites are projected to retain 68% or more of the original design acreage at year 50. The remaining sites include the five Jamaica Bay Marsh Islands, Oak Island Yards and Meadowlark. While the percent of original design acreage at year 50 under the high curve is low for these sites, an analysis of the area above MTL for select sites generally indicates excellent performance through year 30, with deterioration increasing from that date forward and then rapid deterioration during the final ten years of the planning horizon. Given the fact that the overall magnitude of sea level rise under the high curve approaches 3 feet for 50 years, and the typical vertical range for a salt marsh in the HRE region is between 2.5 to 3 feet (depending on the tidal range) the result generally indicate that the degree of resiliency designed into most sites is near to the maximum that is practicable. The lower probability of the high curve, combined with the robust performance of the sites for the first 30 to 40 years of the planning horizon represent an acceptable risk and justifies the inclusion of these sites in the Recommended Plan.

4.6.2 Climate Change Assessment

In accordance with ECB 2018-14, a qualitative climate change assessment for the HRE study area was performed with a focus on the inland hydrology of the Bronx River in New York and the Branch Brook (aka First River) in New Jersey. This assessment is discussed in Appendix C (Engineering Appendix). Qualitatively, the project sites within both Bronx River watershed (Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park, Bronxville Park, and Garth Woods/Harney Road) and First River watershed (Essex County Branch Brook Park) will likely be impacted by climate change, especially by the increasing precipitation and streamflow trends which may cause extensive flooding around the area. However, the impacts from climate change are considered minimal to moderate or non-quantitative as there is considerable uncertainty with respect to the magnitude, frequency and timing of these changes. The present level of detail for each of these designs is relatively low and further H&H modeling is recommended in the PED phase for each site. The sensitivity of the selected techniques to increases on velocities and flows should be further investigated at this time.

4.6.3 Natural and Nature Based Features

Many sites recommended as part of the Recommended Plan and remaining HRE CRP sites for future feasibility study also have the potential to provide secondary coastal and storm risk management (CSRM) benefits. CSRM benefits include wave attenuation, fetch reduction, and shoreline stabilization/erosion prevention, while improving resiliency and environmental sustainability, through NNBFs.

Coastal systems are increasingly vulnerable to flooding and flood damages due to the combined influence of coastal storms, development and population growth, geomorphic change, and sea level rise. This problem has given rise to efforts to make greater use of ecosystem-based approaches to reduce risks from coastal storms, approaches which draw from the capacity of wetlands, beaches and dunes, biogenic reefs, and other natural features to reduce the impacts of storm surge and waves. NNBFs are those feature that define natural coastal landscapes, and are either naturally occurring or have been engineered to mimic natural conditions. The devastating effects of Hurricane Sandy, which impacted the Atlantic Coast in October 2012, emphasized the need for coastal resilience and climate adaptation in the region. In the aftermath of the storm, federal, state, and municipal assessments and planning documents emphasized the need for NNBFs that may reduce the risk of damages due to coastal flooding (USACE, 2015a, 2015b). The evaluation of opportunities to incorporate NNBFs into future federal, state, and local costal storm risk management projects can be integrated into future studies using the HRE or other authorities and programs.

The most critical restoration sites that provide secondary CSRM benefits include the Jamaica Bay Marsh Islands. One of New York City's best defenses against coastal storms, the marsh islands provide natural wave attenuation that aids in minimizing marsh edge erosion to the perimeter shorelines as well as infrastructure within Jamaica Bay. For example, the Cross Bay Bridge (which is near recent marsh island restoration at Yellow Bar), through Jamaica Bay, connects the Rockaways and Long Island into Brooklyn and Queens in New York. This high traffic commuter route is located within the National Park Service's (NPS) Gateway National Recreation Area (GNRA). Due to Hurricane Sandy, the Cross Bay Bridge was closed on October 29th 2012. It was not washed out during the storm and was "mostly" open again by November 6th with toll collection suspended through the end of November 2012. In contrast, the railroad bridges east of the Cross Bay Bridge suffered substantial damage and the rail line was closed until May 30, 2013. Stakeholders within the Jamaica Bay Planning Region have suggested that the restored marshes resulting from the beneficial use of dredge material dispersed wave energy thus mitigating the impact of the storm surge flooding on the Cross Bay Bridge. It has been hypothesized that the marsh islands previously constructed may have reduced the horizontal fetch at critical bridge support points (ERDC SR-15-1, January 2015)."

In addition to the Jamaica Bay Marsh Islands, a total of 133 HRE CRP sites, including the Recommended Sites, have the potential to serve as NNBFs. Appendix K presents that more than half of the CRP sites identified have the potential to serve as a NNBF are located within the Jamaica Bay and Lower Bay planning regions. The breakdown of HRE CRP sites, by planning region, with potential NNBF categories is as follows:

- 36 in the Jamaica Bay Planning Region;
- 15 in the Harlem River, East River and Western Long Island Sound Planning Region;
- 24 in the Newark Bay, Hackensack River and Passaic River Planning Region;
- Four (4) in the Upper Bay Planning Region;
- 32 in the Lower Bay Planning Region;
- 16 in the Arthur Kill/Kill Van Kull Planning Region;
- Six (6) in the Lower Hudson Planning Region; and
- Five (5) in the Lower Raritan Planning Region;

The sites included in the Recommended Plan that have been identified as having the potential to serve as NNBFs with potential CSRM benefits are:

- Fresh Creek;
- Marsh Islands (Duck Point, Pumpkin Patch, Stony Creek, Elders Center);
- Meadowlark Marsh;
- Metromedia Tract;
- Oak Island Yards (Tier 2); and
- Flushing Creek.

Most of the recommended sites were identified as NNBFs as illustrated in Figure 4-22 to 4-26 for the Jamaica Bay; Harlem River, East River and Western Long Island Sound; and Newark Bay, Hackensack River and Passaic River planning regions.

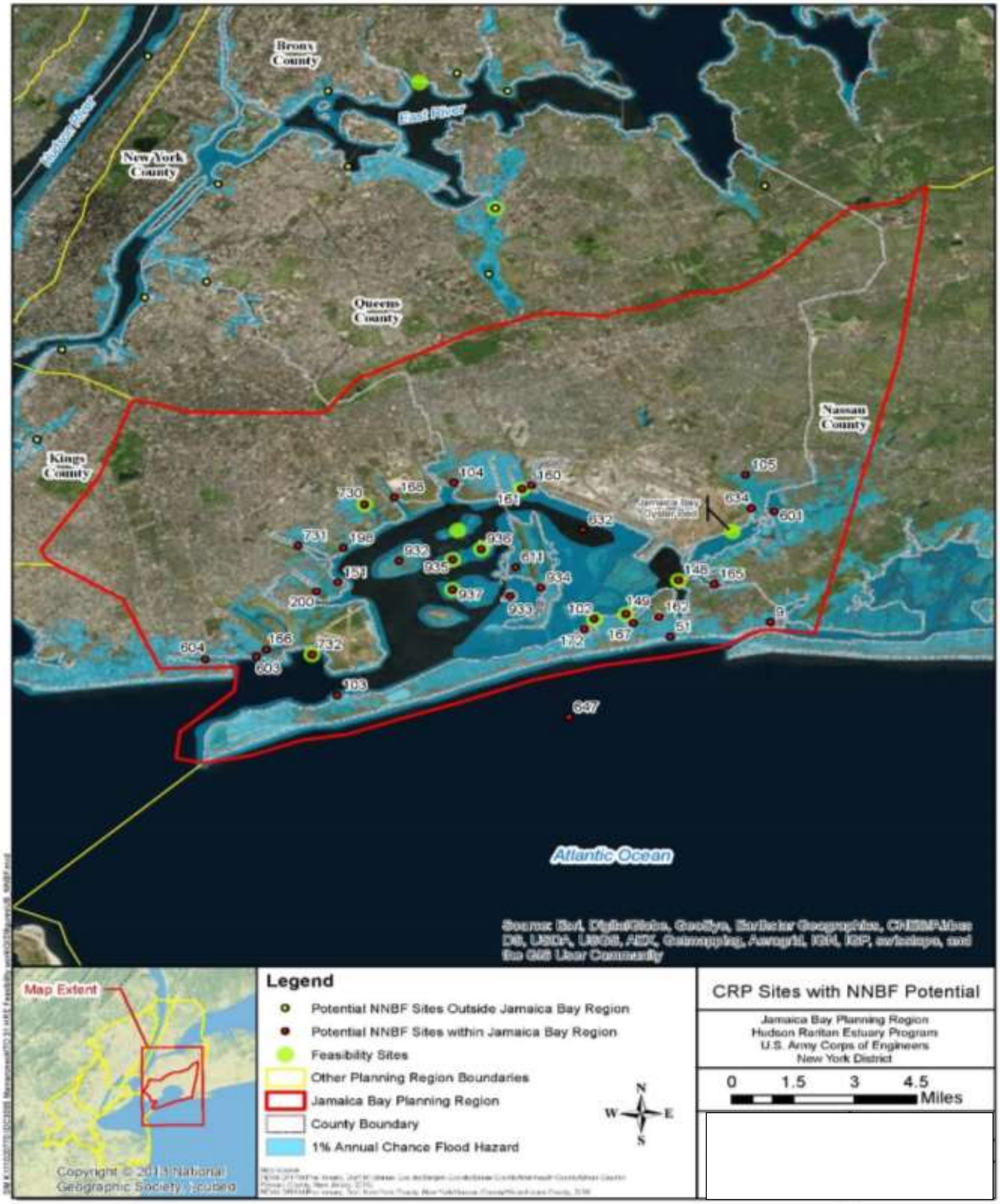


Figure 4-22. CRP and Recommended Sites that Could Serve as NNBFs in the Jamaica Bay Planning Region

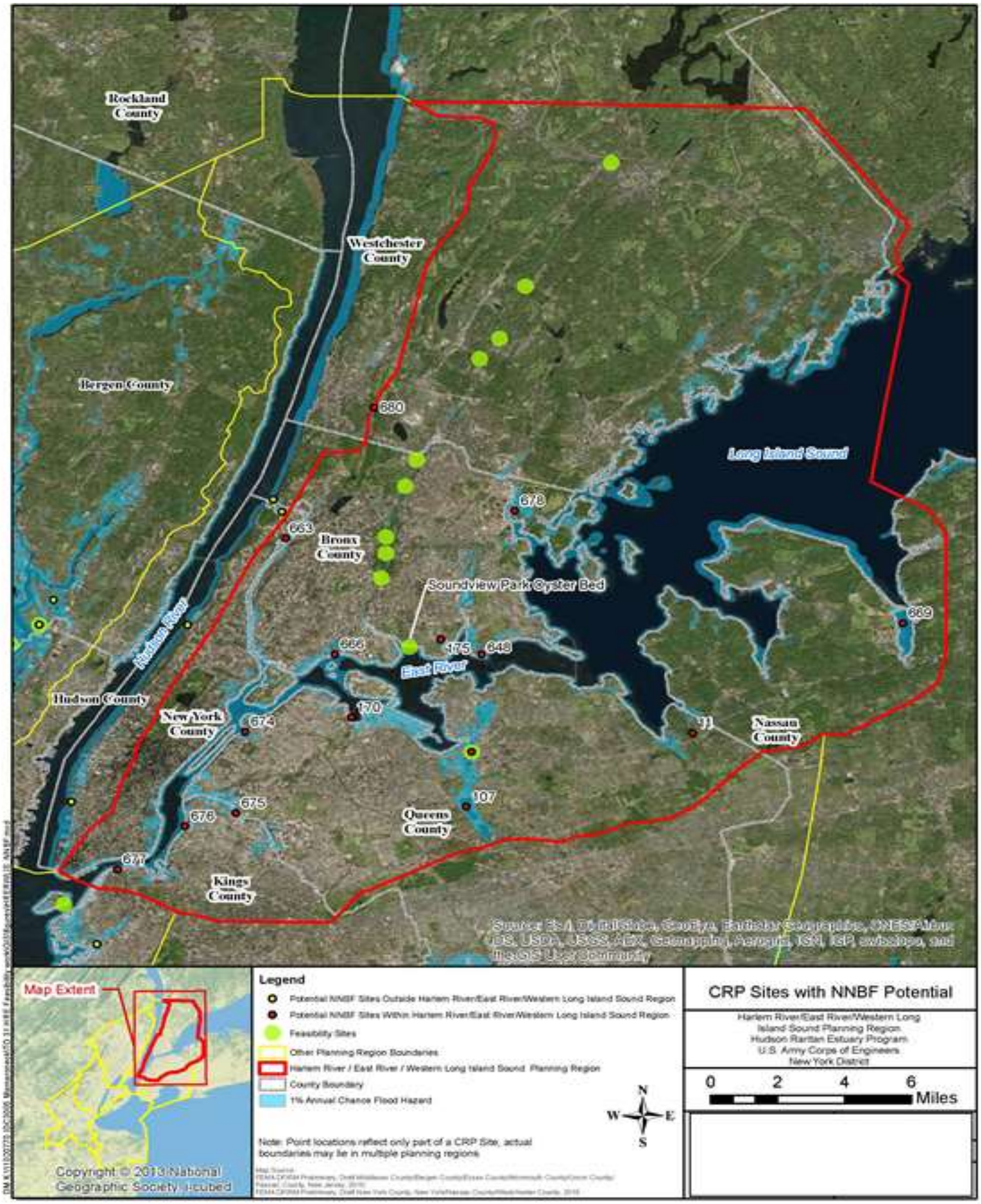


Figure 4-23. CRP and Recommended Sites that Could Serve as NNBFs in the Harlem River, East River and Western Long Island Sound Planning Region

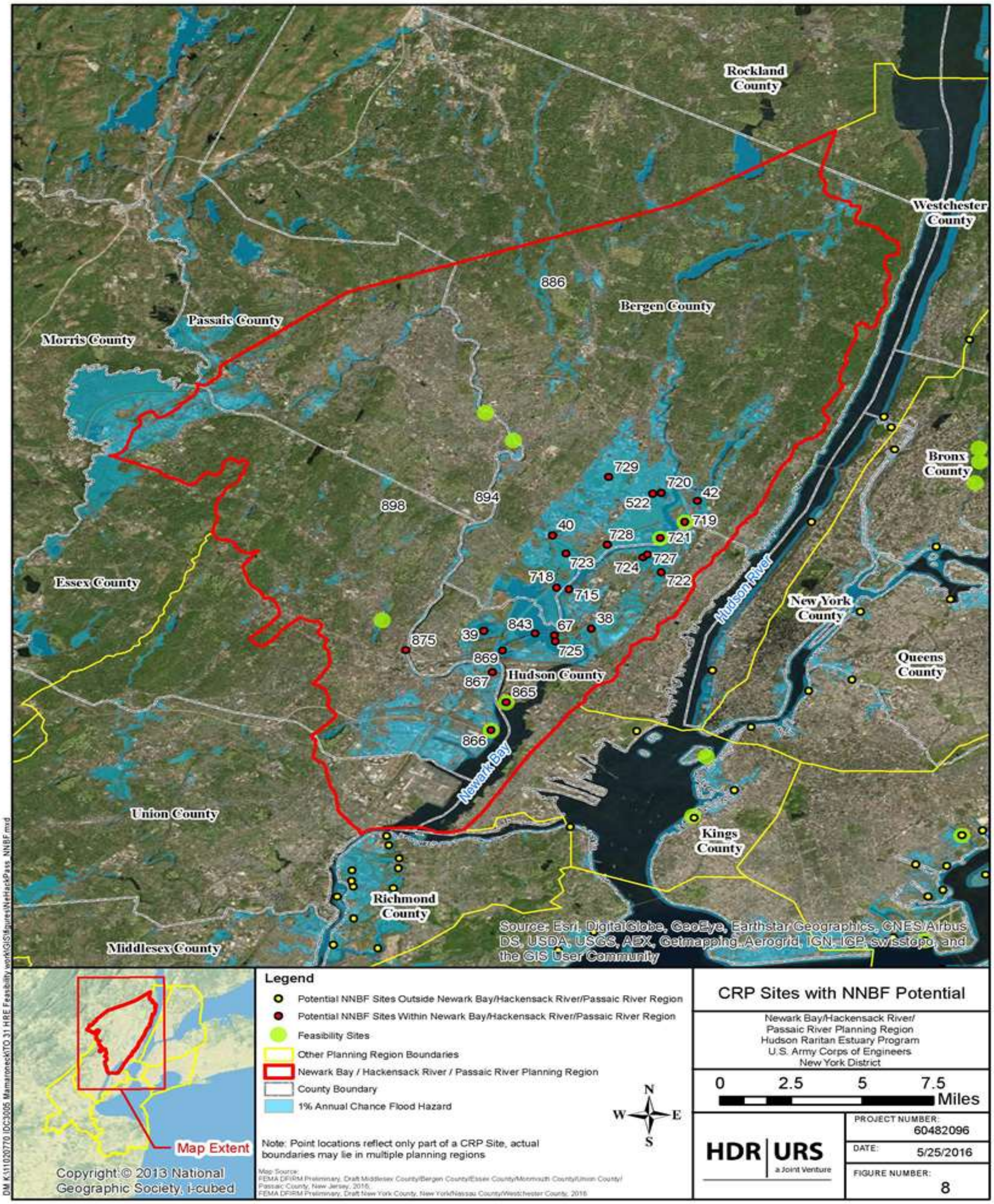


Figure 4-24. CRP and Recommended Plan Sites that Could Serve as NNBFs in the Newark Bay, Hackensack River and Passaic River Planning Regio

Figure 4-25. CRP and Recommended Plan Sites that Could Serve as NNBFs in the Upper Bay Planning Region

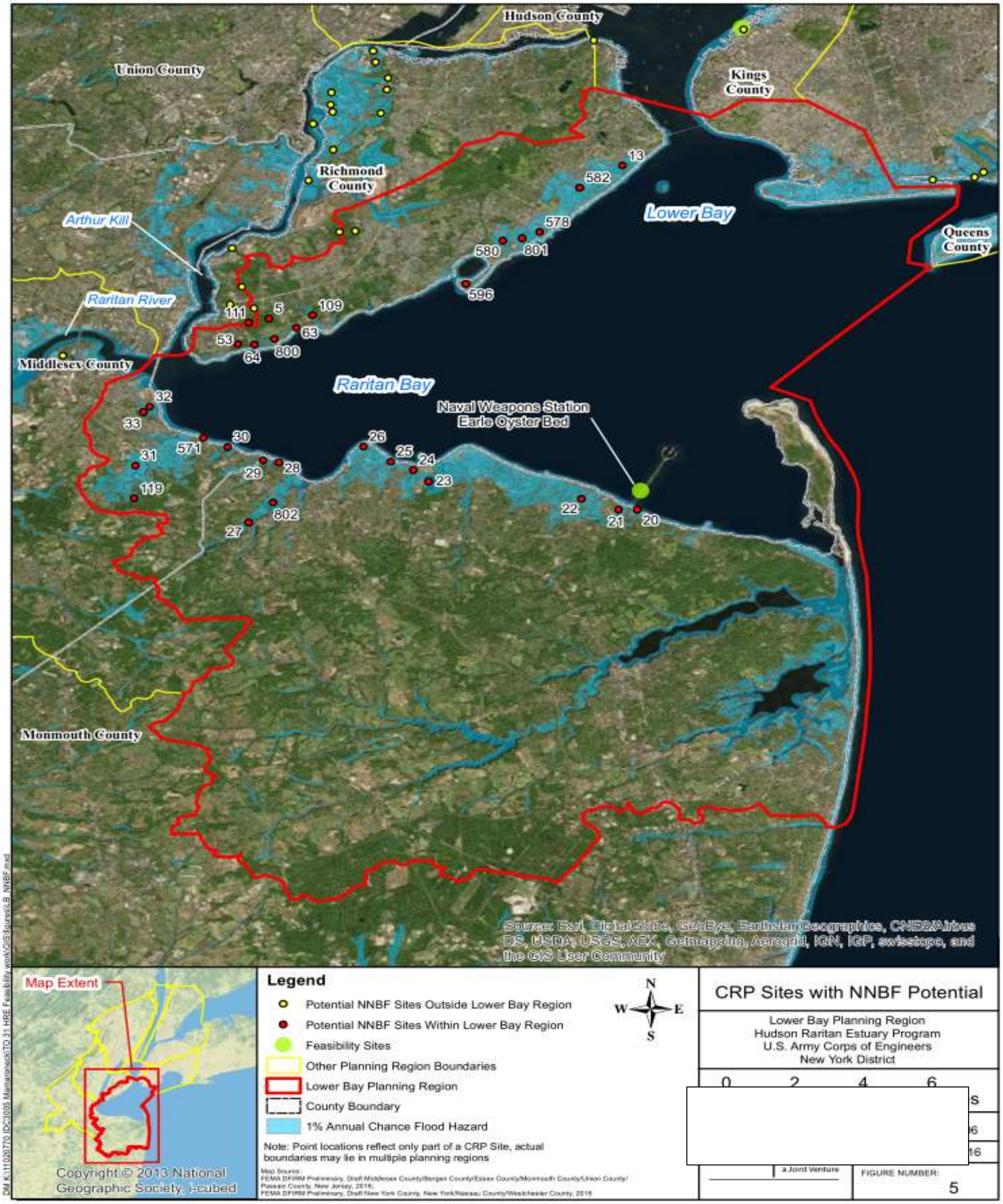


Figure 4-26. CRP and Recommended Plan Sites that Could Serve as NNBFs in the Lower Bay Planning Region

4.7 Significance of the Recommended Plan

The criteria for determining the significance of resources are provided in the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (United States Water Resources Council, 1983), Resource Significance Protocol for Environmental Project Planning, (IWR Report 97-R-4, July1997) and in USACE planning guidance such as the Planning Guidance Notebook (Engineering Regulation 1105-2-100, April 22, 2000). As stated in Chapter 1, significance of resources and effects of the Recommended Plan are derived from institutional, public, and technical recognition of the ecological, cultural and aesthetic attributes of resources within the study area. The institutional and public recognition for the resources in the HRE Study (in Chapter 1) are similar to the significance of the Recommended Plan.

The technical recognition and significance and documentation on the relative scarcity of the resources further illustrates the significance of the resources to be restored. The significance and the relative scarcity of the resources also further establishes a federal interest in the project. The technical significance of the restoration outputs from the Recommended Plan are presented in Table 4-14.

Table 4-14. Technical Significance of the Recommended Plan

Habitat	Recommended Sites	Technical Significance
Estuarine Wetlands 381 acres including 16 acres/30,650 linear feet of tidal creeks	Dead Horse Bay Fresh Creek Flushing Creek Meadowlark Marsh Metromedia Tract Oak Island Yards Flushing Creek	• Habitat Scarcity – Entire HRE, including NYC, only 14 square miles of coastal wetlands remain from the original 86 to 100 square miles, a loss of 83% to 86%. • Approximately 35% of shorelines within the study area have been hardened. • Hydrologic and Geographic Connectivity – Infrastructure like roadways, landfills, railways and airports fragmented wetlands • Migratory Flyways – Habitat Restoration will provide increased habitat for migratory birds in the Atlantic Flyway. • Fisheries - Estuarine marshes/wetlands serve as nursery, feeding, spawning sites, and refuge from predators. • Arthur Kill/Kill Van Kull Region-the tidal wetlands support over 60 migratory and residence fish such as winter flounder.
Marsh Islands 175 acres	Duck Point Stony Creek Pumpkin Patch East Pumpkin Patch West Elders Center	• Habitat Scarcity – Approximately 80% of wetlands and over 2,000 acres of tidal salt marshes in Jamaica Bay have been lost. Left alone the marshes were projected to vanish by 2025. • The marsh islands serve as a secondary coastal storm risk management benefit. • The HRE accounts for 25% of the wading birds that nested in New York, New Jersey, and Connecticut. • Jamaica Bay provides critical spawning and nursery habitat for more than eighty (80) anadromous and estuarine fish species and nearly 20% (over 300 species) of North America's birds which use this area as a stopover point along the Atlantic Flyway including horseshoe crabs, roseate terns, common tern, and least tern. It is critical habitat for horseshoe crabs and diamond back terrapins. • The federally listed and endangered Kemp's ridley and leatherback sea turtles have been observed in Jamaica Bay which would use the unvegetated open shoreline to lay eggs.
Freshwater Wetlands 50 acres	Essex County Branch Brook Park Bronx Zoo and Dam Shoelace Park Bronxville Lake Garth Woods-Harney Road	• Habitat Scarcity – Within the HRE, 99% of freshwater wetlands have been lost and continue to be threatened by development, chemical pollution, excess nutrients and sediment, and climate change. Almost all of the 224,000 acres of freshwater wetlands that existed in New York City have been filled or eliminated.

Habitat	Recommended Sites	Technical Significance
Tributary Connectivity 24 miles habitat opened	Bronx Zoo and Dam Stone Mill Dam Bronxville Lake	• Habitat Scarcity due to construction of dams • Hydrologic and Geographic Connectivity – Removal of barriers and restoration of connectivity could restore the salinity gradient, restore hydrology to the system, and provide previously accessible habitat to migratory species (Alewife, blueback herring, striped bass, American shad, and American eel) for spawning, nesting, and foraging. • Re-establish flow regimes by performing bed and channel restoration, restoring riffle and pool complexes, and shoreline modification would result in improved fish habitat and reduces turbidity and erosion. • Restoring aquatic, wetland, and upland habitats by removing invasive species, planting native vegetation and improving hydrology would benefit wildlife and promote communities of greater diversity and ecological value.
Oysters 52 acres	Naval Weapons Station Earle Bush Terminal Head of Jamaica Bay	• The HRE area once had the largest population of oysters worldwide. • Habitat Scarcity – Increased runoff, dredging, hardened shorelines, and poor land management has resulted in increased sedimentation smothering oyster beds (a once prominent keystone species). There has been a 99% loss of oyster reefs relative to historic levels. • Oysters are an important food source for blue crabs, an important food source for the federally-endangered Whooping Crane. • Magnuson-Stevens Fishery Conservation Act recognizes oyster reefs as a category of essential fish habitat. • Ecosystem Services – Oysters successfully improve water quality and reduce turbidity as they filter food, reduce excess nitrogen, and provide spawning, nursery, and foraging habitat. • Provide secondary coastal storm risk management benefits

4.8 Environmental Operating Principles & USACE Campaign Plan

The USACE has reaffirmed its long-standing commitment to environmental conservation by formalizing a set of environmental operating principles (EOPs) applicable to decision-making in all programs. The EOPs outline the USACE's role and responsibility to sustainably use and restore our natural resources in a world that is complex and changing. The Recommended Plan meets the intent of the EOPs.

The USACE Campaign Plan includes specific goal and objectives to deliver integrated, sustainable, water resources solutions. This project primarily supports the Campaign Plan Goal 2. This goal, "Integrated Water Resource Solutions" reflects a concerted effort to operationalize the Civil Works Strategic Plan focusing on a holistic Integrated Water Resource Management. The project meets the intent of the campaign plan goal.

4.9 Acceptability, Completeness, Effectiveness, and Efficiency

Per the USACE Planning Guidance Notebook (Engineering Regulation 1105-2-100, April 22, 2000), planning for federal water resources projects constructed by the USACE is based on the principles and guidelines adopted by the United States Water Resources Council (1983). Acceptability, completeness, effectiveness, and efficiency are the four (4) evaluation criteria specified that the USACE uses in the screening of alternative plans. The Recommended Plan meets the minimum subjective standards of these criteria four (4) criteria.

4.9.1 Acceptability

Acceptability is the workability and viability of the recommended plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies (United States Water Resources Council, 1983). An ecosystem restoration plan should be acceptable to federal and state resource agencies, local governments, and stakeholders in the study area. There should be evidence of broad based public consensus and support for the plan. A recommended plan must also be acceptable to the non-federal cost-sharing partners.

The HRE Ecosystem Restoration Feasibility study was developed in a collaborative fashion in which planning and design meetings screened and refined habitat restoration measures. The federal, state and local groups that participated in these activities are discussed in Chapter 8. The stakeholders played a significant role in the development of the needs and opportunities report (RPA, 2003) and the HRE CRP (USACE and PANYNJ, 2009 and 2016). Their participation ensured that the program meets the needs of the region's interested agencies and non-governmental organizations. Stakeholders have reached a broad consensus on a harbor-wide restoration goal and restoration targets, as well as a shared vision of a restored future state. In December 2009, the Hudson Estuary Program (HEP), which brought together federal, state, local, and non-governmental organizations interested in improving ecological conditions within the HRE, adopted the HRE CRP as a path forward for restoration within the HRE. The Recommended Plan supports the goals of the HRE CRP (Section 4.4), and were acceptable to the non-federal sponsor (Appendix A) and stakeholders (Appendix N).

The no action alternative at each site provides no ecosystem improvements and does not meet the federal objective, the non-federal sponsor's goals and stakeholder desires. The projects included in the Recommended Plan were acceptable in terms of the federal objective and non-federal sponsor/stakeholder vision for reestablishing the mosaic of sustainable and viable habitats within the HRE study area. Taking the federal objective, study objectives, and non-federal sponsor/stakeholder needs into consideration, the plans address many of the problems within the study area and would provide critical restoration for the diverse habitat types within HRE.

4.9.2 Completeness

Completeness is the extent to which a given plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects (United States Water Resources Council, 1983). Completeness also includes consideration of real estate issues, operation and maintenance, monitoring, and sponsorship factors. Adaptive management plans formulated to address project uncertainties also have to be considered. The alternatives considered were independent and were unique in that all contribute to the goals of the HRE CRP and the consensus-based multi-stakeholder regional plan for ecosystem restoration. The alternatives also do not require any additional public or private actions. However, a remedial action of the Lower Passaic at Oak Island Yards is needed and a potential action and NPS coordination at Dead Horse Bay will be required prior to the restoration at these sites which have been sequenced appropriately.

4.9.3 Effectiveness

Effectiveness is the extent to which a given plan alleviates the specified problems and achieves the specified opportunities (United States Water Resources Council, 1983). An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e., restore important ecosystem structure or function to some meaningful degree). The problems identified that may be addressed under this ecosystem restoration authority include impaired hydrology, geomorphology and wetland plant communities. The Recommended Plan addresses objectives that include the improvement of hydrogeomorphology, habitat complexity, native plant species richness, removal of invasive species and restoring lost critical habitats. All recommended plans provide positive net habitat benefits over the period of analysis, and greater net benefits than those under the future without-project condition, as measured by AAFCUs. The alternatives contribute to the planning objectives and together support the region's mosaic of habitats.

4.9.4 Efficiency

Efficiency is the extent to which a given plan cost effectively alleviates specified problems and realizes specified opportunities, consistent with protecting the Nation's environment (United States Water Resources Council, 1983). Plan efficiency was primarily assessed via CE/ICA (Section 3.11) and incremental unit cost. Cost effectiveness analysis identified a subset of plans that efficiently provide benefits on a per cost basis. Incremental cost analysis then revealed changes in unit cost as output levels increase to identify plans that efficiently provide benefits on an incremental unit cost basis (i.e., "best buys"). Additionally, total unit cost provided a metric for comparing the relative efficiency of actions across sites and regions. Site-scale recommendations were typically "best buys," and any exceptions were cost-effective with acceptable unit cost. Region-scale recommendations were all "best buys" with acceptable incremental unit cost.

4.9.5 P&G Evaluation Accounts

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (US Water Resources Council, 1983) require evaluation of alternative plans according to the following four (4) evaluation accounts:

National Economic Development: Per the P&G and the USACE Planning Guidance Notebook (Engineering Regulation 1105-2-100, April 22, 2000), the prime federal goal in water and related land resources planning is to contribute to national economic development, consistent with protecting the nation's environment, in accordance with national environmental statutes, applicable executive orders, and other federal planning requirements. Contributions to national economic development (national economic development outputs) are increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the nation.

Ecosystem restoration projects differ from traditional USACE planning studies because ecological benefits typically are not expressed in monetary terms. For all project purposes except ecosystem restoration, the national economic development account displays changes in the economic value of the national output of goods and services, expressed in monetary units. For this study, there is no evaluation for national economic development, as benefits of the alternative plans are not monetized and no measurable economic benefits would accrue.

Regional Economic Development: This account registers changes in the distribution of regional economic activity that result from each alternative plan. Chapter 5 provides a detailed assessment of the potential economic effects that would result from implementing the Recommended Plan.

The Recommended Plan would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education.

At the scale of the HRE study area, improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Increased shoreline stabilization may reduce municipal expenditures, including those for emergency services. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences. These restoration projects provide long-term stimulation of the local economy and provision of educational opportunities.

Environmental Quality: This account displays non-monetary effects on significant natural and cultural resources. The expected environmental quality effects of implementing the alternatives are primarily beneficial, although there would be short-term adverse effects during construction. Chapter 5 provides a detailed assessment of the potential environmental quality effects that would result from implementing the Recommended Plan. In the long term, environmental quality will be greatly enhanced by construction of the project. Improving the habitat and aesthetic values at the 20 sites within the HRE would be achieved with all alternatives.

Other Social Effects: This account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three (3) accounts. Social effects refer to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness, are affected by some water resources condition or proposed intervention. The expected social effects of implementing the alternatives are primarily beneficial, although there would be short-term adverse effects during construction such as noise and dust in the local vicinity. Chapter 5 and Section 3.11.2 provides a detailed assessment of the potential social effects that would result from implementing the Recommended NER Plan. The Recommended Plan provides for the enhancement of many important educational and recreational areas that are important to the region, especially for urban communities that don't have access to many natural areas.

4.10 Plan Implementation

As a non-federal construction partner, project sponsors must sign a design agreement that will carry the project through the Preconstruction Engineering and Design (PED) phase, which includes development of Plans and Specifications (P&S). The PED phase will be followed by project construction. Funds must be budgeted by the federal government and the non-federal partner to support these activities. A project management plan will be prepared to identify tasks, responsibilities, and financial requirements of the federal government and the non-federal partner during PED. A project schedule will be established based on reasonable assumptions for the detailed design and construction schedules.

Design agreements and project partnership agreements would be signed separately for individual sites, depending on non-federal sponsor priorities and available funding. Accordingly, cost apportionment and schedules are presented on a per site basis, rather than as if the Recommended Plan was a single, homogenous suite of activities.

4.10.1 Real Estate Requirements

In accordance with each Project Partnership Agreement (PPA), the non-Federal sponsors are responsible for performing or ensuring the performance of the Lands, Easements, Right-of-Ways, Relocations and dredge or excavated material Disposal areas (LERRD) requirements for the construction, operation and maintenance of each of the 20 projects. The Recommended

Plan requires the acquisition of a total of approximately 708.80 acres of land. Since most of the properties are sponsor or government owned, only approximately 7 private landowners would be affected. Table 4-15 summarizes the Recommended Plan's real estate requirements.

The Recommended Plan neither requires relocations of persons or businesses under Public Law 91-646, Uniform Relocation Assistance and Real Property Acquisition Policies Act, nor does it require the physical relocation of public utilities or facilities. Upon the non-Federal sponsors securing all the required real estate for the project and USACE receiving a copy of all easements and deeds recorded with their respective county, USACE will certify the real estate and move the project toward construction.

The non-Federal Sponsors are responsible for all upfront LERRD costs – both direct and indirect costs – for the Recommended Plan. The non-Federal Sponsors are eligible to receive credit toward their overall cost-shared amount for the project for LERRD costs incurred that are found to be reasonable, allowable, and allocable. Receipts, invoices and other supporting documents on all LERRD costs incurred by the non-Federal Sponsor will be submitted to USACE as part of its claim for credit. The Sponsor's claim for credit packet will be reviewed and evaluated by USACE for credit approval. See Appendix M for detailed real estate requirements for each site and each non-federal sponsor.

Table 4- 11. Real Estate Requirements for each Planning Region

		Approximate LER Acreage Required					No. of Parcels		
Planning Region	**Site Name**	**Fee**	**Road Easement**	**Temporary Easement**	**Total**		**Private**	**Public**	**Total**
Jamaica Bay	Dead Horse Bay	43.97	0.00	0.00	43.97		0	1	1
	Fresh Creek	94.41	1.39	0.91	96.71		4	30	34
	Duck Point	39.61	0.00	0.00	39.61		0	1	1
	Stony Creek	53.42	0.00	0.00	53.42		0	1	1
	Pumpkin Patch West	26.68	0.00	0.00	26.68		0	1	1
	Pumpkin Patch East	29.41	0.00	0.00	29.41		0	1	1
	Elders Center	28.26	0.00	0.00	28.26		0	1	1
	Head of Jamaica Bay	18.08	0.00	0.00	18.08		0	0	0
	Subtotal:	***333.83***	***1.39***	***0.91***	***336.13***		***4***	***36***	***40***
Harlem River, East River and Western Long Island Sound	Flushing Creek	19.97	1.93	0.28	22.18		0	15	15
	Bronx Zoo and Dam	3.10	0.00	0.00	3.10		0	2	2
	Stone Mill Dam	0.35	0.00	0.00	0.35		0	2	2
	Shoelace Park	28.57	0.00	0.00	28.57		0	2	2
	Bronxville Lake	13.51	0.00	0.00	13.51		0	4	4
	Garth Woods/Harney Road	5.84	0.00	0.00	5.84		0	4	4
	Subtotal:	***71.35***	***1.93***	***0.28***	***73.56***		***0***	***29***	***29***
Newark Bay, Hackensack River and Passaic River	Oak Island Yards	13.99	1.72	0.00	15.72		3	0	3
	Essex County Branch Brook Park	55.31	0.00	0.00	55.31		0	3	3
	Metromedia Tract	69.33	1.30	0.00	70.63		0	14	14
	Meadowlark Marsh	84.38	0.00	0.00	84.38		0	2	2
	Subtotal:	***223.01***	***3.02***	***0.00***	***226.03***		***3***	***19***	***22***
Upper Bay	Bush Terminal	62.82	0.00	0.00	62.82		0	3	3
	Subtotal:	***62.82***	***0.00***	***0.00***	***62.82***		***0***	***3***	***3***
Lower Bay	Naval Weapons Station Earle	10.26	0.00	0.00	10.26		0	0	0
	Subtotal:	***10.26***	***0.00***	***0.00***	***10.26***		***0***	***0***	***0***
HRE (Overall)	***Grand Total:***	***701.27***	***6.34***	***1.19***	***708.80***		***7***	***87***	***94***

4.10.2 Monitoring and Adaptive Management

Even the most well planned restoration actions can yield unexpected results. To reduce the risk of project failure, the Recommended Plan provides for monitoring and adaptive management of restoration sites. USACE Implementation Guidance for Section 2039 of the WRDA of 2007 (amended by WRRDA 2016) defines monitoring as "the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits" (USACE 2009). Monitoring includes documenting and diagnosing these results, especially in the early, formative stages of a project, which can provide information useful for taking corrective action. Monitoring reduces the risk of failure and enables effective, responsive management of restoration actions.

Adaptive management requires monitoring the condition of the system using selected indicators, assessing progress using previously established goals and performance criteria, and making decisions when corrective actions are needed. An adaptive management program involves incorporating successful techniques and lessons learned into successive projects within the same program or geographic range.

Section 1010 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) allows for up to 10 years of monitoring; however, the project assumed 5 years for costing purposes. USACE and the non-Federal sponsor are responsible for carrying out the monitoring and adaptive management plan after construction of each project phase until ecological success criteria are met, but for no more than ten years. It is anticipated that the restored habitats can reasonably be expected to achieve success within five years for most or all project components. Upon the determination of the District Engineer that ecological success criteria have been met, cost-shared monitoring will be concluded, and in no case shall cost-shared monitoring extend beyond ten years after construction of each project. Costs for monitoring beyond a 10-year period will be a non-federal responsibility.

A plan for pre- and post-construction monitoring and adaptive management activities triggered by specific success criteria is included in Appendix L and summarized in Table 4-16. Adaptive management will be implemented if specific restoration standards are not met or if it appears that actual conditions will diverge sufficiently far from the intended conditions to threaten the achievement of overall project goals. Funding for adaptive management will be included in the project cost estimates so that these actions can be implemented in the future if needed.

Table 4-12. Success Criteria, Metrics, Decision Criteria and Adaptive Management Actions for Restoration Actions

Measure	Metric	Decision Trigger	Adaptive Management Action
Tidal Wetlands (low and high marsh)	• Vegetation: survival and percent cover • Survey twice per year	Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives: percent cover • Survey twice per year	Greater than 20% coverage of non-native species in the restored habitat	Removal of invasive species via manual pulling or selective herbicide application.
	• Hydrology: inundation regimes, depth and duration of inundation, soils, erosion/sedimentation across site. • Visual inspection twice per year	Failure to achieve wetland hydrological regimes and/or failure to achieve soils that trend towards wetland soil characteristics	A hydrologist will investigate the cause of failure and recommend minor topographic modifications. Potential strategies include but are not limited to the addition of runnels to increase water conveyance, small berms to hold back drainage, or drainage swells.
Scrub/shrub (tidal)	• Vegetation: survival and percent cover • Survey twice per year.	Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives: percent cover. • Survey twice per year	Greater than 20% coverage of non-native species in the restored habitat	Removal of invasive species via manual pulling or selective herbicide application.

Measure	Metric	Decision Trigger	Adaptive Management Action
Emergent Wetland (FW)	• Vegetation: survival and percent cover • Survey twice per year	Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives: percent cover • Survey twice per year.	Greater than 20% coverage of non-native species in the restored habitat.	Removal of invasive species via manual pulling or selective herbicide application. Subsequent replanting as necessary.
	• Hydrology: water inundation, depth to groundwater, erosion/ sedimentation process across site. • Visual inspection twice per year	Failure to achieve wetland hydrological regimes and/or failure to achieve soil trending towards wetland soil characteristics	A hydrologist will investigate the cause of failure and recommend minor topographic modifications. Potential strategies include but are not limited to the addition of runnels to increase water conveyance, small berms to hold back drainage, or drainage swales.
Wet Meadow (FW)	• Vegetation: survival and percent cover • Survey twice per year	Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives: percent cover • Survey twice per year	Greater than 20% coverage of non-native species in the restored habitat.	Removal of invasive species via manual pulling or selective herbicide application. Subsequent replanting as necessary.

Measure	Metric	Decision Trigger	Adaptive Management Action
	• Hydrology: depth to groundwater, soils or surface water • Visual inspection: twice per year	Failure to achieve wetland hydrological regimes and/or failure to achieve soils trending towards wetland soil characteristics.	A hydrologist will investigate the cause of failure and recommend minor topographical modifications. Potential strategies include, but are not limited to, addition of runnels to increase surface water conveyance, lower elevation in areas to depth of groundwater.
Forested Scrub/shrub Wetland (FW)	• Vegetation: survival and percent cover • Survey once per year.	Less than 80% survival or 75% coverage of target vegetation.	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives and Hydrology: percent cover • Survey and visual inspection once per year	Greater than 20% coverage of non-native species in the restored habitat	Removal of invasive species via manual pulling or selective herbicide application. Subsequent replanting as necessary.
Bed Restoration (and In-Stream Structures)	• Structural: Inspection of channel morphology, thalweg, presence of riffle pool complexes • Biological: SVAP • Survey and visual inspection once per year	Inadequate cross-sectional stability and structural integrity	Minor re-positioning or re-shaping, addition of material, vein and/or j hook adjustment (minor changes in elevation or location) or repair.

Measure	Metric	Decision Trigger	Adaptive Management Action
Streambank Restoration	• Inspection for structural integrity/stability. • Visual inspection once per year	Structural failure	Minor adjustments to structure, replace rocks, replace plantings, reinforcement with rocks at toe/other stabilization measures.
Emergent Wetland with Sediment Load Reduction	• Vegetation: survival and percent cover • Survey twice per year	Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post-construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
	• Invasives: percent cover • Survey twice per year	Greater than 20% coverage of non-native species in the restored habitat	Removal of invasive species via manual pulling or selective herbicide application. Subsequent replanting as necessary.
	• Sedimentation/erosion, blockage, drainage, standing water • Visual inspection twice per year	Inspection results do not meet design standard/physical index requirements	Investigate the cause of failure and recommend minor topographic modifications. Potential strategies to increase water conveyance, small berms to hold back drainage, or drainage swales.
Fish Ladder	• Inspection of structural integrity of ladder • Visual inspection three times per year	Inhibits movement of fish or points to larger structural failure	Repair.
	• Debris jamming in structure or inlet, any observable geomorphic changes (e.g. scour hole)	Inhibits movement of fish	Clear.

Measure	Metric	Decision Trigger	Adaptive Management Action
	• Visual inspection every year during fish migration		
	• Significant hydrologic drop at downstream edge (fish can't make jump into ladder) • Visual inspection every year during fish migration	Significant hydraulic drop > 1 foot at the outlet (downstream edge)	Modification of inlet or outlet, or manual regarding
Sediment Forebay	• Measure volume of accumulation in forebay • Survey three times per year	Greater than 12 inches sediment accumulation	Increase frequency of sediment removal from forebay.
Oysters	• Measurement of performance metrics: physical reef structure, density of live oysters, survivability • Survey twice per year	Reefs fail to meet standard of relevant performance metrics	Install new oyster stock and/or new substrate. Minor adjustments to location or configuration of structures (labor).

4.10.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation

Per Implementation Guidance for section 1161 of WRDA 2016 (19 October 2017), the responsibility of a non-federal sponsor to conduct Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities on non-structural and non-mechanical elements of an ecosystem restoration project (or component of a project) will cease ten years after ecological success has been determined (the cessation of operation and maintenance of restoration features poses low risk to the ecological success and sustainability of project features and functions). There are no mechanical elements within the Recommended Plan. OMRR&R activities of structural features (including instream structures, toe protection/stacked rock wall and fishways) will continue as outlined in the future operations manual for the project. Post-construction adjustments for purposes of optimization of ecological function will be performed under the Monitoring and Adaptive Management Plan.

OMRR&R is 100% non-federally funded and minimal annual OMRR&R of each completed project is expected. Each constructed project will be inspected once a year after a project is completed. Additional OMRR&R activities may include actions such as surveys, removal of invasive plant species, trash removal, maintenance of bed restoration structures and oyster reefs, and sediment removal within a forebay. Additional maintenance may be required after major storm events for the removal of possible debris on-site. The average annual OMRR&R estimate is approximately $156,019 for all sites. The total OMRR&R cost is $7,415,508 as presented in Table 4.3. The OMRR&R costs were included in the average annual economic cost.

Subsequent to the completion of the design of each individual project (and prior to construction), a draft OMRR&R manual would be prepared in coordination with each non-Federal sponsor. A final OMRR&R manual would be prepared after the completion of construction and provided to the non-Federal sponsor.

4.10.4 Pre-construction Engineering and Design

Detailed designs and cost estimates are presented in this Final FR/EA providing a defensible 902 cost limit. The study team has identified the necessary studies and data collection to be performed during the Pre-construction Engineering, and Design (PED) phase to manage specific risks and uncertainties. A preliminary list of studies which have been identified in Appendix C (Engineering), F (Regulatory Correspondence), G (Hazardous Toxic Radioactive Waste [HTRW]), H (Cultural Resources Documentation) and M (Real Estate Plan) include:

- Property and utility investigations: Parcel ownership, property boundaries and utility survey, needed to confirm acquisition requirements and refine real estate and relocation costs
- Data collection: Topography, bathymetry, bio-benchmarking, wetland delineation, tidal gauging and soils testing needed to support civil and ecological design as well as hydraulic and hydrologic analyses
- Hydraulic and hydrologic analysis and modeling: Riverine, coastal and sedimentation studies, needed to optimize design features, refine construction cost estimates, confirm

areas of environmental benefits, identify areas of induced flooding and predict/minimize actions for operations and maintenance

- Geotechnical analyses: Foundation design, analysis of settlement and seepage of project features and identification of disposal and borrow sites, needed to finalize design features and refine cost estimates
- HTRW sampling: Contaminant concentrations in soil and sediment sampling to identify additional activities and costs (to be paid 100% by the non-federal sponsor) associated with the restoration action
- Regulatory compliance and permits
- Preparation of Plans and Specifications (30, 60, 90, 100 percent)
- Value Engineering
- Cultural Resources Surveys

4.10.5 Construction Schedule and Phasing Engineering and Design

The project includes 20 different sites spanning five (5) planning regions and will require a phased approach for the design and construction of the restoration for each site. The phasing for the design and construction activities have been developed in coordination with the non-federal sponsors based on sponsor readiness and priorities; as well as implementing restoration with geographic distribution among the planning regions. The phasing plan was used to develop the fully funded cost estimates (determining the mid-point of construction) and the relative sea level change (RSLC) analysis. The general construction schedule is presented in the Cost Appendix.

Sites that require remedial actions would be restored following remediation or in coordination with Superfund activities. The Lower Passaic River site (Oak Island Yards - Tier 2 site) will require remedial actions prior to restoration. The governmental partnership established to coordinate the Superfund Program (USEPA and Trustees [NJDEP, USFWS and NOAA]) with the USACE's restoration have worked closely since 2003 to develop a plan that would result in restoration following the remedial action. The restoration of Oak Island Yards would be sequenced after the EPA Superfund cleanup (dredging and capping) has been completed in the lower 8.2 river miles per EPA's Record of Decision (April 2016). The partners assumed that restoration activities would be able to proceed following the Superfund cleanup, after which the level of residual contamination within the river and the projected level of recontamination would be considered acceptable.

Dead Horse Bay, Jamaica Bay was updated to become a Tier 2 site after National Park Service (NPS) determined in late 2017 that a CERCLA Removal Site Evaluation (RSE) and Engineering Evaluation/Cost Analysis (EE/CA) was needed to evaluate appropriate remedial options to minimize human and ecological exposure from migration of hazardous substances that are potentially released from the landfill along the southern shoreline at Dead Horse Bay South. In addition, a site-wide RI/FS is underway that will determine the need for remedial actions at Dead Horse Bay North prior to restoration. Dead Horse Bay would be deferred until a remedial action decision has been made and the removal action on South was scheduled. If remedial action is required on Dead Horse Bay North, NPS would be responsible for cleanup activities prior to restoration. In addition, the restoration at Dead Horse Bay North will be coordinated with cleanup actions on Dead Horse Bay South in order to place excavated soil/sediment on-site. Therefore, the timing of design and construction of Dead Horse Bay will be dependent upon the timing of the remedial action decisions and timing of NPS.

The remaining sites are assumed to not require a remedial action. However, if during PED, contamination is identified at an unacceptable level and remedial actions are required prior to restoration (paid for 100% by the non-federal sponsor), the site would be sequenced accordingly.

The general construction sequence at the project sites would include the following activities:

1. Mobilization;
2. Installation of construction fence and staging features;
3. Vector pest control, if necessary;
4. Installation of soil erosion and sediment control features;
5. Installation/modification of temporary work access road(s) and crossings, where applicable;
6. Installation of water control features, where applicable;
7. Site clearing, including removal of existing vegetation and invasive species treatment, where applicable;
8. Earthwork including excavation, grading and import of select amended soils, where applicable;
9. Installation of shoreline stabilization structures where applicable;;
10. Installation of herbivory fencing;
11. Planting and seeding;
12. Installation of site amenities; and
13. Demobilization.

4.11 Cost Sharing and Non-Federal Partner Responsibilities

The federal share of the project's total cost is 65-percent of the total project cost. The federal government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of non-federal interests. The non-federal share of the estimated total cost of the proposed project is 35-percent of the total. The non-federal share consists of a number of components including real estate (of which the non-federal portion is deducted from the non-federal cash contribution). The total project first cost is $408,184,134, with a total federal cost of $265,319,600 and total non-federal cost of $142,864,400. However, the Project Partnership Agreements will be based on the total fully funded project cost for each project. Currently the fully funded costs are escalated to the midpoint of construction based on a phased implementation strategy as described in Section 4.9.5 and outlined in Appendix I. The Total Fully Funded Project Cost is $ 587,661,000.

4.11.1 Implementation Requirements and Cost Sharing

Table 4-17 presents the total fully funded costs for each site recommended in the Recommended Plan broken down by federal and non-federal contributions. Upon approval of the FR/EA, project partnership agreements would be executed between the USACE and the non-federal sponsor.

Table 4-13. Cost Apportionment, Sponsors and Total Fully Funded Costs of the Recommended Plan

Planning Region	Site	Federal ($)	First Costs ($)			Fully Funded Cost ($)	Annual OMRR&R Cost ($)	Sponsor
			Non-Federal ($)		Total ($)			
			Total	LERRD Costs *				
Jamaica Bay	Dead Horse Bay	$26,487,781	$14,262,651	$30,500	$40,750,432	$68,645,000	$4,541	NYCDEP NYC Parks NYSDEC
	Fresh Creek	$22,044,430	$11,870,077	$1,806,350	$33,914,507	$44,377,000	$5,086	NYCDEP NYC Parks NYSDEC
	Duck Point	$13,910,712	$7,490,383	$14,950	$21,401,095	$27,271,000	$4,734	NYSDEC NYCDEP
	Stony Creek	$15,093,028	$8,127,015	$14,950	$23,220,043	$27,976,000	$5,264	NYSDEC NYCDEP
	Pumpkin Patch West	$13,080,817	$7,043,517	$14,950	$20,124,334	$31,897,000	$4,326	NYSDEC NYCDEP
	Pumpkin Patch East	$14,027,731	$7,553,394	$14,950	$21,581,125	$38,856,000	$4,382	NYSDEC NYCDEP
	Elders Center	$12,728,717	$6,853,924	$14,950	$19,582,641	$28,318,000	$4,369	NYSDEC NYCDEP
	Head of Jamaica Bay	$3,694,374	$1,989,278	$13,000	$5,683,652	$7,276,000	$11,911	NYCDEP
Harlem River, East River and Western Long Island Sound	Flushing Creek	$10,498,710	$5,653,152	$114,075	$16,151,862	$19,786,000	$4,639	NYCDEP
	Bronx Zoo and Dam	$7,145,726	$3,847,699	$26,000	$10,993,425	$13,020,000	$15,653	NYCDEP NYC Parks

Planning Region	Site	Federal ($)	First Costs ($)			Fully Funded Cost ($)	Annual OMRR&R Cost ($)	Sponsor
			Non-Federal ($)		Total ($)			
			Total	LERRD Costs *				
	Stone Mill Dam	$3,028,123	$1,630,528	$26,000	$4,658,650	$5,606,000	$9,661	NYC Parks
Harlem River, East River and Western Long Island Sound	Shoelace Park	$13,463,484	$7,249,569	$39,000	$20,713,053	$27,969,000	$22,690	NYCDEP NYC Parks
	Bronxville Lake	$10,010,012	$5,390,006	$65,000	$15,400,018	$22,389,000	$5,044	Westchester County
	Garth Woods - Harney Road	$6,709,638	$3,612,882	$52,000	$10,322,520	$13,134,000	$12,871	Westchester County
Newark Bay, Hackensack River and Passaic River	Oak Island Yards	$10,036,500	$5,404,269	$62,400	$15,440,769	$25,906,000	$4,308	NJDEP
	Essex County Branch Brook Park	$33,817,981	$18,209,682	$3,513,900	$52,027,663	$75,928,000	$7,864	NJDEP
	Metromedia Tract	$20,218,952	$10,887,128	$521,775	$31,106,080	$43,087,000	$5,171	NJSEA NJDEP
	Meadowlark Marsh	$19,284,492	$10,383,957	$931,770	$29,668,449	$46,351,000	$5,066	NJSEA NJDEP
Upper Bay	Bush Terminal	$4,508,066	$2,427,420	$39,000	$6,935,486	$9,514,000	$10,107	NY Harbor School NYC Parks
Lower Bay	Naval Weapons Station Earle	$5,530,414	$2,977,915	$13,000	$8,508,329	$10,354,000	$8,334	NY/NJ Baykeeper NJDEP

*LERRD Costs – The Lands, Easements, Rights-of-way, Relocations, and dredged or excavated material Disposal areas (LERRD) costs are a subset of the Total Non-Federal Costs.

Table 4-18 shows the total cost for all projects within a planning region.

Table 4-14. Total Cost by Planning Region (FY 2020)

Planning Region	Federal ($)	First Costs ($)			Fully Funded Cost ($)	Annual OMRR&R Cost ($)
		Non-Federal ($)		Total ($)		
		Total	LERRD Costs *			
Jamaica Bay	$121,067,589	$65,190,240	$1,924,600	$186,257,829	$274,616,000	$44,613
Harlem River, East River and Western Long Island Sound	$50,855,693	$27,383,835	$322,075	$78,239,528	$101,904,000	$70,558
Newark Bay, Hackensack River and Passaic River	$83,357,925	$44,885,036	$5,029,845	$128,242,961	$191,272,000	$22,409
Upper Bay	$4,508,066	$2,427,420	$39,000	$6,935,486	$9,514,000	$10,107
Lower Bay	$5,530,414	$2,977,915	$13,000	$8,508,329	$10,354,000	$8,334
Total	**$265,319,686**	**$142,864,447**	**$7,328,520**	**$408,184,133**	**$587,661,000**	**$156,021**

*LERRD Costs – The Lands, Easements, Rights-of-way, Relocations, and dredged or excavated material Disposal areas costs are a subset of the Total Non-Federal Costs.

4.11.2 Division of Plan Responsibilities

The Water Resources Development Act (WRDA) of 1986 (Public Law 99-662) and various administrative policies have established the basis for the division of federal and non-federal responsibilities in the construction, maintenance, and operation of federal water resource projects accomplished under the direction of the USACE. Anticipated federal and non-federal responsibilities are described in this section. The final division of specific responsibilities will be formalized in the project partnership agreement.

4.11.2.1 Federal Responsibilities

The estimated federal share of the total project cost of the project is 65 percent of project costs related to ecosystem restoration. Total fully funded project costs are typically all costs to implement the project exclusive of Lands, Easements, Rights-of-way, and Disposal sites (LERRD), and do not include Operation Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs or remediation of hazardous substances regulated by CERCLA. The federal government's responsibilities are anticipated to be:

- Sharing a percentage of the costs for PED, including preparation of the plans and specifications, which is cost-shared at the same percentage that applies to construction of the project.

- Sharing a percentage of construction costs for the project.
- Administering contracts for construction and supervision of the project after authorization funding and receipt of non-federal assurances.

4.11.2.2 Non-Federal Sponsor's Financial Capability

The non-federal sponsor(s) have committed to provide their share of total project costs, as well as all LERRD required for the project including LERRD that is excluded from reimbursement. Non-federal sponsor Self-certification of financial capability forms have been provided. The non-federal sponsor has also made a commitment to undertake all necessary response and remediation for CERCLA construction of the project features on those lands and handling groundwater contamination during construction activities. The LERRD costs were assumed per site and subject to change with updates to the Real Estate Plan.

4.12 Recommended Restoration Opportunities for Future Study

The Recommended Plan includes a recommendation for the future study into the feasibility of constructing sites included in the HRE CRP that are within the USACE aquatic restoration mission.

A total of 296 HRE CRP sites have been identified as opportunities for restoration or acquisition. Of these, only 20 are included in this Recommended Plan for near-term construction. In addition, 13 have been removed from the Recommended Plan and 20 are being implemented by other Regional Partners. Two sites that have been removed from the HRE Recommended Plan are being implemented by other regional partners. The remaining site studies are expected to be initiated using the existing authorization. As stated in Section 4.9.2 (Completeness), additional CRP opportunities (Appendix K) in the federal interest, within any planning region, that are not recommended in this Recommended Plan for near-term construction could be recommended as a New Phase future Spin-Off Feasibility Study under the HRE Ecosystem Restoration Feasibility Study Authorization. The additional sites presented in Appendix K could be advanced upon sponsor readiness and support and implementation of the budgeting process.

These studies may start the feasibility phase without competing as a new start, where each spin-off study is considered a new investment decision and would be categorized as a "New Phase" (EC 11-2-222, 31 March 2020). The EC states "A Feasibility Study that is specifically identified in a final report from a Comprehensive or Basin-wide Study and that would be carried out under the same study authority as the Comprehensive or Basin-wide, if provided for by that authority, is termed a Spin-off Study. This study may start the feasibility phase without competing as a New Start. Each Spin-off Study is considered a new investment decision, and should be categorized as New Phase (NP)." The 253 sites that have been identified as future spinoffs are included in the Comprehensive Restoration Plan but not the recommended plan have been vetted with the partners (the Harbor Estuary Program's Restoration Work Group) and identified as priorities for the region for restoration. The sites have been evaluated by the PDT for federal interest, but have not been evaluated for their "value" or cost effectiveness as part of the HRE or any other USACE study. The budget EC allows an APPROVED HRE Feasibility Report to satisfy the requirements for future spinoffs to be New Phases rather than new starts. Until the HRE FR/EA is authorized, the spinoffs will be new starts.

Currently, the highest priority site with sponsor readiness and regional interest is a new phase spin-off study at Spring Creek South in Jamaica Bay. This site was initially recommended in the Jamaica Bay "source" study, but was removed in order to be advanced by NYSDEC utilizing the Federal Emergency Management Administration (FEMA) Hazard Mitigation Grant Program (HMGP). This project is no longer moving forward under the HMGP and has now been requested to be the first new phase feasibility study spin-off using the HRE authority.

4.13 Risk & Uncertainty

In a risk-informed decision making framework, the study team has identified risk and uncertainty throughout the plan formulation, performing analysis to reasonably minimize the uncertainty and facilitate effective risk-informed decision making. This section discusses uncertainty and associated potential risk and how it is managed as they pertain to project performance and adaptability, particularly as it relates to future RSLC, real estate considerations in Feasibility, PED, and Construction phases, as well as potential for cultural resources assessments and mitigation and the hazardous and toxic, or radioactive waste. The views of our partners and sister agencies are also discussed as they pertain to risk and uncertainty going forward for implementation. The technical risks and uncertainties identified during the study and were included in a Risk Register. The register was used to highlight areas of study risks and identify ways to address those risks, such as conducting technical analysis on controversial measures and seeking early input from key stakeholders on proposed measures and alternatives.

4.13.1 Performance and Adaptability of the Project with RSLC

As described in Section 3.1.3, while sea levels are expected to change, the rate at which they will rise is uncertain. Sea level change analysis informed the development of the conceptual designs. The USACE "intermediate" sea level change curve was used for the development of the concept alternatives. Analyses using the USACE historic "low", "intermediate" and "high" sea level change scenarios were used to evaluate the Recommended Plan alternatives. While the design can be expected to perform well under the "low" and "intermediate" scenarios, they, like much of the Hudson Raritan Estuary Habitat, will be challenged if future sea level change rates trend towards the high curve.

Designs were developed so as to yield immediate benefits that were sustainable over the project duration, with minimized loss of habitat or benefit. These considerations will continue to guide the design development process as critical details such as optimized flood plain elevations and channel cross-section morphology will be greatly refined during the detailed design and Pre-Engineering and Design phases. Designs were, and will continue to be, developed to augment both resiliency and adaptability, where critical habitats are afforded the opportunity to migrate in response to rising water surface elevations and natural processes are harnessed to promote adaptability.

4.13.2 Study and Implementation

A certain degree of risk and uncertainty is inherent in any restoration project. Restoration of some types of ecosystems may have relatively low risk. For example, removal of urban fill to restore hydrology to a wetland area. Other activities may have higher associated risks such as restoration of coastal marsh in an area subject to hurricanes. The associated risk and uncertainty of achieving the proposed level of outputs by implementing the alternatives were considered. When the costs and outputs of alternative restoration plans are uncertain and/or there are substantive risks that outcomes will not be achieved, which may often be the case, the selection of a recommended alternative becomes more complex. It is essential to document the assumptions made and uncertainties encountered during the course of planning analyses.

The major drivers of uncertainty are typical of aquatic ecosystem restoration projects. Native plantings have an associated risk of not establishing due to a variety of unforeseen events. Predation from herbivorous animals and insects is a possibility and can be reasonably estimated based on baseline surveys of the existing flora and fauna. However, weather also plays a large role in the establishment success of new plantings. Periods of drought or early frost may alter the survival percentage of plantings. Although historical records can help to predict the best possible location and timing of new plantings, single unforeseen events may lead to failure. In addition, climate change in the years to come may play a role in impacting the project outcome. Increased temperatures or rainfall may lead to changes in the ecosystem of the project area. Complete eradication of invasive species always presents a certain level of risk and uncertainty as the chances of reinvasion are likely to occur without proper management, increasingly so when native species have not yet established. Changes in nutrient cycling processes and soil chemistry (due to impaired hydrology and prolonged invasive species establishment) further increases uncertainty with the eradication of invasive species.

The feasibility level detailed designs proposed herein were based on limited and in some cases historic data. The level of analysis in design development was similarly limited. A greater level of field data collection, analysis and design development will therefore be necessary in the PED phase of each project to address the uncertainties listed below (4.13.3).

The constructed project will be adaptively managed, as detailed in a Monitoring and Adaptive Management Plan. Adaptive management is a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. Adaptive management will partly offset potential risks to success of habitat output, by relying on monitoring data to identify underperformance and the adaptive management strategy to adjust implementation to provide projected benefits. To mitigate these risks, planting over several years, overplanting and/or adaptive management and monitoring have been incorporated into the overall plan. Measures that prevent further degradation to soils and measures that alleviate impaired hydrology can reduce the invasibility of the ecosystem and should lessen the risk and uncertainty associated with invasive species removal. Management actions may be incorporated into the final plan as appropriate. Adaptively managing the project will greatly reduce risk and uncertainty, and support project success.

4.13.3 Plan Formulation

The key uncertainties during plan formulation that have the potential for resulting in risks are the following:

- Use of legacy and/or low resolution survey, hydrologic and geotechnical data for design development.
- Limited hydraulic, hydrologic and hydrodynamic modeling was available or developed for design preparation.
- Habitat values are captured in a numerical representation of habitat values utilize a certified habitat evaluation model (EPW) to address relative suitability and habitat value. Uncertainties are associated with user bias and model limitations.
- Data collection for the EPW, wetland mapping, habitat assessments, stream conditions, and water levels were conducted via field visit once during the summer between 2014 and 2016.
- Absent performance of tree surveys, location, species, condition, and health of trees are not known.
- Wetlands were mapped, but not delineated.
- Restoration site plan development was not informed by public perception, knowledge, and opinions.
- Stormwater inputs, water quality levels, and existing issues were not fully quantified for restoration sites.
- Stream morphology/geomorphology or reference reach studies were not undertaken.
- Absent performance of cultural resource surveys, presence of cultural resources could impact costs and schedule.
- Zoning/planning changes may require new permits/approvals which could lead to scheduling issues.

4.13.4 Real Estate

Identification of LERRDs is reliant on the non-Federal Sponsors. Most of the lands needed for the restoration projects are public and are owned by the non-federal sponsor. Of the total 708.80 acres of land needed, a total of 7 parcels are privately owned and must be acquired in order to implement 2 of the 20 Recommended Plan sites.

4.13.5 Cultural Resource Coordination and Costs

Costs for additional investigations and potential mitigation to implement the project's Programmatic Agreement (PA) were estimated for each site using existing information. Additional cultural resources surveys identified in Appendix H and the PA will be carried out during Pre-Construction Engineering and Design and will determine the need for and type of mitigation required, in consultation with relevant SHPO, ACHP, invited signatories and consulting parties.

All costs incurred by the government for actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties, and the mitigation of adverse effects, will be included in construction costs. These costs, not including the costs for data recovery, are cost-shared in accordance with other project costs. Data recovery costs are a full federal costs and are not cost-shared and are subject to a cap of 1% of the total federal project cost. Data recovery costs in excess of 1% are subject to review and a waiver in accordance with ER 1105-2-100. Based upon current estimates, data recovery costs for this project will not exceed the 1% cap.

4.13.6 Hazardous Toxic and Radioactive Waste

Site specific HTRW data will be collected during the PED phase. USACE will follow the requirements of ER 1165-2-132, which provides guidance on Hazardous, Toxic, and Radioactive Waste (HTRW) for civil works projects, throughout all phases of the project. If HTRW is discovered at any site during PED, work will stop at that site until HTRW remediation is complete. HTRW remediation is the responsibility of the non-federal sponsors, and must be carried out at 100% non-federal cost. The non-federal sponsors acknowledge and accept the responsibility for any HTRW remediation required, including the requirement to pay 100% of costs associated with HTRW remediation.

HTRW – contamination has been identified adjacent to the Oak Island Yard site along the Lower Passaic River, where the USACE has partnered with the USEPA and NJDEP on the remedial investigation of the Lower Passaic River, which is a designated Superfund Site. The Superfund remediation must be completed prior to any PED or construction work on the HRE ecosystem restoration project. The HRE project has been sequenced in order to allow time for the completion of the HTRW remediation prior to the commencement of HRE construction.

HTRW – contamination has also been identified at Dead Horse Bay which triggered the National Park Service to conduct a CERLCA investigation and evaluation of a removal action in 2019. NPS plans to conduct a removal action on Dead Horse Bay South and may identify additional remedial actions following a site-wide RI/FS. Restoration actions must be coordinated with NPS to ensure any required remedial actions take place prior to restoration at Dead Horse Bay North (if deemed necessary). If determined no actions are needed at Dead Horse Bay North, the restoration would still be timed in coordination with the NPS removal action on South given clean excavated soil from the restoration project is planned as clean cap material for the NPS remedial action.

Each site was designed where appropriate with the placement of clean growing media/cover for the restoration of habitat. This will isolate and reduce risk if contamination was found on site at unacceptable levels. The site may not move forward for future consideration if there is an unacceptable risk. Unfortunately, restoration at that location would not advance meeting objectives at that site. This risk is considered minimal given the ongoing coordination with the NJDEP, NYSDEC, and the USFWS.

If sites are found to contain HTRW and the non-federal sponsor is unable or unwilling to clean up the unacceptable levels of contamination, the site may not be restored in the future and project objectives and benefits would not be realized at that site.

Chapter 5: Environmental Consequences of the Alternatives*

Sections 1500.1(c) and 1508.9(a)(1) of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321 et seq.) require federal agencies to “provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact” on actions authorized, funded, or conducted by the federal government to insure such actions adequately address “environmental consequences, and take actions that protect, restore, and enhance the environment." This chapter provides an assessment of the potential environmental consequences or impacts that would result from implementing the recommended plan presented in Chapter 4 of this integrated feasibility report and environmental assessment (FR/EA) for the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study (HRE Feasibility Study). Tables 4-1 through 4-7, in Chapter 4, show the principal restoration measures applied under the recommended plan at each site to achieve the target ecosystem characteristic (TEC) objectives. This chapter also supplements the ecosystem benefits outlined in Chapters 3 and 4 for each project.

As this study includes recommendations for construction of restoration opportunities that are designed at a feasibility level of detail, as well as possible new phase future spin-off studies for restoration opportunities, a qualitative evaluation of impacts resulting from the restoration measures associated with the recommended plan is discussed in this chapter. Chapter 2 serves as the baseline for the impact analysis and cumulative impacts of implementing the recommended plan are discussed in Chapter 6.

As the FR/EA does not include recommendations for construction at any sites in the following three (3) planning regions, these planning regions are not addressed in this chapter:

- Lower Raritan River
- Arthur Kill/Kill Van Kull
- Lower Hudson River

In addition, impacts in the Upper Bay and Lower Bay planning regions are focused on small-scale oyster restoration only and have been combined in this chapter.

The report sections marked with an asterisk (*) include required content for compliance with NEPA.

5.1 Recommended Plan – Overview

The expected environmental effects of implementing the recommended plan would be overwhelmingly beneficial to the flora and fauna of the HRE, and beneficial to the public living in the HRE study area. Implementation of the recommended plan would be a substantial first step in the large-scale restoration of the HRE; realizing habitat restoration and expansion of available habitat for a host of fauna, including anadromous and catadromous species, and small-scale restoration of the eastern oyster (*Crassostrea virginica*), a once omnipresent keystone species in the HRE. Secondary benefits would include, but not be limited to, the following:

- Removal of large swathes of invasive species;

- Immediate (expected) and long-term improvements to water quality and storage of floodwaters
- Immediate (expected) and long-term benefits for coastal storm risk management through wave attenuation;
- Removal of waterway obstructions and debris;
- Short-term job creation during construction;
- Improved public access to the estuary and its resources; and
- Educational and “hands on” restoration opportunities for the public and students of the region.

For the purposes of this FR/EA, the terms “impacts” and “effects” are used interchangeably. Impacts can be short-term or long-term. In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only during the time required for construction activities. Long-term impacts are those that are more likely to be persistent and chronic. Impacts of a proposed action can be positive or negative. A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes. A single action might result in positive impacts on one environmental resource and negative impacts on another.

Implementation of the recommended plan would result in some short-term, negative impacts to the environment; however, these impacts would be temporary and localized. All restoration measures would be implemented in accordance with regulatory agency stipulations and construction contractors would employ best management practices (BMPs) at all times—e.g., use of silt curtains and adherence to sediment and erosion control plans. In the March 2017 Draft Fish and Wildlife Coordination Act Report (FWCAR), U.S. Fish and Wildlife Service (USFWS) provided the District with planning, mitigation, and site specific recommendations for the HRE Draft Feasibility Report. Upon review of the recommendations, the District issued a response back to USFWS which was then incorporated into the Final FWCAR dated April 2018 (USFWS coordination is located in Regulatory Appendix F).

5.1.1 No Action Alternative (Future Without-Project Condition)

The no action alternative, which is synonymous with the future without-project condition (FWOP), would be the state of the HRE study area under the anticipated future condition if no actions were implemented by the United States Army Corps of Engineers (USACE), New York District under the HRE Feasibility Study. The no action alternative provides a basis upon which a comparison of the potential impacts associated with implementing the recommended plan can be made.

Under the no action alternative, ongoing and planned restoration and conservation actions, undertaken by agencies, municipalities, and non-governmental entities would continue (see Appendix B). Although all regional partners are working towards implementing the HRE Comprehensive Restoration Plan goals and targets for the future; small-scale restoration funded through local and state funding is based largely on an opportunistic approach. It is known that absent a large scale federal investment, partner efforts will only accomplish a small percentage of the restoration needed in the harbor. The current programs in the HRE study area, are typically conducted independent of one another or in isolation from the rest of the estuary. The significant acreage that is recommended as part of the recommended plan is needed to achieve measurable progress for many of the Target Ecosystem Restoration goals. Historically, the USACE has been the entity that has the technical experience to implement large scale restoration projects in the region.

This chapter reviews the FWOP at a regional scale followed by the site specific impacts of the FWOP throughout the planning horizon. This analysis is supported by Chapter 4 (Recommended Plan) and the Plan Formulation Appendix (Appendix D), which discuss ongoing work and complementary projects completed outside of this recommendation.

5.2 Jamaica Bay Planning Region

It is anticipated that without restoration there would be a further degradation of existing estuarine habitats within Jamaica Bay, due to continuing natural erosive forces and rising sea levels, and anthropogenic stressors, like urbanization, dredging, compromised water quality, landfilling and landfill leachate intrusions, illegal dumping, off-road vehicle traffic, and encroachment from invasive species. However, given the intensity of development in the HRE study area, even low quality undeveloped lands have become a priority for protection.

The future without-project condition of Jamaica Bay will likely be the continuation of non-point source inputs into the Bay, thereby continuing to impact water quality at some level. It should be noted that NYCDEP is continuing to improve water quality within Jamaica Bay through the ongoing implementation of NYCDEP's Nitrogen Control Program and Jamaica Bay CSO Long Term Control Plan. Water quality impacts in the area are not expected to be significant enough to influence the sustainability of the proposed restoration action. In the absence of federal action, wetlands and marshes along the periphery of the Bay will decrease in acreage due to erosion, subsidence sea level rise and invasive species interference. Invasive species will expand in many of the sites, resulting in the continuing loss of native *Spartina*-based wetlands. Increases in coastal flooding related to relative sea level change RSLC will exacerbate loss of shoreline and coastal habitat. Without restoration, the remaining marsh islands could be lost to continued erosional forces and rising sea levels (Gornitz et al., 2002). The loss of Jamaica Bay marsh islands could, in turn, unleash accelerated erosional forces upon the shorelines along the perimeter of the bay (Gedan et al., 2011).

Implementation of the recommended plan would restore estuarine, marsh islands and oyster habitat at 8 sites in the Jamaica Bay Planning Region:

- **Estuarine habitat restoration**, including the elimination of invasive-dominated communities and restoration of native vegetation communities, would be conducted at two (2) locations—Dead Horse Bay and Fresh Creek. The restoration would total approximately 85 acres, predominantly comprising the restoration of low and high salt marsh, scrub shrub, maritime forest, tidal waterbodies and shallow water habitat.
- **Jamaica Bay Marsh Island restoration** would be undertaken at five (5) locations—Duck Point, Stony Creek, Pumpkin Patch West, Pumpkin Patch East, and Elders Center.

Approximately 174 acres of low and high salt marsh with a small area of scrub shrub and tidal channels. Additionally, approximately 30 acres of shallow water habitat will also be restored around the perimeter of the marsh islands.
- **Small-scale oyster restoration** would be undertaken at one (1) site, at Head of Jamaica Bay, where approximately ten (10) acres of oyster reef habitat would be restored.

5.2.1 Geomorphology and Sediment Transport

Under the no action alternative, tidal action and stormwater runoff would continue to erode soils, particularly where vegetation is not well established. For the estuarine habitat restoration sites, without action, continued shoreline erosion and loss of salt marsh would occur. Increased degradation from all-terrain vehicles (ATV) use and dumping of construction debris, mixed soils or other rubbish would persist without prevention measures in place that are planned for in restoration. Marsh island loss from erosion, which has been estimated at 47 acres per year, would continue without restoration. Based on previous marsh island construction and engineering judgment, the PDT has estimated the FWOP area for Stony Creek and Duck Point marsh islands will reach zero by year 50 of the planning horizon. The other marsh islands in the recommendation (Elders Center, Pumpkin Patch East, and Pumpkin Patch West) are currently below the surface (see Benefits Appendix E).

Monitoring of previously constructed Marsh Islands has shown some accretion in the footprint of Elders Center between already constructed marsh islands, Elders East and Elders West. This accretion is largely due to the placement of sand on the two constructed islands and the District notes that this area has now achieved equilibrium. In regards, to the accretion and sediment transport regime and absent natural recruitment, there is no evidence that natural formation of a marsh island will take hold without vegetation due to velocities in the channel and the resulting dynamic sediment environment.

Excavation and regrading at the estuarine habitat and marsh island restoration sites would result in a long-term change to local topography. Excavations will be done along the shorelines to allow for the influx of tidal waters to restore the tidal marshes. These elevations more closely reflect the historical elevations of each of the project sites, prior to fill activities, and utilize biobenchmarking to help establish elevations that currently support the desired habitat type in the bay. The excavation and regrading of the sites would involve the displacement and the replacement of soils. Suitable materials excavated from the shorelines would be reused onsite to establish maritime habitats that would support and add to the values of the recreated wetland/aquatic restorations, as well as buffer them from human intrusion. Excavation of the fill layers from the water’s edge to restore tidal marsh is expected to return this area to a more historic elevation and historic soil complex, possibly even re-exposing the old peat surfaces of the buried marsh. All excavated soil will be handled and managed in accordance with applicable City, State, and Federal regulations.

During restoration construction under the recommended plan, it is unlikely that geological resources would be impacted, as construction would occur only at very shallow depths. Grading and earthmoving activities, dredging, and sediment resuspension from vessel movements and prop wash could result in temporary disturbances to sediment transport. However, these activities and their effects would be short-term and localized. On land, silt fences and other BMPs would be employed to reduce erosion and sedimentation. As appropriate, silt curtains or cofferdams may be used to minimize sediment transport in open water areas, precluding resuspended sediments being transported by currents and forming new shoals or sandbars. Even absent these practices, such geomorphic features likely would be temporary and would disappear as the system reaches a new post-construction equilibrium. All soil erosion measures will be coordinated with USFWS during the PED phase.

Implementing the recommended plan at the restoration sites within the Jamaica Bay Planning Region would restore wetlands, tidal channels, and maritime forest; armor and stabilize shorelines; and establish oyster habitat. Vegetated intertidal zones help buffer adjacent areas from flood damage and maintain bank stability during flood events, and tidal marshes with natural channel configurations buffer coastal areas from storm surges and provide floodwater storage functions. Restoration would have long-term, positive effects, through attenuating wave velocities, controlling erosion, retaining sediments, and reducing sediment loads, thereby establishing more resilient shorelines, riverbanks and streambanks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Under the recommended plan, associated construction activities would cause short-term release or resuspension of sediments and a concomitant short-term increase in turbidity, in nearby waters in Jamaica Bay. The restored habitats would reduce long-term turbidity by filtering and retaining stormwater runoff, providing storm surge and flood buffering, attenuating waves, and thereby reducing shoreline erosion. Oyster beds established under the recommended plan would reduce turbidity by mitigating shoreline erosion and filtering suspended solids and phytoplankton (Meyer et al., 1997; Coen et al., 2007; Scyphers et al., 2011). The resulting reduction in turbidity under the recommended plan would provide long-term habitat enhancement for shellfish and fish communities, and aquatic vegetation (Cahoon et al., 1999; Paul and Meyer, 2001; Steinberg et al., 2004).

Restoration Sites	Potential Environmental Consequences*
All Sites	• BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term wave and turbidity attenuation, sediment accretion, erosion and sedimentation control, sediment load reduction, and coastal resiliency improvements. • During construction, negligible, short-term local soil and sediment disturbance and sedimentation from in-water offshore, nearshore, shoreline, or onshore earthmoving activities, and vessel and equipment movement. • Long-term changes to local topography.

5.2.2 Water Resources

Under the no action alternative, the Jamaica Bay Planning Region would experience continuing or worsening degradation of hydrologic conditions, depending on the magnitude and effects of

RSLC. Continued loss of salt marsh at the estuarine habitat restoration sites would reduce tidal flushing and stormwater storage capacity. Without restoration of the marsh island sites, the ability of the islands to act as natural wave attenuation areas would be reduced. Without oyster reef restoration at Head of Jamaica Bay, localized water quality improvements from the natural filter feeding would not occur. Oyster reefs also act as a buffer attenuating waves and reducing turbidity. Absent oyster restoration, Head of Jamaica Bay would not benefit from localized benefit to flood and storms protection. Water quality at the recommended sites is expected sites is expected to remain on a similar trajectory to the existing condition. In the absence of restoration, estuarine wetland loss along with its positive impacts to water quality, is expected. However, commitments from NYCDEP to long term control plans should support water quality improvements in the vicinity of the recommended sites.

While Jamaica Bay does experience water quality impairments from multiple sources, these impacts are not expected to be significant enough to influence the sustainability of the proposed restoration actions. In dead end basins such as Fresh Creek, where water quality could potentially pose a risk to project success, NYCDEP's Jamaica Bay CSO Long Term Control Plan coupled with the planned restoration is expected to create an environment where restored habitats will thrive.

A RSLC analysis was conducted to aid ecosystem restoration planning and impact assessment of the recommended projects in the Planning Region (see Engineering Appendix D for RSLC Analysis). All recommended sites in Jamaica Bay are expected to be effected by SLC; however, within the 50 year period of analysis results under the intermediate SLC curve show that sites will see a growth of low marsh due to high marsh to low marsh conversion and no loss of low marsh at the lower end till the years 40-50. This is because the low end of the low marsh elevation ranges have been designed at 1 foot above mean tide level (MTL) so there is no impact till sea level rises 1 foot. After 50 years, the analysis predicts that measures would need to put into place to prevent drowning of the marsh islands from continued SLR because there would be no room to migrate.

Under the recommended plan, grading and earthmoving activities, dredging, temporary construction-related structures, and resulting temporary geomorphologic features—e.g., shoals and pools—would cause short-term disruption of local wave and current regimes, hydrology, and stormwater runoff. These activities and their effects would be short-term and localized. A Section 404(b)(1) Guidelines Evaluation has been completed for these sites and is provided in the Regulatory Appendix.

The change of existing elevations from excavation and regrading of material on the estuarine habitat and marsh island restoration sites would allow for more land to be inundated by the daily tides. Tidal creeks would be restored on many of the estuarine habitat sites and large areas would be excavated down to low marsh elevations, both actions allowing for better overall tidal inundation. The alteration of tidal influences is necessary to provide the proper hydrology and inundation frequencies to support the desired marsh plant communities.

Wetlands restored and oyster beds established under the recommended plan would provide long-term regulation of water flow, and storm surge and flood buffering, wave attenuation, and protection of shorelines, per the findings of Woodward and Wui (2001), Zelder and Kercher (2005), Koch et al. (2009), Barbier et al. (2011), Gedan et al. (2011), and Shepard et al. (2011). Likewise, restored maritime forest and scrub/shrub habitat on the estuarine restoration sites would provide stormwater runoff mitigation (Bolund and Hunhammar, 1999; Bonan, 2002; Neary et al., 2009). Restoring tidal channels and basins would improve tidal flushing, restore salinity regimes, and reduce water residency times. In the Jamaica Bay Planning Region, under the recommended plan, restoration would contribute to more natural hydrology and hydraulics by creating more resilient shorelines, channel banks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, negligible, short-term disruption of local wave and current regimes, hydrology, and stormwater runoff from in-water offshore, nearshore, shoreline, or onshore earthmoving activities and temporary structures. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term improvements in regulation of water flow, storm surge and flood buffering, and wave attenuation, and/or shoreline protection and stormwater runoff control.
Fresh Creek	• Restoring basins would improve dissolved oxygen throughout the water column by improving flushing of the entire basin.
Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	• During construction, negligible, short-term disruption of local wave and current regimes, hydrology, and stormwater runoff from in-water nearshore, shoreline, and onshore earthmoving activities and temporary structures. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term improvements in regulation of water flow, storm surge and flood buffering, wave attenuation, shoreline protection, and stormwater runoff control.
Head of Jamaica Bay	• During construction, negligible, short-term disruption of local wave and current regimes, and hydrology from offshore construction of oyster beds and installing super trays. • BMPs employed to minimize erosion and sedimentation. • Long-term improvements in regulation of water flow, storm surge and flood buffering, and wave attenuation.

5.2.3 Vegetation

Under the no action alternative, we expect demise and degradation of terrestrial, emergent, and aquatic plant communities beyond the existing condition. This is due largely to continued erosional forces, rising sea levels, anthropogenic disturbances, and further expansion and colonization of invasive plant species. In the absence of estuarine habitat restoration, it is anticipated that invasive species would continue to dominate and expand throughout the proposed sites, resulting in the ongoing loss of estuarine wetlands. Currently only two of five recommended marsh islands are above surface water. Without restoration, it is estimates that these islands would lose substantial areas of salt marsh due to erosion and SLR, disappearing completely by the end of the 50 year planning horizon.

In the short term, construction associated with implementation of the recommended plan would remove or disturb existing vegetation. The impact footprint would include the restoration area, construction yards, temporary access roads, and dredge sites and resulting sediment plumes. Subsequent to completion of construction, disturbed areas would be planted and seeded in order to mitigate any impacts. Onshore construction activities and dredging and soil deposition would likely cause short-term release or resuspension of sediments in Jamaica Bay and a concomitant short-term increase in turbidity. This increase in turbidity could have a short-term, negative impact on aquatic macrophytes (Erftemeijer and Lewis, 2006). BMPs such as hay bales and/or erosion control fabric and floating turbidity barriers would be installed prior to and maintained throughout construction to prevent and/or minimize temporary increases in turbidity.

Restoration involving habitat modification would result in some long-term, habitat-specific vegetation trade-offs. Activities of this nature include lowering elevations for coastal marsh restoration. There would also be a permanent elimination of any submerged aquatic macrophytes in bay bottom areas targeted for deposition of fill for marsh island enlargement, conversion of mudflat to salt marsh, and for oyster restoration. However, the increases in new habitat from restoration activities are expected to outweigh any loss of existing habitat.

Estuaries and coasts, in general, and restored ecosystems in particular, are prone to introductions of nonnative species (Kettenring and Adams, 2011; Williams and Grosholz, 2008). Restoration plantings, soil inputs, vegetation clearing, construction-related disturbance, or incomplete habitat conversion may facilitate colonization of invasive plant species. Wetlands are often prone to invasion due to high levels of resources—e.g., high fertility and high moisture. Additionally, exotic species may be the first to colonize after a planned disturbance even if they were not present in the pre-disturbance community and may alter successional processes that would otherwise lead to a native assemblage. Removal of invasive species may also adversely alter some ecological processes, such as reducing native plant pollinator levels (Carvaleiro et al., 2008) and denitrification services (Findlay et al., 2003). If herbicides are employed for invasive species removal, there is a possibility of residual herbicidal impacts on newly transplanted vegetation (Cornish and Burgin, 2005).

Implementation of vegetation components of the recommended plan would include restoration of approximately 295.5 acres of various native plant communities within the Jamaica Bay Planning Region. Restoration of these communities likely would cause a qualitative improvement of their biodiversity and ecological services (Rey-Benayas et al., 2009; Duffy, 2009). The resilience of the Jamaica Bay ecosystem would be enhanced due to an increase in regulating ecological services, which can attenuate the impact of shocks on ecosystems. The reduction or elimination of nonnative plant species would enhance native biodiversity and ecological community functioning, and the restored habitats would provide for an increased diversity of plant species, in part by exporting native seed to nearby habitats. Likewise, increasing the size of habitat patches would promote higher levels of biodiversity (Gilbert-Norton et al., 2010; Damschen and Brudvig, 2012; Beninde et al., 2015).

The District will incorporate native species, where practicable, in design plans for all sites. Design optimization will be coordinated, to the extent possible, with the USFWS during PED (see FWCAR in the Regulatory Appendix).

Restoration of tidal channels and basins would improve tidal flushing and natural salinity regimes, which may 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. Restoration of oyster beds would provide water filtration and an attendant reduction in turbidity (Coen et al., 2007), which would provide long-term benefits to aquatic macrophytes.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term disturbance of existing terrestrial and aquatic vegetation. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, or control stormwater runoff. • Negligible, long-term removal of existing terrestrial and/or aquatic vegetation, and disruption of associated ecosystem services. Risk of minor, long-term establishment or reestablishment of invasive, nonnative vegetation. • For estuarine habitat and marsh island restoration, long-term improvement of terrestrial vegetation community biodiversity and associated ecosystem services. • For oyster restoration, long-term benefit to aquatic vegetation through water filtration and turbidity reduction.

5.2.4 Finfish

Under the no action alternative it is anticipated that fish habitats and nursery grounds in the estuarine habitat and marsh island restoration sites would decline from the existing condition. Estuarine marshes serve as nursery, feeding, and spawning sites, as well as refuge from predators; these benefit are removed from the system as the bays estuarine and marsh islands disappear. Without action, finfish would not be able to benefit from the additional habitat and prey from the restoration of oyster habitat at the Head of Jamaica Bay. The loss of the marsh buffers and increased sediment suspension from increased shoreline erosion and flooding will also be detrimental to finfish. Some localized water quality impacts from stormwater runoff, and anthropogenic inputs, such as landfill leachate and illegal dumping are expected in the no action scenario; however, effects are expected to be offset by NYCDEP commitments to CSO Long Term Control Plans, water quality improvements, and landfill rehabilitation.

Under the recommended plan, construction associated with in-water and onshore restoration would result in short-term, negative impacts to fish. Fish may be displaced due to noise, changes in currents or stream flow, and changes in water quality, including increases in turbidity from onshore construction activities and dredging. Suspension or resuspension of sediments or other materials may be injurious to fish, provide less suitable nursery habitats, or reduce hatching success and larvae development (Auld and Schubel, 1978; Wilber and Clarke, 2001; Bilkovic, 2011). Reduced water clarity can also affect fish by interfering with their ability to feed or by changing the composition of prey species (Newcombe and MacDonald, 1991). On land, silt fences and other BMPs would be employed to reduce runoff into waterways. As appropriate, silt curtains or cofferdams may be used to minimize sediment transport in open water areas. Short-term, negative impacts to fish populations also would occur if construction activities deterred fish from using essential migratory pathways, breeding, foraging, or seeking shelter from predators. However, under the recommended plan, construction effects would have primarily short-term, localized influence and fish would return to the area shortly after the cessation of construction activities. These short-term adverse effects would be outweighed by substantive long-term benefits.

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, also would contribute to an improved habitat for fish (Dibble and Meyerson, 2012). Shoreline stabilization would 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. The District will continue coordination with NOAA, NJDFW, and NYSDEC to protect migrating, overwintering, and/or spawning fish species.

Restoration Sites	Potential Environmental Consequences*
All Sites	• BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Long-term positive impacts to fish from improved water quality and provision of forage, spawning, nursery, and refuge habitat.
Dead Horse Bay Fresh Creek Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	• During construction, negligible, short-term local displacement of fish due to noise, changes in currents or stream flow, and water quality impact, including increased turbidity. • Negligible, short-term, local adverse effects to managed and associated species.
Head of Jamaica Bay	• During construction, negligible, short-term local displacement of fish due to offshore construction of oyster beds and installing super trays.

Restoration Sites	Potential Environmental Consequences*
	• Negligible, short-term, local negative impacts to fish from water quality impact, including increased turbidity. • Negligible, short-term, local adverse effect to managed and associated species.

5.2.5 Essential Fish Habitat

Under the no action alternative it is anticipated that fish habitats and nursery grounds in the estuarine habitat and marsh island restoration sites would decline further from the existing condition. As stated above, the species benefits derived from estuarine marsh habitat are removed as the bays estuarine and marsh islands disappear. Without action, finfish would not benefit from the additional habitat and prey from the oyster reef restoration at the Head of Jamaica Bay. Loss of the marsh buffer and increased sediment suspension from shoreline erosion may create a habitat that is unhospitable to finfish. Some localized water quality impacts from stormwater runoff, and anthropogenic inputs, such as landfill leachate and illegal dumping are expected in the no action scenario; however, effects are expected to be offset by NYCDEP commitments to CSO Long Term Control Plans, water quality improvements, and landfill rehabilitation.

With respect to EFH, construction activities under the recommended plan would employ BMPs to reduce construction impacts. A minor increase in turbidity and sedimentation would be generated by the proposed construction activities. BMPs would be employed to reduce runoff into waterways and to minimize sediment transport in open water areas. If eggs and larvae are present during construction, they could be affected. During the construction period, adult and juvenile fish would leave the area of construction and move to nearby suitable locations outside the area of disturbance. Also, for a short period of time after construction, there would be a reduction in benthic organisms immediately adjacent to the in-water construction footprint; however, this area would be recolonized quickly.

In the long term, due to marsh island and tidal channel restoration, and shoreline armoring, adverse effects would result from the removal of water column and benthic EFH. Given that these impacts would occur over comparatively small, discrete areas and would not adversely impact local water flow and circulation, implementation of the recommended plan may affect EFH but is not likely to adversely effects EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. On balance, however, it is anticipated that ecosystem restoration would result in long-term, net benefits to managed species (all life stages), associated species, and EFH (Appendix F).

In a letter dated April 13, 2018, the NMFS agreed with the USACE assessment that the implementation of the ecosystem restoration plan will result in long-term, net benefits to many federally managed species, their essential fish habitat, as well as many other NOAA trust resources (see Regulatory Appendix for correspondence). NMFS acknowledged that impacts to EFH could be temporary, due to construction activities, or result from permanent changes in habitat type. USACE and NMFS agreed to continued coordination and to evaluate impacts through site-specific EFH consultations as more detailed plans are developed for each action during the PED Phase.

Agency consultation for federally listed threatened and endangered marine species is discussed in Section 5.2.8.

Restoration Sites	Potential Environmental Consequences*
All Sites	• BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • On balance, long-term benefits to EFH.
Dead Horse Bay Fresh Creek Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	• During construction, negligible, short-term local displacement of fish due to noise, changes in currents or stream flow, and water quality impact, including increased turbidity. • Negligible, short-term, local adverse effect to EFH.
Head of Jamaica Bay	• During construction, negligible, short-term local displacement of fish due to offshore construction of oyster beds and installing super trays. • Negligible, short-term, local negative impacts to fish from water quality impact, including increased turbidity. Negligible, short-term, local adverse effect to EFH.

5.2.6 Shellfish and Benthic Resources

Under the no action alternative it is anticipated that shellfish and benthic resources habitats in the estuarine habitat and marsh island restoration sites would decline further from the existing condition. Estuarine marshes provide critical habitat for and a greater abundance and variability of both shellfish and benthic organisms. These benefits are removed from the system in the no action scenario as the estuarine and marsh islands continue to disappear from the bay. Similarly, shellfish and benthic populations would not benefit from the additional habitat brought about by the restoration of an oyster reef at the Head of Jamaica Bay. The loss of the marsh buffer and increased sediment suspension from shoreline erosion and flooding may create an environment which is inhospitable to shellfish and certain benthic organisms.

Restoration of the estuarine and marsh island habitats would have an overall beneficial effect on shellfish and macroinvertebrates that utilize the project area. Once construction is complete additional habitat would be available for these species. Tidal creeks constructed during the estuarine habitat restoration would provide additional shellfish and benthic habitat. Also by improving water quality at Fresh Creek and improving the bottom habitat characteristics, benthic habitat is expected to greatly improve its long-term sustainability.

The projects may have temporary impacts on local shellfish and benthic macroinvertebrate populations during construction, principally through an increase in sedimentation and turbidity. BMPs would be employed to reduce runoff into waterways and to minimize sediment transport in open water areas. However, due to the poor habitat quality that exists and the low species numbers found at the sites during sampling, the impact is not expected to result in a significant loss of species and re-colonization is expected to begin quickly after completion of the construction and flourish under improved sediment and water quality.

Wetlands restoration would improve long-term water quality in Jamaica Bay and, therefore, would provide enhanced environments for invertebrates. Tidal channel and basin restoration would improve tidal flushing, which likewise would contribute to improved habitat for shellfish (Portnoy and Allen, 2006). Also in the long term, oyster restoration would provide suitable habitat for other shellfish species (Steimle and Zetlin, 2000; Peterson et al., 2003; Scyphers et al., 2011). Increases in intertidal and subtidal habitat acreage, establishment of native tidal wetland vegetation, improved tidal connectivity and flushing, and improved sediment and water quality would result in a more diverse and abundant benthic invertebrate resource.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term negative impacts from benthic invertebrate mortality in areas undergoing aquatic habitat conversion or restoration, typically with rapid recovery expected. • Negligible, short-term, local negative impacts to benthic invertebrates from water quality impact, including increased turbidity. • BMPs employed to minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term positive impacts to shellfish and micro invertebrates from improved water quality and habitat restoration.
Head of Jamaica Bay	• Long-term positive impacts to shellfish from oyster habitat restoration.

5.2.7 Wildlife

Under the no action alternative, wildlife abundance and diversity would continue along a similar trajectory to the existing condition in the estuarine habitat restoration sites. This is primarily due to the low ecological value of the invasive species dominated sites, ATV use, and dumping of construction debris. Continued loss of salt marsh habitat in the marsh islands and estuarine habitat restoration sites would decrease the availability of suitable habitat for marine and avian wildlife in the region.

Construction associated with estuarine habitat and marsh island restoration in Jamaica Bay would result in both adverse and beneficial effects on mammals; although, adverse impacts are anticipated be short term and minor. Short-term impacts from construction include species displacement and the potential for species mortality. Muskrats and other small mammal species that are associated with surface waters, wetlands, or coastal habitats could be displaced to nearby comparable habitats but dens, nesting areas and individuals may be harmed or destroyed during construction activities. Harbor seals might avoid construction areas in Jamaica Bay because of the environmental disturbance (noise, turbidity, increased traffic, and human presence) associated with construction. Potential long-term impacts include changes to habitat type and disturbances associated with increased public access. These impacts are likely to be offset by increases in habitat, as well as habitat enhancement. No population-level effects are expected.

Some negative short-term impacts on bird species that utilize scrub uplands or marsh may result from operation of construction equipment. The Migratory Bird Treaty Act (MBTA) requires a restriction on shrub and tree removal during construction activities to protect bird species that may potentially nest within the project areas. In order to comply with the MBTA, trees and shrubs will be cleared outside of a March 15 through July 31 (NJDEP, 2006) window to avoid adverse impacts to the listed species that are covered under this act. In October 2019, the USACE determined that construction of the Jamaica Bay sites will have no effect on the 60 species of migratory birds that may occur within the vicinity of the restoration sites.

Reptiles and amphibians resident to the project sites and in the immediate vicinity will be susceptible to the same kinds of disturbance factors as previously described for mammals, birds and fish. However, many reptile and amphibian species are much less capable of disbursing quickly, or to distances that remove them to habitats unaffected by project activities. Many will simply try and hide. Thus, the threat of direct adverse impacts due to active construction may be greater to reptile and amphibian species initially inhabiting or utilizing the project site. However, once the restoration has been completed, the new, restored or enhanced habitats will have a long-term beneficial impact on reptiles and amphibians that could result in measureable differences in the size and distribution of reptile and amphibian populations.

Construction associated with small-scale oyster restoration at Head of Jamaica Bay would not impact terrestrial wildlife, as restoration would occur from the water. However, construction activities may result in mortality among sessile and less mobile aquatic fauna. Some aquatic wildlife may be displaced temporarily, but eventually would populate or return to using the restored habitats. BMPs would be employed to minimize sedimentation that would impact aquatic wildlife.

In the long term, restoration that involves habitat alteration would restore conditions more favorable for certain wildlife groups and species, and uninhabitable or more challenging to others. Overall, however, restored habitats would be higher in quality and function than the existing habitats they replace. For a myriad of wildlife, restored habitats would provide refugia—i.e., habitats that, under changing environmental conditions, the wildlife retreat to, persist in, and potentially can expand from (Askins and Philbrick, 1987; Keppel et al., 2012; Soga et al., 2014). In particular, restoring aquatic, wetland, and upland habitats by removing invasive vegetation, planting native vegetation, and improving hydrology and connectivity would benefit wildlife. With the growth and maturation of restored habitats, wildlife communities of greater diversity and ecological value are anticipated.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term negative impacts from mortality of sessile wildlife in areas undergoing habitat conversion or restoration. • Negligible, short-term local displacement of mobile wildlife due to habitat alteration, and construction-related noise and human activity, with rapid recovery expected. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Long-term positive impacts to wildlife from establishment of higher-quality habitats and refugia.

5.2.8 Rare, Threatened, and Endangered Species

Under the no action alternative, impacts to rare, threatened and endangered species are expected to be a continuation of the existing conditions. Sustained pressure on rare species is anticipated due to displacement by nonnative species and continued loss and degradation of habitats from rising sea levels, erosion, and anthropogenic disturbances.

In the short term, construction associated with implementation of the recommended plan potentially could displace or disturb rare, threatened, and endangered species on or in the vicinity of the restoration sites. Such effects would result from clearing vegetation, changes in currents or stream flow, changes in water quality, including increases in turbidity, and construction-related noise and human activity.

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species, and species of special concern within the Jamaica Bay Planning Region project sites and their vicinities. The United States Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) were contacted regarding federally listed threatened and endangered species under the Endangered Species Act (ESA), while the New York State Department of Environmental Conservation (NYSDEC) Division of Fish, Wildlife, and Marine Resources was contacted regarding state listed species in the New York Natural Heritage Program (NYNHP). Numerous endangered, threatened, or rare plant and animal species exist within the boundaries of the bay, and correspondences with the agencies can be found in the Regulatory Appendix F. Prior to restoration activities, onsite surveys will be conducted at each restoration site to fully assess any potential impacts on biological resources and confirm whether any documented species are present in restoration areas. If rare, threatened, and endangered species are confirmed at the sites and could be adversely impacted by restoration activities, precautions will be taken to avoid, minimize, or mitigate the impacts as determined by the appropriate agency.

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. Disruptions to marine wildlife are expected to be insignificant and short-term during construction, and BMPs would be employed to minimize impacts from suspended sediments. If construction activities are determined to make the water habitat unsuitable for wildlife, the use of timing restrictions or noise attenuating tools will be implemented. USACE determined that construction at Dead Horse Bay, Fresh Creek, and Head of Jamaica Bay would have no effect on the listed species and that construction at the marsh island sites may affect, but is not likely to adversely affect (NLAA), listed species (October 2019). NMFS concurred with the USACE NLAA determination for the marsh island restoration sites on October 29, 2019. The District will continue to consult with NMFS with regard to any potential impacts to threatened and endangered species. Summary tables of the Threatened and Endangered species identified by NMFS and USFWS can be seen in Tables 5-1 and 5-2. See Regulatory Appendix F for additional analysis.

Table 5-1. Determination for NMFS identified Threatened and Endangered species for the Jamaica Bay planning region.

Restoration Site	NMFS Threatened and Endangered Species		
	Sea Turtles*	Atlantic Sturgeon	Shortnose Sturgeon
Jamaica Bay Planning Region			
Dead Horse Bay	No effect	No effect	No effect
Fresh Creek	No effect	No effect	No effect
Duck Point	NLAA	NLAA	
Stony Creek	NLAA	NLAA	
Pumpkin Patch West	NLAA	NLAA	
Pumpkin Patch East	NLAA	NLAA	
Elders Center	NLAA	NLAA	
Head of Jamaica Bay	No effect	No effect	No effect
*Loggerhead (*Caretta caretta),* North Atlantic DPS of green (*Chelonia mydas)*, Kemp's ridley (*Lepidochelys kempii*), and leatherback (*Dermochelys coriacea*)			

The NYNHP identified several rare, federal- or state-listed bird species on or within one-half mile of potential restoration sites (April 15, 2016 and May 31, 2016 correspondence). 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)* as bird species that could potentially be affected by construction activities, as well as seabeach amaranth (*Amaranthus pumilus*). As most of these species are highly mobile and capable of avoiding construction activities, disturbance would be short-term and localized. For some species, construction buffers and/or timing restrictions would be employed during nesting season, which typically occurs between March and August. In coordination with USFWS, the District will conduct pre-construction monitoring for red knot.

USACE determined that construction of the Jamaica Bay sites would have no effect on piping plover, roseate tern, or seabeach amaranth. Additionally, USACE determined that construction at all Jamaica Bay sites with the exception of the Head of Jamaica Bay oyster restoration, may affect, but is not likely to adversely affect red knot (October, 2019). USFWS concurred with the USACE ESA and NLAA determinations on March 2, 2020, SLOPES forms and accompanying analysis are located in Regulatory Appendix F.

Table 5-2. Determination for USFWS identified Threatened and Endangered species within the Jamaica Bay Planning Region.

Restoration Site	USFWS Threatened and Endangered Species				
	Piping Plover	Red Knot	Roseate Tern	Seabeach Amaranth	Migratory Birds
Jamaica Bay Planning Region					
Dead Horse Bay	No effect	NLAA	No effect	No effect	No effect
Fresh Creek	No effect	NLAA	No effect	No effect	No effect
Duck Point	No effect	NLAA	No effect	No effect	No effect
Stony Creek	No effect	NLAA	No effect	No effect	No effect
Pumpkin Patch West	No effect	NLAA	No effect	No effect	No effect
Pumpkin Patch East	No effect	NLAA	No effect	No effect	No effect
Elders Center	No effect	NLAA	No effect	No effect	No effect
Head of Jamaica Bay	No effect	No effect	No effect	No effect	No effect

The USFWS FWCAR (Appendix F) noted that the butterfly species white-m hairstreak (*Parrhasius m-album)* and red-banded hairstreak (*Calycopis cecrops)* were observed in Floyd Bennett Field near Dead Horse Bay. As these species are mobile, except for the larval stage, they would not be expected to be affected by restoration activities and restoration of Dead Horse Bay would provide additional habitat for the butterflies to prosper.

The low salt marsh found throughout Jamaica Bay is considered a significant natural community of high ecological and conservation value. New York state-listed vascular plants were documented at or near the Dead Horse Bay and the Head of Jamaica Bay restoration sites. Prior to construction activities, these sites will be surveyed for the existence of the plants. If listed plants are found, measures will be taken to avoid disturbance, such as fencing and signage placed around the plants.

As the restoration goals include restoring, and protecting wildlife habitat, impacts to rare, threatened, and endangered species are expected to be short-term and insignificant. In the long term, implementation of the recommended plan would benefit rare, threatened, and endangered species by increasing favorable habitat and improving the quality of existing habitat.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Long-term positive impacts to rare, threatened, or endangered species from habitat and ecosystem restoration. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Implement appropriate protective measures for NLAA species.

5.2.9 Land Use

The proposed restoration sites in the Jamaica Bay Planning Region are on existing open land owned by various agencies including National Park Service (NPS), New York City Department of Parks and Recreation (NYC Parks), and New York State Office of Parks, Recreation, and Historic Preservation (NYSOPRHP). No permanent housing exists on these sites. Under the no action alternative, no changes to the land use of the estuarine habitat, marsh islands, or oyster restoration sites are planned. Without measures put in place as part of the restoration, the Fresh Creek estuarine habitat site would continue to be degraded by anthropogenic threats from ATV use or onsite dumping of debris.

Implementation of the recommended plan at each site would not change the existing land use of the site. The sites would remain in the same ownership with public access remaining similar to or better than existing conditions.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Implementation of the recommended plan at each site would not change the existing land use of the site.

5.2.10 Hazardous, Toxic, and Radioactive Waste

The no action alternative would have minimal impact on HTRW at the recommended sites (with the exception of Dead Horse Bay) in the Jamaica Bay Planning Region. It is expected that the HTRW status would be more or less a continuation of the existing condition at the estuarine habitat restoration sites; there is no known existing HTRW at the Jamaica Bay Marsh Islands. The NPS removal action planned for the landfill at Dead Horse Bay South will improve contaminant inputs into Jamaica Bay. Jamaica Bay sediments often have high amounts of trace metals and other contaminants derived from a combination of sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed area. NYCDEP has made future commitments to Jamaica Bays CSO Long Term Control Program along with landfill rehabilitation, which is expected to benefit ongoing and existing inputs.

Dead Horse Bay is a “Tier 2” due to NPS’s current CERCLA response actions. All remedial actions and engineering controls would be identified during the NPS Investigation. Since the project no longer considers Dead Horse Bay South as part of the recommendation the restoration of the landfill is no longer a concern. However, soil excavated from Dead Horse Bay North will be placed on Dead Horse Bay South in coordination with NPS following soil testing and acceptability. Any additional costs associated with addressing unacceptable contamination would be paid for 100% by the non-federal sponsor (or Potential Responsible Party in coordination with NPS). This site continues to be a high priority for many agencies in the region as illustrated by the formation of a Multi-Agency Steering Committee. Thus, this site is within the recommended plan but may require remediation prior to restoration similar to the Oak Island Yard site in the Lower Passaic River.

At all sites, soils to be removed are fill soils that have been placed along the shorelines in the past, burying salt marsh, mudflat and shallow water communities that occupied the areas before.

Hazardous, toxic, and radioactive waste reports for these areas show minimal contamination, typical of ambient levels found in urban contexts, with most fill comprising sands dredged from the bay. Re-contouring the land would not place contaminated soils onto clean soils, rather it is expected that similar soils and contaminant levels exist throughout the sites. Moreover, restoration plans include placement of a clean planting growing media following soil/sediment regrading on each site. Further contaminant testing will be conducted during the Preconstruction Engineering and Design (PED) phase. The removal of any soil or sediment would be accomplished with the use of appropriate BMPs to limit and/or eliminate the transport of materials during construction by alluvial and/or aeolian forces.

In the long term, restoring wetlands and maritime forest, armoring and stabilizing shorelines, and establishing oyster habitat would improve water quality and provide nutrient removal and denitrification services. Improved tidal flushing and reduced water residency time, due to restoring tidal channels and basins, would increase dissolved oxygen levels and reduce fecal coliform levels (Portnoy and Allen, 2006). Restored wetlands likewise would improve tidal flushing and increase dissolved oxygen levels.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, risk of local water quality impact from construction-related, accidental spills. • Safeguards employed to prevent and respond to spills. • Long-term surface water quality improvements—i.e., increased turbidity reduction, nutrient removal, and denitrification, and/or increased dissolved oxygen levels and reduced fecal coliform levels.
Dead Horse Bay	• Removal of landfill may require investigation and special handling and disposal of fill.

5.2.11 Noise

The no action alternative would have minimal impact to noise at the recommended sites. Restoration would not take place and short-term increases in ambient noise levels due to construction activities would not occur. Population growth and increased use of railways and roadways in the region may cause noise levels to rise in the future.

At each of the Jamaica Bay Planning Region restoration sites there would be a temporary increase in noise levels in the immediate project area during construction due to the increase in traffic and the operation of construction equipment. However, these impacts are expected to be short-term. The temporary impacts to ambient noise levels from construction equipment would occur during normal working hours, in compliance with local noise ordinances. The recommended plan would not negatively impact long-term ambient noise levels at any of the restoration sites. In the long term, sites with maritime forest restoration, such as Dead Horse Bay and Fresh Creek, mature trees may even create a natural buffer to reduce ambient noise levels.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Short-term increases in noise levels from construction equipment would occur during normal daytime working hours. • Implementation of the recommended plan at each site would not cause any negative long-term noise impacts.
Dead Horse Bay Fresh Creek	• Long-term potential to reduce ambient long-term noise when trees mature in maritime forest.

5.2.12 Social and Economic Resources

The no action alternative would have minimal impact to social and economic resources at the recommended sites. Construction activities would not take place and changes to social and economic resources would not occur. The degraded condition of the Jamaica Bay ecosystem would continue into the future, decreasing public access and recreational opportunities in the planning region, and potentially adversely affecting social and economic resources.

Restoration under the recommended plan would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education. As no permanent jobs will be created, there are no anticipated long-term effects to the local economy or income and there would be no increase in housing demands.

Larger populations of waterbirds in Jamaica Bay and throughout the planning region, particularly in the vicinity of John F. Kennedy International Airport, could lead to a greater potential for bird-aircraft strikes, potentially requiring increased expenditures by the Port Authority of New York and New Jersey (PANYNJ) to mitigate the heightened hazard. Due to the increasing concern regarding aircraft-wildlife strikes, the Federal Aviation Administration (FAA) has implemented standards, practices, and recommendations for holders of Airport Operating Certificates issued under Title 14, CFR, Part 139, Certification of Airports, Subpart D (Part 139), to comply with the wildlife hazard management requirements of Part 139. Airports that have received federal grant-in-aid assistance must use these standards. In accordance with the FAA Advisory Circular 150/5200-33B and the Memorandum of Agreement with FAA to address aircraft-wildlife strikes, when considering proposed flood risk management measures and mitigation (and restoration) areas, USACE must take into account whether the proposed action could increase wildlife hazards.

The FAA recommends minimum separation criteria for land-use practices that attract hazardous wildlife to the vicinity of airports. These criteria include land uses that cause movement of hazardous wildlife onto, into, or across the airport's approach or departure airspace or air operations area (AOA). These separation criteria include:

- Perimeter A: For airports serving piston-powered aircraft, hazardous wildlife attractants must be 5,000 feet from the nearest AOA
- Perimeter B: For airports serving turbine-powered aircraft, hazardous wildlife attractants must be 10,000 feet from the nearest AOA; and
- Perimeter C: Five-mile range to protect approach, departure, and circling airspace.

Head of Jamaica Bay, Stony Creek, Duck Point, Elders Center, Pumpkin Patch East, and Pumpkin Patch West are within the limits of the five-mile perimeter of John F. Kennedy International Airport. The proposed plans for these sites include habitats that were designed as feeding habitats only so as to not to introduce additional hazardous wildlife into the area. Consultation with the FAA took place on September 6, 2018, and initial site descriptions and coordination plan were sent on November 19, 2018 to the FAA. USACE received a letter from the FAA on February 25, 2019 stating that the FAA had no major wildlife concerns with the project. See the Regulatory Appendix F for correspondence. Coordination with the FAA will continue through PED.

At the scale of the HRE study area, improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Increased shoreline stabilization may reduce municipal expenditures, including those for emergency services. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term increases in local employment, earnings, induced spending, and tax revenues, and provision of educational opportunities.
Dead Horse Bay Fresh Creek	• Combined total first cost of approximately $74,665,000. • Negligible, long-term increased expenditures to mitigate heightened bird-aircraft strike hazard. • Provides potential educational opportunities.
Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center	• Combined total first cost of approximately $105,909,000. • Long-term stimulation of the local economy and provision of educational opportunities.
Head of Jamaica Bay	• Total first cost of approximately $5,684,000. • Provides provision of educational opportunities.

5.2.13 Navigation

The no action alternative would have no impact to navigation at the recommended sites. Under the no action alternative, no restoration will occur and no changes or impacts to navigation would occur.

The recommended plan at most of the sites would have no long-term impact on navigation near the project site, as construction and planting activities do not involve the neighboring waterways. Based on 2017 Automatic Identification System (AIS) vessel transit counts (https://portal.midatlanticocean.org), Fresh Creek is a low use channel (3 trips total in 2017) for AIS carrying vessels. Additionally, impacts to large vessels in Fresh Creek is limited to the head of basin only and the creek would still be accessible. Therefore, it is assumed that minor impacts would be caused by areas of permanent restricted access for large vessels in Fresh Creek.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minimal, short-term limitations to local boat craft during construction activities.
Fresh Creek	• Negligible, long-term impact due to filling head of creek to intertidal marsh, limiting boat traffic to small craft.

The proposed restoration sites are close to Federal and recreational channels making them, and construction vessels, susceptible to wake and/or surge damage. During construction, coordination with the First Coast Guard District (Sector New York) will be required for publication in the Local Notice to Mariners before starting operations and if needed, request the movement of any Federal Channel marker buoys.

Construction activities for the recommended plans may create short-term limitations to the local recreational vessel traffic due to BMPs (e.g. silt curtains) which will curtail suspended sediments. These would be minimal, of short durations and likely not affect the full span of the waterways at one time.

5.2.14 Recreation

The no action alternative would have minimal impact to recreation at the recommended sites. Erosion and short-term construction impacts would not occur; however, long-term improvements to passive recreational activities from enhanced wildlife and viewing opportunities at the estuarine habitat restoration and marsh island sites would also not occur.

The recommended plan would have very minor temporary construction-related impacts on existing recreational resources. At sites which currently offer recreational resources, there may be adverse temporary impacts during construction due to the closing of the interior footpaths and some fishing access. However, construction would be phased to occur during the colder winter months when the paths are not as heavily utilized. Boat activity would not be substantially impacted at most sites during construction, with the exception of Fresh Creek.

After the recommended plan is implemented, there would be positive impacts to the recreational and educational features of the sites. Improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would increase activities such as fishing, hiking, boating, and bird watching. The interior walking trails would be reestablished but would traverse a much more diverse landscape with enhanced wildlife habitat and viewing opportunities. The bike trail would remain in the same location but would also overlook a diverse salt marsh landscape with an increased possibility of viewing waterfowl and other wildlife. The recommended plan would restore native plant communities and place boulders (permanent barriers) along the landside boundary of the site as a blockade to motorized vehicles.

The head of Fresh Creek would be filled to intertidal marsh, thus permanently limiting boat traffic to only small craft such as canoes and kayaks. However, the impacts to the head waters above the marinas are expected to be negligible as deeper draft recreational crafts generally do not venture into the head of creeks since the bay proper is the destination of the vast majority of larger craft. The recommended plan may provide additional points of access into the salt marsh by canoe or kayak through the tidal creeks.

Public outreach to the recreational boating and fishing vessel industries will be undertaken to ensure maximum visibility of the restoration activities within the action area.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts from limited access to recreational resources during construction. • Long-term improvement in recreational opportunities for wildlife viewing, hiking, recreational fishing, kayaking, and canoeing through habitat improvement.
Fresh Creek	• Minor impacts caused by areas of permanent restricted access for larger vessels.

5.2.15 Cultural Resources

Under the no action alternative impacts to cultural resources are expected to be minimal; however, loss of historic resources due to SLR and erosion could occur.

Under the action alternative, there is a potential to cause adverse effect to historic properties from excavation or material placement over the resources. As an initial look into the effects of the action alternative, a desktop search was completed of the known cultural resources in and around the recommended sites. This desktop search found that no known cultural resources are located within the eight restoration sites located in the Jamaica Bay Planning Region. Within one mile of the restoration sites there are one historic property and ten archeological sites (Table 2). The next step is to survey the Areas of Potential Affect (APEs) to find if any cultural resources are present that have not yet been recorded. To carry out this work, the USACE entered into a Programmatic Agreement (PA) with the Advisory Council on Historic Preservation, New York State Historic Preservation Office, New Jersey State Historic Preservation Office, New York City

Landmarks Preservation Commission and National Park Service (see Appendix H) that stipulates the actions the USACE will take to satisfy its responsibilities under Section 106 of the National Historic Preservation Act and other applicable laws and regulations. Pursuant to the PA, archaeological survey work will take place in the Preconstruction Engineering and Design Phase. Since this survey work has not yet been carried out, the full effects the recommended plan will have on cultural resources is not yet known.

Some cultural resources work was previously done for the source studies and a preliminary analysis for the HRE study area. This work covered some of the APE of the recommended plan, and gave recommendations for future work in these areas. This previous work will inform the future cultural resources work that will be carried out pursuant to the PA, and when appropriate, the recommendations from the previous investigations will be followed. Below is a listing of the reports:

- *Cultural Resources Baseline Study, Jamaica Bay Ecosystem Restoration Project, Kings, Queens, and Nassau Counties, New York (Panamerican Consultants Inc., 2003);*
- *Phase IA Documentary Study for the Jamaica Bay Islands Ecosystem Restoration Project, Kings and Queens Counties, New York (Panamerican Consultants Inc., 2004);*
- *Phase IB Investigation of Bayswater State Park and Paerdegat Basin, Jamaica Bay Ecosystem Restoration Project, Kings, Queens, and Nassau Counties, New York (Panamerican Consultants Inc., 2006); and*
- *Cultural Resources Overview for the Hudson-Raritan Estuary Comprehensive Restoration Plan (Harris et al., 2014).*

Table 5-3. Historic Properties Located within or Nearby the Recommended Restoration Sites in the Jamaica Bay Planning Region.

Restoration Sites	Historic Properties Identified
All Sites	• Additional survey is required under the stipulations of the PA to determine whether resources are present within the project area. • Mitigation would be required for impacts to significant resources.
Dead Horse Bay	• One (1) historic property (Floyd Bennett Field) is within one (1) mile of the restoration site. • Two (2) archaeological sites were recorded within one (1) mile of the study areas. • Dead Horse Bay is considered archaeologically sensitive.
Fresh Creek	• Four (4) archaeological sites are listed near or within one (1) mile of the restoration sites. The sites are considered archaeologically sensitive.
Duck Point Pumpkin Patch West Pumpkin Patch East Elders Center	• No historic or archaeological resources are listed within one (1) mile of the restoration sites.

Restoration Sites	Historic Properties Identified
Stony Creek	• One (1) archaeological site is listed within one (1) mile of the restoration site.
Head of Jamaica Bay	• Three (3) archaeological sites are within one (1) mile of the restoration site. The site is considered archaeologically sensitive.

5.2.16 Aesthetics

The future without project conditions are anticipated to involve further expansion of invasive species and commercial and residential development pressures, which are likely to cause further aesthetic degradation to the recommended sites in the Jamaica Bay Planning Region. Erosion and illegal filling/dumping at the estuarine habitat restoration sites is also expected to continue, causing further degradation of the habitat and loss of wetlands. Further loss of marsh islands to erosion would reduce their aesthetic value.

During construction of the recommended plan there would be temporary impacts to the aesthetic and scenic resources on site due to the presence of construction equipment, vegetation clearing, and earthwork. The existing project sites do not provide a quality viewshed for the surrounding environs. A substantial amount of disturbed area is within the project site due to past fill activities. The sites are overgrown with invasive species such as common reed and mugwort. The proposed restoration would replace these invasive species with diverse vegetation including maritime forest and tidal marsh species. This would provide increased aesthetic and scenic resources.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts to aesthetic and scenic resources during construction. • Long-term improvement in scenic resource value with vegetation restoration and overall habitat improvement.

5.2.17 Coastal Zone Management

Under the no action alternative, no restoration will occur and no impacts to state or local coastal zone management plans would occur.

Restoration activities within the Jamaica Bay Planning Region were evaluated with respect to their consistency with New York State's *State Coast Policies* and New York City's *The New Waterfront Revitalization Program* and the goals are directly in line with the respective coastal zone policies. The restoration activities are consistent with state and local coastal zone management programs (Appendix F). USACE sent a coastal zone consistency determination for each site to the relevant State and city agencies for review (October 2019) and received concurrence from these agencies.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Restoration activities are consistent with state and local coastal zone management programs.

5.3 Harlem River, East River and Western Long Island Sound Planning Region

Under the future without-project condition, ongoing and planned restoration and conservation actions undertaken by agencies, municipalities and nongovernmental entities in the Harlem River, East River and Western Long Island Sound Planning Region (see Appendix B), would continue; however, no formal comprehensive program of restoration will be undertaken.

It is anticipated that without restoration there would be a further demise and degradation of existing estuarine and riverine habitats at the recommended sites, due to continuing natural erosive forces and rising sea levels, and anthropogenic stressors such as urbanization, dredging, compromised water quality, landfilling and landfill leachate intrusions, illegal dumping, and off-road vehicle traffic. Additionally, invasive plant species that dominate degraded sites would continue to pose colonization pressures to nearby native habitats. Habitat along the Bronx River and Flushing Creek would remain fractured and low-quality. However, given the intensity of development in the HRE study area, even low quality undeveloped lands have become a priority for protection.

In the absence of federal action, local programs such as NYCDEP Long Term Control Plan will seek to address the issue of water quality by working to control inputs from sewage and industrial discharge. Both Westchester County and the City of New York have extensive plans for green infrastructure along the Bronx River corridor that will help reduce, but not alleviate, the amount of stormwater run-off and sedimentation entering the river. Local green infrastructure initiatives will also help to reduce the propensity for flash flooding in the Bronx River, but these actions are expected to only partially address the flash flooding issue. The need to modify impoundments to improve water flow and fish passage along the river is recognized but unlikely to occur in the absence of federal action because of budget constraints on the County and State levels. The problem of elevated levels of lead, copper, and nickel in Bronx County soils is expected to stay unchanged in the period of analysis, as no new inputs are anticipated, but there will be no local plans to remove the contaminants without the impetus of a larger restoration project. The current acreage of wetlands is expected to remain at the current level or increase on a modest scale, as local interest in restoring wetlands is high but limited by budgetary constraints.

Implementation of the recommended plan would restore estuarine, freshwater riverine, and oyster habitat at six (6) sites in the Harlem River, East River and Western Long Island Sound Planning Region:

- **Estuarine habitat restoration** would be conducted at one (1) site, at Flushing Creek, where approximately 17.7 acres of low and high salt marsh, scrub shrub, maritime forest, tidal waterbodies and shallow water would be restored, including the elimination of invasive-dominated communities and restoration of native vegetation communities.

- **Freshwater riverine habitat restoration** would be undertaken at five (5) locations—Shoelace Park, Bronxville Lake, Garth Woods/Harney Road, Bronx Zoo and Dam, and Stone Mill Dam. Approximately 4.9 acres of emergent wetland would be restored, approximately 11.3 acres of invasive-dominated communities would be eliminated, native vegetation communities would be restored, two (2) fish ladders would be installed, and three (3) weirs would be modified for fish passage.

5.3.1 Geomorphology and Sediment Transport

Under the no action alternative, impacts to geomorphology and sediment transport at the sites recommended for restoration in the Planning Region will experience some improvements but generally continue on a similar trajectory of the existing condition. Stormwater runoff and tidal action would continue to erode soils, particularly along riverbanks or where vegetation is not well established. At the Flushing Creek estuarine habitat restoration site, the altered stream geomorphology would remain and erosion and sedimentation would continue. Without action at the freshwater riverine restoration sites along Bronx River, the existing steep flood hydrography would continue to produce sediment imbalances, streambank erosion, and channel instability. This would lead to continued filling of the ponded areas behind impoundments and bank cutting along the river. Both Westchester County and the City of New York have extensive plans for green infrastructure along the Bronx River corridor that would help reduce, but not alleviate, the amount of stormwater run-off and sedimentation entering the river. Maintenance dredging of the impounded areas along the Bronx River has not been conducted in the recent past, nor is it planned for in the future and this represents a large impediment to optimal flood storage and sediment equilibrium.

During restoration construction under the recommended plan, it is unlikely that geological resources would be impacted, as construction would occur only at very shallow depths. Local topography at the Flushing Creek restoration site would result in minimal changes to topography from regrading. Bed restoration, channel dredging and modification, streambank restoration and sediment control features at the Bronx River freshwater riverine habitat restoration sites would affect the transportation and deposition of sediments. All excavated soil will be handled and managed in accordance with applicable City, State, and Federal regulations.

Grading and earthmoving activities, dredging, and sediment resuspension from vessel movements and prop wash could result in temporary disturbances to sediment transport. Weir modification for fish passage may disturb sediments and cause the release and downstream transport of sediments retained by the structures. However, these activities and their effects would be short-term and localized. On land, silt fences and other BMPs would be employed to reduce erosion and sedimentation. As appropriate, silt curtains or cofferdams may be used to minimize sediment transport in open water areas, precluding resuspended sediments being transported by currents and forming new shoals or sandbars. Even absent these practices, such geomorphic features likely would be temporary and would disappear as the system reaches a new post-construction equilibrium. All soil erosion measures will be coordinated with USFWS.

Implementing the recommended plan at the restoration sites would restore wetlands, channels, and riparian forest, armor and stabilize shorelines, and establish native vegetation. Vegetated intertidal and riparian zones help protect adjacent areas from flood damage and maintain bank stability during flood events, and tidal marshes with natural channel configurations buffer coastal areas from storm surges and provide floodwater storage functions. Restoration would have long-term, positive effects, through attenuating wave velocities, controlling erosion, retaining sediments, and reducing sediment loads, thereby establishing more resilient shorelines, riverbanks and streambanks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, negligible, short-term local soil and sediment disturbance and sedimentation from shoreline and onshore earthmoving activities, and equipment and vehicle or vessel movement. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term erosion and sedimentation control, sediment load reduction, and/or coastal resiliency improvements.

5.3.2 Water Resources

Under the no action alternative, the planning region would experience continuing or worsening degradation of hydrologic conditions, depending on the magnitude and effects of SLR and climate change. At the Flushing Creek estuarine habitat restoration site, poor hydrologic connections, water circulation, and tidal flushing between Flushing Bay, Flushing Creek, and Meadow Lake would persist. Unchecked by engineering measures (wetlands, forebay, weir modification, dredging of impoundments) in the recommendation, flash flooding would continue to contribute to the sediment imbalance, streambank erosion, and channel instability at the recommended sites along the Bronx River. Leading to increased flooding along the Bronx River Parkway. Multiple dams and impoundments along the Bronx River create additional flow restrictions, trap sediments, and prevent fish passage. While the Bronx River Inter-municipal Watershed Management Plan indicates that impoundments should be removed or modified to improve fish passage and water flow, based on the current priorities of the county and state resources, there is no expectation that these impoundments would be modified in the absence of federal action. In the no action scenario, some improvements to water quality, beyond the existing condition, are expected through NYCDEP's CSO Long Term Control Plan at Flushing Creek and along the NYC portions of the Bronx River.

A RSLC was conducted to aid ecosystem restoration planning and SLC impact assessment of the recommended projects (see Engineering Appendix D for RSLC Analysis). Flushing Creek is expected to be impacted by SLC; however, within the 50 year period of analysis, results under the intermediate SLC curve show a growth of low marsh due to high marsh to low marsh conversion and no loss of low marsh at the lower end till the years 40-50. This is because the low end of the low marsh elevation ranges have been designed at 1 foot above mean tide level (MTL), so there is no impact till sea level rises 1 foot. After the 50 year planning horizon, the analysis predicts that preventive measures may need to be implemented to prevent drowning from SLR as there will be little room for the Flushing Creek wetland to migrate in the highly urban setting.

The District has completed a nonstationarity and inland hydrology analysis as a means of incorporating relevant information about observed and expected climate change impacts in hydrologic analyses for the recommended project at fresh water site along the Bronx River (see Engineering Appendix D). Nonstationarity can provide useful predictive ability in natural system but complications arise in highly altered systems. Inland hydrology is a more useful tool for this Planning Region and the District will conduct a more detailed analysis relative to recent inland hydrology changes during PED.

Under the recommended plan, grading and earthmoving activities, dredging, temporary construction-related structures, and resulting temporary geomorphologic features—e.g., shoals and pools—would cause short-term disruption of local streamflow, wave, and current regimes, hydrology, and stormwater runoff. These activities and their effects would be short-term and localized, and BMPs would be employed to minimize sediment transport in open water areas. A Section 404(b)(1) Guidelines Evaluation has been completed and is provided as Appendix F.

Urbanization in the Bronx River Basin has resulted in the degradation of existing riparian habitat, water quality, and channel capacity. Restoration alternatives may accommodate and provide some ancillary flood risk management benefits, but the primary goal would not be flood risk management. Ecosystem restoration opportunities would not increase flooding or present additional flood risks in the Bronx River Basin.

In the long term, bed restoration and channel modification would help reestablish beneficial flow regimes and decrease downstream velocities by restoring river and stream channels, pools, and riffles. Shoreline softening and streambank restorationwould help restore tidal and riverine hydrology, and withstand storm surges and rising sea levels. Wetlands restored under the recommended plan would provide long-term regulation of water flow, and storm surge and flood buffering, wave attenuation, and protection of shorelines, per the findings of Woodward and Wui (2001), Zelder and Kercher (2005), Koch et al. (2009), Barbier et al. (2011), Gedan et al. (2011), and Shepard et al. (2011). Expansion of forest cover and scrub/shrub habitat would provide stormwater runoff mitigation (Bolund and Hunhammar, 1999; Bonan, 2002; Neary et al., 2009) and flood control. In the Harlem River, East River and Western Long Island Sound Planning Region, under the recommended plan, restoration would contribute to more natural hydrology and hydraulics by creating more resilient shorelines, streambanks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Long-term improvements in regulation of water flow, storm surge and flood buffering, wave attenuation, shoreline protection, and stormwater runoff control. • During construction, negligible, short-term disruption of local streamflow, wave, and current regimes, hydrology, and/or

Restoration Sites	Potential Environmental Consequences*
	stormwater runoff from in-water, shoreline, and/or onshore earthmoving activities and/or temporary structures. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff.

5.3.3 Vegetation

It is anticipated that, under the no action alternative, there would be further demise or degradation of existing terrestrial, emergent, and aquatic plant communities, due to continued erosional forces, rising sea levels, anthropogenic disturbances, and further expansion and colonization of invasive plant species. The Flushing Creek estuarine habitat restoration site would continue to suffer from exposed mudflats and dominant invasive vegetation. The freshwater riverine restoration sites along Bronx River would remain degraded due to lack of riparian buffers, loss of wetlands, and dominance of invasive species. Although the Bronx River Intermunicipal Watershed Management Plan recommends wetland restoration, few specific projects are identified for restoration of these wetland areas. NYC Parks has developed a master plan for Shoelace Park; however, the predominant restoration opportunities for this park are upland forests outside of the floodplain.

In the short term, construction associated with implementation of the recommended plan would remove or disturb existing vegetation. The impact footprint would include the restoration area, construction yards, temporary access roads, and dredge sites and resulting sediment plumes. Onshore construction activities and dredging and soil deposition would likely cause short-term release or resuspension of sediments in the Bronx River and Flushing Creek and a concomitant short-term increase in turbidity. Although BMPs would be employed to reduce runoff and minimize sediment transport in open water areas, this increase in turbidity could have a short-term, negative impact on aquatic macrophytes (Erftemeijer and Lewis, 2006).

Restoration involving habitat modification would result in some long-term, habitat-specific vegetation trade-offs. Activities of this nature include lowering elevations for riverine and coastal marsh restoration.

Estuaries and coasts, in general, and restored ecosystems, in particular, are prone to introductions of nonnative species (Kettenring and Adams, 2011; Williams and Grosholz, 2008). Restoration plantings, soil inputs, vegetation clearing, construction-related disturbance, or incomplete habitat conversion may sometimes result in the colonization of invasive plant species. However, recommended plan would include invasive species removal and adaptive management plans in order to avoid or minimize invasive species colonization. Removal of invasive species may also adversely alter some ecological processes, such as reducing native plant pollinator levels (Carvaleiro et al., 2008) and reducing denitrification services (Findlay et al., 2003). If herbicides are employed for invasive species removal, there is a possibility of residual herbicidal impacts on newly transplanted vegetation (Cornish and Burgin, 2005).

Implementation of vegetation components of the recommended plan would include restoration of approximately 35 acres of various native plant communities within the Harlem River, East River and Western Long Island Sound Planning Region. Restoration of these communities likely would cause a qualitative improvement of their biodiversity and ecological services (Rey-Benayas et al., 2009; Duffy, 2009). The resilience of the Bronx River and Flushing Creek ecosystem would be enhanced due to an increase in regulating ecological services, which can attenuate the impact of shocks on ecosystems. The reduction or elimination of nonnative plant species would enhance native biodiversity and ecological community functioning, and the restored habitats would provide for an increased diversity of plant species, in part by exporting native seed to nearby habitats. Likewise, increasing the size of habitat patches would promote higher levels of biodiversity (Gilbert-Norton et al., 2010; Damschen and Brudvig, 2012; Beninde et al., 2015).

The District will incorporate native species, where practicable, in design plans for all sites. Design optimization will be coordinated, to the extent possible, with the USFWS during PED [See FWCAR (Appendix F)].

Bed restoration and channel modification, by restoring river and stream channels, pools, and riffles, would help reestablish beneficial flow regimes, which may inhibit further expansion and colonization of the invasive vegetation and may allow the establishment of native aquatic vegetation.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term disturbance of existing terrestrial and/or aquatic vegetation. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term improvement of terrestrial vegetation community biodiversity and associated ecosystem services.
All Sites (except Flushing Creek)	• Negligible, long-term removal of existing terrestrial and/or aquatic vegetation, and disruption of associated ecosystem services.

5.3.4 Finfish

Under the no action alternative, fish habitats and nursery grounds are anticipated to remain on the same trajectory as the existing condition. Fisheries resources would continue to be limited in species diversity and abundance due to poor water quality and lack of appropriate habitat at the Flushing Creek estuarine habitat restoration site. Without action, impacts to finfish in the freshwater riverine restoration sites along the Bronx River are expected to improve slightly from the existing condition due to the continuation of anadromous fish programs run by NYC Parks, NYSDEC, and local stakeholders. The need to modify additional impoundments to improve water flow and fish passage along the river is recognized but unlikely to occur in the absence of federal action because of budget constraints on the county and state levels. Although the NYC sites may experience some improvements to water quality from the NYC CSO Long Term

Management Plan, they would not benefit from the lift of coupling these improvements with restoration.

Under the recommended plan, construction associated with in-water and shoreline restoration would result in short-term, negative impacts to fish. BMPs would be employed to reduce runoff and minimize sediment transport in open water areas. Fish may be displaced due to noise, changes in currents or stream flow, and changes in water quality, including increases in turbidity from onshore construction activities and dredging. Suspension or resuspension of sediments or other materials may be injurious to fish, provide less suitable nursery habitats, or reduce hatching success and larvae development (Auld and Schubel, 1978; Wilber and Clarke, 2001; Bilkovic, 2011). Reduced water clarity can also affect fish by interfering with their ability to feed or by changing the composition of prey species (Newcombe and MacDonald, 1991). Short-term, negative impacts to fish and fish populations also would occur if construction activities deterred fish from using essential migratory pathways, breeding, foraging, or seeking shelter from predators. However, under the recommended plan, construction effects would have only short-term, localized influence and fish would return to the area shortly after the cessation of construction activities. These short-term, adverse effects would be outweighed by substantive long-term benefits. The District will continue coordination with NOAA, NJDFW, and NYSDEC to protect migrating, overwintering, and/or spawning fish species.

In the long term, wetland habitat restoration in and along the Bronx River and along Flushing Creek would directly benefit multiple life stages of resident, transient, and migratory fish species, by providing forage, spawning, nursery, and refuge habitat. Bed restoration and channel modification, by restoring river and stream channels, pools, and riffles, would help reestablish beneficial flow regimes, which would also contribute to improved habitat for fish (Dibble and Meyerson, 2012). Shoreline stabilization would reduce long-term turbidity levels by reducing shoreline erosion.

In the Bronx River, installing fish ladders and modifying weirs for fish passage would enhance the connectivity of the waterway and enable fish migration.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Negligible, short-term, local adverse effect to managed and associated species. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term positive impacts to fish from improved water quality and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to managed and associated species. • During construction, negligible, short-term local displacement of fish due to noise and water quality deterioration, including increased turbidity.

All Sites (except Flushing Creek)	• During construction, minor, short-term local displacement of fish from dredging, bed restoration, channel modification, changes in currents or stream flow, and installation of instream structures.

5.3.5 Essential Fish Habitat

As stated above, under the no action scenario, it is expected that impacts to EFH would improve slightly from the existing condition. This is largely due to the continuation of anadromous fish programs run by NYC Parks, NYSDEC, and local stakeholders as well as increased public awareness surrounding these issues.

With respect to EFH (Appendix F), construction activities under the recommended plan would employ BMPs to reduce construction impacts. Although BMPs would be employed to minimize sediment transport in open water areas, a minor increase in turbidity and sedimentation could be generated by the proposed construction activities. If eggs and larvae are present during construction, they could be affected. During the construction period, adult and juvenile fish would leave the area of construction and move to nearby suitable locations outside the area of disturbance. Also, for a short period of time after construction, there would be a reduction in benthic organisms immediately adjacent to the in-water construction footprint; however, this area would be recolonized quickly. All adverse impacts on managed species, associated species, and EFH are expected to be temporary and localized. Implementation of the recommended plan may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. On balance, however, it is anticipated that ecosystem restoration would result in long-term, net benefits to managed species (all life stages), associated species, and EFH. Moreover, removal of barriers to fish passage, through installing fish ladders and modifying weirs, would increase the habitat available to diadromous fish that use the Bronx River.

In a letter dated April 13, 2018, NMFS agreed with the USACE assessment that the implementation of the ecosystem restoration plan will result in long-term, net benefits to many federally managed species, their essential fish habitat, as well as many other NOAA trust resources (see Appendix F for correspondence). NMFS acknowledged that impacts to EFH could be temporary (due to construction activities) or result from permanent changes in habitat type. USACE and NMFS agreed to continued coordination and to evaluate impacts through site-specific EFH consultations as more detailed plans are developed for each action during the PED Phase.

Agency consultation for federally listed threatened and endangered marine species is discussed in Section 5.3.8.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Negligible, short-term, local adverse effect to EFH.

Restoration Sites	Potential Environmental Consequences*
	• BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term positive impacts to fish from improved water quality and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to EFH.

5.3.6 Shellfish and Benthic Resources

Under the no action alternative the poor quality shellfish and benthic habitat at the Flushing Creek estuarine restoration site would continue to support a low diversity of pollution tolerant organisms with expected impacts to be a continuation of the existing condition. Similarly, the freshwater riverine restoration sites along the Bronx River would continue to suffer from poor water quality and impacts from sedimentation from shoreline erosion and stormwater runoff.

In general, habitat for benthic invertebrates would improve under the recommended plan. Restoration of freshwater riverine habitat along the Bronx River would reduce transport and deposition of sediment, stabilizing habitat for benthic invertebrates. Estuarine habitat restoration in Flushing Creek would restore beneficial marsh habitat and improve sediment and water quality.

Permanent loss of specific invertebrate populations and replacement with others would result from habitat changes such as the replacement of soft mud with a sand cap.
However, adverse impacts to benthic organisms would be limited and short-term due to limited existing species diversity and pollution tolerant composition.

Onshore construction activities and dredging and dredged material deposition could cause short-term release or resuspension of sediments in the Bronx River and Flushing Creek, and a concomitant short-term increase in turbidity. This increase in turbidity and resuspension of sediments could have a short-term, negative impact on shellfish (Wilber and Clarke, 2001; Knott et al., 2009) and micro invertebrates. However, where benthic habitats suitable for shellfish are restored, and where existing shellfish habitat is not substantively changed or is restored, recovery of shellfish populations to levels that occurred prior to construction is expected to occur relatively rapidly. Additionally, BMPs would be employed to reduce runoff and minimize sediment transport in open water areas.

Wetlands restoration would improve long-term water quality in the river and creek and, therefore, would provide enhanced environments for benthic invertebrates. Bed restoration and channel modification, by restoring river and stream channels, pools, and riffles, would help reestablish beneficial flow regimes, which likewise would contribute to improved habitat for shellfish (Portnoy and Allen, 2006).

Restoration Sites	Potential Environmental Consequences*
All Sites	• Negligible, short-term, local negative impacts to shellfish from water quality deterioration, including increased turbidity. • BMPs employed to minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term positive impacts to shellfish from improved water quality and habitat restoration.
All Sites (except Flushing Creek)	• During construction, minor, short-term negative impacts from shellfish mortality in areas undergoing aquatic habitat conversion or restoration typically with rapid recovery expected.

5.3.7 Wildlife

Under the no action alternative, impacts to existing terrestrial, wetland, and aquatic faunal communities, at the Flushing Creek site are expected to remain or slightly degrade from the existing condition due to continued habitat loss and anthropogenic disturbances. The already sparse wetlands at the Flushing Creek estuarine habitat restoration site would continue to degrade and be lost to mud flats and invasive species, limiting habitat for waterfowl and wading birds. Without action, impacts to wildlife at the Bronx River freshwater riverine habitat restoration sites are expected to be a continuation of the existing condition. The existing habitats would continue to support wildlife species commonly found in urban habitats.

Under the recommended plan, construction associated with estuarine habitat and freshwater riverine restoration would result in both adverse and beneficial effects on mammals. Short-term impacts from construction include species displacement and the potential for species mortality. Displaced animals may be more vulnerable to predation and other threats. Muskrats and other small mammal species that are associated with surface waters, wetlands or riverine habitats could be displaced to nearby comparable habitats but dens, nesting areas and individuals may be harmed or destroyed during construction activities. However, construction activities may result in mortality among sessile and less mobile aquatic fauna. Some wildlife may be displaced temporarily, but eventually would populate or return to using the restored habitats. No population-level effects are expected.

Some negative short-term impact on bird species that utilize scrub uplands or marsh may result from operation of construction equipment. The MBTA requires a restriction on shrub and tree removal during construction activities to protect bird species that may potentially nest within the project areas. In order to comply with the MBTA, trees and shrubs would be cleared outside of a March 15 through July 31 (NJDEP, 2006) window to avoid adverse impacts to the listed species that are covered under this act. In October 2019, the USACE determined that the migratory bird species potentially occurring in the vicinity of the restoration sites, 20 species around the Bronx River sites and 18 species around Flushing Creek, would not be impacted by construction activities.

Reptiles and amphibians resident to the project sites and in the immediate vicinity will be susceptible to the same kinds of disturbance factors as previously described for mammals, birds and fish. However, many reptile and amphibian species are much less capable of disbursing quickly, or to distances that remove them to habitats unaffected by project activities. Many will simply try and hide. Thus, the threat of direct adverse impacts due to active construction may be greater to reptile and amphibian species initially inhabiting or utilizing the project site. However, once the restoration has been completed, the new, restored or enhanced habitats will have a long-term beneficial impact on reptiles and amphibians that could result in measureable differences in the size and distribution of reptile and amphibian populations.

In the long term, restoration that involves habitat alteration would restore conditions more favorable for certain wildlife groups and species, and uninhabitable or more challenging to others. Potential long-term impacts include changes to habitat type and disturbances associated with increased public access. These impacts are likely to be offset by increases in habitat, as well as habitat enhancement. Overall, restored habitats would be higher in quality and function than the existing habitats they replace. For a myriad of wildlife, restored habitats would provide refugia—i.e., habitats that, under changing environmental conditions, the wildlife retreat to, persist in, and potentially can expand from (Askins and Philbrick, 1987; Keppel et al., 2012; Soga et al., 2014). In particular, restoring aquatic, wetland, and upland habitats by removing invasive vegetation, planting native vegetation, and improving hydrology and connectivity would benefit wildlife. With the growth and maturation of restored habitats, wildlife communities of greater diversity and ecological value are anticipated.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term negative impacts from mortality of sessile wildlife in areas undergoing conversion to low marsh (Flushing Creek) or habitat conversion or restoration (all freshwater riverine restoration sites). • Negligible, short-term local displacement of mobile wildlife due to habitat alteration, and construction-related noise and human activity, with rapid recovery expected. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and/or control stormwater runoff. • Long-term positive impacts to wildlife from establishment of higher-quality habitats and refugia.

5.3.8 Rare, Threatened, and Endangered Species

Under the no action alternative, sustained pressure on rare species in the Planning Region is anticipated due to displacement by nonnative species and continued loss and degradation of habitats from rising sea levels, erosion, and anthropogenic disturbances. As such, impacts at the recommended sites are expected to be a continuation of the existing conditions. Already sparse and fragmented estuarine wetlands and riverine habitats in the Flushing Creek and Bronx River freshwater riverine habitat sites would continue to degrade and limit the availability of high-ecological value habitats that could potentially support rare, threatened and endangered species.

In the short term, construction associated with implementation of the recommended plan potentially could displace or disturb rare, threatened, and endangered species on or in the vicinity of the restoration sites. Such effects would result from clearing vegetation, changes in currents or stream flow, changes in water quality, including increases in turbidity, and construction-related noise and human activity.

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species, and species of special concern within the Harlem River, East River and Western Long Island Sound Planning Region project sites and their vicinities (Appendix F). The USFWS and NMFS were contacted regarding federally listed threatened and endangered species under the ESA, while the NYSDEC Division of Fish, Wildlife, and Marine Resources was contacted regarding state listed species in the NYNHP. Numerous endangered, threatened, or rare plant and animal species exist within the boundaries of the bay, and correspondences with the agencies are in Appendix F. Summary tables of the Threatened and Endangered species identified by NMFS and USFWS can be seen in Tables 5-4 and 5-5. Prior to restoration activities, onsite surveys will be conducted at each restoration site to fully assess any potential impacts on biological resources and confirm whether any documented species may be impacted by any restoration activities. If rare, threatened, and endangered species are confirmed at the sites that could be adversely impacted by restoration activities, precautions will be taken to avoid, minimize, or mitigate the impacts as determined by the appropriate agency.

According to NMFS correspondence (April 27, 2016), the endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) may be present in the East River and their adjacent bays and tributaries, which could include the Flushing Creek and Bronx River restoration sites. Disruptions to marine wildlife are expected to be insignificant and short-term during construction, and BMPs would be employed to minimize impacts from suspended sediments. If construction activities are determined to make the water habitat unsuitable for wildlife, the use of timing restrictions or noise attenuating tools will be implemented. USACE has determined that construction activities at these sites will have no effect on Atlantic and shortnose sturgeon (October 2019).

Table 5-4. Determination for NMFS Threatened and Endangered species for the Harlem River, East River and Western Long Island Sound Planning Region.

Restoration Site	NMFS Threatened and Endangered Species	
	Atlantic Sturgeon	Shortnose Sturgeon
Harlem River, East River and Western Long Island Sound Planning Region		
Bronx Zoo and Dam		
Stone Mill Dam		
Shoelace Park		
Bronxville Lake		
Garth Harney		
Flushing Creek	No effect	No effect

The NYSDEC does not have any recent records of rare or state-listed bird species on or within one-half mile of potential restoration sites (September 19, 2014 correspondence), although historical records exist for the dragonfly Arrowhead Spiketail (*Cordulegaster obliqua)* at Bronx River Park and the Bronx Zoo. Historic records also exist for vascular plants at the Bronxville Lake, Garth Woods/Harney Road, and Bronx Zoo restoration sites. The USFWS documented the threatened seabeach amaranth (*Amaranthus pumilus)* as potentially affected by construction the Flushing Creek restoration site. Prior to construction activities, restoration sites will be surveyed for the existence of rare or state-listed plants. If found, measures will be taken to avoid disturbance, such as fencing and signage placed around the plants. USACE determined that construction of the Flushing Creek site would have no effect on seabeach amaranth (October 2019). USFWS concurred with the USACE ESA and NLAA determinations on March 2, 2020, SLOPES forms and accompanying analysis are located in Regulatory Appendix F.

The USFWS identified the threatened Piping Plover (*Charadrius melodus*) and Bog Turtle (*Clemmy muhlenbergii)* as potentially occurring along the Bronx River where site restoration may take place. The USFWS also identified the endangered Roseate Tern (*Sterna dougallii*) and the threatened Red Knot (*Caliris canutus rufa)* and Piping Plover as bird species that could potentially be affected by construction activities at the Flushing Creek site. As these species are highly mobile and capable of avoiding construction activities, disturbance would be short-term and localized. For some species, such as the Piping Plover, construction buffers and/or timing restrictions would be employed during nesting season, which typically occurs between March and August. USACE determined that construction of these sites would have no effect on Piping Plover, Bog Turtle, or Roseate Tern and that construction of the Flushing Creek site may affect, but is not likely to adversely affect Red Knot (October 2019). USFWS concurred with the USACE ESA and NLAA determinations on March 2, 2020, SLOPES forms and accompanying analysis are located in Regulatory Appendix F. In coordination with USFWS, the District will conduct pre-construction monitoring for red knot. See the Regulatory Appendix F for additional analysis.

Table 5-5. Determinations for USFWS Threatened and Endangered species within the Harlem River, East River and Western Long Island Sound planning region.

Restoration Site	USFWS Threatened and Endangered Species					
	Piping Plover	Bog Turtle	Red Knot	Roseate Tern	Seabeach Amaranth	Migratory Birds
Harlem River, East River and Western Long Island Sound Planning Region						
Bronx Zoo and Dam	No effect	No effect				No effect
Stone Mill Dam	No effect	No effect				No effect
Shoelace Park	No effect	No effect				No effect
Bronxville Lake	No effect	No effect				No effect
Garth Harney	No effect	No effect				No effect
Flushing Creek	No effect		NLAA	No effect	No effect	No effect

As the restoration goals include restoring, and protecting wildlife habitat, impacts to rare, threatened, and endangered species are expected to be short-term and insignificant. In the long term, implementation of the recommended plan would benefit rare, threatened, and endangered species by increasing favorable habitat and improving the quality of existing habitat.

Restoration Sites	Potential Environmental Consequences*
All Sites	• No long-term negative impacts to protected species. • Long-term positive impacts to rare, threatened, or endangered species from habitat and ecosystem restoration. • Potential impact to Atlantic and shortnose sturgeon would be avoided by sediment control and timing restrictions as necessary.
Bronx Zoo and Dam	• Historic records for protected insect may need survey confirmation prior to construction and disturbance avoidance measures during construction.
Bronx Zoo and Dam Bronxville Lake Garth Woods/Harney Road	• Historic records for protected plant species may need survey confirmation prior to construction and disturbance avoidance measures during construction.
Flushing Creek	• Potential impacts of seabeach amaranth plant would be avoided by monitoring and protection using fencing and signage. • Potential short-term disturbance to federally listed birds. Construction buffers and/or timing restrictions utilized if present during nesting season.
Bronx River	• Potential short-term disturbance to Piping Plover. Construction buffers and/or timing restrictions utilized if present during nesting season.

5.3.9 Land Use

In the no action alternative, impacts from land use changes are expected to be minimal. The location of the Fresh Creek estuarine habitat restoration site is currently undeveloped and would be expected to remain undeveloped without federal action. Both Westchester County and Bronx County are subject to long-range plans that call for reclamation of waterfront, redevelopment of urban neighborhoods, strengthening of transportation corridors, and protection of open space. If these plans were to be fully implemented, current land use patterns at the freshwater riverine restoration sites would not change by very much in terms of losing open space to development. The open space areas of the Bronx Zoo, New York Botanical Gardens and other parks and recreation areas along the Bronx River corridor would remain as this land use type over the period of analysis and is unlikely to change as they are protected from development by state law.

The proposed estuarine habitat and freshwater riverine restoration sites are all on existing parkland or open space owned by various public agencies. No permanent housing exists on these sites. Implementation of the recommended plan at each site would not change the existing land use of the site. The sites would remain in the same ownership with public access remaining similar to, or better than, existing conditions.

During construction activities at the Bronx River freshwater riverine restoration sites, short-term public access restriction may occur but would be of short duration.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Implementation of the recommended plan at each site would not change the existing land use of the site.
All freshwater riverine restoration sites (Bronx River Sites)	• Short-term restrictions to public access at park locations along the Bronx River.

5.3.10 Hazardous, Toxic, and Radioactive Waste

In the no action scenario impacts from HTRW are expected to be a continuation of the existing condition with continued degradation of water quality at the recommended sites in the Planning Region, due to shoreline erosion, stormwater runoff, and anthropogenic inputs, such as landfill leachate and illegal dumping. Some local efforts would reduce direct inputs into the Bronx River and Flushing Creek. Improvements to CSO volume discharges to the Bronx River were completed by the NYCDEP in 2009, but no further improvements are planned. The NYCDEP Interim Floatable Containment Program is expected to continue to remove floatable debris from the Bronx River to prevent its discharge into the East River and Long Island Sound. Municipal programs that reduce pollution from stormwater discharge would continue to be developed and upheld. Improvements to stormwater and CSO inputs to Flushing Creek would continue per NYCDEP Long Term Control Plan. In 2007, DEP completed a $363M CSO storage facility, and the agency will invest another $56M in seasonal disinfection technology by 2025. Therefore, water quality is expected to improve in the future in Flushing Creek.

Under the recommended plan, habitat restoration and associated construction activities would cause short-term release or resuspension of sediments and a concomitant short-term increase in turbidity, in nearby waters in the Bronx River and Flushing Creek. BMPs would be employed to reduce erosion, turbidity and sedimentation. Removal of sediments during channel dredging, modification or realignment activities may require investigation and special handling and disposal if contaminated sediment is present. Phase I environmental investigations at potential Flushing Creek restoration sites found metal contamination that would require special disposal of sediment. Additional contaminant investigations will take place in PED.

In the long term, restoring wetlands and maritime forest, armoring and stabilizing shorelines would improve water quality and provide nutrient removal and denitrification services. The restored habitats would reduce long-term turbidity by filtering and retaining stormwater runoff, providing storm surge and flood buffering, attenuating waves, and thereby reducing shoreline erosion. Improved tidal flushing and reduced water residency time, due to restoring tidal channels and basins, would increase dissolved oxygen levels and reduce fecal coliform levels

(Portnoy and Allen, 2006). Restored wetlands likewise would improve tidal flushing and increase dissolved oxygen levels. Groundwater resources may also benefit from restored wetlands, as wetlands filter pollutants moving between surface water and groundwater.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Safeguards employed to prevent and respond to spills. • Long-term surface water quality improvements—i.e., decreased turbidity, nutrient removal, and denitrification. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff.
Bronxville Lake Garth Woods/Harney Road	• Removal of sediments during channel dredging, modification or realignment activities may require investigation and special handling and disposal if contaminated sediment is found.

5.3.11 Noise

No long-term impacts to noise are expected from implementing the no action alternative. Restoration would not take place and short-term, temporary increases in ambient noise levels due to construction activities would not occur. Population growth and increased use of railways and roadways in the region may cause noise levels to rise in the future.

Heavy equipment used during construction may contribute to short-term increase in noise levels. However, noise levels would not exceed those cited in local ordinances and would occur only during normal daytime working hours. In the long term, sites with forested and scrub/shrub wetland restoration, such as Bronxville Lake and Garth Woods/Harney Road, mature trees may even create a natural buffer to reduce ambient noise levels.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Short-term increases in noise levels from construction equipment will occur during normal daytime working hours. • Implementation of the recommended plan at each site would not cause any negative long-term noise impacts.
Bronxville Lake Garth Woods/Harney Road	• Long-term potential to reduce ambient noise from mature trees in forested and scrub/shrub wetlands.

5.3.12 Social and Economic Resources

No long-term impacts are expected from implementing the no action alternative. Under the no action alternative, no change to the social and economic resources would occur from short-term job opportunities. The degraded condition of the recommended sites in the Planning Region is anticipated to continue into the future, decreasing public access and recreational opportunities in the planning region, and potentially adversely affecting social and economic resources.

Restoration under the recommended plan would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education. No permanent or long-lasting economic effects are anticipated as a result of temporary construction activities.

Larger populations of waterbirds throughout the planning region, particularly in the vicinity of LaGuardia Airport, could lead to a greater potential for bird-aircraft strikes, potentially requiring increased expenditures by the PANYNJ to mitigate the heightened hazard. Due to the increasing concern regarding aircraft-wildlife strikes, the FAA has implemented standards, practices, and recommendations for holders of Airport Operating Certificates issued under Title 14, CFR, Part 139, Certification of Airports, Subpart D (Part 139), to comply with the wildlife hazard management requirements of Part 139. Airports that have received federal grant-in-aid assistance must use these standards. In accordance with the FAA Advisory Circular 150/5200-33B and the Memorandum of Agreement with FAA to address aircraft-wildlife strikes, when considering proposed flood risk management measures and mitigation (and restoration) areas, USACE must take into account whether the proposed action could increase wildlife hazards.

The FAA recommends minimum separation criteria for land-use practices that attract hazardous wildlife to the vicinity of airports. These criteria include land uses that cause movement of hazardous wildlife onto, into, or across the airport's approach or departure airspace or AOA. These separation criteria include:

- Perimeter A: For airports serving piston-powered aircraft, hazardous wildlife attractants must be 5,000 feet from the nearest AOA;
- Perimeter B: For airports serving turbine-powered aircraft, hazardous wildlife attractants must be 10,000 feet from the nearest AOA; and
- Perimeter C: Five-mile range to protect approach, departure, and circling airspace.

Flushing Creek is within the limits of the five-mile perimeter of LaGuardia Airport. The proposed plans for this site include habitats that were designed as feeding habitats only so as to not to introduce additional hazardous wildlife into the area. Consultation with the FAA took place on September 6, 2018, and initial site descriptions and coordination plan were sent on November 19, 2018 to the FAA. USACE received a letter from the FAA on February 25, 2019 stating that the FAA had no major wildlife concerns with the project. See Appendix F for correspondence. Coordination with the FAA will continue through PED.

At the scale of the HRE study area, improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Increased shoreline stabilization and stormwater management along the Bronx River may reduce municipal expenditures, including those for emergency services. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Combined total first cost of approximately $78,240,000 • During construction, minor, short-term increases in local employment, earnings, induced spending, and tax revenues, and provision of educational opportunities. • Long-term stimulation of the local economy and provision of educational opportunities.

5.3.13 Navigation

A 2.5-mile federal navigation channel on the lower Bronx River, from its confluence with the East River to East 172nd Street, is used frequently by commercial barges. Although not the primary purpose of the ecosystem restoration effort, a need for safe and reliable navigation channels on the Bronx River still exists. In the no action alternative, federal navigation channels in Flushing Creek, the East River, and the tidal Bronx River would be unchanged and maintained as needed. Upper portions of the Bronx River would continue to have obstacles to canoe and kayak navigation, requiring portage over and around man-made dams and weirs. While the Bronx River Intermunicipal Watershed Management Plan indicates that impoundments should be removed or modified to improve water flow, based on the current priorities of the county and state resources, there is no expectation that these impoundments would be modified in the absence of federal action.

Short-term restrictions of small craft use in portions of the Bronx River during construction may occur but would be limited in duration.

Implementation of the recommended plan would not be contrary in the long term to navigation or create possible obstructions to navigation. Restoration efforts may even serve to benefit future navigation maintenance by reducing future operations costs. Channel dredging and modifications for fish passage may improve ease and safety of boat navigation, and public access for small craft would be improved in some Bronx River restoration sites.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minimal, short-term limitations to local boat craft during construction activities. • No adverse long-term impacts from implementation of the recommended plan.
All Freshwater Riverine Restoration Sites (Bronx River Sites)	• Potential long-term positive improvements to small craft access and navigation.

5.3.14 Recreation

No long-term impacts to recreation are expected from implementing the no action alternative. Under the no action alternative erosion, estuarine and freshwater riverine habitat restoration would not occur, decreasing public access and recreational opportunities in the planning region. Public access improvements would not occur at any freshwater riverine restoration sites. Upper portions of the Bronx River would continue to have obstacles to canoe and kayak navigation, requiring portage over and around man-made dams and weirs and limiting small craft use on the river.

Under the recommended plan, access to recreational resources may be negatively affected temporarily, during construction. At sites which currently offer public access for recreational use, there may be adverse temporary impacts during construction due to the closing of the interior footpaths. However, construction would be phased to occur during the colder winter months when the paths are not as heavily utilized.

After the recommended plan is implemented, positive impacts to the recreational and educational features of the sites would be realized. Within the freshwater riverine habitat restoration sites, three (3) of the five (5) sites are recommended for improvements to public access. In addition to public access improvements, estuarine and freshwater riverine habitat restoration would provide improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, which potentially would increase activities such as fishing, hiking, boating, and bird watching.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts from limited access to recreational resources during construction. • Long-term improvement in recreational opportunities for wildlife viewing, hiking, recreational fishing, kayaking, and canoeing through habitat improvement.
Bronxville Lake Bronx Zoo and Dam	• Long-term benefits from improved public access

5.3.15 Cultural Resources

Under the no action alternative impacts to cultural resources are expected to be minimal; however, loss of historic resources due to SLR and erosion could occur.

Under the action alternative, there is a potential to cause adverse effect to historic properties from excavation or material placement over the resources. As an initial look into the effects of the action alternative, a desktop search was completed of the known cultural resources in and around the recommended sites. This desktop search found that the six restoration sites are located within four, potentially five, historic properties. The Stone Mill Dam restoration site is located within the New York Botanical Gardens, which is a National Historic Landmark, National

Register Listed, and State Register Listed. The Stone Mill Dam may also be associated with the Lorillard Snuff Mill, which is also a National Historic Landmark, National Register Listed, and State Register Listed. The Bronx Zoo Dam restoration site is located within the Rainey Memorial Gates historic property, which is National Register Listed and State Register Listed. The dam at this restoration site is the Bronx Zoo Dam, which is National Register Eligible. Lastly, two restoration sites, Bronxville Lake and Garth Harney are located within the Bronx River Parkway Reservation Historic District which is a National Register Listed and State Register Listed. In addition to these, there are 1 other historic districts, 74 historic properties, and 12 archaeological sites within one mile of the six restoration sites in the Harlem River, East River and Western Long Island Sound (Table 5-6).

The effects the proposed restoration will have on the New York Botanical Gardens, Lorillard Snuff Mill, Rainey Memorial Gates, Bronx Zoo Dam, and the Bronx River Parkway Reservation will be negotiated with the signatories of the PA. The District will work to avoid adverse effect to the historic properties, but if necessary treatment plans will be developed in accordance with the situations of the PA to address effects to the historic properties.

Almost none of the APE for the six restoration sites has been previously surveyed. Survey work will be required find if there are any unknown historic properties within the recommended plan APE. To carry out this work, the USACE entered into a Programmatic Agreement (PA) with the Advisory Council on Historic Preservation, New York State Historic Preservation Office, New Jersey State Historic Preservation Office, New York City Landmarks Preservation Commission and National Park Service (see Appendix H) that stipulates the actions the USACE will take to satisfy its responsibilities under Section 106 of the National Historic Preservation Act and other applicable laws and regulations. Pursuant to the PA, archaeological survey work will take place in the Preconstruction Engineering and Design Phase. Since this survey work has not yet been carried out, the full effects the recommended plan will have on cultural resources is not yet known.

Some cultural resources work was previously done for the source studies and a preliminary analysis for the HRE study area. This work covered some of the APE of the recommended plan, and gave recommendations for future work in these areas. This previous work will inform the future cultural resources work that will be carried out pursuant to the PA, and when appropriate, the recommendations from the previous investigations will be followed. Below is a listing of the reports:

- *Cultural Resources Baseline Study: Flushing Bay Ecosystem Restoration Project, Queens County, New York (Panamerican Consultants, Inc., 2003);*
- *Cultural Resources Baseline Study, Bronx River Ecosystem Restoration Study, Westchester and Bronx Counties, New York (Atwood et al., 2007); and*
- *Cultural Resources Overview for the Hudson-Raritan Estuary Comprehensive Restoration Plan (Harris et al., 2014).*

Table 5-6. Historic Properties Located within or Nearby the Recommended Restoration Sites.

Restoration Sites	Historic Properties Identified
All Sites	• Potential for archaeological sites exists in the study area. • Additional survey is required under the stipulations of the draft PAs to determine whether other resources are present within the project area. • Mitigation would be required for impacts to significant resources
Flushing Creek	• One (1) archaeological site is listed within the site boundaries, but was likely destroyed by the construction of the World's Fair facilities. Five (5) other archaeological sites are located within one mile of the restoration site. • Nineteen (19) historic properties are located within one (1) mile
Stone Mill Dam	• Located within the New York Botanical Gardens (NHL, NRL, SRL). • May be associated with the Lorillard Snuff Mill (NHL, NRL, SRL) • Nine (9) other historic properties are located within one (1) mile
Bronx Zoo Dam	• Located within the Rainey Memorial Gates (NRL, SRL) • Located within the Bronx Zoo Dam Historic Property (NRE) • 12 other historic properties are located within one (1) mile
Bronxville Lake	• Located within the Bronx River Parkway Reservation Historic District (NRL, SRL) • 12 other historic properties are located within one (1) mile • Three (3) archaeological sites located within one (1) mile
Shoelace Park	• 13 historic properties within one (1) mile • One (1) archaeological site located within one (1) mile
Garth Harney	• Located within the Bronx River Parkway Reservation Historic District (NRL, SRL) • Four (4) historic properties located within one (1) mile • Two archaeological sites located within one (1) mile

5.3.16 Aesthetics

No long-term impacts to aesthetics are expected from implementing the no action alternative. Under the no action alternative, the degraded condition of the recommended sites in the Harlem River, East River and Western Long Island Sound ecosystems is anticipated to continue, decreasing aesthetic and scenic resource value in the planning region. The expansion of invasive plants at all restoration sites would decrease visual quality. Public access improvements would not occur at any freshwater riverine restoration sites, limiting scenic viewing opportunities.

During construction of the recommended plan temporary impacts to the aesthetic and scenic resources would occur on site due to the presence of construction equipment, vegetation clearing and the earthwork. However, the sites are overgrown with invasive species and the proposed restoration would replace invasive species with diverse vegetation including native low marsh, high marsh, scrub/shrub wetland, and maritime forest species at the estuarine habitat restoration sites, and native riparian forest vegetation within freshwater riverine habitat restoration sites, thus improving aesthetic and scenic resource value. Additionally, public access improvements would increase opportunities for wildlife and natural landscape observation.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts to aesthetic and scenic resources during construction. • Long-term improvement in scenic resource value with vegetation restoration and overall habitat improvement.
Bronxville Lake Bronx Zoo and Dam	• Long-term benefits from improved public access.

5.3.17 Coastal Zone Management

Under the no action alternative, no restoration would take place and no impacts to state or local coastal zone management plans would occur.

Restoration activities within the Harlem River, East River and Western Long Island Sound Planning Region were evaluated with respect to their consistency with New York State's *State Coast Policies* and New York City's *The New Waterfront Revitalization Program* and the goals are directly in line with the respective coastal zone policies. The restoration activities are consistent with state and local coastal zone management programs (Appendix F). USACE sent a coastal zone consistency determination for each site to the relevant State and city agencies for review (October 2019) and received concurrence from these agencies.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Restoration activities are consistent with state and local coastal zone management programs.

5.4 Newark Bay, Hackensack River and Passaic River Planning Region

Under the future without-project condition, ongoing and planned restoration and conservation actions undertaken by agencies, municipalities and nongovernmental entities in the Newark Bay, Hackensack River and Passaic River Planning Region would continue (see Appendix B); however, no formal comprehensive program of restoration will be undertaken.

It is anticipated that without restoration further demise and degradation of existing estuarine habitats would occur within the planning region, due to continuing natural erosive forces and rising sea levels, and poor sediment and water quality, derived from a combination of sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed areas. Additionally, invasive plant species that dominate degraded sites would continue to pose colonization pressures to nearby habitats. Given the intensity of development in the HRE study area, even low quality undeveloped lands have become a priority for protection.

The USEPA remediation of the Lower Passaic River is a critical action needed to reduce risk to human health and the environment within the planning region and improve the health of the overall HRE study area. With the exception of the cleanup of legacy sediments in the Lower Passaic River proper, the environmental health of the area is still expected to decline or remain a continuation of the existing condition. This FWOP is due to a continuation of climate change and SLR, sedimentation from non-point source water quality inputs, erosion, and invasive species expansion contributing to the poor health of the area.

Implementation of the recommended plan would restore estuarine and freshwater riverine habitat at four (4) sites in the Newark Bay, Hackensack River and Passaic River Planning Region:

- **Estuarine habitat restoration** would be conducted at three (3) locations—Meadowlark Marsh and Metromedia Tract on the Hackensack River, and the Oak Island Yards Tier 2 site on the Lower Passaic River. The restoration would total approximately 134 acres of high marsh, low marsh, scrub/shrub wetland, and channel restoration, with additional areas of maritime forest restoration and shallow water habitat restoration as well as invasive species removal and planting of native vegetation.
- **Freshwater riverine habitat restoration** would be undertaken at one (1) locations—Essex County Branch Brook Park on the Lower Passaic River. Approximately 18 acres of freshwater stream channel would be dredged, 10.25 acres of emergent wetland would be restored, 8.8 acres of riparian forest scrub shrub would be restored, banks would be stabilized, and native vegetation would be planted.

5.4.1 Geomorphology and Sediment Transport

Natural shorelines along Newark Bay, Hackensack, and Lower Passaic Rivers have been largely replaced by bulkheads and riprap. Shoreline armoring has resulted in substantial erosion with many shoreline structures in the region actively failing and contributing to further erosion. Under the no action alternative the recommended sites in the Planning Region would continue to degrade on a trajectory similar to the existing condition. This is due largely to natural erosive forces, rising sea levels, and poor sediment and water quality. The estuarine habitat sites would remain fragmented by historic fill material onsite, a result of former and current industrial uses. In particular, Oak Island Yards is currently subject to encroachment from the neighboring industrial lot, this may exacerbate future no action impacts to geomorphology and sediment regimes through erosion and loss of vegetation on land. Tidal action would continue to erode shorelines in both estuarine and freshwater riverine sites. Stormwater runoff would continue to erode soils and deposit sediment downstream, particularly along portions of the riverbank in

Essex County Branch Brook Park where vegetation is not well established. The shorelines of many the restoration sites are highly eroded and it is anticipated that, without restoration, additional wetlands and shoreline would be lost at all sites.

During restoration construction under the recommended plan, it is unlikely that geological resources would be impacted, as construction would occur only at very shallow depths. Excavation and regrading at the estuarine habitat restoration sites would result in a long-term change to local topography. Excavations will be done along the shorelines to allow for the influx of tidal waters to restore the tidal marshes. Excavation of the fill layers from the water's edge to restore tidal marsh is expected to return this area to a more historic elevation and historic soil complex. Channel dredging and modification, streambank restoration and sediment control features at the freshwater riverine habitat restoration sites would affect the transportation and deposition of sediments. All excavated soil will be handled and managed in accordance with applicable City, State, and Federal regulations.

Grading and earthmoving activities, dredging, and sediment resuspension from vessel movements and prop wash could result in temporary disturbances to sediment transport. However, these activities and their effects would be short-term and localized. On land, silt fences and other BMPs would be employed to reduce erosion and sedimentation. As appropriate, silt curtains or cofferdams may be used to minimize sediment transport in open water areas, precluding resuspended sediments being transported by currents and forming new shoals or sandbars. Even absent these practices, such geomorphic features likely would be temporary and would disappear as the system reaches a new post-construction equilibrium. All soil erosion measures will be coordinated with USFWS. None of the proposed restoration measures are anticipated to cause the release and resuspension of sediments in quantities that could form new shoals or sandbars that potentially would affect aquatic habitats or navigation.

Implementing the recommended plan at the restoration sites would restore wetlands, channels, and maritime and riparian forest, armor and stabilize shorelines, and establish native vegetation. Vegetated intertidal and riparian zones help protect adjacent areas from flood damage and maintain bank stability during flood events, and tidal marshes with natural channel configurations buffer coastal areas from storm surges and provide floodwater storage functions. Restoration would have long-term, positive effects, through attenuating wave velocities, controlling erosion, retaining sediments, and reducing sediment loads, thereby establishing more resilient shorelines, riverbanks and streambanks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, negligible, short-term local soil and sediment disturbance and sedimentation from in-water, shoreline, and onshore earthmoving activities and construction, and vessel and equipment movement. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term changes to local topography.

- Long-term wave and turbidity attenuation and sediment accretion, and/or erosion and sedimentation control, sediment load reduction, and coastal resiliency improvements.

5.4.2 Water Resources

The hydrology and hydraulics of the proposed restoration sites in the planning region have been altered considerably by industrial and commercial development over the last two centuries. Vast areas of wetlands have been altered and filled, and dense growth of invasive common reed has impaired the natural hydrology of tidal marsh systems. Under the no action alternative, the sites recommended for restoration would experience continuing or worsening degradation of hydrologic conditions. As a consequence of climate change, low-elevation areas, such as most of the Planning Region, will become more vulnerable to flooding from the tidal waters of the river. More severe storms may also increase flooding from non-tidal surface waters. Riverbanks in Branch Brook Park would continue to be scoured by tidal or stormwater surges, alternately resulting in channel deepening and shoaling downstream. In the no action scenario, wetlands would remain hydrologically isolated from rivers and streams, and limited in their capacity to provide beneficial ecological functions. In the estuarine habitat restoration sites, habitat would also continue to be hydrologically disconnected. Under the no action alternative, flood storage and conveyance would not improve at the Branch Brook Park riverine site. It is assumed that water quality at the proposed restoration sites in the Planning Region will likely improve in the future under the no action alternative due to the effects of increased awareness of water quality and upgraded sewer and storm water systems; however, at this time no specific projects or plans have been funded or undertaken.

A RSLC was conducted to aid ecosystem restoration planning and impact assessment of the recommended projects (see Engineering Appendix D for RSLC Analysis). All estuarine habitat restoration sites in the Planning Region are expected to be impacted by SLC. However, within the 50 year period of analysis, results under the intermediate SLC curve show that the estuarine habitat restoration sites will see a growth of low marsh due to high marsh to low marsh conversion and no loss of low marsh at the lower end till the years 40-50. This is because the low end of the low marsh elevation ranges have been designed at 1 foot above mean tide level (MTL), so there is no impact till sea level rises 1 foot. After the 50 year planning horizon, the analysis predicts that preventive measures may need to be implemented to prevent drowning from SLR in areas where there is no room to migrate.

The District has completed a non-stationary and inland hydrology analysis as a means of incorporating relevant information about observed and expected climate change impacts in hydrologic analyses for the recommended project at fresh water site in Branch Brook Park (see Engineering Appendix D). Nonstationarity can provide useful predictive ability in natural system but complications arise in highly altered systems. Inland hydrology is a more useful tool for this Planning Region and the District will conduct a more detailed analysis relative to recent inland hydrology changes during PED.

Under the recommended plan, grading and earthmoving activities, dredging, temporary construction-related structures, and resulting temporary geomorphologic features—e.g., shoals and pools—would cause short-term disruption of local streamflow, wave, and current regimes, hydrology, and stormwater runoff. These activities and their effects would be short-term and localized, and BMPs would be employed to minimize sediment transport in open water areas. A Section 404(b)(1) Guidelines Evaluation has been completed for these sites and is provided in the Regulatory Appendix F.

In the long term, bed restoration and channel modification, would help reestablish beneficial flow regimes and decrease downstream velocities by restoring river and stream channels, pools, and riffles. Shoreline softening and streambank restoration would help restore tidal and riverine hydrology, and withstand storm surges and rising sea levels. Wetlands restored under the recommended plan would provide long-term regulation of water flow, and storm surge and flood buffering, wave attenuation, and protection of shorelines, per the findings of Woodward and Wui (2001), Zelder and Kercher (2005), Koch et al. (2009), Barbier et al. (2011), Gedan et al. (2011), and Shepard et al. (2011). Expansion of forest cover and scrub/shrub habitat would provide stormwater runoff mitigation (Bolund and Hunhammar, 1999; Bonan, 2002; Neary et al., 2009) and flood control. In the Newark Bay, Hackensack River and Passaic River Planning Region, under the recommended plan, restoration would contribute to more natural hydrology and hydraulics by creating more resilient shorelines, streambanks, and wetlands that can better withstand flooding and strong storms associated with climate change.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, negligible, short-term disruption of local wave and current regimes, hydrology, and stormwater runoff from in-water, shoreline, and onshore earthmoving activities and temporary structures. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff. • Long-term improvements in regulation of water flow, storm surge and flood buffering, wave attenuation, shoreline protection, and stormwater runoff control.

5.4.3 Vegetation

It is anticipated that, under the no action alternative, there would be increased demise and degradation of existing terrestrial, emergent, and aquatic plant communities, due to continued erosional forces, rising sea levels, anthropogenic disturbances, and further expansion and colonization of invasive plant species. The estuarine habitat restoration sites would continue to be dominated by common reed and habitats would remain degraded. Oak Island Yards, subject to encroachment from the neighboring industrial lot, will likely experience greater vegetation and habitat loss in the absence of restoration. Under the no action alternative Branch Brook Park would continue to face pressures from invasive species, steepened banks, or revetments on a similar trajectory to the existing condition; however, it is assumed that small scale improvements will occur. NJDEP has previously (2005) funded small scale ecosystem restoration in portions of Branch Brook Park. Similarly, in 2012 additional upgrades to the Park were completed through a public-private-non-profit partnership coordinated through the Branch Brook Park Alliance. In the no action scenario, NJDEP, Essex County Parks, New Jersey Sports and Exposition Authority (NJSEA), and other stakeholders will continue efforts to preserve open space, increase educational and recreational opportunities, and manage invasive species at some of the recommended sites in this Planning Region. However, at the same time, development pressures throughout the Planning Region continue to encroach on the remaining natural and open space habitats. Under the no action alternative, it is assumed that these various land uses will continue to impact these habitats and in turn the remaining wetlands, other habitats, and open spaces will be affected by both preservation efforts and development pressures. Under the no action alternative, it is unlikely that these competing pressures will be coordinated in a framework, which takes into account the different facets vying for the limited open space resources.

In the short term, construction associated with implementation of the recommended plan would remove or disturb existing vegetation. The impact footprint would include the restoration area, construction yards, temporary access roads, and dredge sites and resulting sediment plumes. Onshore construction activities and dredging and dredged material deposition would likely cause short-term release or resuspension of sediments in the Hackensack and Lower Passaic Rivers and an associated short-term increase in turbidity. This increase in turbidity could have a short-term, negative impact on aquatic macrophytes (Erftemeijer and Lewis, 2006). BMPs would be employed to reduce runoff and minimize sediment transport in open water areas.

Restoration involving habitat modification would result in some long-term, habitat-specific vegetation trade-offs. Activities of this nature include lowering elevations for riverine and coastal marsh restoration, and replacing mudflats with wetlands.

Estuaries and coasts, in general, and restored ecosystems, in particular, are prone to introductions of nonnative species (Kettenring and Adams, 2011; Williams and Grosholz, 2008). Restoration plantings, soil inputs, vegetation clearing, construction-related disturbance, or incomplete habitat conversion may facilitate colonization of invasive plant species. Wetlands are often prone to invasion due to high levels of resources—e.g., high fertility and high moisture. Additionally, exotic species may be the first to colonize after a planned disturbance even if they were not present in the pre-disturbance community and may alter successional processes that would otherwise lead to a native assemblage. Removal of invasive species may also adversely alter some ecological processes, such as reducing native plant pollinator levels (Carvaleiro et al., 2008) and reducing denitrification services (Findlay et al., 2003). If herbicides are employed for invasive species removal, there is a possibility of residual herbicidal impacts on newly transplanted vegetation (Cornish and Burgin, 2005).

Implementation of vegetation components of the recommended plan would include restoration of approximately 157 acres of various native plant communities within the Newark Bay, Hackensack River and Passaic River Planning Region. Restoration of these communities likely would cause a qualitative improvement of their biodiversity and ecological services (Rey-Benayas et al., 2009; Duffy, 2009). The ecosystem resilience of the Hackensack and Lower Passaic rivers would be enhanced due to an increase in regulating ecological services, which can attenuate the impact of shocks on ecosystems. The reduction or elimination of nonnative plant species would enhance native biodiversity and ecological community functioning, and the restored habitats would provide for an increased diversity of plant species, in part by exporting native seed to nearby habitats. Likewise, increasing the size of habitat patches would promote higher levels of biodiversity (Gilbert-Norton et al., 2010; Damschen and Brudvig, 2012; Beninde et al., 2015).

The District will incorporate native species, where practicable, in design plans for all sites. Design optimization will be coordinated, to the extent possible, with the USFWS during PED [See FWCAR (Appendix F)].

Bed restoration and channel modification, by restoring river and stream channels, pools, and riffles, would help reestablish beneficial flow regimes, which may inhibit further expansion and colonization of the invasive vegetation and may allow the establishment of native aquatic vegetation.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term disturbance of existing terrestrial and aquatic vegetation. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Negligible, long-term removal of existing terrestrial and aquatic vegetation, and disruption of associated ecosystem services. • Risk of minor, long-term establishment or reestablishment of invasive, nonnative vegetation. • Long-term improvement of terrestrial vegetation community biodiversity and associated ecosystem services.

5.4.4 Finfish

Under the no action alternative, continued loss or degradation of fish habitats and nursery grounds is anticipated to remain on a similar trajectory to existing condition. This outcome would result from hydrologic impairments and continued compromised water quality due to shoreline erosion, sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed areas. The estuarine habitat restoration sites would continue to have low ecological value for finfish without restoration of tidal channels, marshes, and in the absence of structural complexity in the benthic environment. The water bodies in Branch Brook Park currently exist as shallow manmade impoundments they are highly prone to excessive inputs of nutrients and sediment. In the no action alternative, Branch Brook Park would not benefit from stream naturalization, excavation of channels and pond deepening and it is reasonable to assume that the habitat will continue to be unfavorable to finfish, due to excess nutrient inputs, sedimentation and in-channel debris.

Under the recommended plan, construction associated with in-water and shoreline restoration would result in short-term, negative impacts to fish. Fish may be displaced due to noise, changes in currents or stream flow, and changes in water quality, including increases in turbidity from onshore construction activities and dredging. Suspension or resuspension of sediments or other materials may be injurious to fish, provide less suitable nursery habitats, or reduce hatching success and larvae development (Auld and Schubel, 1978; Wilber and Clarke, 2001; Bilkovic, 2011). Reduced water clarity can also affect fish by interfering with their ability to feed or by changing the composition of prey species (Newcombe and MacDonald, 1991). BMPs would be employed to reduce runoff and minimize sediment transport in open water areas. Short-term, negative impacts to fish and fish populations also would occur if construction activities deterred fish from using essential migratory pathways, breeding, foraging, or seeking shelter from predators. However, under the recommended plan, construction effects would have only short-term, localized influence and fish would return to the area shortly after the cessation of construction activities. These short-term, adverse effects would be outweighed by substantive long-term benefits. The District will continue coordination with NOAA, NJDFW, and NYSDEC to protect migrating, overwintering, and/or spawning fish species.

In the long term, wetland habitat restoration in and along the Hackensack and Lower Passaic rivers would directly benefit multiple life stages of resident, transient, and migratory fish species, by providing forage, spawning, nursery, and refuge habitat. Bed restoration and channel modification, by restoring river and stream channels, pools, and riffles, would help reestablish beneficial flow regimes, which would also contribute to improved habitat for fish (Dibble and Meyerson, 2012). Shoreline stabilization would reduce long-term turbidity levels by reducing shoreline erosion.

Restoration Sites	Potential Environmental Consequences*
All Sites	• BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Long-term positive impacts to fish from improved water quality and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to managed and associated species. • Negligible, short-term, local adverse effect to managed and associated species. • During construction, negligible, short-term local displacement of fish due to noise, changes in currents or stream flow, and water quality deterioration, including increased turbidity.
Essex County Branch Brook Park	• During construction, minor, short-term local displacement of fish from dredging, bed restoration, channel modification, and installation of instream structures.

5.4.5 Essential Fish Habitat

As described above, it is anticipated that the no action alternative will be a continuation of the existing condition for Essential Fish Habitat.

With respect to essential fish habitat (EFH), construction activities under the recommended plan would employ BMPs to reduce construction impacts. A minor increase in turbidity and sedimentation would be generated by the proposed construction activities. BMPs would be employed to reduce runoff and minimize sediment transport in open water areas. If eggs and larvae are present during construction, they could be affected. During the construction period, adult and juvenile fish would leave the area of construction and move to nearby suitable locations outside the area of disturbance. Also, for a short period of time after construction, there would be a reduction in benthic organisms immediately adjacent to the in-water construction footprint; however, this area would be recolonized quickly. In the long term, due to tidal channel restoration and shoreline armoring, adverse effects would result from the removal of water column and benthic EFH. Given that these impacts would occur over comparatively small, discrete areas and would not adversely impact local water flow and circulation, implementation of the recommended plan may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. On balance, however, it is anticipated that ecosystem restoration would result in long-term, net benefits to managed species (all life stages), associated species, and EFH.

In a letter dated April 13, 2018, NMFS agreed with the USACE assessment that the implementation of the ecosystem restoration plan will result in long-term, net benefits to many federally managed species, their essential fish habitat, as well as many other NOAA trust resources (See Regulatory Appendix F for EFH Assessment and correspondence). NMFS acknowledged that impacts to EFH could be temporary (due to construction activities) or result from permanent changes in habitat type. USACE and NMFS agreed to continued coordination and to evaluate impacts through site-specific EFH consultations as more detailed plans are developed for each action during the PED Phase.

Agency consultation for federally listed threatened and endangered marine species is discussed in Section 5.4.8.

Restoration Sites	Potential Environmental Consequences*
All Sites	• BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Long-term positive impacts to fish from improved water quality and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to EFH. • Negligible, short-term, local adverse effect to EFH.

5.4.6 Shellfish and Benthic Resources

Under the no action alternative, impacts to benthic macroinvertebrate populations would continue along the same trajectory to existing condition and it is expected that population composed of low diversity pollution tolerant assemblages will remain. Compromised water quality, due to shoreline erosion, sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed areas would contribute to these conditions. Estuarine habitat sites would remain of low-quality and without tidal connectivity, although USEPA remediation at the Oak Island Yards site would reduce contamination and may allow the return of pollutionintolerant species, locally. Benthic invertebrate populations in the freshwater riverine site would continue to suffer from turbidity and low water quality in the no action alternative.

Under the recommended plan, construction associated with in-water and onshore restoration would result in short-term, negative impacts on benthic invertebrates, especially in aquatic areas designated for habitat conversion. Bivalves are slow-moving or sessile and would experience some degree of mortality or removal during construction in intertidal waters and subtidal shallows, and crab mortality and displacement likely would also occur during construction. Permanent loss of specific invertebrate populations and replacement with others would result from habitat changes such as the replacement of soft mud with a sand cap. However, impacts to benthic organisms would be limited and short-term due to limited existing species diversity and pollution tolerant composition. Mortality of sessile and less motile species is expected on shellfish beds and habitats targeted for dredging, shoreline stabilization, regrading, and removal of remnant shoreline structures and debris. However, it is anticipated that the restoration efforts of the HRE will benefit, and not adversely affect, the continued existence of any endangered and/or threatened species which occur in the project area.

Onshore construction activities and dredging and dredged material placement would cause short-term release or resuspension of sediments in the Hackensack and Lower Passaic rivers, and a concomitant short-term increase in turbidity. Although BMPs would be employed to reduce runoff and minimize sediment transport in open water areas, this increase in turbidity and resuspension of sediments could have a short-term, negative impact on shellfish (Wilber and Clarke, 2001; Knott et al., 2009). However, where benthic habitats suitable for shellfish are restored, and where existing shellfish habitat is not substantively changed or is restored, recovery of shellfish populations to levels that occurred prior to construction is expected to occur relatively rapidly.

Wetlands restoration would improve long-term water quality in the rivers and, therefore, would provide enhanced environments for benthic invertebrates. Bed restoration and channel modification, by restoring river and creek channels and pools, would help reestablish beneficial flow regimes, which likewise would contribute to improved habitat for shellfish (Portnoy and Allen, 2006). Increases in intertidal and subtidal habitat acreage, establishment of native tidal wetland vegetation, improved tidal connectivity and flushing, and improved sediment and water quality would result in a more diverse and abundant shellfish and benthic invertebrate resource.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term negative impacts from shellfish mortality in areas undergoing aquatic habitat conversion or restoration, typically with rapid recovery expected. • Negligible, short-term, local negative impacts to shellfish from water quality deterioration, including increased turbidity. • BMPs employed to minimize erosion and sedimentation, and control stormwater runoff.

	• Long-term positive impacts to shellfish from improved water quality, and habitat expansion and restoration.

5.4.7 Wildlife

Under the no action alternative, it is expected that a loss or degradation of terrestrial, wetland, and aquatic faunal communities from continued habitat degradation, pressures from nonnative species, erosional forces, rising sea levels, and anthropogenic disturbances will produce heightened impacts to wildlife populations than the existing condition. Wildlife in the estuarine habitat sites would continue to suffer from fragmented habitats and wetlands of low ecological value. Some improvements to wildlife habitat may result from USEPA remedial action at the Oak Island Yards restoration site although quality would remain low since wetlands would not be restored pursuant the Superfund program.

Construction associated with estuarine and freshwater riverine restoration would result in both adverse and beneficial effects on mammals. Short-term impacts from construction include species displacement and the potential for species mortality. Muskrats and other small mammal species that are associated with surface waters, wetlands or riverine habitats could be displaced to nearby comparable habitats but dens, nesting areas and individuals may be harmed or destroyed during construction activities. Potential long-term impacts including changes to habitat type and disturbances associated with increased public access. These impacts are likely to be offset by increases in habitat, as well as habitat enhancement. No population-level effects are expected.

Some negative short-term impact on bird species that utilize scrub uplands or marsh may result from operation of construction equipment. The MBTA requires a restriction on shrub and tree removal during construction activities to protect bird species that may potentially nest within the project areas. In order to comply with the MBTA, trees and shrubs will be cleared outside of a March 15 through July 31 (NJDEP, 2006) window to avoid adverse impacts to the listed species that are covered under this act. In October 2019, the USACE determined that construction of these restoration sites would have no impact on the migratory bird species identified as potentially occurring in the vicinity (9 species in the Lower Passaic River sites and 33 species in the Hackensack River sites).

Reptiles and amphibians resident to the project sites and in the immediate vicinity will be susceptible to the same kinds of disturbance factors as previously described for mammals, birds and fish. However, many reptile and amphibian species are much less capable of disbursing quickly, or to distances that remove them to habitats unaffected by project activities. Many will simply try and hide. Thus, the threat of direct adverse impacts due to active construction may be greater to reptile and amphibian species initially inhabiting or utilizing the project site. However, once the restoration has been completed, the new, restored or enhanced habitats will have a long-term beneficial impact on reptiles and amphibians that could result in measureable differences in the size and distribution of reptile and amphibian populations.

In the long term, restoration that involves habitat alteration would restore conditions more favorable for certain wildlife groups and species, and uninhabitable or more challenging to others. Overall, however, restored habitats would be higher in quality and function than the existing habitats they replace. For a myriad of wildlife, restored habitats would provide refugia—i.e., habitats that, under changing environmental conditions, the wildlife retreat to, persist in, and potentially can expand from (Askins and Philbrick, 1987; Keppel et al., 2012; Soga et al., 2014). In particular, restoring aquatic, wetland, and upland habitats by removing invasive vegetation, planting native vegetation, and improving hydrology and connectivity would benefit wildlife. With the growth and maturation of restored habitats, wildlife communities of greater diversity and ecological value are anticipated.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, minor, short-term negative impacts from mortality of sessile wildlife in areas undergoing habitat conversion or restoration. • Negligible, short-term local displacement of mobile wildlife due to habitat alteration, and construction-related noise and human activity, with rapid recovery expected. • BMPs employed to limit vegetation disturbance, minimize erosion and sedimentation, and control stormwater runoff. • Long-term positive impacts to wildlife from establishment of higher-quality habitats and refugia.

5.4.8 Rare, Threatened, and Endangered Species

Under the no action alternative, impacts to rare, threatened and endangered species are expected to be a continuation of the existing conditions. Sustained pressure on rare species is anticipated due to displacement by nonnative species and continued loss and degradation of habitats from rising sea levels, erosion, and anthropogenic disturbances. Rare, threatened and endangered species in the estuarine habitat sites would continue to suffer from fragmented habitats and wetlands of low ecological value. Some improvements to habitat may result from USEPA remedial action at the Oak Island Yards restoration site although quality would remain low since wetlands would not be restored.

In the short term, construction associated with implementation of the recommended plan potentially could displace or disturb rare, threatened, and endangered species on or in the vicinity of the restoration sites. Such effects would result from clearing vegetation, changes in currents or stream flow, changes in water quality, including increases in turbidity, and construction-related noise and human activity.

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species, and species of special concern within the Newark Bay, Hackensack River and Passaic River Planning Region project sites and their vicinities. The USFWS and NMFS were contacted regarding federally listed threatened and endangered species under the ESA, and the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry was contacted regarding state listed species in the New Jersey Natural Heritage Program (NJNHP). While no federally-listed endangered, threatened, or rare plant and animal species exist in the vicinity of the restoration sites, several state-listed species were identified at all sites except for Oak Island Yards. As construction at the Oak Island Yards site is deferred following EPA Remedial Action, site specific coordination will occur at a later date. Correspondences can be found in the Regulatory Appendix F. Prior to restoration activities, onsite surveys will be conducted at each restoration site to fully assess any potential impacts on biological resources and confirm whether any documented species could be impacted by any restoration activities. If rare, threatened, and endangered species are confirmed at the sites that could be adversely impacted by restoration activities, precautions will be taken to avoid, minimize, or mitigate the impacts as determined by the appropriate agency. Summary tables of the Threatened and Endangered species identified by NMFS and USFWS can be seen in Tables 5-7 and 5-8.

Table 5-7. Determinations of USFWS Threatened and Endangered species within the Newark Bay, Hackensack River and Passaic River Planning Region

Restoration Site	USFWS Threatened and Endangered Species
	Migratory Birds
Newark Bay, Hackensack River and Passaic River Planning Region	
Oak Island Yards	Deferred Site
Essex County Branch Brook Park	No effect
Metromedia Tract	No effect
Meadowlark Marsh	No effect

Table 5-8. Determination of NMFS Threatened and Endangered species within the Newark Bay, Hackensack River and Passaic River planning region

Restoration Site	NMFS Threatened and Endangered Species	
	Atlantic Sturgeon	Shortnose Sturgeon
Newark Bay, Hackensack River and Passaic River Planning Region		
Oak Island Yards	Deferred Site	
Essex County Branch Brook Park		
Metromedia Tract	No effect	No effect
Meadowlark Marsh	No effect	No effect

The NJNHP identified several rare or state-listed bird species on or within one-quarter mile of potential restoration sites in letters dated April 12, 2016 and May 21, 2015. Species that may forage in or around the restoration sites include the state-endangered Bald Eagle (*Haliaeetus leucocephalus);* the state-threatened Cattle Egret (*Bubulcus ibis*), Yellow-crowned Night-heron (*Nyctanassa violacea),* and Black-crowned Night-heron (*Nycticorax nycitorax)*; and other state species of concern*.* As these birds are highly mobile and capable of avoiding construction activities, disturbance from construction activities would be short-term and localized.

Some birds are documented as nesting or breeding in or near the restoration sites. A Bald Eagle nest was documented in the vicinity of the Meadowlark Marsh site, and an urban nest for the state-endangered Peregrine Falcon (*Falco peregrinus)* was documented at the Meadowlark Marsh and Metromedia sites. Coordination with USFWS, the NJ Department of Fish and Wildlife Endangered Nongame Species Program, and the NYSDEC will continue through PED regarding bald eagles. Breeding and non-breeding sightings for the state-endangered Northern Harrier (*Circus cyaneus)* were documented at and around the Metromedia site and in the vicinity of the Meadowlark site. Breeding sightings were also documented at and around the Essex County Branch Brook Park for the state-threatened Red-headed Woodpecker (*Melanerpes erythrocephalus).* If pre-construction surveys confirm the presence of nesting or breeding species, construction buffers and/or timing restrictions would be employed during nesting season, which typically occurs between March and August.

As the restoration goals include restoring, and protecting wildlife habitat, impacts to rare, threatened, and endangered species are expected to be short-term and insignificant. In the long term, implementation of the recommended plan would benefit rare, threatened, and endangered bird species in the Newark Bay, Hackensack River and Passaic River Planning Region by increasing favorable habitat and improving the quality of existing habitat.

Restoration Sites	Potential Environmental Consequences*
All Sites	• No long-term negative impacts to protected species. • Long-term positive impacts to rare, threatened, or endangered species from habitat and ecosystem restoration.
Essex County Branch Brook Park Metromedia Tract Meadowlark Marsh	• Negligible, short-term impacts to state-listed bird species due to construction activities. • Construction buffers and/or timing restrictions may be required to avoid impacts during breeding or nesting periods.

5.4.9 Land Use

The recommended restoration sites are a combination of public open space, public parkland, or former industrial land use; as such, no impacts to land use are expected in the no action scenario. No permanent housing exists on these sites. Under the no action alternative, Branch Brook Park would remain as parkland maintained by local governments and may undergo minor improvements budgets and fund raising allow. The Metromedia Tract and Meadowlark Marsh estuarine habitat restoration sites would likely remain open space if no action is taken, although the Oak Island Yards site could potentially be developed as portions of the site are currently zoned industrial and/or commercial. Sites with parcels formerly used for industrial purposes would be converted to public land. Site access would remain similar to or better than existing conditions.

Restoration Sites	Potential Environmental Consequences*
Oak Island Yards Metromedia Tract	Long-term impacts from former industrial land converted to open space, preventing future development opportunities.

Meadowlark Marsh	
Essex County Branch Brook Park	Implementation of the recommended plan would not change the existing land use of the sites. Minimal short-term impacts from restricting public access to existing park areas.

5.4.10 Hazardous, Toxic, and Radioactive Waste

Under the no action alternative, impacts from HTRW expected to improve from the existing condition at Oak Island Yards as legacy sediments will be removed and capped as a result of the USEPA remedial action in the lower 8.3 miles of the Lower Passaic River. This cleanup will take place prior to restoration of the Oak Island Yards site. Each site would require additional HTRW sampling during PED to determine if additional remedial activities are required prior to restoration. Impacts from HTRW at the Meadowlands and Branch Brook Park are expected to be a continuation of existing condition. In all recommended sites, sediment and water quality impacts derived from a combination of sewage inputs, landfill leaching, industrial activity, and runoff from roads and developed areas are expected to remain.

Under the recommended plan, habitat restoration and associated construction activities would cause short-term release or resuspension of sediments and a concomitant short-term increase in turbidity, in nearby waters in Hackensack and Lower Passaic rivers. BMPs would be employed to reduce erosion and sedimentation. Removal of the debris and fill at the Oak Island Yards restoration site may require investigation and special handling and disposal of fill if contaminants are present. Channel dredging at the Essex County Branch Brook Park site and tidal channel restoration at the Meadowlark Marsh and Oak Island Yards restoration sites may also require special handling of sediments if contaminants are found.

In the long term, restoring wetlands, and maritime and riparian forest, and armoring and stabilizing shorelines would improve water quality and provide nutrient removal and denitrification services. The restored habitats would reduce long-term turbidity by filtering and retaining stormwater runoff, providing storm surge and flood buffering, attenuating waves, and thereby reducing shoreline erosion. Improved tidal flushing and reduced water residency time, due to restoring tidal channels and basins, would increase dissolved oxygen levels and reduce fecal coliform levels (Portnoy and Allen, 2006). Restored wetlands likewise would improve tidal flushing and increase dissolved oxygen levels. Groundwater resources may also benefit from restored wetlands, as wetlands filter pollutants moving between surface water and groundwater.

Restoration Sites	Potential Environmental Consequences*
All Sites	• During construction, risk of local water quality deterioration from construction-related, accidental spills. • Safeguards employed to prevent and respond to spills. • Long-term surface water quality improvements—i.e., increased turbidity reduction, nutrient removal, denitrification, and/or increased dissolved oxygen levels, and reduced fecal coliform levels.
Essex County Branch Brook Park	• Possible long-term groundwater quality improvements.
Oak Island Yards Essex County Branch Brook Park Meadowlark Marsh	• Handling or removal of debris, fill, or sediments during restoration, channel dredging, or tidal restoration activities may require investigation and special handling and disposal if contaminated sediment is found.

5.4.11 Noise

Under the no action alternative, restoration would not take place and short-term, temporary increases in ambient noise levels due to construction activities would not occur. Population growth and increased use of railways and roadways in the region may cause noise levels to rise in the future.

Heavy equipment used during construction may contribute to short-term increase in noise levels. However, noise levels would not exceed those cited in local ordinances and would occur only during normal daytime working hours. In the long term, sites with riparian or maritime forest restoration, such as Metromedia Tract and Meadowlark Marsh, mature trees may create a natural buffer to reduce ambient noise levels.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Short-term increases in noise levels from construction equipment would occur during normal daytime working hours. • Implementation of the recommended plan at each site would not cause any negative long-term noise impacts.
Metromedia Tract Meadowlark Marsh	• Long-term potential to reduce ambient long-term noise from mature trees in riparian and maritime forest.

5.4.12 Social and Economic Resources

Under the no action alternative, construction would not take place and no short-term employment benefits would occur. Lack of public access at the estuarine habitat restoration sites and degraded conditions at the freshwater riverine restoration sites could potentially limit long-term social and economic opportunities.

Restoration under the recommended plan would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education. No permanent or long-lasting economic effects are anticipated as a result of construction activities.

Larger populations of waterbirds throughout the planning region, particularly in the vicinity of Newark International Airport, could lead to a greater potential for bird-aircraft strikes, potentially requiring increased expenditures by the PANYNJ to mitigate the heightened hazard. Due to the increasing concern regarding aircraft-wildlife strikes, the FAA has implemented standards, practices, and recommendations for holders of Airport Operating Certificates issued under Title 14, CFR, Part 139, Certification of Airports, Subpart D (Part 139), to comply with the wildlife hazard management requirements of Part 139. Airports that have received federal grant-in-aid assistance must use these standards. In accordance with the FAA Advisory Circular 150/5200-33B and the Memorandum of Agreement with FAA to address aircraft-wildlife strikes, when considering proposed flood risk management measures and mitigation (and restoration) areas, USACE must take into account whether the proposed action could increase wildlife hazards.

The FAA recommends minimum separation criteria for land-use practices that attract hazardous wildlife to the vicinity of airports. These criteria include land uses that cause movement of hazardous wildlife onto, into, or across the airport's approach or departure airspace or AOA. These separation criteria include:

- Perimeter A: For airports serving piston-powered aircraft, hazardous wildlife attractants must be 5,000 feet from the nearest AOA;
- Perimeter B: For airports serving turbine-powered aircraft, hazardous wildlife attractants must be 10,000 feet from the nearest AOA; and
- Perimeter C: Five-mile range to protect approach, departure, and circling airspace.

Oak Island Yards is within the five-mile perimeter of Newark International Airport but is not being considered for near-term construction until EPA's Superfund Program completes the remedy of the Lower Passaic River.

Improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Increased shoreline stabilization may reduce municipal expenditures, including those for emergency services. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts to access to recreational resources. • During construction, minor, short-term increases in local employment, earnings, induced spending, and tax revenues, and provision of educational opportunities. • Minor, long-term stimulation of the local economy and provision of educational opportunities.
Oak Island Yards	• Negligible, long-term increased expenditures to mitigate heightened bird-aircraft strike hazard.
Meadowlark Marsh Metromedia Tract	• Combined total first cost of approximately $60,775,000 for Hackensack River sites.
Oak Island Yards Essex County Branch Brook Park	• Total first cost of approximately $52,028,000 for Branch Brook Park and $15,441,000 for Oak Island Yards (Tier 2 site) for near-term construction following remedial action.

5.4.13 Navigation

Under the no action alternative, no restoration will occur and no changes or impacts to navigation would occur.

Short-term impacts to navigation in the Newark Bay, Hackensack River and Passaic River Planning Region would be limited to recreational boat usage during in-water construction activities. The freshwater riverine restoration sites are not located on waters used by shipping traffic. Estuarine habitat restoration activities would take place on land or in the shallows and would not be in close proximity to heavily used navigation channels. No long-term impacts are expected from the restoration activities.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minimal, short-term limitations to local boat craft usage during construction activities. • Implementation of the recommended plan would not impact navigation at the restoration sites.

The proposed restoration sites (except Essex County Branch Brook Park) are close to Federal and recreational channels making them, and construction vessels, susceptible to wake and/or surge damage. During construction, coordination with the First Coast Guard District (Sector New York) will be required for publication in the Local Notice to Mariners before starting operations and if needed, request the movement of any Federal Channel marker buoys.

Public outreach to the recreational boating and fishing vessel industries will be undertaken to ensure maximum visibility of the restoration activities within the action area.

5.4.14 Recreation

Under the no action alternative, the estuarine habitat restoration sites would remain in their degraded state, and walking trails and other improvements to public access would not occur. Essex County Branch Brook Park would remain as existing parkland; however public access improvements from restoration that would otherwise enhance community use and experience would not take place.

Under the recommended plan, access to recreational resources may be negatively affected temporarily during construction. At sites which currently offer recreational resources, there may be adverse temporary impacts during construction due to the closing of the interior footpaths and some fishing access restrictions. However, construction would be phased to occur during the colder winter months when the paths are not as heavily utilized.

After the recommended plan is implemented, positive impacts to the recreational and educational features of the sites would be realized. Within the estuarine habitat restoration sites, improvements include upgrades to an existing path at Oak Island Yards. Upland areas at Meadowlark Marsh are currently used by ATVs. Under the recommended plan, vehicle access would be prohibited in restoration areas. Within the freshwater riverine habitat restoration sites improvements at the Essex County Branch Brook Park include installation of interpretive signs to support ongoing public access improvements.

In addition to public access improvements, estuarine and freshwater riverine habitat restoration would provide improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, which potentially would increase activities such as fishing, hiking, boating, and bird watching.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts from limited access to recreational resources during construction. • Long-term improvement in recreational opportunities for wildlife viewing, hiking, recreational fishing, kayaking, and canoeing through habitat improvement.
Oak Island Yards Essex County Branch Brook Park	• Long-term benefits from improved public access.

5.4.15 Cultural Resources

Under the no action alternative impacts to cultural resources are expected to be minimal; however, loss of historic resources due to SLR and erosion could occur.

Under the action alternative, there is a potential to cause adverse effect to historic properties from excavation or material placement over the resources. As an initial look into the effects of the action alternative, a desktop search was completed of the known cultural resources in and around the recommended sites. This desktop search found that one of the restoration sites is located within a Nation Register Listed Historic District. This is the Essex County Branch Brook Park restoration site, which is located inside the Branch Brook Park National Register Historic District. In addition to this, there are 20 other historic districts, 1,467 historic properties, and 13 archaeological sites within one mile of the four restoration sites in the Newark Bay, Hackensack River and Passaic River Planning Region (Table 5-9). The majority of these resources are located around the Essex County Branch Brook Park restoration site.

The effects of the proposed restoration will have on the New York Botanical Gardens, Lorillard Snuff Mill, Rainey Memorial Gates, Bronx Zoo Dam, and the Bronx River Parkway Reservation will be addressed by implementing the provisions of the PA. The District will work to avoid adverse effects to the historic properties, but if necessary, treatment plans will be developed in accordance with the stipulations of the PA and negotiated with the signatories to resolve adverse effects to the historic properties.

The majority of the APE for the four restoration sites has been previously surveyed, but additional survey will be required to cover the areas that have not been survey, or were surveyed a very long time ago. To carry out this work, the USACE entered into a Programmatic Agreement (PA) with the Advisory Council on Historic Preservation, New York State Historic Preservation Office, New Jersey State Historic Preservation Office, New York City Landmarks Preservation Commission and National Park Service (see Appendix H) that stipulates the actions the USACE will take to satisfy its responsibilities under Section 106 of the National Historic Preservation Act and other applicable laws and regulations. Pursuant to the PA, archaeological survey work will take place in the Preconstruction Engineering and Design Phase. Since this survey work has not yet been carried out, the full effects the recommended plan will have on cultural resources is not yet known.

Some cultural resources work was previously done for the source studies and a preliminary analysis for the HRE study area. This work covered some of the APE of the recommended plan, and gave recommendations for future work in these areas. This previous work will inform the future cultural resources work that will be carried out pursuant to the PA, and when appropriate, the recommendations from the previous investigations will be followed. Below is a listing of the reports:

- *Cultural Resources Investigation of Ten Sites in the Hackensack Meadowlands, Hackensack Meadowlands Ecosystem Restoration Project, Hudson and Bergen Counties, New Jersey (Hunter Research Inc., 2006);*
- *Historic Context Development, Hackensack Meadowlands Drainage Systems and Features, Hackensack Meadowlands Ecosystem Restoration Project, Hudson and Bergen Counties, New Jersey (Hunter Research Inc., 2010); and*
- *Cultural Resources Overview for the Hudson-Raritan Estuary Comprehensive Restoration Plan (Harris et al., 2014).*

Table 5-9. Historic Properties Located within or Nearby the Recommended Restoration Sites in the Newark Bay, Hackensack River and Passaic River Planning Region.

Restoration Sites	Historic Properties Identified
All Sites	• Potential for archaeological resources at all the sites. • Additional survey is required under the stipulations of the draft PAs to determine whether other resources are present within the project area. • Mitigation would be required for impacts to significant resources.
Meadowlark Marsh	• One historic district and four historic resources are listed within one (1) mile of this site
Metromedia Tract	• Zero historic resources or archaeological sites are located within one (1) mile of this site.
Oak Island Yards	• Three (3) historic resources and one (1) historic resource is located within one (1) mile of the site.
Essex County Branch Brook Park	• 17 Historic Districts, 1,479 historic resources, and 13 archaeological sites are located within one (1) mile of this site.

5.4.16 Aesthetics

Under the no action alternative, the degraded condition of the region is anticipated to continue into the future, decreasing aesthetic and scenic resource value in the planning region. Areas of historic fill at the estuarine habitat restoration sites would remain dominated by unsightly invasive species and lack of vegetative diversity. Trash and invasive species dominance would increasingly degrade the freshwater riverine restoration site. Lack of public access improvements would continue to limit scenic viewing opportunities in the region.

During construction of the recommended plan temporary impacts to the aesthetic and scenic resources would occur on site due to the presence of construction equipment, vegetation clearing, and earthwork. However, the sites are overgrown with invasive species and the proposed restoration would replace invasive species with diverse vegetation including native low marsh, high marsh, scrub/shrub wetland, and maritime forest species at the estuarine habitat restoration sites, and native riparian forest vegetation within freshwater riverine habitat restoration sites, thus improving aesthetic and scenic resource value. Additionally, the construction and enhancement of trails and overlooks would provide improved public access to scenic resources.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Minor, short-term negative impacts to aesthetic and scenic resources during construction. • Long-term improvement in scenic resource value with vegetation restoration and overall habitat improvement.

Restoration Sites	Potential Environmental Consequences*
All Sites (except Metromedia Tract, Meadowlark Marsh)	• Long-term benefits from improved public access.

5.4.17 Coastal Zone Management

Under the no action alternative, no restoration will occur and no impacts to state or local coastal zone management plans would occur.

Restoration activities within the Newark Bay, Hackensack River and Passaic River Planning Region were evaluated with respect to their consistency with NJDEP Coastal Zone Management Program and the restoration activities were found to be consistent with the coastal zone management rules (Appendix F). As it is a deferred site, a consistency determination for Oak Island Yards will be completed in the future.

Following coordination with NJDEP, the Federal Consistency requests for the Branch Brook Park, Metromedia Tract, and Meadowlark Marsh sites were withdrawn (December 9, 2019). NJDEP gave conditional approval of Federal Consistency Determinations and Water Quality Certificates (WQC) for the sites provided that USACE submits a Federal Consistency and WQC request along with PED level designs for the final selected project design and that NJDEP can confirm that the proposed project is consistent with its Coastal Zone Management rules (April 16, 2020). See Appendix F for correspondence.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Restoration activities are consistent with state and local coastal zone management programs.

5.5 Upper and Lower Bay Planning Regions

It is anticipated that without restoration there would be a further demise and degradation of existing estuarine habitats within the Upper Bay and Lower Bay, due to continuing natural erosive forces and rising sea levels, and anthropogenic stressors, like urbanization, dredging, compromised water quality, landfilling and landfill leachate intrusions, and illegal dumping.

The environmental health in both the Upper and Lower Bay Planning Regions is expected to decline with projected non-point source water quality inputs, SLR, and climate change. As such, continued losses of low lying coastal habitats from erosion and sedimentation are expected in the without project condition. Although oyster populations do exist in isolated areas, much of the reefs in the Upper Bay have been degraded or destroyed by human activities. Experimental programs, such as the Oyster Restoration Research Program and NY/NJ Baykeeper oyster restoration at Naval Weapons Station Earle, are promising, but expansion to large scale reefs is needed to fully benefit from the effects on water quality, nutrient processing, shoreline stabilization, and the provision of nursery habitat for many estuarine-dependent finfish and shellfish species. These benefits from the increase in oyster populations would not occur in the without-project condition.

Implementation of the recommended plan would restore oyster habitat at one (1) site in the Upper Bay Planning Region and one (1) site in the Lower Bay Planning Region. Small-scale oyster restoration would be undertaken at Bush Terminal in Upper Bay, where approximately 32 acres of oyster reef habitat would be restored, and at Naval Weapons Station Earle in Lower Bay, where approximately ten (10) acres of oyster reef habitat would be restored with the placement of gabion blocks and reef balls.

5.5.1 Geomorphology and Sediment Transport

Under the no action alternative, conditions in the Upper Bay and Lower Bay planning regions, with respect to geomorphology and sediment transport, would remain unchanged. Substrates at the Bush Terminal oyster restoration site would continue to be laden with sediments that reduce available habitat.

During restoration construction under the recommended plan, sediment resuspension from placing spat on shell, installing reef balls, oyster condos, super trays, and wire cages/gabions, and vessel movements and prop wash could result in temporary disturbances to sediment transport and a concomitant short-term increase in turbidity in nearby waters in the bay. These activities and their effects would be localized and, generally, short-term. As appropriate, silt curtains may be used to minimize sediment transport, precluding resuspended sediments being transported by currents and forming new shoals. All soil erosion measures will be coordinated with USFWS.

Oyster restoration could naturally change the local bathymetry as the reefs mature and expand. With increased elevation, established reefs provide long-term, incremental improvements to shoreline stability, by attenuating waves and boat wakes, and retaining sediments, potentially reducing shoreline and bottom erosion, and reducing the sediment load. Shoreline retreat has been reduced by as much as 40 percent by constructed oyster reefs (Scypher et al., 2011). Oyster beds established under the recommended plan also would reduce turbidity, by mitigating shoreline erosion and filtering suspended solids and phytoplankton (Meyer et al., 1997; Coen et al., 2007; Scyphers et al., 2011). The resulting reduction in turbidity under the recommended plan would provide long-term habitat enhancement for shellfish, fish communities, and aquatic vegetation (Cahoon et al., 1999; Paul and Meyer, 2001; Steinberg et al., 2004).

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, negligible, short-term local sediment disturbance and sedimentation and minor, short-term local increase in turbidity from offshore placing spat on shell, installing reef balls, oyster condos, super trays, and wire cages/gabions, and vessel and equipment movement. • BMPs employed to minimize erosion and sedimentation.

	• Long-term wave and turbidity attenuation, sediment accretion, erosion and sedimentation control, sediment load reduction, shoreline protection, and coastal resiliency improvements.

5.5.2 Water Resources

Under the no action alternative, the Bush Terminal oyster restoration site in the Upper Bay Planning Region and the Naval Weapons Station Earle oyster restoration site in Lower Bay Planning Region would experience continuing or worsening degradation of hydrologic conditions, depending on the magnitude and effects of SLR and climate change.

The hard structure of oyster reefs, in both intertidal areas and further offshore in deeper subtidal waters, may function to moderate wave climate and potentially reduce shoreline erosion from storm events and vessel wakes. With increased reef elevation, up thrusting reefs can divert and modify surrounding currents (Hargis and Haven, 1999). Large reefs (or series of smaller reefs) can act as natural wave attenuators, protecting nearby shorelines and other aquatic, tidal, and terrestrial habitats. Oyster beds/reefs seaward of salt marshes may enhance/supplement the ability of marshes to stabilize shorelines and moderate wave energy. Within the immediate area of the sites, oyster restoration under the recommended plan would provide long-term regulation of water flow, storm surge and flood buffering, wave attenuation, and protection of shorelines, per the findings of Woodward and Wui (2001), Zelder and Kercher (2005), Koch et al. (2009), Barbier et al. (2011), Gedan et al. (2011), and Shepard et al. (2011).

A Section 404(b)(1) Guidelines Evaluation has been completed for each site and is provided in Appendix F.

Restoration Sites	Potential Environmental Consequences*
Naval Weapon Station Earle Bush Terminal	• During construction, negligible, short-term disruption of local wave and current regimes, and hydrology from offshore placing spat on shell, and installing reef balls, oyster condos, super trays, and wire cages/gabions. • BMPs employed to minimize erosion and sedimentation. • Long-term improvements in regulation of water flow, storm surge and flood buffering, and wave attenuation.

5.5.3 Vegetation

It is anticipated that, under the no action alternative, no change would occur with respect to vegetation at the Bush Terminal or Naval Weapon Station Earle oyster restoration sites.

In the short term, construction associated with implementation of the recommended plan would not remove or disturb existing vegetation. However, placing spat on shell, installing oyster condos, super trays, and wire cages/gabions, and vessel movements and prop wash likely would cause short-term resuspension of sediments and a concomitant short-term increase in turbidity, in nearby waters in the Upper and Lower Bays. In turn, this increase in turbidity could have a short-term, negative impact on aquatic macrophytes (Erftemeijer and Lewis, 2006). BMPs would be employed to minimize suspended sediments in open water areas. There would also be a permanent elimination of any submerged aquatic macrophytes in bay bottom areas targeted for oyster restoration.

Conversely, establishment of oyster reefs would provide water filtration and an attendant reduction in turbidity (Coen et al., 2007), which would provide long-term benefits to aquatic macrophytes (Newell and Koch, 2004). Improved water clarity can increase light penetration, which can increase growth of benthic vegetation (Grabowski and Peterson, 2007).

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, minor, short-term disturbance of existing aquatic vegetation from offshore placing spat on shell, and installing reef balls, oyster condos, super trays, and wire cages/gabions. • BMPs employed to limit vegetation disturbance, and minimize erosion and sedimentation. • Negligible, long-term removal of existing aquatic vegetation, and disruption of associated ecosystem services. • Long-term benefit to aquatic vegetation through water filtration and turbidity reduction.

5.5.4 Finfish

Under the no action alternative, sedimentation and poor water quality around the Bush Terminal and Naval Weapons Station Earle oyster restoration sites would be a continuation of the existing condition.

Under the recommended plan, construction associated with small-scale oyster restoration would result in short-term, negative impacts to fish. Fish may be displaced due to noise, changes in currents, and changes in water quality, including increases in turbidity from placing spat on shell, installing reef balls, oyster condos, super trays, and wire cages/gabions, and vessel movements and prop wash. Suspension or resuspension of sediments or other materials may be injurious to fish, provide less suitable nursery habitats, or reduce hatching success and larvae development (Auld and Schubel, 1978; Wilber and Clarke, 2001; Bilkovic, 2011). Reduced water clarity can also affect fish by interfering with their ability to feed or by changing the composition of prey species (Newcombe and MacDonald, 1991). BMPs would be employed to minimize suspended sediments in open water areas. Short-term, negative impacts to fish and fish populations also would occur if construction activities deterred fish from using essential migratory pathways, breeding, foraging, or seeking shelter from predators. However, under the recommended plan, construction effects would have only short-term, localized influence and fish would return to the area shortly after the cessation of construction activities. These short-term, adverse effects would be outweighed by substantive, long-term benefits. The District will continue coordination with NOAA, NJDFW, and NYSDEC to protect migrating, overwintering, and/or spawning fish species.

Oysters are described as a keystone species on the Atlantic coast of the United States (Stanley and Sellers, 1986; Rothschild et al., 1994; USFWS, 2010)—i.e., a species whose presence is vital to the structure of the rest of the associated estuarine community. In the long term, larval, juvenile, and adult oysters would provide a prey resource for many fish species. Establishment of oyster reefs would provide water filtration and an attendant reduction in turbidity (Coen et al., 2007), which would provide long-term benefits to fish. Additionally, oyster establishment and growth creates three-dimensional reefs, providing habitat for large numbers of species, including fish (Kellogg et al., 2013).

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, negligible, short-term local displacement of fish from placing spat on shell and installing reef balls, oyster condos, super trays, and wire cages/gabions. • Negligible, short-term, local adverse effect to managed and associated species. • BMPs employed to limit vegetation disturbance, and minimize erosion and sedimentation. • Long-term positive impacts to fish from improved water quality, provision of a prey resource, and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to managed and associated species.

5.5.5 Essential Fish Habitat

Under the no action alternative, impacts to EFH are expected to be a continuation of the existing condition. Lack of essential fish habitat and nursery grounds would continue around the Bush Terminal and Naval Weapons Station Earle oyster restoration sites as a result of sedimentation and poor water quality.

With respect to EFH (Appendix F), construction activities under the recommended plan would employ BMPs to reduce construction impacts. A short-term increase in turbidity and sedimentation would be generated by the proposed construction activities. If eggs and larvae are present during construction, they could be affected. BMPs would be employed to minimize suspended sediments in open water areas. During the construction period, adult and juvenile fish would leave the area of construction and move to nearby suitable locations outside the area of disturbance. Also, for a short period of time after construction, there would be a reduction in benthic organisms immediately adjacent to the in-water construction footprint; however, this area would be recolonized quickly. All adverse impacts on managed species, associated species, and EFH are expected to be temporary and localized. Implementation of the recommended plan may result in short-term adverse effects on EFH, but the resulting changes to EFH and its ecological functions would be relatively small and insignificant. On balance, however, it is anticipated that ecosystem restoration would result in long-term, net benefits to managed species (all life stages), associated species, and EFH, as oyster establishment and growth creates three-dimensional reefs which can provide habitat for large numbers of fish (Kellogg et al., 2013).

In a letter dated April 13, 2018, NMFS agreed with the USACE assessment that the implementation of the ecosystem restoration plan will result in long-term, net benefits to many federally managed species, their essential fish habitat, as well as many other NOAA trust resources (see Appendix F for correspondence). NMFS acknowledged that impacts to EFH could be temporary (due to construction activities) or result from permanent changes in habitat type. USACE and NMFS agreed to continued coordination and to evaluate impacts through site-specific EFH consultations as more detailed plans are developed for each action during the PED Phase.

Agency consultation for federally listed threatened and endangered marine species is discussed in Section 5.5.8.

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, negligible, short-term local displacement of fish from placing spat on shell and installing reef balls, oyster condos, super trays, and wire cages/gabions. • Negligible, short-term, local adverse effect to EFH. • BMPs employed to limit vegetation disturbance, and minimize erosion and sedimentation. • Long-term positive impacts to fish from improved water quality, provision of a prey resource, and provision of forage, spawning, nursery, and refuge habitat. • On balance, long-term benefits to EFH.

5.5.6 Shellfish and Benthic Resources

Under the no action alternative, benthic habitat around the Bush Terminal and Naval Weapon Station Earle oyster restoration sites would be a continuation of existing condition with degradation due to sedimentation and poor water quality. Oyster populations would remain limited to small, localized communities that are threatened by the continued degradation of the estuary.

Under the recommended plan, construction associated with small-scale oyster restoration would result in short-term, negative impacts on benthic invertebrates. Mortality of sessile and less motile species is expected on shellfish beds and habitats targeted for placing spat on shell and installing reef balls, oyster condos, super trays, and wire cages/gabions. Establishing these structures, and vessel movements and prop wash, would cause short-term resuspension of sediments in the bay and a concomitant short-term increase in turbidity. Although BMPs would be employed to minimize suspended sediments in open water areas, this increase in turbidity and resuspension of sediments could have a short-term, negative impact on shellfish (Wilber and Clarke, 2001; Knott et al., 2009) and benthic invertebrates. However, where benthic habitats suitable for shellfish are restored, and where existing shellfish habitat is not substantively changed or is restored, recovery of shellfish populations to levels that occurred prior to construction is expected to occur relatively rapidly.

In the long term, oyster restoration would provide suitable habitat for other shellfish species (Steimle and Zetlin, 2000; Peterson et al., 2003; Scyphers et al., 2011). Oyster restoration would provide hard-bottom habitat that support more productive and higher density invertebrate communities (Grizzle et al., 2013). Larval, juvenile, and adult oysters also provide a prey resource for invertebrates, including blue and mud crabs (Stanley and Sellers, 1986). Establishment of oyster reefs would provide water filtration and an attendant reduction in turbidity (Coen et al., 2007), which would provide long-term benefits to shellfish. Oyster establishment and growth creates three-dimensional reefs, providing habitat for large numbers of species (Kellogg et al., 2013).

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, minor, short-term negative impacts from shellfish mortality due to placing spat on shell and installing reef balls, oyster condos, super trays, and wire cages/gabions. • Negligible, short-term, local negative impacts to shellfish from water quality deterioration, including increased turbidity. • BMPs employed to minimize erosion and sedimentation. • Long-term positive impacts to shellfish from improved water quality and establishment of shellfish habitat.

5.5.7 Wildlife

Under the no action alternative, wildlife habitat at the Bush Terminal or Naval Weapons Station Earle oyster restoration sites would remain unchanged.

Under the recommended plan, construction associated with small-scale oyster restoration at Naval Weapons Station Earle and Bush Terminal would not impact terrestrial wildlife, as restoration would occur along the existing piers and bulkheads, or from the water. However, construction activities may result in mortality among sessile and less mobile aquatic fauna. Construction, and construction-related noise and human activity would cause short-term disruption to more mobile wildlife present at the restoration sites. Some aquatic wildlife may be displaced temporarily, but eventually would populate or return to using the restored habitats.

No impact on bird species that utilize scrub uplands or marsh is expected to result from operation of construction equipment. The project areas of the recommended reefs are within the channel and completely submerged. In October 2019, the USACE determined that construction of the oyster restoration sites would have no effect on migratory birds that may occur in the vicinity (23 species around Naval Weapons Station Earle and 51 species around Bush Terminal).

In the long term, oyster restoration would restore conditions more favorable for certain aquatic wildlife groups and species, and uninhabitable or more challenging to others. Overall, however, the established oyster reef would be higher in quality and function than the existing habitat it replaces. The reef would provide refugia and, with the growth and maturation of the reef, aquatic wildlife communities of greater diversity and ecological value are anticipated.

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, minor, short-term negative impacts from mortality of sessile aquatic wildlife due to placing spat on shell and installing reef balls, oyster condos, super trays, and wire cages/gabions. • Negligible, short-term, local negative impacts to mobile aquatic wildlife from construction-related noise and human activity, with rapid recovery expected. • BMPs employed to limit vegetation disturbance, and minimize erosion and sedimentation. • Long-term positive impacts to aquatic wildlife from improved water quality and establishment of oyster habitat.

5.5.8 Rare, Threatened, and Endangered Species

Under the no action alternative, impacts on rare, threatened, and endangered species at the Bush Terminal or Naval Weapons Station Earle restoration sites would remain unchanged.

In the short term, construction associated with implementation of the recommended plan potentially could displace or disturb rare, threatened, and endangered species on or in the vicinity of the restoration sites. Such effects would result from changes in water quality, including increases in turbidity, and construction-related noise and human activity.

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species, and species of special concern within the Upper and Lower Bay planning region project sites and their vicinities. The NMFS and USFWS were contacted regarding federally listed threatened and endangered species under the ESA, while the NYSDEC Division of Fish, Wildlife, and Marine Resources was contacted regarding state listed species in the NYNHP and the NJDEP Division of Parks and Forestry was contacted regarding state listed species in the NJNHP. Correspondences with the agencies are in Appendix F. Prior to restoration activities, onsite surveys will be conducted at each restoration site to fully assess any potential impacts on biological resources and confirm whether any documented species may be impacted by any restoration activities. If rare, threatened, and endangered species are confirmed at the sites that could be adversely impacted by restoration activities, precautions will be taken to avoid, minimize, or mitigate the impacts as determined by the appropriate agency.

According to NMFS correspondence (April 27, 2016), four (4) different species of protected marine turtles, the endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), and the endangered shortnose sturgeon (*Acipenser brevirostrum*) may be present at the Bush Terminal or Naval Weapons Station Earle restoration sites. Disruptions to marine wildlife are expected to be insignificant and short-term during construction, and BMPs would be employed to minimize impacts from suspended sediments. If construction activities are determined to make the water habitat unsuitable for wildlife, the use of noise attenuating tools will be implemented. In a letter to NMFS dated October 2019, USACE determined that construction of these restoration sites will have no effect on marine turtles, Atlantic sturgeon, or shortnose sturgeon (see Appendix F for correspondence). Table 5-10 includes a summary determination for Threatened and Endangered species identified by NMFS.

Table 5-10. Determination of NMFS Threatened and Endangered species within the Oyster Reef restoration sites

Restoration Site	NMFS Threatened and Endangered Species		
	Sea Turtles*	Atlantic Sturgeon	Shortnose Sturgeon
Oyster Reefs			
Naval Station Earle	No effect	No effect	No effect
Bush Terminal	No effect	No effect	No effect
*Loggerhead (Caretta caretta), North Atlantic DPS of green (Chelonia mydas), Kemp's ridley (Lepidochelys kempii), and leatherback (Dermochelys coriacea)			

Piping plover (*Charadrius melodus)*, red knot (*Calidris canutus rufa*), roseate tern (*Sterna dougalli dougalli)*, and seabeach amaranth (*Amaranthus pumilus*), were identified as potentially existing in the vicinity of the restoration sites. In an October 2019 letter to USFWS, USACE determined that construction of the proposed Bush Terminal and Naval Weapons Station Earle restoration sites would have no effect on these species. USACE received concurrence from USFWS on ESA Effects Determinations on March 2, 2020, see Appendix F for correspondence. Table 5-11 includes a summary determination for Threatened and Endangered species identified by USFWS.

Table 5-11. Determination for Threatened and Endangered species in the Oyster Reefs restoration sites

Restoration Site	USFWS Threatened and Endangered Species				
	Piping Plover	Red Knot	Roseate Tern	Seabeach Amaranth	Migratory Birds
Oyster Reefs					
Naval Weapons Station Earle	No effect	No effect	No effect	No effect	No effect
Bush Terminal	No effect	No effect	No effect	No effect	No effect

As the restoration goals include restoring, and protecting wildlife habitat, impacts to rare, threatened, and endangered species are expected to be short-term and insignificant. In the long term, implementation of the recommended plan would benefit rare, threatened, and endangered species by establishing oyster reefs that would be higher in quality and function than the existing habitats they replace, and providing water filtration, a reduction in turbidity, and a prey resource for wildlife.

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• No long-term negative impacts to protected species. • Long-term positive impacts to rare, threatened, or endangered species from habitat and ecosystem restoration. • Insignificant, short-term impacts to sea turtles and sturgeon possible during construction. Sediment controls, noise attenuation, and/or timing restrictions may be utilized.

5.5.9 Land Use

Oyster restoration in the Upper Bay Planning Region will take place at the Bush Terminal site. Oyster restoration in the Lower Bay Planning Region will take place at the Naval Weapons Station Earle pier owned by the United States Navy. Under the no action alternative, land use at these sites would remain unchanged.

Restoration activities at the oyster restoration sites will take place under or around existing piers and would not alter the current land use of the sites in the long term. In the short term, public access or boat use of the piers may be suspended during construction activities.

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• Implementation of the recommended plan would not change the existing land use of the sites. • Short-term limitations to recreational boat traffic during construction activities.

5.5.10 Hazardous, Toxic, and Radioactive Waste

It is anticipated that, under the no action alternative, there would be continued or worsening degradation of water quality in the Upper and Lower bays, due to shoreline erosion, stormwater runoff, and anthropogenic inputs, such as landfill leachate and illegal dumping.

Site remediation of Bush Terminal was conducted between 2009 and 2014 (NYSDEC, 2017) through excavation, capping and shoreline stabilization. NYSDEC has made a determination that the “contamination does not presently constitute a significant threat to public health or the environment” and 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. To ensure USACE HTRW compliance, all future activities at Bush Terminal would be closely coordinated with NYSDEC under the Site Management Plan (NYSDEC, 2014).

Under the recommended plan, construction activities, vessel movements, and prop wash likely would cause short-term resuspension of sediments and a concomitant short-term increase in turbidity, in nearby waters in the bay. BMPs would be employed to minimize turbidity and sedimentation. At Bush Terminal, BMPs would also be employed to maintain the integrity of the cap on-site.

Prior to construction activities, contaminant concentration sampling will be conducted as a part of HTRW analysis at Naval Station Earle. For Bush Terminal, the District will coordinate with NYSDEC and the HTRW monitoring that is conducted for the completed remedial action. HTRW sampling will occur during the PED phase and if concentrations are found to be unacceptable and additional actions are needed prior to restoration, the non-federal sponsor (or in the case of Bush Terminal the Potential Responsible Party) would pay 100% of the cost for such activities.

In the long term, establishing oyster habitat would improve water quality and provide nutrient removal and denitrification services. As filter feeders, oysters filter large quantities of seston (organic particulates, including phytoplankton) from the water column. At high densities, oysters can filter large volumes of water, which can modify biogeochemical cycles and improve water quality in the surrounding environment. Filtered seston is digested and utilized for growth and maintenance of the organism, or is deposited by the organism on the sediment surface as feces (Dame and Patten, 1981; Bayne and Newell, 1983; Hadley et al., 2005; Kellogg et al., 2013). This removal and deposition of organic material can act as a buffer against eutrophication by removing nitrogen, carbon, and phosphorous from the water column, and depositing it in the sediment, where it becomes buried. Removal of seston reduces water turbidity, and reduces water concentrations of nitrogen, phosphorous, and organic carbon. Each of these factors is often elevated in waters adjacent to urban areas, such as the HRE. Removal of seston and nutrients from the water column eases the oxygen debt of the water. The organic molecules are digested and deposited, rather than settling to decay, which can cause oxygen debt and, in extreme conditions, anoxia.

Oyster habitat established under the recommended plan also would reduce turbidity, by mitigating shoreline erosion and filtering suspended solids and phytoplankton (Meyer et al., 1997; Coen et al., 2007; Scyphers et al., 2011). The resulting reduction in turbidity under the recommended plan would provide long-term habitat enhancement for shellfish and fish communities, and aquatic vegetation (Cahoon et al., 1999; Paul and Meyer, 2001; Steinberg et al., 2004).

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• During construction, minor, short-term local increase in turbidity from offshore placing spat on shell, installing reef balls, oyster condos, super trays, and wire cages/gabions, and vessel movements and prop wash.

	• BMPs employed to minimize turbidity and sedimentation, and safeguards employed to prevent and respond to spills. • Long-term surface water quality improvements—i.e., increased turbidity reduction, nutrient removal, and denitrification.

5.5.11 Noise

Under the no action alternative, restoration would not take place and short-term, temporary increases in ambient noise levels due to construction activities would not occur. Population growth and increased use of railways and roadways in the region may cause noise levels to rise in the future.

Heavy equipment used during construction may contribute to short-term increase in noise levels. However, noise levels would not exceed those cited in local ordinances and would occur only during normal daytime working hours. No long-term impacts to noise levels are anticipated.

Restoration Sites	Potential Environmental Consequences*
Naval Weapons Station Earle Bush Terminal	• Short-term increases in noise levels from construction equipment will occur during normal daytime working hours. • Implementation of the recommended plan at each site would not cause any negative long-term noise impacts.

5.5.12 Social and Economic Resources

Under the no action alternative, no change to the social and economic resources would occur from short-term job or educational opportunities. The degraded condition of the Upper and Lower Bay ecosystem is anticipated to continue potentially adversely affecting social and economic resources.

Under the recommended plan, access to recreational resources may be negatively affected temporarily, during construction. Oyster restoration at Bush Terminal and Naval Weapons Station Earle would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education. No permanent or long-lasting economic effects are anticipated as a result of construction.

Improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences.

Restoration Sites	Potential Environmental Consequences*
Bush Terminal	• Total first cost of approximately $6,935,000 • During construction, minor, short-term increases in local employment, earnings, induced spending, and tax revenues, and provision of educational opportunities. • Negligible, long-term stimulation of the local economy and provision of educational opportunities.
Naval Weapons Station Earle	• Total first cost of approximately $8,508,000 • During construction, minor, short-term increases in local employment, earnings, induced spending, and tax revenues.

5.5.13 Navigation

Under the no action alternative, no restoration will take place and no changes or impacts to navigation would occur.

Construction activities at the Bush Terminal oyster restoration site may create short-term limitations to the local boat traffic to minimize the agitation of the water, to allow the suspended sediments to settle, and to avoid accidents. Impacts would be minimal, of short durations and likely not affect navigation channels where major boat traffic is likely to occur.

The proposed oyster restoration at the Naval Weapons Station Earle would have no temporary impact on navigation near the project site, as construction activities would be limited to a section of the pier that is closer to land and away from naval ship activities. The presence of naval security and exclusion areas already prevents commercial and recreational boat traffic from navigation near the project site.

Restoration Sites	Potential Environmental Consequences*
Bush Terminal	• Short-term limitations to boat traffic during construction activities.
Naval Weapons Station Earle	• Implementation of the recommended plan would not affect navigation near the project site.

The proposed sites are close to Federal and recreational channels making them, and construction vessels, susceptible to wake and/or surge damage. During construction, coordination with the First Coast Guard District (Sector New York) will be required for publication in the Local Notice to Mariners before starting operations and if needed, request the movement of any Federal Channel marker buoys. Additionally, there is a 750 yard radius security zone surrounding Naval Weapons Station Earle Procedures to request entry to these security zones will be required.

Public outreach to the recreational boating and fishing vessel industries will be undertaken to ensure maximum visibility of the restoration activities within the action area.

5.5.14 Recreation

Under the no action alternative, construction will not take place and impacts to recreational opportunities would not occur.

The recommended plan would have very minor temporary construction related impacts on existing recreational resources. At sites which currently offer recreational resources, there may be adverse temporary impacts due to the presence of heavy equipment, however boat activity would not be substantially impacted during construction.

Though no direct improvements to recreational opportunities are proposed, oyster restoration would provide educational and research opportunities and potentially provide opportunities for public awareness and involvement due to easy access from Bush Terminal Park to the proposed Bush Terminal restoration site. The recommended plan would complement other ongoing oyster restoration work and would benefit students through expanded scientific study opportunities.

Improvements to the environment, particularly cleaner water and greater abundance and diversity of desirable fish, potentially would increase some recreational activities such as fishing and boating. However, the proposed oyster restoration at the Naval Weapons Station Earle would have no impact on recreational resources. The presence of naval security and exclusion areas prevents recreational use near the project site.

Restoration Sites	Potential Environmental Consequences*
Bush Terminal	• Minor, short-term negative impacts from limited access to recreational resources during construction. • Long-term improvement in educational and research opportunities.
Naval Weapons Station Earle	• Implementation of the recommended plan would not affect recreation near the project site.

5.5.15 Cultural Resources

Under the no action alternative impacts to cultural resources are expected to be minimal; however, loss of historic resources due to SLR and erosion could occur.

Under the action alternative, there is a potential to cause adverse effect to historic properties from excavation or material placement over the resources. As an initial look into the effects of the action alternative, a desktop search was completed of the known cultural resources in and around the recommended sites. This desktop search found that the two restoration sites are each located within a historic district. The Bush Terminal oyster site is located within the Bush Terminal Historic District, which is National Register Eligible. The Naval Weapons Station Earle oyster site is located within the Naval Ammunition Depot Earle Historic District, which is National Register Eligible, and State Register Listed. In addition to these, there are four other historic districts, more than 18 historic properties, and zero archaeological sites within one mile of the two restoration sites in the Upper and Lower Bay Planning Regions (Table 5-12).

The effects the proposed restoration will have on the Bush Terminal Historic District and Naval Ammunition Depot Earle Historic District will be negotiated with the signatories of the PA. The District will work to avoid adverse effect to the historic properties, but if necessary treatment plans will be developed in accordance with the stipulations of the PA to address effects to the historic properties.

Some of the APE for the two restoration sites has been previously surveyed. Additional survey work will be required to find if there are any unknown historic properties within the recommended plan APE. To carry out this work, the USACE entered into a Programmatic Agreement (PA) with the Advisory Council on Historic Preservation, New York State Historic Preservation Office, New Jersey State Historic Preservation Office, New York City Landmarks Preservation Commission and National Park Service (see Appendix H) that stipulates the actions the USACE will take to satisfy its responsibilities under Section 106 of the National Historic Preservation Act and other applicable laws and regulations. Pursuant to the PA, archaeological survey work will take place in the Preconstruction Engineering and Design Phase. Since this survey work has not yet been carried out, the full effects the recommended plan will have on cultural resources is not yet known.

Table 5-12. Historic Properties Located within or Nearby the Recommended Restoration Sites

Restoration Sites	Historic Properties Identified
All Sites	• Additional survey is required under the stipulations of the draft PAs to determine whether other resources are present within the project area. • Mitigation would be required for impacts to significant resources.
Bush Terminal	• Located within the Bush Terminal Historic District (NRE) • At least seventeen (17) other historic properties or districts within one (1) mile • Potential for submerged cultural resources

Restoration Sites	Historic Properties Identified
Naval Weapons Station Earle	• Located within Naval Ammunition Depot Earle. The adjacent pier is a contributing feature to the district. • One other historic district and one historic property are located within one (1) mile

5.5.16 Aesthetics

Under the no action alternative, construction will not take place and no changes to aesthetics would occur. The degraded condition of the Upper and Lower Bay ecosystem would continue to decrease aesthetic and scenic resource value in the planning regions.

Oyster restoration in the Upper Bay Planning Region would take place at Bush Terminal. The Upper Bay Planning Region provides many opportunities to view the waters of the area, mostly found along the waterfront of South Brooklyn, Bayonne, Jersey City, and a few on the waterfront of northern Staten Island. During construction of the recommended plan there would be temporary impacts to the aesthetic and scenic resources on site due to the presence of construction equipment. Post construction, limited visual and aesthetic impacts are anticipated if on-bottom techniques are used. However, potential visual effects may be detected if buoys and floats are used with off-bottom techniques.

Oyster restoration in the Lower Bay Planning Region will take place at the Naval Weapons Station Earle pier owned by the United States Navy. Negligible, short-term negative impacts to local aesthetics would occur as a result of minimal construction equipment on site. Once constructed, the proposed oyster restoration would have no impact on aesthetic resources. All structures will set under the existing pier. The presence of naval security and exclusion areas limits access and therefore scenic resource value in the vicinity of the recommended plan.

Restoration Sites	Potential Environmental Consequences*
Bush Terminal	• Minor, short-term negative impacts from presence of construction equipment. • Minor, long-term impact to aesthetic resource value dependent upon technique.
Naval Weapons Station Earle	• Implementation of the recommended plan would not affect aesthetic resource value near the project site.

5.5.17 Coastal Zone Management

Under the no action alternative, no restoration will occur and no impacts to state or local coastal zone management plans would occur.

Restoration activities at the Bush Terminal oyster site in the Upper Bay Planning Region were evaluated with respect to their consistency with New York State's *State Coast Policies* and New York City's *The New Waterfront Revitalization Program* and the goals are directly in line with the respective coastal zone policies. The restoration activities are consistent with state and local coastal zone management programs. USACE sent a coastal zone consistency determination for Bush Terminal to the relevant State and city agencies for review (October 2019) and received concurrence from those agencies (Appendix F).

Restoration activities at the Naval Weapons Station Earle oyster restoration site in the Lower Bay Planning Region were evaluated with respect to their consistency with NJDEP Coastal Zone Management Program and the restoration activities were found to be consistent with the coastal zone management rules (Appendix F). Following coordination with NJDEP, the Federal Consistency requests for the Naval Weapons Station Earle site was withdrawn (December 9, 2019). NJDEP gave conditional approval of Federal Consistency Determination and Water Quality Certificate (WQC) for the site provided that USACE submits a Federal Consistency and WQC request for the final selected project design and that NJDEP can confirm that the proposed project is consistent with its Coastal Zone Management rules (April 16, 2020). See Appendix F for correspondence.

Restoration Sites	Potential Environmental Consequences*
All Sites	• Restoration activities are consistent with state and local coastal zone management programs.

5.6 Air Quality

The No-Action Alternative would result in continued degradation of the subject areas. While emissions from taking no action may be lower overall than the temporary emissions from the recommended plan, none of the benefits of the recommended plan would be realized.

While the No-Action Alternative scenario may result in lower emissions in the short term, later maintenance may produce higher emissions under this scenario because more work would likely be needed to remedy more degraded sites. However, it is anticipated that neither the No-Action Alternative nor the recommended plan would result in a significant change to air quality in the area.

The recommended plan will temporarily produce emissions associated with diesel fueled equipment relating to sand placement and related landside construction activities. The project is anticipated to be conducted in a series of phases over a 14-year period starting in calendar year 2025. The localized emission increases from the diesel-fueled equipment will last only during the project’s construction period (and only local to where work is actually taking place at any time), and then end when the project is over. Therefore, any potential impacts will be temporary in nature.

The recommended plan will take place at various location in Kings County, Queens County, Bronx County, and Westchester County, New York and Bergen County, New Jersey. The General Conformity applicability trigger levels in these Counties for ‘serious’ ozone nonattainment areas are: 50 tons of NO_x or VOCs per year (any year of the project) and for $PM_{2.5}$

maintenance areas the level is 100 tons of PM2.5 or SO2 (a $PM_{2.5}$ precursor) per year (40 CFR§93.153(b)(1) and (2)).

The General Conformity-related emissions associated with the project have been estimated as part of the General Conformity Review and are summarized in Table 5-13 below. Emission calculations are provided in the Regulatory Appendix.

Table 5-13. General Conformity-Related Emissions per Calendar Year in tons

Pollutant	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
		tons per year												
NO_x	9.5	4.4	13.5	3.7	14.7	2.4	24.0	10.1	35.7	1.6	8.8	2.5	18.6	2.3
VOC	0.29	0.13	0.42	0.11	0.45	0.07	0.74	0.31	1.10	0.05	0.27	0.08	0.57	0.07
$PM_{2.5}$	0.31	0.14	0.44	0.12	0.48	0.08	0.78	0.33	1.17	0.05	0.29	0.08	0.61	0.08
SO_x	0.06	0.03	0.08	0.02	0.09	0.01	0.15	0.06	0.22	0.01	0.05	0.02	0.11	0.01
CO	1.12	0.51	1.60	0.44	1.73	0.28	2.83	1.20	4.20	0.19	1.03	0.30	2.19	0.27

The emission levels do not exceed the General Conformity 'de minimis' trigger levels for any pollutant in any one year. Therefore, the project is presumed to conform with the General Conformity requirements and is exempted from Subpart B under 40CFR§93.153(c)(1). The Record of Non-Applicability (RONA) and associated emission estimates can be found in the Regulatory Appendix.

5.6.1 Greenhouse Gases

The project will temporarily produce GHG emissions from the equipment used in the project. Delaying action on the areas being enhanced by this project may result in higher GHG emissions in the future because more extensive work would be required as a result of continuing degradation.

5.7 Environmental Justice

Executive Order 12898, Environmental Justice directs federal agencies to determine whether the recommended action would have a disproportionate adverse impact on minority or low-income population groups within the project area. Based on a demographic analysis of the study area and the environmental justice review, the recommended plan would not have a disproportionately high and adverse impact on any low-income or minority population. USACE has determined that although there would be short-term adverse effects during construction such as decreased access, noise, and dust in the local vicinity; the recommended plan will have no negative impact on the Environmental Justice of the surrounding communities. It is expected that the recommended plan will provide short- and long-term benefits to the existing population by protecting the area from the detrimental effects of waves, currents, and sea-level storms, as well as improved outdoor experiences based on increased fish and wildlife populations. Overall, the project poses no negative impact that could be interpreted as contrary to Environmental Justice policies.

5.8 Mitigation Measures*

NEPA regulations at 40 CFR 1500.2(f) state that federal agencies shall, to the fullest extent possible, use all practicable means consistent with the requirements of the Act and other essential considerations of national policy to restore and enhance the quality of the human environment, and avoid or minimize any possible adverse effects of their actions on the quality of the human environment. Furthermore, at 40 CFR 1508.20, NEPA defines mitigation to include avoiding impacts by not taking an action, minimizing the magnitude, rectifying the impact through restoring the resource, reducing the impact over the life of the action, or compensating for the impact. Agencies are required to identify and include in the action all relevant and reasonable mitigation measures that could reduce negative effects of the action.

Site restoration would involve construction in proximity to ecological resources. Each site would have short-term construction-related effects with varying spatial and temporal scales and degrees of intensity. Construction designs would include practices that avoid and minimize effects to significant resources.

5.8.1 Standard Practices to Mitigate (Minimize) Negative Effects of Construction

Specific measurable and enforceable measures to minimize negative effects of construction will be developed for each site based on its specific impacts. Construction designs and timing would include standard measures:

- In-water work would occur during designated periods consistent with recommended periods established by NYSDEC, NJDEP, NMFS and USFWS.
- Work would be scheduled outside of bird nesting season except where unavoidable.
- Each construction site would have an approved environmental protection plan.
- Traffic alterations would be designed to minimize impediments, with the shortest and least disruptive detours possible, and in coordination with the relevant transportation agency(s).
- Use matting to stabilize construction areas and prevent soil compaction where practicable.
- Use vehicles with high flotation tires within wetland to prevent rutting and soil compaction.
- Low ground pressure vehicles for all work proposed in marshes and open waters, when necessary, will be implemented.

5.8.2 Best Management Practices to Protect Water Quality

Restoration sites will require in-water work and significant areas of ground clearing. Protecting water quality from storm water runoff would require implementation of BMPs to avoid excessive runoff and elevated turbidity in the receiving waterbody. Every site would have a stormwater pollution prevention plan and a temporary erosion and sedimentation control plan approved by a USACE staff biologist. Standard construction stormwater BMPs can be incorporated into site designs, operational procedures, and physical measures on site. The following are some examples of frequently used BMPs:

- Minimize area of ground disturbance and vegetation clearing.
- Use the site's natural contours to minimize run-off and erosion.
- Do not expose the entire site at one time and avoid bare soils during rainy months.
- Stabilize erodible surfaces with mulch, compost, seeding, or sod.
- Use features such as silt fences, gravel filter berms, silt dikes, check dams, and gravel bags for interception and dissipation of turbid runoff water.
- Work will begin from landward side before breaking out into open water areas.
- Use stabilized construction entrances for all ingress and egress points.
- Fencing will be inspected following installation and significant storm events to ensure proper function.
- Temporary access routes and staging areas for all construction activities will be restricted from sensitive habitat areas (including wetlands and riparian zones), as practicable.

5.8.3 Mitigation/Minimization Measures for Effects of Greenhouse Gas Emissions

Mitigation for GHG emissions is not legally required; however, BMPs are available for fuel and material conservation during construction. Such BMPs include the following:

- Maximizing use of construction materials that are reused or that have a high percentage of recycled material content, such as recycled asphalt pavement, concrete, and steel.
- Obtaining construction materials and equipment from local producers or vendors to minimize energy use for shipping.
- Turning off equipment when not in use to reduce idling.
- Maintaining equipment in good working order to maximize fuel efficiency.
- Routing truck traffic through areas where the number of stops and delays would be minimized, and using off-peak travel times to maximize fuel efficiency.
- Scheduling construction activities during daytime hours or during summer months when daylight hours are the longest to minimize the need for artificial light.
- Implementing emission-control technologies for construction equipment.
- Using ultra low sulfur (for air quality) and biodiesel fuels in construction equipment.

5.8.4 Best Management Practices and Mitigation/Minimization Measures for Cultural Resources

USACE has consulted with the SHPO, ACHP, and federally recognized Native American Tribes on appropriate mitigation measures following the procedures laid out in the referenced PA. If any cultural resources identified within the APE are eligible for the National Register, the USACE will make effects assessments. Should the proposal have an adverse effect on an eligible cultural resource that cannot be avoided, USACE would work toward a resolution of adverse effects with the SHPO/ACHP, tribes, and other consulting parties following the procedures defined in the PA. Examples of mitigation measures include but are not limited to the following:

- Recordation packages using digital photography and 35 mm black-and-white film photography;
- Treatment plans;
- Public interpretation;
- Historic property inventory; and
- Geo-referenced historical maps and aerial photographs.

Chapter 6: Cumulative Effects*

The approach taken in this analysis of cumulative effects follows the objectives of the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations, and CEQ guidance. A cumulative effect is an “impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions” (40 Code of Federal Regulations §1508.7). In addition, it is defined as “two or more individual effects, which, when considered together, are considerable or which compound or increase other environmental impacts” (CEQ Guidelines §15355). Cumulative effects can result from individually minor but collectively significant actions taking place over time (40 Code of Federal Regulations §1508.7). CEQ guidance for considering cumulative effects states that NEPA documents “should compare the cumulative effects of multiple actions with appropriate national, regional, state, or community goals to determine whether the total effect is significant” (CEQ, 2010).

The analysis of cumulative effects may go beyond the scope of project-specific direct and indirect effects to include expanded geographic and time boundaries, and a focus on broad resource sustainability. The true geographic range of an action’s effect may not be limited to an arbitrary political or administrative boundary. Similarly, the effects of an action may continue beyond the time the action ceases. This “big picture” approach is becoming increasingly important as growing evidence suggests that the most significant effects to natural and socioeconomic resources result not from the direct effects of a particular action, but from the combination of individual, often minor, effects of multiple actions over time. The underlying issue is whether or not a resource can adequately recover from the effect of a human action before being exposed to subsequent action or actions.

Consistent with CEQ guidance, this analysis focuses on potential cumulative effects that can be described as the reasonable and foreseeable estimate for implementation of cumulative projects, in addition to the proposed action (CEQ, 1997). The timeframe for this analysis and discussion of existing, ongoing, or planned projects extends from 2020 to 2070.

In this chapter, an effort has been made to identify past and present actions associated with the resources analyzed in Chapters 2 and 5, plus those actions that are in the planning phase—limited to future actions that are reasonably foreseeable. Only actions that have the potential to interact with or be impacted by the recommended plan are addressed in this cumulative effects analysis. The analysis evaluates only actions with potential effects on the environment that are fundamentally similar to the anticipated effects of the Recommended Plan, in terms of the nature of the effects, the geographical area affected, and the timing of the effects.

This cumulative effects analysis covers actions in the study area from the recent past through the 50-year planning period of analysis described in Section 2.2. Assuming the proposed project is expected to be operational in 2025, the planning period of analysis is 2025 to 2075. Additional ongoing ecosystem and coastal restoration efforts that are not highlighted and summarized below are included in Ongoing Restoration Efforts (Appendix B).

6.1 Recent Past, Present, and Foreseeable Future Actions

The no action alternative has no cumulative effects associated with restoring the mosaic of habitats within the HRE. The continued lack of functioning habitats that currently has a cumulative negative effect on ecological resources influences socioeconomic and recreational quality throughout the region. The existing negative impacts on ecological processes in the study area are a result of past and present development activities due to urbanization.

A number of actions unrelated to the Recommended Plan, occurring historically and up to the present time, or reasonably expected to occur in the future, have the potential to influence the resources affected by implementation of the Recommended Plan, as identified in Chapter 5. Multiple restoration and conservation programs and development projects were identified. A brief description of these relevant past, present, and reasonably foreseeable future actions follows, with an emphasis on components of the activity that are relevant to the effects previously identified. When determining whether a particular activity may contribute cumulatively and significantly to the effects identified in Chapter 5, the following attributes are considered: geographical distribution, intensity, duration, and the historical effects of similar activities.

6.1.1 Combined Sewer Overflow Abatement Program

Timeframe: Recent past, present, and foreseeable future
Sources: New York State Department of Environmental Conservation (NYSDEC), 2012
New York City Department of Environmental Protection (NYCDEP), 2016

In 2012, the NYSDEC and NYCDEP signed an agreement to reduce combined sewer overflows and improve water quality through the collection and treatment of sewerage prior to release into the HRE. Under this agreement, several long-term control plans for specific waterbodies and one for the City of New York were drafted to identify appropriate combined sewer overflow controls necessary to improve water quality. Overflow abatement measures include conducting environmental dredging of several tributaries within the City of New York to remove combined sewer overflow mounds that contribute to nuisance odors and dissolved oxygen deficits within affected waterbodies. These waterbodies include Paerdegat Basin, Flushing Bay, Flushing Creek, Gowanus Canal, Bergen Basin, Fresh Creek, Newtown Creek, and Thurston Basin. While construction activities may have short-term negative impacts on water quality resulting from disturbance of sediments and stormwater runoff during the program, the long-term impacts to water quality will be very positive.

6.1.2 Superfund Program

Timeframe: Recent past, present, and foreseeable future
Source: United States Environmental Protection Agency (USEPA), 2016
National Park Service (NPS), 2019

The USEPA Superfund program is responsible for cleaning up some of the nation's most contaminated areas. A National Priorities List has been established to serve as a list of hazardous waste sites that are eligible for remedial action financed under the Superfund program. In recent years, the USEPA has made major progress on planning for the remediation of contaminated sediments on several sites within the HRE study area that are on the list.

Remediation projects include measures such as contaminated sediment removal and capping. The Superfund program is especially relevant for the Lower Passaic River Tier 2 site that is dependent on completion of remediation activities. Short-term impacts from suspension of sediment may occur during dredging activities, but would be minimized through the use of best management practices (BMPs). Long-term positive effects will result from sediment and water quality improvements, minimized exposure to contamination and overall risk reduction to human health and ecological communities.

The NPS future potential CERLCA non-time critical removal actions (consisting primarily of capping actions) at Spring Creek South and Dead Horse Bay South will also provide significant benefits to these national parks and Jamaica Bay. Short-term impacts from suspension of sediment may occur during construction activities, but would be minimized through the use of best management practices (BMPs). Long-term positive effects will result from sediment and water quality improvements, minimized exposure to contamination and overall risk reduction to human health and ecological communities.

6.1.3 Public Greenways

Timeframe: Recent past, present, and foreseeable future
Source: New York City Department of Parks and Recreation (NYC Parks), 2003
Byron and Greenfield, 2006
New York City Department of Transportation (NYCDOT), 2014
MillionTrees NYC, 2015
Bronx River Alliance, 2016
Brooklyn Greenway Initiative, 2016
NYCDOT, 2016
New York City Economic Development Corporation (NYCEDC), 2016

Greenway initiatives and the development of waterfront greenways are underway throughout the HRE:

- MillionTrees NYC, a PlaNYC initiative, is a public-private program. In 2015, two (2) years ahead of schedule, MillionTrees NYC achieved the program goal of planting 1,000,000 trees in New York City.
- The Manhattan Waterfront Greenway is a 32-mile multi-use trail that circumnavigates Manhattan Island, and includes over 23 miles of waterfront pathways and facilitates access to over 1,500 acres of parkland throughout the borough. The greenway builds on recent efforts to transform a long-neglected waterfront into a green attraction for recreational and commuting use.
- Construction on the South Bronx Greenway and the Bronx River Greenway is underway and most of the construction phases should be near completion by 2018. The South Bronx Greenway compasses 1.5 miles of waterfront greenway, 8.5 miles of inland green streets, and nearly 12 acres of new waterfront open space throughout the Hunts Point and Port Morris neighborhoods in the Bronx. The Bronx River Greenway extends for 23 miles along the Bronx River, from Westchester County to Soundview Park in the South Bronx. Approximately 19 miles of the greenway are currently in place with completion anticipated within the next decade.

- The Brooklyn Waterfront Greenway will comprise 14 miles of landscaped, designated off-street pathways, enhanced sidewalks, and on-street bike lanes that will connect neighborhood parks and open spaces from Greenpoint to Bay Ridge. Six (6) miles have already been completed with eight (8) miles remaining.
- The Jamaica Bay Greenway will be a 28-mile network of bicycle and pedestrian paths connecting more than 10,000 acres of parks and beaches. More than 10 miles are in place.

Construction of the greenway projects may have short-term negative impacts on water quality resulting from disturbance and runoff in areas adjacent to the waterfront. In the long term, these projects would improve public access and aesthetics in the region.

6.1.4 Rebuild by Design

Timeframe: Recent past, present, and foreseeable future
Source: Rebuild by Design, 2016

In 2013, following Hurricane Sandy, the United States Department of Housing and Urban Development (HUD) and the Hurricane Sandy Rebuilding Task Force initiated the Rebuild by Design (RBD) competition to create solutions for improving coastal resiliency in the region. From the 148 international applicants, 10 interdisciplinary teams were selected to compete in the year-long process. Several winning proposals within the HRE were chosen, including the Big U in Manhattan, New Meadowlands in the New Jersey Meadowlands, OMA in Hoboken, Hunts Point Lifelines in the Bronx, and Living Breakwaters on Staten Island. These projects include many resiliency measures, such as living shorelines, flood protection structures, tide gates, and reefs. The projects are largely located adjacent to or in close proximity to the waterfront, and are likely to have extensive short-term construction impacts to resources found along the shoreline, as well as long-term beneficial impacts from increases in habitat and flood protection when completed. The projects have been allocated over $1,100,000,000 in federal funding and the federal government has continued to invest in and recognize the innovations that these projects have brought to the region.

6.1.5 New York State Governor's Office of Storm Recovery

Timeframe: Recent past, present, and foreseeable future
Source: United States Department of Housing and Urban Development, 2014
New York State Governor's Office of Storm Recovery, 2016

New York State established the Governor's Office of Storm Recovery to address communities' most urgent needs, while also encouraging the identification of innovative and enduring solutions to strengthen the state's infrastructure and critical systems. Operating under the umbrella of New York Rising, the office utilizes approximately $4,400,000,000 in flexible funding made available by the HUD Community Development Block Grant Disaster Recovery Program to concentrate aid to four (4) main areas: housing recovery, small business, community reconstruction, and infrastructure. Paired with additional federal funding that has been awarded to other state agencies, the program enables homeowners, small businesses, and entire communities to build back even better than before. While the program will primarily result in short-term construction impacts from rebuilding on existing developed property, some long-term negative impacts could result from reconstruction or infrastructure projects that have a larger impervious footprint or that alter existing hydrology and habitat, long-term positive impacts could result from buyout and acquisition programs or shoreline stabilization projects that increase habitat and return developed land to a natural state.

6.1.6 Wetland Mitigation

Timeframe: Recent past, present, and foreseeable future
Source: NYCEDC, 2015
New Jersey Department of Environmental Protection (NJDEP), 2016b

Wetland mitigation banks are becoming increasingly important within the HRE study area, as on-site mitigation areas are scarce and development increases mitigation demands. Wetland mitigation banks currently servicing the HRE study area are all located in New Jersey and include the MRI-3 Mitigation Bank, Kane Wetland Mitigation Bank, Oradell Reservoir Mitigation Bank, Cranbury Wetland Mitigation Bank, and Pio Costa Wetland Mitigation Bank, among others. Additional mitigation banks that would service the HRE are proposed in New Jersey and New York, including the Saw Mill Creek Wetland Mitigation Bank on Staten Island. Creating wetland mitigation banks requires extensive construction activities, such as excavation, sediment removal, grading, hydrologic restoration, and planting. Many of these activities would occur below the high tide line and potentially within contaminated sediments. Wetland mitigation activities may have cumulative impacts with projects implemented under the Recommended Plan including short-term construction impacts to sediments and water quality or long-term alterations to local topography, hydrology, and habitat. While these impacts may be negative in the short-term, the long-term benefits from adding high-value habitats would be very positive.

Wetland restoration and creation projects not associated with wetland mitigation banks are also common throughout the HRE. Many smaller projects that provide compensatory mitigation for development can be found in all of the CRP planning regions. In general, on-site mitigation is preferred by the agencies, but off-site mitigation is also acceptable within the same watershed.

6.1.7 Tappan Zee Bridge Environmental Mitigation

Timeframe: Present, and foreseeable future
Implementing Entity: New York State Thruway Authority

As part of the replacement of the Tappan Zee Bridge with the Governor Mario M. Cuomo Bridge, restoration projects will occur to mitigate environmental damages. Restorations projects will include oyster restoration in the Hudson River in proximity to the bridge, wetland restoration and management, and Green Infrastructure and stormwater treatment construction projects.

6.1.8 Coastal Storm Risk Management Projects

Coastal storms have severely impacted the north Atlantic coast of the United States, including the New York-New Jersey Harbor region. Within the HRE, the USACE and states of New York and New Jersey partner on multiple projects that manage coastal storm risk. Short-term construction impacts may occur during these projects, but will likely be minor and minimized through the use of BMPs. Although the long-term goals of these projects are to minimize negative impacts on the environment, they may cause permanent alterations to hydrology and natural habitats as an unavoidable consequence. These impacts may adversely affect implementation of the Recommended Plan or can potentially cause cumulative impacts. Projects that are considered in this analysis are:

6.1.9 Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet, and Jamaica Bay Reformulation Study

Timeframe: Present and foreseeable future
Source: USACE (http://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/East-Rockaway-Inlet-to-Rockaway-Inlet-Rockaway-Be/)

In August 2019, the Chief's Report for the Atlantic Coast of New York East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Hurricane Sandy Reformulation Study was signed by Lt. Gen. Todd T. Semonite, USACE Commanding General and has been transmitted to the Assistant Secretary for the Army for Civil Works for review and final approval.

USACE examined coastal storm risk management problems and opportunities for the project area, and identified and screened alternatives based on the following principal planning objectives: reduce vulnerability; do so sustainably and economically; improve community resiliency; and enhance natural storm surge buffers. Since the problems and opportunities varied within the project area, the USACE tentatively selected a plan that addresses two (2) planning reaches: the Atlantic Ocean Shoreline Reach and the Jamaica Bay Reach. The Recommended Plan includes a composite seawall in combination with beachfill and groin features along the Atlantic Ocean Shoreline and a Coastal Storm Surge Barrier across Rockaway Inlet in Jamaica Bay.

The study's non-federal sponsor is the NYSDEC, with the New York City Mayor's Office of Recovery and Resiliency as the local sponsor to New York State. Other project partners include NYCDPR, NYCDEP, and the National Park Service (NPS). USACE may consider a phased decision process that would move forward the implementation of discreet components while finalizing the details associated with more technically complex features. Construction start of the first phase is targeted for 2020-21, but will depend on the length of reviews and approvals, and the relative complexity of design.

6.1.10 NY/NJ Harbor and Tributaries Coastal Storm Risk Management Study

Timeframe: Present and foreseeable future
Source: USACE (https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/New-York-New-Jersey-Harbor-Tributaries-Focus-Area-Feasibility-Study/)

USACE is investigating measures to manage future flood risk in ways that support the long-term resilience and sustainability of the coastal ecosystem and surrounding communities, and reduce the economic costs and risks associated with flood and storm events. In support of this goal, the

Corps completed the North Atlantic Coast Comprehensive Study, which identified nine high-risk, focus areas on the north Atlantic Coast for further in-depth analysis into potential coastal storm risk management measures. One of the nine areas identified was the New York-New Jersey Harbor and Tributaries study area (USACE, 2015). This coastal storm risk management study (CSRM) covers the New York & New Jersey Harbor and tidally affected tributaries encompassing all of New York City, the Hudson River to Troy, NY; the lower Passaic, Hackensack, Rahway, and Raritan Rivers; and the Upper and Lower Bays of New York Harbor, Newark, Jamaica, Raritan and Sandy Hook Bays; the Kill Van Kull, Arthur Kill and East River tidal straits; and Western Long Island Sound. The purpose of this coastal storm risk management (CSRM) study is to investigate comprehensive approaches to improve community resilience and to manage risk of damages from future coastal storms and impacts of sea level rise (SLR). The objective of the New York-New Jersey Harbor and Tributaries CSRM Study is to identify and explore areas of coastal storm risk and develop the most feasible comprehensive combination of structural, non-structural, and/or natural and nature-based measures into alternatives that best manage risks from current and projected future coastal flooding in both the short and long term. The study will be preparing a tiered Environmental Impact Statement, is evaluating five initial alternatives, which currently are comprised of measures that address severe coastal storm risks for specific geographic regions within the study area, in addition to the no action alternative. These five alternatives encompass a variety of water- and land-based measures identified throughout the estuary at areas of high projected coastal storm risk and include combinations of shoreline structures, such as beach nourishment, levees, floodwalls and seawalls, and storm-surge barriers.

6.1.11 USACE Navigation Projects

New York and New Jersey Harbor Deepening Channel Improvements Feasibility Study
Timeframe: Present and foreseeable future
Source: USACE

USACE in partnership with the Port Authority of New York and New Jersey will be undertaking a Feasibility Study to determine the possibility of improving navigation within the constructed 50 foot New York and New Jersey Harbor (NY/NJ Harbor). Examination of alternatives to include widening, bend-easing, and/or deepening the existing navigation channel's dimensions will occur in a study area from the Atlantic Ocean Channel (Ambrose Channel) to the Port Authority of New York and New Jersey (PANYNJ) facilities within the harbor.

6.1.12 USACE Restoration Projects

The USACE has implemented the following restoration projects that may have had short-term negative cumulative impacts from construction activities, but has created significant positive, long-term benefits from the restoration and connection of fragmented habitats:

<u>Elders East Mitigation for NY/NJ Harbor Deepening</u>

Timeframe: Recent past (2006)
Source: USACE and Port Authority of New York and New Jersey (PANYNJ)

Approximately 40 acres of marsh islands restored

Gerritsen Creek, Marine Park, NY Ecosystem Restoration Project (Continuing Authorities Program [CAP] 1135)

Timeframe: Recent past (2010)
Source: USACE and NYC Parks

Approximately 20 acres of tidal marsh and 20 acres of coastal grassland restored

Elders West Marsh Restoration

Beneficial use of dredged material (CAP Sections 204/207)

Timeframe: Recent past (2010)
Source: USACE, PANYNJ, NPS, NYSDEC, and NYCDEP

Approximately 43 acres of marsh islands restored

Soundview Park, Bronx, New York (CAP Section 206)

Timeframe: Recent past (2012)
Source: USACE and NYCDPR

Approximately 3.7 acres of tidal marsh restored

Yellow Bar Hassock Marsh Restoration

Beneficial use of dredged material (CAP Sections 204/207)

Timeframe: Recent past (2012)
Source: USACE, PANYNJ, NPS, NYSDEC, and NYCDEP

Approximately 47 acres of marsh islands restored

Rulers Bar and Black Wall

Beneficial use of dredged material

Timeframe: Recent past (2012)
Source: USACE, PANYNJ, NYCDEP, and NYSDEC

Rulers Bar: Approximately 10 acres of sand placed
Black Wall: Approximately 20 acres of sand placed

The USACE is expected to conduct the following restoration projects within the next two (2) years. These projects may have short-term negative cumulative impacts from construction activities, but will provide significant positive, long-term benefits from the restoration and connection of fragmented habitats:

Spring Creek North, Brooklyn, New York (CAP Section 1135)

Timeframe: Foreseeable future (2020)
Source: USACE and NYCDPR

Restoration of approximately 35 acres of habitat, including approximately 13 acres of intertidal salt marsh and approximately 22 acres of maritime upland habitat. This recommendation complements the additional 2.4 acres of maritime forest that NYCDPR will construct in the north eastern portion of the site.

6.1.13 Smaller Development Projects

Timeframe: Recent past, present, and foreseeable future

Many other, smaller development projects have been, are, or will be constructed within the HRE. These projects, although too numerous to enumerate and too early in their planning to ensure their ultimate implementation, could also lead to cumulative impacts.

6.2 Summary of Cumulative Effects Relative to the Recommended Plan

Environmental effects associated with the Recommended Plan were analyzed in Chapter 5. The proposed alternative at each restoration site will increase the amount of high-quality habitat through restoration measures. Some alternatives address restoration of ecosystem function, and thus increasing levels of sustainability. All of the alternatives, except the no action alternative, are presumed to improve the habitat and ecological integrity at the planning region level with varying degrees of effectiveness. In addition to the long-term ecological and societal benefits of improving habitats and providing access to natural resources, construction activities associated with the Recommended Plan could cause temporary adverse impacts. These effects were determined individually to be negligible or minor, or to have no impact. Implementation of the Recommended Plan may have cumulative effects when combined with other similar actions occurring in the region of influence, on the resources discussed below.

6.2.1 Cumulative Effects on Biological Resources

Short-term, negative impacts to species diversity and abundance, including rare, threatened, and endangered species, are anticipated as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementing the Recommended Plan alone, but may become cumulative if larger construction projects that are unrelated to the Recommended Plan occur in the vicinity. As previously discussed, impacts related to construction would be short term and would be minimized using applicable BMPs. Ongoing consultation with USFWS, NMFS, NYSDEC, and NJDEP will take place over the duration of the project to prevent adverse impacts to federal- or state-listed species from implementation of the Recommended Plan.

Long lasting, cumulative impacts may result from Recommended Plan implementation in the vicinity of wetland mitigation banks, land acquisition and protection areas, and coastal resiliency and green infrastructure projects. The cumulative effects would be beneficial to species because the actions would improve existing habitats, provide additional new habitat, and enhance the connectivity between new and existing habitats. Ongoing improvements to habitat and connectivity throughout the HRE would increase biodiversity, as species that are more sensitive to environmental degradation or have specific habitat needs would colonize the restored habitats.

Widespread habitat improvements and enhanced connectivity resulting from Recommended Plan implementation also would work in concert with state and federal programs that manage and protect species listed under the Endangered Species Act, the NYSDEC Endangered Species Program, and the NJDEP Endangered and Nongame Species Program. The USFWS and NMFS implement the Endangered Species Act using recovery programs that aim to stop the decline of a species or population and remove or reduce the threats to ensure long-term survival in the wild. Tools used in a recovery program include restoring and acquiring habitat, removing introduced animal predators or invasive plant species, conducting surveys, monitoring individual populations, and breeding species in captivity before releasing them into their historic range. Recovery plans exist for several species that are in the HRE study area.

The Mid-Atlantic Fisheries Management Council, NMFS, and Atlantic States Marine Fisheries Commission implement fisheries management programs in the HRE study area. These programs focus on species that may not be listed as threatened or endangered, but otherwise may be important for commercial or other reasons. The programs provide management objectives and strategies, such as harvest limits and habitat protection. Fisheries management coupled with habitat improvements and creation of new habitats resulting from implementing the Recommended Plan would cumulatively enhance sustainable fish population within the HRE and throughout the Mid-Atlantic Bight. Healthier fish stocks would benefit the fishing industry within the HRE and bolster the regional economy.

Species that are not of commercial value would also benefit from the cumulative effects of implementing the Recommended Plan and existing, ongoing species protection programs. The Recommended Plan combined with existing programs would increase the rate of habitat improvement, protection, and creation, thereby increasing biodiversity within the HRE at a faster pace than would happen if the Recommended Plan were not implemented.

6.2.2 Cumulative Effects on Water Quality

Cumulative adverse impacts to surface waters, and in particular to water quality, may result from implementation of the Recommended Plan concurrently or in close proximity to other development projects in the area. Examples include recommended alternatives requiring in-water construction or sediment removal activities that may be constructed at the same time as a site remediation, wetland mitigation bank, or development project that requires dredging.

These projects result in a cumulative increase of turbidity in the region, leading to short-term cumulative impacts to water quality for the duration of construction and dredging activities. The cumulative impacts to water resources resulting from implementation of the Recommended Plan and other construction projects in the HRE are unlikely to be significant as these activities are generally short term and require the use of BMPs that minimize erosion and sedimentation.

Long lasting, beneficial cumulative impacts to water quality may result from implementing the Recommended Plan alongside other, ongoing and future restoration projects, such as combined sewer overflow abatement. Many of the past, present, and foreseeable future actions involve projects that improve water quality in the long term by treating wastewater, reducing contaminants, and constructing softer shorelines, wetlands, reefs, and other structures that reduce wave action and water velocity. Because most recommended alternatives include the same restoration measures, substantial beneficial cumulative impacts would be anticipated over time throughout the HRE. Improvements to water quality and reductions in turbidity would also increase primary productivity and available oxygen in the water by increasing light penetration in the water column.

6.2.3 Cumulative Effects on Climate Change and Sea Level Rise

Individual activities in the HRE study area make incremental contributions to greenhouse gas emissions, together representing a very small percentage of total United States and global emissions. The potential effects of greenhouse gas emissions are by nature global and cumulative, as individual sources of greenhouse gas emissions are not large enough to have an appreciable effect on climate change. An appreciable impact on global climate change would only occur when proposed greenhouse gas emissions combine with emissions from other man-made activities on a global scale. Implementation of the Recommended Plan would contribute a negligible amount of greenhouse gases. When combined with other past, present, and reasonably foreseeable future actions, implementing the Recommended Plan would have the potential for negligible, long-term negative impacts on climate change.

Estuarine salt marshes and other wetlands potentially affected by RSLC face new risks related to climate change. Increasing rates of RSLC may lead to substantial loss of salt marsh habitat, especially in areas that are subsiding and/or where sediment supply is reduced, or where upland migration of marshes is prevented by shoreline armoring, coastal development, or natural bluffs. Projected changes in water temperature, water salinity, and soil salinity could change the mix of plant species in salt marshes and the viability of invertebrates that play a key role in the health of salt marshes. Furthermore, many freshwater marshes adjacent to marine waters are likely to convert to salt marshes or to transitional marshes that experience frequent saltwater inundation. If coastal development occurs or if shoreline armoring continues to be used as a countermeasure for RSLC, the new salt marshes will also, in turn, disappear due to subsidence or lack of sediment supply.

6.2.4 Cumulative Effects on Social and Economic Resources

Construction activities of the Recommended Plan over the implementation period would have beneficial socioeconomic impacts to the region. When evaluated with other projects and programs, cumulative beneficial impacts to the local recreation economy are anticipated.

Implementation of the Recommended Plan would have no adverse human health or environmental effects on environmental justice, minority or low-income populations within HRE. In fact, many of the ongoing restoration and conservation programs will improve aesthetics in the area and others, such as the Combined Sewer Overflow Abatement Program and the Superfund program, will also improve sediment and water quality. Programs such as the New York City Comprehensive Waterfront Plan and local waterfront revitalization programs would also improve access to the waterfront and waterways. Cumulatively, these improvements would attract tourists and create recreation and ecotourism jobs, bringing capital into the area. In addition, local community groups and educational institutions would have opportunities to participate in restoration and monitoring efforts associated with implementation of the Recommended Plan and the projects constructed under other programs. If such projects are funded by grants and other outside sources, these investments would further help to bolster the local economy. Cumulatively, creating new jobs and increasing the amount of income entering the local economy and the additional educational benefits from implementing the Recommended Plan and other programs would be a long-term beneficial impact to the region.

Over the long term, recommended alternatives that restore roosting, nesting, and foraging habitat for waterbirds near airports, in concert with wetland mitigation projects that increase habitat for birds, are likely to have cumulative impacts on airport activities and aviation as there would be increased risk of bird-aircraft strikes. To manage this risk, restoration projects targeting bird habitat would be completed outside of Federal Aviation Administration (FAA) prescribed buffer areas, or in close coordination with the FAA. Other activities that may indirectly attract birds near airports, if needed, would utilize bird deterrent measures, such as reflective flagging, fencing, and string.

Implementing the Recommended Plan alongside other restoration and development programs, especially the greenways initiatives that are currently underway and existing waterfront programs, would have beneficial impacts to recreation and public access. The greenways and waterfront programs work to improve and increase the number of public access areas. When combined with recommended alternatives that restore degraded habitats, improve public access and provide the added benefits of improved water quality and educational opportunities, the cumulative effects are beneficial to the people in the region. The New York City Department of City Planning has developed the New York City Waterfront Revitalization Program for shoreline areas around the city, and in Rockland and Westchester Counties, in the HRE study area. The communities of Piermont, Dobbs Ferry, Mamaroneck, Port Chester, and Rye also have approved local waterfront revitalization programs. Projects developed under these programs potentially may interact with Recommended Plan activities, cumulatively contributing to beneficial impacts to public access to the waterfront and waterways. Implementation of the Recommended Plan would also be subject to local waterfront development plans and programs leading to an organized approach to development, with isolated projects—both Recommended Plan and non-Recommended Plan projects—linked to each other under an overarching plan or program that has specific goals.

6.2.5 Irreversible or Irretrievable Commitments of Resources Involved in the Implementation of the Recommended Plan

No irreversible or irretrievable commitment would foreclose the formulation or implementation of any reasonable and prudent alternative. No commitment of resources would prejudice the selection of any alternative before making a final decision.

Chapter 7: Environmental Compliance with Environmental Statutes*

This chapter provides documentation of how the Recommended Plan complies with all applicable federal environmental laws, statutes, and executive orders.

7.1 National Environmental Policy Act of 1969 *(In Compliance)*

The National Environmental Policy Act (NEPA) (42 United States Code 4321 et seq.) commits federal agencies to considering, documenting, and publicly disclosing the environmental effects of their actions. This Final Integrated FR/EA is intended to achieve NEPA compliance for the proposed recommended alternative. Before preparing this document, the USACE held a series of public information meetings in each of the eight study areas during the development of the Comprehensive Restoration Plan (CRP). Comments received to date were considered in determining which opportunities and which resources must be considered in a detailed analysis. The draft FR/EA was published for a 45-day public comment period to ensure satisfactory public review. This final FR/EA, which takes into account all comments received, as well as additional feasibility-level activities (e.g., more detailed designs and accurate cost estimates), will be published prior to project implementation.

7.1.1 USACE Procedures for Implementing NEPA (33 Code of Federal Regulations [CFR], part 230, ER 200-2-2)

This regulation provides guidance for implementation of the procedural provisions of the NEPA for the Civil Works Program of the USACE. It supplements Council on Environmental Quality (CEQ) regulations 40 CFR 1500-1508, in accordance with 40 CFR 1507.3. This FR/EA has been prepared in compliance with Engineering Regulation (ER) 200-2-2.

7.2 Bald and Golden Eagle Protection Act of 1940 *(In Compliance)*

The Bald and Golden Eagle Protection Act (16 United States Code 668-668c) applies to USACE Civil Works projects through the protection of bald and golden eagles from disturbance. A Bald Eagle nest was documented in the vicinity of the Meadowlark Marsh site during planning survey. If pre-construction surveys confirm the presence of nesting or breeding species, construction buffers and/or timing restrictions would be employed during nesting season. Review of the state databases of critical habitats showed no additional recorded eagle nesting site within two miles of any of the proposed projects. No aspects of the proposed projects are anticipated to have any effect on eagles.

7.3 Clean Air Act of 1963 *(In Compliance)*

The Clean Air Act (CAA) as amended (42 United States Code 7401, et seq.) prohibits federal agencies from approving any action that does not conform to an approved state, tribal, or federal implementation plan. Under the CAA General Conformity Rule (Section 176(c)(4)), federal agencies are prohibited from approving any action that causes or contributes to a violation of a national ambient air quality standard in a nonattainment area. Construction activities associated with the proposal would create air emissions, but these would not affect implementation of New

York's and New Jersey's CAA implementation plans. The proposed actions would occur in a nonattainment or maintenance area. The individual estimated emissions were prepared to meet the standards set forth by the USEPA and implemented by the states and are based on the detailed feasibility-level designs. All recommended projects are in compliance with the CAA as part of project implementation, a RONA (21 January 2020) can be found in Appendix F.

7.4 Coastal Zone Management Act of 1972 *(Partial Compliance)*

Section 307 of the federal Coastal Zone Management Act (CZMA) of 1972, as amended (16 United States Code 1451 et seq.) requires federal agency actions to be consistent to the maximum extent practical with the enforceable policies of the approved state's coastal zone management program as well as New York City's Local Waterfront Revitalization Program. USACE received concurrence from the relevant State and City agencies that the New York sites are consistent with coastal zone management policies (October 2019); New Jersey sites were conditionally approved and will be further coordinated in PED (April 16, 2020). Please refer to Appendix F for the CZMA consistency determination for the projects according to the relevant enforceable policies.

7.5 Coastal Barrier Improvement Act of 1990 *(In Compliance)*

This act is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and preclude the expenditure of federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The Coastal Barrier Improvement Act (CBIA) of 1990 expanded the Coastal Barrier Resources System (CBRS) and created a new category of lands known as otherwise protected areas (OPAs). The only federal funding prohibition within OPAs is federal flood insurance. Other restrictions to federal funding that apply to CBRS units do not apply to OPA's. The two CBRS units are located within the Gateway National Recreation Area: 1) Unit NY-60P is located in the western portion of Rockaway Peninsula and all of Jamaica Bay and 2) Unit NJ-01P, located on the Sandy Hook peninsula. Both unites are located OPAs and under National Park Service jurisdiction. CBRS Unit NJ-04A (Navesink/Shrewsbury) is located south of Unit NJ-01P, but no restoration activities are proposed within the unit. Accordingly, no further coordination under the CBIA or CBRA is necessary.

7.6 Endangered Species Act of 1973 *(In Compliance)*

The Endangered Species Act (ESA) (16 United States Code 1531-1544), Section 7(a) requires that federal agencies consult with the NMFS and USFWS, as appropriate, to ensure that proposed actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats. The USFWS and NMFS concurred with USACE species determinations (October 2019). Refer to Chapters 2 and 5 regarding ongoing agency coordination and Appendix F1 for site specific species analysis.

7.7 Federal Water Pollution Control Act of 1972 (Clean Water Act) *(In Compliance)*

The Clean Water Act (CWA) (33 United States Code 1251 et seq.) requires federal agencies to protect waters of the United States. The regulation implementing the CWA disallows the placement of dredge or fill material into water unless it can be demonstrated there are no practical alternatives that are less environmentally damaging. Under Section 401 of the CWA, any project that involves placing dredged or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands requires a water quality certification from the state agency as delegated by USEPA. For the Recommended Plan, the NYSDEC and the NJDEP are the delegated authorities within their respective states. The USACE has had initial coordination with agencies to certify that the proposed federal action will not violate established water quality standards. The USACE will produce and submit documentation necessary for the respective Departments individual 401 review based on the feasibility-level design. The Corps will submit the Section 401 water quality certification request at the 65% design phase and will receive the certification before completion of the 95% design package. Based on New York District experience, NYSDEC and NJDEP typically issues a 401 certification within a 6 month period. The Corps has anticipated standard best management practices that are typically required by NYSDEC for similar ecosystem restoration projects and have accounted for those in the design and associated cost estimate. Section 404(b)(1) Evaluation and Compliance Review have been completed for each site and can be found in Appendix F5.

7.8 Fish and Wildlife Service Coordination Act of 1934 *(In Compliance)*

The Fish and Wildlife Coordination Act (FWCA) of 1934 as amended (16 United States Code 661-667e) ensures that fish and wildlife conservation is given equal consideration as is given to other features of water resource development programs. This law provides that whenever any water body is proposed to be impounded, diverted, deepened or otherwise controlled or modified, the USACE shall consult with the USFWS and NMFS as appropriate, and the agency administering the wildlife resources of the state. Any reports and recommendations of the wildlife agencies shall be included in authorization documents for construction or modification of projects. Recommendations provided by the USFWS in FWCA Reports must be specifically addressed in USACE feasibility reports.

The USACE initiated coordination for consideration of fish and wildlife species in spring 2016. The USACE received a final FWCA Report from USFWS in April 2018. Results of the coordination and USFWS recommendations are discussed in Chapter 5 and can be found in Appendix F2.

The USACE determined that construction may affect, but is not likely to adversely affect red knot (October 2019) at sites within the Jamaica Bay Planning Region. USFWS concurred with the USACE NLAA determination on March 2, 2020.

7.9 Magnuson-Stevens Fishery Conservation and Management Act of 1976 *(Partial Compliance)*

The Magnuson-Stevens Fishery Conservation and Management Act (MFCMA) (16 United States Code 1801 et. seq.), requires federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) “may adversely affect” designated EFH for relevant commercial, federally managed fisheries species within the proposed action area. The assessment also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

The HRE is designated as EFH for various groundfish and coastal pelagic species, and two species of sturgeon. The USACE has prepared an EFH determination (refer to Appendix F3) for this final FR/EA. NMFS concurred with USACE's EFH assessment and further site-specific coordination will be conducted as more detailed plans are developed in PED. Refer to Chapters 2 and 5, and Appendix F3 for additional discussion regarding EFH within the proposed action area.

7.10 Marine Mammal Protection Act of 1972 *(In Compliance)*

The Marine Mammal Protection Act (MMPA) of 1972 (16 United States Code 1361-1407) restricts harassment of marine mammals and requires interagency consultation in conjunction with the ESA consultation for federal activities. All marine mammals are protected under the MMPA regardless of whether they are endangered, threatened, or depleted. The primary concern for protection of marine mammals is underwater noise from construction. The USACE will consult with NMFS on effects to marine mammals in conjunction with the ESA Section 7 consultation. The USACE anticipates implementing all practicable conservation measures and will use BMPs as appropriate to avoid and minimize impacts of noise to marine mammals. The Recommended Plan is in compliance with the MMPA.

7.11 Migratory Bird Treaty Act of 1918 and Executive Order 13186 Migratory Bird Habitat Protection *(In Compliance)*

The Migratory Bird Treaty Act (16 United States Code 703-712) as amended protects over 800 bird species and their habitat, and commits that the United States will take measures to protect identified ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations. Executive Order (EO) 13186 directs federal agencies to evaluate the effects of their actions on migratory birds, with emphasis on species of concern, and inform the USFWS of potential negative effects to migratory birds. Implementation of restoration would not have any negative effects to migratory bird habitat and would provide positive impacts on feeding habitat. USACE determined that there would be no effects on migratory birds from construction of the project (refer to Chapter 5 and Appendix F for further analysis) and is in compliance with the referenced regulations.

7.12 National Historic Preservation Act of 1966 *(In Compliance)*

In accordance with Section 106 of the National Historic Preservation Act of 1966, the USACE carried out consultation with the New Jersey State Historic Preservation Office (NJSHPO), the New York State Historic Preservation Office (NYSHPO), the New York City Landmarks Preservation Commission (NYCLPC), upon completion of the Cultural Resources Overview for the HRE in 2014 (Harris, 2014). The USACE met with the NJSHPO in May of 2016 to discuss the NER plan and the need for development of a Programmatic Agreement (PA) that would outline the steps that the USACE shall take when the project is authorized and additional funds become available to ensure the project is in compliance with Section 106 of the National Register of Historic Places.

A PA was executed on March 4, 2020 and details the steps that will be taken to identify resources and determine and address adverse effects to significant historic resources. The signatories of the PA include the New York District, New Jersey State Historic Preservation Office, New York State Historic Preservation Office, and Advisory Council on Historic Preservation. The invited signatories include the New York City Landmarks Preservation Commission and the National Park Service. The Delaware Nation, Delaware Tribe of Indians, the Shawnee and Eastern Shawnee Tribes of Oklahoma, the Stockbridge Munsee, and the Shinnecock Tribe were invited to review and participate in the PA as well, but ultimately no tribes wished to be an invited signatory on the PA. The PA was also sent to 20 interested parties (historic societies and local groups) for public comment, but no comments were received.

7.13 Executive Order 11988 Floodplain Management *(In Compliance)*

This EO directs federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practicable alternative. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision making on projects that have potential impacts on or within the floodplain. The eight step assessment is as follows:

1. **Determine if the proposed action is in the base floodplain.** The proposed actions are located within the base floodplain for the Bronx, Hackensack and Passaic Rivers.

2. **If the action is in the floodplain, identify and evaluate practicable alternatives to locating in the base floodplain.** As the primary objective of the project is aquatic ecosystem restoration, no practicable alternatives are completely outside of the base floodplain for the sites that would achieve this objective.

3. **Provide public review.** The proposed projects in the Recommended Plan were coordinated with the public, government agencies, and interested stakeholders.

4. **Identify the impacts of the proposed action and any expected losses of natural and beneficial floodplain values.** Practicable measures and alternatives were formulated and potential impacts and benefits were evaluated in Chapter 5 of this document. The anticipated impacts associated with the Recommended Plan are summarized. While construction of project features would result in mostly minor and temporary adverse impacts to the natural environment, the proposed restoration would result in a substantial and long-term increase in habitat values including an increase in the quantity and quality of riparian and aquatic habitat. For each resource analyzed in Chapter 5, wherever there is a potential for adverse impacts, appropriate best management practices or other environmental considerations were identified. As there is a net benefit to biological resources, no mitigation is required for the Recommended Plan.

5. **Minimize threats to life and property and to natural and beneficial floodplain values. Restore and preserve natural and beneficial floodplain values.** Implementing the Recommended Plan would have no significant flooding impacts on human health, safety, and welfare.

6. **Reevaluate alternatives.** Chapters 3 and 4 of this document present an analysis of alternatives. As the primary objective of the project is aquatic ecosystem restoration, no practicable alternatives are completely outside of the base floodplain for the sites that would achieve this objective.

7. **Issue findings and a public explanation.** The public will be advised that no practicable alternative to locating the proposed action in the floodplain exists, as indicated in Item 2 above.

8. **Implement the action.** The proposed project does not contribute to increased development in the floodplain and does not increase flood risk, but rather it restores "natural and beneficial values." The Recommended Plan is consistent with the requirements of this Executive Order.

This assessment concludes that all practicable alternatives have been considered in developing the Recommended Plan, and that the main federal objective of reducing coastal flood risk cannot be achieved by alternatives outside the floodplain. Additionally, USACE has determined that the Recommended Plan does not induce direct or indirect floodplain development within the base floodplain.

7.14 Executive Order 11990 Protection of Wetlands *(In Compliance)*

EO 11990, Protection of Wetlands, dated May 24, 1977, requires federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, preserve the values of wetlands, and prescribe procedures to implement the policies and procedures of the executive order. In addition, federal agencies shall incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision-making processes. One of the primary goals of the Recommended Plan is to restore wetlands that have been lost or degraded due to the presence of dikes, fill, armoring, and urban development. The proposed actions would be beneficial to wetlands, as a functional increase in habitat and water quality would occur. USACE is in compliance with the requirements of this Executive Order.

7.15 Executive Order 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations *(In Compliance)*

EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" provides that each federal agency shall make achieving environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Environmental justice concerns may arise from impacts on the natural and physical environment, such as human health or ecological impacts on minority populations, low-income populations, and Indian tribes or from related social or economic impacts. The USACE evaluated the location and design of each restoration site to determine whether they would affect minority populations, low-income populations, and Indian tribes. The USEPA Environmental Justice Viewer was used to determine whether protected groups are present in the proposed restoration areas. Based on a demographic analysis of the study area and based on findings of an environmental justice review, the Recommended Plan would not have a disproportionately high and adverse impact on any low-income or minority population. USACE has determined that the Recommended Plan will provide short- and long-term benefits to the disproportionately affected populations adjacent to the areas where restoration activities would occur. USACE is in compliance with the requirements of this Executive Order.

7.16 Executive Order 13045 Protection of Children from Environmental Health Risks and Safety Risks *(In Compliance)*

EO 13045, requires each Federal agency to "identify and assess environmental risks and safety risks [that] may disproportionately affect children" and ensure that its "policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks." USACE has analyzed each proposed restoration project footprint and surrounding area for the restoration project's potential to cause health and safety risks to children. The project sites where construction activity will occur are more than one mile away from any schools, parks, libraries, and grocery stores. Infants and children are not expected to be exposed to any health or safety risks because of these actions; therefore, this project has no environmental or safety risks that may disproportionately affect children. Once each project site is constructed, the ancillary benefits of the habitat restoration will potentially decrease environmental health risks to the area residents. The plan is in compliance.

7.17 Executive Order 13112 Invasive Species *(In Compliance)*

This EO states that each federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, use relevant programs and authorities to: (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and (vi) promote public education on invasive species and the means to address them. This Recommended Plan includes removal of invasive species and establishment of native habitat, and is in compliance with this EO.

Chapter 8: Summary of Coordination, Public Views, and Comments

Throughout any planning effort, the U.S. Army Corps of Engineers (USACE) strives to inform, educate, and involve the many groups who may have an interest in proposed action. This coordination is paramount to assuring that all interested parties have the opportunity to be part of the planning process. USACE has been working together with federal, state, and local agencies, non-governmental organizations, academic institutions and stakeholders throughout the implementation of the Hudson Raritan Estuary (HRE) Ecosystem Feasibility Study, the development of the HRE Comprehensive Restoration Plan (CRP) since 2003 and the “source” studies that have been integrated into this Draft Integrated Feasibility Report and Environmental Assessment (FR/EA). Substantial coordination throughout the program has resulted in a consensus restoration plan for the region, a strategy for advancing restoration priorities within the region and unprecedented support garnered for HRE restoration. The collaborative approach taken for the study, in accordance with Engineering Circular 1105-2-409 (Planning in a Collaborative Environment), has been touted as an excellent national example of extensive public outreach and collaboration.

8.1 Public Coordination

Key coordination with partners throughout the HRE Restoration Feasibility Study Program (including “source studies”) is summarized below and includes:

8.1.1 Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study: 1998-2005

This study had included an extensive collaborative effort to reach out and include the needs/concerns of the general public as well as a myriad of government agencies from the City to the federal level. Site selection in Jamaica Bay was focused through numerous meetings with various agencies and local community boards in late 1998. In May 1999, a newsletter was published and mailed to interested parties as a way to introduce the project before the formal public meetings. Also in May 1999, interviews were conducted with stakeholders including community board members, local environmental interest groups, and city officials to gather an understanding of local issues and a general level of interest in the restoration of Jamaica Bay. Two (2) public meetings were held in June 1999 to discuss Jamaica Bay Feasibility Study and gather further public feedback on the initial stages of the project.

Numerous informal presentations had been given at public and professional forums regarding the ongoing studies and plans for Jamaica Bay. Special attention was paid to providing ongoing updates at regularly scheduled meetings of the Jamaica Bay Taskforce, an outreach group attended by government agencies, community groups and individuals with interest and/or responsibility for the bay. These meetings occurred on a roughly quarterly basis and provided an active and ongoing forum to continually engage the communities and agencies.

An interagency team conducted the background existing conditions inventories and research for this project. The Jamaica Bay Ecosystem Research and Restoration Team included individuals from many local universities and colleges, as well as the National Park Service (NPS), USACE, the Wildlife Conservation Society, the American Museum of Natural History, local engineering firms, and the New York City Butterfly Club. The Jamaica Bay Ecosystem Research and Restoration Team report was completed in 2002.

All steps of the process allowed for input from various agencies and local constituents, in addition to the non-federal sponsor New York City Department of Environmental Protection (NYCDEP). Meetings were held to discuss site selection, concept plan creation, background research, project direction, and project progress to create an open forum with partner agencies and stakeholders. Table 8-1 is a summary of some of the meetings that occurred to discuss the Jamaica Bay, Marine Park and Plumb Beach Feasibility Study.

Table 8-1. Summary of interagency meetings held regarding the Jamaica Bay Feasibility Study

Date	Jamaica Bay Study Meetings
07-Dec-98	Site selection meetings with United States Fish and Wildlife Service (USFWS), National Oceanographic and Atmospheric Administration (NOAA), New York State Department of Environmental Conservation (NYSDEC), NPS, and United States Environmental Protection Agency (USEPA)
15-Dec-98	Presentation of sites and continued site selection process with NOAA, NPS, USEPA, NYCDEP, New York City Department of Parks and Recreation (NYC Parks), and local citizens.
May-99	Jamaica Bay Ecosystem Restoration Project Update Newsletter
07-May-99	Interviews with stakeholders from Queens CB 10
13-May-99	Interviews with stakeholders from Queens CB 14
13-May-99	Interviews with stakeholders from the Friends of Rockaway
20-May-99	Interviews with stakeholders from Brooklyn CB 15
25-May-99	Interviews with stakeholders from the Jamaica Bay Task Force and New York City Soil & Water Conservation District
22-Jun-99	Site visit with USEPA, USFWS, NOAA, NPS, NYSDEC, New York State Department of State and others
29-Jun-99	Public meeting in Howard Beach
30-Jun-99	Public meeting in Rockaway Park
8-Feb-00	Jamaica Bay Task Force Meeting, study update
20-Mar-00	Research meeting on marsh change in Jamaica Bay with NPS, United States Geological Survey, NYSDEC, and Columbia University.
09-Aug-00	Jamaica Bay Ecosystem Research and Restoration Team progress and direction meeting with all the constituents (colleges, NPS, environmental groups, etc)
22-Sep-00	Jamaica Bay site visit with Representatives from Congress, local community boards, NYCDEP, NYSDEC, NPS, USEPA, NOAA, Port Authority of New York

Date	Jamaica Bay Study Meetings
	and New Jersey (PANYNJ), Baykeeper, New York City Economic Development Corporation (NYCEDC), and USFWS
28-Nov-00	Meeting with NYCDEP and the Queen Borough President
25-Apr-01	Jamaica Bay EcoWatchers meeting and site visit discussing marsh loss in Jamaica Bay
01-May-01	Blue Ribbon Panel of Scientists discussion on investigating sea level rise and marsh loss and contributing factors in Jamaica Bay
22-May-01	A large interagency meeting held with NYSDEC, USEPA, NYCDEP, NPS, United States Department of Agriculture National Resources Conservation Service, PANYNJ, contractors, and several local colleges and universities
26-Jul-01	Jamaica Bay EcoWatchers meeting, included Jamaica Bay project updates
10-Dec-01	Jamaica Bay Task Force Meeting, included a Blue Ribbon Panel update and discussion on the Jamaica Bay estuary reserve legislation
11-Apr-02	Mosquito Task Force meeting with NYSDEC, Community Board members, New York City Department of Health, NYC Parks, New York State Department of State, New York State Office of Parks, Recreation and Historic Preservation, NPS, New York State Senate, New York State Department of Health, and NYCDEP
24-Jun-02	Jamaica Bay Task Force Meeting, including a study update
01-Nov-02	Site evaluation with NPS and other agencies
13-Jan-03	USFWS program review of Jamaica Bay and other USACE projects
27-May-03	Site visits with property owners including NPS, NYC Parks, New York State Office of Parks, Recreation and Historic Preservation for concept plan selection
28-May-03	Site visits with property owners including NPS, NYC Parks, New York State Office of Parks, Recreation and Historic Preservation for concept plan selection
04-Jun-03	Site visits and finalization of draft conceptual plans with NPS, NYCDEP
23-Sep-03	Site visits with agencies including NPS, NYC Parks, USEPA, NYCDEP, and USFWS to discuss site plans
16-Feb-05	Jamaica Bay Task Force Meeting to discuss Jamaica Bay draft concept plans
7-Dec-10	Alternative Formulation Briefing with HQUSACE and obtained approval on Tentatively Selected Plan
11-Mar-13	Meeting with NYSDEC to discuss contamination at the 8 restoration sites
16-Sept-13	Jamaica Bay Stakeholder Outreach Meeting to discuss study progress as a Coastal Restoration project following inclusion in the Second Interim Report to Congress (May 2013). Meeting discuss restoration proposed at 8 sites with representatives from NPS, USEPA, USFWS, NYSDEC, PANYNJ, NYC Parks, NYCDEP, NMWA, Rockaways Waterfront Alliance, Jamaica Bay Ecowatchers,

Date	Jamaica Bay Study Meetings
	American Littoral Society, Jamaica Bay Task Force, Environmental Defense Fund, NY/NJ Baykeeper, The Nature Conservancy, Hudson River Foundation, Eastern Queens Alliance, NYC Audubon, Rockaway Chamber of Commerce, Belle Harbor Yacht Club, SUNY at Stony Brook, Harbor Coalition, National Parks Conservation Association
5-Dec-13	Jamaica Bay Restoration and Hurricane Sandy Jamaica Bay/Rockaway Reformulation Study Coordination Partner meeting with NYSDEC, NYCDEP, NPS, NYC Mayor's Office
16-Dec-13	Jamaica Bay Resilience Institute meeting to coordinate USACE coastal restoration and other ongoing partner efforts with NPS, NYSDEC, NYCDEP NYC Parks, NYC Mayor's Office, Hunter College, CUNY
16-Jan-14	Agency coordination meeting on Jamaica Bay restoration following submittal of USACE Initial Assessment (January 2014)
2014-current	Continued Jamaica Bay Task Force, Jamaica Bay Science and Resilience Institute and agency coordination meetings on coastal restoration with Jamaica Bay/East Rockaway Reformulation Study and the HRE Feasibility Study (Section 8.1.5)

8.1.2 Bronx River Ecosystem Restoration Feasibility Study

Bronx River Basin Ecosystem Restoration Study Scoping Meeting: 2004

A scoping meeting was held to coordinate with local, county, state, and federal agencies and identify issues and concerns that may be associated within the Bronx River Basin and associated scoping document (USACE, 2004). The scoping document provided a description of potential opportunities for ecosystem restoration; a discussion of the existing water, biological, and cultural resources within the study area known to date; and a preliminary assessment of potential impacts and benefits of any action that may be recommended.

8.1.3 HRE- Lower Passaic River Ecosystem Feasibility Study: 1999- present

A governmental partnership between the USACE, USEPA, New Jersey Department of Transportation (NJDOT), NJDEP, NOAA and USFWS was initiated in 1999 to develop comprehensive solutions for remediation and restoration within the 17 miles of the Lower Passaic River and major tributaries within the watershed. The agencies planned to bring together the authorities of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA; Superfund) Program, Water Resource Development Act (WRDA), the Clean Water Act and other laws to improve the health of the river. In 2002, the Urban Rivers Restoration Initiative was launched and USEPA and the USACE signed a National Memorandum of Understanding (MOU) for the purpose of coordinating and planning the execution of urban river cleanup and restoration.

Dozens of meetings occurred between the USACE, NJDOT [non-federal sponsor] and USEPA to develop a joint/integrated WRDA and Superfund Project Management Plan; as well as dozens of meetings with all six (6) partners to develop a local Memorandum of Agreement and confidentiality agreement. The study officially was initiated in 2003 upon the execution of the Feasibility Cost Share Agreement (FCSA) between USACE and NJDOT.

In 2004, USEPA entered into an Administrative Order on Consent (AOC) with 31 Potential Responsible Parties (PRPs) to fund the Superfund portion of the Lower Passaic River Study. In 2005, 12 additional PRPs were added to the AOC for the Superfund portion of the study and all PRPs formed a group known as the “Cooperating Parties Group” which the agencies coordinated with throughout the study.

The partner agencies prepared a coordinated Community Involvement Plan for the “Lower Passaic River Restoration Project” and the USEPA Newark Bay Study (Malcolm Pirnie [MPI], USEPA and USACE, 2006) which considered community concerns and suggestions from interviews conducted by the agencies in 2004 and 2005 outlined in a Community Interview Report (MPI, 2005). The study also utilized the USEPA Technical Assistance Grant awarded to the Passaic River Coalition (PRC) to assist the community in the interpretation of technical documents generated by the project.

The Passaic River Community Advisory Group (CAG) that had been established for the Diamond Alkali Site was utilized throughout the study. The Passaic River CAG provides advice and recommendations to the USEPA and its partner agencies to help ensure a more effective and timely cleanup and restoration of the Lower Passaic River. USACE is a participating agency in monthly meetings in order to coordinate the HRE restoration goals as it pertains to the Lower Passaic River. Study information and reports were accessible and posted in a timely fashion on www.ourpassaic.org.

This study’s unique governmental partnership held monthly meetings among all six (6) partner agencies in order to execute tasks to conduct the remedial investigation, restoration planning, environmental dredging pilot, decontamination technology pilots, the USEPA Focused Feasibility Study (river miles 0 to 8.3) and remaining investigation of the overall 17 miles. Work Groups were established for various parts of the study including:

- Lower Passaic River Restoration Work Group (2004-2006): Partner agencies, CPG, and environmental constituent groups (including NY/NJ Baykeeper, PRC, Ironbound Community Corporation, etc), City of Newark and others met periodically to discuss restoration opportunities and organizational priorities.
- Lower Passaic River Dredging and Decontamination Technology Pilot Work Group (2004-2005): Agencies and stakeholders held periodic meetings to plan and execute the environmental dredging pilot and decontamination technology pilots (including BioGenesis Soil Washing and Cement Lock).
- Remedial Options Work Group (2006-2012): Agencies, CPG, environmental constituent groups periodically met to discuss baseline remedial investigation data (contamination, hydrodynamics, sediment transport, pilot results) and feasibility options to determine clean up alternatives including dredging, capping, and disposal options (e.g., off-site, local decontamination or contained aquatic disposal).

Municipality Outreach Meetings (August 2007): Two (2) municipality outreach meetings, one for river miles 0 to 8 and one for river miles 8 to 17) were held to discuss the results of municipality surveys submitted by local officials from Bayonne, Elizabeth, Kearny, Harrison, Newark, East Newark, Belleville, Bloomfield, Nutley, East Rutherford, Rutherford, Clifton, Passaic County, Essex County. The surveys and outreach meetings were held to document and coordinate ongoing and future projects outlined in local master plans for the river shoreline.

Commercial Navigation Meeting (August 2009): USACE and USEPA hosted a meeting with Commercial Navigational Users of the Lower Passaic River to determine the navigational depths needed for their future use.

Lower Passaic River Symposium (2004, 2006, 2008, 2010, 2012, 2014 and 2016): The Passaic River Institute/Montclair University hosts biannual symposia featuring the Lower Passaic River Remedial Investigation and Feasibility Study to coordinate remediation, restoration and flood risk management within the Passaic River basin.

8.1.4 HRE- Hackensack Meadowlands Ecosystem Restoration Feasibility Study

Notice of Intents: 2004

Two (2) Notice of Intents for the preparation of an Environmental Impact Statement (EIS) were published in the Federal Register (Volume 69, No. 248) on December 28, 2004 for the HRE-Lower Passaic River Ecosystem Restoration Feasibility and HRE-Hackensack Meadowlands Ecosystem Restoration Feasibility Studies. Since that time, resource agency involvement through meetings, changes in plan formulation, and re-evaluation of the project, it was decided that an EIS was no longer necessary.

HRE-Hackensack Meadowlands Public Scoping and Stakeholder Meetings: 2005-2006

One (1) public scoping meeting and one (1) stakeholder meeting were held with Meadowlands stakeholders and partners to identify the needs (water resource problems) and potential restoration opportunities within the Meadowlands (USACE, 2003).

8.1.5 Hudson Raritan Estuary Ecosystem Restoration Feasibility Study

Needs and Opportunities Workshops: 2003

Multiple public outreach and workshops were held with the region's stakeholders and partners to identify the needs (water resource problems) and potential restoration opportunities throughout the HRE (USACE, 2003).

HRE Target Ecosystem Characteristics (TEC) Development: 2004-2005

Regional scientists and representatives from federal, state, local, non-governmental organizations and academic institutions participated in more than 14 workshops to identify the problems of the region, the habitats needing to be restored, regional restoration goals and near-term (2020) and long-term (2050) targets. These workshops enabled consensus on developing scientifically based regional goals and targets that formed the foundation of the planning objectives for this FR/EA and formed the vision for a restored estuary for all partners to work towards.

HRE CRP Development: 2006-2009

The USACE New York District Team worked closely with the NY/NJ Harbor Estuary Program (HEP) and participated in quarterly meetings to identify restoration opportunity locations that had been nominated since 1994. Moreover, additional sites were identified using geographic information system (GIS) evaluation for each TEC and evaluated sites that provided opportunities to meet the overall CRP goal of “creating a mosaic of habitats..” throughout the HRE Study Area. These sites, representing known restoration opportunities, were subsequently evaluated for the FR/EA.

CRP Release and Coordination: 2009-2011

Following the release of the HRE CRP in March 2009 (USACE and PANYNJ, 2009a and b), the NY/NJ HEP Policy Committee agreed to adopt the HRE CRP as the consensus master plan for restoration for the region. Between that time and mid-summer 2012, the USACE, HEP, and their partners held public meetings in each of the HRE planning regions and participated in numerous local and National watershed conferences. The planning region outreach meetings were attended by the public and representatives from more than 100 different stakeholder organizations. Workshop participants contributed numerous comments and recommendations concerning the revision and future implementation of the CRP as a regional restoration strategy. Despite vastly diverse participant backgrounds and comments that reflected the broad geographic scope of the HRE, strong support for the CRP was evident at all meetings.

HRE CRP – TEC Workshop: May 2012

Many comments were obtained on the draft HRE CRP resulting from the significant public outreach that occurred over the subsequent two (2) years. The USACE and other participants from the original 14 TEC workshops were brought back together to discuss any changes to the restoration goals, TECs and the changes to the near-term and long-term targets.

NY/NJ HEP Restoration Work Group (RWG): 2009-Current

The HEP RWG, chaired by the USACE, was formed for the sole purpose of managing the HRE CRP and coordinating restoration within the region to achieve the restoration goals outlined for the study. Representatives from partner agencies who participate on the RWG, were continuously consulted during plan formulation and site selection to identify regional priorities among the 296 sites identified in the 2016 HRE CRP. Given sponsor readiness is mandatory to recommend restoration sites in the HRE FR/EA, coordination with the RWG was helpful as sites advanced with FS-level design in the Feasibility Study. In addition, HEP RWG Partners reviewed Version 1.0 of the HRE CRP (USACE, 2016) solidifying the consensus nature of the HRE CRP.

As part of the charter of the HEP RWG, the group hosts a biannual restoration conference with the public highlighting partner progress for restoration, acquisition and public access efforts and advancements throughout the Harbor Estuary. To date, three (3) major symposia “Restoring the New York-New Jersey Harbor & Estuary” were held in June 2014, June 2016 and November 2019. The symposia were attended by over 200 scientists, engineers, academics, and restoration professionals to discuss the progress of restoring the HRE and initiatives to continue improving the region’s ecological health and resiliency. Progress reports prepared by the RWG highlight the restoration efforts in the harbor estuary by partners, as well as the progress of the study (HEP, 2015, 2017 and 2019)

Urban Waters Federal Partnership: 2011-Current

The Urban Waters Federal Partnership's (UWFP) goal is to work closely with local partners to restore urban waterways and offers an opportunity to realize urban waterway and watershed revitalization goals that are larger than, and beyond the resources of any individual community, agency, or mission. Portions of two (2) planning regions (Newark Bay, Hackensack River and Passaic River and Harlem River, East River and Western Long Island Sound) are represented within the Partnership's program. Both the Lower Passaic River and the Bronx River/Harlem River are two project locations within the UWFP program. The USACE and USEPA are co-leads for the Lower Passaic River UWFP and have coordinated the restoration opportunities with other federal, state and local organizations within this program.

Science & Resilience Institute at Jamaica Bay (SRIJB): 2013-Current

As a member of the Institute Public Agency Council, USACE representatives coordinate and better assess the resiliency investments that are needed and ongoing within Jamaica Bay. USACE used this forum to receive stakeholder input on the alternative formulation for the study.

Non-federal Sponsor Coordination during Plan Formulation (alternatives development) of the TSP (33 Restoration Sites) and Feasibility Level Activities on the Recommended Plan: 2014-2019

- USACE coordinated with NYCDEP, NYC Parks and Bronx River Alliance during the alternatives development for the nine (9) Bronx River sites. Design Charrettes were held with NYCDEP, NYC Parks, and Bronx River Alliance (December 2015) and Westchester County Department of Planning (February 2016).
- USACE coordinated with NYCDEP to optimize the restoration designs for the Flushing Creek site from 2013 through 2016; as well as the reformulation of the Flushing Creek site assuming no environmental dredging of the creek.
- In addition to ongoing partner coordination since 2003 with USEPA, NJDEP, NOAA and USFWS for the Superfund investigation on the Lower Passaic River, the USACE coordinated with NJDEP, Natural Resource Damage group to advance the Lower Passaic River restoration sites. A design charrette was held in July 2015 and field visits in August 2015 were held with NJDEP in order develop alternatives and determine sponsor readiness. Ongoing coordination with NJDEP on the Recommended Plan also occurred in 2019.
- USACE coordinated with NYSDEC, NYCDEP, NYC Parks and key stakeholders (including Jamaica Bay Task Force, Jamaica Bay Guardian, Jamaica Bay Ecowatchers, American Littoral Society, Science and Resilience Institute at Jamaica Bay, among others) on the concept designs that were approved as the Tentatively Selected Plan at the Jamaica Bay Alternatives Formulation Briefing (held in 2010).
- USACE coordinated with National Park Service to achieve mutual acceptability on the Dead Horse Bay and Marsh Island projects.
- USACE coordinated with non-federal sponsor New Jersey Meadowlands Commission (currently New Jersey Sports and Exposition Authority [NJSEA]) since 2003 on the site selection and design of Hackensack River restoration sites.

- USACE initially participated with more than 30 organizations on the Oyster Restoration Research Project in 2010 implementing oyster restoration pilots at five (5) locations in the HRE study area. Continued coordination occurred with NY/NJ Baykeeper, NY Harbor School, Hudson River Foundation and NYCDEP to advance small-scale oyster restoration designed and recommended in the FR/EA.

Collaborative planning will continue with the HEP RWG, which is composed of all of the study's non-federal sponsors, to advance the HRE CRP and advance the Recommended NER Plan that is included in this FR/EA. In addition, the HEP RWG will continue to coordinate, leverage programs and resources among the partners to influence federal and local investment for ongoing regional restoration.

Websites:
The public has also been made aware of study activities via two (2) study websites (http://www.nan.usace.army.mil/Missions/Navigation/New-York-New-Jersey-Harbor/HudsonRaritanEstuary/ and http://www.harborestuary.org/watersweshare/).

8.2 Views of the Non-federal Sponsors and Stakeholders

Substantial coordination throughout the program has resulted in a consensus restoration plan for the region and unprecedented support garnered for the HRE CRP and the Feasibility Study (and "source" studies). The collaborative approach taken for the HRE study, has been touted as an excellent national example of extensive public outreach and collaboration. Significant support has been garnered as a result of all the partner and stakeholder coordination throughout the study. The collaborative approach taken for the HRE study, has been touted as an excellent national example of extensive public outreach and collaboration. All non-federal sponsors during the feasibility studies and additional non-federal construction sponsors are committed to advance restoration of the HRE. The Recommended NER Plan represents the highest priorities of the USACE and the non-federal sponsors. Appendix A includes letters of non-federal sponsor support to construct the sites recommended in this Final FR/EA; as well letters that were provided to support the TSP included in the Draft FR/EA.

Letters of support for the TSP included in the Draft FR/EA were received from the NJDEP, NYCDEP, NYC Parks, NYSDEC, Westchester County, NY/NJ Baykeeper, the New Jersey Sports and Exposition Authority (NJSEA) and the New York Harbor Foundation (NYHF) (Appendix A). The Draft FR/EA was released for public review on 27 February 2017 for a 45 day review period. A 15-day extension request was granted and the formal public review period was closed on 1 May 2017. Three (3) public meetings were held in April 2017 during the public comment period.

A summary of public comments received during the public review and comment period is included in Appendix N of this Final Integrated FR/EA. In addition to the sponsor support letters, support letters from Congresswoman Meng (NY-6) and Congressman Meeks (NY-5); federal, state, local agencies; universities; community groups; and private entities were received. All support and comment letters are found in Appendix N. The following is a summary of the public and agency comments:

Congressional Representatives

- Congresswoman Grace Meng, along with New York State Senator Toby Ann Stavinky, New York State Assemblyman Ron Kim and New York City Councilman Peter Koo expressed support for the Flushing Creek and Bay Restoration plan presented in the Draft FR/EA. Recommended the final plan include two restoration measures from "Alternative C"; eliminating mudflats and adding stormwater infiltration features to collect runoff from adjacent areas and roads to improve stormwater quality (NAN acknowledges if these features were added, NYCDEP would pay 100% of the costs of the features).

- Congressman Meeks provided a letter (May 14, 2018) supporting the Jamaica Bay Ecowatchers request to advance the restoration of the Jamaica Bay Marsh Islands and stressed that:

  "..*this project is the most critical in terms of priority from both an ecological perspective (the proposed are is one in which has some of the largest habitat loss and water quality issues) and will help this issue tremendously from the perspective of critical storm resiliency. To that end, as a Member of United States House of Representatives I am urging the United States Corps of Engineers, New York District to approve the Jamaica Bay Ecowatcher's request, so that collectively our efforts will result in this critical ecological project that will double as a natural storm resiliency element for this estuary of national significance, as described by the Academy of Science and for the Fifth Congressional District communities I represent, that surround Jamaica Bay, that were so critically impacted by Hurricane Sandy*."

Federal Agencies

- National Park Service concurs with the restoration plans for Jamaica Bay (specifically the marsh islands and Dead Horse Bay) and will be considered mutually acceptable pursuant the enabling legislation (P.L. 95-592, 1972) for Gateway National Recreation Area (GNRA).
- The U. S. Environmental Protection Agency (EPA), Region 2, supports the recommendations of the Draft FR/EA. The EPA provided a copy of their Green Recommendations which encourages use of local and recycled materials and utilization of technologies and fuels that minimize greenhouse gas emissions.
- U.S. Coast Guard provided permitting and implementation guidance.
- The New York-New Jersey Harbor Estuary Program (HEP) wrote in support of the project.

State Agencies

- The Historic Preservation Offices of New Jersey and New York (NJSHPO and NYSHPO) expressed their support of the District's approach to addressing potential impacts to cultural resources through implementation of a Programmatic Agreement (PA).

Local Agencies

- The Superintendent of Recreation for the City of Passaic enthusiastically supports the project, specifically the plan recommended in the FR/EA for Dundee Island Park.
- The NYC Parks expressed their support of the recommendations of the FR/EA.

Public Stakeholders

- The Jamaica Bay Ecowatchers expressed their support stating that of the projects in Jamaica Bay, they believe that restoration of the marsh islands will have the greatest positive environmental impacts. They also offered recommendations for implementation of the project and sources of additional support for the project.
- The Broad Channel Civic Association, which represents a residential community in Jamaica Bay, wrote in support of the project, specifically the five marsh island sites noting their potential to reduce damaging wave energy.
- The NY/NJ Baykeeper expressed their support for the recommendations of the FR/EA.
- The Bronx River Alliance supports the Districts efforts for the improvement of environmental quality, especially for the South Bronx community, an EJ community. They reviewed the alternatives and made recommendations for the Bronx River Alternatives that align best with their restoration and water quality enhancement goals.
- The Environmental Defense Fund, a national and international environmental organization headquartered in New York City, offered their support for the study recommendations.
- The Guardians of Flushing Bay expressed their support for the FR/EA, specifically for the Flushing Creek site for its potential to improve the water quality of the waterway, which is heavily used by the surrounding communities. Concern was expressed regarding the DEP's Long Term Control Plan which uses chlorine to disinfect Combined Sewer Outfalls (CSO) discharge into Flushing Creek.
- The Rutgers Center for Urban Environmental Sustainability offered implementation recommendations for Oyster reef creation, specifically to increase focus on Raritan Bay and Naval Weapons Station Earle (NWSE) sites.
- Rutgers University (Professor and HEP Science and Technical Advisory Committee Chair) wrote to offer support of the study as well as to provide examples of recent scientific research that could guide future actions.
- The Science and Resiliency Institute at Jamaica wrote to offer support of the FR/EA, for all sites, especially those at Jamaica Bay. The Institute included comments about expanding monitoring and adaptive management and offered other recommendations regarding feasibility.
- Other Community Representatives including The Friends and Residents of Greater Gowanus support the study.
- Brian Sandilands wrote to make recommendations regarding the direction of the study, offering support of the District's TECs as goals for restoration projects and to encourage the District to expand the study to include areas further upstream and additional measures.

Chapter 9: Recommendations

I recommend that the Recommended National Ecosystem Restoration (NER) Plan for the Hudson-Raritan Estuary (HRE), New York and New Jersey as described in this report be authorized as a federal project, with such modifications thereof at the discretion of the Commander, U.S. Army Corps of Engineers (USACE) Headquarters, may be advisable. This Recommended NER Plan satisfies the recommendation for the HRE Ecosystem Restoration Feasibility Study as well as the following feasibility studies:

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

I have given full consideration to all significant aspects of this recommendation in the overall public interest including environmental, social, and economic effects; and engineering feasibility. The Recommended NER Plan includes the restoration of 20 sites throughout the estuary that will provide for an increase in the quality and extent of estuarine, freshwater riverine, marsh island and oyster habitat. The sites that are recommended for construction authorization are presented in Table 9-1 per cost allocation with non-federal sponsors specified in Table 4-17.

Table 9- 1. Restoration Sites Recommended for Construction.

Location	Recommended Restoration	Site
Jamaica Bay Planning Region		
Jamaica Bay	Estuarine Habitat Restoration	Dead Horse Bay Fresh Creek
	Jamaica Bay Marsh Island Restoration	Duck Point Stony Creek Pumpkin Patch West Pumpkin Patch East Elders Center
	Small-Scale Oyster Restoration	Head of Jamaica Bay
Harlem River, East River and Western Long Island Sound Planning Region		
Flushing Creek	Estuarine Habitat Restoration	Flushing Creek
Bronx River	Freshwater Riverine Habitat Restoration	Bronx Zoo and Dam Stone Mill Dam Shoelace Park Bronxville Lake Garth Woods/Harney Road

Location	Recommended Restoration	Site
Newark Bay, Hackensack River and Passaic River Planning Region		
Hackensack River	Estuarine Habitat Restoration	Metromedia Tract Meadowlark Marsh
Lower Passaic River	Tier 2 Estuarine Habitat Restoration	Oak Island Yards
	Freshwater Riverine Habitat Restoration	Essex County Branch Brook Park
Upper Bay Planning Region		
Upper New York Bay	Small-Scale Oyster Restoration	Bush Terminal
Lower Bay Planning Region		
Sandy Hook Bay	Small-Scale Oyster Restoration	Naval Weapons Station Earle

The Recommended NER Plan provides positive ecosystem and social benefits that support the USACE's restoration mission. Restoration measures were developed to restore ecosystem function while recognizing the urban nature of the existing environment. Each site is incrementally justified and a cost-effective approach. Each site meets the study planning objectives for ecosystem restoration of National and regionally significant resources. All recommended sites are considered best buy plans. Finally, all sites optimize the restoration measures for different levels of output.

As documented in this report, no significant adverse environmental impacts would occur as a result of implementation of the Recommended Plan. Pending completion of public and State and Agency Review, a Finding of No Significant Impact (FONSI) will be prepared as part of the final recommendation. The plan includes monitoring and adaptive management until ecological success criteria are met, for no more than 10 years, and adaptive management as described in this document. A Final Operations, Maintenance, Repair, Replacement, and Rehabilitation plan will be established upon completion of each project.

The Recommended NER Plan will provide for the restoration of approximately 381 acres of estuarine wetland habitat including 16 acres/six (6) miles linear feet of tidal channels, 50 acres of freshwater riverine wetland habitat, 27 acres of coastal and maritime forest habitat, 39 acres of shallow water habitat and 52 acres of oyster habitat. Two (2) fish ladders would be installed and three (3) weirs would be modified to re-introduce or expand fish passage and control flow rate and water volume along the Bronx River. Additionally, 1.6 miles of streambank restoration and 72 acres of bed and channel restoration is recommended.

The Recommended NER Plan has an estimated project first cost of $408,184,000 which includes monitoring costs of $2,977,000 and adaptive management costs of $12,359,000 (October 2019/FY2020 price level). The estimated total project cost, fully funded with escalation to the estimated midpoint of construction, is $587,661,000. The fully funded costs will be the basis for the Project Partnership Agreements.

The Recommended NER Plan supports HRE program objectives and restoration goals in the HRE (Tables 4-9 through 4-12). It compliments past, ongoing, and planned restoration work by the USACE and other parties as described in the HRE Comprehensive Restoration Plan (CRP). In order to fully address the restoration needs of the HRE, I also recommend that the USACE participate in additional future restoration feasibility studies identified in the HRE Comprehensive Restoration Plan via the study authorization.

My recommendation is made with the provisions that the non-federal sponsors will:

A. Provide, during the periods of design and construction, funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of the total project cost;
B. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal government to be required or to be necessary for the construction, operation, and maintenance of the project;
C. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;
D. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal government;
E. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
F. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments;
G. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;
H. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and

Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction or operation and maintenance of the project;

I. Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction, operation, maintenance, repair, rehabilitation, or replacement of the project;

J. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

K. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

L. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

M. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army”; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c);

N. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

O. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor’s obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

The recommendations contained herein reflect the information available at this time and current Department of the Army policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the United States Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the states of New York and New Jersey, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

ASBERY.THOMAS.DEAN.1171299833

Digitally signed by ASBERY.THOMAS.DEAN.1171299833
Date: 2020.04.21 11:07:53 -04'00'

Thomas D. Asbery
Colonel, U.S. Army
Commander and District Engineer

Chapter 10: References

Able, K.W., and J.T. Duffy-Anderson. 2006 Impacts of Piers on Juvenile Fishes in the Lower Hudson River. The Hudson River Estuary, edited by J.S. Levinton and J.R. Waldman, New York: Cambridge University Press, pages 428-440.

Adams, D., and S. Benyi. 2003 Sediment Quality of the NY/NJ Harbor System: A 5-year Revisit, 1993/4 - 1998. Final Report, EPA/902-R-03-002. United States Environmental Protection Agency (USEPA), Electronic.

Anderson, P. W., and S. D. Faust. 1974 Water Quality and Streamflow Characteristics, Raritan River Basin, New Jersey. Water-Resources Investigations 14-74. Trenton: United States Geological Survey, Electronic.

Anderson, R G., J. G. Canadell, J T. Randerson, R. B. Jackson, B.A. Hungate, D. D. Baldocchi, G. A. Ban-Weiss, G. B. Bonan, K. Caldeira, L. Cao, N. S. Diffenbaugh, K. R. Gurney, L. M. Kueppers, B. E. Law, S. Luyssaert, and T. L O'Halloran.2011 Biophysical Considerations in Forestry for Climate Protection. Frontiers in Ecology and the Environment, 9(3):174-182. Electronic.

ASI, 2005. "Taxonomic Identification of Benthic Invertebrates from Sediment Collected in the Lower 17 Miles of the Lower Passaic River." Under contract to Earth Tech, Inc. (Bloomfield, New Jersey). Prepared for NJDOT and USACE-NY District. September 2005.

Askins, R. A., and M. J. Philbrick. 1987 Effect of Changes in Regional Forest Abundance on the Decline and Recovery of a Forest Bird Community. The Wilson Bulletin 99(1):7-12. Electronic.

Auld, A.H., and J.R. Schubel. 1978 Effects of Suspended Sediment on Fish Eggs and Larvae: A Laboratory Assessment. Estuarine and Coastal Marine Science 6(2):153-164.

Avery, M.L., M.A. Pavelka, D.L. Bergman, D.G. Decker, C.E. Knittle, and G.M. Linz. 1995 Aversive Conditioning to Reduce Raven Predation on California Least Tern Eggs. Colonial Waterbirds, 18:131-138. Electronic.

Ayres, R. U., and S. R. Rod1986 Patterns of pollution in the Hudson-Raritan Basin. Environment, 28(4):14-43. Electronic.

Bain, M., J. Lodge, D. Suszkowski, W. Matuszeski, D. B. Botkin, R. J. Diaz, K. Farley, J. S. Levinton, F. Steimle, and P. Wilber. 2007. Target Ecosystem Characteristics for the Hudson Raritan Estuary: Technical Guidance for Developing a Comprehensive Ecosystem Restoration Plan. New York: Hudson River Foundation, Electronic.

Barbier, E. B., S. D. Hacker, C. Kennedy, E. W. Koch, A. C. Stier, and B. R. Silliman.2011 The Value of Estuarine and Coastal Ecosystem Services: Ecological Monographs, 81(2):169-193. Electronic.

Barry, D.W., and G.D. Fish. 1995 Biting Fly Management, Pesticide Applicator Training Manual: Category 7E. University of Maine Cooperative Extension, Electronic.

Bartoldus, C., E. Garbisch, and M. Kraus. 1994 Evaluation for Planned Wetlands, A Procedure for Assessing Wetland Functions and a Guide to Functional Design. St. Michaels: Environmental Concern Inc., Electronic.

Bayne, B.L., and R.C. Newll. 1983 Physiological Energetics of Marine Molluscs. The Mollusca, Volume 4: Physiology, edited by S.M. Saleuddin and K. M. Wilbur, Elsevier, pages 407-515.

Beck, A. J., J. K. Cochran, and Sergio A. Sanudo-Wilhelmy.2009 Temporal Trends of Dissolved Trace Metals in Jamaica Bay, NY: Importance of Wastewater Input and Submarine Groundwater Discharge in an Urban Estuary. Estuaries and Coasts, 32(3):535-550.

Beninde, J., M. Veith, and A. Hochkirch. 2015 Biodiversity in Cities Needs Space: A Meta-Analysis of Factors Determining Intra-Urban Biodiversity Variation. Ecology Letters, 18:581-592. Electronic.

Berg, D. L., and J. S. Levinton. 1985 The Biology of the Hudson-Raritan Estuary, with Emphasis on Fishes. NOAA Technical Memorandum NOS OMA 16. Rockville: National Oceanic and Atmospheric Administration (NOAA). Electronic.

Bernick, A. J. 2006 New York City Audubon’s Harbor Herons Project: 2006 Interim Nesting Survey. New York: New York City Audubon Society. Electronic.

_____. New York City Audubon Harbor Herons Project: 2007 Nesting Survey. New York: New York City Audubon Society, 2007. Electronic.

Bilkovic, D. M. 2011 Response of Tidal Creek Fish Communities to Dredging and Coastal Development Pressures in a Shallow-Water Estuary. Estuaries and Coasts, 34(1):129-147. Electronic.

Bird, E. C.F. 2008 Coastal Geomorphology: An Introduction. Second Edition. Chichester: John Wiley & Sons Ltd.

Black, J. 2011 Oyster Reef Restoration in North Carolina: Recommendations for Improvements in Techniques and Monitoring. Masters Project, Nicholas School of the Environment, Duke University. Durham: Duke University. Electronic.

Blanchard, P. P., III, P. Kerlinger, and M. J. Stein. 2001 An Islanded Nature: Natural Area Conservation and Restoration in Western Staten Island, including the Harbor Herons Region. New York: The Trust for Public Land and the New York City Audubon Society.

Bokuniewicz, H.J. 1988 The Study of Subaqueous Sand Mining in New York Harbor. Marine Mining, 7(1):7-18.

Bolund, P., and S. Hunhammar 1998. Ecosystem Services in Urban Areas. Ecological Economics, 29:293-301. Electronic.

Bonan, G. B. 2008 Ecological Climatology: Concepts and Applications. New York: Cambridge University Press.

Bone, K. 1997 Horizontal City: Architecture and Construction in the Port of New York. The New York Waterfront: Evolution and Building Culture of the Port and Harbor, edited by Kevin Bone, New York: Monacelli Press Inc., pages 87-151.

Bopp, R. F., S. N. Chillrud, E. L. Shuster, H. J. Simpson, and F. D. Estabrooks. 1998 Trends in Chlorinated Hydrocarbon Levels in Hudson River Basin Sediments. Environmental Health Perspectives, 106 Suppl. 4:1075-1081. Electronic.

Bronx River Alliance. 2016 Greenway. Bronx River Alliance. Version unknown. New York City Department of Parks and Recreation. Web. August 29, 2016 from <http://www.bronxriver.org/greenway>.

Brooklyn Greenway Initiative. Brooklyn Greenway Initiative. Version unknown. Brooklyn Greenway Initiative. Web. September 9, 2016 from <http://www.brooklyngreenway.org/>.

Brown, M., and C. Cheeseman.2013 Identification of Biologically Important Barriers in the Hudson River Estuary. Final Report. Arlington: The Nature Conservancy. Electronic.

Bulleri, F., and M. G. Chapman. 2010 The Introduction of Coastal Infrastructure as a Driver of Change in Marine Environments. Journal of Applied Ecology, 47(1):26-35. Electronic.

Byrnes, M. R., R. M. Hammer, T. D. Thibaut, and D. B. Snyder. 2004 Effects of Sand Mining on Physical Processes and Biological Communities Offshore New Jersey, U.S.A. Journal of Coastal Research Winter, 20(1):25-43. Electronic.

Byron, J., and M. S. Greenfield. 2006 Bronx River Greenway Plan. Bronx, New York: Bronx River Alliance. Electronic.

Cahoon, L.B., J.E. Nearhoof, and C.L. Tilton.1999 Sediment Grain Size Effect on Benthic Microalgal Biomass in Shallow Aquatic Ecosystems. Estuaries, 22(3B):735-741. Electronic.

Carvalheiro, L.G., E.R.M. Barbosa, and J. Memmott. 2008 Pollinator Networks, Alien Species and the Conservation of Rare Plants: *Trinia glauca* as a Case Study. *Journal of Applied Ecology*, 45:1419-1427. Electronic.

Castro, M. S., C. T. Driscoll, T. E. Jordan, W. G. Reay, and W. R. Boynton. 2003 Sources of Nitrogen to Estuaries in the United States. Estuaries, 26(3):803-814.

Chambers, R. M. 1997 Porewater Chemistry Associated with *Phragmites* and *Spartina* in a Connecticut Tidal Marsh." *Wetlands*, 17(3):360-367. Electronic.

Chambers, R. M., L. A. Meyerson, and K. Lellis-Dibble. 2012 Ecology of *Phragmites australis* and Responses to Tidal Restoration. Tidal Marsh Restoration: A Synthesis of Science and Management, edited by C. T. Roman and D. M. Burdick, Washington, DC: Island Press, pages 81-96. Electronic.

Chant R.J. and T.P. Wilson, 2004. "Characterizing the Circulation and dispersive Nature of the Passaic River and its Dependence on river Discharge and tidal Range: Elucidation of Major

Processed that Determine the Impact of the Proposed River Dredging Project." Prepared for NJDOT and USACE-NY District. July 2004.

Chrysler, M. A. 1930. The Origin and Development of the Vegetation of Sandy Hook. Bulletin of the Torrey Botanical Club, 57(3):163-176.

Coen, L. D., R. D. Brumbaugh, D. Bushek, R. Grizzle, M.W. Luckenbach, M.H. Posey, S.P. Powers, and S. G. Tolley. 4 2007 Ecosystem Services Related to Oyster Restoration. Marine Ecology Progress Series, 341:303-307. Electronic.

Coen, Loren D., and M. W. Luckenbach. 2000 Developing Success Criteria and Goals for Evaluating Oyster Reef Restoration: Ecological Function or Resource Exploitation? Ecological Engineering, 15:323-343. Electronic.

Connell, D.W. 1982 An Approximate Petroleum Hydrocarbon Budget for the Hudson Raritan Estuary—New York. Marine Pollution Bulletin, 13(3):89-93.

Cordell, J. R., and S. M. Morrison. September 1996 The Invasive Asian Copepod *Pseudodiaptomus inopinus* in Oregon, Washington, and British Columbia Estuaries. Estuaries, 19(3):629-638.

Cornell University Cooperative Extension of Suffolk County. Methods of Restoring Eelgrass. SEAGRASS.LI, Long Island's Seagrass Conservation Website. Version unknown. Cornell Cooperative Extension Marine Program. Web. 2016 from http://www.seagrassli.org/restoration/methods.html.

Cornish, P.S., and S. Burgin. 2005 Residual Effects of Glyphosate Herbicide in Ecological Restoration. Restoration Ecology, 13(4):695-702. Electronic.

Council on Environmental Quality. (CEQ) 1997. Considering Cumulative Effects under the National Environmental Policy Act. Executive Office of the President, Electronic.

Craig, E. 2010 New York City Audubon's Harbor Herons Project: 2010 Nesting Survey – 25th Annual Report. New York: New York City Audubon. Electronic.

Crawford, D.W., N.L. Bonnevie, C.A. Gillis, and R.J. Wenning. 1994 Historical Changes in the Ecological Health of the Newark Bay Estuary, New Jersey. Ecotoxicology and Environmental Safety. 29(3):276-303.

Dame, R. F., and B. C. Patten.1981 Analysis of Energy Flows in an Intertidal Oyster Reef. Marine Ecology Progress Series, 5:115-124. Electronic.

Damschen, E. I., and L. A. Brudvig. 2012 Landscape Connectivity Strengthens Local–Regional Richness Relationships in Successional Plant Communities. *Ecology*, 93(4):704-710. Electronic.

Dehon, D. D. 2010 Investigating the Use of Bioengineered Oyster Reefs as a Method of Shoreline Protection and Carbon Storage. Master of Science Thesis, Louisiana State University and Agricultural and Mechanical College. Baton Rouge: Louisiana State University. Electronic.

Dibble, K. L., and L. A. Meyerson. 2012 Tidal Flushing Restores the Physiological Condition of Fish Residing in Degraded Salt Marshes. PLoS ONE, 7(9):1-16. Electronic.

Drinkwater, K. F., and K. T. Frank. 1994 Effects of River Regulation and Diversion on Marine Fish and Invertebrates. Aquatic Conservation: Freshwater and Marine Ecosystems, 4:135-151. Electronic.

Duffy, J. Emmett. 2009 Why Biodiversity is Important to the Functioning of Real-World Ecosystems. Frontiers *in Ecology and the Environment*, 7(8):437-444. Electronic.

Durkas, S. J. 1992 Impediments to the Spawning Success of Anadromous Fish in Tributaries of the NY/NJ Harbor Watershed. Highlands: American Littoral Society. Electronic.

_____. A Guideline to Restore Anadromous Fish Runs in Selected Tributaries of the NY/NJ Harbor Watershed. Highlands: American Littoral Society, 1993. Electronic.

Erftemeijer, P. L.A., and R. R. Robin Lewis III. 2006 Environmental Impacts of Dredging on Seagrasses: A Review. Marine Pollution Bulletin, 52:1553-1572. Electronic.

EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016*, April 2018.

Federal Aviation Administration, U.S. Department of Transportation (FAA). 2007. Hazardous wildlife attractants on or near airports. Advisory Circular: 150/5200-33B

Findlay, S. G., and D. T. Fischer. 2013 Ecosystem Attributes Related to Tidal Wetland Effects on Water Quality. Ecology, 94(1):117-125.

Findlay, S. G., P. M. Groffman, and S. Dye.2003 Effects of *Phragmites australis* Removal on Marsh Nutrient Cycling. Wetlands Ecology and Management, 11(3):157-165.

Fitzhugh, T. W., and B. D. Richter. 2004 Quenching Urban Thirst: Growing Cities and Their Impacts on Freshwater Ecosystems. Bioscience, 54(8):741-754.

Flory, S. Luke, and K. Clay. 2009 Invasive Plant Removal Method Determines Native Plant Community Responses. Journal of Applied Ecology, 46:434-442. Electronic.

Foreman, L., and R.P. Johns.1940 The Regulation of Stream Pollution in the Raritan River Basin by the New Jersey State Department of Health. Sewage Works Journal, 12(3):571-585.

Gedan, K. B., M. L. Kirwan, E. Wolanski, E. B. Barbier, and B. R. Silliman. 2011 The Present and Future Role of Coastal Wetland Vegetation in Protecting Shorelines: Answering Recent Challenges to the Paradigm. Climatic Change, 106(1):7-29.

Gibson, R.J., R.L. Haedrich, and C.M. Wernerheim. 2005 Loss of Fish Habitat as a Consequence
Of Inappropriately Constructed Stream Crossings. Fisheries, 30(1):10–17. Electronic.

Gilbert-Norton, L., R. Wilson, J. R. Stevens, and K. H. Beard. 2010 A Meta-Analytic Review of Corridor Effectiveness. Conservation Biology, 24(3):660-668. Electronic.

Glenn, S.D. 2013, editor. New York Metropolitan Flora Database. New York: New York Metropolitan Flora Project, Brooklyn Botanic Garden.

Good, R.E., N.F. Good, and B.R. Frasco. 1982. A review of primary production and decomposition dynamics of the belowground marsh component. pp. 139-157 in: V.S. Kennedy, Ed., Estuarine Comparisons. Academic Press, NY.

Gorman, L.T., and D.W. Reed. 1989 Shoreline Response of Northern New Jersey Barrier System. Barrier Islands: Process and Managemen*t*, edited by Donald K. Stauble, New York: American Society of Civil Engineers.

Gornitz, V., S. Couch, and E. K. Hartig. 2002 Impacts of Sea Level Rise in the New York City Metropolitan Area. Global and Planetary Changes, 32:61-88. Electronic.

Grabowski, J. H., and C. H. Peterson. 2007 Restoring Oyster Reefs to Recover Ecosystem Services. Ecosystem Engineers, Theoretical Ecology Series Volume 4, edited by K. Cuddington, J. E. Byers, W. G. Wilson, and A. Hastings, Elsevier, pages 281-298. Electronic.

Gratton, C., and R. F. Denno.2006 Arthropod Food Web Restoration Following Removal Of An Invasive Wetland Plant. Ecological Applications, 16(2):622-631.

Grizzle, R., K. Ward, J. Lodge, K. Mosher-Smith, K. Kalchmayr, and P. Malinowski. 2012 Oyster Restoration Research Project (ORRP) Technical Report, ORRP Phase 1: Experimental Oyster Reef Development and Performance Results, 2010-2011. ORRP. Electronic.

Grizzle, R., K. Ward, J. Lodge, D. Suszkowski, K. Mosher-Smith, K. Kalchmayr, and P. Malinowski. 2013 Oyster Restoration Research Project (ORRP) Final Technical Report, ORRP Phase 1: Experimental Oyster Reef Development and Performance Results, 2009-2012. ORR. Electronic.

Hadley, N., A. Hollis, L. Coen, and W. Anderson. 2005 Murrells Inlet Special Area Management Plan. Final Report. Columbia: South Carolina Department of Natural Resources. Electronic.

Hall, M. J., and O. H. Pilkey. 1991 Effects of Hard Stabilization on Dry Beach Width for New Jersey. Journal of Coastal Research Summer, 7(3):771-785. Electronic.

Hall, S. G., D. Dehon, R. Beine, M. Campbell, T. Ortego, and M. Turley. , June 21 - June 24, 2009 Use of Bioengineered Artificial Reefs for Ecological Restoration in Estuarine Environments. Reno, Nevada. St. Joseph: American Society of Agricultural and Biological Engineers, 2009.

Hapke, C. J., O. Brenner, R. Hehre, and B.J. Reynold, 2013 Coastal Change from Hurricane Sandy and the 2012-13 Winter Storm Season: Fire Island, New York. Open-File Report 2013-1231. Reston: United States Geological Survey. Electronic.

Hapke, C. J., E. A. Himmelstoss, M. G. Kratzmann, J. H. List, and E. Robert Thieler. 2010 National Assessment of Shoreline Change: Historical Shoreline Change along the New England and Mid-Atlantic Coasts. Open-File Report 2010-1118. Reston: United States Geological Survey, Electronic.

Harbor Herons Subcommittee. *The Harbor Herons Conservation Plan, New York/New Jersey Harbor Region*. New York: New York-New Jersey Harbor Estuary Program, 2010. Electronic.

Harding, J.M. and R. Mann. 1999. Fish species richness in relation to restored oyster reefs, PIankatank River, Virginia. Bulletin of Marine Science 65(1):289-300

Hardy, C. 2011 Chief, Habitat and Enhancement Section, North Carolina Division of Marine Fisheries. Personal communication. As cited in Black, 2011.

Harris, M.D., E.K. Hood, and J. Dworsky. 2014 Cultural Resources Overview for Hudson-Raritan Estuary Comprehensive Restoration Plan. New York: United States Army Corps of Engineers (USACE), New York District.

Hartig, E. K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon.2002 Anthropogenic and Climate-Change Impacts on Salt Marshes of Jamaica Bay, New York City. Wetlands, 22(1):71-89. Electronic.

Hascic, I., and J. Wu.2006 “Land Use and Watershed Health in the United States.” Land Economics, 82(2):214-239.

Heleno, R., I. Lacerda, J A. Ramos, and J. Memmott. 2010 Evaluation of Restoration Effectiveness: Community Response to the Removal of Alien Plants. Ecological Applications 20(5):1191k-1203. Electronic.

Holmes, R., and B. Milligan. 2016. Feedback: Designing the Dredge Cycle. *Scenario 03: Rethinking Infrastructure*. Version unknown. Scenario Journal, Inc., 2013. Web. June 2, 2016 from
<http://scenariojournal.com/article/feedback-designing-the-dredge-cycle/>.

Iannuzzi, T.J., S.L. Huntley, C W. Schmidt, B.L. Finley, R.P. McNutt, and S.J. Burton. 1997. Combined Sewer Overflows (CSOs) as Sources of Sediment Contamination in the Lower Passaic River, New Jersey. I. Priority Pollutants and Inorganic Chemicals. Chemosphere, 34(2):213-231.

Iannuzzi, T. J., and D. F. Ludwig.2004 Historical and Current Ecology of the Lower Passaic River. Urban Habitats. Version unknown. Urban Habitats. Web. June 20, 2016 from
<http://www.urbanhabitats.org/v02n01/passaicriver_full.html>.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: Intergovernmental Panel on Climate Change, 2014. Electronic.

Jackson, N. L. March 1995 Wind and Waves: Influence of Local and Non-Local Waves on Mesoscale Beach Behavior in Estuarine Environments. Annals of the Association American Geographers 85(1):21-37.

Jackson, N. L., and K. F. Nordstrom. 1992 Site Specific Controls on Wind and Wave Processes and Beach Mobility on Estuarine Beaches in New Jersey, U.S.A. *Journal of Coastal Research* Winter 1992. 8(1):88-98.

Jahr, K., J., and G. E. Crow. 2005 Floristic Reevaluation of Created Wetland in Portsmouth, New Hampshire. Rhodora, 107(929):87-102.

Jamaica Bay Ecosystem Research and Restoration Team. Final Report. 2002.

Jay, D. A., and C. A. Simenstad.1994 Downstream Effects of Water Withdrawal in a Small, High-Gradient Basin: Erosion and Deposition on the Skokomish River Delta. Estuaries. 17(3):702-715.

_____. Downstream Effects of Water Withdrawal in a Small, High-Gradient Basin: Erosion and Deposition on the Skokomish River Delta. Estuaries September 1996. 19(3):501-517. Electronic.

Jones, K. W., H. Feng, E A. Stern, J. Lodge, and N. L. Clesceri.2001, "Dredged Material Decontamination Demonstration for the Port of New York/New Jersey." *Journal of Hazardous Materials* 85:127–143. Electronic.

Kastens, K. A., C. T. Fray, J.R. Schubel, and R. E. Wilson. 1978 Environmental Effects of Sand Mining in the Lower Bay of New York Harbor, Phase 1. Special Report 15. Stony Brook: Marine Science Research Center, Stony Brook University.

Kelley, S. W., J. S. Ramsey, and M. R. Byrnes. 2004 "Evaluating Shoreline Response to Offshore Sand Mining for Beach Nourishment." Journal of Coastal Research, 20(1):89-100. Electronic.

Kellogg, M. L., J. C. Cornwell, M. S. Owens, and K. T. Paynter. 2013 Denitrification and Nutrient Assimilation on a Restored Oyster Reef. Marine Ecology Progress Series, 480:1-19. Electronic.

Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation 29(1): 78-107

Keppel, G., K. P. Van Niel, G. W. Wardell-Johnson, C. J. Yates, M. Byrne, L. Mucina, A. G. T. Schut, S D. Hopper, and S. E. Franklin. 2012 Refugia: Identifying and Understanding Safe Havens for Biodiversity under Climate Change. *Global Ecology and Biogeography*, 21:393-404. Electronic.

Kettenring, K.M., and C.R. Adams.2011 Lessons Learned from Invasive Plant Control Experiments: A Systematic Review and Meta-Analysis. Journal of Applied Ecology, 48(4):970-979. Electronic.

Kirby, M.X., and H.M. Miller. 2005 Response of a Benthic Suspension Feeder (*Crassostrea virginica*) to Three Centuries of Anthropogenic Eutrophication in Chesapeake Bay. Estuarine, Coastal and Shelf Science, 62:679-689. Electronic.

Kiviat, E., and K. MacDonald. 2004. "Biodiversity Patterns and Conservation in the Hackensack Meadowlands, New Jersey." *Urban Habitats*. Version unknown. Urban Habitats, Web. June 3, 2016 from <http://urbanhabitats.org/v02n01/biodiversitypatterns_full.html>.

Knott, N. A., J. P. Aulbury, Trevor H. Brown, and Emma L. Johnston. 2009 Contemporary Ecological Threats from Historical Pollution Sources: Impacts of Large-Scale Resuspension of Contaminated Sediments on Sessile Invertebrate Recruitment. Journal of Applied Ecology, 46(4):770-781. Electronic.

Koch, E. W., E. Barbier, B. R. Silliman, D. J. Reed, and G. M.E. Perillo. 2007. Non-Linearity in Ecosystem Services: Temporal and Spatial Variability in Coastal Protection. Frontiers in Ecology and the Environment, 7(1):29-37. Electronic.

Kortekaas, Stella, Ingrida Bagdanaviciute, Paolo Gyssels, J. M. Huerta, and A. Hequette. 2010. Assessment of the Effects of Marine Aggregate Extraction on the Coastline: An Example from the German Baltic Sea Coast. Journal of Coastal Research, Special Issue 51: 205-214. Electronic.

Kraus, Nicholas C., and Francis A. Galgano. 2001 Beach Erosional Hot Spots: Types, Causes, and Solutions. ERDC/CHL CHETN-II-44. Vicksburg: United States Army Corps of Engineers (USACE), Engineer Research and Development Center, Coastal and Hydraulics Laboratory. Electronic.

Kurlansky, M. 2006. The Big Oyster: History on the Halfshell. New York: Ballantine Books Publishing, Paper.

Lambert, S. J., and A. J. Davy.2011. Water Quality as a Threat to Aquatic Plants: Discriminating between the Effects of Nitrate, Phosphate, Boron and Heavy Metals on Charophytes. New Phytologist, 189(4):1051-1059.

Latimer, J. S., and S. A. Rego. 2010 “Empirical Relationship between Eelgrass Extent and Predicted Watershed-Derived Nitrogen Loading for Shallow New England Estuaries.” Estuarine, Coastal and Shelf Science, 90(4):231–240.

Lesser, C.R. 2007 Open Marsh Water Management*:* A Source Reduction Technique for Mosquito Control. Dover: Delaware Mosquito Control Section, Division of Fish and Wildlife, Department of Natural Resources and Environmental Control. Electronic.

Levinton, J.S., and J.R. Waldman. 2006 *The Hudson River Estuary*. New York: Cambridge University Press, Electronic.

Liu, W.C., M.H. Hsu, A.Y. Kuo, and J. T. Kuo. 2001. The Influence of River Discharge on Salinity Intrusion in the Tanshui Estuary, Taiwan. Journal *of Coastal Research* 17(3):544-552. Electronic.

Lodge, J., R. Grizzle, L. Coen, A. Mass Fitzgerald, M. Comi, and P. Malinowski. 2015a Community Based Restoration of Oyster Reef Habitat in the Bronx River: Assessing Approaches and Results in an Urbanized Setting. New York: Hudson River Foundation. Electronic.

Lodge, J., R. E. Landeck Miller, D. Suszkowski, S. Litten, S. Douglas. 2015b Contaminant Assessment and Reduction Project Summary Report. New York: Hudson River Foundation. Electronic.

Mack, L. and M. J. Feller. 1990 Salt Marshes of New York City. New York: New York City Department of Parks and Recreation (NYC Parks), Natural Resource Group. Electronic.

MacKenzie, C.L. 1992. The Fisheries of Raritan Bay. New Brunswick: Rutgers University Press.

_____. 1996. History of Oystering in the United States and Canada, Featuring the Eight Greatest Oyster Estuaries. Marine Fisheries Review, 58:1-78.

Malhadas, M. S., Adelio S., P. C. Leitão, and R.Neves. 2009. Effect of the Bathymetric Changes on the Hydrodynamic and Residence Time in Óbidos Lagoon (Portugal). *Journal of Coastal Research* Special Issue 56:549-553. Electronic.

Marshall, S. 2004. The Meadowlands Before the Commission: Three Centuries of Human Use and Alteration of the Newark and Hackensack Meadows. Urban Habitats. Version unknown. Urban Habitats, Web. June 20, 2016 from <http://www.urbanhabitats.org/v02n01/3centuries_full.html>.

Mayo, R., F. Serchuk, and E. Holmes, editors. 2006 Status of Fishery Resources off the Northeastern United States. Gloucester: Northeast Fisheries Science Center, National Marine Fisheries Service. Electronic

Mayor's Office. PlaNYC*,* Update April 2011. The City of New York, 2011. Electronic.

Mayor's Office of Long-Term Planning and Sustainability and Mayor's Office of Recovery and Resiliency. 2014. PlaNYC*,* Progress Report 2014. The City of New York, Electronic.

Mayor's Office of Recovery and Resiliency. Mayor's Office of Recovery & Resiliency. Version unknown. New York City Department of Environmental Protection (NYCDEP). Web. August 26, 2016 from <http://www.nyc.gov/html/planyc/html/home/home.shtml>.

McKay S.K., Reif M., Conyngham J.N., and Kohtio D. 2017. Barrier prioritization in the tributaries of the Hudson-Raritan Estuary. ERDC TN-EMRRP-SR-82. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Meyer, D. L., E. C. Townsend, and G. W. Thayer. 1997 "Stabilization and Erosion Control Value of Oyster Cultch for Intertidal Marsh. Restoration Ecology, 5(1):93-99.

Meyers, S. D., A. J. Linville, and M. E. Luther. Alteration of Residual Circulation Due to Large-Scale Infrastructure in a Coastal Plain Estuary. Estuaries and Coasts 2014, 37:493–507. Electronic.

MillionTrees NYC. Version unknown. 2015. Web. August 26, 2016 from <http://www.milliontreesnyc.org/html/home/home.shtml>.

Mitsch, W. J., L. Zhang, K. C. Stefanik, A. M. Nahlik, C. J. Anderson, B. Bernal, M. Hernandez, and K. Song. 2012 Creating Wetlands: Primary Succession, Water Quality Changes, and Self-Design over 15 Years. BioScience, 62(3):237-250. Electronic.

Montalto, F. A., and T. S. Steenhuis. 2004 The Link Between Hydrology and Restoration of Tidal Marshes in the New York/New Jersey Estuary. Wetlands, 24(2):414–425. Electronic.

Mosher-Smith, K. 2012 Oyster Restoration Research Project, Monitoring of and Improvements to the Oyster Restoration Research Partnership Experimental Reefs. Final Report, Keyport: NY/NJ Baykeeper. Electronic.

National Biological Service. 1995. Ecology of maritime forests of the southern Atlantic coast: A community profile. U.S. Department of the Interior, Biological Report 30.

National Oceanic and Atmospheric Administration (NOAA). 2015. "Oyster Restoration. NOAA Habitat Conservation. Version unknown. National Marine Fisheries Service. Web. 2015 from <http://www.habitat.noaa.gov/restoration/techniques/oysterrestoration.html>.

_____. 2016. Central Park, NY Historical Data. National Weather Service. Version unknown. NOAA. Web. June 14, 2016 from <http://www.weather.gov/okx/CentralParkHistorical>.

National Research Council.1987. Responding to Changes in Sea Level, Engineering Implications. Washington, DC: National Academy Press,

_____. 1992. Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy. Washington, DC: National Academy Press.

Neary, D. G., G. G. Ice, and C. R. Jackson. 2009 Linkages Between Forest Soils and Water Quality and Quantity. Forest Ecology and Management, 258(10):2269-2281.

Neves, V.C., S. Panagiotakopoulos, and R.W. Furness. 2006. "A Control Taste Aversion Experiment on Predators of Roseate Tern (Sterna dougallii) Eggs. European Journal of Wildlife Research, 52(4):259-264.

New Jersey Department of Environmental Protection (NJDEP). Open Marsh Water Management Standards for Salt Marsh Mosquito Control. Trenton: NJDEP Office of Mosquito Control Coordination, no date. Electronic.

_____. 2016. State of New Jersey Approved Wetlands Mitigation Banks as of 7/21/16. NJDEP Division of Land Use Regulation. Electronic.

New York City. Manhattan Waterfront Greenway Map. The City of New York, no date. Electronic.

_____. 2011. Vision 2020: New York City Comprehensive Waterfront Plan. New York City Department of City Planning, 2011. Electronic.

_____. *2016a.* New York City Waterfront Revitalization Program - *Overview*. Version unknown. New York City Department of City Planning. Web. August 26, 2016 from <http://www1.nyc.gov/site/planning/applicants/wrp/wrp.page>.

_____. 2016b.The New York City Waterfront Revitalization Program. New York City Department of City Planning,. Electronic.

_____. *2016c. Vision 2020, New York City Comprehensive Waterfront Plan*. Version unknown. New York City Department of City Planning. Web. August 26, 2016 from <http://www1.nyc.gov/site/planning/plans/vision-2020-cwp/vision-2020-cwp.page>.

New York City Department of Environmental Protection (NYCDEP). 2012. *The State of the Harbor 2012*. New York: NYCDEP. Electronic.

_____. *2016. Combined Sewer Overflows (CSOs)*. Version unknown. NYCDEP. Web. August 26, 2016 from <http://www.nyc.gov/html/dep/html/stormwater/combined_sewer_overflow.shtml>.

New York City Department of Health and Mental Hygiene. 2015. *New York City 2015, Beach Surveillance and Monitoring Program*. New York: New York City Department of Health and Mental Hygiene Electronic.

New York City Department of Parks and Recreation (NYC Parks). 2003. Manhattan Waterfront Greenway Comes Full Circle. *The Daily Plant*, vol. XVII, no. 3965, Electronic.

_____. 2014. *Guidelines for Urban Forest Restoration*. NYC Parks. Electronic.

_____. 2016. New York City Water Trail. *NYC Parks*. Version unknown. City of New York. Web. August 26, 2016 from <https://www.nycgovparks.org/facilities/kayak>.

New York City Department of Transportation. 2014. *A Guide to the Jamaica Bay Greenway, 2014-2015 Edition*. New York City Department of Transportation. Electronic.

_____. 2016. *Brooklyn Waterfront Greenway*. Version unknown. City of New York. Web. September 9, 2016 from <http://a841-tfpweb.nyc.gov/greenway/category/brooklyn-waterfront-greenway/>.

New York City Economic Development Corporation. 2015. *Saw Mill Creek Wetland Mitigation Bank Environmental Assessment*. City of New York, Electronic.

_____. *2016. South Bronx Greenway*. Version unknown. New York City Economic Development Corporation, Last updated March 30, 2016. Web. August 29, 2016 from <http://www.nycedc.com/project/south-bronx-greenway>.

New York City Panel on Climate Change. 2015. Building the Knowledge Base for Climate Resiliency: New York City Panel on Climate Change 2015 Report. *Annals of the New York Academy of Sciences* January 2015, 1336:1-150. Web. August 31, 2016 from <http://onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc>.

New York-New Jersey Harbor Estuary Program (HEP). 1996. *New York-New Jersey Harbor Estuary Program, including the Bight Restoration Plan, Final Comprehensive Conservation and Management Plan*. New York: HEP. Electronic.

_____. 2012. *The State of the Estuary 2012: Environmental Health and Trends of the New York-New*

Jersey Harbor Estuary. New York: HEP, Electronic.

New York Invasive Species Information (NYIS). 2019. Common Reed. Accessed January 2020. Available online at: http://nyis.info/invasive_species/common-reed/

New York State (NYS) 2100 Commission. 2013. Recommendations to Improve the Strength and Resilience of the Empire State's Influence. Retrieved from http://www.governor.ny.gov/assets/documents/NYS2100.pdf

New York State Department of Environmental Conservation (NYSDEC). 2001. Jamaica Bay, Queens County, NY. *Tidal Wetlands Losses*. Version unknown. . Web. August 17, 2016 from <http://www.dec.ny.gov/lands/5489.html>.

New York State Department of Environmental Conservation (NYSDEC). 2016. County Maps Showing Potential Environmental Justice Areas. Accessed August 2017. Available online at: http://www.dec.ny.gov/public/899.html

_____. 2012. Order on Consent, CSO Order Modification to CO2-20000107-8. NYSDEC, March 8, 2012. Electronic.

_____. 2016. Shoreline Stabilization. *Protection of Waters Program*. Version unknown. NYSDEC. Web. March 2016 from <http://www.dec.ny.gov/permits/50534.html>.

New York State Governor's Office of Storm Recovery. 2016. *Governor's Office of Storm Recovery*. Version unknown. New York State. Web. September 13, 2016 from <http://stormrecovery.ny.gov/>.

Newcombe, C.P., and D.D. Macdonald.1991 Effects of Suspended Sediments on Aquatic Ecosystems. *North American Journal of Fisheries Management*, 11(1):72-82.

Nilsson, C., A. Ekblad, M. Gardfjell, and B. Carlberg. 1991 Long-Term Effects of River Regulation on River Margin Vegetation. *Journal of Applied Ecology*, 28(3):963-987. Electronic.

Nordenson, C. S., editor. 2015 *Jamaica Bay Marsh Island Restoration*. New York: SCR Jamaica Bay Team, Spitzer School of Architecture, The City College of New York. Electronic.

Nordstrom, K. F., N. L. Jackson, and J. P. Tiefenbacher. 1990 Threats to Beach Resources and Park Boundaries Caused by Shoreline Migration in an Urban Estuarine Park. Environmental Management 14(2):195-202.

Nowak, D. J., E. J. Greenfield, R. E. Hoehn, and E. Lapoint. 2013 Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States. Environmental Pollution, 178:229-236. Electronic.

Odum, E. P. 1971 Fundamentals of Ecology. Philadelphia: W. B. Sanders Company. Print.

Olsvig, L.S., J.F. Cryan, and R.H. Whittaker. 1998. Vegetation gradients of the pine plains and barrens of Long Island, New York. Pp. 265-282 in: R.T.T. Forman, ed. Pine Barrens: Ecosystem and landscape. Rutgers University Press, New Brunswick, NJ.

Orth, R. J., S. R. Marion, K. A. Moore, and D. J. Wilcox. 2010 Eelgrass (*Zostera marina* L.) in the Chesapeake Bay Region of Mid-Atlantic Coast of the USA: Challenges in Conservation and Restoration. Estuaries and Coasts, 33(1):139-150.

Parkman, A. 1983 History of the Waterways of the Atlantic Coast of the United States. National Waterways Study, Navigation History NWS-83-10. Alexandria: United States Army Corps of Engineers (USACE) Water Resources Support Center, Institute for Water Resources.

Parsa, J. and A. Etemad-Shahidi. 2009. Prediction of the Influence of Estuarine Modifications on the Salinity Intrusion. *Journal of Coastal Research*, Special Issue 56:1390-1394. Electronic.

Paul, M. J., and J. L. Meyer.2001 Streams in the Urban Landscape. Annual Review of Ecology and Systematics, 32:333-365. Electronic.

Pearce, J. B. 1979. *Raritan Bay - A Highly Polluted Estuarine System*. C.M. 1979/E:45. Copenhagen: International Council for the Exploration of the Sea, Electronic.

Peckarsky, B.L., P.R. Fraissainet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of Northeastern North America. Cornell University Press. Ithaca, NY.

Peterson, C. H., J. H. Grabowski, and S. P. Powers. 2003 Estimated enhancement of Fish Production Resulting from Restoring Oyster Reef Habitat: Quantitative Valuation. Marine Ecology Progress Series, 264:249-264. Electronic.

Poff, N. L, J. David Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. sparks, and J. C. Stromberg. December 1997. The Natural Flow Regime: A Paradigm for River Conservation and Restoration. BioScience, 47(11):769-784. Electronic.

Port Authority of New York and New Jersey (PANY/NJ). 2014. Successful Port Authority Land Preservation Program Renewed with Additional $60 Million Open Space Commitment Made by Agency's Board of Commissioners. Press Release Article. April 24, 2014, PANY/NJ Press Release Number 87-2014. Electronic.

_____. 2016a. Coastal Ecosystems. *The Port Authority of New York & New Jersey*. Version unknown. PANY/NJ. Web. August 25, 2016 from <http://www.panynj.gov/about/coastal-eco-systems.html>.

_____. 2016b. Harbor Deepening. *The Port Authority of New York & New Jersey*. Version unknown. PANY/NJ. Web. September 13, 2016 from <http://www.panynj.gov/port/harbor-deepening.html>.

Portnoy, J. W., and J. R. Allen. 2006 Effects of Tidal Restrictions and Potential Benefits of Tidal Restoration on Fecal Coliform and Shellfish-Water Quality. Journal of Shellfish Research, 25(2):609-617.

Raposa, K. B. 2008. Early Ecological Responses to Hydrologic Restoration of a Tidal Pond and Salt Marsh Complex in Narragansett Bay, Rhode Island. *Journal of Coastal Research*, Special Issue 55:180-192. Electronic.

Rebuild by Design. 2016. *Rebuild by Design*. Version unknown. September 13, 2016 from <http://www.rebuildbydesign.org/>.

Regional Plan Association (RPA). 2003. *Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary*. New York: United States Army Corps of Engineers (USACE), New York Distric.

Rey-Benayas, J.M., A.C. Newton, A. Diaz, and J.M. Bullock. 2009 Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta-Analysis. *Science*, 325(5944):1121-1124.

Rohman, S. O. 1998 Hazardous Chemicals in the Hudson: An Examination of Available Water Quality and Nonpoint source Pollution Data. Hudson/Raritan Estuary: Issues, Resources, Status, and Management, NOAA Estuarine Programs Office, Washington, DC: United States Department of Commerce, pages 157-170. Electronic.

Rosenzweig, C., W. D. Solecki, R. Blake, M. Bowman, C. Faris, V. Gornitz, R. Horton, K. Jacob, A. LeBlanc, R. Leichenko, M. Linkin, D. Major, M. O'Grady, L. Patrick, E. Sussman, G. Yohe, R. Zimmerman. 2011 Developing Coastal Adaptation to Climate Change in the New York City Infrastructure-shed: Process, Approach, Tools, and Strategies. Climatic Change, 106:93-127. Electronic.

Rothschild, B.J., J.S. Ault, P. Goulletquer, and M. Héral.1994. Decline of the Chesapeake Bay Oyster Population: A Century of Habitat Destruction and Overfishing. Marine Ecology Progress Series, 111(1-2):29-39. Electronic.

Salisbury, R. D. and H.B. Kümmel. 1895 Lake Passaic: An Extinct Glacial Lake. *The Journal of Geology*. 3(5):533-560.

Sanderson, E. W. 2005 Urban Legend: Discovering Manhattan's Wetlands. National Wetlands Newsletter, 27(1):14-17. Electronic.

_____. 2016. Cartographic Evidence for Historical Geomorphological Change and Wetland Formation in Jamaica Bay, New York. *Northeastern Naturalist* 23(2):277-304.

Saltonstall, K; Peterson, PM; Soreng, RJ (2004). Recognition of Phragmites australis subsp. Americanus (Poacaeae: Arundinoideae) in North America. Evidence from morphological and genetic analyses. SIDA, Contributions to Botany. 21 (2): 683–692.

Scyphers, S. B., S. P. Powers, K. L. Heck, Jr., and D. Byron. 2011 Oyster Reefs as Natural Breakwaters Mitigate Shoreline Loss and Facilitate Fisheries. PLoS ONE, 6(8):1-12. Electronic.

Seneca, E. D. and S. W. Broome. 1992 Restoring tidal marshes in North Carolina and France. Pages 53-78 in G.W. Thayer, editor. Restoring the nation's marine environment. Maryland Sea Grant College, College Prk, Maryland

Shepard, C.C., C. M. Crain, and M.W. Beck. 2011 The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis. PLoS ONE, 6(11):1-11. Electronic.

Shin, J. Y., F. Artigas, C. Hobble, and Y. S. Lee.2013 Assessment of Anthropogenic Influences on Surface Water Quality in Urban Estuary, Northern New Jersey: Multivariate Approach. Environmental Monitoring and Assessment, 185(3):2777-2794. Electronic.

Short, F. T., and D. M. Burdick. 1996 Quantifying Eelgrass Habitat Loss in Relation to Housing Development and Nitrogen Loading in Waquoit Bay, Massachusetts. Estuaries, 19(3):730-739. Electronic.

Short, F.T., B.W. Ibelings, and C. den Hartog.1988 Comparison of a Current Eelgrass Wasting Disease to the Wasting Disease of the 1930s. Aquatic Botany, 30(4):295-304.

Short, F.T., A.C. Mathieson, and J.I. Nelson. 1986 Recurrence of the Eelgrass Wasting Disease at the Border of New Hampshire and Maine, USA. Marine Ecology - Progress Series, 29:89-92. Electronic.

Short, F.T., C.A. Short, C.L. Burdick-Whitney. 2002. A Manual for Community-Based Eelgrass Restoration. NOAA Restoration Center Report. Durham: University of New Hampshire

Shwiff, S. A., R. T. Sterner, J. W. Turman, and B. D. Foster. 2005 Ex Post Economic Analysis of Reproduction-monitoring and Predator-removal Variables Associated with Protection of the Endangered California Least Tern. Ecological Economics April 15, 2005, 53:277-287. Electronic.

Simenstad, C. A., D. A. Jay, and C. R. Sherwood. 1992 Impacts of Watershed Management on Land-Margin Ecosystems: The Columbia River Estuary. Watershed Management: Balancing Sustainability and Environmental Change, edited by R. Naiman, New York: Springer-Verlag, pages 266-306.

Sipple, W. S. 1971. The Past and Present Flora and Vegetation of the Hackensack Meadows. Bartonia, (41):4-56.

Smith, A. D., and M. W. Tooker. 2013 Naval Weapons Station Earle Reassessment. Champaign, Illinois: United States Army Engineer Research and Development Center. Electronic.

Society for Ecological Restoration International, Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration*. Society for Ecological Restoration International Electronic.

Soga, M., U. Yamaura, S. Koike, and K. J. Gaston. 2014 Woodland Remnants as an Urban Wildlife Refuge: A Cross-Taxonomic Assessment. Biodiversity and Conservation, 23(3):649-659.

Special Initiative for Rebuilding and Resiliency. 2013. PlaNYC, A Stronger, More Resilient New York. The City of New YorkElectronic.

_____. 2015. *One New York: The Plan for a Strong and Just City*. The City of New York, 2015. Electronic.

Squires, D. F. October 1992Quantifying Anthropogenic Shoreline Modification of the Hudson River and Estuary from European Contact to Modern Time. Coastal Management, 20:343-354.

Stalter, R., and E. E. Lamont. October 2002 Vascular Flora of Jamaica Bay Wildlife Refuge, Long Island, New York. Journal of the Torrey Botanical Society, 129(4):346-358.

Stanley, J. G., and M. A. Sellers. July 1986 Species Profile: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico) – American Oyster. Biological Report 82 (11.64), TR EL-82-4. Slidell: National Wetlands Research Center. Electronic.

Steimle, F. W., and C. Zetlin. 2000 Reef Habitats in the Middle Atlantic Bight: Abundance, Distribution, Associated Biological Communities, and Fishery Resource Use. Marine Fisheries Review, 62(2):24-42. Electronic.

Steinberg, N., D. J. Suszkowski, L. Clark, and J. Way. 2004 Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary. A report to the New York/New Jersey Harbor Estuary Program. New York: Hudson River Foundation. Electronic.

Stinnette, I., Taylor, M., Kerr, L., Pirani, R., Lipuma, S., Lodge, J. State of the Estuary 2018. Hudson River Foundation. New York, NY.

Stout, D. 1996. Governors Island Historic District Created. The New York Times. Electronic.

CUNY (move). 2016. *Structures of Coastal Resilience*. Version unknown. Rockefeller Foundation, no date. Web. July 29, 2016 from <http://structuresofcoastalresilience.org/locations/jamaica-bay-ny/>.

Swaney, D. P., K. E. Limburg, and K. Stainbrook. 2006 Some Historical Changes in the Patterns of Population and Land Use in the Hudson River Watershed. Hudson River Fishes and Their Environment, edited by J. Waldman, K. Limburg, and D. Strayer, Bethesda: American Fisheries Society, pages 75-112.

Trust for Governors Island. 2016. "About." *Governors Island*. Version unknown. Trust for Governors Island. Web. September 8, 2016 from <https://govisland.com/about>.

Turner, E.J., R.K. Zimmer-Faust, M.A. Palmer, M. Luckenbach, and N.D. Pentcheff. 1994 Settlement of Oyster (*Crassostrea virginica*) Larvae: Effects of Water Flow and a Water-Soluble Chemical Cue. *Limnology and Oceanography*, 39(7):1579-1593. Electronic.

United States Census Bureau, 2010. Available online http://www.census.gov/2010census/. Electronic

United States Army Corps of Engineers (USACE). 1999. *Environmental Impact Statement for the New York and New Jersey Harbor Navigation Study, Final Report*. USACE, New York District

_____. 2000. *Draft Expedited Reconnaissance Study: Hudson-Raritan Estuary Environmental Restoration*. USACE, New York District

_____. 2003. *Draft Integrated Ecosystem Restoration Report/Environmental Assessment for the Gerritsen Creek Ecosystem Restoration Project*. USACE, New York District.

_____. 2004a. *Hudson-Raritan Estuary Environmental Restoration Feasibility Study, Study Area Reports*. USACE, New York District

_____. 2004b. *Meadowlands Environmental Site Investigation Compilation (MESIC): Hudson-Raritan Estuary, Hackensack Meadowlands, New Jersey, Final Report*. USACE, New York District.

_____. 2005. *Meadowlands Comprehensive Restoration Implementation Plan, Draft*. USACE, New York District. Electronic.

_____. 2006. *Hudson-Raritan Estuary Ecosystem Restoration Study: Building a World-Class Estuary. Brochure*. USACE, New York District

_____. 2008a. *Lower Passaic River Commercial Navigation Analysis*. USACE, New York District

_____. 2008b. *Dredged Material Management Plan for the Port of New York and New Jersey: Volume I, August 2008 Update*. USACE, New York District, 2008b. Electronic.

_____. 201

_____. 2015a. *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Main Report*. USACE Electronic.

_____. 2015b. *Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience*. USACE, Engineer Research and Development Center Electronic.

_____. 2015c. "Appendix C Engineering." *Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study*. USACE,. Electronic.

_____. 2016a. "Army Corps and Port Authority Announce Completion of NY & NJ Harbor Deepening Navigation Program." Press Release Article. September 1, 2016, USACE, New York District News Release Number 16-015. Electronic.

_____. 2016b. *Hudson Raritan Estuary Ecosystem Restoration Feasibility Study Comprehensive Restoration Plan Environmental Document, Final*. USACE, New York District. Electronic.

______. 2018. ECB-2018-2: Implementation of Resilience Principles in the Engineering & Construction Community of Practice, dated 25 Jan 2018

______. 2019a. ER-1100-2-8162: INCORPORATING SEA LEVEL CHANGE IN CIVIL WORKS PROGRAMS, dated 15 June 2019

_____. 2019b. EP-1100-2-1: PROCEDURES TO EVALUATE SEA LEVEL CHANGE: IMPACTS, RESPONSES, AND ADAPTATION, dated 20 June 2019.

United States Army Corps of Engineers (USACE) and Port Authority of New York and New Jersey (PANY/NJ). 2009a. *Hudson-Raritan Estuary Comprehensive Restoration Plan, Draft, Volume I*. USACE, New York District Electronic.

_____. 2009b. *Hudson-Raritan Estuary Comprehensive Restoration Plan, Draft, Volume II*. USACE, New York District,Electronic.

_____. 2014. *Hudson-Raritan Estuary Comprehensive Restoration Plan, Executive Summary*. USACE, New York District Electronic.

_____. 2016. *Hudson-Raritan Estuary Comprehensive Restoration Plan, Version 1.0, Volume I*. USACE, New York District, 2016. Electronic.

United States Army Corps of Engineers (USACE), Institute of Water Resources. *2007. Management Measures Digital Library, Ecosystem Restoration*. Version unknown. USACE, Institute of Water Resources, Revised May 15, 2007. Web. June 24, 2016 from <http://library.water-resources.us/docs/MMDL/ECO/index.asp>.

United States Department of Agriculture. 2015. *Asian Long Horned Beetle Eradication Program, Draft Programmatic Environmental Impact Statement–March 2015*. United States Department of Agriculture

United States Department of Housing and Urban Development. *2014. Community Development Block Grant Disaster Recovery Program*. Version unknown. United States Department of Housing and Urban DevelopmentWeb. September 13, 2016 from <https://www.hudexchange.info/programs/cdbg-dr/>.

United States Environmental Protection Agency (USEPA). *2016. Superfund*. Version unknown. USEPA, Last updated June 21, 2016. Web. August 26, 2016 from <https://www.epa.gov/superfund>.

United States Environmental Protection Agency (USEPA). 2004. Environmental Justice – Frequently Asked Questions.
www.epa.gov/compliance/resources/faqs/ej/index.html.

United States Fish and Wildlife Service (USFWS). 1997. *Significant Habitats and Habitat Complexes of the New York Bight Watershed*. Southern New England - New York Bight Coastal Ecosystem Program. Web. April 28, 2016 from <http://nctc.fws.gov/resources/knowledge-resources/pubs5/begin.htm>.

United States Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. United States Water Resources Council Electronic.

Valle-Levinson, A. and K. M.M. Lwiza. 1995 The Effects of Channels and Shoals on Exchange Between the Chesapeake Bay and the Adjacent Ocean. *Journal of Geophysical Research*, 100(C9):18551-18563.

Valverde, H. R., A. C. Trembanis and O. H. Pilkey. 1999 Summary of Beach Nourishment Episodes on the U.S. East Coast Barrier Islands. *Journal of Coastal Research* Autumn, 15(4):1100-1118.

Walters, C.J., and C.S. Holling. 1990 Large-Scale Management Experiments and Learning by Doing. Ecology, 71(6):2060-2068. Electronic.

Wilber, D. H., and D. G. Clarke. 2001. "Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries." *North American Journal of Fisheries Management* 21(4):855-875.

Williams, S. J. 2013 Sea-Level Rise Implications for Coastal Regions. Journal of Coastal Research Spring, Special Issue 63:184-196.

Williams, S. L., and E. D. Grosholz. 2008 The Invasive Species Challenge in Estuarine and Coastal Environments: Marrying Management and Science. Estuaries and Coasts, 31:3-20. Electronic.

Windward Environmental, 2011a. Avian Community Survey Data Report for the Lower Passaic River Study Area Summer and Fall 2010. Prepared for Cooperating Parties Group, Newark, New Jersey. Lower Passaic River Restoration Project. Lower Passaic River Study Area RI/FS. Windward Environmental LLC, Seattle, WA. April 5, 2011.

Wise, M. Z., W. Woods, and E. Bone. 1997. Evolving purposes: The case of the Hudson River waterfront. p. 193-233, In: Bone, K. (ed.). The New York Waterfront: Evolution and Building Culture of the Port and Harbor. Monacelli Press Inc., New York, NY.

Wolfe, D. A., E. R. Long, and G. B. Thursby. 1996 Sediment Toxicity in the Hudson-Raritan Estuary: Distribution and Correlations with Chemical Contamination. Estuaries, 19(4):901-912. Electronic.

Wong, K. C., and R. E. Wilson. 1979 An Assessment of the Effects of Bathymetric Changes Associated with Sand and Gravel Mining on Tidal Circulation in the Lower Bay of New York Harbor. Special Report No. 8. Stony Brook: State University of New York, Marine Sciences Research Center.

Woodward, R. T., and Y. S. Wui2001 The Economic Value of Wetland Services: A Meta-Analysis. Ecological Economics, 37(2):257-270. Electronic.

Xiao, H., W. Huang, E. Johnson, S. Lou, and W. Wan. 2014 Effects of Sea Level Rise on salinity Intrusion in St. Marks River Estuary, Florida, U.S.A. *Journal of Coastal Research*, Special Issue 68:89-96. Electronic.

Yasso, W. E., and E. M. Hartman. 1975 Beach Forms and Coastal Processes. New York Bight Atlas Monograph No. 11. Albany: New York Sea Grant Institute.

Yozzo, D. J., J. M. Rhoads, P. Wilber, W. H. Nuckols, III, L. A. Hollen, and Robert J. Will. 2001 Beneficial Uses of Dredged Material for Habitat Creation, Enhancement, and Restoration in NY/NJ Harbor. USACE, New York District.

Yozzo, D.J., J. E. Davis, and P.T. Cagney. 2003. Coastal Engineering for Environmental Enhancement. Chapter V-7: in: L. Vincent and Z. Demirbilek, (eds.), Coastal Engineering manual, EM-1110-2-1100, U.S. Army Corps of Engineers, Washington D.C.

Zelder, J. B., and S. Kercher.2005 Wetland Resources: Status, Trends, Ecosystem Services, and Restorability. Annual Review of Environment and Resources, 30:39-74.

Chapter 11: Preparers

Name	Education/Experience	Responsibility
U. S. Army Corps of Engineers		
Lisa Baron	B.S. Biology/Marine Biology M.S. Biology/ 28 years	HRE Project Manager- Preparer and Reviewer
Diana Kohtio	B.S. Environmental Science M.S. Marine Ecology/ 16 years	Project Biologist- Preparer and Reviewer
Peter Weppler	B.S. Biology/ 28 years	Chief, Environmental Analysis Branch – Preparer and Reviewer
Anna Jansson	B.A. Anthropology M.A. Applied Archaeology/ 8 years	Plan Formulation Specialist and Cultural Specialist – Preparer and Reviewer (Final)
Danielle Tommaso	B.S. Ecology/ 13 years	Plan Formulation Specialist- Preparer and Reviewer (Draft)
Carissa Scarpa	B.A. Anthropology M.A. Anthropology, RPA/ 18 years	Senior Archeologist- Preparer and Reviewer
Gail Woolley	B.S. Civil Engineering M.S. Administration / 31 years	Project Engineer- Preparer and Reviewer
Michael Morgan	M.A. Geography / 18 years	Team Leader, Engineering- Preparer and Reviewer
Cynthia Zhang	B.S. Civil Engineering M.S. Civil Engineering / 9 years	Cost Engineer, Preparer and Reviewer
S. Kyle McKay	B.S. Environmental Engineering M.S. Civil Engineering (Hydraulics) Ph.D. Ecology / 12 years	ERDC Ecosystem Restoration Specialist- Preparer and Reviewer (Final)
Carlos Gonzalez	B.S. Finance/ 12 years	Real Estate Specialist- Preparer and Reviewer
Jonathan Ruder	B.S. Resource Management M.A. Political Economy and Development / 9 years	Economics-Cost Effectiveness/Incremental Cost Analysis (Draft)
Steve Weinberg	B.E.E / 29 years	Chief, Civil Works Section, Engineering- Contracting Office Representative for A/E Task Order
Elena Manno	B.S. Mechanical Engineering/ 30 years	Contracting Office Representative for A/E Task Order (Draft)
Ellen Simon	J.D. LLM / 28 years	Office of Counsel- Reviewer (Legal Consistency- Draft)
Carolyn Kelly	B.A. and J.D./ 9 Years	Office of Counsel – Reviewer (Legal Consistency - Final)
Christopher Minck	B.S. Biology M.S. Biology/ 2 Years	Rotating Intern - Preparer and Reviewer (Final)
Katherine Pijanowski	B.S. Geology M.S. Marine Studies/ 3.5 Years	Planning Division– Preparer and Reviewer (Final)

Name	Education/Experience	Responsibility
AECOM (Draft Report)		
Christopher Benosky	B.E. Civil Engineering M.S. Civil Engineering / 28 Years	Regional Director - Overall Project Lead
Bhavin Gandhi	B.E. Civil Engineering M.S. Civil & Environmental Engineering / 18 Years	Project Manager/Engineering Lead - Preparer and Reviewer
John Rollino	B.A., History/Anthropology M.A. Environmental Studies (Marine Ecology) M.S. Geoscience/ 24 Years	Deputy Project Manager/Environmental Lead – Preparer and Reviewer
Vic Frankenthaler	B.S. Biology, M.S. Environmental Planning / 30 Years	Planning Technical Lead - Preparer
Colby Siebert	B.S. Civil Engineering / 9 Years	Project Engineer - Preparer
Ellen Fyock	B.S. Marketing M.S. Environmental Science / 27 Years	Environmental Scientist / GIS Lead - Preparer
Melissa Smith	B.S. Natural Resource Management / 15 Years	Project Ecologist - HRE Preparer
Albert Macaulay	B.A. Architecture MCRP, City and Regional Planning/ 6 Years	Environmental Planner - Preparer
Steven Glenn	BS Botany/ 5 Years	Biologist - Preparer
Kelly Sheehan	B.S. Biology / 13 Years	Senior Scientist - Technical Editor
Ricky Torres-Cooban	B.S. - Civil Engineering B.M. - Music M.S. - Civil and Environmental Engineering / 7 Years	Project Engineer - Preparer
Rei-Hua Wang	B.S. Environmental Science / 12 Years	Scientist - Preparer
Karen Appell	B.S. Agricultural and Biological Engineering / 20 Years	Ecological Engineer – Preparer
Paul Kovnat	B.S. Civil Engineering / 28 Years	Cost Engineer - Preparer
Pritpal Bamhrah	MCRP, City and Regional Planning/ 11 Years	Project Planner and GIS Specialist - Preparer
Louis Berger, Inc. (Draft Report)		
Bethany Bearmore	B.S Bioresource Engineering B.S Environmental Science M.E. Ocean Engineering / 23 Years	Manager, Coastal Environmental Services/ Project Manager- Preparer and Reviewer

Name	Education/Experience	Responsibility
Margaret McBrien	B.A., Geology M.S., Environmental Engineering / 31 Years	Technical Director, Environmental Services- Reviewer
Ed Samanns	B.S., Biology M.S., Geography/ 34 Years	Project Manager, Environmental Sciences- Preparer and Reviewer
Justin Baker	B.S., Environmental Science M.S., Biology/ 20 Years	Senior Biologist- Preparer
Tara Stewart	B.S., Marine Biology/ 21 Years	Senior Biologist- Preparer
Heather Shaw	B.S., Natural Resource Management Certification in Geomatics/ 21 Years	GIS Analyst - Preparer
Matthew Holthaus	BS, Civil and Environmental Engineering MS, Civil and Environmental Engineering, Water Resources Specialization/ 10 Years	Junior Engineer- Preparer
Tom Shinskey	M.S., Biology, B.S., Natural Science/ 29 Years	Senior Biologist - Preparer
Dana Flynn	B.S., Wildlife Conservation/ 14 Years	Biologist- Preparer
Greg Russo	B.S. Environmental Science & Policy M.P.S. Conservation Biology/ 10 Years	Junior Biologist- Preparer
Kaitlin Garvey	B.S., Biology, Minor in Mathematics M.S., Biology/ 8 Years	Junior Biologist- Preparer
Sachin Apte	BS, Civil Engineering MS, Civil Engineering/ 18 Years	Senior Engineer-Preparer
e4sciences (Draft Report)		
Josephine Durand	Ph.D, Geosciences/Hydrology M.Eng., Geophysical Engineering M.S., Geosciences B.A., Geosciences/ 6 Years	Project Manager- Preparer/ Reviewer
Kurt Schollmeyer	BE, Civil Engineering/ 34 Years	Civil Engineer, P.E. - QC
Bruce Ward	BS, Geology MS, Geology PhD, Geology/ 30 Years	Expert Geologist- Geotechnical Lead- Preparer
William Murphy, III	Ph.D., Geophysics M.S., Engineering B.A., Geology/Physics/ 37 Years	Managing Scientist - Preparer
James Trotta	B.A., Geology/ 9 Years	Geologist- Preparer
Alice Chapman	B.A., Chemistry, Geology/ 5 Years	Geochemist- Preparer