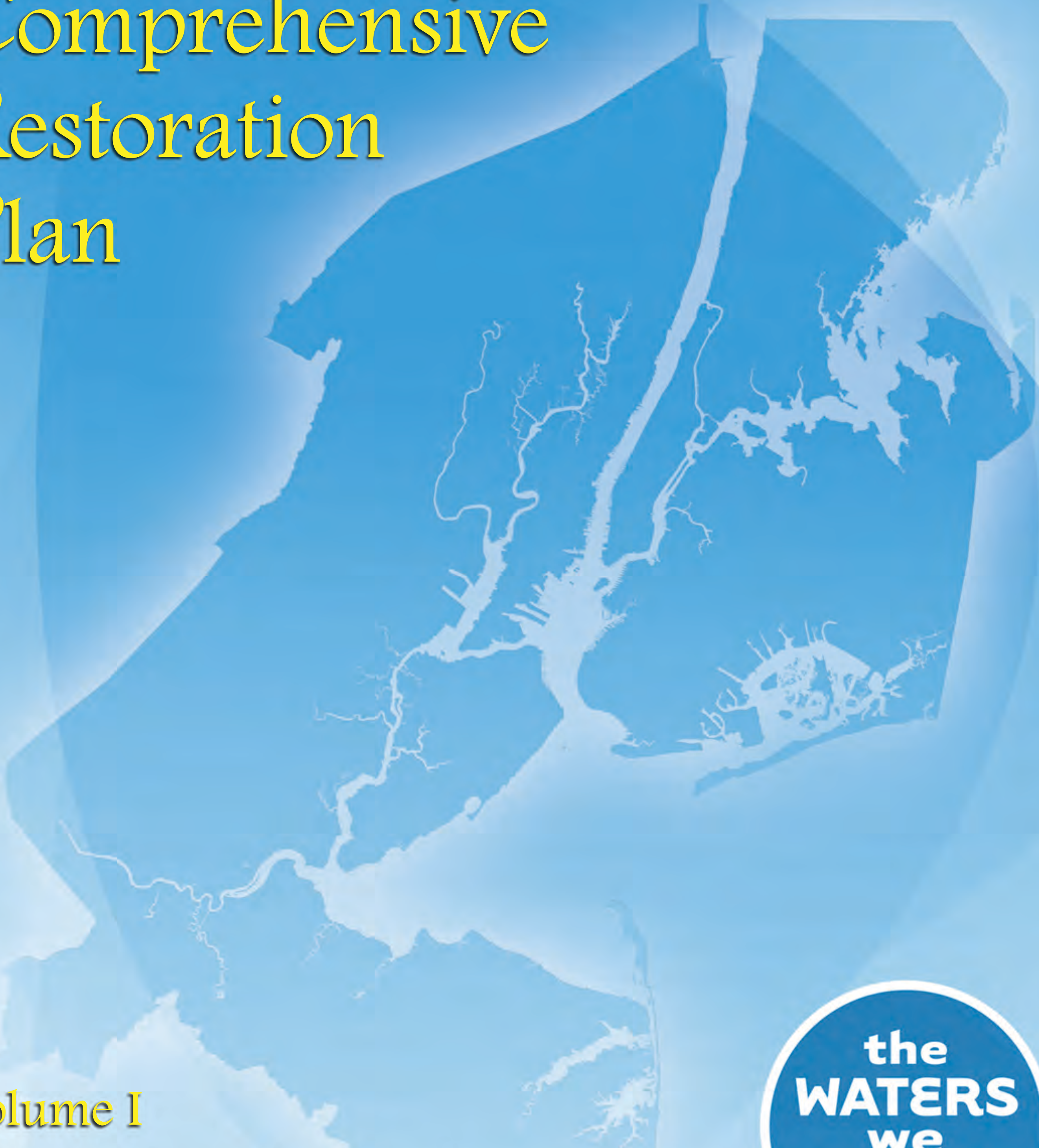
Hudson~Raritan Estuary Comprehensive Restoration Plan



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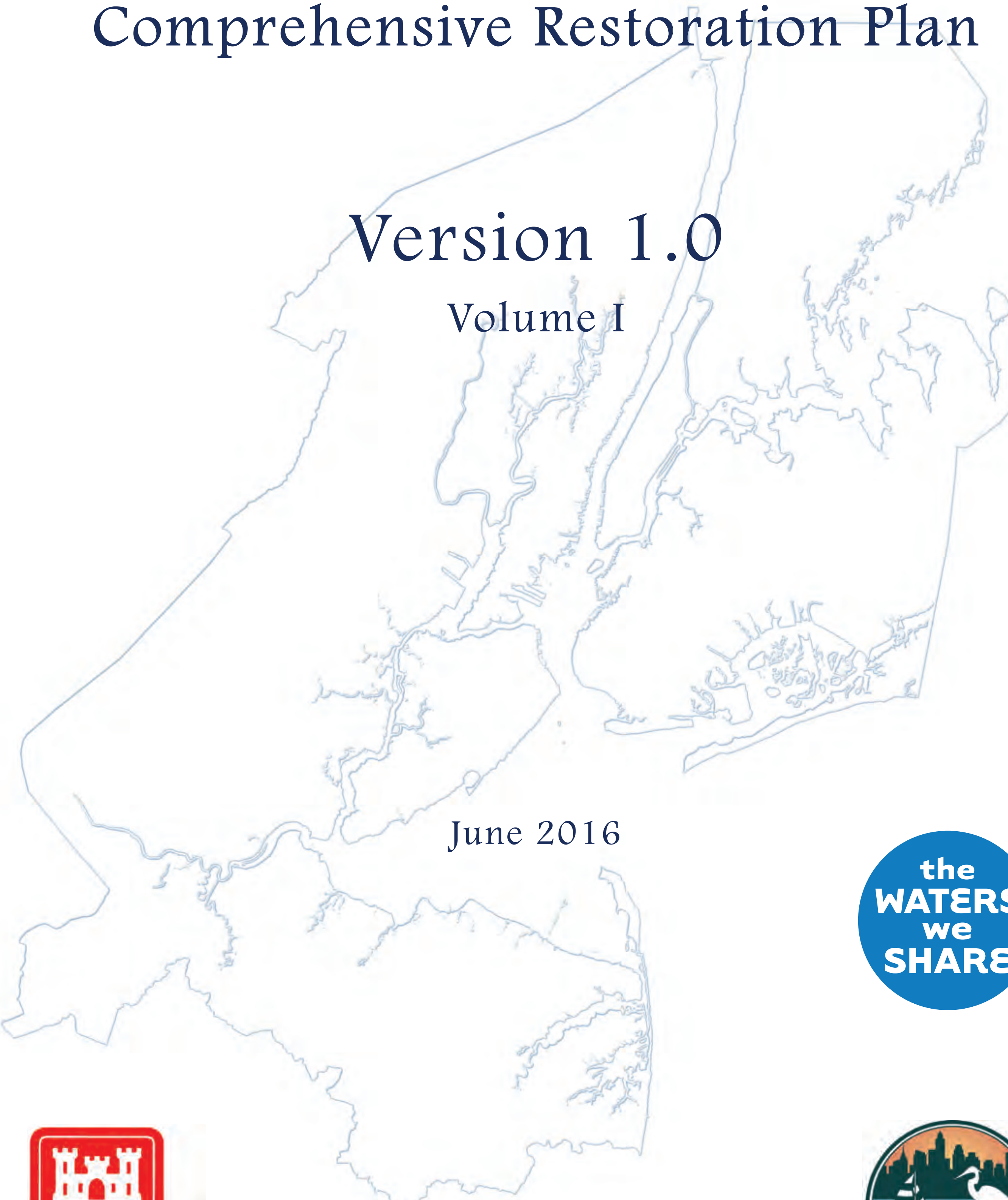
Comprehensive Restoration Plan



Version 1.0

Volume I

June 2016

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Contributing Organizations

Government

- U.S. Army Corps of Engineers, New York District
- The Port Authority of New York & New Jersey
- National Park Service
- National Oceanic and Atmospheric Administration
- U.S. Department of Agriculture, Natural Resources Conservation Service
- U.S. Environmental Protection Agency
- U.S. Fish & Wildlife Service
- Empire State Development Corporation
- New Jersey Department of Environmental Protection, Division of Fish and Wildlife
- New Jersey Department of Transportation
- New Jersey Meadowlands Commission
- New York State Department of Environmental Conservation
- New York State Department of State, Division of Coastal Resources
- New York City Mayor's Office
- New York City Department of Parks and Recreation
- New York City Department of Environmental Protection
- New York City Department of Health
- New York City Economic Development Corporation
- New York City Soil & Water Conservation District
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- Hudson County, New Jersey
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- City of Newark, New Jersey
- City of New Brunswick Planning Department
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- Liberty Science Center
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- State University of New York at Stony Brook
- State University of New York – College of Environmental Science and Forestry
- Stevens Institute of Technology
- St. John's University
- The New York Academy of Sciences - Harbor Project
- Virginia Institute of Marine Science

Non-Profit Organizations

- American Littoral Society
- Bayonne Oyster Gardeners
- Bergen County Audubon
- Brooklyn Botanical Gardens
- Citizens Advisory Committee
- Clean Air Campaign Inc., Open Rivers Project
- Clean Ocean Action
- Clifton Environmental Commission
- Concerned Citizens of Bensonhurst
- Crossroads of the American Revolution
- Downtown Boathouse
- East Coast Greenway

- Edison Wetlands
- Environmental Defense Fund
- Evergreen Environmental, LLC
- Friends of Liberty State Park
- Gateway Bike & Boathouse
- Going Coastal
- Gowanus Canal Conservancy
- Hackensack Riverkeeper
- Highland Park Environmental Commission
- Hoboken Cove Community
- Hudson River Fishermen's Association
- Hudson River Park
- Hutchinson River Restoration Project
- Interstate Environmental Commission
- Ironbound Community Corporation
- Jamaica Bay EcoWatchers
- Jamaica Bay Task Force
- Jamaica Bay Watershed Protection Plan Advisory Committee
- Lower Passaic Watershed Alliance
- National Fish and Wildlife Federation
- National Parks Conservation Association
- National Parks of New York Harbor Conservancy
- Natural 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
- 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
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- Princeton Hydro
- Public Service Electric & Gas
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- RBA Group
- Robins Reef Yacht Club
- The Elm Group
- Weston

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List of Acronyms

°C	degrees Celsius
ABU	Authorized But Unconstructed
ADA	Americans with Disabilities Act
ALS	American Littoral Society
BLM	Bureau of Land Management
CAC	Citizens' Advisory Committee
CAP	Continuing Authorities Program
CARP	Contamination Assessment and Reduction Program
CCMP	Comprehensive Conservation Management Plan
CCPR	Committee on Climate Preparedness and Resilience
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CG	Construction General
CPG	Cooperating Parties Group
CRP	Comprehensive Restoration Plan
CSO	Combined Sewer Overflow
CSRM	Coastal Storm Risk Management
CUES	Rutgers Center for Urban Environmental Sustainability
CUNY	City University of New York
CWA	Clean Water Act
CWP	Comprehensive Waterfront Plan
CY	Cubic yards
CYD	Cubic yards of debris
CZMA	Coastal Zone Management Act
DDT	Dichloro-Diphenyl-Trichloroethane
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
EPF	Environmental Protection Fund
ERM	Effects Range Medium
ERL	Effects Range Low
FCCE	Flood Control and Coastal Emergencies
FDA	U.S. Food and Drug Administration
GI	General Investigations
GIS	Geographic Information System
HARS	Historic Area Remediation Site
HEP	New York-New Jersey Harbor & Estuary Program
HHMT	Howland Hook Marine Terminal
HRE	Hudson-Raritan Estuary
HRERP	Hudson-Raritan Estuary Resources Program
HRF	Hudson River Foundation
HTRW	Hazardous, Toxic, and Radioactive Waste
HUD	U.S. Department of Housing and Urban Development
HWG	Habitat Work Group

IPCC	Intergovernmental Panel on Climate Change
JEM	Jamaica Bay Eutrophication Model
KCS	Known Contaminated Sites
LGNJ	Local Government in New Jersey
LTCP	Long Term Control Plan
MARSHES	Mitigation and Restoration Strategies for Habitat and Ecological Sustainability
MAST	Harbor School's Marine Science and Technology
MCY	Million cubic yards
MERI	Meadowlands Environmental Research Institute
NACCS	National Atlantic Coast Comprehensive Study
NEP	National Estuary Program
NEPA	National Environmental Policy Act
NEPORT	National Estuary Program Online Reporting Tool
NERR	National Estuarine Research Reserve
NFWF	National Fish and Wildlife Foundation
NGO	Non-government organization
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJMC	New Jersey Meadowlands Commission
NJPDES	New Jersey Pollutant Discharge Elimination System
NMFS	National Marine Fisheries Service
NNBF	Natural/Nature Based Feature
NOAA	National Oceanic and Atmospheric Administration
NPCC	New York City Panel on Climate Change
NPS	National Park Service
NRCA	National Resources Conservation Service
NRDA	Natural Resource Damage Assessment
NRG	Natural Resources Group of the New York City Department of Parks and Recreation
NYC	New York City
NYC CWP	New York City Comprehensive Waterfront Plan
NYCDEP	New York City Department of Environmental Protection
NYCDPR	New York City Department of Parks and Recreation
NYCEDC	New York City Economic Development Corporation
NYC OASIS	New York City Open Accessible Space Information Systems
NWI	National Wetlands Inventory
NWS	Naval Weapons Station
NYSDOT	New York State Department of Transportation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State

OMRR&R	Operation, maintenance, repair, replacement and rehabilitation
OPRHP	Office of Parks, Recreation & Historic Preservation
ORIS	Oyster Restoration Index Score
ORRP	Oyster Restoration Research Partnership
PAH	Polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyl
PCDFs	Polychlorinated dibenzofurans
PeCDF	Pentachlorodibenzofuran
PFAS	perfluoroalkyl and polyfluoroalkyl substance
PRP	Potential Responsible Parties
PVSC	Passaic Valley Sewerage Commission
RI/FS	remedial investigation and feasibility study
RSM	Regional Sediment Management
RWG	Restoration Work Group
SAGE	Systems Approach to Geomorphic Engineering
SCR	Structures of Coastal Resilience
SIRR	Special Initiative for Rebuilding and Resiliency
SNWA	Special Natural Waterfront Area
SRIRC	Sandy Regional Infrastructure Resilience Coordination
STAC	Science and Technical Advisory Committee
SWEM	System-Wide Eutrophication Model
SWG	State Wildlife Grants
TEC	Target Ecosystem Characteristic
TCDD	Tetrachlorodibenzo-p-dioxin
TSS	Total suspended solids
UAO	Unilateral Administrative Order
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U. S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWFP	Urban Waters Federal Partnership
WEDG	Waterfront Edge Design Guidelines
WRDA	Water Resources Development Act
WRRDA	Water Resources Reform and Development Act
WRP	Waterfront Revitalization Plan

Executive Summary

The Comprehensive Restoration Plan (CRP) for the Hudson-Raritan Estuary (HRE) is a master plan to guide ecosystem restoration efforts throughout the estuary. It is intended to be used by all stakeholders (environmental and community groups, government agencies, and others), thereby allowing the whole region to work toward a series of shared restoration goals providing benefits to the estuary.

This effort was initiated in 1988 when Congress recognized the New York-New Jersey Harbor as an estuary of national importance and accepted it into the National Estuary Program (NEP). Following this designation, in March 1996, the NY-NJ Harbor & Estuary Program (HEP) completed a Comprehensive Conservation and Management Plan (CCMP). CCMP recommendations included the need to develop a comprehensive strategy for habitat protection and restoration. The U.S. Army Corps of Engineers (USACE), in partnership with their non-Federal sponsor, the Port Authority of New York and New Jersey (PANYNJ), joined the process of developing this strategy with the initiation of the HRE Ecosystem Restoration Feasibility Study.

The Committee on Transportation and Infrastructure of the U.S. House of Representatives authorized the HRE Ecosystem Restoration Feasibility Study in an April 15, 1999 resolution:

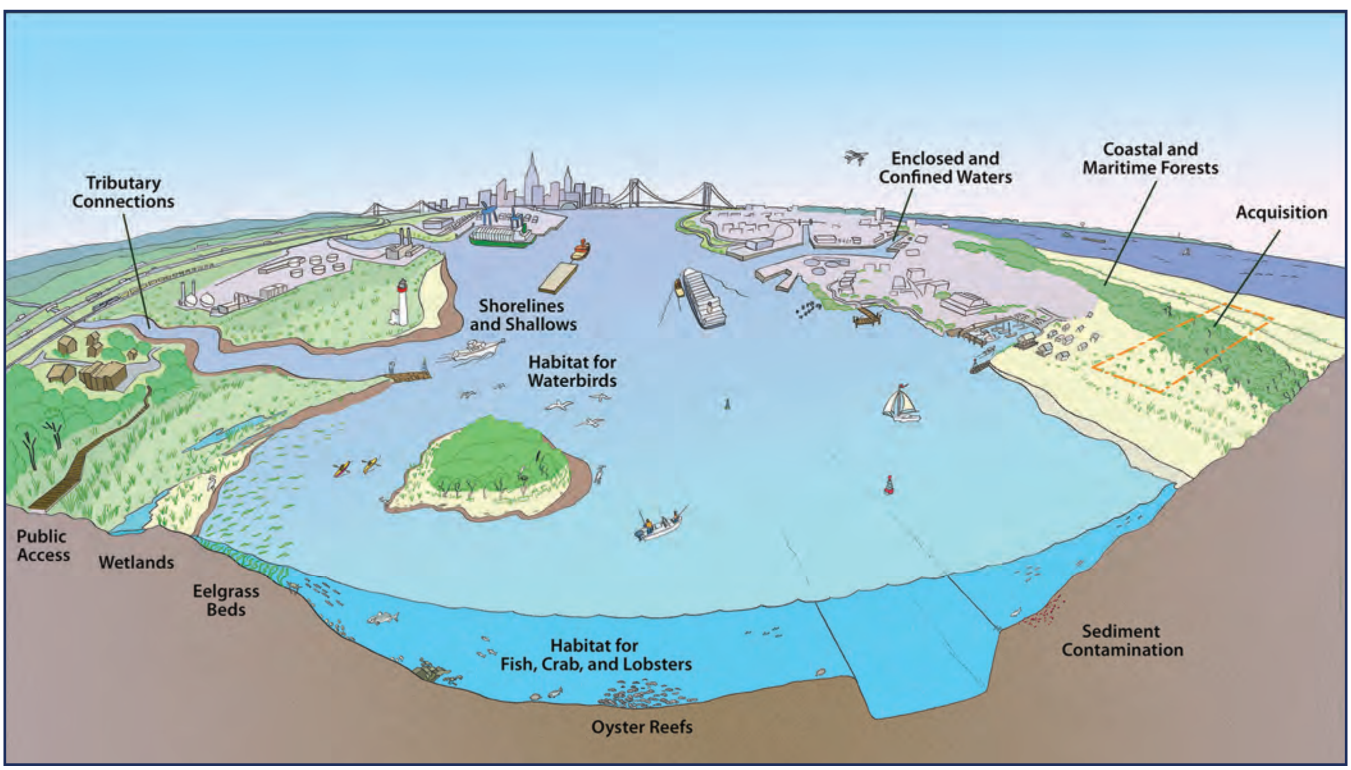
> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the New York and New Jersey Channels, published as House Document 133, 74th Congress, 1st Session; 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.*

In 2005, the Hudson River Foundation (HRF) and The Center for the Environment at Cornell University began leading a series of workshops focused on developing a strategy for restoration planning for this highly urbanized estuary. From the outset, scientists agreed that the restoration program should emphasize creating and restoring a mosaic of habitats within the human-dominated landscape.

To achieve this goal, a team of estuarine scientists initially identified 11 measurable objectives for restoration, termed Target Ecosystem Characteristics (TECs), each defining specific goals for an important ecosystem property or feature of ecological and/or societal value. In 2012, a twelfth TEC was added in response to public comments emphasizing the need to highlight the importance of protecting and preserving existing open and undeveloped lands. In addition to updating certain quantitative objectives, other TECs were revised in 2012 in order to place greater emphasis on valuable habitat, including coastal forest habitat, freshwater habitat, shorelines and shallows, and foraging habitat for waterbirds. The value of additional shellfish species, other than oysters, was also emphasized.

The TECs reflect the broad interest of HRE stakeholders and address habitat and degradation issues. Each TEC has short-term and long-term objectives for the eight planning regions identified within the estuary. For example, the short-term objective for the ***Wetlands*** TEC is to create or restore 1,000 acres (4.05 kilometers^2) of wetlands by 2020, while the long-term objective is to create or restore a total of 5,000 acres (20.24 kilometers^2) by 2050. Achieving the objectives in the TECs will increase the sustainability and resiliency of the HRE. Some 2020 goals have already been met or exceeded, including targets for public access, habitat for waterbirds, coastal and maritime forests, and improving tributary connections critical to migratory fish. Progress toward other goals, such as oyster reefs and eelgrass beds, has proved more challenging.

The HEP Restoration and Public Access Work Groups' acquisition and restoration site nomination process and associated assessments have helped to catalog numerous restoration opportunities. Additional sites have been identified during outreach efforts conducted as a part of USACE's Needs and Opportunities evaluation. Collectively, a total of 296 sites with opportunities for restoration and/or acquisition have been nominated, accepted in the CRP, and cataloged in an online mapping tool featured on www.watersweshare.org, as well as in the New York City Open Accessible Space Information System (NYC OASIS)[1]. In addition, 330 completed restoration projects and over 41,000 acres (165.9 kilometers^2) of public access areas have been cataloged and mapped by HEP (Alderson and Bowers 2012, Boicourt et al. 2015). While many of these sites provide opportunities to conduct restoration activities, additional areas are needed to achieve the ambitious objectives of the program.



1 At the time of publication, there were 296 sites approved in 2016 by the Restoration Work Group. The following sites are not included in this document: Conference House Park freshwater wetland, Crescent Beach, Depot Place, Hammond Cove, Idlewild Cove, City Island, Ambrosini fields, and Snug Harbor.

A series of Geographic Information Systems (GIS) analyses were conducted to identify additional restoration opportunities. These estuary-wide analyses aided the planning efforts and helped estimate whether the TEC objectives are achievable. For each target, existing datasets were used to identify habitat suitability (e.g., appropriate depth, water quality parameters) as well as potential constraints to ecological restoration. Preliminary findings indicate that sufficient habitat is available for achieving the TEC objectives throughout the eight planning regions.

There are many challenges to implementing the CRP. Restoration projects and their associated monitoring programs are costly. Therefore, achieving the objectives will require a substantial dedication of funds and creative funding strategies. Innovative local financing techniques, combined with state and Federal funding opportunities, will generate the support necessary to make these projects a reality. Mitigation and/or Natural Resources Damage Assessment (NRDA) funding should also be considered to support restoration projects. At this stage of planning, accurately estimating project costs for all of the restoration opportunities would not be possible. The costs to conduct restoration vary greatly by project and by type of restoration (i.e., TEC). For example, a rough estimate of the costs to achieve the ***Wetlands*** objectives range between $218 and $713 million for the short-term objective and $1.0 to $3.5 billion for the long-term objective, based on average costs per acre for this type of project. Considering that these are only the costs associated with one of the 12 TECs, funding to implement all the targets will be difficult to secure. The success of the CRP in improving the estuary's ecosystem is dependent upon successful partnering among stakeholders.

Multi-jurisdictional regulatory boundaries present another challenge to restoration planning within the HRE. Resource management agencies are tasked with balancing multiple, often conflicting goals of resource conservation while providing for compatible uses of the environment. Examples of policy issues that should be addressed include habitat exchange issues; placement of fill in water, specifically as it relates to beneficial use of dredged material for habitat restoration; attractive nuisance issues; and issues affecting management of contaminated sediments.

The CRP is a long-term strategy for restoration in the HRE study area, and thus should be periodically reviewed and updated to acknowledge successes, outline new restoration and acquisition targets, specify implementation schedules, and reaffirm commitments to the estuary and its stakeholders. This review, as well as documenting the progress of CRP implementation, will be carried out by the HEP Restoration Work Group (RWG).

This CRP for the HRE has been prepared by the USACE and the PANYNJ as a part of the HRE Ecosystem Restoration Feasibility Study. The full report can be downloaded from www.watersweshare.org or http://www.nan.usace.army.mil/Missions/Environmental/EcosystemRestoration/HREEcosystemRestoration.aspx.

1.0 Introduction

The HRE, located within one of the most urbanized regions in the United States, has undergone centuries of industrial and residential development. Coincident with extensive navigation and infrastructure improvements, urbanization and industrialization within the HRE have resulted in extensive degradation of aquatic and terrestrial ecosystems, including wetlands, stream corridors, island rookeries, and shellfish beds. In March 2009, the Draft CRP, a master plan to guide ecosystem restoration efforts within the HRE, was published by USACE in partnership with the non-Federal sponsor, PANYNJ, and HEP. The Draft CRP was the culmination of years of collaborative planning among the region's stakeholders and estuarine scientists. Prior to release of the Draft CRP, there was no regional consensus on ecosystem restoration goals or objectives among Federal, state, municipal, and non-governmental habitat restoration programs within the HRE. As a result, individual restoration efforts were measured and assessed on a project-specific basis, without considering the benefits achieved in the context of the entire HRE.

The collaborative planning effort for restoring the HRE was initiated in 1988 when, at the request of the Governors of New York and New Jersey, the U.S. Environmental Protection Agency (USEPA) designated the New York-New Jersey Harbor ("the Harbor") as an estuary of national importance and accepted it into the National Estuary Program. Following this designation, in March 1996, HEP completed a CCMP, which included a recommendation for the development of a comprehensive strategy for habitat protection and restoration. In April 1999, U.S. Congress authorized the USACE to conduct the HRE Ecosystem Restoration Feasibility Study. The USACE and the PANYNJ then initiated the HRE Feasibility Study whose goal was to develop a long-term strategy to restore and enhance degraded environments within the HRE in partnership with regional stakeholders.

The CRP is the product of a collaborative effort among many agencies and non-governmental organizations (NGOs) to address the need for a comprehensive master plan for ecological restoration within the HRE study area, broadly defined as the area within 25 miles (40 kilometers) of the Statue of Liberty. It provides a framework for estuary-wide ecological restoration and land conservation by presenting restoration targets identified and developed in cooperation with the region's stakeholders, outlines a comprehensive strategy for restoration, and presents the opportunity to efficiently and effectively coordinate separate restoration, acquisition, and habitat improvement projects into a well defined program. Working with partner programs, the CRP also provides the opportunity to track the progress and challenges of individual projects, thereby increasing the likelihood for future successes. Finally, the CRP serves as a central source document that can be drawn upon to foster and mobilize broad public support for diverse HRE restoration efforts.

The CRP consists of two volumes. Volume I provides the broad framework of the plan by introducing the program goal and objectives, identifying opportunities to meet those objectives, and laying out a strategy for success. Volume II provides technical guidance to interested stakeholders for planning, evaluating, and conducting individual restoration projects in support of the Estuary's TECs. Volume I of the CRP consists of the following:

Chapter 1	Introduction	Appendix A	Target Ecosystem Characteristics Development
Chapter 2	Existing Conditions	Appendix B	Geographic Information Systems Evaluation Methodology
Chapter 3	Target Ecosystem Characteristics	Appendix C	Sediment Contamination Target Ecosystem Characteristic
Chapter 4	Restoration Opportunities	Appendix D	Atlas of Restoration Opportunities
Chapter 5	Comprehensive Restoration Plan		

1.1 Study Background

The CRP is the culmination of decades of planning and outreach efforts among the region's stakeholders and scientific community. Comprehensive restoration planning in the HRE was initiated in 1988 following its recognition by the U.S. Congress as an estuary of national importance and induction into NEP. HEP, which brought together Federal, state, local, and NGOs interested in improving ecological conditions within the HRE, was formed in conjunction with this designation. HEP completed a CCMP in March 1996 that documented the condition of environmental resources and proposed a series of critical actions to address the environmental threats facing these resources. Included among its recommendations was the development of a comprehensive regional plan to restore and protect habitat within the HRE (HEP 1996).

The CCMP's recommendation to restore the HRE received support from the region's stakeholders, including state and municipal regulators and policy makers, Federal agencies, non-governmental organizations, and the public. In response to this broad support, the U.S. Congress authorized the USACE to investigate and identify opportunities to implement the

What is the Harbor Estuary Program?

Incorporation of the Hudson-Raritan Estuary (HRE) (the study area) into the National Estuary Program (NEP) required the creation of an organizational structure, the New York-New Jersey Harbor & Estuary Program (HEP), to provide program direction and help carry out key actions. HEP was established in 1988. HEP's primary program goals were to develop and implement a conservation plan that would curb the harmful effects of pollution and garner public awareness, appreciation, and support for the HRE. HEP's major accomplishments include preparing the initial conservation strategy for the estuary (CCMP); developing a community based process for nominating sites for acquisition and restoration; providing site information via an online interactive map; developing a contaminant assessment program that will be used to reduce contaminants (Contaminant Assessment and Reduction Program [CARP]); developing the first ever harbor-wide water quality survey; refining and using modeling tools to assess loading reductions for nutrients and pathogens; mapping public access sites and needs; and supporting numerous outreach and stewardship programs. Active participants in the HEP program include:

Federal Government

- National Oceanic and Atmospheric Administration (NOAA)
- National Park Service (NPS)
- U.S. Army Corps of Engineers (USACE)
- U.S. Department of the Interior (DOI)
- U.S. Environmental Protection Agency (USEPA)

State and Local Governments

- Interstate Environmental Commission
- New Jersey Department of Environmental Protection (NJDEP)
- New Jersey Sports and Exposition Authority
- New York City Department of Environmental Protection (NYCDEP)
- New York City Department of Parks and Recreation (NYCDPR)
- New York City Soil and Water Conservation District (NYCSWCD)
- New York State Department of Environmental Conservation (NYSDEC)
- New York State Department of State
- The Port Authority of New York/New Jersey (PANYNJ)
- State of New Jersey
- State of New York

Non-Government Organizations

- Citizens Advisory Committee
- Hudson River Foundation (HRF)
- National Parks Conservation Association
- Science and Technology Advisory Committee
- NY/NJ Baykeeper
- Waterfront Alliance
- The Nature Conservancy
- New York City Audubon
- New Jersey Audubon
- The Trust for Public Land
- New York Restoration Project
- New Yorkers for Parks
- Hackensack Riverkeeper
- City Parks Foundation
- Rutgers University
- New York Harbor School
- Geraldine R. Dodge Foundation
- and so many more...

1987
- National Estuary Program (NEP) created

1988
- The NY-NJ Harbor & Estuary Program (HEP) designated to protect the Hudson-Raritan Estuary (HRE)

1996
- Comprehensive Conservation and Management Plan (CCMP) approved

1999
- USACE 905(b) Reconnaissance Study finalized

2001
- The USACE and the PANYNJ sign agreement to fund the HRE Ecosystem Restoration Feasibility Study
- The HRE Ecosystem Restoration Feasibility Study initiated
- The PANYNJ initiates the Hudson-Raritan Estuary Resources Program (HRERP)

2003
- Needs and Opportunities Report prepared

2004
- Health of the Harbor Report published

2005 - 2007
- Workshops conducted to define Target Ecosystem Characteristics (TECs) for the HRE

March 2009
- Draft CRP released

December 2009
- HEP Policy Committee adopts the CRP as the master plan for future restoration

February 2010
- HEP Habitat Work Group (HWG) evolved into the Restoration Work Group (RWG)

2009 - 2011
- Public Outreach

May 2012
- TEC & CRP Update Workshop

October 2012
- Hurricane Sandy

January 2013
- Disaster Relief Appropriations Act of 2013 (PL 113-2)
- NYS 2100 Commission Report released
- North Atlantic Coast Comprehensive Study (NACCS) initiated

April 2013
- NY Rising Community Reconstruction (NYRCR)Program announced
- NJ Community Development Block Grant (CDBG) Disaster Recovery announced

June 2013
- PlaNYC Special Initiative for Rebuilding and Resiliency (SIRR)/ A Stronger, More Resilient New York Report released
- U.S. Department of Housing and Urban Development (HUD) Rebuild by Design Initiative announced

June - July 2013
- NACCS Natural/Nature-Based Features (NNBF) workshops

2013
- CRP addresses coastal restoration and resiliency

January 2015
- Release of USACE North Atlantic Coast Comprehensive Study Report and Natural & Nature-Based Features for Coastal Resiliency

Figure 1-1.
Timeline of important events in the Hudson-Raritan Estuary study area.

CCMP's habitat goals within the estuary. A 2000 USACE Reconnaissance Study determined Federal interest in restoration (USACE 2000) and, in 2001, the HRE Ecosystem Restoration Feasibility Study was initiated by the USACE in partnership with the non-Federal sponsor, the PANYNJ (Figure 1-1).

Since 1994, HEP has worked with hundreds of organizations, elected officials, and community proponents to nominate priority acquisition and restoration sites within the HRE that are within priority watersheds. This program helps direct potential project sponsors to ecologically important lands that are potentially vulnerable to development. In 2001, the PANYNJ initiated the Hudson-Raritan Estuary Resources Program (HRERP), which established a $60 million fund ($30 million for New York and $30 million for New Jersey) to acquire and preserve ecologically valuable land in New York and New Jersey. In addition, HRERP protects and preserves land parcels that provide important access to the waterfront and are vulnerable to development. In 2014, the PANYNJ approved an additional $30 million authorization each for the states of New York and New Jersey to preserve open space throughout the HRE. The HEP Restoration Work Group (RWG and prior to formation of the RWG, the Habitat Work Group [HWG]) identifies the highest priority sites for acquisition. HRERP was built on the restoration and land conservation programs identified by HEP's HWG. Additional HEP recommended projects that corresponded to specific priority watersheds were funded through the New York State Clean Water/Clean Air Environmental Bond

Act of 1997 and Natural Resources Damages funds, exceeding $100 million.

A Needs and Opportunities Report that added to the list of existing candidate sites developed through HEP work groups was also prepared in the early planning phase of the HRE Ecosystem Restoration Feasibility Study. In addition to the value placed on habitat acquisition and preservation, both the CCMP and the Needs and Opportunities Report emphasized the need for a coordinated and comprehensive plan for habitat restoration and preservation. This was the genesis for what became the CRP. Starting in 2005, the HRF and the Center for the Environment at Cornell University began working with the region's stakeholders and scientists to develop a unifying framework for the CRP. Ultimately, this work established a set of scientifically credible estuary-wide restoration targets (e.g., TECs) to guide restoration efforts for a wide range of estuarine habitats. The TECs form the scientific foundation and analytical structure of the CRP. They provide the template for the HRE's ecological restoration program and are applied to identify and design restoration projects and measure programmatic success.

USACE and the PANYNJ worked with many partners to develop a CRP that would achieve the objectives the region's stakeholders first expressed in the CCMP. Throughout the planning process, the region's stakeholders emphasized the need for collaborative planning and a regional partnership in which stakeholders look beyond political boundaries to focus on estuary-wide issues through science-based planning. The stakeholders emphasized the need for a plan that included the acquisition and preservation of ecologically valuable lands, as well as active restoration and enhancement of habitat.

Development of the Target Ecosystem Characteristics

As part of the Hudson Raritan Estuary (HRE) Ecosystem Feasibility Study, the Hudson River Foundation (HRF) in cooperation with the Center for the Environment at Cornell University guided the development of the restoration targets for the HRE by defining the program goal, identifying candidate restoration objectives, and defining the initial 11 Target Ecosystem Characteristics (TECs).

In May 2012, the U.S. Army Corps of Engineers (USACE) convened a workshop for the participants at the original TEC workshop to provide an update on the HRE Ecosystem Restoration Program and to obtain consensus about proposed modifications to the Draft CRP. The USACE presented public and stakeholder comments regarding the Draft CRP and led discussion of proposed strategies for responding to the major comments.

Workshop participants agreed to the following major modifications to the TECs:

1. Add a twelfth TEC, "***Acquisition***." ***Acquisition*** is added to highlight the importance of protection and preservation of existing open and undeveloped lands.
2. ***Coastal Wetlands*** are changed to ***Wetlands*** in order to be more inclusive of valuable freshwater habitats.
3. Increased emphasis is placed on the importance of Riparian Forest and Stream Restoration in the ***Tributary Connections*** TEC.
4. The ***Habitat for Fish, Crabs, and Lobsters, Wetlands,*** and ***Shorelines and Shallows*** TECs now place additional emphasis on the value of shellfish species other than ***Oysters***.
5. Living shorelines and shellfish restoration are now emphasized in the ***Shorelines and Shallows*** TEC.
6. More emphasis is placed on coastal forest in the ***Coastal and Maritime Forest*** TEC.
7. The ***Islands for Waterbirds*** TEC has been changed to ***Habitat for Waterbirds*** in recognition of the value of nearby foraging habitat for breeding waterbird populations.
8. The ***Habitat for Waterbirds*** TEC has been modified placing greater emphasis on the importance of ***Shorelines and Shallows*** and ***Coastal and Maritime Forests*** associated with foraging habitat for shorebirds and seabirds.

The development of the TECs is documented in two reports:

Setting Targets for Restoration of the Hudson-Raritan Estuary: Report of an Interdisciplinary Workshop (2006)

Target Ecosystem Characteristics for the Hudson-Raritan Estuary: Technical Guidance for Developing a Comprehensive Ecosystem Restoration Plan (2007)

To learn more, please visit: www.hudsonriver.org.

The CRP, supported by the actions and public outreach initiatives of HEP, establishes a framework for all stakeholders in the HRE study area to coordinate, discuss, and plan restoration efforts. Stakeholders have reached a broad consensus on harbor-wide restoration goals and targets as well as a shared vision of a restored future state. In December 2009, HEP adopted the Draft CRP as a path forward for restoration within the HRE. In 2010, the RWG was created to facilitate programmatic restoration efforts in keeping with CRP guidance, to promote and track programmatic success, and to identify critical sites and the other tasks previously carried out by HEP's HWG.

Subcommittees charged with restoration planning for individual TECs have also formed to share information and develop consensus on the future needs for successful projects. To date, Oyster, Tributary Connections, and the Harbor Herons subcommittees have been established; additional subcommittees may be created to discuss and advocate projects relating to other TECs. The TEC/CRP framework recommends that all restoration and acquisition programs, regardless of the authority under which they are conducted, work toward shared estuary-wide goals.

In 2011, HEP updated its geographic footprint to include the Hudson River watershed up to the Federal Troy Lock and Dam, New York, as well as the watersheds of the Raritan, Passaic, and Hackensack Rivers in New Jersey. The HRE study area focuses within the estuarine portion of the HEP boundary, maintaining the 25-mile (40 kilometer) radius around the Statue of Liberty (Figure 1-2). Due to the recent expansion of HEP's geographic scope, and to continue managing with the watershed approach, it is acknowledged that planning efforts of the Upper Hudson River Basin and upstream New Jersey tributaries will require greater coordination. For example, the New York State Department of Environmental Conservation's (NYSDEC) Hudson River Estuary Program efforts focus on the tidal portion of the Hudson River up to the Federal Troy Lock and Dam, New York. The program is guided by an Action Agenda (NYSDEC 2015) and Hudson River Estuary Habitat Restoration Plan (Miller 2013), which seeks to protect and improve

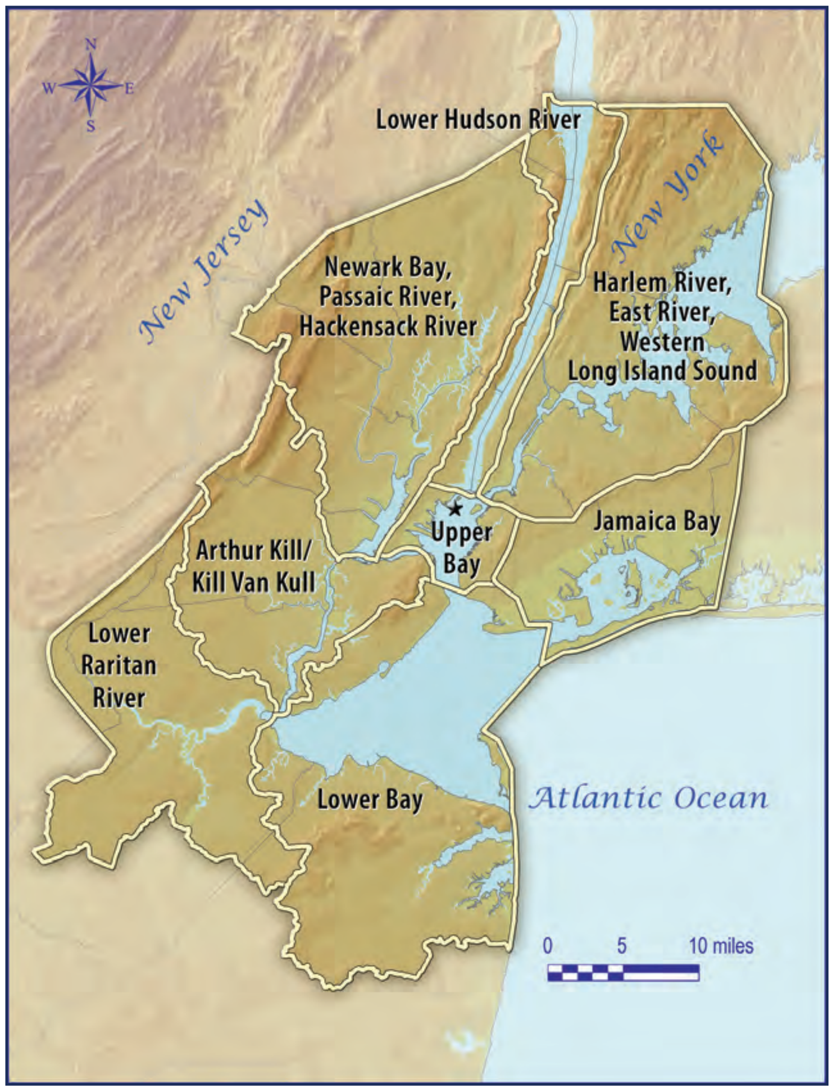


Figure 1-2. The eight planning regions of the Hudson-Raritan Estuary study area. The Statue of Liberty is represented by the star.

the natural and scenic Hudson River watershed. In 2016, the Hudson River Habitat Restoration Feasibility Study, which had been suspended since 2001, was resumed by the USACE in partnership with New York State and the "Partners Restoring the Hudson." A comprehensive restoration plan and feasibility study will be prepared from the Tappan Zee Bridge to Federal Troy Lock and Dam in order to advance the strategy for large-scale restoration of river habitats within the approximate 140-mile (225 kilometers) study area.

In October 2012, in the midst of planning for ecosystem restoration activities in the HRE, Hurricane Sandy moved up the coast of New Jersey and New York and drove a catastrophic storm surge onto the coastlines. Storm surge, wave attack, flooding, and erosion dramatically altered coastal habitats within the HRE and damaged many wastewater treatment plants, resulting in the discharge of approximately 10.3 billion gallons of untreated and partially treated sewage into New York and New Jersey waters. The devastating effects of Hurricane Sandy emphasized the need for coastal resilience and climate adaptation in the HRE study area. In the aftermath of the storm, Federal, state, and municipal assessment and planning documents emphasized the need for Natural/Nature-Based Features (NNBFs) that would protect the coastline of the HRE from future storms. Many recommendations of these plans directly coincide with the goals and objectives of the CRP, and a portion of the funds made available to rebuild after Hurricane Sandy were designated to restore and create resilient coastal habitats.

1.2 Restoration Goals and Targets

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 the distribution and resiliency of open-water, near-shore, and coastal habitats. Ecological restoration, as defined by the Society of Ecological Restoration, is "the process of assisting with the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SERISPWG 2004).

A plan to assist with the recovery of such an altered ecosystem would require developing new and innovative planning mechanisms capable of establishing realistic restoration goals based on appropriate scientific information and incorporating the desires of a diverse stakeholder group. To address these needs in the HRE Ecosystem Restoration Feasibility Study, HRF, in partnership with the Center for the Environment at Cornell University, sponsored a technical workshop and developed a restoration planning framework centered on the development of TECs, which were intended to provide the scientific foundation for a comprehensive restoration of the HRE (Bain et al. 2007). The workshop of regional and national scientific experts and government agency representatives was followed by several years of additional work by small teams of scientists and representatives from Federal, state, and local agencies, and non-government organizations. From the outset, the group acknowledged that the estuary would remain a populous area with a landscape continuously re-shaped by humans. Therefore, a "renaturing" approach to habitat restoration would be the most realistic for the HRE, designing an ecosystem where nature and people co-exist, a system wherein environmental and societal needs are equivalent ecosystem elements (Bain et al. 2007).

The group agreed that the restoration program should focus on creating and restoring a variety of habitats with high ecological value and function interspersed within the human-dominated landscape, as well as support public access to the waterfront to afford opportunities for communities to appreciate the estuary. The overall CRP Program Goal is:

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

To define a successful restoration program within the HRE, it was essential to identify specific restoration targets that are collectively critical to the estuary's ecological viability. Twelve (12) TECs, representing estuarine-dependent habitat types, habitat complexes, environmental support structures, contamination issues, and societal values, guide the HRE Ecosystem Restoration Feasibility Study (Table 1-1).

The TECs reflect solutions to the water resource problems within the estuary, incorporate the habitat and degradation issues repeatedly emphasized in the past two decades of HEP outreach efforts, and reflect interests of HRE stakeholders. Increasing the availability of estuarine habitats and enhancing the diversity of species residing therein should improve the sustainability and resiliency of the HRE's ecological resources. Detailed information about the development of the TECs is in Appendix A.

Establishing measurable objectives was the next critical step in defining the restoration program. These objectives will allow the HRE stakeholders to prioritize actions and track progress in achieving the program goal over time. The TEC working groups established measureable short-term and long-term objectives for each TEC in the 2009 Draft CRP.

Many large-scale restoration projects have been constructed since the 2009 release of the Draft CRP and many short-term restoration actions were conducted to assess the feasibility of restoring various habitat types and to measure performance. Evaluation of successes and challenges encountered while attempting to meet these short-term objectives provided guidance for adaptively refining and strengthening the short-term and long-term plan outlined in this revised CRP (Table 1-2).

Table 1-1. Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area.

TEC	Target Statement
Wetlands	Create and restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage.
Habitat for Waterbirds	Restore and protect roosting, nesting, and foraging habitat (i.e., inland trees, wetlands, shallow shorelines) for long-legged wading birds.
Coastal and Maritime Forests	Create a linkage of forests accessible to avian migrants and dependent plant communities.
Oyster Reefs	Establish sustainable oyster reefs at several locations.
Eelgrass Beds	Establish eelgrass beds at several locations in the HRE study area.
Shorelines and Shallows	Create or restore shoreline and shallow sites with a vegetated riparian zone, an inter-tidal zone with a stable slope, and illuminated shallow water.
Habitat for Fish, Crab, and Lobsters	Create functionally related habitats in each of the eight regions of the HRE.
Tributary Connections	Reconnect and restore freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms.
Enclosed and Confined Waters	Improve or maintain water quality in all enclosed waterways and tidal creeks within the estuary to match or surpass the quality of their receiving waters.
Sediment Contamination	Isolate or remove one or more sediment zone(s) that is contaminated until such time as all HRE sediments are considered uncontaminated based on related water quality standards, related fishing / shellfishing bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria or protocols.
Public Access	Improve direct access to the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation.
Acquisition	Protect ecologically valuable coastal lands throughout the HRE from future development through land acquisition.

Table 1-2. Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area.

TEC	2020	2050
Wetlands	Create and/or restore a total of 1,000 total acres of freshwater and coastal wetland	Continue creating an average of 125 acres per year for a total system gain of 5,000 acres
Habitat for Waterbirds	Enhance at least one island without an existing waterbird population in HRE regions containing islands and create or enhance at least one foraging habitat	All suitable islands provide roosting and nesting sites and have nearby foraging habitat
Coastal and Maritime Forests	Establish one new maritime forest of at least 50 acres and restore at least 200 acres among several coastal forest/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	20 acres of reef habitat across several sites	2,000 acres of established oyster reef habitat
Eelgrass Beds	Create one bed in at least three HRE regions	Three established beds in each suitable HRE region
Shorelines and Shallows	Develop new shoreline sites in two HRE regions	Restore available shoreline habitat in three HRE regions
Habitat for Fish, Crab, and Lobsters	Complete a set of two related habitats in each HRE region	Complete four sets of at least two related habitats in each HRE region
Tributary Connections	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas
Enclosed and Confined Waters	Upgrade water quality of eight enclosed waterways	Upgrade water quality of all enclosed waterways
Sediment Contamination	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years
Public Access	Create one access and upgrade one existing access per year	All waters of the HRE are accessible
Acquisition	Acquire a total of 1,000 acres to be preserved at an average rate of 200 acres per year	Acquire and preserve 200 acres of coastal property per year for a total of 6,000 acres

1.3 Public Involvement and Achieving Consensus

HRE stakeholders have been involved throughout the development of the program goal and the TECs, along with their measurable objectives, to ensure that the CRP meets the needs of the region's interested agencies and NGOs. In the period between the release of the Draft CRP in 2009 and mid-summer 2012, USACE, HEP, and their partners held public meetings at each of the HRE planning regions and participated in numerous local and national watershed conferences. The planning region outreach meetings were attended by representatives from more than 100 different stakeholder organizations. Despite vastly diverse participant backgrounds and comments that reflected a broad geographic scope of the HRE, strong support for the CRP was evident at all meetings. Stakeholders highlighted the following as requirements for successful restoration: maximize the opportunities provided by existing state and Federal programs; ensure science-based decision making; support education and outreach programs; incorporate all levels of governance; and apply lessons learned from other initiatives. Workshop participants contributed numerous comments and recommendations concerning the revision and future implementation of the CRP as a regional restoration strategy.

In May 2012, the USACE convened a workshop for the participants in the 2005-2007 TEC workshops to provide an update on the Hudson-Raritan Estuary Resources Program and to present public and stakeholder comments regarding the Draft CRP. At this workshop, the USACE led a discussion with the goal of reaching consensus on how to refine the CRP and TECs in response to the public's input and how best to capture the diversity of concerns throughout the estuary (Appendix A). Workshop participants agreed to several major modifications to the TECs to make them more inclusive and to place additional emphasis on valuable habitats such as freshwater wetlands, coastal forests, and living shorelines, which are all important to the resiliency of the HRE. These modifications included the adoption of ***Acquisition*** as the twelfth TEC, highlighting the importance of protection and preservation of existing open and undeveloped lands. In addition to the modifications to the TECs, several significant modifications were made to TEC short-term and long-term objectives. These changes reflect the findings from recent research and lessons learned from restoration projects within the HRE since the 2009 Draft CRP. The revised TECs (Table 1-1) and short-term (2020) and long-term (2050) targets (Table 1-2) represent a regional consensus on the framework for the HRE's CRP.

Achieving the goals outlined in the CRP will advance the vision of a World Class Harbor Estuary—where the importance of a sustainable environment is balanced with the Port's economic revitalization, navigation and port infrastructure requirements, and the protection of public safety.

2.0 Existing Conditions

2.1 Study Area

The HRE study area is located within one of the largest estuaries on the east coast of the U.S., encompassing over 1,600 square miles (4,144 $kilometers^2$, USACE 2004a) and almost 1,600 linear miles (2,575 kilometers) of shoreline (USACE 2006a, HEP 2016a). The HRE study area, as identified in the USACE study authorization, is broadly defined by a 25-mile (40-kilometer) radius from the Statue of Liberty. The HRE spans many political and ecological borders, posing a challenge to planning for restoration on an estuary-wide scale. To facilitate restoration planning among the diverse habitat types and stakeholder communities, the HRE study area was delineated into eight planning regions: (1) Jamaica Bay; (2) Lower Bay; (3) Lower Raritan River; (4) Arthur Kill/Kill Van Kull; (5) Newark Bay, Hackensack River, and Passaic River; (6) Lower Hudson River; (7) Harlem River, East River, and Western Long Island Sound; and (8) Upper Bay (refer back to Figure 1-2).

The HRE is situated within the northwestern boundary of the New York Bight and consists of those ocean, coastal, and estuarine waters of the Atlantic Ocean lying south of Long Island, New York, from New York City (NYC) south to Sandy Hook, New Jersey, including Raritan Bay and its tributaries. The eastern boundary of the HRE study area is Long Island Sound to the east of Hempstead Harbor, including the Harlem River, the East River, and the Long Island Sound shoreline of Westchester County (USACE 1999). The study area also includes all tidally influenced portions of rivers flowing into the Harbor, including the Hudson, Raritan, Hackensack, Passaic, Shrewsbury, and Navesink Rivers (USFWS 1997). The 320-mile (515-kilometer) Hudson River dominates the hydrology of this system, with a watershed of 13,400 $miles^2$ (34,705 $kilometers^2$) and an average flow of 21,000 $feet^3$/second (683 $meters^3$/second). The Hackensack, Passaic, Raritan, Shrewsbury, and Navesink Rivers collectively account for approximately 13 percent of the flow into the Harbor (USFWS 1997).

The HRE study area has been shaped by the region's complex geological and glacial history. The HRE is located at the convergence of three physiographic provinces: the sand, gravels, and clays of the Atlantic Coastal Plain; the sandstones, shales, and igneous intrusions of the Piedmont Province; and the metamorphic crystalline rock ridges of the New York-New Jersey Highlands and Manhattan Hills extensions of the New England Province (USFWS 1997). The HRE study area also includes the terminal or end moraine of the most recent (Wisconsin) glacial advance (USFWS 1997). 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 (USACE 1999).

The HRE study area is also 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 U.S. Fish and Wildlife Service (USFWS) list almost 400 plant, animal, and fish species of special emphasis as occurring within the HRE study area (USFWS 1997). Additionally, the Atlantic Flyway, one of four major avian migratory routes in North America, passes directly over the HRE study area. The HRE supports residents and migrants of almost 300 species of birds, over 100 species of fishes, diverse plant communities, and many important terrestrial and aquatic invertebrates (Steinberg et al. 2004, USFWS 1997).

Jamaica Bay, the Hackensack Meadowlands, and Sandy Hook Bay are examples of existing large-scale open space and habitat complexes within the HRE. Wetlands and open-water habitats in these areas contribute to preservation of the integrity and productivity of the nearshore zone (Bain et al. 2007). For decades, the islands of the HRE study area have functioned as rookeries, supporting more than a thousand breeding pairs of long-legged wading birds (Kerlinger 2004). Many critical natural areas within the HRE study area have been preserved or restored. However, many others represent isolated sites surrounded by industrialized or densely populated urban areas and are vulnerable to degradation from surrounding land uses. Some of these degraded habitats continue to support fish and wildlife; however, many ecosystem functions are impaired due to human encroachment and would benefit significantly from habitat improvements.

The HRE study area is the most densely populated estuary in the U.S., with more than 20.1 million residents in the New York metropolitan area according to 2014 Census estimates (USOMB 2015) and an estimated 8.5 million residents in NYC alone (USDOC 2015; Figure 2-1). In addition to residential land use, a large portion of the HRE study area is used for industry and commerce, and many industries are closely linked to the ports of the HRE study area. Therefore, shipping channels are

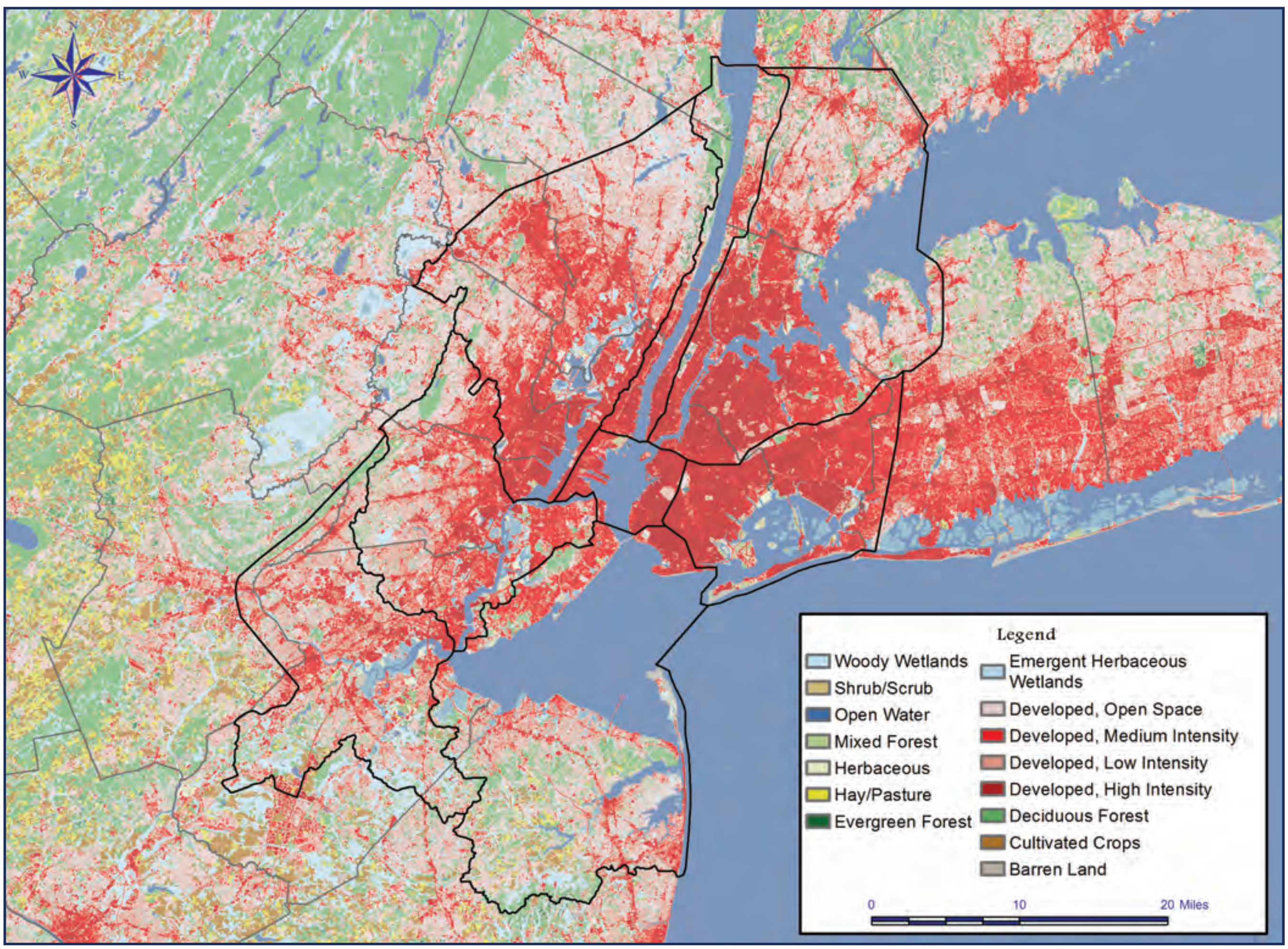


Figure 2-1. Land use in the Hudson-Raritan Estuary study area.
Source: US Geological Survey, NLCD 2011 Land Cover (2014). North American Datum 1983, 30 m resolution

maintained in most waterways and surface waters are used primarily by commercial boat traffic (USACE 2004a). Many power plants and other industrial facilities withdraw water from the HRE study area, and at least 27 major wastewater treatment plants currently discharge treated and untreated effluent into the estuary through combined sewer overflows (CSOs) (NYCDEP 2003).

Figure 2-2. Historic presence of oysters in the Hudson-Raritan Estuary study area.
Source: Metropolitan Sewerage Commission 1911

The HRE study area has suffered extensive losses in wetland habitat and aquatic vegetation communities such as eelgrass beds (USACE 2004b, Squires 1992). More than 80 percent of the harbor's tidal wetlands have been filled to accommodate the demands and changing needs of the region (Bain et al. 2007). As a result of this significant decline in the acreage of coastal and freshwater wetlands, which intercept and store floodwaters, most of the current overland runoff from impermeable urban surfaces enters directly into open water (HEP 1996, Bain et al. 2007). The losses of shoreline aquatic vegetation have resulted in increased turbidity, shoreline erosion, and reductions in wildlife breeding and wintering grounds. Moreover, alterations in tidal exchange and urban encroachment have converted many of the remaining coastal wetlands from native plant assemblages to monocultures of invasive species (USACE 2004a). Nearly all of the approximately 224,000 acres (906 $kilometers^2$) of freshwater wetlands that existed in NYC prior to the American Revolution have been filled or otherwise eliminated (PlaNYC 2010, 2012).

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 its once expansive range, likely due to high sedimentation rates resulting from the combined effects of increased overland runoff, dredging, shoreline modification, and land management practices in the HRE study area (Mackenzie 1996). Cascading effects on other estuarine communities resulted from the disappearance of oyster beds, which provide benthic structure over a range of depths and habitat for many aquatic species, including those that support important commercial and recreational fisheries (MacKenzie 1992; Figure 2-2). The construction of bulkheads and 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

Figure 2-3. Wildlife Conservation Society's Welikia Project: The Mannahatta Map depicts the estuary along Manhattan, NY as its pre-colonization self.
Source: Markley Boyer/The Mannahatta Project/Wildlife Conservation Society (digital reconstruction); Yann Arthus-Betrand/Corbis (photograph)

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. Currently, the island of Manhattan barely resembles its pre-colonization self, as depicted in the Manhattan Map created as part of the Wildlife Conservation Society's Welikia Project (Figure 2-3).

2.2 History of Habitat Degradation and Losses

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, natural forces such as Hurricane Sandy have also resulted in habitat loss and degradation.

2.2.1 Bathymetric Alterations

Before colonial settlement, the HRE study area was a relatively shallow system, with most waters less than 20 feet (6 meters) in depth at mean low water. 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 (9-meter) deep passage was dredged through the Lower Bay, followed by an extensive deepening to 40 feet (12 meters) completed in 1914 (Parkman 1983). During World War II, the network of channels and supporting berthing areas were deepened to almost 45 feet (14 meters) 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 (400 kilometers) of established channels and associated berthing areas. In 2000, Congress authorized the deepening of the main shipping channels of the HRE to 50 feet (15 meters) to meet shipping needs and ensure the Harbor's long-term economic viability (§101 (a) (2) of Water Resources Development Act (WRDA) 2000, P.L. 106-541). This harbor deepening effort is scheduled for completion in 2016.

2.2.2 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 created fast lands (i.e., land created above the high-water mark by shoreline hardening). Most of Manhattan's southern shorelines were hardened and approximately 279 acres (1.12 kilometers^2) 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 (180 meters) 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, and Newark International Airports were constructed on filled wetlands, as was Floyd Bennett

Field in Brooklyn. Decks were assembled into Flushing Bay to enlarge LaGuardia Airport by 50 acres (0.20 kilometers[2]; HEP 1990). Major shipping terminals were established within the HRE, which currently occupy a total of 755 miles (1,209 kilometers) of shoreline between New York and New Jersey, with 460 miles (736 kilometers) and 295 miles (473 kilometers), respectively (USFWS 1997).

Urban and industrial uses currently dominate nearshore areas in the HRE study area, and these uses have eliminated natural shoreline habitat from much of the estuary. These hardened and often deepened shorelines have replaced the gently sloping and vegetated natural shorelines. Remaining stretches of natural shoreline within the HRE study area are typically littered with debris, such as dilapidated piers or abandoned buildings, which suppress the growth of aquatic and terrestrial vegetation and diminish habitat value and ecosystem function.

2.2.3 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. Flow from the Hudson River, the primary source of freshwater to the HRE study area, is significantly diminished relative to historical conditions due to reservoirs, impoundments, and other water diversions. Impoundments alter stream flow patterns and encourage upstream siltation that can alter channel structure, benthic substrate, and bank stability in downstream river reaches. 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.

2.2.4 Water Quality and Sediment Degradation

Four centuries of human impacts have adversely affected water and sediment quality in the HRE study area. 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 in 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 CSOs remaining in the HRE. The wastewater contains floatable debris, as well as chemical and biological pollutants that include pesticides, fertilizers, nutrients, metals, organochlorines, pharmaceuticals, pathogens (disease causing microorganisms), and sediment. The nutrients released from the CSOs promote the formation of algal blooms, which upon senescence and decomposition reduce water column dissolved oxygen concentration and produce noxious odors. 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).

Pathogens enter the HRE waterways by way of the sewage released from CSOs. Swimming in sewage-contaminated waters or consuming tainted shellfish can cause illnesses such as gastroenteritis, typhoid fever, cholera, and hepatitis. As a result, the actual or suspected presence of pathogens can result in beach closures and restrictions on activities involving contact with water, as well as shellfish harvest and consumption (HEP 2012).

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.

There are also many point sources and historic discharges of contaminants of concern that have contributed to the legacy contamination within the sediments and soils of the HRE study area. Implementation of the TECs 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 (1 kilometer) buffer of a CRP restoration opportunity site. 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 the TECs, 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 contaminates 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. 2015).

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, PCB, dioxin, and dichloro-diphenyl-trichloroethane (DDT) in fish and shellfish (HEP 2012). Much of the harbor is closed to commercial fishing and recreational fishing is primarily limited to anglers that practice catch-and-release techniques; however, there remains significant subsistence consumption of locally caught fish 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.

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. 2015).

2.2.5 Hurricane Sandy

Since the 2009 publication of the Draft CRP for the HRE, a major coastal storm radically altered the coastal habitats within the HRE. On October 29, 2012, Hurricane Sandy made landfall near Brigantine, New Jersey as a post-tropical cyclone with hurricane-force winds, driving a catastrophic storm surge into the New Jersey and New York coastlines and affecting the HRE study area. This surge was accompanied by powerful and damaging waves, especially along the coast of central and northern New Jersey, Staten Island, and the southern-facing shores of Long Island. Flood depths due to the storm surge combined with a high tide cycle were as much as 9 feet (3 meters) above the ground surface in Manhattan, Staten Island, and other low-lying areas within the New York/New Jersey Metropolitan Area. With estimated damages of $65 billion, Hurricane Sandy was the second costliest hurricane in the nation's history and the largest storm of its kind to hit the U.S.

east coast. Twenty-six states were affected by Hurricane Sandy, with disaster declarations issued in 2013 (USACE 2013). Peak Hurricane Sandy storm tide elevations at discrete locations throughout the HRE are listed in Table 2-1.

Surveyed high water marks from the U.S. Geological Survey (USGS) indicate that the highest water levels in New York occurred on Staten Island. The highest direct measurement was 7.9 feet (2 meters) above ground level in the Oakwood neighborhood of Staten Island. A direct measurement of 4.7 feet (1 meter) above ground level was made at One World Trade Center in the Financial District in Lower Manhattan. Higher flooding likely occurred in other parts of Manhattan that are at lower elevations.

The highest high-water mark measured by the USGS in New Jersey was 8.9 feet (3 meters) above ground level at the U.S. Coast Guard Station on Sandy Hook. Elsewhere, a high-water mark of 7.9 feet (2 meters) above ground level was measured in Keyport on the southern side of Raritan Bay, and a mark of 7.7 feet (2 meters) above ground level was measured in Sayreville near the Raritan River. The deepest water occurred in areas that border Lower Bay, Raritan Bay, and the Raritan River.

As the storm surge from Hurricane Sandy was pushed into the Upper and Raritan Bays, water piled up within the Hudson River and the coastal waterways and wetlands of northeastern New Jersey, including Newark Bay, the Passaic and Hackensack Rivers, Kill Van Kull, and Arthur Kill. Significant flooding occurred along the Hudson River in Weehawken, Hoboken, and Jersey City, where many high-water marks were between 4 and 6.5 feet (1 to 2 meters) above ground level.

Table 2-1. Hurricane Sandy Peak Storm Tide Elevations

HRE Planning Region	Site Location	Peak Storm Tide Elevation[1]
Jamaica Bay	Breezy Point – West End of Rockaway Barrier Beach	10.7 (3.3 m)
	Howard Beach – East of Spring Creek	10.8 (3.3 m)
Lower Bay	Keyport Harbor	14.5 (4.4 m)
	Great Kills Park – Eastern Shore, Staten Island	14.0 (4.3 m)
Lower Raritan River	South River	12.8 (3.3 m)
	Perth Amboy - North Bank of Raritan River	12.9 (3.9 m)
Arthur Kill and Kill Van Kull	Elizabeth – Elizabeth River	12.2 (3.7 m)
	Staten Island – North Shore along Kill Van Kull	11.5 (3.5 m)
Newark Bay, Hackensack River, and Passaic River	Laurel Hill Park – Eastern Bank of Hackensack River	9.2 (2.8 m)
	City of Newark – Near Newark Bay	11.6 (3.5 m)
Lower Hudson River	Jersey City – Near Hudson River	10.4 (3.2 m)
	Yonkers – Eastern Shore of Hudson River	9.2 (2.8 m)
Harlem River, East River, and Western Long Island Sound	Harlem River – Near Little Hell Gate at Confluence of Bronx Kill	10.3 (3.1 m)
	Flushing Bay – Near LaGuardia Airport	10.4 (3.2 m)
Upper Bay	Liberty Island	11.3 (3.4 m)
	Gowanus Bay	11.2 (3.4 m)

[1]Tide elevations provided in feet above NAVD88;
Source: USGS Hurricane Sandy Storm Tide Mapper

Inundations of 4 to 6 feet (1 to 1.8 meters) were also measured across Newark Bay in Elizabeth and the area around Newark Liberty International Airport (NHC 2013).

The effects of Hurricane Sandy were not limited to increased water elevations and flooding; storm surges caused damage to many wastewater treatment plants causing widespread discharge of partially treated and untreated sewage into the waters of the HRE. Approximately 10.3 billion gallons of sewage was discharged from treatment plants in New York and New Jersey, and many of these plants are located within or near the HRE study area. About one-third of that volume represented untreated sewage. Several local authorities issued health advisories to avoid contact with flood waters and boil drinking water that may have been contaminated. As discussed in Section 2.2.4, in addition to potential human health risks associated with these overflows, sewage discharges contain high concentrations of nutrients that promote phytoplankton growth and potentially result in harmful algal blooms (Kenward et al. 2013).

The USACE New York District, American Littoral Society (ALS), National Fish and Wildlife Foundation (NFWF), and Hudson River Foundation conducted impact assessments to document the effects of Sandy on regional habitats and wildlife (USACE 2012, ALS 2012, HRF 2012,). Hurricane Sandy had the largest effect on areas close to the Atlantic Ocean, including Jamaica Bay, Sandy Hook, and Staten Island. Areas located farther inland in the estuary experienced less damage from flooding, although winds were still damaging. Areas around the HRE experienced heavy flooding, carrying with it high volumes of sand, vegetation wrack, and trash, which remained in upland communities covering understory plants in thick layers of debris when the tides and floodwaters receded. The erosion impacts described by the region's resource managers indicate more than 50 percent of the beach and dune habitat in the HRE, Jamaica Bay, and Long Island Sound experienced some degree of storm damage or erosion (ALS 2012). In addition, NYC estimated that 20,000 trees were downed as a result of Sandy's winds (NYC 2013). The following sections provide additional information on the effects of Hurricane Sandy along with the existing conditions of the habitats within each of the HRE planning regions.

2.3 HRE Planning Regions

Within the HRE study area, each of the eight planning regions consists of different habitats that contribute to the overall health of the ecosystem. The following sections describe the existing conditions of the HRE's planning regions. These same regions were part of the North Atlantic Coast Comprehensive Study (NACCS): Resilient Adaptation to Increasing Risk conducted by USACE under the Disaster Relief Appropriations Act of 2013 in response to the damage caused by Hurricane Sandy and the growing threat of climate change and sea level rise. The study looked at ways to manage flooding risks and increase community resiliency, while considering multiple stakeholders and projects already in progress (USACE 2015a).

2.3.1 Jamaica Bay

The Jamaica Bay Planning Region, located on the southwestern shore of Long Island, is enclosed by the Rockaway peninsula (Figure 2-4). This region includes portions of Brooklyn, Queens, and Nassau Counties, New York, as well as the John F. Kennedy 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, John F. Kennedy International Airport, and several landfills.

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 urban park and remains a dominant feature of this planning region (NPS 2014a). The refuge includes over 12,600 acres (50 kilometers^2) 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). Widely recognized as a uniquely valuable habitat complex within the HRE, NYC designated Jamaica Bay as a Special Natural Waterfront Area (SNWA) in response to recommendations in the 1992 *Comprehensive Waterfront Plan* (NYC 2011).

Figure 2-4. Jamaica Bay Planning Region.

The northern shore of Jamaica Bay is flanked by heavily developed lands, including the Belt Parkway, John F. Kennedy International Airport, and several landfills. Land and water uses along the waterfront 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. Surface waters are used for commercial shipping and contact recreation, such as fishing and boating (USACE 2004a). Water is withdrawn from Jamaica Bay and used as cooling water at the Far Rockaway power plant. Six sewage treatment plants occur in the planning region; four are owned and operated by the NYC Department of Environmental Protection (NYCDEP); one is owned and operated by the Village of Cedarhurst, NY; and one is owned and operated by the Nassau County Department of Public Works.

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, the Rockaway Peninsula is predominantly a residential area from its border with Nassau County on the east to Rockaway Point on the west. Residential uses include single-family homes, apartment buildings, and a large number of community facilities geared towards older residents: senior centers, nursing homes, adult care facilities, and hospitals. Several publicly accessible open spaces are situated on the Rockaway Peninsula, including large parks like Jacob Riis Park, Rockaway Beach, Bayswater Point State Park, and the Dubos Point Wildlife Refuge, as well as smaller neighborhood parks and playgrounds.

Jamaica Bay's Disappearing Wetlands

Over the last 150 years, Jamaica Bay has experienced interior wetland islands and perimeter wetlands loss due to a variety of factors, including sea level rise, anthropogenic manipulation (dredging and filling), erosional losses caused by invasive species, and increased tidal height. From 1924 to 1974, 780 acres (3.16 kilometers^2) of marsh islands were lost due to direct dredging and filling (which were unregulated activities until 1974). Despite regulation, loss of Jamaica Bay's interior wetlands is accelerating; between 1974 and 1994, 526 acres (2.13 kilometers^2) of marsh islands were lost at an average rate of 26 acres (0.12 kilometer^2) per year, and between 1994 and 1999, 220 acres (0.89 kilometer^2) were lost at an average rate of 44 acres (0.18 kilometer^2) per year.

Several recommendations for future watershed protection have been proposed in the Jamaica Bay Watershed Protection Plan developed by the New York City Department of Environmental Protection (NYCDEP) to protect existing wetlands and curb continuing losses. The wetland-specific planning measures include:

- Prioritize restoration of additional salt marsh islands (Canarsie Pol, Goose Pond Marsh, Duck Point Marsh, Pumpkin Patch Marsh, Stony Creek Marsh, and Silver Hole Marsh).
- Investigate existing literature and examine various technologies to protect salt marshes from erosion.
- Evaluate the potential for acquisition and restoration of tidal wetlands and upland buffer areas.
- Reduce the extent of invasive vegetation to create wetlands and/or upland buffers.
- Where applicable, implement freshwater habitat restoration plans within the watershed

The USACE's Jamaica Bay Ecosystem Restoration Feasibility Study would investigate these measures with NYCDEP as a non-Federal sponsor in collaboration with the New York State Department of Environmental Conservation (NYSDEC), New York City Department of Parks and Recreation (NYCDPR), the National Park Service (NPS), and other agencies. Through this study and other partner initiatives, the agencies are working to protect and restore this 9,155-acre area (37 kilometers^2). Restoration efforts began in 1992, and since, have focused on several areas along the region's perimeter at sites including Gerritsen Creek, Paerdegat Basin, and marsh islands (including Elders East and West, Yellow Bar, Black Wall, and Rulers Bar). Today the partners are working together to advance many projects including new marsh islands (including Elders Center, Pumpkin Patch [East & West], Duck Point, and Stoney Creek) and perimeter sites (including Bayswater, Dead Horse Bay, Dubos Point, Fresh Creek, Hawtree Point, and Brant Point Creek) recommended by the HRE Feasibility Study; as well as other sites such as Spring Creek North and Spring Creek South among others. The partners plan to increase the habitat diversity and overall connectivity among adjacent habitat types to create a full-functioning, integrated estuarine system.

Sources:
Gateway National Recreation Area and Jamaica Bay Watershed Protection Plan Advisory Committee. 2007. An update on the disappearing salt marshes of Jamaica Bay, New York.
New York City Department of Environmental Protection. 2007. Jamaica Bay Watershed Protection Plan.
New York State Department of Environmental Conservation. Jamaica Bay, Queens County, NY. Available at http://www.dec.ny.gov/lands/5489.html. Accessed March 16, 2016.

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. Breezy Point, at the western tip of Rockaway Barrier Beach, sustains large populations of beach-nesting birds, including one of the largest nesting colonies of piping plovers (*Charadrius melodus*) in the New York Bight coastal region (USFWS 1997). Although fish and wildlife species make use of what habitat remains 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).

Jamaica Bay is threatened by poor water and sediment quality, and habitat loss. 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 1,400 acres (5.67 kilometers^2) 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 (0.89 kilometer^2) of salt marsh were lost at a rate of 47 acres (0.19 kilometer^2) per year. Left alone, the marshes were projected to vanish by 2025, destroying wildlife habitat and threatening the bay's shorelines (NYSDEC 2001).

About 4,000 acres (16 kilometers^2) of the original wetland habitat remains, a reduction of almost 75 percent (RPA 2003). Dredging and filling of the wetlands accounts for historic habitat losses in this region; these direct impacts were responsible for approximately 780 acres (3 kilometers^2) of marsh loss between 1924 and the passage of the CWA in 1974 (NYSDEC 2001). Remnant borrow pits and channels in the Bay, some as deep as 60 feet (18 meters), 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 also alter the hydrodynamics of Jamaica Bay by increasing the residence time of water as much as three-fold (Hartig et al. 2002, USFWS 1997).

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 (30 meters) and lowering dune and berm elevations up to 5 feet (2 meters; USACE 2012). Storm surge induced inundation of up to 5 feet (2 meters) 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, NYCDEP, 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 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 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. In addition, these efforts require coordination with the Final General Management Plan for the "New Vision for a Great Urban National Park Gateway National Recreation Area" (NPS 2014b).

2.3.2 Lower Bay

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 2-5). 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. The Lower Bay Planning Region is predominantly developed with industrial, commercial, residential, and recreational land uses. Sandy Hook peninsula, and Hoffman and Swinburne Islands just off Staten Island, are part of the Gateway National Recreation Area. 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 and recreational boating and fishing/shellfishing (USACE 2004a). 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 (280 kilometers^2) at less than 20 feet (6 meters) 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.

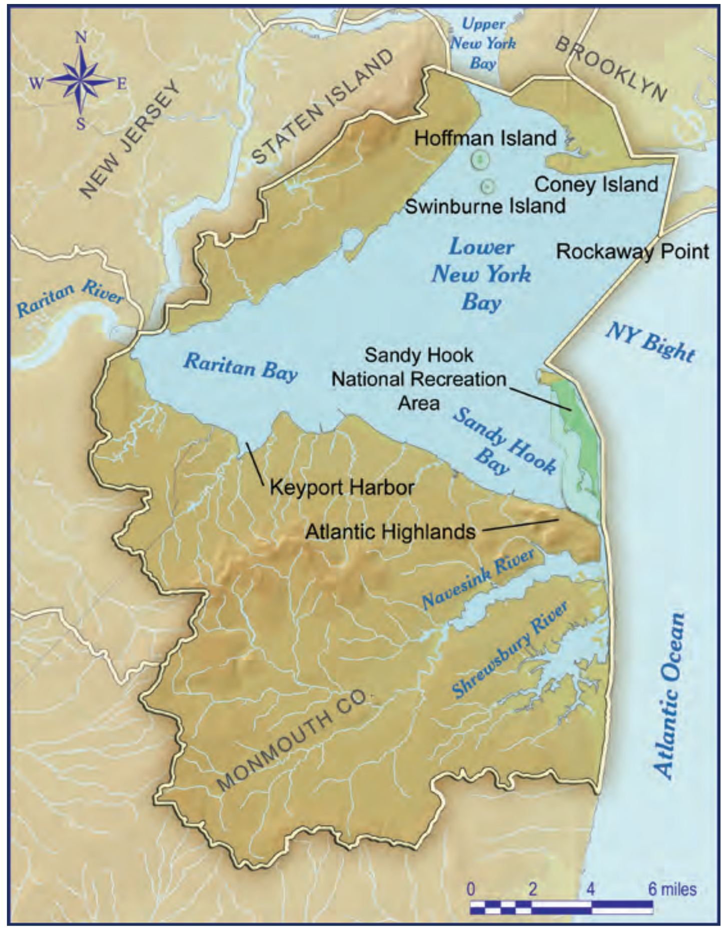


Figure 2-5. Lower Bay Planning Region.

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 (19 kilometers^2) of intertidal and subtidal sand flats and mudflats off the shorelines of the bays and western Staten Island (USFWS 1997). Sandy Hook is a 9-mile (15-kilometer) narrow sand spit that has a fairly extensive vegetated dune system and two distinct maritime forest communities that encompass 285 acres (1 kilometer^2).

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).

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 5 to 10 feet (2 to 3 meters). 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 (18 to 46 meters) 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.

Hoffman and Swinburne Islands

In the nineteenth century, people with contagious diseases were placed in quarantine hospitals around the city, particularly on Staten Island. Public disapproval and unrest over their proximity led quarantine commissioners to construct islands off the coast of Staten Island (Seitz and Miller 2001). Construction of Hoffman and Swinburne Islands began in the mid-1860s using dredged sand from New York Harbor. Both islands were completed nearly a decade later. For almost 50 years, facilities on these islands housed thousands of immigrants, residents, and soldiers infected with contagious diseases like yellow fever and cholera. After the quarantine facilities closed in the 1920s, several uses of the islands were proposed, like creating parkland, waste disposal facilities, or rehabilitation centers. In 1972, the islands were deeded to the Federal government to become a part of the Gateway National Recreational Area. Although there are currently no formal plans for the islands, they remain important, protected nesting habitat for waterbirds in the HRE.

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 (*Circus cyaneus*), a New York State threatened, 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 man-made 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

Figure 2-6. Harbor Seals on Swinburne Island in the Lower Bay Planning Region.

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).

On June 12, 2015, HEP and Sustainable Raritan River Initiative brought together more than 200 stakeholders from New Jersey and New York for "Two States: One Bay, bi-state conversation about the future of Raritan Bay." Discussions centered on water quality, climate resiliency, habitat conservation and restoration, fish and shellfish management, and public access. A report published following the event detailed specific insights and opportunities for action for these foci. Particularly relevant to habitat, opportunities focused on expanding the existing inventory of opportunities, supporting a larger-scale connectivity analysis, and working across both states to address scientific and management challenges to oyster restoration (HEP 2016b).

2.3.3 Lower Raritan River

Primarily located in Middlesex County, New Jersey, the Lower Raritan River is the western-most planning region of the HRE study area (Figure 2-7). This region contains the lower 6 miles (10 kilometers) 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 bulkheaded 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 (Figure 2-7). Although there are no public bathing areas in the

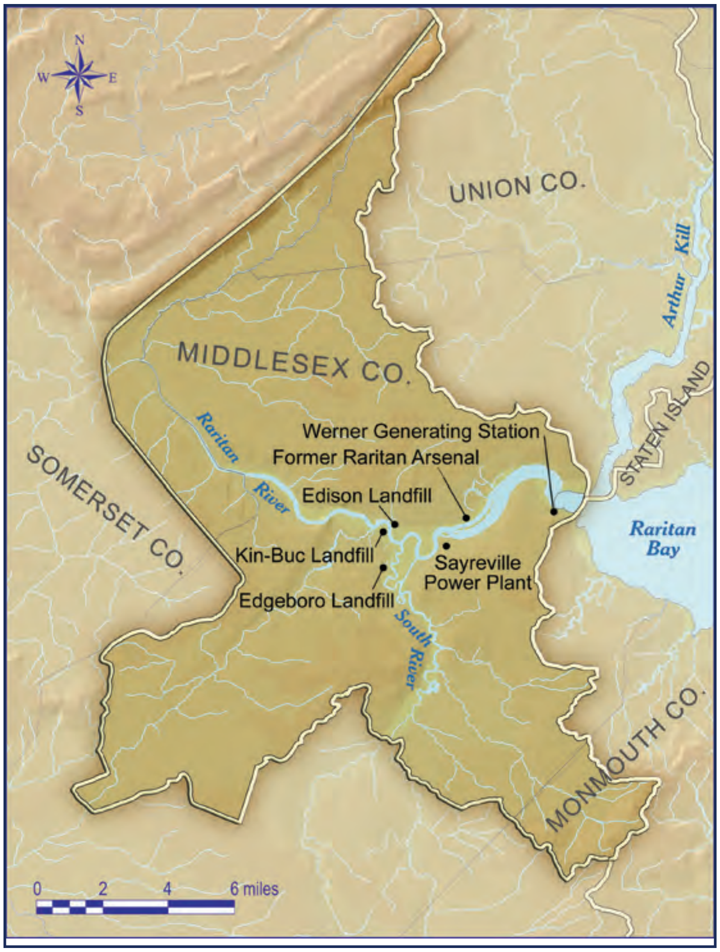


Figure 2-7. Lower Raritan River Planning Region.

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 (4 kilometers^2), 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 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 other pathogens, and a general degradation of water quality. Impacted resources included fish, invertebrates, small mammals, wading birds, and amphibians (ALS 2012).

2.3.4 Arthur Kill and Kill Van Kull

The Arthur Kill and Kill Van Kull Planning Region lies between Newark Bay and the Lower Raritan River (Figure 2-8). 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 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 (2,000/kilometer^2). 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 (1.6 kilometers) 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

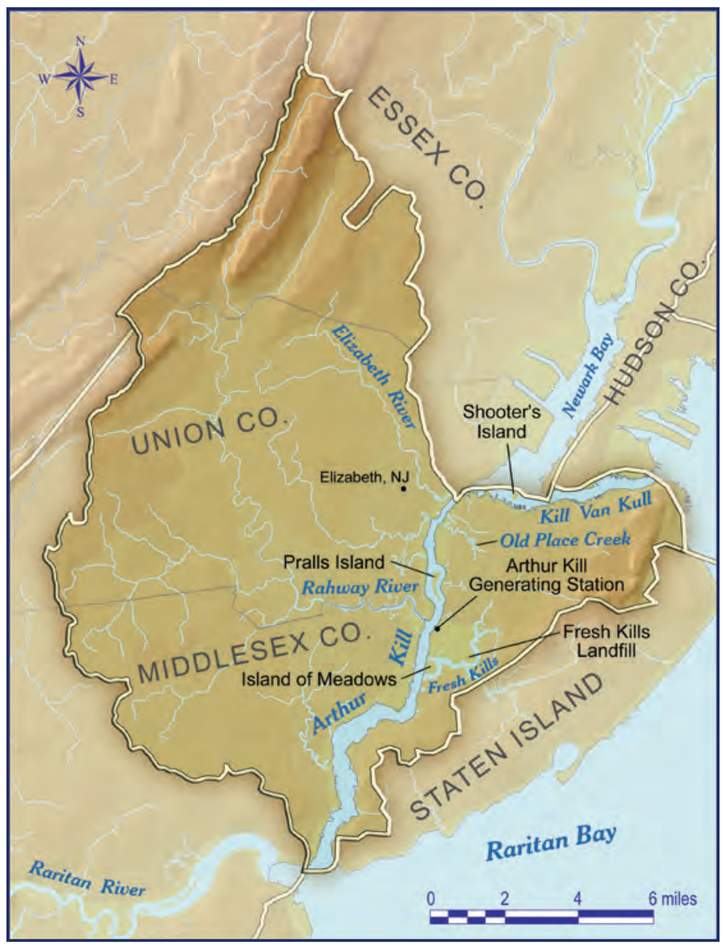


Figure 2-8. Arthur Kill and Kill Van Kull Planning Region.

(NYC 2011). Arlington Marsh and Graniteville Swamp are examples of important habitats within this planning region.

Figure 2-9. A great egret in marsh grasses.

Three 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 (>120 kilometers^2) 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 down (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).

2.3.5 Newark Bay, Hackensack River, and Passaic River

The Hackensack and Passaic River basins create the upper boundary of this HRE planning region, with the lower boundary encompassing Newark Bay (Figure 2-10). 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 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.

Predominant land uses in this planning region include commercial, industrial, and residential development. Surface waters are withdrawn from the Hackensack and Passaic Rivers by three power plants. Three sewage treatment plants are also located in this region (USACE 2004b). The lower 1.7 miles (2.74 kilometers) of the Lower Passaic River is dominated by petroleum refineries. The upstream reaches of the Lower Passaic 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 New Jersey Meadowlands District is a dominant feature within this region, measuring approximately 19,730 acres (80 kilometers^2). The District contains residential, commercial, industrial, and landfill areas, as well as tidal wetlands and large areas of 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 provide drinking water to municipalities in New Jersey (NJDEP 2012).

Two large habitat complexes of regional importance and ecological value in this region are a portion of the Central Basin Wetlands and the Hackensack Meadowlands. Near the Watchung Mountains, the Central Basin Wetlands support large swamp areas and forested wetlands fed by several important tributaries. The Hackensack Meadowlands is one of the largest remaining brackish wetland complexes in the HRE study area, measuring approximately 8,400 acres (34 kilometers^2) (USACE 2004b). Originally encompassing 21,000 acres (85 kilometers^2) of marshland, the Meadowlands have diverse habitat types and over

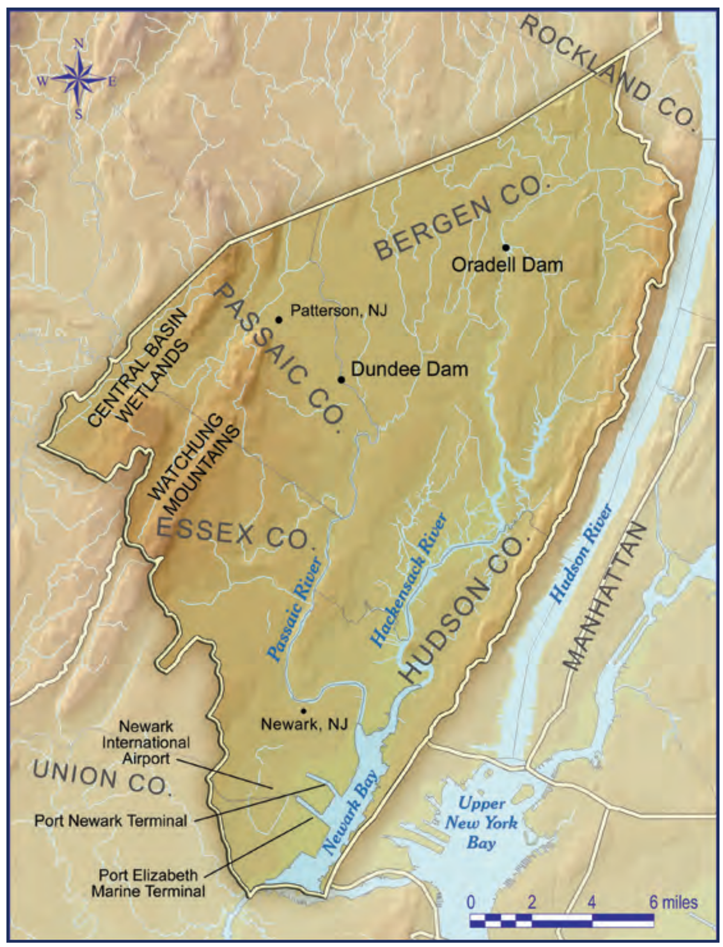


Figure 2-10. Newark Bay, Hackensack River, and Passaic River Planning Region.

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).

Lower stretches 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 and invertebrate species as nursery habitat, although its shorelines and river channels have been greatly modified by bulkheads and riprap. Unfortunately, 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 (USFWS 1997). Anadromous fishes make annual spawning runs up the 17-mile (27-kilometer) tidal stretch of the Passaic River to the Dundee Dam, but are blocked from going farther. The Oradell Reservoir Dam, on the Hackensack River, blocks passage of American shad (*Alosa sapidissima*), alewife (*A. pseudoharengus*), and blueback herring (*A. aestivalis*) from reaching upstream segments of the watershed (USACE 2004b). Other smaller dams and inoperable tide gates in the planning region degrade habitat and impair passage for diadromous species, including American eel (*Anguilla rostrata*) (Durkas 1993).

Development in this planning region has contributed to extensive habitat losses. Historic wetland losses and hydrologic modifications have transformed the Hackensack Meadowlands from a rich combination of fresh 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, one of the largest remaining tracts of estuarine wetland habitat in HRE study area. In the past few years, the Meadowlands have been the subject of large-scale ecosystem restoration projects through the establishment of mitigation banks and mitigation projects.

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 level of contamination in this region is of great concern to stakeholders. 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. 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 [TCDD]), mercury, lead, polychlorinated dibenzofurans (PCDF), 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 (27 kilometer) 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 70 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 conducting the remedial investigation and feasibility study (RI/FS) for the 17-miles (27 kilometers) of the lower Passaic River, from Newark Bay to the Dundee Dam on behalf of USEPA. In June 2000,

Mitigation Banks

A mitigation bank is a wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or (in certain circumstances) preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 of the Clean Water Act (CWA) or a similar state or local wetland regulation. Mitigation banks may be created when a government agency, corporation, nonprofit organization, or other entity undertakes these activities under a formal agreement with a regulatory agency (USEPA, Compensatory Mitigation Fact Sheet).

The U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE) proposed new rules in 2008 to encourage wetland creation and enhancement through mitigation banking as the preferred method of compensation, in a watershed-based approach. As of December 2015, 20 mitigation banks were active in the State of New Jersey; two of those sites, the Richard P. Kane and Evergreen MRI3 mitigation banks, have restored over 300 acres (1.21 kilometers^2) of coastal wetlands.

Construction of the Evergreen MRI3 Wetland Mitigation Bank was completed by Evergreen Environmental, LLC. The approximately 51-acre (0.21 kilometer^2) mitigation bank is located in Carlstadt, Bergen County, New Jersey along the banks of the Hackensack River. The mitigation bank is bordered on the west by Bashes Creek and is drained by Moonachie Creek to the east. The site was a berm and tide gate impoundment dominated by a monoculture of common reed (*Phragmites australis*). Restoration activities included excavation of dredged material, creation of low marsh, high marsh, and tidal channels, creation of upland islands from the excavated material, and planting of native vegetation (e.g., *Spartina*). The restored marsh, of which more than 11 acres (0.04 kilometer^2) are new wetlands, is now flooded by daily tides and fish and wildlife use of the marsh has increased.

New tidal channels.

Restored marsh with native plantings of *Spartina*.

Source: Evergreen Environmental, LLC; http://www.evergreenenv.com/mitbank.htm

USACE New York District initiated a reconnaissance study to identify and inventory water resources and sediment quality related problems and needs in the HRE. The 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 one 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). For the purpose of this study, a 'governmental partnership' was formed and includes USEPA, USACE, National Oceanic and Atmospheric Administration (NOAA), USFWS, NJDOT, and the New Jersey Department of Environmental Protection (NJDEP) 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 (Tierra) 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 (13.4 kilometers) 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). 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).

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).

An example of a program that promotes recreational use in this planning region is the Passaic Valley Sewerage Commission's (PVSC) Passaic River Blueway, a 76-mile (122-kilometers) canoe and kayak trail that spans the Passaic River from Fairfield, New Jersey to Newark Bay. Existing and proposed public access points and facilities along the Passaic River Blueway provide new opportunities for the community to enjoy and learn about the natural resources in the area.

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 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 (10-kilometer) 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 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).

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 6 feet (2 meters) above sea level, and were not able to prevent Sandy's 9-foot (2.7-meter) 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. As part of the Rebuild By Design competition sponsored by the U.S. Department of Housing and Urban Development (HUD) and the Hurricane Sandy Rebuilding Task Force, a design has been proposed to transform parts of the Meadowlands to better protect surrounding communities from future storm surges and floodwaters. This design, named "New Meadowlands: Productive City + Regional Park" combines ecosystem restoration, technology, and innovative re-development to help transform the area for multiple benefits to the local communities and economy. This project, along with other winning designs in the region, is discussed further in Section 2.6.2 "Responses to Hurricane Sandy."

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 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 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. For example, Lincoln Park in Jersey City, the subject of a major restoration project completed in 2011, was not visibly impacted by the storm (Figure 2-11). The Lincoln Park project restored 42 acres (0.17 kilometer^2) of freshwater wetland, stream, and salt marsh habitat along the

*Figure 2-11. Multiple habitats were restored at Lincoln Park West in Jersey City.
Credit: Carl Alderson, NOAA*

Hackensack River, creating new habitat for birds and fish and providing a coastal buffer zone against sea level rise impacts. According to resource managers who visited the site after Sandy, the area experienced “zero damage” (ALS 2012).

2.3.6 Lower Hudson River

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 2-12). 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.

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 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 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. Shallow-water 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).

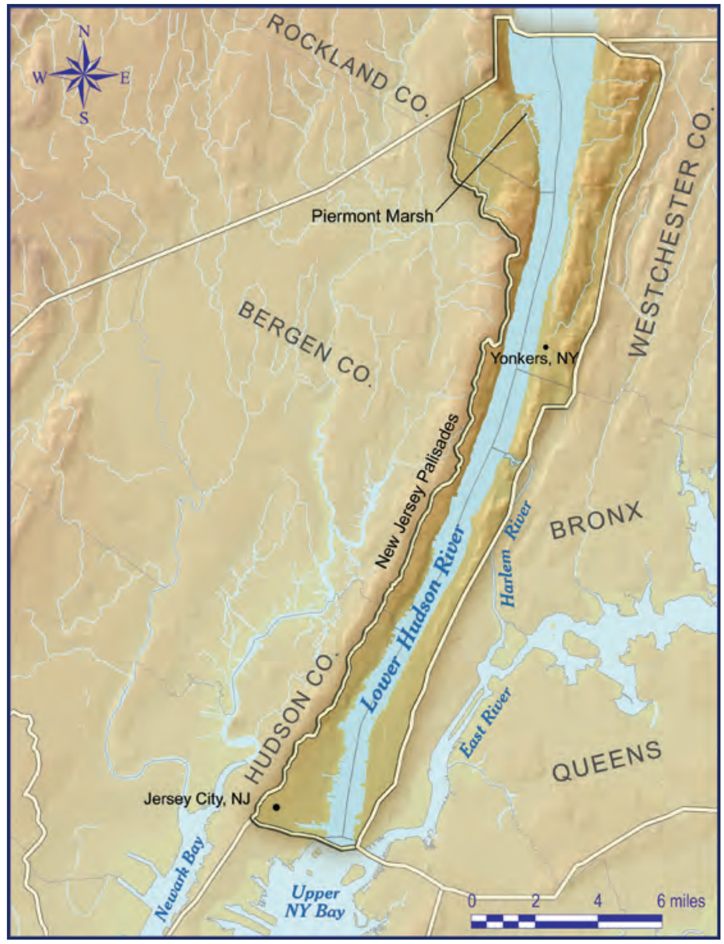


Figure 2-12. Lower Hudson River Planning Region.

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 General Electric Company plants located in the Upper Hudson River, upstream from the HRE study area (NYSDEC 2015). The USEPA designated a 200-mile (322-kilometer) stretch of the Hudson River, from Hudson Falls to the Battery in NYC, as a Superfund site due to this contamination. In 2009, the USEPA and General Electric initiated dredging a 14-mile (23-kilometer) 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). PCBs from the discharge points were transported to the Lower Hudson River, causing bioaccumulation and contamination of fishery resources throughout the river. Remediation of the Upper Hudson River is expected to result in the decrease of PCB contamination in the Lower Hudson River over time. At the end of 2014, approximately 2.4 MCY of PCB-contaminated sediments had been removed (NYSDEC 2015). The project is expected to be complete in 2016 when the benthic habitat will be restored (USEPA 2014c).

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.

2.3.7 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 (Figure 2-13). 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 designated as the Upper East River-Long Island Sound SNWA by NYC 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).

Shorelines along the East River are lined with urban residential, commercial, and industrial development. Commercial ferry terminals, marinas, and parkland are also 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 sewage treatment plants, and water is withdrawn from the East River by four power plants, as well as industrial/commercial interests (USACE 2004a).

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 estuarine bodies that serves as a significant route for migratory fishes (RPA 2003, USACE 2004a). However, many of these fish populations, including American eel, winter flounder, and especially the Atlantic and shortnose sturgeons, are significantly reduced from their historic population levels, likely due to overharvesting, impoundments, and or habitat degradation within this planning region as well as the entire HRE study area (Mayo et al. 2006).

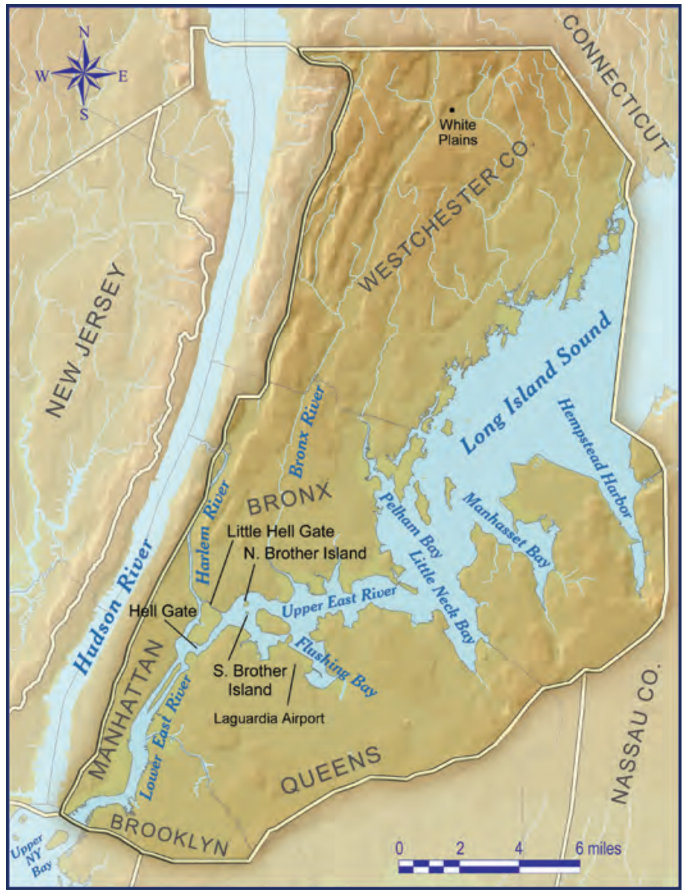


Figure 2-13. Harlem River, East River, and Western Long Island Sound Planning Region.

Many tributaries of the East and Harlem Rivers have been channelized and re-directed through culverts. The upper East River still exhibits habitat features such as bays and creek mouths but only sparse remnants of tidal wetlands natural upland habitats remain (RPA 2003, USACE 2004a). 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 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). Many marine and estuarine finfish species, including bluefish (*Pomatomus saltatrix*), scup (*Stenotomus chrysops*), striped bass, and winter flounder, also seek out these bays as nursery and foraging areas (USACE 2004a). Pelham Bay is regionally distinct, pairing rocky outcroppings of the New England rocky coast with intertidal mudflats that are exposed during low tide.

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 leachate from landfills and several 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 (*Sterna hirundo*); these species breed and nest on beaches, dunes, and overwash fans. Migratory shorebirds such as sanderling (*Calidris alba*), semipalmated sandpiper (*C. pusilla*), ruddy turnstone (*Arenaria interpres*), black-bellied plover (*Pluvialis squatarola*), and red knot (*C. canutus*) 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 (61 meters) 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).

2.3.8 Upper Bay

The Upper Bay Planning Region is centrally located within the HRE study area, connecting five other HRE regions (Figure 2-14). The Upper Bay begins at the mouth of the Hudson River as it empties into the Lower New York Bay, is connected to the Newark Bay and 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 Governor's Islands, includes adjacent portions of Manhattan, Brooklyn, and Staten Island, New York, as well as Hudson County, New Jersey.

Land use along the shoreline of the Upper Bay Planning Region is primarily commercial and industrial, with few non-industrial uses. Two sewage treatment plants discharge effluent into the Upper Bay (USACE 2004a). 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.

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 includes 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 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).

Sediment and water quality limit the waterways primarily to 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.

Natural shorelines in the Upper Bay are limited. Small tidal wetlands occur on the west side of Liberty Island. Remnant mudflats are located along the New Jersey coastline (USACE 2000, USACE 1999). Sandy shallows that have been significantly reduced in size over time by dredging are located within the Bay Ridge Flats, along the eastern edge of the Bay. These flats provide nursery and foraging habitat for a variety of fish species. The Upper Bay also serves as a migratory fish pathway, providing access to important feeding, overwintering, and nursery areas within other planning regions (USACE 2004a).

Figure 2-14. Upper Bay Planning Region.

The Upper Bay represents a vital link within the HRE study area; both influencing and being influenced by the hydrology, biology, and impairments of the other planning regions. This region is heavily urbanized along its perimeter and exhibits extensive shoreline filling and hardening. The open waters of the Upper Bay are crowded with ship traffic and large channels requiring continuous maintenance. Sediment contamination occurs throughout the Upper Bay as a result of historic industrial uses, local runoff, and CSO inputs. Shallow sheltered areas and littoral habitats are almost non-existent, 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 days after the storm. *Enterococcus* levels in the Gowanus Canal were 230 times greater than what is considered acceptable for swimming (ALS 2012).

2.4 Trends in Environmental Quality

Although the HRE study area has lost a substantial amount of habitat and ecological function and while legacy contaminants remain in the sediments, policies and programs instituted in the past century have resulted in improved water quality and a decrease in the rate of habitat destruction. Public concern over drinking water in the 1940s led to the Federal Water Pollution Control Act and programs to assist states in constructing wastewater treatment facilities. Unfortunately, the limited scope, enforcement policies, and state-enforced standards generally rendered this legislation ineffective. With the passing of the CWA in 1972 and its amendments, Congress set national goals to address water quality issues. This legislation regulates pollutant dischargers, sets water quality standards, specifies effluent limitations for wastewater treatment facilities, protects wetlands, and addresses issues of non-point source pollution.

In the 40 years since the CWA was implemented, concentrations of contaminants, bacteria, and nutrients have started to decrease and dissolved oxygen levels in the waters have started to increase (HEP 2012). These water quality improvements have been substantial but there is significant room for improvement. In most HRE planning regions, 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 (NYSDOH 2014, NJDEP 2013). 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). As previously described, the CARP study shows that legacy sediments continue to be a large source of contamination. Due to the natural processes in the harbor, burying of contaminated sediments by cleaner sediments may result in lower surficial sediment concentrations over time. The model, however, did not look at the effect of larger storm events and their effect on re-suspending deeper layers of contaminated sediments (Lodge et al. 2015).

Water quality programs initiated since the CWA have reduced, treated, and prevented many sources of pollution and immediate human health threats. Sewage treatment plants in New York and New Jersey have been upgraded and additional plants were constructed. Further improvements since the late 1980s are the result of improved maintenance and operation of sewage collection systems, wastewater treatment facilities, and year-round water quality surveillance programs. Regulation of industrial and treated sewage discharges have reduced concentrations of heavy metals (i.e., mercury, cadmium) dissolved in the water column by up to 90 percent since the 1970s (Steinberg et al. 2004). The amount of fecal coliform in the waters decreased significantly between the 1970s and 1990s, and has remained stable since (HEP 2012).

In addition to habitat restoration and regulatory programs, government initiatives are also helping to improve the habitat within the HRE study area by restricting habitat disturbance and the spread of contamination. Federal, state, and local regulations are, in most cases, restricting losses of valuable aquatic habitats. These agencies' mitigation programs are requiring the restoration of increased acreages of habitats to restore ecosystem goods and services. Solid waste programs at the local, state, and Federal levels have created strict guidelines to protect and preserve public health and the environment through the introduction of clay and geotextile landfill liners to contain potential contaminants, and leachate collection, treatment, and disposal systems. Many capped landfills in the HRE study area are being transformed into recreational areas or natural upland sites, like the Elizabeth Landfill in New Jersey or the former Pennsylvania and Fountain Avenue Landfills in Jamaica Bay (NYCDEP 2007). As discussed above, in recent years, the USEPA has made major progress on planning for the remediation of contaminated sediments on several sites on the National Priorities List within the HRE study area. As the remediation progresses, sediment quality throughout much of the HRE study area will gradually improve.

Given the momentum to improve environmental quality through legislation and habitat restoration programs, it is an opportune time to coordinate and accelerate the implementation of restoration projects in the HRE study area. HEP updated and revised their Action Plan in 2011 and intends to update the Action Plan again in 2016. Priority actions for habitat include preservation and land acquisition, initiating pilot scale restorations that advance the state of the science of each TEC outlined within the Draft 2009 CRP (updated herein), updating the Harbor Herons conservation plan, advancing the TEC goals outlined in this CRP, considering climate change in planning habitat restorations, and developing recommendations for collaborative action on the CRP goals (HEP 2011).

2.5 Sea Level Rise

The design and implementation of coastal habitat restoration projects within the HRE will require 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). New York State has established the Sea Level Rise Task Force, which released a report to the New York State Legislature in 2011 that identified recommendations for an action plan to protect coastal communities and natural resources from rising sea levels (NYSDEC, 2010). The New York State Climate Action Council, which assesses how all economic sectors can adapt to climate change, and the NYC's Climate Change Adaptation Task Force, which works closely with the NYC Panel on Climate Change (NPCC) to develop adaptation strategies to secure the City's infrastructure from the effects of climate change were also established.

A multi-stakeholder effort, the Rising Waters project, developed and described four different scenarios, outcomes, and trajectories for preparedness and adaptive capacity within the HRE study area from 2010-2030. The Nature Conservancy and its partners, the Cary Institute of Ecosystem Studies, Hudson River National Estuarine Research Reserve (NERR), NYSDEC Hudson River Estuary Program, New York State Water Resources Institute at Cornell University, and Sustainable Hudson Valley spearheaded the effort. Recommendations based on the likely future impacts of climate change included adaptation strategies in the Hudson Valley such as improved community planning, communication, and preparedness for extreme weather threats, and the incorporation of expected changes (e.g., frequent flooding and heat waves) in all land-use decision-making processes. Recommendations also include actions to reduce and minimize future losses in flood-prone areas, improved resiliency of shorelines, using NNBFs to reduce community vulnerability to flooding, establishment of climate-change adaptation funding, and conservation of healthy forests, wetlands, and river ecosystems, and agricultural resources (The Nature Conservancy 2009).

In 2013, following Hurricane Sandy, the Executive Office of the President released the President's Climate Action Plan and Executive Order 13653, Preparing the United States for the Impacts of Climate Change. The Action Plan outlined strategies to combat and prepare for the impacts of climate change on a national and international stage. The devastation of Hurricane Sandy and the subsequent release of the Action Plan sparked local and national interest in climate change. Funding became available for new programs and resources such as the USACE Engineering with Nature Program, the NOAA Ecological Effects of Sea Level Rise Program and Digital Coast Green Infrastructure Website, the USGS Hurricane Sandy Science Plan, Systems Approach to Geomorphic Engineering (SAGE), Hudson River Sustainable Shorelines Project, the Structures of Coastal Resilience (SCR) Project, and the DEC Coastal Green Infrastructure Research Plan for NYC, among many others. Federal agencies also adopted climate change initiatives such as USACE's 2014 Climate Change Adaptation Plan which outlines current activities and future plans to manage significant climate change related risks and build long-term and short-term resilience.

These initiatives provide avenues to analyze the impacts of sea level rise and the tools necessary to protect existing infrastructure and improve future resiliency. The primary impact of sea level rise on coastal environments and infrastructure is the direct loss of land and habitat due to inundation. The inland migration of coastal landforms (retreat) is a secondary impact. However, in urbanized areas such as NYC, the likelihood of this occurring is severely limited given approximately three centuries of shoreline development and re-alignment (Titus et al. 2009). Increased salinity in the upper reaches of the estuary, ultimately resulting in the conversion of freshwater tidal wetlands to brackish salt marshes, is an additional impact of climate change and sea level rise in the HRE.

Presently, the rate of sea level rise in the HRE area is approximately 0.1 inches (2.7 millimeters) per year, which exceeds the global average of 0.07 inches (1.8 millimeters) per year (IPCC 2007, Kirshner et al. 2008, Needelman et al. 2012). The higher observed average rate of sea level rise in the NYC area is partially the result of post-glacial rebound, exacerbating the amount of observed wetland/shoreline subsidence attributed to eustatic sea level rise, (i.e., an increase in the volume of the world's oceans solely due to thermal expansion) (Hartig et al. 2002, Needelman et al. 2012). NPCC estimates that the rate of sea level rise is increasing and predicts the sea level will be between 4.0 and 11.0 inches (0.1 to 0.3 meter) above current elevations by the 2020s. By the 2050s, the NPCC predicts that the sea level could be between 11.0 inches (0.1 meters) and nearly 3 feet (1 meter) above current elevations (NYC 2013).

The Intergovernmental Panel on Climate Change (IPCC) has estimated a 0.6 to 1.9 foot (0.18 to 0.56 meter) rise in sea level independent of ice cap melting. Estimates that consider the contribution of the melting Greenland and Antarctic ice caps (which contribute a high degree of uncertainty to sea level rise forecasts) range from 3.3 to 6.6 feet (1 to 2 meters) by the year 2100 (IPCC 2007, Needelman et al. 2012). Along with increases in mean sea level, storm intensity and frequency are predicted to increase. A shift in storm intensity towards the polar regions is anticipated, with more frequent and damaging storms expected to occur in the North Atlantic (NWF 2011). These processes are complementary, as an increase in mean sea level will exacerbate the surge effects associated with more intense and frequent coastal storms.

Tidal range, which varies considerably along the world's coastlines, is an important factor that has been ignored in forecasting the response of coastal wetlands to sea level rise. Estuarine and coastal habitats characterized by a micro-tidal regime (e.g., the U.S. coastline of the Gulf of Mexico) may experience the greatest effects of sea level rise, as native plant and animal communities are not accustomed to large fluctuations in inundation frequency and depth. In contrast, macro-tidal systems, such as the Puget Sound region of Washington or estuaries along Maine's coast, are expected to exhibit a considerable degree of resilience to changes in sea level, as the plant and animal communities present in these systems are adapted to wide fluctuations in tides and current regimes. Meso-tidal estuaries, such as the HRE, are likely to exhibit a moderate degree of resilience in comparison to micro- or macro-tidal systems (Needelman et al 2012).

Non-linear response patterns are an additional source of uncertainty in predicting the effects of climate change and sea level rise on coastal habitats within the HRE (and elsewhere) (Needelman et al. 2012). Impacts to wetlands and other coastal habitats are often unobserved until reaching a disturbance threshold, perhaps explaining the rapid and recent loss of salt marsh islands in Jamaica Bay. Jamaica Bay wetlands were subjected to impacts associated with dredging, coastal development, and wastewater inputs for several decades before exhibiting tangible degradation. However, once the impact threshold was reached, perhaps in the late 1990s, the system reached a tipping point, and degradation became readily discernible (NPS-GNRA 2007). Non-linear responses in coastal systems are not well studied and future restoration programs in the HRE would benefit substantially from a better understanding of ecological tipping points and disturbance thresholds, especially with regard to enhancing resiliency in the face of climate change impacts.

Regional variation in response to sea level rise within the HRE will be apparent. For example, Jamaica Bay, a back-barrier system with limited sediment sources, will likely continue to experience rapid erosion and/or subsidence of wetlands in the face of rising sea level. In contrast, wetlands associated with a continuous source of alluvial sediments from extensive riverine drainage basins (e.g., Raritan River wetlands) may persist for a much longer duration before reaching disturbance thresholds. Anthropogenic activities within estuaries or along coastlines (e.g., dredging, channelization, hydrologic modifications) exacerbate or accelerate disturbance response times, mainly by altering patterns of sediment distribution (Needelman et al. 2012). In areas where wetlands are bordered by natural uplands, they will be able to migrate inland, as uplands are eventually converted to intertidal habitats. However, in developed urban areas, natural shorelines landward of coastal marshes are rare, and marshes are unable to migrate (Titus et al. 2009). This phenomenon has been previously described as "coastal squeeze" and has been implicated in the loss of considerable acreage of salt marsh in the U.S. and elsewhere (Yozzo et al. 2000, NWF 2011). Existing low-elevation marsh areas will convert to mud or sand flats; some of these areas may eventually provide suitable habitat for eelgrass colonization or eelgrass restoration efforts.

A proposed solution to "coastal squeeze," along the U.S. East Coast and elsewhere, is to selectively allow marshes to migrate landward in the face of rising sea level by abandoning or relinquishing low-lying coastal properties, a strategy referred to as "managed retreat" or "managed re-alignment." This is a controversial management approach, but one which has received increasing attention in recent years as a coastal resource management option (Yozzo et al. 2000). While the idea of promoting or enhancing the opportunity for coastal wetlands to migrate or retreat in the face of advancing sea level rise is appealing, very few opportunities exist within the HRE to abandon land to accommodate this process without loss of valuable infrastructure or public services (e.g., rail or road infrastructure). Also, the current predicted sea level rise rates for the HRE region are likely to exceed the time frame in which meaningful coastal landform migration can take place (Needelman et al. 2012).

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.

The NYC CWP also emphasizes and encourages non-structural alternatives for the protection of sensitive coastal areas, including beach and dune construction, and the development of "living shorelines," which are more resilient and adaptable under uncertain climate change scenarios (NYC 2011). Living shoreline projects also provide ecosystem functions that are not available from traditional shoreline armoring techniques. Examples of living shoreline approaches include the construction of oyster reefs and mussel beds and the use of salt marsh and or riparian plantings along eroding river/estuary banks (NWF 2011). The feasibility of these techniques needs to be assessed on a site-specific basis prior to implementation in lieu of traditional shore protection structures.

In its June 2013 report, A Stronger, More Resilient New York, the NYC Special Initiative for Rebuilding and Resiliency (SIRR) provided specific strategies to minimize future storm damage from wave impacts, including the establishment of natural features. Storm-surge modeling completed for the SIRR indicates that when placed appropriately, ***Wetlands***, ***Oyster Reefs***, and living shorelines (including ***Coastal and Maritime Forests***) have wave-attenuating properties. The report recommends establishing these TECs in Jamaica Bay, Tottenville in Staten Island, Bay Ridge Flats, along the Arthur Kill and Kill Van Kull, and along Long Island Sound (NYC 2013).

Recommendations for large scale wetland restoration in the HRE include prioritizing restoration opportunities that are likely to survive the upper range of predicted increases in sea level rise by 2100 in order to recoup lost ecosystem services and function and to enhance sustainability. Individual projects, where feasible, should be designed to allow wetlands and other coastal landscape features to migrate inland by removing structures and fill or by prohibiting construction on the landward fringe of restored wetlands (Kirshner et al. 2008, Titus et al. 2009). Efforts should be made to dismantle obsolete shore protection structures in favor of living shoreline approaches, especially in areas with relatively low population and infrastructure densities (e.g., city/state/Federal parks and recreation areas). It will also be essential to examine how relatively undisturbed reference wetlands within the HRE have responded historically to extreme weather events.

2.6 Restoration Efforts

Ecosystem restoration and conservation programs have existed in the HRE study area for decades and many of these efforts have been successful. Prior to 1990, restoration programs coordinated by state governments and local organizations focused on habitat protection by acquiring land with ecologically important habitats and protecting public lands from development. Land acquisition of wetlands and other valuable open spaces still regularly occur in NYC, Long Island, and northeastern New Jersey, and some programs are supported through public funding and legal settlements from parties responsible for discharges and spills (NYSDEC 2008, NJDEP 2008). For example, the Green Acres Program in New Jersey is working to achieve a system of interconnected open spaces to enhance New Jersey's natural environment, and in New York, the State Environmental Protection Fund (EPF) provides funding to purchase lands to be included in state parks and preserves.

In 2001, the PANYNJ established a $60 million program to acquire and preserve ecologically valuable tracts of land around agency facilities in New York and New Jersey. The program is designed to help the PANYNJ balance its redevelopment plans with the need to protect critical habitats and waterfront areas for public use. The HRERP has protected approximately 393 acres (1.19 kilometers^2) of habitat from development since its inception. In 2014, the PANYNJ reauthorized the HRERP for the next 10 years and committed $60 million to acquire valuable land.

Between 2009-2014 roughly $240 million was spent on habitat restoration, nearly 500 acres (2.02 kilometers^2) were acquired for conservation and/or public access purposes, and over 500 acres (2.02 kilometers^2) of new parks or public spaces were either designated or opened for public access purposes along the HRE waterfront (Boicourt 2015). However, much more funding and progress is required to meet 2020 and 2050 goals for all targets. A study by Alderson and Bowers found that roughly one quarter of restoration projects were paid for through Natural Resource Damages, mitigation, or other permit requirement or settlement, suggesting that the full picture of habitat gained is more nuanced (Alderson and Bowers 2012).

For the past two decades, HRE stakeholders have also adopted a proactive approach to conservation. Current programs often consist of physically altering areas and re-creating upland, wetland, and aquatic habitat to bring the habitat closer to its original condition. Several factors have led to an increase in restoration programs in the HRE study area, such as funding availability, incorporating restoration considerations into resource management programs, the expansion of restoration ecology and scientific information, and increased stakeholder awareness.

2.6.1 Ongoing Restoration Programs in the HRE

Many large-scale aquatic restoration programs coordinated by state and Federal agencies and NGOs in the HRE study area are in the planning stage. Several USACE feasibility studies have evolved from the HRE Ecosystem Restoration Study authority (1999), including the Lower Passaic River, Hackensack Meadowlands, and Gowanus Canal. Ecosystem Restoration Feasibility Studies were also initiated on the Bronx River in 2003, Flushing Bay and Creek in 1999, and Jamaica Bay in 1996. With the exception of the HRE-Gowanus Canal Study, which was suspended following the river's designation on the Superfund National Priorities List, each study was advancing with their local sponsors including the NJDOT, the New Jersey Sports & Exposition Authority (formerly New Jersey Meadowlands Commission [NJMC]), the NYCDEP, NJDEP, the PANYNJ, and Westchester County Planning. However, through the USACE's Civil Works Transformation and use of SMART Planning principles, it became apparent that these studies and their recommendations should be integrated and included in the HRE Ecosystem Restoration Feasibility Report.

While the above feasibility studies were in progress, the USACE had significant success completing the construction of key restoration projects at Gerritsen Creek, Soundview Park, and the Jamaica Bay Marsh Islands. The USACE seeks to beneficially use dredged material from their navigation program to create a variety of habitats including wetlands, upland habitat, intertidal mudflats, and reefs to the greatest extent possible. Restoration at Elders Point (East and West), Yellow Bar Hassock, Black Wall, and Rulers Bar Marsh Islands are examples of a successful use of dredged material to counter the extensive habitat losses in Jamaica Bay.

There are many other encouraging examples of local and regional ecological restoration within the HRE. For example, the NYC Department of Parks and Recreation's (NYCDPR's) Natural Resources Group (NRG) has several acquisition and restoration sites throughout the HRE study area, encompassing over 1,000 acres (4 kilometers^2) of protected land (NYCDPR 2008). The NYCDEP Office of Ecological Services looks for opportunities to maximize the habitat value of reclaimed lands and mitigation projects. The office has created diverse upland habitats on former landfill sites and has restored more than the required acreage of compensatory mitigation projects to increase the success of the restoration efforts. The NY/NJ Baykeeper offers many programs ranging from habitat restoration to conservation and advocacy programs that protect or save lands (NY/NJ Baykeeper 2007). Several decades of data collected by the NYC Audubon have been essential to protecting heron species and their rookeries in the HRE study area (Kerlinger 2004, Bernick 2006). Some examples of Federal, state, and local restoration programs within the HRE study area are highlighted in Table 2-2.

Table 2-2 Current Restoration Programs and Projects

KeySpan Corporation Marsh Restoration Project in Staten Island, NY

USACE, PANYNJ

Status: Constructed

Website: http://www.nan.usace.army.mil/media/factsheets/factsheetarticleview/tabid/11241/article/487669/fact-sheet-salt-marsh-mitigation-project-at-keyspan-corporation-site-staten-isl.aspx

Nine acres (0.04 kilometer^2) of tidal marsh were restored adjacent to the Keyspan Corporation facility in Staten Island, NY. The project was constructed to mitigate for potential shallow water impacts resulting from the deepening of the Arthur Kill Channel.

South Bronx Greenway – Hunts Point Landing Project, NY

NYCEDC

Status: Constructed

Website: http://www.nycedc.com/project/south-bronx-greenway

The South Bronx Greenway creates sustainable connections between the waterfront and the residential and business communities in the Hunts Point peninsula in the south Bronx. Hunts Point Landing is a new public open space located along the Greenway at the southern end of the Hunts Point peninsula, adjacent to the former Marine Transfer Station site. Hunts Point Landing includes a new fishing pier, ecological restoration through tidal pools, a kayak launch, and passive recreational areas.

Woodbridge Creek Restoration and Mitigation Project, NJ

USACE, PANYNJ, NOAA, and NJDEP

Status: Constructed

Website: http://www.nan.usace.army.mil/Portals/37/docs/harbor/Harborfact/FS_Woodbridge_FEB_2013.pdf

This project includes tidal wetland restoration and preservation to reconnect nearly 70 acres (0.28 kilometer^2) of healthy existing and newly created wetlands to the Arthur Kill and provide public access and educational nature trails.

Waterfront Alliance

Status: On-Going

Website: http://www.waterfrontalliance.org/

Composed of hundreds of civic organizations, public agencies, companies, utilities, and community groups, the Waterfront Alliance is working to transform the waterways of the HRE to make the waters of NYC cleaner and more accessible. Coordination with diverse stakeholders has resulted in creating a clear agenda of action.

Long Island Sound Study, NY

Save the Sound, NOAA, USEPA, USFWS, CTDEP, NYSDEC, and NYCDEP

Status: On-Going

Website: www.longislandsoundstudy.net

Part of the National Estuary Program, this program is a collaborative effort to protect and restore degraded fish and wetland habitat. Particular focus is given to hypoxia, habitat restoration, public involvement and education, and water quality monitoring.

Joseph P. Medwick Park Restoration Project, NJ

USACE, PANYNJ, in partnership with Middlesex County, NJ, Department of Parks and Recreation

Status: Constructed

Website: http://www.nan.usace.army.mil/Portals/37/docs/harbor/Harborfact/FS_carteret_FEB_2013.pdf

Approximately 14 acres (0.06 kilometer^2) of tidal wetlands were restored in the northern portion of Joseph P. Medwick Park along the southern shore of the Rahway River, Rahway, NJ. The project was constructed to mitigate for potential shallow water impacts resulting from the deepening of the Arthur Kill Channel.

Citywide Combined Sewer Overflow Dredging Project, NY

NYCDEP

Status: On-Going

Website: http://www.nyc.gov/html/dep/html/cso_long_term_control_plan/index.shtml

Under the CSO Dredging Program, the NYCDEP is dredging contaminated sediments from poorly flushed waterbodies to improve water quality and habitat. Hendrix Creek was dredged to remove the CSO mounds in 2011. The following waterbodies will also be dredged as a part of this program: Paerdegat Basin, Gowanus Canal, Flushing Bay, Flushing Creek, Bergen Basin, Thurston Basin, Fresh Creek, and Newtown Creek.

Harbor Herons Project, NY/NJ

New York City Audubon Society and New Jersey Audubon Society

Status: On-Going

Website: http://nycaudubon.org/issues-of-concern/harbor-herons

The Harbor Herons Project, led by the New York City and New Jersey Audubon Societies, conducts annual breeding bird surveys of heron, egret, and ibis colonies in NYC, providing valuable information on their population status and breeding habits.

Table 2-2 (Cont'd). Current Restoration Programs and Projects

Oyster Restoration Research Project (ORRP), NY/NJ

Hudson River Foundation, NY/NJ Baykeeper, USACE, Urban Assembly New York Harbor School, the PANYNJ, NOAA, and many others.

Status: Ongoing

Website: http://www.hudsonriver.org/?x=orrp

The ORRP formed in 2009 to conduct oyster research experiments to determine the feasibility of restoring oysters to the HRE and gain important insights into which restoration methods would be most successful. The partnership successfully constructed six experimental oyster reefs in 2010. These reefs were designed to mimic natural oyster reefs and to allow regular assessment of oyster development and ecosystem functions. Building off of the earlier experiments, the group constructed a 1-acre (0.004 kilometer^2 reef at Soundview Park, Bronx NY in 2012. The ORRP is currently using the reefs to monitor and analyze reef development (health and growth of mollusks; disease and die-off, and predation); base environmental data (water salinity, turbidity, temperature, dissolved oxygen concentrations, nutrient loading); ecosystem development (presence and biological productivity of a reef fish community); and other flora and fauna improvements in water quality. This project also serves as a platform for numerous education and outreach opportunities allowing partners to further engage the public in the oyster restoration effort and the overall ecosystem restoration agenda.

Trust for Public Land

Status: On-Going

Website: www.tpl.org

Since 1972, the Trust for Public Land has protected land from inner cities to wilderness, pioneering new land conservation techniques across the nation. One of TPL's goals is to provide close-to-home nature, and in the 40 years since, TPL has grown into the nation's premier conservation organization creating parks and protecting urban watersheds and habitat.

Waterfront Vision and Enhancement Strategy, NY

NYCEDC, NYCDCP, and the Mayor's Office

Status: On-Going

Website: http://www.nycedc.com/project/waterfront-vision-and-enhancement-strategy

The NYCEDC Waterfront Vision and Enhancement Strategy will create a new sustainable blueprint for the City's more than 500 miles (800 kilometers) of shoreline. Each of the many initiatives under this program includes providing public access to the shoreline for active and passive waterfront recreation as well as ecological enhancements at the water's edge. The program includes 130 projects between 12 City agencies.

Old Place Creek Tidal Wetlands Restoration and Mitigation Project, NY

PANYNJ, USACE, NOAA, USEPA, USFWS, USDA NYSDEC

Status: On-Going

Website: http://www.panynj.gov/press-room/press-item.cfm?headline_id=1321

Studied under the Estuary Restoration Act of 2000, as amended, the site is part of the larger Old Place Creek Wetland, Staten Island, NY and a tributary to the Arthur Kill. Restoration will reinstate tidal flow to a 25-acre (0.10 kilometer^2) remnant salt marsh that is currently isolated from the creek by a berm and overrun by non-native common reed (*Phragmites*). The project was delayed but is now being constructed by PANYNJ as part of mitigation for the Goethals Bridge Replacement Project.

Liberty State Park Restoration Project, NJ

USACE and NJDEP

Status: Pre-construction and Engineering Design (PED)

Website: http://www.nan.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11241/Article/9281/fact-sheet-hudson-raritan-estuary-liberty-state-park-jersey-city.aspx

Restoring natural habitats to the 251-acre (1.02 kilometers^2) interior of Liberty State Park was one of the first restoration studies conducted under the HRE study authority. The project design includes the reintroduction of tidal wetland habitat, protection, and enhancement of freshwater wetlands, native grasslands and maritime forests, and creation of public access trails for the approximately 4.3 million visitors a year. Contingent upon funding, PED could begin at Liberty State Park at any time.

Lincoln Park Wetland Restoration Project, NJ

NOAA, NJDEP, USACE, Hudson County

Status: Constructed

Website: http://www.habitat.noaa.gov/highlights/landfillturnedurbanoasis.html

The Lincoln Park Wetland Restoration Project received Federal Recovery Act funds to restore native salt marsh community and increase public access to a restored urban ecological area. This project restored 42 acres of wetland, stream and salt marsh habitat along the Hackensack River with the 270-acre Lincoln Park in Jersey City, New Jersey.

Table 2-2 (Cont'd). Current Restoration Programs and Projects

Lower Passaic River, NJ Investigation and Feasibility Study for Remediation and Ecosystem Restoration

Coordinated Remediation and Restoration Project: USEPA, USACE, NOAA, USFWS, NJDEP, NJDOT

Status: Remedial Investigation/Feasibility Study

Website: www.ourpassaic.org

The purpose of the study was to develop a comprehensive watershed-based plan for the remediation and restoration of the Lower Passaic River Basin. Overall goals included remediation of sediment contamination, improvement of water quality, restoration of degraded shorelines and habitat, creation of new habitat and improvement of human uses along a 17-mile (27-kilometer) stretch of the Lower Passaic and in several tributaries from Dundee Dam to Newark Bay. The Final Remedial Investigation Report and Focused Feasibility Study were issued in 2014. The USEPA issued the Record of Decision in March 2016. The USACE will recommend a sub-set of restoration opportunities as part of the HRE Feasibility Study and the agencies will also coordinate as part of the Urban Waters Federal Partnership program.

New York City Department of Environmental Protection

Status: On-going

Website: www.nyc.gov/dep

The NYCDEP leads many restoration efforts to protect and improve water quality and the NYC water supply. Related efforts include creating a mosaic of salt marsh and upland habitat at Alley Creek in Queens, NY and helping to implement the Jamaica Bay Watershed Protection Plan (2007). In addition, NYCDEP plans to be the construction sponsor with the USACE for restoration actions on the Bronx River and Jamaica Bay.

Contamination Assessment and Reduction Project (CARP), NY/NJ

HRF, PANYNJ, NJDOT, NYSDEC, NJDEP, USACE, USEPA, USGS, Environmental Defense, multiple universities, and research groups

Status: On-Going

Website: www.carpweb.org/main.html

The CARP formed in 1997 to identify and quantify the sources of contaminants causing dredged material disposal problems and to determine the length of time needed for dredged material to meet ocean disposal criteria (HARS suitability). An additional goal was to predict the impact of planned sediment remediation activities on the timeline, and to recommend additional actions to decrease the time needed for future dredged sediments in the Harbor to be "clean" enough to meet ocean disposal criteria. The project produced a suite of state-of-the-science contaminant fate and transport models, collectively called the CARP model. The model forecasted that over the next 30 years, many of the current contaminants of concern in dredged material were expected to decrease to levels that would allow ocean placement, but PCBs and dioxins would continue to be a problem without large-scale remedial actions. In 2016, the NJDOT requested proposals for a research team to lead an effort to update and refine the CARP results focusing on the next 15-year and 25-year horizons.

Soundview Park Ecosystem Restoration Project, NY

USACE, NYC Department of Parks & Recreation, NRG

Status: Constructed

Website: http://www.nan.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11241/Article/14743/fact-sheet-soundview-park-bronx-new-york.aspx

The project involved restoring aquatic resources and adjacent upland habitats in southern Soundview Park to improve water quality through nutrient removal, sediment trapping, and providing habitat for fish species. Approximately 3.7 acres (0.01 kilometer^2), formerly dominated by common reed (*Phragmites*) and debris was restored into a vegetated tidal wetland immediately north of the park's lagoon area. An additional 15 acres (0.06 kilometer^2) of coastal forest and grassland were restored surrounding the wetland.

Hudson River Habitat Restoration (HRHR) Feasibility Study, NY

USACE, NYSDEC, NYSDOS, and "Partners Restoring the Hudson"

Status: On-going Study

Websites: http://thehudsonweshare.org/ and http://www.nan.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11241/Article/566424/fact-sheet-hudson-river-habitat-restoration.aspx

The HRHR Feasibility Study was initiated in 1996 to investigate restoration opportunities within 140 miles of the Hudson River from the Tappan Zee Bridge (upstream boundary of HRE) to the Federal Troy Lock and Dam. Activities were suspended in 2002 and were formally resumed by the USACE in 2016. The USACE will work with the non-federal sponsors and the "Partners Restoring the Hudson" on the development of the Hudson River Comprehensive Restoration Plan (to complement this HRE CRP) and prepare a Feasibility Study that will recommend restoration projects for construction authorization.

Table 2-2 (Cont'd). Current Restoration Programs and Projects

Hudson River Estuary Program, NY

NYSDEC

Status: On-going

Website: www.dec.ny.gov/lands/4920.html

The Estuary Program protects and improves the natural and scenic Hudson River watershed. The program was created in 1987; its work focuses on the tidal Hudson and its adjacent watershed from the Federal Troy Lock and Dam to upper New York harbor. Its core mission is to: ensure clean water; protect and restore fish, wildlife and their habitats; provide water recreation and river access; adapt to climate change; and conserve the world famous scenery.

Bridge Creek Wetland Restoration Project, NY

NOAA and NYSDEC

Status: Constructed

Website: http://www.publicaffairs.noaa.gov/releases2006/apr06/noaa06-r110.html

This project on Staten Island is part of a larger effort to restore degraded wetland habitat, remove invasive species, and preserve existing wetlands and uplands using NRDA funds from the 1990 oil spill in the Arthur Kill. The project restored 10 acres (0.04 kilometer^2) of wetlands creating habitat for nearshore and inshore finfish, crabs, ocean bottom invertebrates, and various waterfowl near the Arthur Kill.

American Littoral Society's Coastal Habitat Restoration Program

Status: On-Going

Website: www.LittoralSociety.org

ALS provides community-based restoration of habitats important to the coast, spanning from Jamaica Bay to Delaware Bay as well as in Sarasota Bay, Florida. Project examples within the HRE include Jamaica Bay Clean Sweep, Shrewsbury Island Marsh Restoration Project, NJ Living Shorelines Initiative, the Shadow Lake Fishway and the community planting effort at Black Wall and Rulers Bar Marsh Islands.

The Urban Divers Estuary Conservancy, NY

Status: On-Going

Website: http://www.thebx.net/info/_organizations_urbandivers.php

The Urban Divers Estuary Conservancy is a not for profit environmental and cultural organization committed to active participation in the restoration, revitalization, restoration, protection, as well as a commitment to public education for our coastal resources (rivers, oceans, marine wildlife, green open spaces).

Passaic River Coalition, NJ

Status: On-Going

Website: http://www.passaicriver.org/

The Passaic River Coalition has been working since 1969 to improve the Passaic River watershed by gathering and using pertinent data to protect drinking water, preserve sensitive wildlife habitat, improve water quality, create new open space, and promote natural flood control management. This organization has led or participated in many initiatives, including: Lower Passaic River Restoration Initiative, New Jersey's watershed management area (WMA) programs, Blue Acres Program to reduce flood conditions, and a Land Trust to acquire properties of ecological significance and unique landscape character for water resource protection.

Hackensack Riverkeeper Programs Hackensack Riverkeeper, Inc., NJ

Status: On-going

Website: www.hackensackriverkeeper.org

Hackensack Riverkeeper, Inc. carries out its mission through a combination of both formal and informal environmental education projects focused on raising the level of awareness and sensitivity of the people of the Hackensack River watershed. Hackensack Riverkeeper, Inc. also advocates the responsible restoration and conservation of the various fish and wildlife habitats that exist within the watershed.

New York – New Jersey Harbor Coalition

Status: On-Going

Website: http://www.harborcoalition.org/press-room-updates/tag/mwa

The NY-NJ Harbor Coalition is a campaign of local and national advocacy organizations focused on transforming our region's waterways into a truly world-class harbor and estuary with waterfront parks, ecological health, and critical infrastructure to meet the economic, environmental, and recreational needs of the residents.

Oyster Reef Restoration/Gardening Program, NY/NJ

NY/NJ Baykeeper

Status: On-Going

Website: www.nynjbaykeeper.org

The NY/NJ Baykeeper's Oyster Restoration Program focuses on repopulating the New York and New Jersey bays with oysters and creating sustainable habitat in order to monitor and improve the health of the estuary's ecosystem. Baykeeper was able to secure a protected area at Naval Weapons Station Earl and in 2011. Baykeeper and the Rutgers Center for Urban and Environmental Sciences (CUES) initiated preliminary oyster survivability studies.

Table 2-2 (Cont'd). Current Restoration Programs and Projects

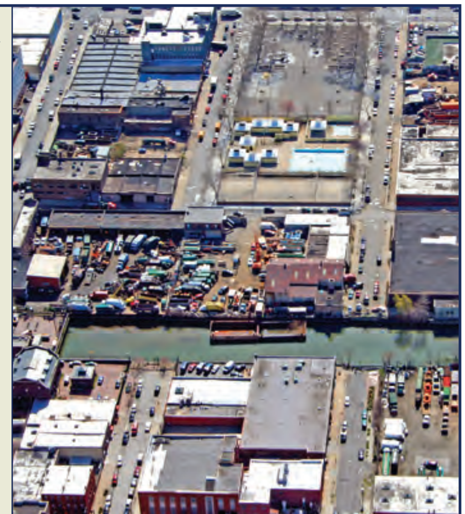
Gowanus Canal Remedial Investigation and Feasibility Study, NY

USEPA

Status: Remedial Investigation/Feasibility Study

Website: www.epa.gov/region2/superfund/npl/gowanus

Investigatory work is underway at the former Fulton MGP and Former Citizens Gas Works MGP and contaminated soils have been removed from the former Metropolitan Gas Light Company MGP. A Feasibility Study was released to the public on December 30, 2011. In September 2013, USEPA issued a Record of Decision to address the contamination in the Canal. Following clean up of the Gowanus Canal by USEPA, ecosystem restoration may take place including wetland creation and water quality improvements in confined waterways.



Newark Bay, NJ Remedial Investigation and Feasibility Study

USEPA

Status: Remedial Investigation/Feasibility Study

Website: www.epa.gov/region02/superfund

The USEPA has been studying the 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. The Newark Bay Study Area includes the bay and portions of the Hackensack River, the Arthur Kill and the Kill Van Kull.

PANYNJ Hudson Raritan Estuary Resources Program

Status: On-going

Website: http://www.panynj.gov/about/coastal-eco-systems.html

In 2001, the PANYNJ established a $60 million fund to acquire and preserve ecologically valuable tracts of land around agency facilities in New York and New Jersey. The program is designed to help the Port Authority balance its redevelopment plans with the need to preserve critical habitats and waterfront areas for public use. The PANYNJ acquired approximately 400 acres, 18 ecologically valuable sites, for preservation within the HRE between 2004 and 2015. In 2014, PANYNJ committed an additional $60 million to acquisition of valuable land.

NYC Department of Parks and Recreation's Natural Resources Group Restoration Program

Status: On-Going

Website: www.nycgovparks.org/greening/natural-resources-group/restoration-sites

The Natural Resources Group, which is a division of the Parks Department, has pioneered the field of urban ecological restoration and acquired natural lands, stabilized eroding shorelines, and conducted restoration programs throughout NYC, including on-going maintenance and management of restored sites. Several programs are specifically focused on coastal restoration, and will add and enhance over 200 acres (0.81 kilometer^2) of critical estuarine and adjacent habitat. NYCDPR also plans to be the construction sponsor with the USACE for restoration actions on the Bronx River and Jamaica Bay.

Gowanus Canal Community Development Corporation, NY

Status: On-Going

Website: www.gowanus.org

The Gowanus Canal Community Development Corporation (GCCDC) is a neighborhood preservation non-profit organization dedicated to the revitalization of the Gowanus Canal area in Brooklyn for the past 29 years. The community-based group has an extensive record of initiatives and involvement in the physical improvement of the Gowanus Canal and the surrounding communities. GCCDC's efforts are focused on the environmental remediation of the Gowanus Canal, housing, economic development, and commercial revitalization.

Table 2-2 (Cont'd). Current Restoration Programs and Projects

Bronx River Alliance, NY

Status: On-Going

Website: www.bronxriver.org

The Alliance, composed of Federal, state, and local organizations, serves as a coordinated voice to protect, improve, and restore the river. Together with NYCDPR, they prepared an Ecological Restoration and Management Plan, the Bronx River Greenway Plan, and the Bronx River Inter-municipal Watershed Plan that offers a comprehensive view of the restoration of the Bronx River and the parks along its banks. They also coordinate outreach, education, and recreation programs and are involved in the Urban Waters Federal Partnership for the Bronx and Harlem Rivers.

Spring Creek (South), NY

NYSDEC, USACE, NPS, FEMA

Status: Plans and Specifications

Website: http://www.dec.ny.gov/about/104426.html

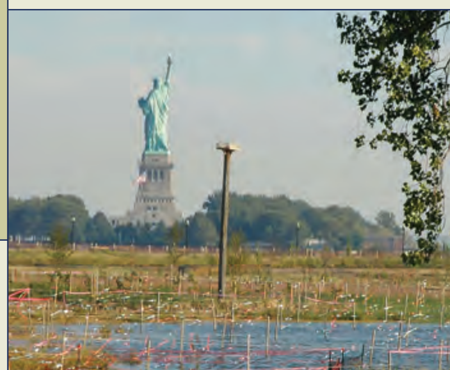
Spring Creek (South) is a 240-acre (0.97-kilometer^2) restoration site located to the north of Jamaica Bay that is owned by the National Park Service. NYSDEC was awarded funding through the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Grant program in 2013 to prepare designs/permits (Phase 1) and construction (Phase 2; upon FEMA approval). NYSDEC has contracted the USACE to provide project management and technical services. Original ecosystem restoration designs consisting of high and low marsh, berm and maritime forest will be modified to serve as natural/nature based features providing flood storage and wave attenuation aiding in managing the flood risks for the Spring Creek community.

Friends and Residents of Greater Gowanus, NY

Status: On-Going

Website: http://froggbrooklyn.org/

FROGG is a community based grass-roots organization advocating for environmentally sound community planning for the Gowanus Canal neighborhoods. They work to see the Gowanus Canal brought back to life with water quality standards that sincerely meet state standards for fishable and contact use; not only for the community but also for local wildlife.



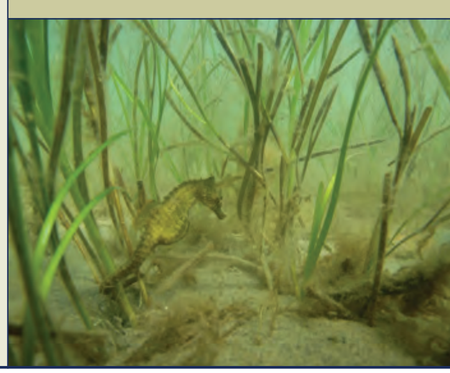
New York City Pier Restoration, NY

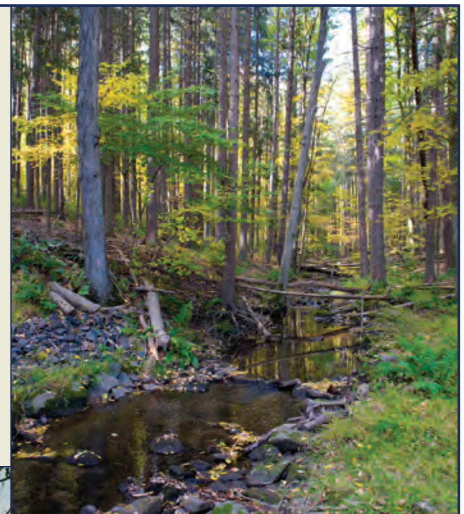
Hudson River Park Trust, HEP, Patagonia Soho, NYU, Harbor Estuary Stewardship Program

Status: On-Going

Website: http://www.hudsonriverpark.org

The dilapidated piers are being reconstructed into public spaces for mixed uses, including lawn/garden areas, scenic overlooks, playgrounds, athletic fields, event space, community docks, historic resources, and educational and research facilities. The 550-acre (2.23 kilometers^2) park is 70 percent complete with 13 reconstructed piers and dozens of landscaped acres.





Harbor and Estuary Program, NY/NJ

Hudson River Foundation, USEPA, USACE, PANYNJ, NY, NJ, Local Government, NGOs.

Status: Planning

Website: www.harborestuary.org

Established as a partnership of federal, state, and local governments; scientists; civic and environmental advocates; and educators under the National Estuary Program, the HEP and its partners work together to protect and restore healthy waterways and productive habitats, manage sediments, foster community stewardship, engage the public, and improve safe public access to our waterways. HEP and its Restoration Work Group have provided overall program direction for the Hudson-Raritan Estuary Comprehensive Restoration Plan.

Raritan Riverkeeper, NJ

NY/NJ Baykeeper

Status: On-Going

Website: http://nynjbaykeeper.org/resources-programs/raritan-riverkeeper/

The Raritan Riverkeeper, as a program of Baykeeper, stops polluters, champions public access, and influences land use decisions. The Riverkeeper pursues opportunities for land preservation and habitat restoration, and partners with other groups to advocate for the Raritan River's environmental importance, as well as its value as a recreational and cultural resource.

2.6.2 Response to Hurricane Sandy

Immediately after Hurricane Sandy, Federal, state, and local agencies, as well as civic and academic organizations, evaluated the devastating impacts and provided recommendations to repair the damage and increase resiliency for future storms. Significant coordination was required to ensure a comprehensive response and eliminate redundancies in current and proposed programs. Programs developed in response to Hurricane Sandy are summarized in Table 2-3. Responses from Hurricane Sandy described within this chapter focus on ecological resources within the HRE, not on repairing the extensive damage to the communities and personal property within the region.

On November 15, 2012, Governor Andrew Cuomo convened the NYS2100 Commission in response to Sandy, Hurricane Irene, and Tropical Storm Lee. The Commission released a report with recommendations that include identifying and assessing long-term options for the use of "hard" barriers and natural systems to protect coastal communities (NYS 2013).

In December 2012, NYC Mayor Michael Bloomberg announced the formation of the Special Initiative for Rebuildling and Resiliancy and charged it with producing a plan to provide additional protection for New York's infrastructure, buildings, and communities from the impacts of climate change. The SIRR report acknowledges that the greatest risk to coastal areas in NYC is storm surge. The report recommends that the strategy for coastal protection focus on 37 specific initiatives and includes selected locations for each initiative which NYC now tasked the Mayor's Office of Resiliency and Recovery to advance. Five of these initiatives were related to ecosystem creation or restoration actions within the HRE.

On January 29, 2013, in response to major damages associated with Sandy, Congress passed The Disaster Relief Appropriations Act – 2013 (commonly referred to as the Sandy Aid Bill or Public Law [PL] 113-2). The legislation provided supplemental appropriations to address damages caused by Hurricane Sandy and to reduce future flood risk in ways that will support the long-term sustainability of coastal ecosystems and communities and reduce the economic costs and risks associated with large-scale flood and storm events. The Act directed the USACE to:

1. Advance near-term coastal restoration (i.e., replacing sand onto beaches previously engineered by the USACE that were severely impacted) for "Constructed Projects" or "Projects Under Construction" as outlined in the First Interim Report (March 11, 2013). The Flood Control and Coastal Emergencies (FCCE) Act, PL 84-99, was used to repair previously constructed projects (i.e., return the project area to pre-storm conditions) and funds from the Disaster Relief Act would be used to restore previously constructed projects to their original design profile.
2. Identify and advance studies (either Authorized But Unconstructed [ABU], or ongoing) outlined in Second Interim Report (May 30, 2013) "for reducing flooding and storm damage risks in the affected area, including updated construction cost estimates, that are, or would be, consistent with the comprehensive study."
3. Conduct a comprehensive study known as the NACCS to address the flood risks of vulnerable coastal populations in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the USACE.

Table 2-3 Examples of Coastal Restoration Responses to Hurricane Sandy within the Hudson-Raritan Estuary (HRE) study area

U.S. Army Corps of Engineers (USACE)

Sandy Disaster Relief Appropriations Act (PL-113-2) -
http://www.gpo.gov/fdsys/pkg/PLAW-113publ2/pdf/PLAW-113publ2.pdf

Supplemental appropriations to address damages caused by Hurricane Sandy and to reduce future flood risk that will support the long-term sustainability of the coastal ecosystem and communities, and reduce the economic costs and risks associated with large-scale flood and storm events. Current estimate of USACE Coastal Restoration Program within New York District is $3.2 billion including Repair of 8 Constructed Projects per Flood Control Coastal Emergencies (FCCE) Act, PL 84-99; 29 Operations and Maintenance Projects; 7 Authorized Ongoing Construction Projects; 4 Authorized but Unconstructed Projects (ABU), 11 Ongoing Studies; and 3 Continuing Authorities Program (CAP) Projects. NOTE: total program is for projects within the NY District not just HRE Study Area.

Report: Interim Report 1 (March, 2013)
http://www.nad.usace.army.mil/Sandy.aspx

Funding: $221.7 Million

(Repair of Constructed Projects per FCCE Act, PL 84-99 and Restoration of Constructed Projects per PL- 113-2)

Projects within HRE include:
- East Rockaway Inlet to Rockaway Inlet
- Atlantic Coast of New York City, Rockaway Inlet to Norton Point (Coney Island), NY
- Oakwood Beach, NY
- Raritan Bay and Sandy Hook -Section 506 (Keansburg)
- Sandy Hook to Barnegat Inlet, NJ (Seabright to Ocean Township and Asbury Park to Manasquan Inlet)

North Atlantic Coast Comprehensive Study (NACCS) -
http://www.nad.usace.army.mil/CompStudy.aspx

Funding: $19.5 Million (Maine to Virginia) -

Goals of the NACCS are to provide coastal storm risk management strategies and promote coastal resilient communities and robust, sustainable coastal landscape system (considering future sea level rise and climate change scenarios) to reduce risk to vulnerable coastal populations, property, ecosystems, and infrastructure. Study provides a Regional Coastal Framework that identifies: opportunities, potential solutions and parametric costs by region/state; activities warranting additional analysis; and barriers to providing comprehensive protection to affected coastal areas.

Report: Interim Report 2 (May, 2013) -
http://www.nad.usace.army.mil/Sandy.aspx

Funding: $1.101 Billion Projected Construction of Authorized But Unconstructed (ABU) Projects

$11.5 Million – Ongoing Studies

Projects included in Report 2 within the HRE ONLY:

Authorized but Unconstructed Projects
- Passaic Main Stem, NJ (Passaic River and Newark Bay upstream to the Dundee Dam)
- Raritan Bay to Sandy Hook Bay, Port Monmouth, NJ
- Raritan Bay to Sandy Hook Bay, Union Beach, NJ
- South River, Raritan River Basin, NJ
- Atlantic Coast of New York City, Rockaway Inlet to Norton Point, NY (Coney Island)
- East Rockaway Inlet to Rockaway Inlet and Jamaica Bay, NY (Reformulation Study)/also Ongoing Study)
- Joseph G. Minish Waterfront Park and Historic Area, NJ

Ongoing Studies
- Rahway River Basin, NJ
- Raritan Bay to Sandy Hook Bay, Highlands, NJ
- Raritan Bay to Sandy Hook Bay, Leonardo, NJ
- Shrewsbury River & Tributaries, NJ
- South Shore of Staten Island, NY
- North Shore of Long Island, Bayville, NY
- Continuing Authorities Program - McClellan Pier, Hudson River, NY (Section 14)

Table 2-3 (Cont'd). Examples of Coastal Restoration Responses to Hurricane Sandy within the Hudson-Raritan Estuary (HRE) study area

U.S. Department of Interior

Sandy Disaster Relief Appropriations Act

http://www.doi.gov/news/pressreleases/upload/2013_05_06-Hurricane-Sandy-Plan-Sm.pdf

Funding: $271 Million - New York;
$42 Million - New Jersey;
$104 Million New York & New Jersey

Hurricane Sandy Coastal Resiliency Competitive Grants Program -

http://www.nfwf.org/hurricanesandy/Pages/home.aspx

Funding: $100 Million (TBD amount within HRE)

National Fish and Wildlife Foundation (NFWF) administered program that supports projects that reduce community's vulnerability to the growing risks from coastal storms, sea level rise, flooding, erosion and associated threats through strengthening natural ecosystems that also benefit fish and wildlife.

National Park Service/Construction

Funding: $248.6 Million New York; $0.2 Million New Jersey; $74.4 Million New York & New Jersey

Funding for response and recovery for clean up of storm debris and repairs to national park units along the eastern seaboard. Over $150 million of this funding is allocated for storm response and recovery at Gateway National Recreation Area total. Much of this funding is to restore critical park infrastructure, including public access facilities. However, a portion of the funding is allocated to the restoration of natural areas, such removing wreckage and restoring impacted wetland areas and coastlines ($2.7 million) and repairing the breached freshwater West Pond in Jamaica Bay ($1 million).

Bureau of Safety and Environmental Enforcement

Funding: $2.85 Million New Jersey

Funding for repairs and future mitigation measures to prevent or reduce wind and water impacts from future storms at the Ohmsett oil spill research facility in Leonardo, New Jersey.

Hurricane Sandy Rebuilding Task Force - USDOI

DOI's responsibilities include the restoration of coastal natural systems such as wetlands and barrier dunes, protection of critical infrastructure (water treatment, wastewater, emergency responses, etc), economic revitalization (tourism, beach access), and data sharing to understand impacts and vulnerability of our coastal environment.

National Park Service/Historic Preservation Fund

Funding: $16 Million New York; $16 Million New Jersey

Funding for historic preservation grants to States.

National Parks Service/Jamaica Bay Science and Resilience Institute

Funding: $3.6 Million New York

Funding supports the Jamaica Bay Science and Resilience Institute to develop innovative approaches and conduct research that will enhance understanding of resilience in the urban, coastal ecosystems. The Institute is led by a Consortium of 9 academic organizations led by City University of NY working with Federal, state, local agency partners and stakeholders.

U.S. Environmental Protection Agency (USEPA)

Sandy Disaster Relief Appropriations Act

Funding: $340 Million - New York; $229 Million - New Jersey

Funding for 1) infrastructure resiliency upgrades beyond Federal Emergency Management Agency (FEMA) support for infrastructure repair, as part of the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund; 2) water quality monitoring to evaluate the effects of Sandy on water quality in the coastal zones of NJ and sediment monitoring to support the water monitoring program; and 3) assessment and remediation of Leaking Underground Storage Tanks.

U.S. Department of Housing and Urban Development (HUD)

Rebuild by Design Competition: Winning Proposals Announced June 2, 2014 -

http://www.rebuildbydesign.org

Rebuild by Design is dedicated to create innovative community- and policy-based solutions to protect U.S. cities that are most vulnerable to increasingly intense weather events and future uncertainties. Initiated by HUD and the Hurricane Sandy Rebuilding Task Force, Rebuild by Design's aim has been to connect the world's most talented researchers and designers with the Sandy-affected area's businesses, policymakers and local groups to better understand how to redevelop their communities in environmentally- and economically-healthier ways and to be better prepared.

Table 2-3 (Cont'd). Examples of Coastal Restoration Responses to Hurricane Sandy within the Hudson-Raritan Estuary (HRE) study area

National Oceanic and Atmospheric Administration (NOAA)

NOAA Office of Response and Restoration, U.S. Coast Guard (USCG)

Funding: $140 Million

NOAA's Office of Response and Restoration is working with the U.S. Coast Guard and affected facilities to reduce the impacts of pollution caused by spread oil, hazardous materials and debris in coastal NY and NJ. Motiva Enterprises spill in Sewaren, NJ, Phillips 66 Refinery spill in Linden, NJ, and Kinder Morgan spill in Carteret, NJ were affected areas.

President Obama's Hurricane Sandy Rebuilding Task Force

The Task Force's Rebuilding Strategy Report serves as a model for communities across the nation facing greater risks from extreme weather and to continue helping the Sandy-affected region rebuild. The Rebuilding Strategy contains policy recommendations to ensure entire communities are better able to withstand and recover from future storms.

New York State

NY Rising Governor's Office of Storm Recovery ~

http://stormrecovery.ny.gov/

Funding: $30 Billion

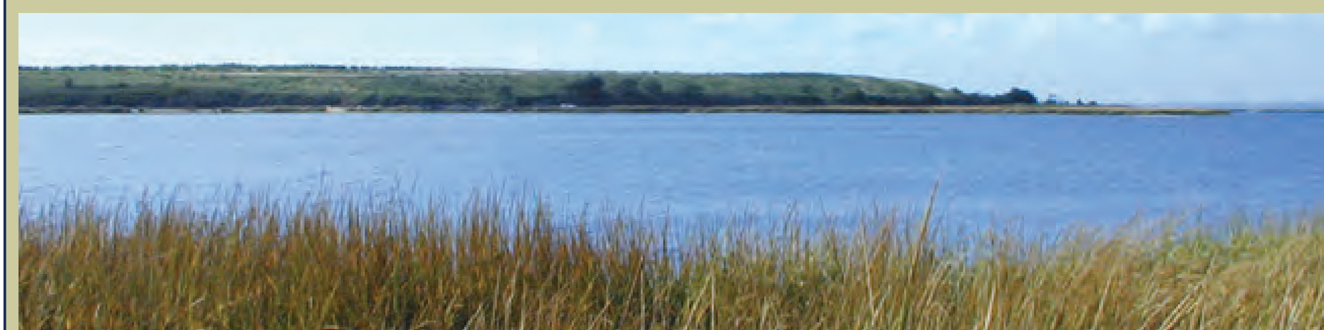
Federal aid for efforts to repair and rebuild from the storm damage; better respond to future disasters; and better protect the state from the impact of future storms. Investments include rebuilding and strengthening critical infrastructure in the areas of transportation, fuel supply, water supply, wastewater treatment systems, electric distribution systems and flood protection systems and building new natural infrastructure (including wetlands, reefs, dunes, and berms to reduce the impact of wave action, storm surges and sea level rise).

New York State Community Development Block Grant Disaster Recovery Program ~

http://www.nyshcr.org/Programs/NYS-CDBG-DR/

Funding: $25 Million

Funding for the preparation of Community's Reconstruction Plan supporting recovery and increased resiliency for communities affected by Hurricanes Sandy and Irene, and Tropical Storm Lee. Regions include Capital Region/North Country/Mohawk Valley, Catskills/Hudson Valley, Long Island, New York City and Southern Tier/Central New York. Planning areas within New York City included Breezy Point, Howard Beach, Lower Manhattan, Red Hook, and Rockaway East and West.



New York State Department of State (NYSDOS) NYS 2100 Commission Report: Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure ~

http://www.governor.ny.gov/assets/documents/NYS2100.pdf

The Commission reviewed the vulnerabilities faced by the State's infrastructure systems, and developed recommendations to increase New York's resilience. Recommendations included: 1) Explore options of natural systems to protect coastal communities against natural disasters such as those seen by Hurricane Sandy (e.g., beaches/dunes); 2) Explore ecological restoration as a cost effective approach to hazard mitigation; and 3) Jamaica Bay Marsh Island Restoration.

State of New Jersey

Department of Community Affairs – Sandy Recovery Division ~

http://www.state.nj.us/dca/divisions/sandyrecovery/

Report: Community Development Block Grant Disaster Recovery Action Plan

Develop a plan for encouraging sustainable community initiatives and implementing green building, energy efficiency and storm hazard mitigation measures.

Table 2-3 (Cont'd). Examples of Coastal Restoration Responses to Hurricane Sandy within the Hudson-Raritan Estuary (HRE) study area

Office of the Mayor of the City of New York

New York City Department of City Planning

New York-Connecticut Sustainable Communities Consortium

Report: Coastal Climate Resilience, Urban Waterfront Adaptive Strategies -

http://www.nyc.gov/html/dcp/html/sustainable_communities/sustain_com7.shtml

Report identifies the range of adaptive strategies that can increase the resilience of urban coastal areas to control hazards associated with sea level rise. These strategies include opportunities for habitat restoration and ecological benefits such as living shorelines, beaches and dunes, constructed wetlands, artificial reefs. floating islands, constructed breakwater islands, and coastal morphology alteration.

PlaNYC,

Special Initiative for Rebuilding and Resiliency (SIRR)

Report: SIRR Report 2013,

A Stronger More Resilient New York -

www.nyc.gov/html/sirr/html/report/report.shtml

Specific Initiatives and recommendations to rebuild New York City and ensure coastal resilient shorelines including installation of wetlands for wave attenuation (#14); creation of living shorelines and floating breakwaters for wave attenuation (#15/17); use of soft infrastructure as flood protection and study innovative coastal protection techniques (#31); and conduct wetland restoration/wetland mitigation banking (#33).

Report: Hurricane Sandy After Action: Report and Recommendations to Mayor Michael R. Bloomberg -

http://www.nyc.gov/html/recovery/downloads/pdf/sandy_aar_5.2.13.pdf

The summary report, prepared by the Office of the Mayor recommends that the NYCDEP create a plan to remove debris, including hazardous materials, from wetlands and beaches.

The NACCS comprehensively evaluated the existing and planned measures to reduce the flooding risk from tidally influenced storm surges, as well as other alternatives for areas at risk to future storm damages. The NACCS identified risk areas, a diverse set of structural, non-structural and programmatic risk reduction and coastal resiliency measures, benefits, planning-level costs, institutional barriers, and areas and activities warranting further analysis. The study identified existing natural protective features, including an evaluation of the performance of these features during Sandy and other recent storms, and considered the performance of these features in reducing the impacts of coastal storm flooding, as well as other impacts at a larger scale and as a system (USACE 2015).

Under the Disaster Relief Appropriations Act of 2013, the USACE works with other Federal, state, and local partners to restore our coastlines and prepare for future storms. The USACE New York District Coastal Storm Risk Management Projects and Studies Map outlines coastal projects throughout the HRE that are in various stages of planning or construction (Figure 2-15).

In 2013, the U.S. Department of Interior (DOI) Hurricane Sandy Coastal Resiliency Competitive Grant Program supported projects that reduce communities' vulnerability to the growing risks from coastal storms, sea level rise, flooding, erosion, and associated threats through strengthening natural ecosystems that also benefit fish and wildlife. Grants were awarded to projects that assess, restore, enhance or create wetlands, beaches and other natural systems to help better protect communities and to mitigate the impacts of future storms and naturally occurring events on fish and wildlife species and habitats.

As part of the competitive grant program, the NFWF and the DOI conducted outreach and workshops to develop a strategic program that aligns ongoing state, city, and local efforts with DOI efforts. The DOI's Executive Council selected projects for

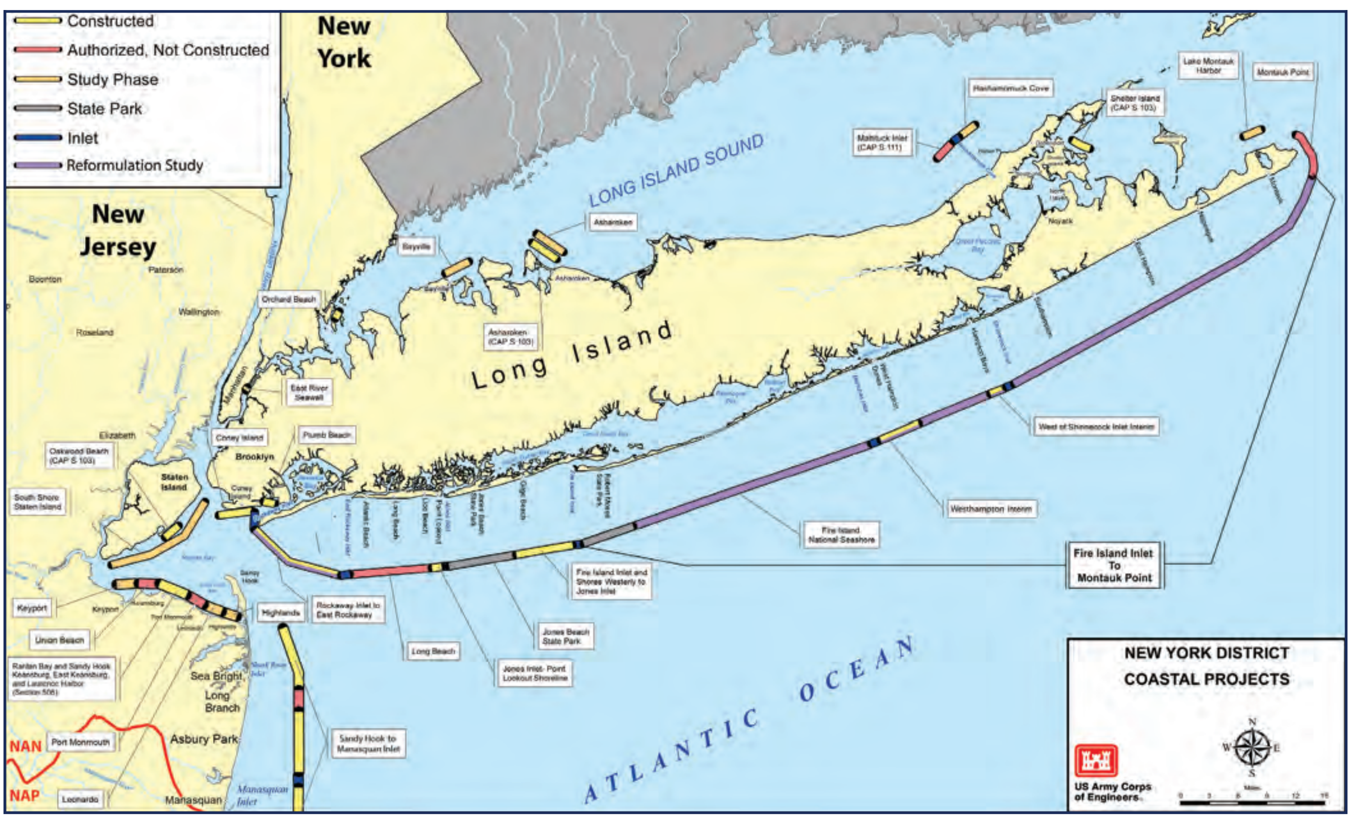


Figure 2-15. NY District Coastal Storm Risk Management Projects and Studies Map.

Rebuild By Design

The destruction of cities, whether man-made or natural, can present unique opportunities to rethink townscapes and communities through architecture. In 2013, in response to Hurricane Sandy's devastation, the U.S. Department of Housing and Urban Development (HUD) launched Rebuild by Design, with organizations including The Institute for Public Knowledge at New York University, The Municipal Art Society, the Regional Plan Association, and The Van Alen Institute. From the 148 international applicants, 10 interdisciplinary teams were selected to compete in Rebuild by Design's year-long process. A common thread among the design projects was the implementation of protective measures to shield communities from stormwater and major flooding events. In 2014, the winning innovative design projects were announced:

- Big U (New York, NY)
- Living with the Bay: A Comprehensive Regional Resiliency Plan for Nassau County's South Shore (Long Island, NY)
- New Meadowlands: Productive City + Regional Park (Meadowlands, NJ)
- Resist, Delay, Store, Discharge: A Comprehensive Strategy for Hoboken (Hoboken, NJ)
- Hunts Point Lifelines (Bronx, NY)
- Living Breakwaters (Staten Island, NY)

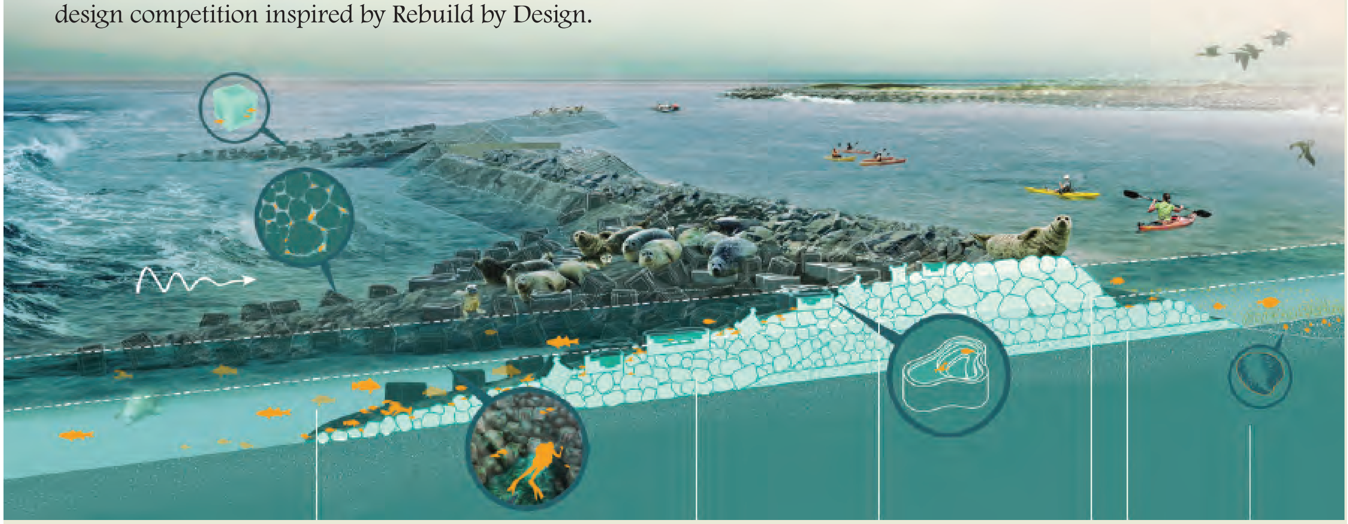
What began as a new design competition after the destruction of Hurricane Sandy has become a model for other processes. In the United States, President Obama launched the National Disaster Resilience Competition in 2014, and in the international sphere, the Global Resilience Partnerships launched a multi-phase resilience design competition inspired by Rebuild by Design.

Big U's vision for world class gardens along the Harbor Berm; Source: http://www.rebuildbydesign.org/project/big-team-final-proposal/

Bridging Berm provides robust vertical protection for the Lower East Side from future storm surge and rising sea levels.
Source: http://www.rebuildbydesign.org/project/big-team-final-proposal/

REBUILDING ECOLOGICAL RESILIENCY

Source: http://www.rebuildbydesign.org/what-is-rebuild-by-design/.



Building Ecological Resiliency: A necklace of breakwaters is proposed along the South Shore to buffer against wave damage, flooding, and erosion.

funding based on criteria and a process developed by DOI's Strategic Sciences Group and project evaluation conducted by a panel of federal technical experts. The program criteria incorporated infrastructure resilience guidelines recommended by the Hurricane Sandy Rebuilding Task Force.

In June 2013, HUD and the Hurricane Sandy Rebuilding Task Force also launched the Rebuild by Design competition. Rebuild by Design was a multi-stage regional design competition to promote resilience for those areas affected by Sandy and innovation by developing solutions that increase resilience in the region, and to implement selected proposals with public and private funding dedicated to this effort. The competition also represented a policy innovation as HUD specifically set aside Community Development Block Grant Disaster Recovery funding to incentivize building the winning projects and proposals. Awarded Rebuild by Design projects have been allocated over $1.1 billion in Federal funding. The Federal government has continued to invest in and recognize the innovations that these projects have brought to the region with the recently announced awards from the National Disaster Resilience Competition. The winning projects were announced in June 2014 (see spotlight project: Rebuild By Design). Additional recommendations and programs were outlined in the Governors' Office of Storm Recovery New York Rising Howard Beach Community Reconstruction Plan.

As noted in many of the post-Sandy recommendations, the regional response to restore coastal resilience and sustainability includes a combination of NNBFs and hard infrastructure improvements to reduce the risk of coastal storm damage and contend with the impacts associated with climate change. The restoration opportunities highlighted in the CRP provide potential locations where ecological restoration can link with engineered projects to support or mimic natural coastal processes, thereby enhancing shoreline resiliency and sustainability. CRP restoration opportunities could also be used to meet potential mitigation requirements for construction impacts. The results of an evaluation to determine which of these sites can serve as NNBFs have been incorporated into the Open Accessible Space Information Systems (OASIS) database.

Greater collaboration among Federal and state agencies and NGOs has been, and always will be, necessary to advance coastal restoration efforts within the HRE. Post-Sandy, the shared vision by restoration partners (including regulatory and resource agencies) should facilitate easier synchronization of these ongoing efforts. There are currently many forums to ensure collaboration and coordination of restoration efforts including the NY/NJ Federal Leadership Resiliency Collaborative, Sandy Regional Infrastructure Resilience Coordination (SRIRC), the Science and Resilience Institute at Jamaica Bay, HEP, and the HEP RWG.

3.0 Target Ecosystem Characteristics

As discussed in Section 1.1, the purpose of the CRP is to provide a master plan for ecosystem restoration in the HRE. This is achieved through the use of TECs to focus restoration goals on distinct actions with measurable objectives (Table 3-1). The TECs were initially developed by a team of estuarine scientists, representatives from Federal, state, and local agencies, and key stakeholders. The TECs represent a consensus of what is desired and achievable, with short- and long-term goals as a basis for gauging overall progress.

The process began with a two-day workshop in October 2005, led by the HRF and the Center for the Environment at Cornell University, to review existing restoration plans and solicit candidate restoration goals and actions (Bain et al. 2007). The multidisciplinary group was composed of approximately 45 people from various Federal, state, and local agencies, NGOs, and national and regional estuarine scientists. The group initially proposed 23 habitat restoration and acquisition actions for the HRE study area.

In early 2006, the group's efforts were synthesized to be consistent with HEP's CCMP. Common elements in candidate restoration actions were merged and actions that would be met indirectly or were actively addressed by other programs were removed. The final 11 TECs were chosen based upon technical merit, relevance to policies within the HRE study area, and feasibility. Once these TECs were developed, documented, and justified by the team, the targets were reviewed by independent scientists and resource or regulatory agency managers. The resulting products were presented at more than 13 workshops and many meetings to further refine each individual TEC. The process of selecting the TECs successfully demonstrated an effective framework for building consensus and defining broad restoration objectives.

The 11 TECs defined specific habitat types, complexes, contamination issues, or societal values that together contribute to the overall program goal of restoring the HRE through the establishment of a mosaic of habitats that provide society with new and increased benefits from the estuary environment. Each TEC was assigned short-term and long-term quantitative objectives (Table 3-1). Each TEC provides a unique range of ecological services and together, all of the TECs cumulatively define the critical habitat and societal needs for the HRE and promote increased biotic diversity, sustainable ecosystem functions, and public access. The TECs provide the basis for a decisive environmental agenda for the estuary as well as a long-term strategy capable of changing with environmental conditions and human needs (Bain et al. 2007). Detailed information about the development of the TECs can be found in Appendix A (including workshops, transcripts, presentations, and technical memoranda).

Once the major objectives were defined, the team searched for potential opportunities to achieve each TEC objective. Coarse GIS data layers related to each TEC goal were identified and applied in a map overlay procedure to identify broad zones of opportunities that met the characteristics of each TEC. The data layers included physical parameters, such as bathymetry, fetch distance, and total suspended solids in the water. Water quality and sediment quality were used for some of the TECs, and land use constraints were also considered.

Table 3-1. Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area, including a list of ecosytem services offered by each TEC.

TEC	2020	2050	Ecosystem Services
Wetlands	Create a total of 1,000 total acres of freshwater and coastal wetland	Continue creating an average of 125 acres per year for a total system gain of 5,000 acres	Climate regulation, Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment, Refugia, Food production, Recreation
Habitat for Waterbirds	Enhance at least one island without an existing waterbird population in HRE regions containing islands and create or enhance at least one foraging habitat	All suitable islands provide roosting and nesting sites and have nearby foraging habitat	Biological control, Recreation, Cultural
Coastal and Maritime Communities	Establish one new maritime forest of at least 50 acres and restore at least 200 acres among several coastal forest/upland habitat	500 acres of maritime forest community among at least three sites and 500 acres of restored coastal forest/upland habitat	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Refugia, Cultural
Oyster Reefs	20 acres of reef habitat across several sites	2,000 acres of established oyster reef habitat	Refugia, Cultural
Eelgrass Beds	Complete a set of two related habitats in each HRE region	Complete four sets of at least two related habitats in each HRE region	Nutrient cycling, Refugia, Cultural
Shorelines and Shallows	Develop new shorelines sites in two HRE regions	Restore available shoreline habitat in three HRE regions	Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment
Fish, Crab, and Lobster Habitat	Complete a set of two related habitats in each HRE region	Complete four sets of at least two related habitats in each HRE region	Biological control, Refugia, Food Production, Recreation, Cultural
Tributary Connections	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Biological control, Refugia, Recreation, Cultural
Enclosed and Confined Waters	Upgrade water quality of eight enclosed waterways	Upgrade water quality of all enclosed waterways	Water regulation, Erosion control & sediment retention, Nutrient cycling, Waste treatment, Food production, Recreation, Refugia
Sediment Quality	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years	Nutrient cycling, Refugia, Cultural
Public Access	Create one access and upgrade one existing access per year	All waters of the HRE are accessible	Recreation, Cultural
Acquisition	Acquire and preserve 1,000 acres of coastal property per year	Acquire and preserve 200 acres of coastal property per year for a total of 6,000 acres.	See above for services provided by TECs that will be acquired and preserved

The data sets used represent the best available spatial data spanning the HRE study area; those data sets that include only a portion of the HRE study area were not incorporated into this analysis. Many of the data sets used in the analysis were developed from satellite imagery and aerial photography of varying age and current accuracy. The existing wetlands layer was developed from the USFWS National Wetlands Inventory (NWI) and incorporates data available as of 2008, although some areas had not been updated for several decades. For this reason, the analyses are applicable at the watershed and regional levels, not at the site-specific level. These preliminary analyses should be used to narrow the potential opportunities and focus attention on the most likely areas for restoring habitat. In many cases, field verification and feasibility investigations will be necessary before proceeding with site-specific project planning. For example, the NY/NJ Baykeeper in cooperation with the Rutgers Center for Urban Environmental Sustainability (CUES) conducted a shoreline mapping investigation of the lower Raritan Bay to identify feasible oyster restoration sites, as described in greater detail below. Additional information on the methods of the GIS analysis is in Appendix B.

In May 2012, the original TEC workshop participants reconvened to discuss the comments obtained from review of the 2009 Draft CRP, identify changes to the TEC Target Statements, and modify short-term and long-term targets. In 2012, a twelfth TEC, ***Acquisition***, was added in response to public comments emphasizing the need to highlight the importance of protecting and preserving existing open and undeveloped lands (Table 3-1). The following sections describe the current status of the TECs in the HRE study area, present the target statements, specify restoration objectives, and identify potential opportunities for restoration and acquisition. A detailed discussion of each TEC, including current research needs, and recommendations for implementation restoration projects and conducting post-construction monitoring, is in Volume II of the CRP.

3.1 Habitats

Four of the TECs represent habitat types that were historically abundant but have been eliminated or significantly reduced in size in the HRE study area. These habitats were deemed essential to the ecology of the HRE and the purpose of these TECs is to restore acreage of these valuable habitats in the HRE study area.

3.1.1 Wetlands

Coastal and non-tidal freshwater wetlands are critical habitat types providing a variety of functions in the HRE. Coastal wetlands, defined as tidally influenced wetlands connected to the open waters, are among the most productive ecosystems on Earth, with measured production rates exceeding those of tropical rain forests and freshwater wetlands (Good et al. 1982). Non-tidal freshwater wetlands can include riparian forested and emergent wetlands along watercourses (including ***Tributaries***), fringing wetlands along lakes and ponds, and isolated wetlands associated with groundwater, seepage, and other hydrologic factors (e.g., vernal pools).

Coastal wetlands are characterized by a distinctive vegetation community. Like many intertidal salt marsh communities today, smooth cordgrass (*Spartina alterniflora*) dominates intertidal salt marsh communities in the HRE study area. This species generally occurs between mean high water and mean sea level and may vary in growth form (i.e., tall, medium, and short), depending on tidal flooding frequency and duration. Above the mean high water (high marsh), the floral composition of salt marshes increases in diversity, with several plant species typically present, including saltmeadow hay (*S. patens*) and salt grass (*Distichlis spicata*). The structure and function of many coastal and freshwater wetlands in the HRE study area have been altered in recent decades by the proliferation of an aggressive European genotype of common reed (*Phragmites australis*) that forms monoculture stands.

Freshwater wetlands can be categorized in terms of the dominant vegetation (e.g., Aquatic Bed, Emergent, Scrub-shrub, and Forested; Cowardin 1979). Aquatic Bed wetlands include permanently or frequently inundated habitats dominated by plants that grow on or below the water surface for most of the growing season. These plants may be rooted or free-floating Emergent wetlands are characterized by the presence of rooted, herbaceous hydrophytes, present throughout the growing season. Scrub-shrub wetlands are characterized by woody vegetation less than 20 feet (6 meters) in height. This may include shrubs and small trees stunted by salinity and flooding. Forested wetlands are characterized by woody vegetation over 20 feet (6 meters) in height, typically with an overstory of trees, an understory of young trees or shrubs, and an herbaceous ground layer. Some of the characteristic plant species found in freshwater wetlands include rushes (*Juncus* and *Scirpus* spp.), sedges (*Carex* spp.), duckweeds (*Lemma* spp.), willows (*Salix* spp.), ashes (*Fraxinus* spp.), and white oak (*Quercus bicolor*).

Freshwater tidal wetlands and freshwater emergent wetlands occur along tidal freshwater rivers (***Tributary Connections***); remnants persist in the Meadowlands (Kiviat and MacDonald 2002), within the tidal freshwater river section in the lower Passaic River (upstream of River Mile 10) (USACE 2008), Lemon Creek on Staten Island, along the fresh reaches of the Raritan River basin, the tidal fresh tributaries of the Hudson River, and the Hudson's main stem from Wappinger Falls north to the Federal Troy Lock and Dam. For this system, low marsh refers approximately to the lower half of the intertidal zone or between mean low water and mean sea level, whereas high marsh refers to the upper intertidal zone between mean sea level and mean high water (USFWS 1997).

Coastal and freshwater wetlands perform a variety of functions including shoreline stabilization, storage of floodwaters, maintenance of surface water quality, groundwater recharge, and sediment retention, 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. Coastal and freshwater wetlands also 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 comprising 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.

Historically, coastal and freshwater wetlands represented a significant habitat complex in the HRE study area. However, a large portion of the coastal and freshwater wetland habitat in the HRE study area has been degraded or destroyed by human activities. The most devastating losses occurred between World War II and the implementation of CWA, when large expanses of wetlands were filled, drained, or diked (Wise et al. 1997). In the last 30 years, cumulative wetland losses have slowed due to the implementation of protective legislation and mitigation (Steinberg et al. 2004). However, acres of wetlands still disappear and are degraded annually in the HRE study area. Many factors have been suggested as possible contributors to current wetland habitat loss: sea level rise; alterations in the estuary's sediment budget; erosion due to changes in wave energy; smothering caused by sea lettuce blooms; effects of contaminants from landfills and other sources; changes in hydrologic connectivity; or excessive consumption of marsh grasses by waterfowl (Steinberg et al. 2004). Nutrient enrichment due to excess nutrient flow (e.g., nitrogen) can result in algal blooms, hypoxia, and fisheries losses, and drive coastal and freshwater wetland loss (Deegan et al. 2012). Field studies and aerial photograph interpretation suggest that large sections of wetlands are deteriorating rapidly, particularly in Jamaica Bay, where eutrophication from excess nutrients may be interacting synergistically with a variety of other factors (Hartig et al. 2002). Other threats arise through changes in soil chemistry and moisture (e.g., during droughts), such as soil oxidation, soil acidification, and metal toxicity, which can cause sudden losses of acres of wetlands. Stressed wetlands may be more susceptible to fungal pathogens and elevated salinities (Lindstedt and Swenson 2006). Polluted runoff from adjacent uplands can degrade coastal and freshwater wetlands. Runoff from roads and other paved surfaces, and nutrient-rich runoff from fertilized lawns, agricultural areas, wastewater treatment plants, CSOs, and septic systems can degrade wetlands by encouraging growth of *Phragmites* and other invasive species. Hundreds of miles of riparian corridors have been lost to urban development. Many streams throughout present-day NYC have been filled, re-routed underground, or disconnected from their floodplains (PlaNYC 2012). Wetland loss is complex and likely a function of many factors, each of which varies in intensity and exposure among regions of the HRE study area.

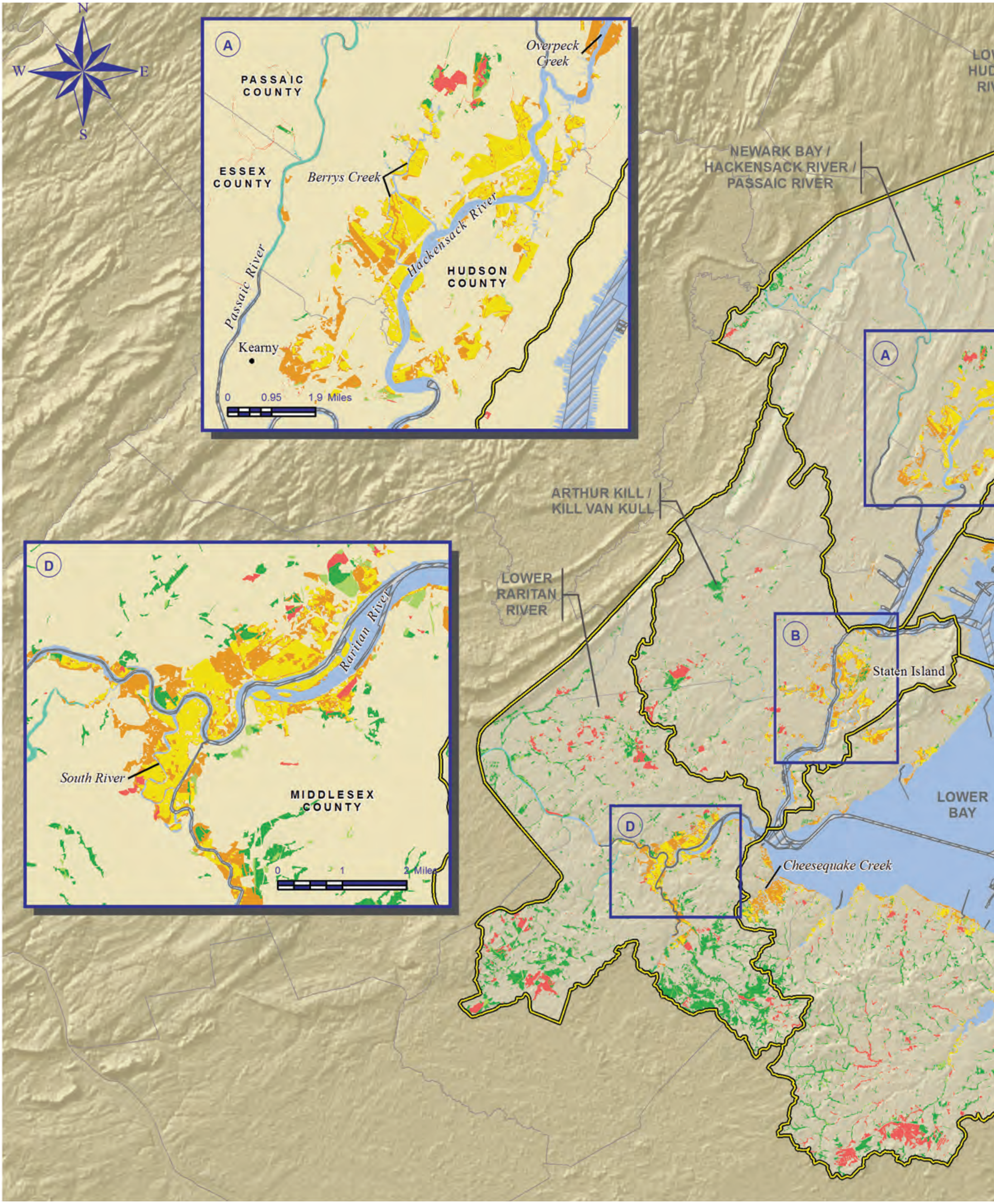
Target Statement

The ***Wetlands*** TEC aims to create and restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage. The target statements for the ***Wetlands*** TEC address acreage and ecosystem function, unlike many other TECs. Wetland restoration data spanning the last decade were used to determine an attainable and realistic target. The short-term objective is to create a total of 1,000 acres (4.05 kilometers^2) of freshwater and coastal wetland habitat by 2020. By 2050, the objective is to continue restoring an average of 125 acres (0.10 kilometers^2) per year for a total system gain of 5,000 acres (20.2 kilometers^2) of coastal and freshwater wetlands.

Restoration Opportunities (Map 3-1)

Substantial coastal and freshwater wetland restoration opportunities exist within the HRE study area. Identification of coastal wetland restoration opportunities was based upon major physical requirements of coastal wetlands (land elevation, bathymetry, and fetch distance) and land use constraints in the estuary (Map 3-1). Two layers are displayed on the map, coastal wetland creation opportunities and coastal wetlands restoration opportunities. No distinction is made between the quality of existing wetland habitat (i.e., this layer represents both degraded and non-degraded wetlands), but it can be assumed that many polygons represent existing degraded coastal wetlands that are dominated by dense stands of

Map 3~1.


N
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Overpeck Creek
Berrys Creek
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ARTHUR KILL / KILL VAN KULL
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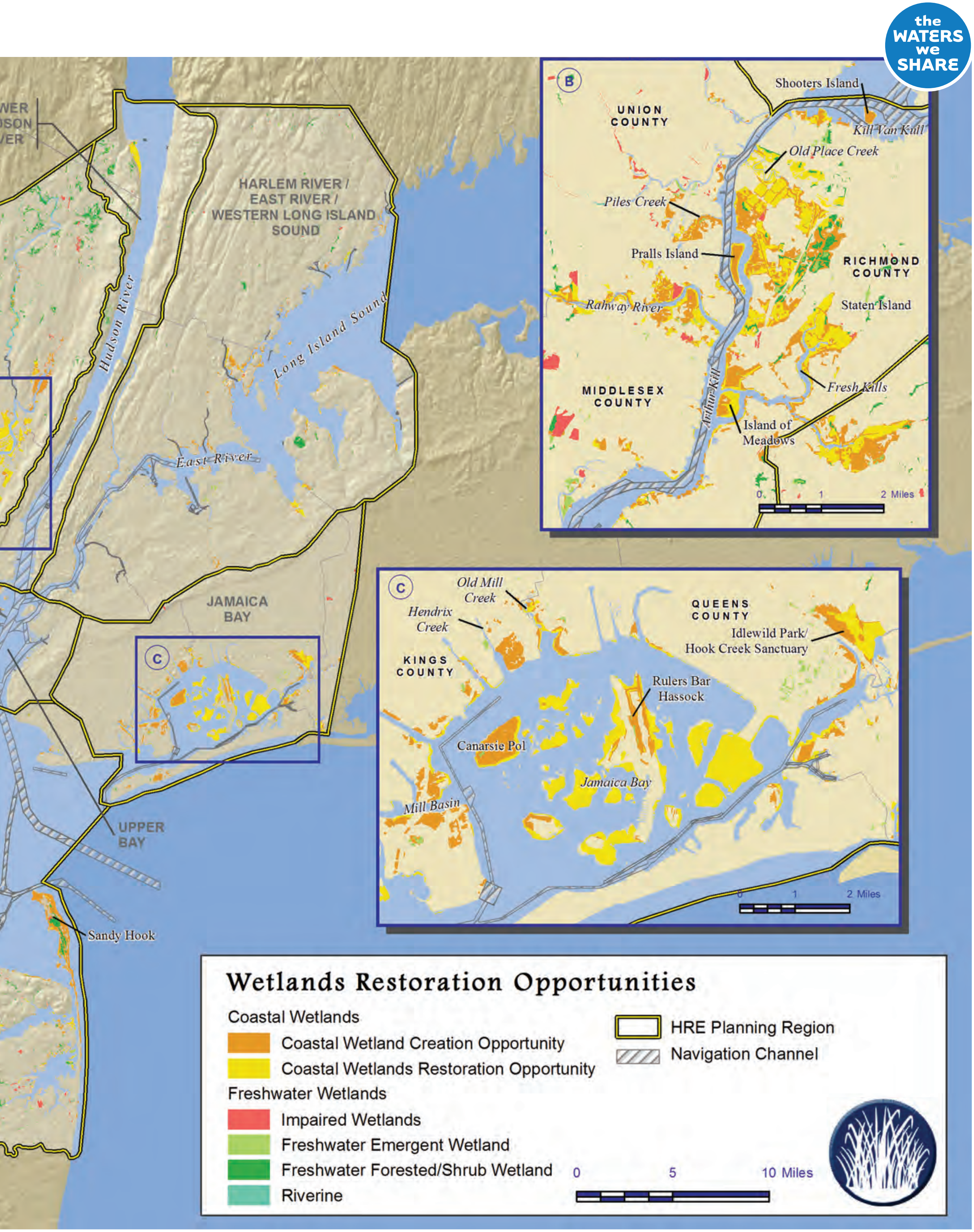
the WATERS we SHARE
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Hudson River
Long Island Sound
East River
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UPPER BAY
Sandy Hook
B
UNION COUNTY
Shooters Island
Kill Van Kull
Old Place Creek
Piles Creek
Pralls Island
RICHMOND COUNTY
Rahway River
Staten Island
MIDDLESEX COUNTY
Arthur Kill
Fresh Kills
Island of Meadows
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Old Mill Creek
Hendrix Creek
QUEENS COUNTY
Idlewild Park/ Hook Creek Sanctuary
KINGS COUNTY
Rulers Bar Hassock
Canarsie Pol
Jamaica Bay
Mill Basin
0 1 2 Miles
Wetlands Restoration Opportunities
Coastal Wetlands
Coastal Wetland Creation Opportunity
Coastal Wetlands Restoration Opportunity
Freshwater Wetlands
Impaired Wetlands
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Riverine
HRE Planning Region
Navigation Channel
0 5 10 Miles

Phragmites. Degraded wetlands represent potential wetland restoration opportunities (as opposed to wetland creation opportunities). Freshwater wetland restoration opportunities were identified using the impaired wetlands information available in the NWI maps. These wetlands include those listed as either diked or impounded in the NWI dataset. Four layers are displayed on the map, impaired wetlands, freshwater emergent wetland, freshwater forested/shrub wetland, and riverine. Existing wetlands adjacent to impaired wetlands represent potential restoration opportunities and are shown (Map 3-1).

In the HRE study area, there are approximately 12,500 acres (50 kilometers^2) of existing coastal wetland habitat and 35,000 acres (142 kilometers^2) of existing freshwater wetlands. The largest acreages occur along the Hackensack River (Inset A), along the Arthur Kill and its tributaries (Inset B), in Jamaica Bay (Inset C), and along the Raritan River and its tributaries (Inset D). Additional large expanses of coastal wetlands exist along Staten Island and the southern shore of the Lower Bay Planning Region (i.e., Middlesex and Monmouth Counties, New Jersey shorelines), and expanses of freshwater wetlands exist at the northern end of the Newark Bay, Hackensack River, Passaic River Planning Region, and the southern portion of the Lower Raritan River Planning Region. The NWI map indicates that approximately 50 percent of the existing wetlands classified as "estuarine" and 22 percent of existing wetlands classified as "freshwater" in the HRE study area are impaired in some way (e.g., diked or impounded, drained or ditched, excavated, or have modified substrate). This suggests that wetland restoration opportunities could contribute significantly to the quality of coastal and freshwater wetland habitat in the HRE.

Areas adjacent to existing wetlands tend to represent the largest areas for coastal wetland creation opportunities in the HRE study area. According to the analysis, coastal wetland creation opportunities total 14,000 acres (56.6 kilometers^2) in the HRE study area. This analysis excluded all existing developed lands and parklands; therefore, the actual coastal wetland creation acreage may be higher if partnerships are made with landowners and parks.

When looking at the restoration opportunities map, several inset maps draw attention to locations where substantial wetland creation and wetland restoration opportunities may exist.

- *Inset A* – Sizeable plots of uplands occur between the Hackensack and Passaic Rivers, particularly east of Kearny and along Berrys Creek. Lands surrounding Overpeck Creek, a tributary of the Hackensack River, may also represent large coastal wetland creation opportunities. In addition, this planning region includes the New Jersey Meadowlands, one of the largest expanses of existing estuarine wetlands. According to the NWI maps, about 80 percent of the Meadowlands are impaired. Many of these wetlands have been degraded and are currently dominated by *Phragmites*. These wetlands provide an opportunity for restoration, especially at the headwaters of Berry's Creek. Two sites located within the Hackensack Meadowlands (Metromedia and Meadowlark) are being recommended for construction authorization as part of the HRE Feasibility Study.
- *Inset B* – Opportunities to create coastal wetlands may exist on the islands of the Arthur Kill, including Shooters Island, Pralls Island, and the Island of Meadows; however, feasibility and cost will play an important role, as these are fill sites. Other areas of interest are on Staten Island, south and west of Old Place Creek, Saw Mill Creek and branches of the Fresh Kills. On the New Jersey side of the Arthur Kill, coastal wetland opportunities may exist along Piles Creek and the Rahway River. Freshwater wetland restoration opportunities also exist in Middlesex County, inland and west of the Arthur Kill, and in Union County, in New Jersey.

- *Inset C*- In Jamaica Bay, the greatest potential for the restoration of coastal wetlands is continuing the success of restoring marsh islands using dredged material. Since 2007, more than 160 acres (0.68 kilometers^2) of marsh island habitat have been restored at Elders Point East and West, Yellow Bar Hassock, Black Wall, and Rulers Bar. Additional marsh islands, including Pumpkin Patch, Duck Point, Elders East/West, and Stoney Point are being designed as part of the HRE Feasibility Study. In addition, six remaining locations along the periphery of Jamaica Bay, including Bayswater State Park, Fresh Creek, Brant Point, Dubos Point, Dead Horse Bay, and Hawtree Basin, are also priority sites to be recommended for construction authorization in the HRE Feasibility Study. Spring Creek South and North and Idlewild Park sites are also key restoration opportunities within Jamaica Bay that are advancing through the FEMA Hazard Mitigation Grant Program and the USACE Continuing Authorities Program (CAP). There are currently no identified potential freshwater wetland restoration opportunities in Jamaica Bay, though small sites exist in the drainage networks of the former tributaries to the bay, such as Spring Creek.
- *Inset D* – Coastal and freshwater wetland restoration opportunities exist adjacent to existing coastal wetland habitat and impaired freshwater habitat along the Raritan River and its main tributary, the South River. Coastal wetland creation opportunities also exist in the area.
- Other wetland creation opportunities may exist along the southeastern coast of Staten Island, throughout Sandy Hook, and along Cheesequake Creek, a tributary of the Raritan Bay. Scattered opportunities may exist in other planning regions, such as Lower Hudson River, Upper Bay (specifically Liberty State Park), and Harlem River, East River, and Western Long Island Sound.

3.1.2 Coastal and Maritime Forests

The ***Coastal and Maritime Forests*** TEC addresses ecologically rare and unique 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 (Table 3-2). These systems have become vulnerable to extirpation, both within the HRE study area and globally.

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

Table 3-2. Coastal and maritime communities that may be possible to create in the Hudson-Raritan Estuary (HRE) study area (adapted from Edinger et al. [2014] and Reschke [1990]). Species status, rare [R], threatened [T], and endangered [E], are detailed.

Community	Landscape/Hydrology	Soil	Characteristic Plant Species	Wildlife Species
TERRESTRIAL BARRENS AND WOODLANDS				
Dwarf pine plains	Woodlands on nearly level outwash sand and gravel plains. Excessively well-drained soils.	Coarse-textured sand	Dwarf individuals of pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*), and a handful of other woody species. Low shrub canopy exists beneath the trees.	Warblers Thrashers Ovenbird Northern harrier
Pitch pine mixed woodlands	Well drained, nutrient poor	Sandy soils	Pitch pine and various oaks (scrub oak, oak-heath, post oak-blackjack, oak barrens). Adapted to periodic fires. Occasionally stunted individuals.	Warblers Eastern towhee Sparrows Catbird
TERRESTRIAL OPEN UPLANDS				
Maritime beach	Above mean high tide/modified by storm waves and wind erosion.	Sand, gravel, or cobble ocean shores	**Sparse vegetation** Beachgrass (*Ammophila breviligulata*) Sea-rocket (*Cakile edentula*) Seaside atriplex (*Atriplex*) Seabeach amaranth (*Amaranthus pumila*) [E] Seabeach knotweed (*Polygonum glaucum*) [R]	Piping plover Least tern Common tern
Maritime dunes	Active and stabilized dunes (depends on stability of the dune, amounts of sand deposition and erosion and distance from ocean)	Sand	**Grasses and low shrubs** Active: Beachgrass, Dusty miller, Beach pea Stabilized: Beach heather, bearberry, beachgrass, cyperus, beach pinweed, jointweed	Piping plover Least tern Common tern
Maritime shrubland	Dry seaside bluffs and headlands that are exposed to offshore winds and salt spray	Sand	**Tall shrubland** Serviceberry (*Amelancier canadensis*) Bayberry (*Myrica pensylvania*) Black cherry (*Prunus serotina*) Southern arrowwood (*Vibrumum dentatum* var. venosum) Shining sumac (*Rhus copallinum*)	Black crowned night heron Fish crow
Maritime heathland	Rolling outwash plains and moraine of glaciated areas, near the ocean and within the influence of offshore winds and salt spray	Sand	**Dwarf shrubland; low heath or heath-like shrubs** Bearberry (*Archtostaphylos*) Beach heather (*Hudsonia tomentosa*) Lowbush blueberry (*Vaccinium angustifolium*) Black huckleberry (*Gaylussacia baccata*) Bayberry (*Myrica pensylvanica*) Beach plum (*Prumus maritima*)	Yellow-rumped warbler
Maritime grassland	Rolling outwash plains of glaciated areas near the ocean and within the influence of offshore winds and salt spray	Sand	**Grasses** Little bluestem (*Schizachyrium scoparium*) Common hairgrass (*Deschampsia flexuosa*) Poverty-grass (Danthonia spicata)	No available information
PALUSTRINE				
Maritime freshwater interdunal swale	Between dunes	Sand or peaty sand	**Sedges and herbs** Beakrush (*Rhynchospora spp.*) Cyperus (*Cyperus spp.*) Twig rush (*Cladium mariscoides*)	Data on characteristic fauna are needed

Table 3-2 (Cont'd). Coastal and maritime communities that may be possible to create in the Hudson-Raritan Estuary (HRE) study area (adapted from Edinger et al. [2014] and Reschke [1990]). Species status, rare [R], threatened [T], and endangered [E], are detailed.

Community	Landscape/Hydrology	Soil	Characteristic Plant Species	Wildlife Species
TERRESTRIAL FORESTED UPLANDS				
Maritime forest	Proximity to marine communities. Influenced by strong salt spray, high winds and dune deposition, shifting and overwash processes (Occur in narrow bands; "strand forest")	Sand	Stunted "salt pruned" trees with contorted branches and wilted leaves and a dense vine layer.	No available information
Maritime post oak forest	Borders salt marshes or occurs on exposed bluffs and sand spits within 200 meters of the seacoast	Sand	**Stunted trees** Post oak (*Q. stellata*) Black oak (*Q. velutina*) Scarlet oak (*Q. coccinea*) White oak (*Q. alba*) Eastern red cedar (*Juniperus virginiana*) Dense shrub thicket and vines	Data on characteristic fauna are needed.
Maritime beech forest	North facing exposed bluffs and back portion of rolling dunes; wind and salt spray	Well-drained fine sand	**Hardwood forest** Beech (*Fagus grandifolia*) Black oak Red maple (*Acer rubrum*)	Data on characteristic fauna are needed.
Maritime holly forest	Low areas on the back portion of maritime dunes, which protect the area from overwash and salt spray enough to allow forest formation.	Sand	**Broadleaf evergreen maritime strand forest; stunted trees** Holly (*Ilex opaca*) Sassafras (*Sassafras albidum*) Serviceberry (*Amelanchier canadensis*) Post oak Black oak	Data on characteristic fauna are needed.
Maritime red cedar forest	Dry sites near the ocean	More data needed	**Conifer forest** Eastern red cedar Post oak Black cherry	Olive hairstreak (*Mitoura grynea*)
Pitch pine-oak forest	Glacial outwash plains or moraines	Sandy or rocky soils	**Mixed forest** Pitch pine and oak (scarlet, white, red, or black)	Eastern towhee Common yellowthroat Field sparrow Warblers Blue jay
Coastal forest	Non-maritime areas within the Coastal Plain; not in immediate proximity to marine communities; (at most) Lightly Influenced by coastal processes inc. minor salt spray associated with extreme storms (e.g., hurricanes), and lacking dune deposition, shifting and overwash processes.	Dry low nutrient	**Normal stature trees** Oak-heath, oak-hickory, oak-beech, oak-laurel, and oak-holly mixed forests	Data on characteristic fauna are needed.

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 one or two 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, and are composed 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 corymbosum*) 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 NNBFs that would protect the coastline of the HRE from future storms. The NNBFs (e.g., 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 protection 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 2015b).

These forests provide a self-perpetuating and increasingly effective permanent erosion control (Brennan and Culverwell 2004). Many wildlife species depend on these forests for at least a portion of their life history, with requirements for feeding, breeding, refuge, and movement/migration. The diamondback terrapin (*Malaclemys terrapin*) and many shorebirds (e.g., plovers, sandpipers, skimmers, terns, and gull species) use sandy soils at the margins of forested habitats inland from dunes for nesting. Some ***Waterbird*** species (e.g., herons and egrets) do not nest in these habitats, but will stage in them during post-breeding dispersal periods. Many maritime/coastal forest tree species are also fruit bearing and provide an important food source to avian migrants. Most coastal and maritime forests in the HRE study area have been degraded or eliminated by timber harvest and development. Recent encroaching development has increasingly affected and fragmented these communities. Many species in these habitat types are opportunistic and can rapidly colonize protected areas, making restoration of these forest communities in the HRE study area potentially feasible (Yozzo et al. 2003). The Natural Areas Conservancy and The Nature Conservancy are working together to restore these forests by reducing fragmentation and threats to maritime forest in Marine Park, Brooklyn. The Nature Conservancy is also working on invasive species removal and reforestation of maritime forest shrub and tree species in the Jamaica Bay Wildlife Refuge.

Target Statement

Implementing the ***Coastal and Maritime Forests*** TEC would create a linkage of forests accessible to avian migrants and dependent plant communities. The short-term objective of the ***Coastal and Maritime Forests*** TEC is to restore or expand one new maritime forest of at least 50 acres (0.2 kilometers^2) and rehabilitate at least 200 additional acres (0.8 kilometers^2) among several coastal forest types by 2020. By 2050, the objective is to have a total of 500 acres (2 kilometers^2) of maritime forest community among at least three sites, potentially at Sandy Hook, Kings/Queens Counties, and/or Staten Island (Bain et al. 2007). In addition, 500 acres (2 kilometers^2) of various coastal forests/upland habitats should be restored within the HRE study area by 2050.

Adjacent habitats, such as dunes and maritime grasslands, or similarly rare communities, such as barrens, should also be created or enhanced when appropriate land exists. Maritime communities represent critically rare habitat types; therefore, they should be targeted for restoration under this TEC.

Restoration Opportunities (Map 3-2)

Opportunities for restoring coastal or maritime forest habitat exist in most planning regions of the HRE study area (Map 3-2). Several areas within these regions could be appropriate for creating these forest habitats. For instance, brownfields and closed landfills could serve as potential restoration opportunities, where clean fill material could be placed over degraded sites to make it suitable. Examples include restoration by NYCDEP of coastal oak, birch and beech forests, and grassland habitat as part of a comprehensive, long-term restoration program at the Fresh Kills Landfill on Staten Island, and restoration of coastal grassland and coastal forest habitat at the Pennsylvania and Fountain Avenue Landfill in Brooklyn.

Maritime forest creation opportunities represent areas where new maritime forests could be created without negatively affecting existing maritime forest habitat. For this reason, the Coastal and Maritime Forests Restoration Opportunities Map displays existing maritime forest communities along with maritime forest creation opportunities; however, these maps do not represent all opportunities, as coastal forests are underrepresented in some regions (e.g., NYC). Maritime forest creation opportunities represent undeveloped land (excludes lawns and developed parks) within 1,000 yards (914 meters) of the shore, that can be expected to be subject to salt spray due to surrounding high winds and salinity.

A single 64-acre (0.3-kilometers^2) plot of existing maritime forest is mapped in the HRE study area on the Sandy Hook peninsula. There were 1,283 acres (5.2 kilometers^2) where maritime forests could potentially be created in the HRE study area, occurring in the Jamaica Bay and Lower Bay Planning Regions, and a small section in the Harlem River, East River,

Map 3~2


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South Beach
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MONMOUTH COUNTY
Shrewsbury River
Navesink River
Sea Bright
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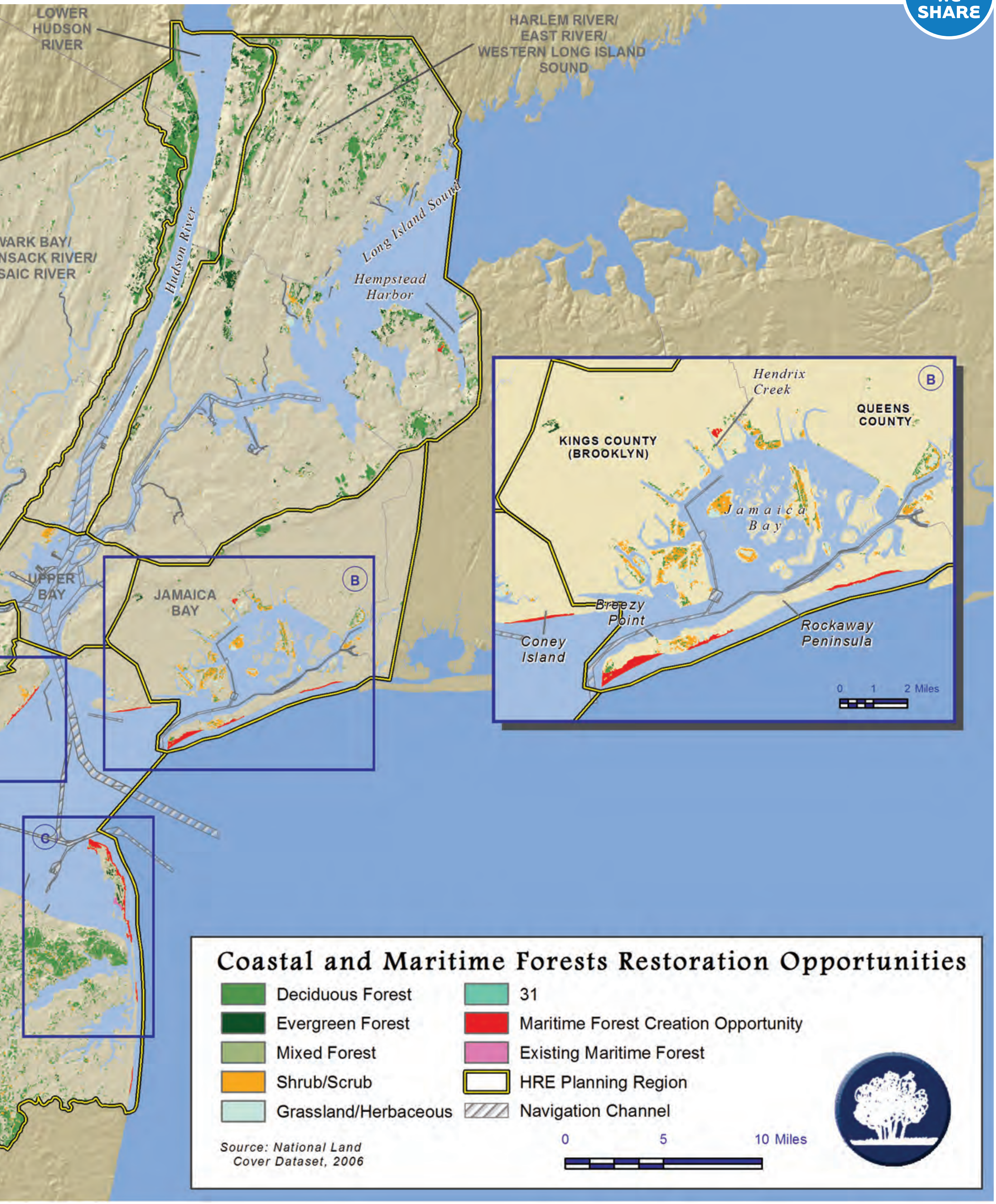
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER
Raritan Bay
LOWER BAY
Point Comfort

the WATERS we SHARE



and Western Long Island Sound Planning Region. The largest areas occurred on exposed shorelines, typically not within coves or bays, like the Sandy Hook peninsula, the southern coast of Staten Island, and Rockaway Peninsula.

Coastal forest restoration opportunities are generally represented by existing forested land. Forested lands make up 15 percent of the land (124,600 acres; 504 kilometers^2) within the HRE study area (826,600 acres; 3,345 kilometers^2), most of which occurs within the coastal plain. Potential sites will need to be field verified to ensure that suitable landscape, hydrology, and soil conditions exist to re-create the coastal forest community (Table 3-2). Although soils may be augmented to meet specific habitat requirements, the cost would generally be prohibitive. These lands may be suitable for restoring coastal forest communities to create habitat linkages with maritime forests as well as barrens and grasslands.

When looking at the restoration opportunities map, three inset maps draw attention to locations where the GIS layering analysis identified maritime and coastal forest creation opportunities and coastal forest restoration opportunities. Coastal forest and/or pine barren and grassland restoration opportunities may occur in areas with existing forest and grassland habitat, respectively. Unvegetated/developed lands represent coastal habitat creation opportunities.

- *Inset A* – Adjacent to the communities of Midland Beach and South Beach on Staten Island are inland unvegetated/undeveloped areas that could be appropriate for creating coastal or maritime forest communities. Farther inland on Staten Island, large tracts of forested land exist that may be appropriate for restoring coastal habitat communities. It would be appropriate to create communities like pitch pine-scrub oak, coastal oak-heath, and coastal oak-hickory in low-lying, outwash plains and within sandy hummock areas of Staten Island. An existing grass savannah community called a serpentine barren is located in the northeastern portion of Staten Island, and there may be opportunities for enhancement or expansion. Together, the Bluebelt Program and NY Rising's Enhanced Buyout Program, which sponsors "buy-outs" of property located in floodplains, have also created new restoration opportunities for Staten Island's East Shore floodplain.
- *Inset B* – A large maritime forest creation opportunity exists on the Rockaway Peninsula, particularly west of Breezy Point along a relatively undeveloped stretch of coastline. Some of the existing forested land adjacent to these areas could be restored to form larger plots of forested habitat. A small plot of land within Jamaica Bay, along Hendrix Creek, was identified as a maritime forest creation opportunity although it may not receive substantial salt spray. A maritime forest creation opportunity was also identified on Coney Island. However, Coney Island has a popular public beach with dense inland development and it would probably not be possible to create a maritime forest or restore adjacent coastal forests here due to residential and commercial development. Coney Island Beach could benefit from re-establishing dunes, grasses, and shrubland near the boardwalk. Opportunities for coastal forest restoration may exist on forested lands along many of the creeks in Jamaica Bay and near the Jamaica Bay Wildlife Refuge Visitor's Center on Ruler's Bar Hassock.
- *Inset C* – Sandy Hook has the only documented plot of existing maritime forest in the HRE study area. The existing maritime forest is flanked by forest/shrubland to the east, where it may be possible to restore the existing forest or create new, adjacent maritime forest habitat. Most of Sandy Hook peninsula's eastern shoreline has been identified as a maritime forest creation opportunity. This land is not densely populated, and there may be a sufficient area inland to establish the necessary beach and dune communities to protect any created maritime forest habitat. However, farther south on the Sandy Hook peninsula, near the community of Sea Bright, substantial shoreline

development and publicly used beaches may exclude these areas from further consideration as maritime forest creation opportunities. The existing deciduous and mixed forests along the north shore of the Navesink River and at the confluence with the Shrewsbury River may be opportunities for coastal forest restoration. Pitch pine oak heath and coastal hackberry could be created along coastal headlands in Monmouth County, New Jersey.

Few other opportunities for maritime forest creation appear to exist in the HRE study area. A narrow section of land along Point Comfort in Monmouth County, New Jersey was identified, but there may not be enough inland area to support the necessary beach and dunes for a maritime forest to be created. A small section of land in Hempstead Harbor, off Long Island Sound and adjacent to existing forested land, may be appropriate for a maritime forest community. This western shore of Hempstead Harbor is well forested and may represent a coastal forest restoration opportunity.

Other coastal forest restoration opportunities may exist in the HRE Study Area based on the geologic features (Table 3-3). For example, in the Arthur Kill/Kill Van Kull Planning Region, lands along the Arthur Kill occur in a coastal outwash plain and interspersed with sandy hummocks and may be suitable for restoration of pitch pine barrens, coastal oak-heath forests, and coastal oak-hickory forests. There may be opportunities to restore pitch pine-oak-heath and coastal hackberry forests along the coastal headlands of Staten Island, at the northeastern and southwestern edges. Rocky areas along the Hudson River shoreline (western and eastern) may provide opportunities for post oak-blackjack oak barrens and/or coastal oak-hickory forests.

Table 3-3. Matrix identifying coastal forest restoration opportunities by geologic feature (courtesy M. Feller, NYCDPR NRG 2010).

	Outwash Plain (Brooklyn, Queens, Staten Island)	Rocky Shoreline (Bronx, Manhattan)	Sandy Hummocks (Staten Island)	Cretaceous Bluffs and Coastal Headlands (Staten Island, Monmouth Co., NJ
Pitch Pine Scrub Oak Barrens	✓		✓	
Pitch Pine Oak Heath	✓			✓
Post Oak Black Jack Oak Barrens		✓	✓	
Coastal Oak Heath Forest	✓		✓	
Coastal Oak Hickory Forest	✓	✓	✓	
Coastal Hackberry Forest				✓
Coastal Swamp Forest	✓			

3.1.3 Oyster Reefs

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 (810 kilometers^2; 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.

Today, no known oyster reefs exist in the HRE study area. However, scattered live oysters can be found in certain areas, indicating the presence of isolated populations. The ***Oyster Reefs*** TEC addresses important biological and physical contributions to the estuary and emphasizes the unique role oysters have played in the culture and history of the HRE. Oyster restoration programs, such as the NY/NJ Baykeeper's Oyster Restoration and Gardening Program have become increasingly popular through enthusiastic grassroots participation. Research efforts have evaluated oyster growth and survivability, susceptibility to disease, natural recruitment, reef designs, and more recently have evaluated concerns with "habitat tradeoffs" and measured water quality benefits of reefs to guide future, large-scale restoration efforts. Research initiatives to identify suitable locations for restoration of oyster reefs have been planned and initiated through the cooperative Oyster Restoration Research Partnership (ORRP). In 2009, the HRF, the NY/NJ Baykeeper, Urban Assembly New York Harbor School, and the USACE led a partnership of more than 30 organizations, not-for-profits, and state and city agencies in creating and conducting research at a series of oyster reef research sites in the HRE. Through the ORRP collaborative effort, five experimental reefs were constructed throughout the HRE during 2010-2011, using rock as the reef base material, covered by a thin veneer of clamshell, followed by live oyster spat settled on to clamshells ("spat-on-shell") as the final layer. Each of the ORRP reefs encompasses an area of approximately 538 feet^2 (50 meters^2), with initial (post-construction) heights of 12 to 20 inches (30 to 50 centimeters) (Grizzle et al. 2011). Results from the Soundview, Hastings, and Governors Island reefs initially showed the most promise, based on survival, growth, natural recruitment, and favorable environmental conditions (e.g., temperature, salinity; Grizzle et al. 2011). Upon the final year of monitoring (2012), the Soundview site had the best overall development patterns indicating the best prospects for successful restoration; however, it is emphasized that this does not mean the other sites do not have potential for future restoration (Grizzle et al. 2013). Examples of recent oyster reef restoration efforts in addition to the ORRP oyster restoration efforts include:

- The NY/NJ Baykeeper, Rutgers CUES, Hackensack Riverkeeper, and the New Jersey Sports and Exposition Authority are working together to determine locations able to support sustainable long-term development of oyster reef habitat within the HRE (RERC 2008). The Keyport Reef, constructed in 2009, was removed in 2010 after the state permit was revoked due to water quality and "attractive nuisance" concerns (see additional information below). In 2011, NY/NJ Baykeeper and the Rutgers CUES initiated preliminary oyster survivability studies at Naval Weapons Station (NWS) Earle in New Jersey within the Lower Bay, a facility that provides secure waters with minimal risk of illegal harvest (Rutgers CUES 2012). Baykeeper was granted permits to conduct oyster research and restoration on just over 10 acres (0.04 kilometers^2) within the boundaries of NWS Earle in late 2012. Baykeeper produces juvenile oysters for oyster restoration projects at the Aquaculture Facility located at the naval station. Hatchery raised oyster larvae attach, set, and grow on shell substrate. Once oysters have grown for approximately two months, they are ready for release onto newly established oyster beds, or reefs. The plot is expected to expand based on the data collected, oyster population research, and evaluation by the HRE Feasibility Study.
- In 2006, prior to the ORRP, NYCDPR NRG began construction of the pilot oyster reef in the Bronx River, off Soundview Park. Following the promising results under the original NRP pilot and the first ORRP, in 2012 funding from NOAA's community restoration grant program was used to expand and monitor the Soundview Reef. The ORRP – phase 2, Soundview project team constructed an approximately 1-acre [0.004-kilometers^2]) reef at the site. One hundred and twenty five (125) CYs of clam shells imported from Massachusetts and 125,000 transplanted oyster spat (juvenile oysters) were used to construct and seed the reef (HRF 2013). The combination of these projects has resulted in the largest oyster reef restoration area within the HRE.
- NYCDEP, in collaboration with Cornell University's Cooperative Extension Service, constructed pilot oyster reef sites in Jamaica Bay in late 2010, by establishing a spat-on shell reef at Dubos Point using similar reef construction methods as ORRP, and placed spat-covered reef balls in Gerritsen Creek. Both sites were monitored through 2012 and exhibited healthy oyster growth and survival, as well as a high degree of utilization by natant macrofauna (NYCDEP 2012).

The NYSDEC has requested that restoration practitioners and project sponsors consider the following when preparing an oyster restoration proposal in New York waters:

- Pilot-scale projects provide the benefit of community involvement.
- Proposals for large-scale projects need to discuss habitat exchange issues.
- Risk management strategies should be discussed.
- All shells must cure out of the water for a year in piles no more than 18 inches (46 centimeters) in height in order to be considered safe for restoration.
- Spat should only be from New York and northern states because of disease concerns.
- Protection of Waters and Coastal Zone Consistency permits will be required for oyster restoration projects.
- Suggest coordination with the Food and Drug Administration (FDA) and the Interstate Shellfish Sanitation Conference.

Since 2010, New Jersey has restricted restoration projects for commercially harvestable shellfish in Restricted or Prohibited waters (i.e., closed to shellfishing) that are not adequately patrolled to prevent illegal harvesting. Due to concerns with illegal harvest of oysters and associated health risks, the NJDEP and NYSDEC recommend considering the restoration of shellfish species that have no commercial value in these waters. Presently efforts are being made to coordinate oyster reef restoration activities within the existing states' permitting framework. While the goals of the regulations are understandable, (i.e., avoiding public harm with respect to navigation or the environment, protecting public health, etc.), alternative mechanisms for achieving them are being considered, including the increased use of "secured" areas. On January 19, 2016, the Governor of New Jersey signed Bill A3944/S2617 which requires NJDEP to revisit existing Shellfish Rules within one year after adoption to provide improved and expanded research and restoration opportunities based on comments received from the public.

Despite the demonstrated success of oyster reef restoration at some locations in the HRE study area, oysters can be considered an "attractive nuisance" for illegal harvest. Therefore, it may be prudent to consider restoring non-commercial shellfish species that provide similar ecosystem services, such as ribbed mussels. In 2011, NYCDEP established a demonstration project of ribbed mussels in Fresh Creek, a tributary to Jamaica Bay. Ribbed mussels are naturally occurring in the Bay, and throughout the estuary, and filter water. The project is being monitored to determine whether a more robust population within the center of the channel could remove substantial quantities of impurities from the water, particularly near CSOs (NYCDEP 2014). By incorporating ribbed mussels, shellfish habitat can be created as part of the ***Habitat for Fish, Crab, and Lobsters*** TEC and along intertidal ***Shorelines and Shallows***. Although the ecological benefits of this species are less substantial than the ecological benefits provided by oyster reefs, the lower risk of "attractive nuisance" may make these projects more attractive to regulators.

Target Statement

The ***Oyster Reefs*** TEC aims to establish oyster reefs at several locations in the HRE study area (Bain et al. 2007). The short-term objective for the ***Oyster Reefs*** TEC is to create 20 acres (0.08 kilometers^2) of self-sustaining and naturally expanding oyster reef habitat in the HRE study area by 2020. By 2050, the objective is to have 2,000 acres (8 kilometers^2) of established oyster reef habitat.

Restoration Opportunities (Map 3-3)

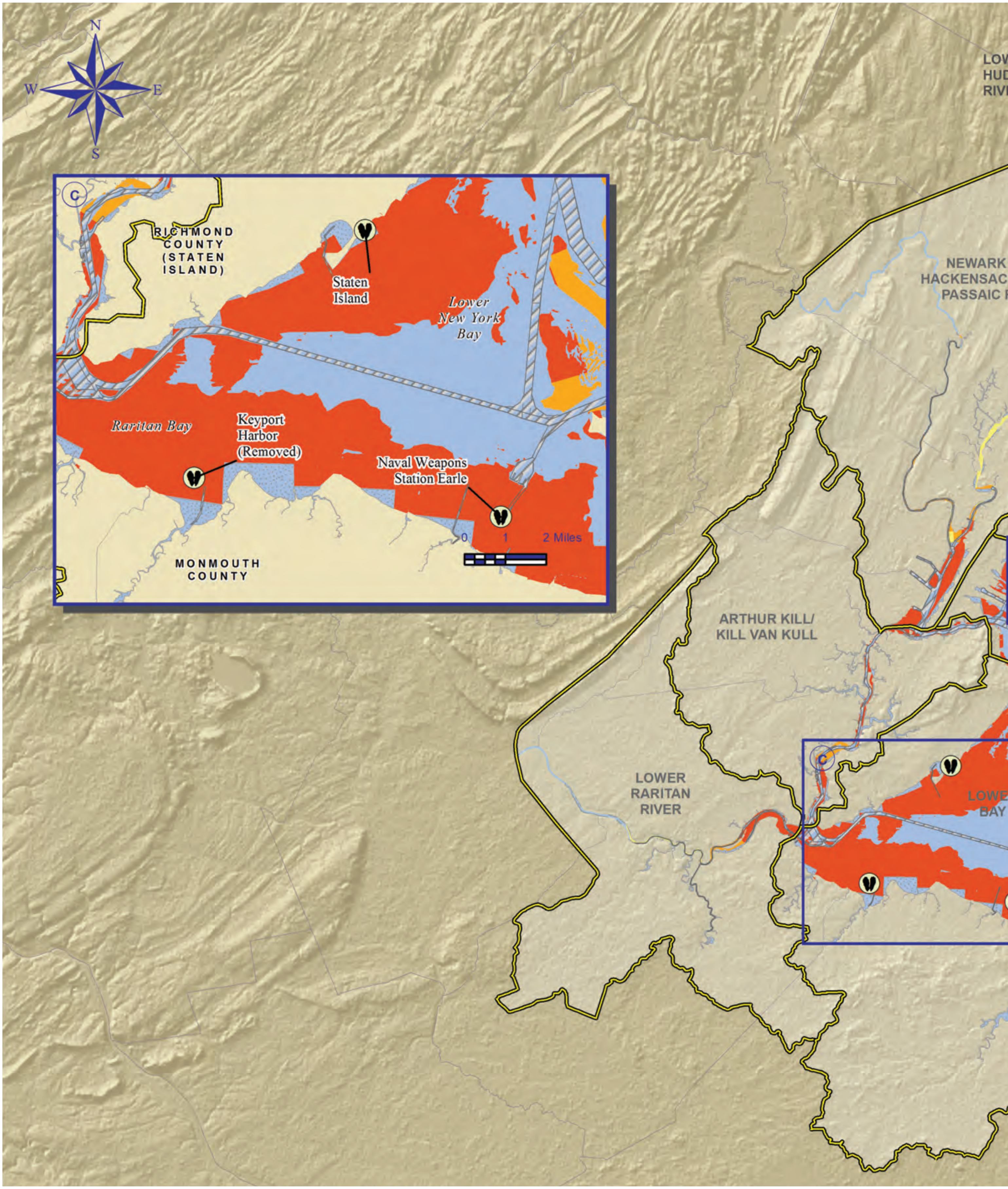
Oysters were historically prevalent throughout the estuary and opportunities for restoration exist in every HRE planning region. Data used to identify restoration opportunities were seasonally and spatially variable water quality parameters developed using calibrated, peer-reviewed models: the System-Wide Eutrophication Model (SWEM) and the Jamaica Bay Eutrophication Model (JEM) that were developed by the NYCDEP and used for the Contamination Assessment and Reduction Program (CARP). As the name suggests, the SWEM covers a large spatial extent that fully encompasses the HRE study area, from the inland rivers of New York and New Jersey into the New York Bight, extending to Cape May, New Jersey and Nantucket Shoals, Connecticut. The JEM was developed using a higher resolution grid for Jamaica Bay.

The Oyster Reefs Restoration Opportunities map (Map 3-3) displays the results from the analysis. All sub-tidal waters of the HRE study area were evaluated for their potential to serve as oyster reef sites using environmental parameters critical for oyster egg and larval survival. Restoration opportunities were identified by layering the modeled parameter values for June through September and creating polygons where multiple criteria were satisfied. Locations where the most criteria were satisfied represent areas that appear to be the most suitable locations for establishing oyster reefs (based on available estuary-wide data sets). The four environmental parameters used to identify suitable locations for oyster restoration sites were based on oyster habitat requirements and feasibility. These parameters are salinity range, dissolved oxygen, total suspended solids, and bathymetry. Large areas of the HRE study area satisfied the four criteria, of which selection seemed to be driven by minimum salinity. Of the areas that met the bathymetry criterion, all of these met at least two other criteria. There were over 50,000 acres (202 kilometers^2) of subtidal habitat that met four criteria, occurring mostly in the Lower Bay and Jamaica Bay. Other areas that may be suitable include along the East River in Flushing Bay, Newark Bay, the Upper Bay, and the East River. Locations of oyster reef pilot sites are also identified.

When looking at the restoration opportunities map, several inset maps draw attention to locations that might be suitable for oyster beds.

- *Inset A* – Sizeable areas that could provide habitat for oyster reefs exist along the East River in Flushing Bay, Westchester Cove, and in the Bronx River. The HRE Feasibility Study plans to recommend the expansion of the reef at Soundview Park in the Bronx River for future construction authorization.
- *Inset B* – A large portion of Jamaica Bay satisfies the water quality and depth habitat preferences for oyster reefs. Reef expansion in the northeast headwaters of Jamaica Bay is currently underway. An oyster larval transport model, based on the Jamaica Bay Eutrophication Model (JEM) grid, was used to determine Phase II oyster restoration sites for NYCDEP (Fitzpatrick and Lodge 2011).
- Inset C – The Lower Bay (reef expansion at NWS Earle is being recommended for HRE construction authority), including Sandy Hook Bay, and the Lower Raritan River, appear to have the potential for the greatest expanses of oysters in the HRE study area.

Map 3~3.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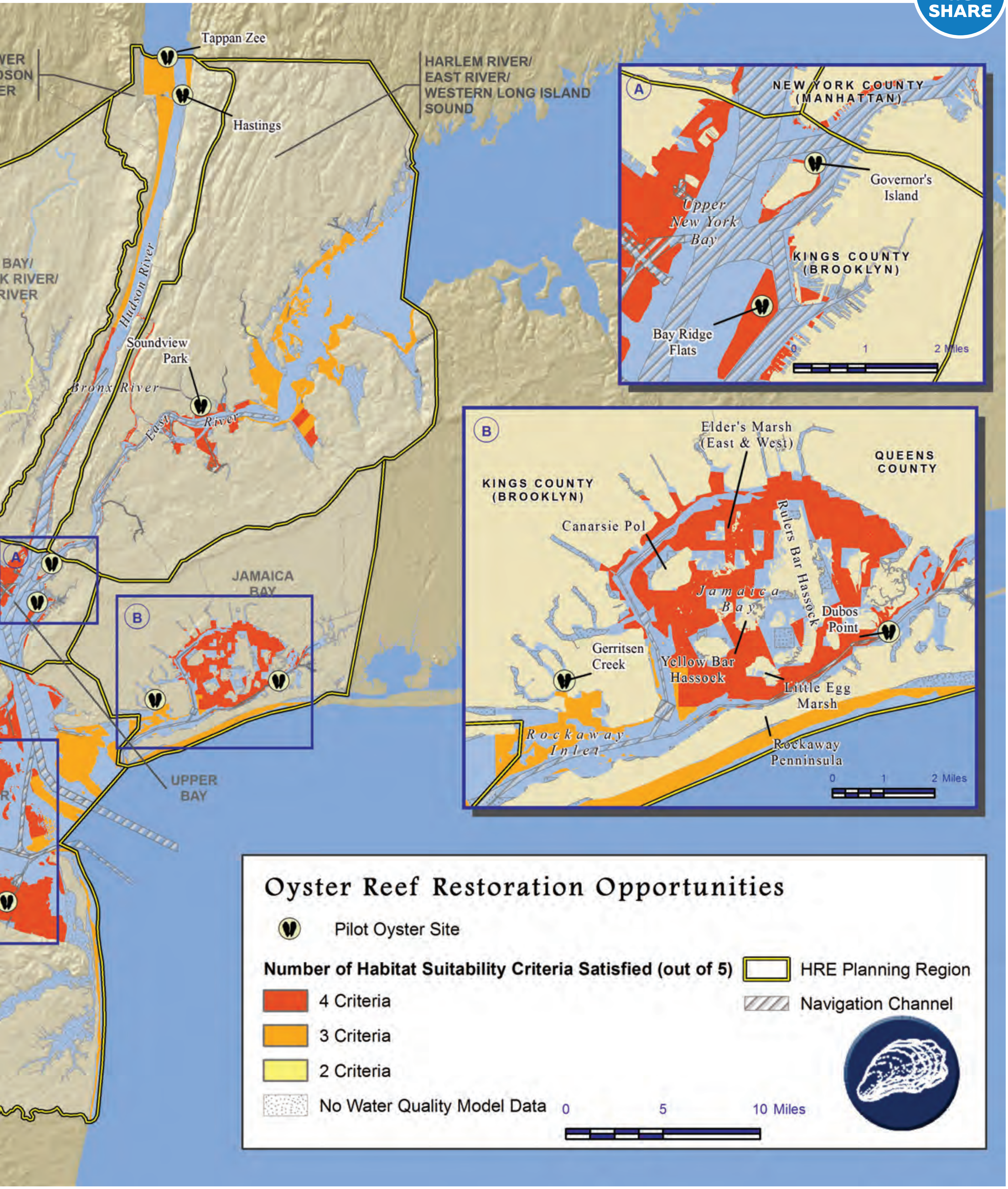
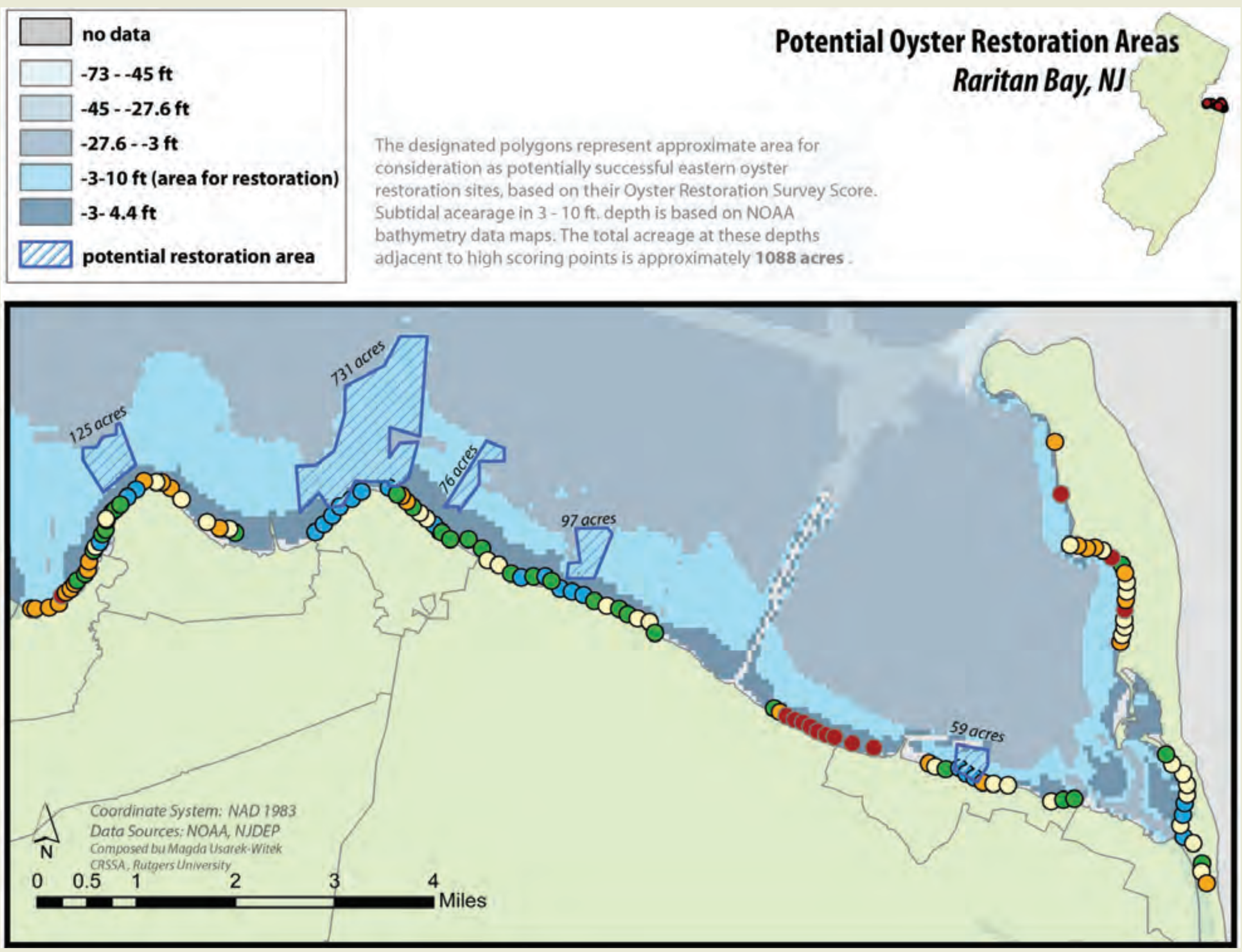


Habitat Suitability Layers from the System-Wide Eutrophication Model/Jamaica Bay Eutrophication Model (2008 model output): Bathymetry, Salinity, Dissolved oxygen, Total suspended solids

A THREE-PRONGED APPROACH TO OYSTER REEF SITE SELECTION

Rutgers Center for Urban Environmental Sustainability (CUES) in collaboration with NY/NJ Baykeeper recommends a three-pronged approach to identifying feasible oyster reef restoration sites: regional analysis, localized investigation, followed by site-specific studies. This approach can be implemented with minimal cost to ensure that limited restoration funds are targeted at the most feasible and promising locations. For oysters, Rutgers CUES referenced the Target Ecosystem Characteristics (TEC) Map, which shows much of the lower Raritan Bay meets at least four out of five habitat suitability criteria. Taking this to a more localized approach in 2011, they implemented the Raritan Bayshore Mapping Project. Over 20 miles (32 kilometers) of shoreline, beginning at Keyport Harbor Municipal Dock and ending at the northernmost tip of Sandy Hook, were rated based on 23 environmental parameters to evaluate potential oyster habitat suitability. The data collected every 100 meters (328 feet) were used to produce an overall Oyster Restoration Index Score (ORIS) for each site. The ORIS is color-coded: green = 'most likely'; blue = 'satisfactory'; red = 'least likely'; orange = 'unsatisfactory'; and beige = 'neutral' (see graphic below). Combining the high-ORIS sites with NOAA bathymetry data, Rutgers calculated the acreage of subtidal habitat between 3-10 feet (1-3 meters). The map indicates that over 1,000 acres (4.05 kilometers^2) of potential oyster habitat may be present on the southern New Jersey Bayshore. The next step will be to test these sites utilizing the Rutgers Site Selection Model, which evaluates oyster survivability and disease susceptibility over multiple seasons and only if both tests prove positive will there be justification to expand oyster restoration at the site. Rutgers CUES promotes utilizing this approach to complete a large-scale, inexpensive survey of the HRE, which would aid in identifying sites that could best contribute to meeting the *Oyster Reefs* restoration goals.



Billion Oyster Project

Billion Oyster Project (BOP) is a project of the New York Harbor Foundation, a non profit dedicated to developing and supporting a diverse and environmentally literate network of students, schools and communities working together to restore New York Harbor. BOP is an oyster restoration and education project aimed at restoring one billion oysters to New York Harbor over a twenty-year time horizon, and in doing so, enhancing the environmental literacy and stewardship ethic of New Yorkers, especially public school students. New York Harbor School is the flagship school in this initiative. Harbor School staff and students work alongside Foundation staff to do the hands-on work of oyster cultivation and restoration. Students at Harbor School learn to operate vessels, design and construct reef infrastructure, grow oysters, scuba dive, and conduct research on these reefs. These students are now joined by students at more than 50 partner schools who learn their math and science lessons through the lens of oyster restoration. Their teachers are trained to implement BOP curricula and empowered with water quality monitoring and oysters cultivation equipment. Each of these schools maintains live oysters in an Oyster Restoration Station at a waterfront site near their school.

Harbor Foundation sees the BOP as a means of developing a city-wide constituency of teachers, youth, and families who are Harbor literate; who want to and are able to access the water; and who have a vested interest in a clean, productive Harbor. The BOP comprises a series of oyster survivability, experimental restoration, and education and stewardship initiatives which seek to build upon and expand the work of the multi-partner, collaborative Oyster Restoration Research Project (ORRP). These initiatives include growing oysters in nurseries in the Brooklyn Navy Yard and other locations, deploying accessible, community reefs, growing oysters on Governors Island, testing different oyster reef substrate types and oyster installation strategies on the experimental Governors Island oyster reef; collaborating on the Living Breakwaters Project and other restoration and resiliency initiatives. For further information, please contact Pete Malinowski at 212-4580-800 ext. 6504 pmalinowski@nyharbor.org.

3.1.4 Eelgrass Beds

Eelgrass (*Zostera marina*) is a seagrass, not a seaweed, and is one of the few plants that occur almost exclusively in subtidal waters with marine salinities, utilizing the water column for vertical support (Fonseca 1992). The ***Eelgrass Beds*** TEC represents a habitat that is vertically and horizontally complex, attracting dense and diverse communities of macroinvertebrates, shellfish, and fishes, as well as providing critical nursery habitat for important fishery species. Eelgrass beds support all trophic levels and provide many ecosystem services to the estuary.

Eelgrass can grow rapidly, producing large quantities of organic matter. This primary production supports a complex food web that cycles nutrients between sediments and surface waters (Fonseca 1992). Eelgrass plants produce oxygen and can filter nutrients and contaminants, improving the surrounding water quality (Bain et al. 2007). Eelgrass beds also provide physical benefits to the ecosystem. Wave and current energy is dissipated through the beds, reducing erosion and sediment resuspension, and preserving sediment-dwelling bacteria and fungi (Bain et al. 2007, Fonseca 1992). Enhanced sediment stability increases the accumulation of organic and inorganic materials (Fonseca 1992). The improved conditions surrounding eelgrass beds enhance their self-sustainability by providing stable sediment and optimal water quality for eelgrass bed expansion.

In the HRE study area, eelgrass beds were historically abundant along the Raritan Bay shore in north-central New Jersey. A wide-ranging infestation of the marine slime mold (*Labryinthula zosterae*) along with declining water quality in many coastal areas virtually eliminated eelgrass from the HRE and other Atlantic coast estuaries during the 1930s (Bain et al. 2007).

Today, eelgrass has been nearly eliminated from the HRE study area and only a few small beds remain in the Shrewsbury River between Gunning Island and Oyster Bay.

Target Statement

Restoration of eelgrass beds should initially focus on choosing suitable sites for planting test beds and gaining an understanding of habitat criteria and feasibility of restoration. The short-term objective is to create one test bed in each suitable planning region in the HRE study area by 2020. The long-term objective for the ***Eelgrass Beds*** TEC is to have at least three established, self-sustaining, and expanding eelgrass beds in each suitable planning region by 2050. It must be emphasized that there may be entire planning regions that do not meet the physical requirements (e.g., low wave energy, high salinity) necessary to sustain healthy eelgrass populations. Test beds should be attempted in areas where there is a high probability for success and should not be "forced" in unsuitable areas.

Pilot eelgrass restoration projects and their associated monitoring will help to determine whether the creation of larger eelgrass beds may be possible and will help to increase the likelihood for success of future restoration efforts.

The future of eelgrass restoration in the HRE study area may be advanced through the implementation of the following near-term actions.

- Conduct pilot-scale projects to guide large-scale restoration programs. Pilot projects should span discrete abiotic conditions (depths, sediment types, wave energy regimes) and incorporate a variety of seeding/planting techniques (e.g., adult transplants supplemented by a seed-based program).
- Involve Resource Managers in the eelgrass research/restoration process to better inform and gain support for research and monitoring.
- Share lessons learned from post-restoration monitoring. Monitoring will refine the suitability criteria and improve subsequent restoration programs.
- Develop restoration plans for eelgrass by creating a strategic plan that focuses on suitable locations and sets achievable targets. It may be beneficial to use structural versus functional targets when evaluating restoration success.
- Identify proponents for eelgrass restoration among the agencies and environmental groups.

In Jamaica Bay, pilot-scale eelgrass beds were planted at several locations between 2008 and 2011 as part of the Jamaica Bay Watershed Protection Plan, a component of New York City's PlaNYC program. NYCDEP, in partnership with Cornell University's Cooperative Extension Service, evaluated several potential eelgrass transplant sites in 2008, and three of these (Breezy Point, Floyd Bennett Field, and Little Egg Marsh) were planted the following spring. Subsequent transplant sites included Dubos Point and an additional Breezy Point site, located to the east of the primary site. In 2010, all transplant efforts were focused on the most successful of the initial sites at Breezy Point, and an additional pair of sites was added on the northern shore of Rockaway Inlet, offshore the Kingsborough Community College campus. In 2011, the most recent set of planting efforts focused entirely on the Breezy Point location, the most promising of the Jamaica Bay pilot sites (Figure 3-1).

Although initial plantings were conducted in spring (April), it became apparent that this was not ideal for Jamaica Bay, as brant (*Branta bernicla*) quickly set upon the fresh transplants. In addition, horseshoe crabs (*Limulus polyphemus*) began to move onshore shortly after transplanting. In other New York waters (e.g., Eastern Long Island Sound), brant and horseshoe crabs are less abundant, and planting is generally conducted at greater depths (due to greater water clarity), avoiding these issues. Subsequent planting efforts during 2010 and 2011 were conducted in fall, and exhibit enhanced growth and survival relative to the initial spring planting efforts, both due to avoidance of predation/grazing issues at the outset of planting and partly a result of refined site selection and planting techniques. Unfortunately, despite repeated transplanting and hopeful signs of establishment, none of the test beds has survived to-date.

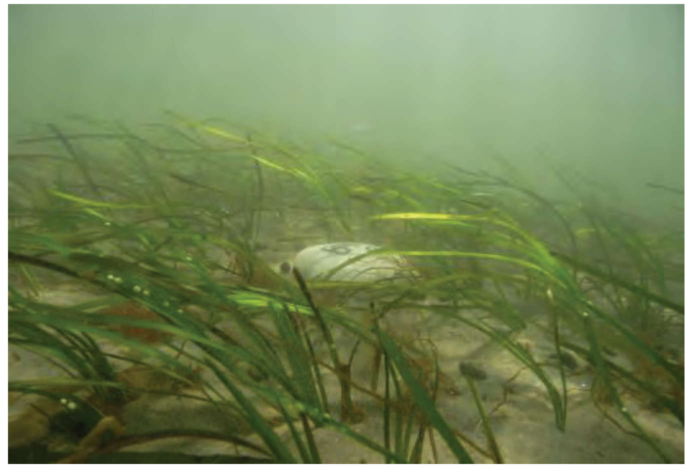


Figure 3~1. Transplanted eelgrass at Breezy Point, Western Jamaica Bay, April 2009 (photo courtesy of NYCDEP).

While plant mortality occurred among several pilot planting populations due to blue mussel (*Mytilus edulis*) colonization and strong sediment movement, referred to as sand waves, the study has provided continuous learning opportunities with regard to both eelgrass and the overall conditions within the bay (NYCDEP 2014). The overall goal of the demonstration project was to determine if eelgrass would survive in Jamaica Bay under existing conditions. The initial project objectives refined site selection parameters, planting methodology, and timing for consideration for potential future restoration efforts. This was essential as this project represents the first documented effort to plant eelgrass in Jamaica Bay.

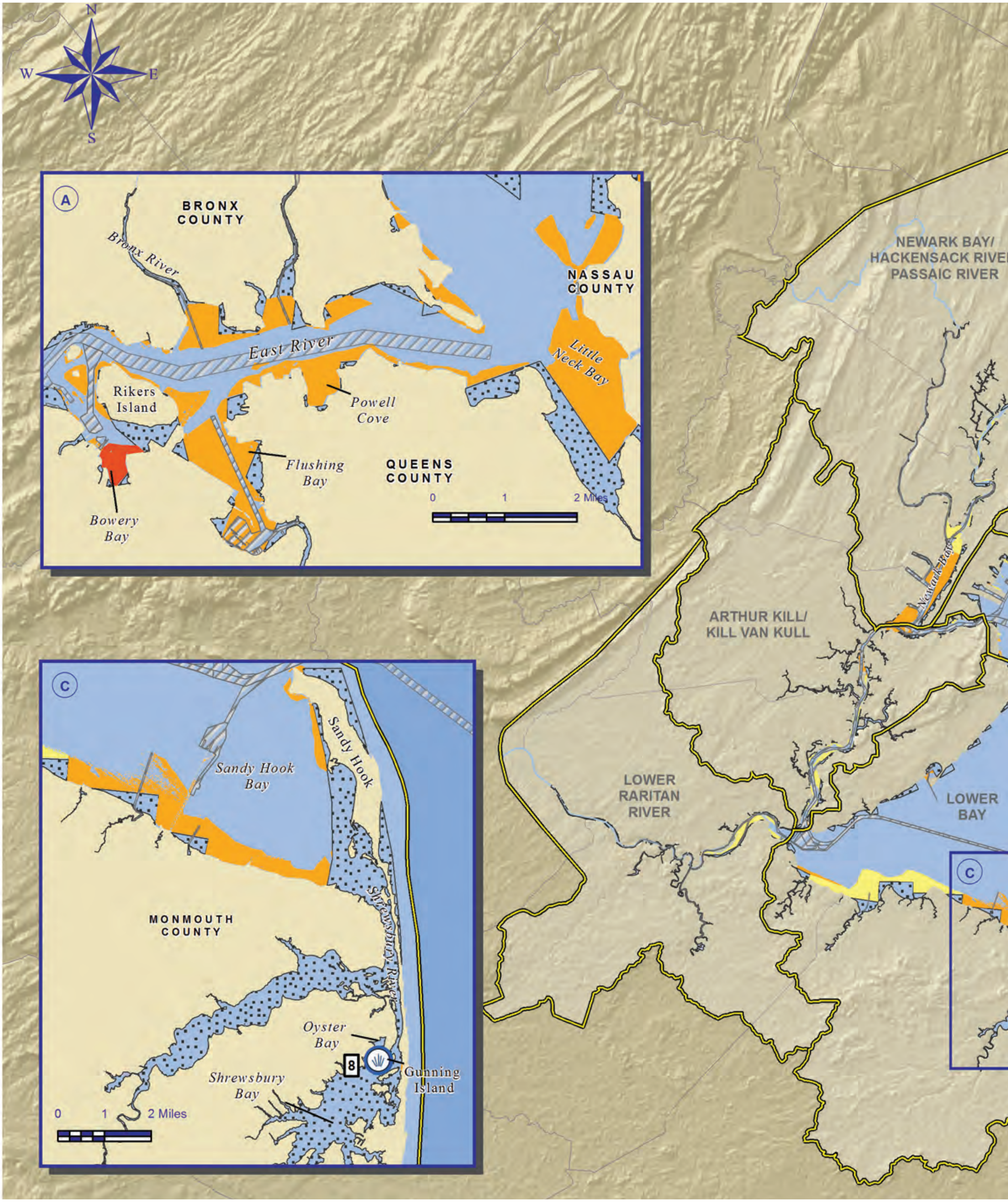
Restoration Opportunities (Map 3-4)

Eelgrass has specific habitat requirements; therefore, opportunities for restoration exist in only a few HRE planning regions. Data used to identify eelgrass pilot projects were seasonally and spatially variable parameters developed using calibrated, peer-reviewed models: the SWEM and the JEM. Eight parameters were used in the analysis, some with overlapping roles in restricting water clarity. The parameters represent habitat requirements, such as nutrient levels (dissolved inorganic nitrogen [DIN] and phosphorus [DIP]), phytoplankton concentrations (as chlorophyll *a*), light penetration and total suspended solids (TSS), salinity, fetch distance, and bathymetry.

Three layers are displayed on the Eelgrass Bed Restoration Opportunities map (Map 3-4), existing eelgrass beds, pilot sites where eelgrass test beds were attempted, and restoration opportunities for eelgrass test beds. The restoration opportunities represent areas where multiple habitat requirements were met, indicating the potential for an area to support eelgrass beds.

The only mapped existing eelgrass bed, 8.7 acres (0.04 kilometers^2), in the HRE study area is in the Shrewsbury River between Gunning Island and Oyster Bay (Inset C). No locations satisfied the criteria for more than five of the eight

Map 3~4.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Newark Bay
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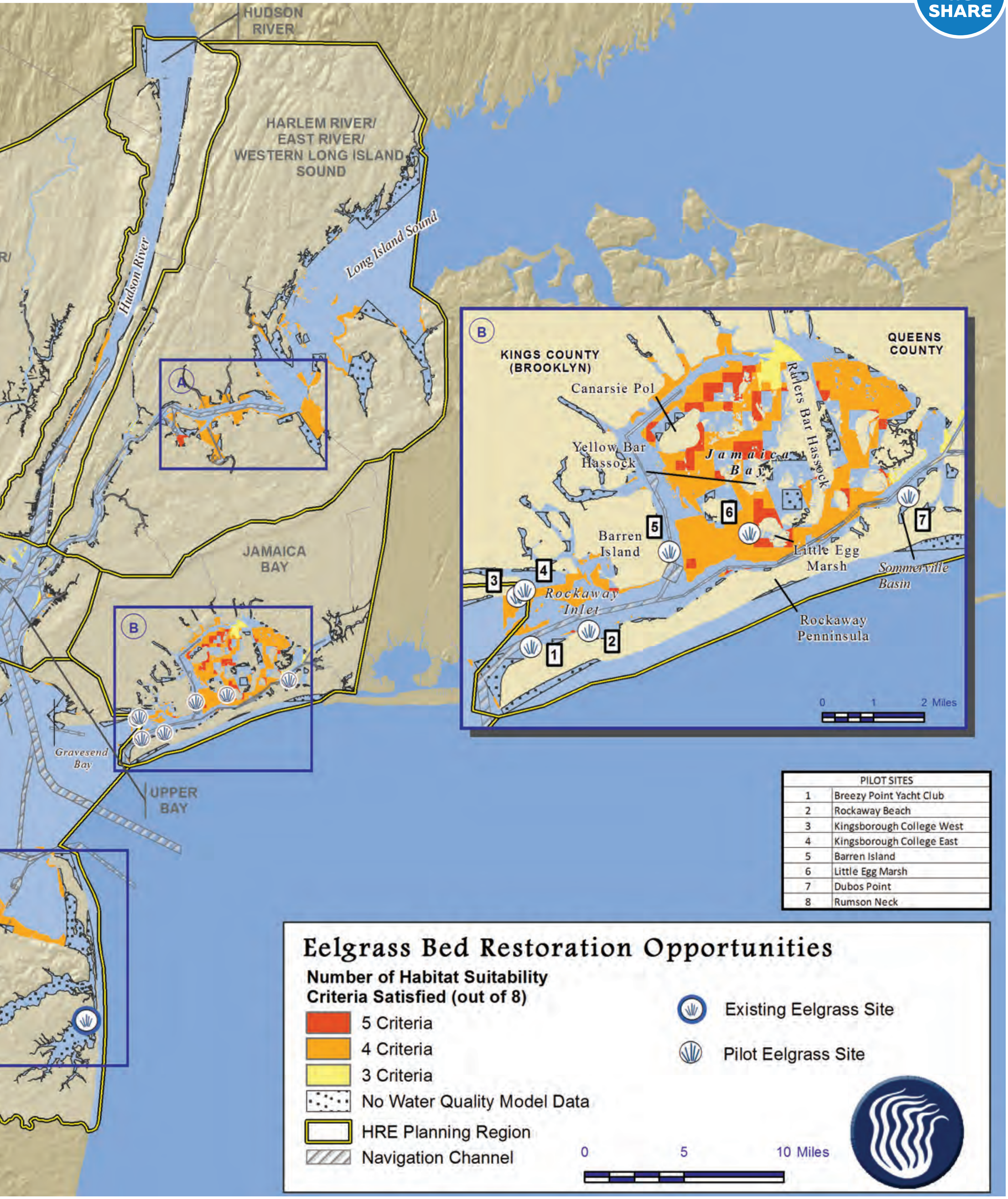


PILOT SITES	
1	Breezy Point Yacht Club
2	Rockaway Beach
3	Kingsborough College West
4	Kingsborough College East
5	Barren Island
6	Little Egg Marsh
7	Dubos Point
8	Rumson Neck

Habitat Suitability Layers from the System-Wide Eutrophication Model/Jamaica Bay Eutrophication Model (2008 model output): Bathymetry, Salinity, Fetch, Chlorophyll a, Dissolved inorganic nitrogen, Dissolved inorganic phosphorus, Light penetration, Total suspended solids parameters, and no waters of the HRE study area met the DIN or DIP criteria. Light also limited the suitable areas, with only Jamaica Bay having areas with optimal light penetration. There were 1,037 acres (4.2 kilometers^2) of subtidal habitat that met five criteria, occurring mostly in Jamaica Bay. Of the suitable areas identified, most satisfied four criteria, totaling 13,800 acres (56 kilometers^2), whereas 5,700 acres (23 kilometers^2) met three criteria. When looking at the restoration opportunities map, several inset maps draw attention to locations that might be suitable for eelgrass test beds.

- Inset A – Most of the areas identified in the bays along the East River satisfied four criteria: bathymetry, salinity, TSS, and fetch. Bowery Bay satisfied five criteria and could be an appropriate location for an eelgrass test bed; meeting the chlorophyll *a* preferences (did not meet DIN, DIP, or light criteria). Other promising locations for test beds appear to occur in the Bronx River and Westchester Creek estuaries, portions of Flushing Bay, Powell Cove, and Little Neck Bay. Subtidal areas surrounding Rikers Island satisfied four criteria, though eelgrass test beds are not recommended for these high velocity areas, even with creative transplanting techniques.
- Inset B – The suitability results suggest Jamaica Bay to be one of the most promising locations for eelgrass test beds. The five criteria satisfied in portions of Jamaica Bay were light penetration, salinity, TSS, bathymetry, and fetch. Although sizeable areas that satisfied five criteria were identified, most surrounding islands west of Rulers Bar Hassock, many of these were eliminated from further consideration following direct observations of water clarity, substrate, the presence/absence of invertebrate grazers/predators, and other disturbance factors. Large portions of the Rockaway Inlet satisfied four criteria. Nearshore locations at Breezy Point where no water quality modeling data were available resulted in test beds with the best establishment and survival of the Jamaica Bay locations.
- Inset C – Portions of Sandy Hook Bay, along Monmouth County and the Sandy Hook Peninsula, met the fetch, bathymetry, salinity, and TSS criteria. Although modeled data did not exist for the Shrewsbury and Navesink rivers, the only mapped location of an existing eelgrass bed occurs in this region. Therefore, it is strongly recommended that these water bodies be further evaluated to determine their suitability as test bed locations.
- Other opportunities – Similar to Shrewsbury and Navesink rivers, many of the inland bays of Long Island Sound were not included in the SWEM, and therefore, could not be evaluated for this analysis. It is strongly recommended that the suitability of these bays be investigated. Other areas of the HRE study area that satisfied four criteria are Newark Bay, the coasts of the Lower Hudson River, and Gravesend Bay, off Brooklyn. These locations may not be the most appropriate for the initial test beds as light penetration may not be sufficient for eelgrass survival.

3.2 Habitat Complexes

Three of the TECs focus on ensuring the connectivity of different habitat types to provide habitat complexes for species that require more than one habitat during their life cycle. These habitat complexes are important for organisms that move between habitats to forage or spawn. Loss of the connectivity of these habitats can have serious consequences, especially when there are blockages that prevent migration to spawning areas. Many of the TEC habitats described above could be connected to form habitat complexes. The following sections describe these habitat complexes, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3.2.1 Shorelines and Shallows

The *Shorelines and Shallows* TEC addresses important physical, chemical, and biological services to the nearshore habitats of estuaries by creating natural sloping shorelines with three contiguous habitat types. These habitat types are generally comprised of (1) littoral zones that remain inundated with shallow water, (2) intertidal areas that are regularly submerged during high tides, and (3) riparian zones that are important transitional habitats between land and water (Steinberg et al. 2004). This TEC targets habitats of 13 feet (4 meters) or less mean low water, based upon the USEPA's working definition of shallow waters, where "critical functions such as biological productivity and ecological balance must be reconciled with human activities" (Reilly et al. 1996).

Subtidal littoral zones typically support high densities of organisms and high species diversity, particularly when vegetated. Due to high densities of invertebrates, slower current velocities, and available refuge, littoral zones support resident populations of small fish and crustaceans and provide critical nursery habitat areas for transient species. Larger fish tend to remain in deeper water habitat, on the outskirts of littoral areas, where they feed on macroinvertebrates and small fishes that may be carried outward by tidal currents (Findlay, Wigand, and Nieder 2006). In addition, some plants and animals have evolved adaptations to life in intertidal environments that are alternately flooded and drained twice daily in the HRE study area.

In the HRE study area, many natural shorelines have been replaced with bulkheads, revetments, riprap, and dock/pier infrastructure. Hardened shorelines, like seawalls, bulkheads, and revetments, in the HRE study area are important and necessary economic and public safety features that protect against storm surges and protect properties from erosion. Although necessary, these shoreline structures have eliminated transitional intertidal and littoral areas. Hardened shorelines amplify wave energy, which can increase erosion and deepen nearshore waters, affecting water quality/clarity and habitat availability. Pier construction can reduce channel width, reduce current velocities, and increase 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 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). The Waterfront Alliance, in coordination with waterfront communities, design experts, and government agencies, has generated the Waterfront Edge Design Guidelines (WEDG). The goal of WEDG is to make NYC waterfronts more resilient, environmentally healthy, accessible, and equitable for all. Design guidelines also promote the improvement of water quality, restoration, and protection of shorefront habitats, and increased resilience to climate change (WA 2015). In addition, HEP is pursuing efforts to better understand the habitat quality associated with current near-vertical urban shorelines and lower-impact shoreline stabilization alternatives.

Target Statement

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 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). Although shoreline restoration opportunities exist in all planning regions, these three planning regions should be targeted for restoration under this TEC.

The short-term objective is to establish a new ***Shorelines and Shallows*** site in two of the planning regions by 2020, while the long-term objective aims to restore all available shoreline and shallows sites in the following priority planning regions (Lower Hudson, Upper Bay, and Harlem/East Rivers/Long Island Sound) and at least two sites in the others planning regions by 2050. Restoration should focus on removing hardened shorelines to create gently sloping areas with three zones: vegetated riparian, stable intertidal, and illuminated littoral zones. Restored areas should target enhancement of sandy shoreline habitat for shorebird nesting and intertidal foraging habitat, as well as creation of shallow subtidal habitat to promote the development of bivalve communities (e.g., blue mussels, hard clams [*Mercenaria mercenaria*]. Creating shellfish habitat as part of this and the ***Habitat for Fish, Crab, and Lobsters*** may be prudent given the "attractive nuisance" concern associated with ***Oysters*** and the ecological services generally provided by all bivalves (e.g., water filtration, foraging habitat, etc.).

Naturally vegetated shoreline restoration can be employed at low energy sites, like creeks or protected inlets and coves, through the strategic placement of native vegetation, sand, and organic materials, and if necessary a small amount of reinforcing structural material (rock, shell, etc.; Figure 3-2a). The term "Living Shoreline" describes this restoration technique and has been successfully implemented in New Jersey, Maryland, Virginia, North Carolina, and Florida to reduce coastal erosion and wetland loss along sheltered coastlines (Frizzera 2009). Although restoration of natural shorelines is ideal, other methods of shoreline softening should be considered in achieving the target conditions, particularly at moderate to high energy sites where some type of engineered structure would be necessary (Figure 3-2b).

Incorporating structural materials, such as offshore rock or shell breakwaters, would allow restoration of natural shoreline habitat and promote tidal exchange at moderate energy sites, while physical complexity through the use of tiered or texturized bulkheads could be added to existing hardened shorelines at high energy sites (Frizzera 2009, Villamagna et al. 2009). In many cases, shoreline restoration and softening techniques can be incorporated into ***Public Access*** promenades and trails.

Shoreline restoration should be carefully planned to incorporate anticipated sea level rise so that estuarine habitats are preserved or can be restored on available land. Wetland scientists estimate that tidal wetlands can keep pace with rising water levels up to about 0.08 inches (2 millimeters) of sea level rise per year, by trapping sediments and forming peat as they expand inland (Climate Change Science Panel 2009). A recent probabilistic model revealed that nearly 70 percent of diverse coastal landscape in the northeastern U.S. has the capacity to respond (e.g., adapt) dynamically to sea level rise (Lentz et al. 2016). Increased carbon dioxide gas (CO_2) and warming can stimulate marsh elevation gain, counterbalancing moderate increases in sea level rise; however, the limited positive impact of warming and increased CO_2 on wetlands will be insufficient to compensate the decline of their extent resulting from other human drivers such as land use change (IPCC 2014). For example, when existing land uses prohibit inland migration of intertidal habitat, the habitat becomes submerged and eventually dies. Local sea level rise is predicted to occur at rates of 0.1 inches (2.8 millimeters) per year at the Battery in NYC and 0.15 inches (3.9 millimeters) per year at Sandy Hook, New Jersey, which presents concerns for tidal wetlands (NOAA 2012). Additionally, as sea level rises and coastal storms increase in intensity, coastal erosion and the number of

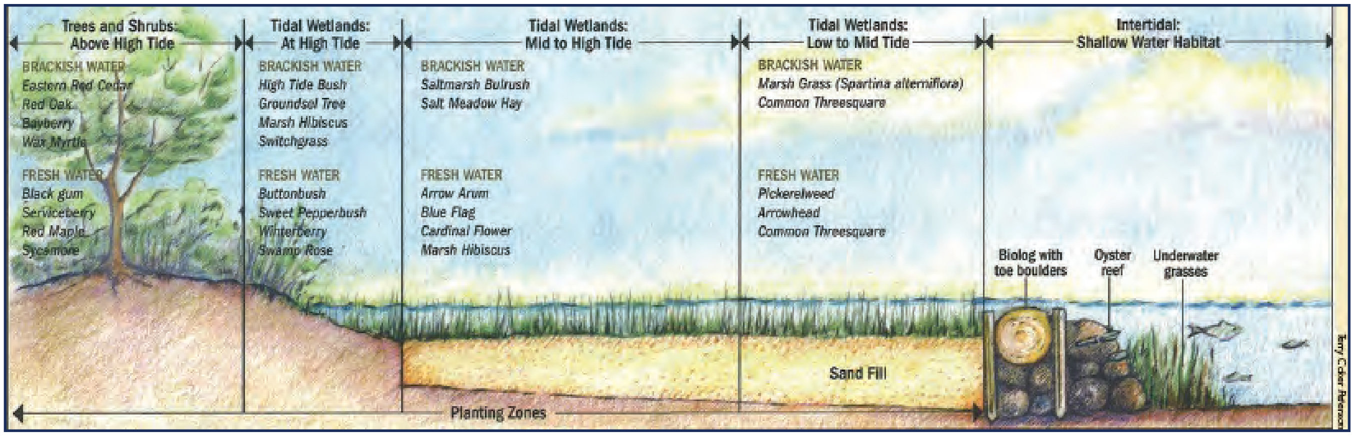


Figure 3~2a. Continuum of living shoreline habitat possible at low energy sites. To reduce coastal risk, NNBFs, such as wetlands, can enhance shoreline resiliency and sustainability. Sources: Chesapeake Bay Foundation 2012, www.cbf.org/livingshorelines and USACE 2015. Source: Chesapeake Bay Foundation 2012, www.cbf.org/livingshorelines.

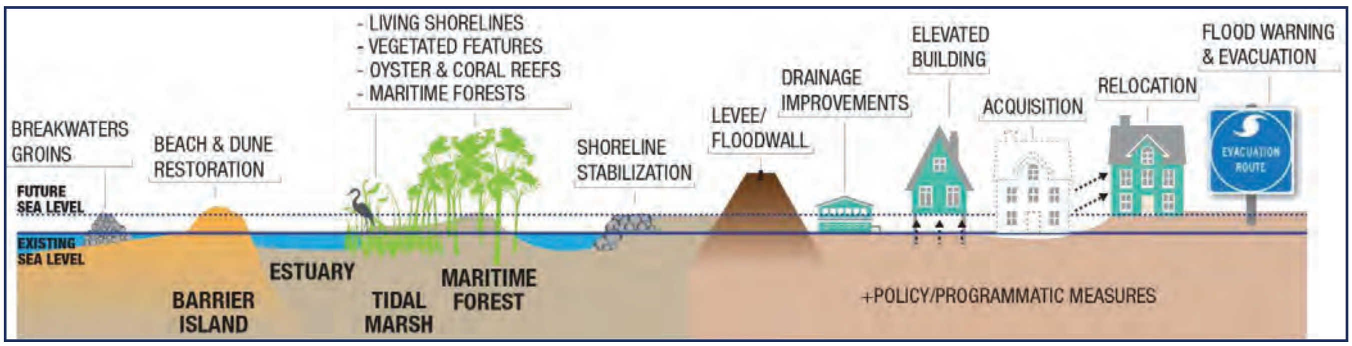


Figure 3~2b. Integration of Natural/Nature Based Features (NNBFs) within Layers of Coastal Protection.

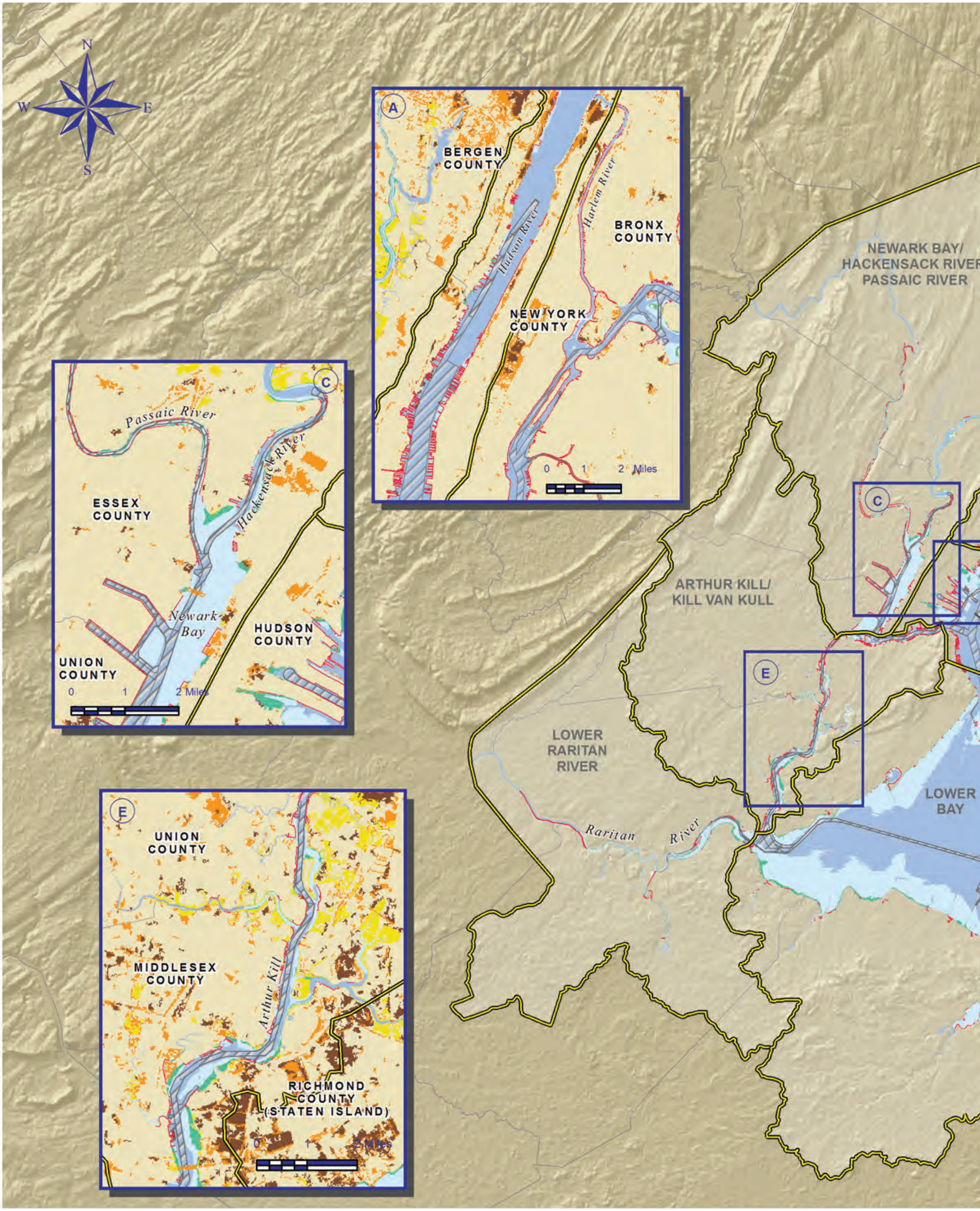
additional bulkheads, and other hard stabilization structures are likely to increase. Therefore, shoreline protection measures can be implemented to not only protect coastal properties but also restore and create ***Wetlands***.

Restoration Opportunities (Map 3-5)

Opportunities for improving ***Shorelines and Shallows*** exist in each planning region of the HRE study area. Map 3-5 displays existing littoral, intertidal, and undeveloped and vegetated upland areas that could be improved by creating gently sloping shorelines and reconnecting the three habitat zones. The shallow littoral layer displays subtidal habitat 13 feet (4 meters) or less below mean low water, where as the intertidal areas are those which inundate twice daily in the HRE study area.

Littoral habitat comprises a large portion of the bays within the estuary, roughly 30 percent, (54,630 acres [221 kilometers^2]) of the total open water acreage in the HRE study area (Table 3-4). Intertidal areas are relatively rare, comprising less than 2 percent (3,022 acres [12.2 kilometers^2]) of the total open water in the study area. The adjacent undeveloped upland areas include forests and shrublands, grasslands, as well as unvegetated areas. Coastal wetlands and lawn/parklands layers are displayed separately on the inset maps. Only areas of the undeveloped and vegetated layers within 3,000 feet (914 meters) of shore are displayed on the map, which was exaggerated from a typical buffer (100 feet

Map 3~5.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Arthur Kill
RICHMOND COUNTY (STATEN ISLAND)
0 1 2 Miles
NEWARK BAY/ HACKENSACK RIVER PASSAIC RIVER
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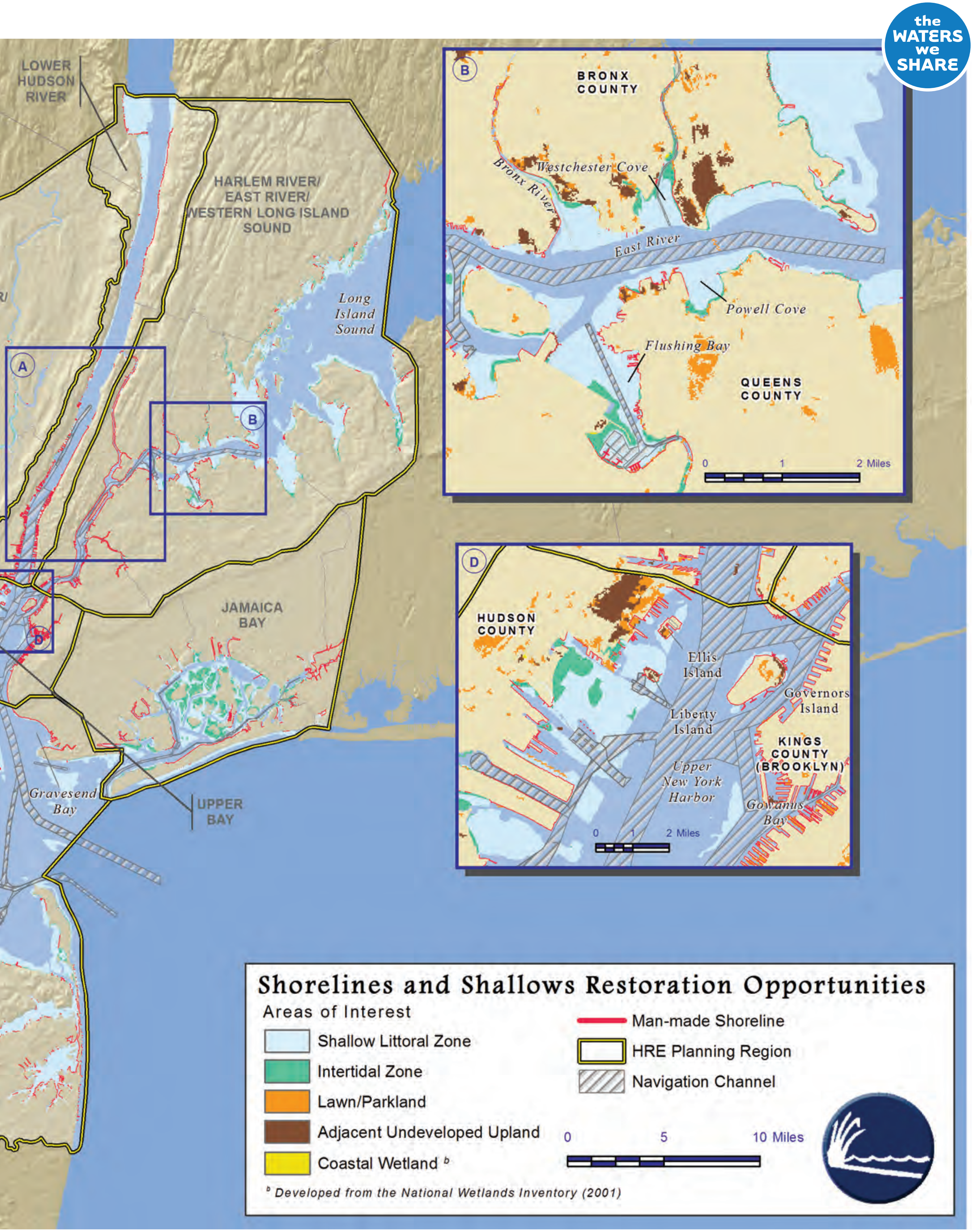
LOWER RARITAN RIVER
Raritan River
LOWER BAY


the WATERS we SHARE
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Gravesend Bay
UPPER BAY
BRONX COUNTY
Westchester Cove
Bronx River
East River
Powell Cove
Flushing Bay
QUEENS COUNTY
0 1 2 Miles
HUDSON COUNTY
Ellis Island
Liberty Island
Governors Island
KINGS COUNTY (BROOKLYN)
Upper New York Harbor
Gowanus Bay
0 1 2 Miles
Shorelines and Shallows Restoration Opportunities
Areas of Interest
Shallow Littoral Zone
Intertidal Zone
Lawn/Parkland
Adjacent Undeveloped Upland
Coastal Wetland [b]
Man-made Shoreline
HRE Planning Region
Navigation Channel
0 5 10 Miles
[b] Developed from the National Wetlands Inventory (2001)

Table 3-4. Areas of habitat and linear distance of man-made shoreline that could be restored in the Hudson-Raritan Estuary (HRE) study area.

GIS Layer	Area or Distance (Standard / Metric)		
Shallow Littoral Zone (< 13 feet [4 meters]) NOAA Electronic Navigation Charts	54,630 acres	/	221 kilometers^2
Intertidal Zone (Negative depths) NOAA Electronic Navigation Charts	3,022 acres	/	12 kilometers^2
Adjacent Undeveloped Upland (within 3,000 feet [914 meters]) 2001 National Land Cover Database	21,234 acres	/	86 kilometers^2
Lawn/Parkland (within 3,000 feet [914 meters]) 2001 National Land Cover Database	30,304 acres	/	123 kilometers^2
Coastal Wetlands* USFWS National Wetland Inventory (2001)	12,544 acres	/	51 kilometers^2
Man-Made Shoreline (including piers) National Geodetic Survey Shoreline	551 miles	/	887 kilometers
Man-Made Shoreline (no piers) National Geodetic Survey Shoreline	458 miles	/	737 kilometers

*Does not include acreage or distance for coastal wetland creation.

[91 meters] wide along shore) so that it would be visible on an estuary-wide scale. Lawn/parkland represents almost 13 percent (30,304 acres [123 kilometers^2]) of the land within 3,000 feet (914 meters) of shore, whereas adjacent undeveloped upland and coastal wetlands represent about 9 percent (21,234 acres [86 kilometers^2]) and 5 percent (12,544 acres [51 kilometers^2]), respectively.

Map 3-5 also displays man-made shorelines (e.g., bulkheads, piers, wharfs, jetties, and riprap shorelines) that could be removed to re-create natural shorelines or softened by adding structurally complex features. There are 551 miles (887 kilometers) of man-made shoreline in the HRE study area, 93 miles (150 kilometers) of which are piers. Many hard structures on the interior of the harbor cannot be removed because of nearshore development, port activities, or vessel-induced wakes, and represent opportunities for shoreline enhancement. Some hard structures are no longer necessary or not functioning properly and may represent a shoreline softening opportunity.

The Shorelines and Shallows Restoration Opportunities map displays several insets, which call out key features and accompanying restoration opportunities where riparian habitat could be created/restored, hardened shorelines could be removed/enhanced, intertidal areas could be created, or littoral areas could be improved:

- *Inset A* – Narrow bands of potential riparian and shallow littoral habitat occur on either shore of the Lower Hudson River, particularly in Bergen County, New Jersey and Westchester County, New York. There may be opportunities to develop intertidal habitats along these stretches. Along the west side of Manhattan, there may be opportunities to soften or enhance the shoreline within inter-pier areas. The Harlem River has fairly continuous hardened shorelines and no intertidal and almost no littoral habitat, representing a potential opportunity to create intertidal or littoral habitat.

- *Inset B* – This section of the upper East River contains many large subtidal flats, in the mouth of the Bronx River, Westchester Creek, Flushing Bay, and Powell Cove. In some cases, the adjacent undeveloped land shown is existing parkland, but in other cases, it may be opportunities to improve the riparian plant community. Upstream segments of the Bronx River have hardened shorelines and opportunities exist to soften these.
- *Inset C* – Long stretches of the lower Passaic and Hackensack Rivers are hardened and contain few intertidal areas, representing areas to soften shorelines, create intertidal habitat, and improve existing littoral habitat.
- *Inset D* – The Upper Bay may be the most difficult planning region in which to find ***Shorelines and Shallows*** restoration opportunities because of competing uses and tradeoffs. There are substantial subtidal flats located on the New Jersey shoreline that may be enhanced. As previously mentioned, there may be opportunities to soften shorelines and restore intertidal habitat along some of the islands including Governors, Liberty, and Ellis Islands. Areas along Brooklyn, like Gowanus Bay, may also be appropriate for shoreline enhancement.
- *Inset E* – The Arthur Kill and its tributaries do not have as many hardened shorelines as some water bodies of the HRE study area, but they still represent areas that would greatly benefit from improved intertidal and littoral habitats. Derelict structures can be removed and riparian shoreline vegetation can be planted and encouraged to grow.
- Other opportunities – Other opportunities may exist along the lower Raritan River, where there appears to be a length of hardened shoreline. Protected areas within Jamaica Bay and Gravesend Bay may also be appropriate areas for re-creating this habitat complex.

Examples of habitat features that can be incorporated into new waterfront features or reconstructed shorelines include:

- Creating underwater baffles or training walls to redirect flows and maintain desirable depths and exposed substrates
- Increasing light transmission through piers by increasing the height or decreasing the width of piers (Able and Duffy-Anderson 2006)
- Adding physical complexity to existing hardened shorelines by incorporating WEDG promoted by the Waterfront Alliance. Concepts include the use of texturized bulkheads or the addition reef-like elements along a shoreline (Figure 3-3a). The NYCDPR incorporated stepped bulkhead walls to create functional intertidal zones with marsh habitat and tide pools at a ***Public Access*** promenade at the Harlem River Park (Figure 3-3b); and installing an upland bulkhead and a submerged bulkhead that are divided by new fill and marshland vegetation to reintroduce habitat to a hardened shoreline (Figure 3-3c). The "Bulking & Tiering Wetland System" (patented by Bionautics, Inc. of Staten Island, NY) can provide remediation options for shorelines with ***Contaminated Sediments*** by capping with clean fill or dredged material and planting native wetland vegetation (Frizzera 2009).

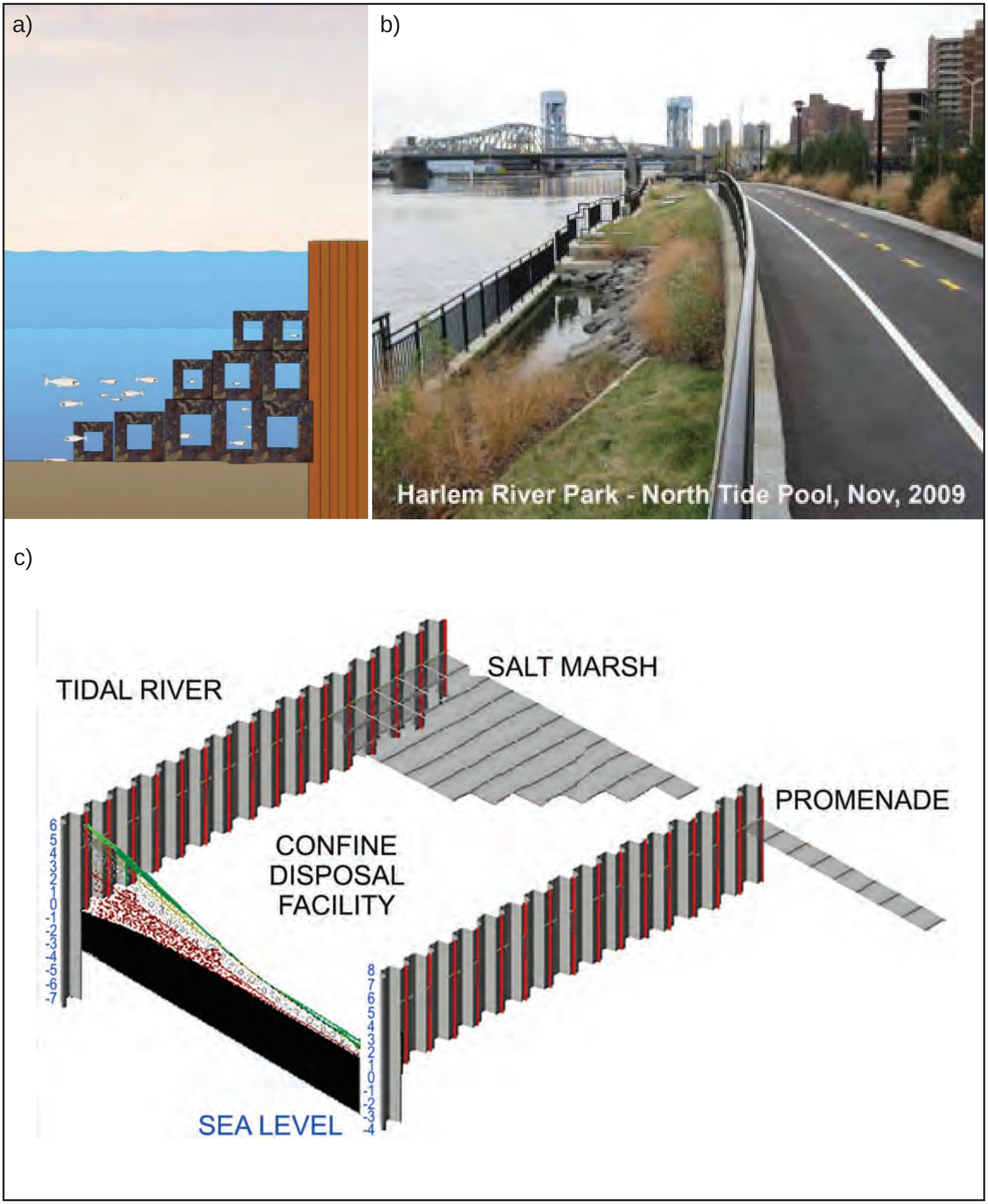


Figure 3-3. Examples of reconstructed shoreline features: (a) remediation option for shorelines using textured bulkheads and reef-like elements; (b) public access promenade at Harlem River Park; and (c) upland bulkhead and submerged bulkhead separated by new fill and marshland vegetation will help reintroduce habitat to hardened shorelines. Source: 2001 Bionautics, Inc.

3.2.2 Habitat for Fish, Crabs, and Lobsters

This TEC ensures that suites of habitats will be created to benefit many life stages for a range of resident, transient, and migratory species (Bain et al. 2007). It calls for the restoration or development of a mosaic of diverse, quality habitats intermixed throughout the estuary to sustain fish, crab, and lobster populations, with the understanding that doing so will also benefit numerous other aquatic species with overlapping habitat requirements (e.g., small finfish, other motile invertebrates). Many important estuarine and marine species are in low or declining abundance throughout the HRE study area, and the relationships among these habitats are important for many aquatic species to complete their life history.

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 and/or create mosaics of critical habitats, to provide what habitat was historically lost (i.e., intertidal ***Wetlands***, ***Eelgrass Beds***, ***Oyster Reefs***, etc.), as well as expand upon existing habitats (e.g., subtidal shallows, rocky intertidal).

Target Statement

The short-term goal of this TEC states that one complex of at least two functionally-related habitats should be created in each HRE planning region by 2020. Further, each region should have four habitat complexes of at least two related habitats by 2050. Progress will be measured in the number and total area of habitat sets developed in the HRE study area.

The overall intent of this TEC is to promote connectivity among complex habitats. Eight target species have been selected to represent demersal or benthic fish and large crustaceans of the HRE study area. These species and the habitats that are critical to their life stages are provided in Table 3-5. The target species are either abundant or economically important, and all are well-studied. Targeting habitat restoration for these species should also benefit other species in the HRE study area and be an opportunity to incorporate multiple TECs into a project.

Restoration Opportunities

This TEC should be considered during any habitat restoration project because the ecological benefits of a restoration project can be increased by creating a variety of habitats designed for target species. The exact spatial arrangements and distances among habitats have not been specified in the target statement, so as to maintain a degree of flexibility and ensure restored habitats are based upon target species requirements to optimize restoration success. Some example habitat complexes are presented in Table 3-6 (from Bain et al. 2007).

Site selection for this TEC would be most effective if project sponsors decided upon a target species and used the restoration opportunities maps developed for other TECs to identify areas to create appropriate habitat sets for the target species. However, it would also be possible to identify areas to conduct restoration based on the opportunities maps and existing restoration sites, and then determine which target species would most benefit from the planned habitat assemblage. Once a target species or a set of target species are identified, slight alterations could be made to the planned habitat assemblage, optimizing conditions and available resources for these species. Creating *Oyster Reefs* or other shellfish habitat as part of this and the *Shorelines and Shallows* TEC may not be prudent given the "attractive nuisance" concern associated with oysters and the ecological services generally provided by all bivalves (e.g., water filtration, foraging habitat, etc.). Although the ecological benefits of these shellfish species are not as substantial as those of *Oyster Reefs*, the risks associated with restoration may make these projects more attractive to regulators.

Table 3-5. Critical habitats and hypothetical Target Ecosystem Characteristics (TEC) mosaics for select species in the Hudson-Raritan Estuary (HRE) study area (Bain et al. 2007, references therein).

Select Species	Critical Habitat	TEC Mosaic
Summer flounder *(Paralichthys dentatus)*	Spawning: continental shelf Immature: sandy inshore/offshore habitat Adult: estuary/coastal, ocean	
Winter flounder *(Pseudopleuronectes americanus)*	Spawning: mud, sand, gravel sediment Immature: estuary/coastal, aquatic vegetation Adult: coastal	
Black sea bass *(Centropristis striata)*	Spawning: continental shelf Immature: estuary/coastal, structured habitat Adult: ocean, coastal, reefs	
Striped bass *(Morone saxitilis)*	Spawning: oligohaline Hudson River Immature: estuary/near salt front Adult: freshwater/coastal	
American eel *(Anguilla rostrata)*	Spawning: Sargasso Sea Immature: continental shelf ➔estuary ➔tributary Adult: tributary ➔ocean	
Horseshoe crab *(Limulus polyphemus)*	Spawning: polyhaline sandy beaches Immature: shallows, burrow in benthic habitat Adult: estuary/coastal, ocean	
American Lobster *(Homarus americanus)*	Spawning: continental shelf Immature and Adult: rocky, sediment, marsh, eelgrass	
Blue crab *(Callinectes sapidus)*	Spawning: mouth of estuaries Immature and Adult: ocean ➔estuary/freshwater, structured habitat	

Table 3-6. Habitat complexes important to the survival and productivity of estuarine species in the Hudson-Raritan Estuary (HRE) study area (adapted from Bain et al. 2007).

Habitat Complex	Functional Attributes and Spacing
Oyster reef, soft bottom, marsh fringe	Reef provides shelter for juvenile and smaller species, including forage; the soft bottom provides benthic invertebrate prey for predators using the reef for shelter; the marsh fringe is an alternate habitat for predators (e.g., blue crabs), that visit the reef to prey on small oysters, and the reef can dampen erosion forces on the marsh fringe habitat <328 feet (100m)
Oysters, tidal creeks, and salt marshes	These three habitats provide for close-by sheltering habitat for motile species at various tide levels <328 feet (100m)
Submerged Aquatic Vegetation (SAV) beds, soft bottom, and marsh fringe	SAV provides the sheltering habitat structure that is important to many juvenile and adult motile species, that often find food on adjacent habitats <328 feet (100m)
Shallow intertidal zone and SAV beds	Schools of forage or juvenile fishery species often can be chased out of SAV by aggressive predators but can find shelter in nearby shallow intertidal area that does not allow these predators to easily pursue them, although other alert predators, e.g., wading birds and shore birds such as terns, can be advantaged <328 feet (100m)
Piers and piling fields, good water flow, and soft bottom foraging grounds	The complex of baffles created by piers and piling fields have become important sheltering or orienting habitat to many fish and some invertebrates, but they function best when they have good water flow and access to near-pier benthic feeding grounds <328 feet (100m)
Peat banks and open sandy or muddy bottom, and good water flow	Holes in peat banks harbor vulnerable juvenile lobster and American eels during daylight, but they need convenient open bottom foraging ground at night <328 feet (100m)
Shallow sandy or muddy areas and channels	For some prey and predator species, channels provide a nocturnal refuge after daytime foraging on the open bottom, or vice versa, e.g., for mysid shrimp <1,640 feet (500m)

3.2.3 Habitat for Waterbirds

Waterbirds function as important species in estuarine systems, are indicators of ecosystem integrity, and are intrinsically valuable to the public (Bain et al. 2007). Aquatic birds (or "waterbirds") include a variety of birds adapted to life in and around coastal habitats. Waterbird groups include seabirds (e.g., cormorants, gulls, and terns), shorebirds (e.g., plovers and sandpipers), waterfowl (e.g., ducks and geese), and long-legged waders (e.g., herons, egrets, and ibis). Within the HRE study area, long-legged waders are the focus of this TEC. Nine species of egrets, ibises, and herons are collectively known as the "Harbor Herons," and this assemblage has been monitored annually in the HRE by New York City Audubon and its agency and institutional partners for over three decades (Winston 2015). Waterbirds consume fish and crustaceans within coastal wetlands and other littoral areas. In their natural setting, waterbirds are sought after by members of the birding community, some of whom 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).

Long-legged wading birds have experienced a dramatic comeback in the HRE study area since the 1960s, when populations were nearly extirpated by centuries of hunting, pollution, and habitat loss. With improved water and habitat quality, herons began populating the uninhabited islands of the Arthur Kill, Kill Van Kull, East River, and Jamaica Bay during the late 1970s (Steinberg et al. 2004). Eight islands and one mainland roost in the HRE study area currently function as nesting rookeries for resident and transient waterbirds (Table 3-7; Craig 2013).

Target Statement

The *Habitat for Waterbirds* TEC focuses on restoring and protecting roosting, nesting, and foraging habitat (e.g., inland trees, wetlands, shallow littoral habitat) for long-legged wading birds. The short-term objective for this TEC is to enhance at least one island without an existing waterbird population in the HRE planning regions containing islands and create or enhance at least one foraging habitat by 2020. The long-term objective of the *Habitat for Waterbirds* TEC is for all suitable islands to provide roosting and nesting sites and have nearby foraging habitat by 2050. With the exception of predator control, restoration activities will be limited to those islands without active breeding waterbird populations or rookeries.

Restoration Opportunities (Map 3-6)

Opportunities for restoring island habitat exist in most planning regions of the HRE study area (Map 3-6). The *Habitat for Waterbirds* restoration opportunities map displays areas where existing islands could be restored to provide more nesting and feeding habitat for target species. The map includes 68 existing islands over 0.25 acres (0.001 kilometers^2) in size, which are represented as color-coded dots, symbolizing the number of waterbird nests observed (excluding cormorant nests) during the 2013 Harbor Herons Nesting Survey (Craig 2013). Change in waterbird nest numbers is represented as an overall increase or decrease (or no change) based on overall percent change during surveyed years from 2001 to 2013. Shallow wetlands are important foraging areas for waterbirds in the HRE study area; therefore, islands are symbolized in the inset maps to represent the distance to the nearest wetland habitat. Percent tree canopy cover is also displayed on the inset maps to identify islands where trees and large shrubs currently exist.

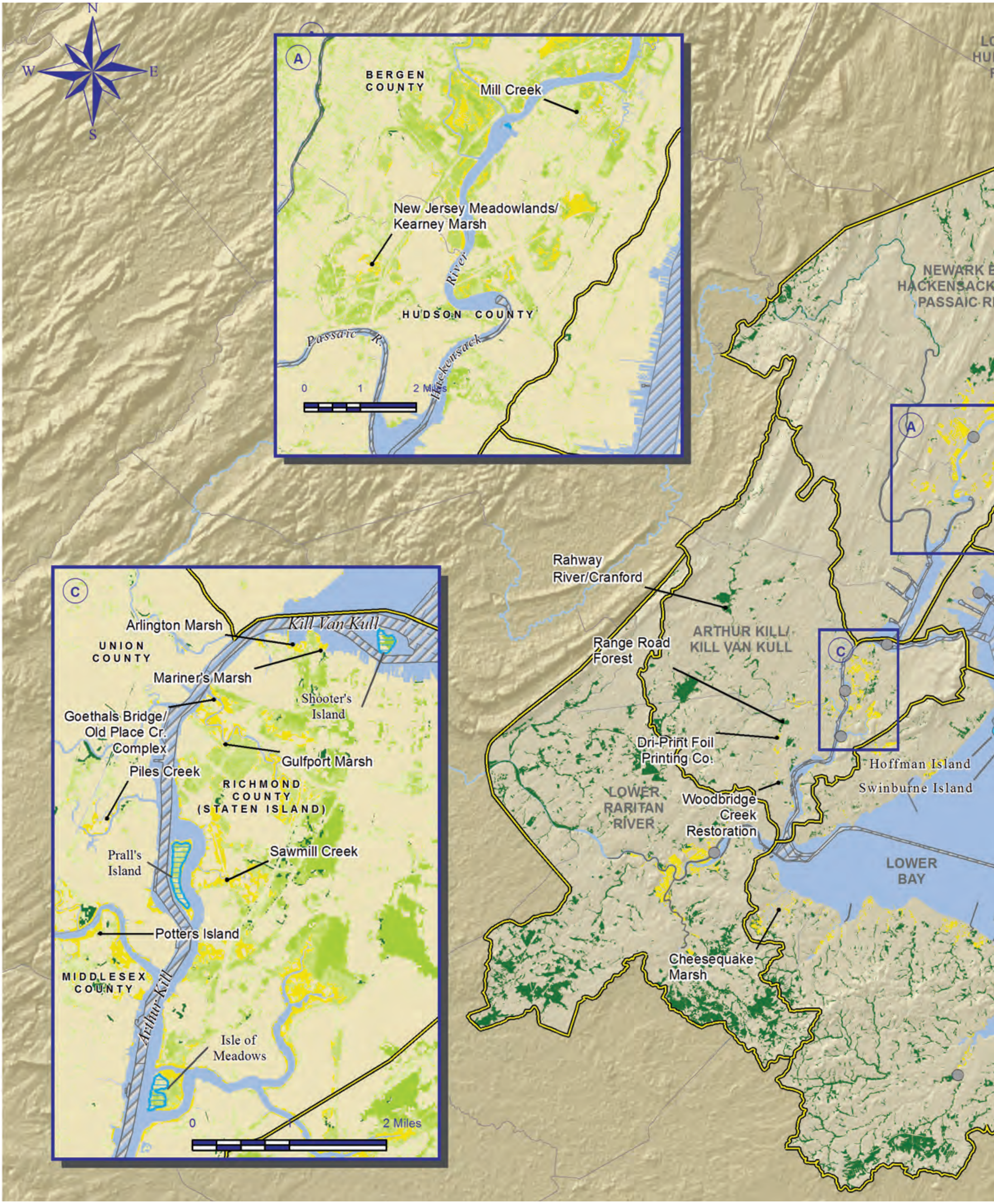
For all 68 islands, the average area was approximately 26 acres (0.1 kilometers^2). On average, the islands were almost 500 feet (152 meters) from the nearest wetland habitat, ranging from adjacent to 1.1 miles (1.8 kilometers) away from the islands. Three surveyed islands in the estuary had more than 200 nests identified during 2013: South Brother Island, Subway Island, and Hoffman Island. Subway Island was the most diverse colony in the harbor in 2013, with six species of nesting waders present. The greatest total number of nests was observed on Hoffman Island in recent years, although this island exhibited a 19 percent decline in total nests since 2010 (Craig 2013). Subway Island, and recently restored Elders Point East, experienced substantial increases (163 percent and 250 percent respectively) in nesting activity, while nesting activity on Canarsie Pol was entirely absent for the first time in the 14 years this island has been surveyed (Craig 2013). South Brother Island exhibited a substantial decline in nesting activity (-37 percent), Goose Island had been recently abandoned, and wader nesting on Huckleberry Island continued at very low levels. Recently inactive islands, including the three islands in the Arthur Kill and Kill Van Kull (Shooters Island, Pralls Island, and Isle of Meadows) and North Brother Island, continued to exhibit no signs of wader nesting activity in 2013 (Craig 2013).

Table 3-7. Islands of the Hudson-Raritan (HRE) study area that are surveyed as part of the Harbor Herons program. Includes acreage, distance to either freshwater or coastal wetland habitat, and the number of nests identified during the 2001-2014 Harbor Herons Nesting Surveys.

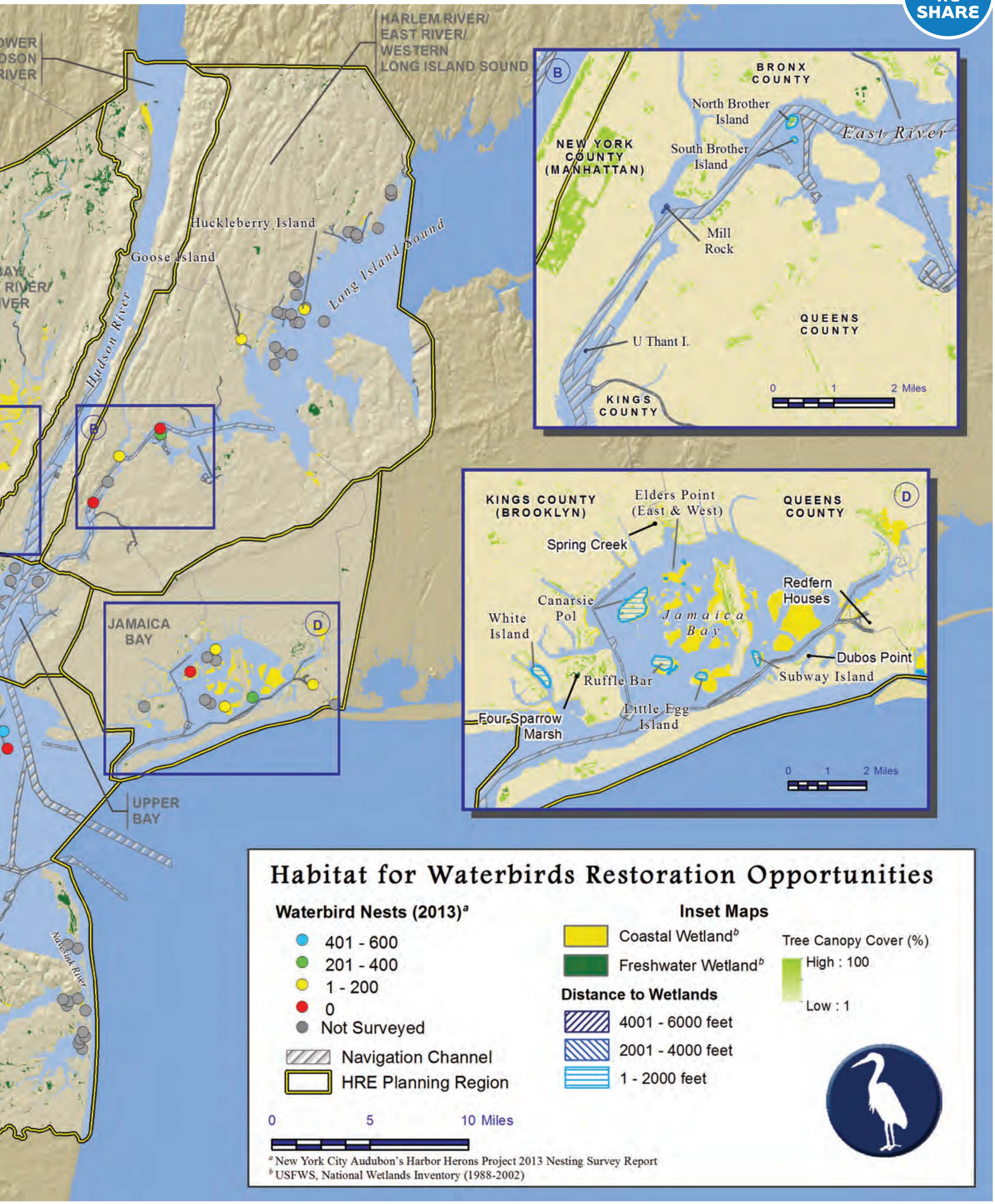
Surveyed Island	Acres	Distance to Wetlands (feet)	Nest Counts												
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Canarsie Pol	244.0	364.1	156	180	504	544	--	192	533	333	412	497	202	7	0
Elders Point Marsh - East	2.7	30.7	--	--	--	--	--	--	0	--	--	18	40	80	64
Elders Point Marsh - West	1.3	24.1	--	--	--	--	--	--	1	2	4	--	--	--	--
Goose Island	0.8	173.2	75	104	123	127	95	108	86	106	102	111	99	111	87
Hoffman Island	11.2	1,386.9	403	513	472	500	--	164	567	446	542	624	824	527	507
Huckleberry Island	5.3	25.3	140	99	118	28	50	20	6	2	7	21	3	1	8
Isle of Meadows	28.4	107.5	--	--	--	--	0	0	0	0	0	0	--	--	--
Little Egg Island	27.4	137.7	--	--	--	--	--	--	0	0	--	--	--	--	20
Mill Rock	2.7	2,983.6	--	--	--	--	43	62	43	--	107	112	169	203	113
North Brother	19.1	1,849.6	244	225	239	116	99	87	15	0	0	0	--	--	0
Pralls Island	43.5	46.3	--	--	--	--	5	0	0	0	0	0	--	--	--
Redfern Houses*	--	--	--	--	--	--	--	--	--	--	59	65	15	39	40
Ruffle Bar	87.7	213.7	--	--	--	--	--	--	0	0	--	--	--	--	--
Shooter's Island	18.8	100.7	--	--	--	--	0	0	0	0	0	0	--	--	--
South Brother	5.2	1,566.0	377	384	379	381	444	485	592	462	445	456	387	351	286
Subway Island	31.8	74.2	--	--	--	--	--	--	2	2	3	142	149	160	373
Swinburne Island	2.7	2,496.6	--	--	--	--	--	1	1	1	2	1	2	0	0
U Thant Island	0.3	5,943.0	--	--	--	--	--	21	0	0	0	0	0	0	0
White Island	81.5	294.1	--	--	--	--	--	--	0	--	--	--	--	--	--
TOTAL	614.4		1,395	1,505	1,835	1,696	736	1,140	1,846	1,354	1,683	2,047	1,928	1,479	1,498

*Redfern Houses is a mainland nesting site in Far Rockaway, Queens.

Map 3~6.



N
S
E
W
A
BERGEN COUNTY
Mill Creek
New Jersey Meadowlands/ Kearney Marsh
River
HUDSON COUNTY
Passaic R.
Hackensack
0
1
2 Miles
C
Arlington Marsh
Kill Van Kull
UNION COUNTY
Mariner's Marsh
Shooter's Island
Goethals Bridge/ Old Place Cr. Complex
Gulfport Marsh
Piles Creek
RICHMOND COUNTY (STATEN ISLAND)
Prall's Island
Sawmill Creek
Potters Island
MIDDLESEX COUNTY
Arthur Kill
Isle of Meadows
0
2 Miles
NEWARK B
HACKENSACK
PASSAIC R
Rahway River/Cranford
ARTHUR KILL/ KILL VAN KULL
Range Road Forest
Dri-Print Foil Printing Co.
LOWER RARITAN RIVER
Woodbridge Creek Restoration
Hoffman Island
Swinburne Island
LOWER BAY
Cheesequake Marsh



HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
Huckleberry Island
Goose Island
Long Island Sound
Hudson River
JAMAICA BAY
UPPER BAY
Navesink River
BRONX COUNTY
North Brother Island
South Brother Island
East River
NEW YORK COUNTY (MANHATTAN)
Mill Rock
QUEENS COUNTY
U Thant I.
KINGS COUNTY
0 1 2 Miles
KINGS COUNTY (BROOKLYN)
Elders Point (East & West)
QUEENS COUNTY
Spring Creek
Redfern Houses
Canarsie Pol
White Island
Jamaica Bay
Dubos Point
Subway Island
Ruffle Bar
Little Egg Island
Four Sparrow Marsh
0 1 2 Miles
Habitat for Waterbirds Restoration Opportunities
Waterbird Nests (2013)a
401 - 600
201 - 400
1 - 200
0
Not Surveyed
Navigation Channel
HRE Planning Region
Inset Maps
Coastal Wetlandb
Freshwater Wetlandb
Tree Canopy Cover (%)
High : 100
Low : 1
Distance to Wetlands
4001 - 6000 feet
2001 - 4000 feet
1 - 2000 feet
0 5 10 Miles
a New York City Audubon's Harbor Herons Project 2013 Nesting Survey Report
b USFWS, National Wetlands Inventory (1988-2002)

Four inset maps on the Habitat for Waterbirds Restoration Opportunities Map draw attention to surveyed islands (excluding islands inhabited by humans) and foraging habitat. These insets indicate the presence of coastal and freshwater ***Wetlands***, canopy cover on these islands, and island proximity to wetland habitat. These restoration opportunities are presented in the Harbor Herons Conservation Plan, which was collaboratively developed to identify and prioritize Harbor Herons conservation efforts (Harbor Herons Subcommittee 2010).

- *Inset A* – The Hackensack River watershed, particularly areas of the New Jersey Meadowlands, contain opportunities to enhance existing wetlands for waterbird foraging habitat. In the last few years, over 300 acres (1.21 kilometers^2) of the Meadowlands have been restored with the completion of the Richard P. Kane and Evergreen MRI3 Mitigation Banks, and additional opportunities for wetland creation and restorations are being explored. Studies indicate that nesting waterbirds from the East River travel to the New Jersey Meadowlands to forage during the nesting season (Harbor Herons Subcommittee 2010). The Kearny Marsh site, a 400-acre (1.62-kilometers^2) parcel acquired by the New Jersey Meadowlands Commission, contains a large freshwater wetland that is dominated by shallow open water. Since the 1970s, the site has been supporting a large nighttime roost of egrets and night herons in the post-breeding season (August through October). Enhancement opportunities exist to reduce contaminants entering the site, remove contaminated sediments, and manage water levels to encourage re-growth of emergent vegetation. Tidal wetlands along Mill Creek, a tributary of the Hackensack River in Secaucus, New Jersey, were recently restored by the New Jersey Meadowlands Commission to increase tidal flow and marsh habitat diversity. Herons and egrets currently forage at the site during summer months, and black-crowned night heron (*Nycticorax nycticorax*), a New Jersey state-endangered species, has been observed nesting at the site. Additional opportunities for ***Wetland*** restoration along Mill Creek may be present. These sites have commonality with HEP acquisition and restoration sites that would benefit waterbirds and provide ecological benefits to a broader faunal range (Harbor Herons Subcommittee 2010).
- *Inset B* – The East River contains surveyed islands with the highest number of nests in the HRE study area. A total of 286 nests on South Brother Island was the third largest nest count during the 2013 survey, however this population did experience a 37 percent decrease from 2010 (Craig 2013). The areas of North Brother Island that had previously supported wader nests were searched during the 2013 survey; however, no evidence of wader or gull nesting was observed. U Thant Island was first surveyed in 2006; approximately the same number of (Double-crested Cormorant [*Phalacrocorax auritus*]) nests (31) have been observed annually on this island since the colony established in 2008 (Craig 2013). A total of 113 wader nests were observed on Mill Rock; a very similar number to that was observed in 2010 (Craig 2013). Although North and South Brother Islands are relatively close to existing wetland habitat, U Thant Island is almost 6,000 feet (1,829 meters) from the nearest wetlands and Mill Rock is almost 3,000 feet (914 meters) from the nearest wetlands. U Thant and Mill Rock Islands have few trees. NYCDPR planted native trees and shrubs on North Brother Island during 2005 and 2006, and again in 2014 after a focused invasive plant management effort during the 2014 growing season, which focused on persistent invasive vines including kudzu (*Pueraria spp.*) and porcelainberry (*Ampelopsis brevipedunculata*). On Pralls Island, the removal of host tree species used by the Asian long-horned beetle (*Anoplophora glabripennis*) (i.e., box elder [*Acer negundo*]) may have impacted the persistence of the colony (Craig 2011). Herons have been documented to nest in invasive species like oriental bittersweet vines (black-crowned night-herons on North Brother Island) and

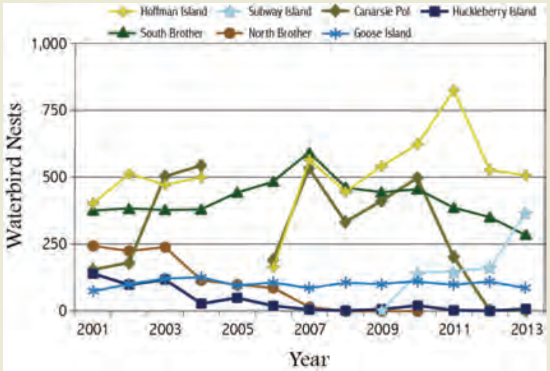
Phragmites (yellow-crowned night-herons [*Nyctanassa violacea*]; little blue herons [*Egretta caerulea*], and glossy ibises [*Plegadis falcinellus*]), in other locations. Consequently, removal of some kinds of invasive plants may affect nesting (Harbor Herons Subcommittee 2010). Early detection surveys for invasive plants and treatment outside of the breeding and nesting seasons can help reduce disturbance to nesting habitat (Craig 2011).

- *Inset C* – The peak of waterbird nesting occurred on the islands of the Arthur Kill and Kill Van Kull during the 1970s through the 1990s (Bernick 2007). However, no successful nesting has been observed on these islands since the 1990s (Kerlinger 2004, Winston 2015). There are substantial coastal and freshwater wetlands near these islands that are used for foraging and loafing by the Harbor Herons (Tsipoura et al. 2016). Despite extensive baseline monitoring, causes of waterbird abandonment on these islands are undetermined. Several potential causes of abandonment at Pralls Island included the Exxon Bayway oil spill in 1990/1991, a die-back of gray birch (*Betula populifolia,* the preferred nesting tree), dramatic change in water level in Goethals Bridge Pond, and increased predator populations (Harbor Herons Subcommittee 2010). Since it was deforested in 2007 to eliminate an Asian long-horned beetle infestation, NYCDPR has undertaken a long-term strategy to restore native upland plant communities on Pralls Island through replanting and invasive species management (Harbor Herons Subcommittee 2010). Supported by a grant from HEP, NYCDPR and NYC and New Jersey Audubon are studying the potential for herons to be socially attracted to new or restored areas, which would support restoration at sites like Pralls Island. Other waterbird nesting and foraging restoration opportunities in the Arthur Kill and Kill Van Kull are identified in Inset C based on recommendations of the Harbor Herons Subcommittee (2010). Potter's Island along the Rahway River could be acquired and restored as a heron and egret rookery. Potential for salt marsh restoration at Arlington and Mariner's Marsh exists as part of compensatory mitigation for disturbance related to the Staten Island Container Terminal construction. A diversity of wetland habitat types exists along Staten Island, including areas along Old Place Creek, Gulfport Marsh, and Saw Mill Creek that could be restored. Unfortunately, most of these areas contain ***Contaminated Sediments***, which will challenge restoration efforts in this area.
- *Inset D* – Ten (10) islands and one mainland location were identified within the Jamaica Bay region, all within 2,000 feet (610 meters) of wetland habitat. Canarsie Pol has been surveyed regularly by the NYC Audubon Society. The number of waterbird nests found on Canarsie Pol has ranged between 156 and 544 over the past 14 years, and 202 were found on the island in 2011. Many of Jamaica Bay's islands have little canopy cover, but this does not seem to deter nesting activity. Canarsie Pol, which is the largest island surveyed, supported the most diverse assemblage of nesting waterbirds and some of the highest nest counts during 2007 (Bernick 2007); however, 2015 marked the fifth consecutive year of massive decline in nesting activity on Canarsie Pol and the first year with no wader activity in the island's 14-year survey history. The other surveyed islands of Jamaica Bay including Ruffle Bar, Subway Island, Little Egg Marsh, and Elders Point (East and West) typically have not supported large nesting populations of waterbirds, although they are thought to have suitable habitat for the target species (Kerlinger 2004). In 2013, however, Elder's Point Marsh East had a 250 percent increase in nesting activity from 2010. This increase coincides with the concurrent decline and recent abandonment of Canarsie Pol (Craig 2013). Although substantial coastal wetland acreage appears in the inset, many of these areas are degraded and represent wetland

HARBOR HERONS SURVEY

The New York City Audubon's Harbor Herons project conducts annual surveys of important waterbird nesting habitat in the Hudson-Raritan Estuary (HRE) study area. Audubon conservationists along with a corps of citizen scientists survey and monitor these birds. The observed active nests from seven islands are depicted below (no data were available for Hoffman Island and Canarsie Pol in 2005, North Brother Island in 2008 and 2011-2012, and prior to 2007 for Subway Island).

Source: Harbor Herons Monitoring Program, New York City Audubon.



restoration or creation opportunities to provide enhanced waterbird feeding areas, including wetlands along Spring Creek, Dubos Point Park, and within Four Sparrow Marsh. Currently, wetlands in Jamaica Bay are visited by nesting birds on nearby islands including Hoffman Island (13-miles [20.9-kilometer] flight distance), as well as from areas outside the HRE as far as John Heinz National Wildlife Refuge in Philadelphia, Pennsylvania (approximately 80-mile [129-kilometer] flight distance) in the post-breeding season.

Other ***Habitat for Waterbirds*** restoration opportunities may exist on islands in Lower Bay. There are at least 12 islands along the Navesink River, although none have been surveyed as part of the Harbor Herons program. Cheesequake State Park in New Jersey contains an extensive 1,000-acre (4.05 kilometers^2) parcel of coastal wetlands that should be protected within which are restoration opportunities to enhance waterbird foraging habitat.

Future baseline studies should evaluate the specific attributes of each island in terms of soils/substrate, vegetation cover, predators, and human disturbance (including contamination of soils and biota). During nesting season, Swinburne Island is typically dominated by cormorants, but there may be opportunities to improve this island for roosting and nesting waterbirds by controlling populations of raccoons, rats, and other mammalian predators, which have been linked to declining waterbird populations in other estuaries (Harbor Herons Subcommittee 2010). Carefully planned and executed predator control is one of the few enhancement activities recommended to take place on islands with existing nesting activity and can result in substantial benefits in breeding population and improved hatchling and fledgling success (Harbor Herons Subcommittee 2010). The Conservation Plan identified evidence of raccoons and rats on some of the island colonies, such as Goose, Swinburne, and Hoffman Islands, and Canarsie Pol (Harbor Herons Subcommittee 2010).

In the face of potentially significant increases in sea level rise within the HRE study area in coming years, island and wetland habitats should be restored with long-term sustainability in mind. This may entail raising island elevations in low-lying areas with clean dredged sand from ongoing channel maintenance projects prior to the restoration of native vegetation communities and creating setbacks from wetlands for vegetation to naturally shift upland as water levels rise. Although restoration should prioritize enhancing existing islands, there is potential to create new islands or expand area on disappearing islands. The beneficial use of dredged material to expand islands to their historic extent (e.g., Jamaica Bay marsh islands) has gained regulatory acceptance and approval, and may set precedents for advancing island expansion in other regions of the HRE study area.

In order to gain a better understanding of the spatial relationships between existing nesting areas and available foraging habitat, it is recommended that telemetry and banding studies be conducted on groups of several birds from each of the active colonies to determine where they are feeding and the direction/distance they travel. This should be implemented as a baseline monitoring component at existing rookeries and incorporated into a long-term monitoring program at restored islands following recolonization by waders.

As indicated in Inset C, an important baseline data component will be to identify the presence of contaminated soils or biota on the islands, evaluate body burdens for the populations, and determine the effect of contaminants on behavior and reproductive health of waterbird populations. Beyond the initial baseline characterization, it will be important to monitor contaminants in soils and biota at restored sites on a long-term basis (years to decades) to be able to evaluate this factor on the integrity of waterbird populations in the HRE study area relative to improvements in nesting/foraging habitat.

3.3 Environmental Support Structures

Two of the TECs focus on repairing the environmental degradation associated with infrastructure that restricts the flow of water. The HRE study area contains many dams that store water for a variety of functions, such as drinking water reservoirs or recreational ponds. Other structures that are common in the HRE study area were designed to allow the passage of water, such as culverts under bridges and roadways. These structures can restrict the movement of fish, change natural circulation or drainage routes, and can result in environmental degradation. The following sections describe the environmental issues associated with these support structures, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3.3.1 Tributary Connections

The purpose of this TEC is to reconnect freshwater streams to the estuary and provide a range of quality habitats to aquatic organisms. This TEC focuses on restoring connections between, and corridors within, streams. This includes but is not limited to restoration of natural stream channels, adjacent freshwater wetlands, riparian uplands, and tributary connections including through barrier removal or fish passage construction.

Streams and rivers are important parts of the landscape as they carry water and sediment from higher elevations to the estuary. The watershed to these tributaries serves an important role by providing water, sediment, and nutrients, thus influencing water quality and functioning downstream habitats. It is important to understand the processes that occur at the watershed scale so that watershed restoration and protection practices can be implemented to support conditions for a functioning estuary and improving water quality downstream.

A stream and its watershed comprise a dynamic balance where the floodplain, channel, and stream bed evolve through natural processes that erode, transport, sort, and deposit sediments (Harman et al. 2012). Land use changes in the watershed, channel straightening, culverts, removal of streambank vegetation, impoundments, and other activities can upset this balance leading to stream instability and adjustments in channel form (Harman et al. 2012). Stream degradation (scour) can result from increased streamflow volume and frequency, while stream aggradation can result from land use practices that cause increased sediment loads. A new equilibrium may eventually result, but not before the associated aquatic and terrestrial environment are altered, often severely (Harman et al. 2012). Watershed protection and 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 the estuary and maintain connections between various quality 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, sediment type). 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, like 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).

Barriers can be man-made or natural "habitat" barriers. Man-made barriers to fish passage are often the easiest to define, such as dams, tide gates, and road culverts. Low dams were typically built in the HRE study area to support early American industry and agriculture. Today, many of these small dams are currently inoperative or no longer needed. However, some dammed waterbodies provide local communities with water supply, recreation, utilities, or have aesthetic/historic value (Bain et al. 2007). Reconnecting estuary-tributary pathways can be accomplished by removing derelict or unnecessary barriers, modifying barriers to promote fish passage (e.g., breaching, notching), or constructing fish passage structures (e.g., fish ladders, bypass channels). Dams that currently provide a water supply or safety function or small historic dams that may be regarded as important historical or cultural resources may be candidates for retrofitting with passage structures.

Whether partially or completely closed, tide gates are barriers to all upstream fish migration. The control schedule of existing tide gates can be modified so that gates remain completely open during upstream fish runs and during downstream juvenile migrations. New, self-regulating tide gates can be installed in place of conventional gates. These allow normal amplitude tides to enter and exit, but are designed to close in the event of atypical storm tides, preventing flooding of homes, roads, and other infrastructure.

Culverts under roads or rail beds can present migration barriers due to an excess drop at the culvert outlet, high velocity or turbulence within the culvert barrel, inadequate water depths within the culvert barrel, or debris/sediment accumulation at the culvert inlet or within the barrel (Gibson et al. 2005). Barriers also affect in-stream and riparian habitat, creating a need to improve tributaries on a system level. For instance, a dam removal project may alter in-stream habitat and riparian zones adjacent to where the water was previously impounded.

Non-structural barriers to fish passage can include water temperature, dissolved oxygen, turbidity, hydrologic and hydraulic alterations, and changes to tributary morphology as a result of sediment aggradation or degradation. These barriers can occur naturally or can be man-made, with water quality impediments often triggered by non-point source or point source discharges (e.g., erosion from construction activities, wastewater treatment plants, thermal discharges) or changes to riparian cover as a result of clearing and logging. Alteration of watershed hydrology and channel hydraulics can lead to changes in flow duration (e.g., subsurface flow), while excessive aggradation or degradation can lead to changes to channel dimension (e.g., high width to depth ratio) and profile (e.g., steep slopes) that may not support fish passage.

Target Statement

The short-term objective for the ***Tributary Connections*** TEC is to remove one barrier per year that blocks the free movement of aquatic life from estuary waters to at least three different inland habitats. The long-term objective is to continue reconnecting coastal and inland habitats at a rate of one project per year until all near-estuary barriers blocking inland access have been removed or made passable. Half of the new connections during this period should reach at least three new habitats. The habitat types that will ultimately be connected to the open waters of the HRE study area include ponds, lakes, ***Wetlands***, streams, and rivers, which should place emphasis on barriers blocking access to a variety of water bodies.

Restoring in-stream habitat upstream or downstream of a barrier and riparian habitat, such as forested floodplains and freshwater wetlands, could fulfill the target statements for this TEC. Where possible, projects should attempt to include multiple components (i.e., in-stream habitat, riparian habitat, barrier removal) to increase the number of functional benefits and the ecological contribution of the tributary to the estuary. Although projects with multiple components are encouraged, small projects that aim to restore even one component may also provide substantial benefits and should be conducted.

The measure of performance for this TEC should be the number and types of habitats reconnected to the open waters of the HRE including riparian natural vegetation areas, floodplain wetlands, and other waterway associated habitats. Although there are no official metrics for this TEC, stream length and riparian acreage restored could be appropriate metrics for the goal statement. For restoring habitat under this TEC, the following guidelines should be followed:

- Habitat restoration should focus on riparian habitat that is, or once was, connected to the estuary.
- Tributaries with higher stream orders that are proximal to an estuary body should be targeted for restoration. These can be freshwater areas with no tidal influence.
- Projects with fish passage components should focus on impediments, which when removed make several miles of stream passable.

A thorough evaluation of the upstream environment should be conducted to determine the impacts of barrier removal. The slow moving water found upstream of impoundments, whether natural or man-made, typically supports different fish communities and shoreline vegetation, and can be highly valued. If these impounded waters provide recreational sport fishing opportunities to nearby residents, it may be extremely difficult to gain support for a barrier removal project. Additionally, the shoreline vegetation may include regulated wetland communities that could be affected by a barrier removal. In scenarios like these, it is important to gain public support during preliminary planning stages.

Restoration Opportunities (Map 3-7)

Tributary Connections restoration opportunities included in this section focus on allowing fish passage along tributaries blocked by dams. Restoration opportunities include removal of derelict dams and installation of fish ladders or other fish passage measures to restore the connectivity. Opportunities for improving tributary habitat and connectivity exist in most planning regions of the HRE study area, but not within the Upper Bay or Jamaica Bay Planning Regions. Information used to identify potential restoration opportunities includes: known dam locations, tributary reaches (length and number of impoundments), freshwater ***Wetland*** locations, and percent tree canopy cover.

Map 3-7 displays the ***Tributary Connections*** restoration opportunities. The color of the dam represents the total length of stream impounded or the length of stream to the next upstream dam. Impounded tributary reaches are color coded to represent the number of dams on a tributary reach (see Inset C, the Lawrence Brook). Restoration practitioners should focus on reaches with fewer impoundments (e.g., above first dam) and focus on providing the most upstream habitat possible to benefit migratory species (e.g., blue/black dams with white tributaries). In the HRE study area, there are 60 dams identified on the USACE data set, impounding over 1,000 miles (1,609 kilometers) of stream habitat. Removing or making only the downstream dams passable would provide access to over 500 miles (805 kilometers) of stream habitat to migratory species.

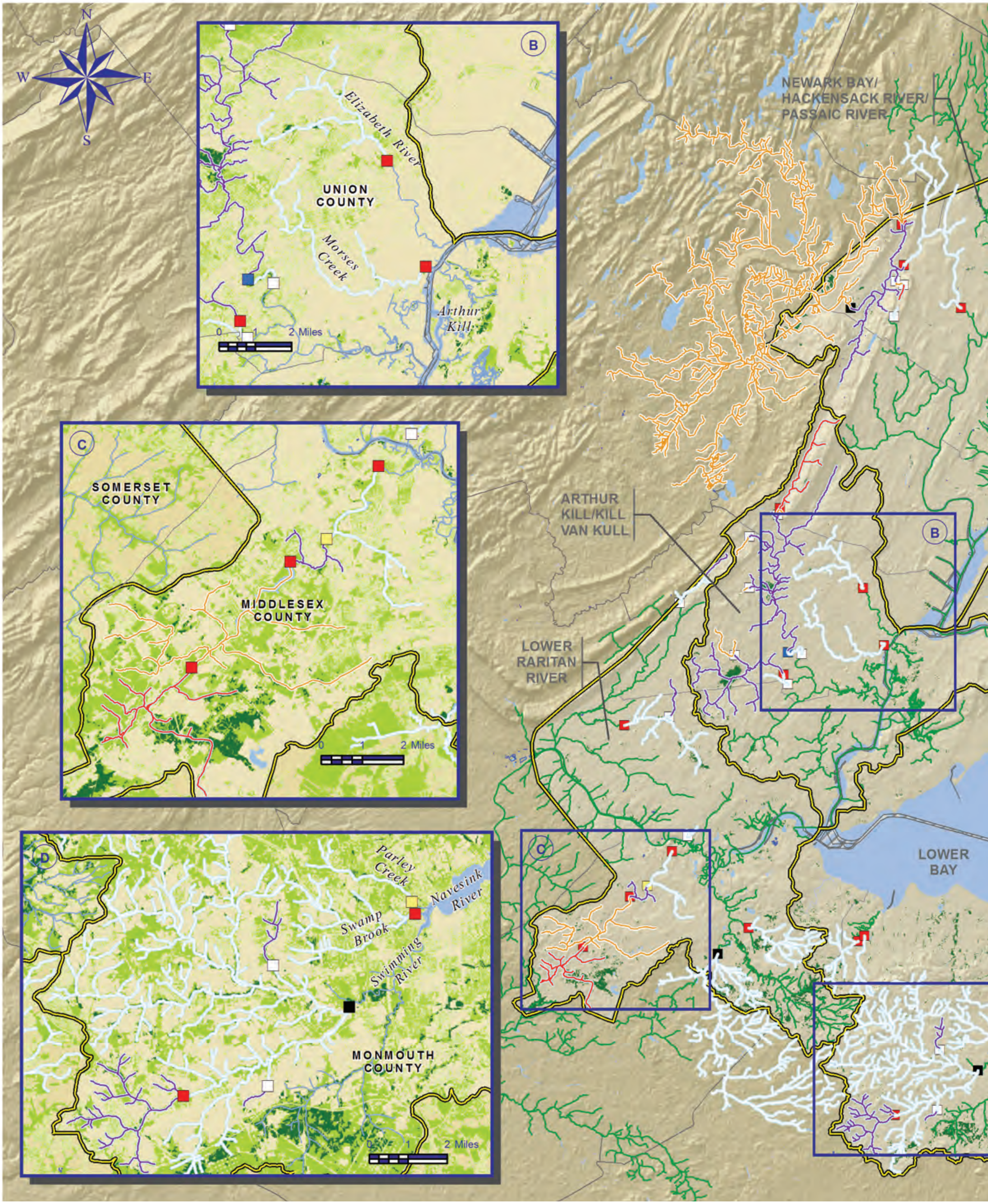
- *Inset A* – Approximately seven impassable dams exist along the lower and middle Bronx River that, if made passable, would provide access to almost 50,000 feet (15,240 meters) of stream. The 182nd Street Dam fish passage, designed to allow migratory river herring to access freshwater spawning habitat began operation in 2015. At approximately the same time, the Bronx River Alliance and NYCDPR's NRG completed an eel pass at 182nd Street Dam in River Park, which provided proof of concept for facilitating American eel migration over dams. Stone Mill Dam and Bronx Zoo and Dam are all fish passage restoration sites on the portion of the Bronx River within New York City. Seven additional sites, including Muskrat Cove, River Park/West Farms Rapids Park, Shoelace Park, Westchester County Center, Bronxville Lake, Crestwood Lake, and Garth Woods/Harney Road are being recommended for riparian and in-stream restoration construction as part of the HRE Feasibility Study.
- *Inset B* – Opportunities to improve tributary connectivity may exist in New Jersey along the Arthur Kill, including impoundments on the Elizabeth River and Morses Creek, with each passable impoundment providing access to 10,000 to 50,000 feet (3,048 to 15,240 meters) each. There may also be opportunities for freshwater restoration along the Elizabeth River upstream of the impoundment.
- *Inset C* – Lawrence Brook is a major tributary of the Raritan River. This tributary clearly demonstrates the color-coding scheme applied to tributary reaches on the map. Multiple dams are located on the Lawrence Brook that prevent upstream passage for fish. The Lawrence Brook Watershed Partnership was awarded a grant to conduct a partial feasibility study for fish ladders at Westons Mill Dam and the north side of Westons Arch Dam, the two lowest dams on the brook. A technical study has been conducted as part of the project and the partnership continues to monitor water levels and flows as the project moves forward (Lawrence Brook Watershed Partnership 2013).

- *Inset D* – Several tributaries of the Navesink River may be appropriate locations for improving fish passage, such as the dams at the mouth of the Parley Creek and Swamp Brook. Swimming River, a tributary of the Navesink River upstream of Red Bank in Monmouth County, New Jersey, may also represent an ideal opportunity to restore fish passage, as it would provide access to over 170,000 feet (51,816 meters) of stream.

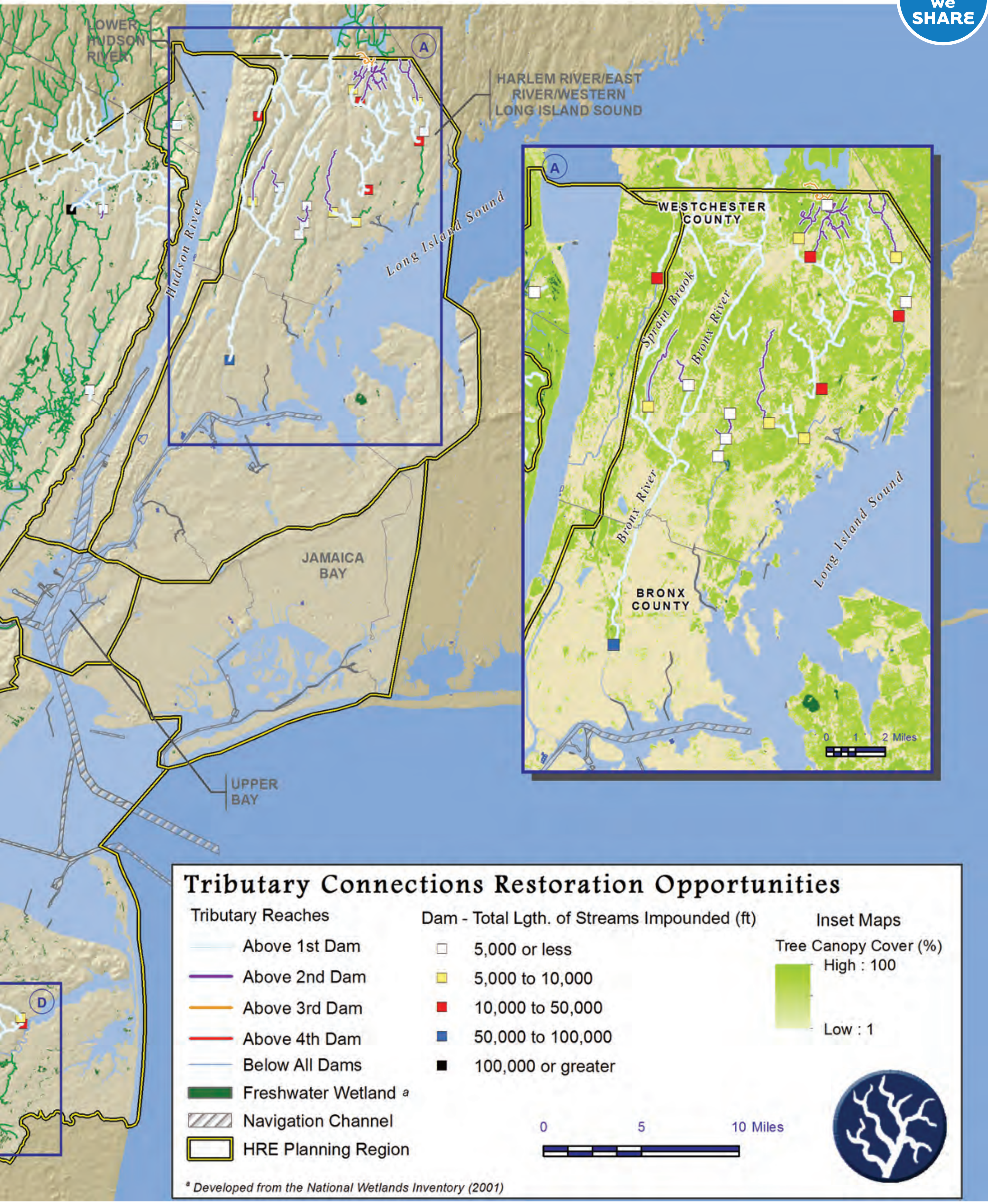
Many other opportunities to restore fish passage exist throughout the HRE study area, specifically at dams that currently prevent fish passage. For example, in the Newark Bay, Hackensack River, and Passaic River Planning Region, two dams have been considered for improvements: the Oradell Reservoir Dam on the Hackensack River and the Dundee Lake Dam on the Passaic River. Installation of a fish ladder at the Oradell Reservoir Dam could provide anadromous fish access to more than 110,000 feet (33,528 meters) upstream, and a fish ladder at the Dundee Dam could provide anadromous fish access to more than 47,000 feet (14,326 meters) upstream. However, after coordination with USEPA a fish ladder at Dundee Dam was considered unacceptable due to the potential migration of contaminated fish from the lower Passaic River Superfund Study Area to areas upstream of the dam.

Where possible, projects should attempt to include multiple components (i.e., in-stream habitat, riparian habitat, and barrier removal). While dam removal has the potential to provide the greatest number of functional benefits and ecological contribution of the tributary to the estuary, it could also alter in-stream habitat and riparian zones adjacent to where the water was previously impounded. Given that the slow moving water found upstream of impoundments, whether natural or man-made, typically supports different fish communities and shoreline vegetation, and can be highly valued a thorough evaluation of the upstream environment should be conducted to determine the impacts of barrier removal and improvements to tributaries must be on a system-level.

Map 3~7.



N
S
E
W
B
Elizabeth River
UNION COUNTY
Morses Creek
Arthur Kill
0
1
2 Miles
C
SOMERSET COUNTY
MIDDLESEX COUNTY
0
1
2 Miles
D
Parley Creek
Navesink River
Swamp Brook
Swimming River
MONMOUTH COUNTY
0
1
2 Miles
NEWARK BAY/ HACKENSACK RIVER/ PASSAIC RIVER
ARTHUR KILL/KILL VAN KULL
LOWER RARITAN RIVER
LOWER BAY
B
C


LOWER HUDSON RIVER
HARLEM RIVER/EAST RIVER/WESTERN LONG ISLAND SOUND
A
Hudson River
Long Island Sound
JAMAICA BAY
UPPER BAY
D
A
WESTCHESTER COUNTY
Sprain Brook
Bronx River
Bronx River
Long Island Sound
BRONX COUNTY
0 1 2 Miles
Tributary Connections Restoration Opportunities
Tributary Reaches
Above 1st Dam
Above 2nd Dam
Above 3rd Dam
Above 4th Dam
Below All Dams
Freshwater Wetland a
Navigation Channel
HRE Planning Region
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
Inset Maps
Tree Canopy Cover (%)
High : 100
Low : 1
0 5 10 Miles
a Developed from the National Wetlands Inventory (2001)

3.3.2 Enclosed and Confined Waters

The ***Enclosed and Confined Waters*** TEC focuses on poorly flushed, enclosed, constricted, and over-excavated subtidal areas of the HRE study area that exhibit periodic or continuous poor water quality. Examples of enclosed and confined water bodies occurring in the HRE study area include modified tidal creeks, enclosed basins, and man-made bathymetric depressions with poor circulation. These water bodies are often characterized by a host of degraded conditions, including contaminated sediments, hypoxic/anoxic water masses, noxious odors, hardened shorelines, accumulation of fine sediments, and little or no vegetated buffers, creating low quality habitat that is of limited use for foraging, nursery, or refuge by estuarine organisms.

Dead-end tidal creeks are remnant natural tidal drainage features that have been cut off from their headwaters and partially filled. Historically, many tidal creeks were present throughout the HRE study area as drainage features associated with intertidal wetlands. As the estuary became increasingly populated and developed, these water bodies were successively straightened and or diverted through culverts, or filled throughout their length (Bain et al. 2007). This created narrow, confined waterways that often exhibit impaired tidal flow, have limited flushing, and are dredged to depths greater than the surrounding estuary, promoting poor water circulation and stratification (Yozzo et al. 2001, Bain et al. 2007).

Man-made bathymetric depressions are deep holes that were created by removing sediment for on-land construction (i.e., borrow pits). Artificial depressions are characterized by impaired water circulation, fine organic sediments, and vertically stratified temperature and dissolved oxygen concentrations that can be as low as 4° C and 0 to 1 milligrams/liter, respectively, in the deepest pits of Jamaica Bay (BVA 2005). These bathymetric depressions may also contain debris, such as derelict vessels or vehicles, construction materials, and pilings.

Enclosed and Confined Waters in the HRE study area often have extremely poor water quality due to years of unregulated dumping and discharge (Yozzo et al. 2001). These basins have been cut off from their historic creeks and there is limited tidal flushing from the estuary. Therefore, major inputs to ***Enclosed and Confined Waters*** often include stormwater runoff coupled with human and industrial wastes from CSOs, vessels, and shoreline facilities (Bain et al. 2007). Confined waters typically exhibit low species diversity and abundance, and are dominated by a few opportunistic species.

Target Statement

The restoration targets for ***Enclosed and Confined Waters*** aim to improve the condition of these water bodies to where they match state-defined designated uses (i.e., shellfishing, bathing, fishing, etc.). The short-term objective is to improve the water quality of eight enclosed waterways by 2020. The long-term objective statement for this TEC is to improve the water quality or environmental conditions of all enclosed waterways by 2050. Progress toward the long-term objective could be measured using interim metrics, such as percent compliance of a confined waterway to a higher designated use because changing state-designated uses can be difficult. Through restoration efforts, these improvements will lead to improved water quality and increase the amount of shallow, protected water habitat in the HRE study area.

Table 3-8. Designated best use classes for surface water use in estuaries in the states of New Jersey and New York.

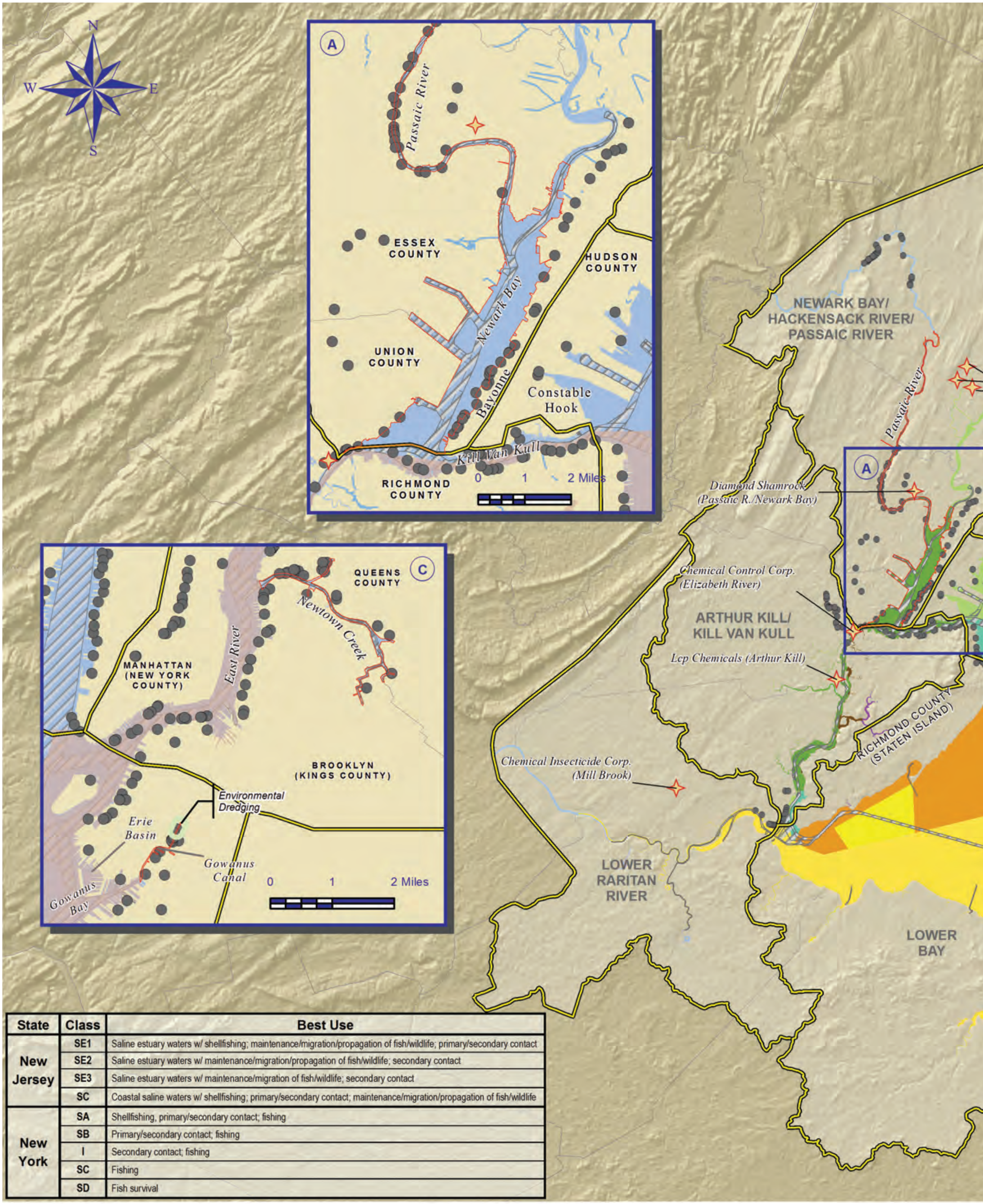
State	Class	Best Use
New Jersey	SE1	Saline estuary waters with shellfishing; maintenance, migration, and propagation of fish and wildlife; and primary and secondary contact recreation
	SE2	Saline estuary waters with maintenance, migration, and propagation of fish and wildlife; and secondary contact recreation
	SE3	Saline estuary waters with maintenance and migration of fish and wildlife; and secondary contact recreation
	SC	Coastal saline waters with shellfishing; primary and secondary contact recreation; and maintenance, migration, and propagation of fish and wildlife
New York	SA	Shellfishing; primary and secondary contact recreation and fishing
	SB	Primary and secondary contact recreation and fishing
	SC	Fishing
	I	Secondary contact recreation and fishing
	SD	Fish survival

Restoration Opportunities (Map 3-8)

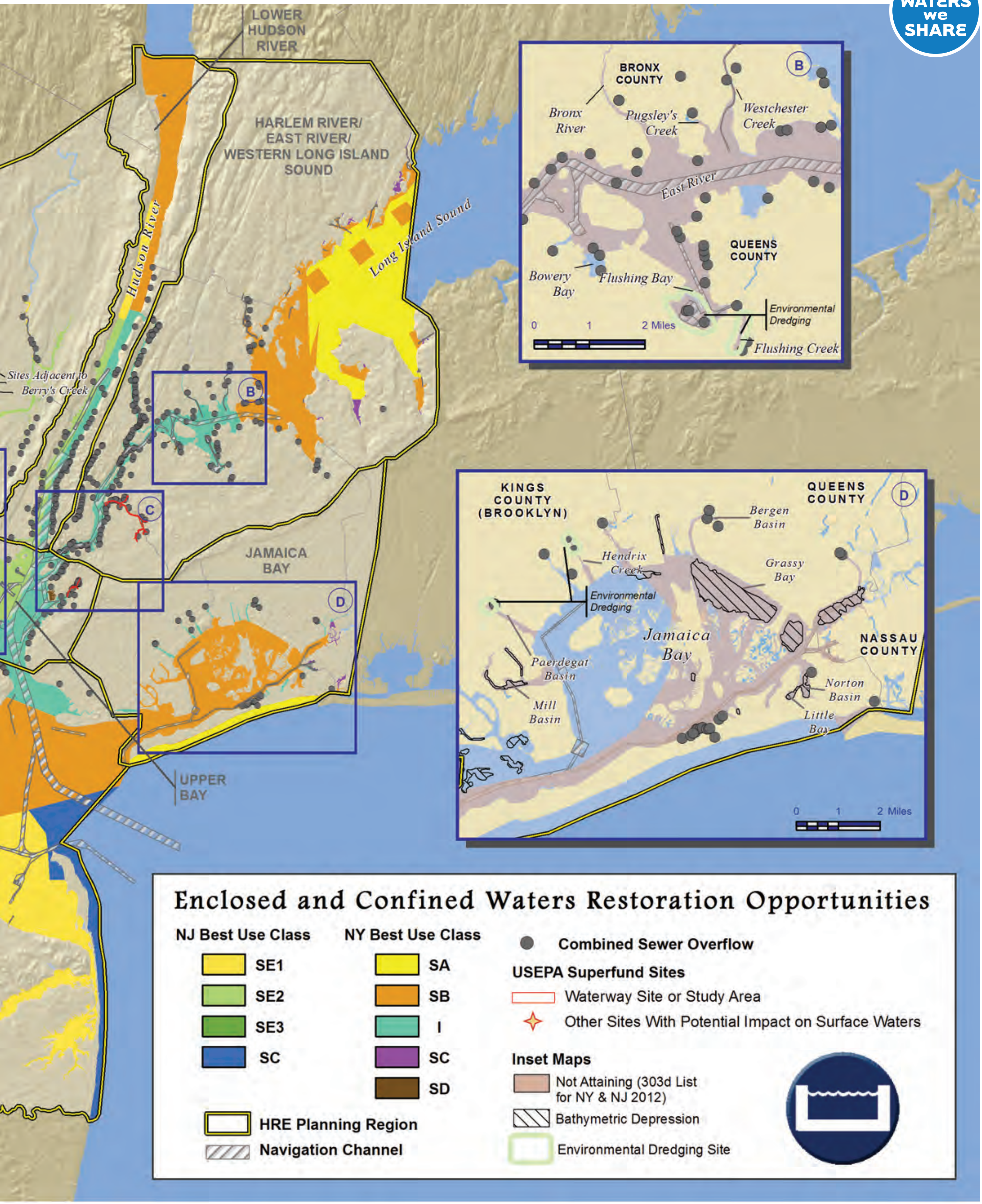
Opportunities for improving ***Enclosed and Confined Waters*** exist in each planning region of the HRE study area. Map 3-8 displays these restoration opportunities. Included on the map are areas where dead-end tidal creeks, head-ends of tributaries, bathymetric depressions, and inter-pier areas do not meet their state designated use. The map also displays the state-designated best use class (Table 3-8), CSOs, and national superfund sites that occur both in waterways and on land with the potential to affect adjacent surface waters. The inset maps highlight those waterbodies that have been documented as not meeting the water quality standards indicated by their designated use (i.e., on the 303(d) List of Impaired Waters). Also on the inset maps, known bathymetric depressions and basins where environmental dredging projects are in-progress to improve water quality are delineated.

Most of the HRE study area is designated to support at least fishing and secondary contact recreation, even within the majority of enclosed or confined water bodies, as defined in this TEC. In New York waters, many of these water bodies are impacted particularly by pathogens, low dissolved oxygen, and nitrogen pollution. However, they have been removed from the 303(d) List due to requirements to implement controls that are expected to result in attainment of water quality standards within a reasonable period of time (NYC CSP Consent Order and Nitrogen Consent Judgment). Additionally, other areas do not meet their designated uses due to aesthetic criteria, such as the presence of floatables; not meeting the criteria for PCBs or metals; or use as migratory fish corridors. In New Jersey, the scale at which non-attaining waters are defined does not distinguish enclosed or confined waters from their receiving waters, but many of the large water bodies have contaminants, metals, or high total suspended solids.

Map 3~8.



State	Class	Best Use
New Jersey	SE1	Saline estuary waters w/ shellfishing; maintenance/migration/propagation of fish/wildlife; primary/secondary contact
	SE2	Saline estuary waters w/ maintenance/migration/propagation of fish/wildlife; secondary contact
	SE3	Saline estuary waters w/ maintenance/migration of fish/wildlife; secondary contact
	SC	Coastal saline waters w/ shellfishing; primary/secondary contact; maintenance/migration/propagation of fish/wildlife
New York	SA	Shellfishing, primary/secondary contact; fishing
	SB	Primary/secondary contact; fishing
	I	Secondary contact; fishing
	SC	Fishing
	SD	Fish survival


LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
Hudson River
Long Island Sound
Sites Adjacent to Berry's Creek
JAMAICA BAY
UPPER BAY
B
C
D
BRONX COUNTY
Bronx River
Pugsley's Creek
Westchester Creek
East River
QUEENS COUNTY
Bowery Bay
Flushing Bay
Environmental Dredging
Flushing Creek
0 1 2 Miles
KINGS COUNTY (BROOKLYN)
QUEENS COUNTY
Bergen Basin
Hendrix Creek
Grassy Bay
Environmental Dredging
Jamaica Bay
NASSAU COUNTY
Paerdegat Basin
Mill Basin
Norton Basin
Little Bay
0 1 2 Miles
Enclosed and Confined Waters Restoration Opportunities
NJ Best Use Class
SE1
SE2
SE3
SC
NY Best Use Class
SA
SB
I
SC
SD
HRE Planning Region
Navigation Channel
Combined Sewer Overflow
USEPA Superfund Sites
Waterway Site or Study Area
Other Sites With Potential Impact on Surface Waters
Inset Maps
Not Attaining (303d List for NY & NJ 2012)
Bathymetric Depression
Environmental Dredging Site

There are also 659 CSOs in the HRE study area, 431 in New York and 228 in New Jersey, some causing or contributing to water quality impairments. Many of the CSOs occur in the Lower Hudson River Planning Region and the Harlem River, East River, Western Long Island Sound Planning Region. Restoration opportunities for the long-term objective (i.e., those waters with lower use classifications than their receiving waters) exist in Bergen Basin of Jamaica Bay, the Kill Van Kull of Staten Island, a few bays in Long Island Sound, and Erie Basin off Red Hook, Brooklyn.

For the short-term objective, the ***Enclosed and Confined Waters*** restoration opportunity map displays four insets, which call out examples of water feature types that could be targeted for restoration (i.e., enclosed basins, dead-end creeks, poorly flushed bays, and inter-pier areas). The inset displays water bodies not attaining their current best use classification and areas that may be hypoxic or anoxic during portions of the year based on the known conditions from 2009.

- *Inset A* – The southern bays of Long Island Sound did not attain their state designated use during 2012[1]. Little Neck Bay is designated for shellfishing, primary/secondary recreation, and fishing (Class SA), but did not meet this best use class due to high nitrogen concentrations and presence of pathogens. There are several CSOs that discharge into the mouth of Little Neck Bay that may be contributing to high nitrogen levels. Manhasset Bay was designated Class SA and SB throughout much of the bay, whereas the most inland segment was designated Class SC, for fishing. The bay did not attain its designated use due to PCB contamination in the Tom's Point area. Hempstead Harbor, which was designated as Class SA and SB, did not meet its designated use due to pathogens, nitrogen concentrations, and PCB contamination. Manhasset and Hempstead bays are high priority waters, scheduled for Total Maximum Daily Load/ restoration strategy development and submission for approval to USEPA within the next 2 years (2016-2018). All three bays may experience low dissolved oxygen conditions during some portion of the year.
- *Inset B* – Newark Bay, the lower Passaic River, portions of the Hackensack River, and portions of the Kill Van Kull are intensively industrialized, with hardened shorelines, inter-pier areas, and enclosed basins. There are several CSOs on the western shore of Bayonne, New Jersey and along both shores of the Kill Van Kull. In addition, dozens of CSOs along the Passaic River discharge into Newark Bay. Some of the inlets associated with the CSOs, like those along Constable Hook, New Jersey, are suspected to be hypoxic or anoxic during portions of the year. Both Newark Bay and the New Jersey side of the Kill Van Kull did not meet their best use during 2012 due to pesticides, PCBs, PAHs, and dioxins. These water bodies also did not meet the mercury standard for Class SE3, which should support secondary contact recreation and maintenance and migration of fish and wildlife.
- *Inset C* – The Upper Bay is intensively developed, with hardened shorelines, inter-pier areas, and enclosed basins. The New Jersey side of the bay is a functioning port, but several near shore areas may experience periods of hypoxia or anoxia. Although the New Jersey side of Upper Bay was non-attaining during 2012, this was due to contaminants such as pesticides, PCBs, PAHs, and dioxins and not necessarily due to poor water quality conditions caused by confined waters. Inter-pier areas, like those along Brooklyn, are typically well-flushed though they do modify sedimentation patterns and may be areas of concern under this TEC. Erie Basin, an enclosed waterway just north of Gowanus Bay, did not meet its designated use of fishing due to high copper levels. Gowanus Canal has been the target of several improvement projects, and although water quality conditions have improved somewhat,

1 At the time of publication, there was a draft 2014 NYS Section 303(d) List of Impaired/TMDL Waters available; however, this document is based on the data presented in the 2012 NYS Section 303(d) List of Impaired /TMDL Waters.

Gowanus Canal did not meet its best use class due to low dissolved oxygen levels. Several CSOs are located along the Gowanus Canal and inter-pier areas that are contributing to the poor water quality conditions of the Upper Bay. These issues were being addressed through a 2004 Administrative CSO Consent Order between NYCDEP and NYSDEC, which calls for a comprehensive watershed-based approach to pollution control (Gibbons and Yuhas 2005). In 2010, the USEPA added the Gowanus Canal to the Agency's Superfund National Priorities List.

- *Inset D* – Jamaica Bay contains numerous dead-end tidal creeks and several large bathymetric depressions with poor circulation. Most of these former tidal creeks have lower use classes then the main bay, not requiring water quality conditions to support primary contact recreation. Despite this, Jamaica Bay and many of its tidal creeks did not attain their designated uses during 2012. Hendrix Creek and Bergen Basin had high nitrogen and low dissolved oxygen. Most of the other basins, such as Paerdegat Basin and Old Mill Creek, which did not meet their use class, are being addressed through the 2004 CSO Consent Order discussed above. The CSO inputs result in extended periods of hypoxia or anoxia in these waters. Mill Basin, on the western side of the bay, is an enclosed basin with a bathymetric depression, and likely experiences hypoxic or anoxic conditions during portions of the year. Grassy Bay, Norton Basin, and Little Bay also contain bathymetric depressions that have poor circulation and experience extended periods of hypoxia. The Jo-Co Marsh pit is located approximately 0.3 miles (0.5 kilometers) west of Bayswater, New York and directly south of John F. Kennedy International Airport. Unlike the Grassy Bay and Norton Basin/Little Bay pits, this bathymetric depression has not been studied with regard to water/sediment quality, but is assumed to represent a highly depositional environment and to exhibit hypoxic conditions seasonally (Yozzo et al. 2001).

3.4 Contamination Issues

Centuries of urbanization have resulted in extensive contamination issues throughout the HRE study area. One of the TECs focuses on contamination issues by establishing objectives to remove contamination and to restore conditions to prevent the future accumulation of contaminants. The following sections describe these contamination issues, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3. 4.1 Sediment Contamination

An important goal of Federal and state natural resource agencies, and estuary management programs (i.e., HEP) has been to undertake efforts to reduce the degree of contamination within sediments of the HRE study area. Sediment quality is critical to the estuarine ecosystem, to the success of other TECs, to human health and safety, and to the port's economic viability (Bain et al. 2007). All areas within the HRE study area exhibit sediment contamination to varying degrees brought about by historical industrial discharges, municipal point and non-point source pollution, and inputs from the upper reaches of the HRE, upstream of the HRE study area, (e.g., the upper Hudson River PCBs). Aditionally, sources within the HRE, including the lower Passaic River, Gowanus Canal, and Newtown Creek contribute contamination. Sediments of the HRE study area are a long-term repository of contaminants including PCBs, dioxins, mercury, pesticides such as DDT, and PAHs. Although the rate of contaminants entering the estuary have substantially declined since the pre-CWA era, many contaminants still enter from tributaries or are widely distributed throughout the HRE study area as historically contaminated sediments, which are transported by tides and currents (USACE 2004b).

Once deposited in the sediments, these contaminants can be transported through a variety of mechanisms (Rand 1995; Table 3-9). Although production and uses of many of these chemicals have been banned in the U.S. for many decades, they have persisted in the benthic environment and within aquatic organisms (Bain et al. 2007).

PCBs are a class of organic compounds used in the electrical industry as insulating fluids and oils for industrial transformers and capacitors, and are characterized by high chemical stability, low flammability, and high resistance to biological degradation (Nadeau and Davis 1976). They are poorly soluble in water and highly soluble in fats. The primary source of PCB contamination in the HRE, as well as the entire tidal Hudson River from Troy to New York Harbor, was the removal of the Fort Edward Dam in 1973, which allowed approximately 3,281,000 feet^{3} (1,000,000 meters^{3}) of PCB-laden sediment to be transported downstream of two former electrical capacitor manufacturing plants. Recent research has shown that more

Table 3-9. Properties of the aquatic environment important in predicting the fate and transport of a contaminant (adapted from Rand [1995]).

Physical Properties	2020	2050
Surface area Depth Flow, extent of mixing, bottom scouring Sedimentation rate Solar irradiation (at surface) and irradiance (wavelength and water depth)	Temperature pH Suspended solids Hardness, salinity, ionic strength Concentration of major ions Concentration of dissolved organic matter Bottom sediments (nature, including organic carbon content)	Microbiological populations and activity Trophic status Nutrient concentrations

than 45 percent of the PCBs entering the Harbor were not from the upstream Hudson River Superfund site, but rather from sources closer to the Harbor, such as small capacitors (found in household appliances), pigment manufacturing, and from stormwater runoff and CSOs (source flows suggested to be from landfills and other contaminated sites where PCB containing products were improperly disposed; NYAS 2008).

Dioxins and furans are chlorinated organic compounds that can be found in the environment due to natural combustion (e.g., forest fires), but also through waste incineration, fuel combustion, and as a manufacturing by-product. Dioxins were a by-product of a widely used defoliant in the 1960s (i.e., Agent Orange). Large amounts of dioxins were released into the lower Passaic River, which have subsequently spread throughout the HRE, with highest concentrations close to the source in the lower Passaic River, in Newark Bay and portions of the Hackensack River, Arthur Kill, and Kill Van Kull. Following legacy sediments, the potentially largest remaining sources of dioxin involve uncontrolled combustion processes, which are extremely difficult to characterize. Fires affecting buildings and landfills may also be contributing sources (NYAS 2008). An RI/FS to address legacy contamination of dioxins for the 17-miles (27 kilometers) of the lower Passaic River, from Newark Bay to the Dundee Dam, was conducted by the potential responsible parties on behalf of USEPA. In March 2016, the USEPA issued the Record of Decision on the final cleanup plan for the lower 8.3 miles (13.4 kilometers) of the Passaic River that includes bank to bank dredging and removal of 3.5 million CY of sediment and subsequent capping (USEPA 2016).

DDT, one of the first and best-known organic pesticides, was used to control insect-vector diseases and as an agricultural insecticide. PAHs are primarily created through the incomplete incineration of organic fuels and are therefore tightly linked to energy production. PAHs can enter the environment through point sources (e.g., oil spills), and non-point sources (e.g., atmospheric deposition and overland runoff).

A variety of heavy metals may be present in HRE sediments. Some metals, such as lead, are widely distributed throughout the HRE study area as a result of atmospheric deposition and other non-point source inputs. Others, such as cadmium, mercury, chromium, and copper may occur in very high concentrations in specific geographic areas as a result of direct point-source inputs. Regional economic changes have dramatically reduced cadmium sources to the HRE study area, with the primary commercial source being nickel-cadmium batteries resulting from increased demand for portable electronic devices (NYAS 2008). Mercury enters water pathways through CSOs, stormwater runoff, and in WWTPs, there is a high potential for mercury to be transformed into methylmercury, which is a more toxic form (NYAS 2008).

In addition, endocrine disruptors and emerging contaminants (e.g., polybrominated diphenyl ethers [PBDEs], perfluoroalkyl and polyfluoroalkyl substances [PFASs]), which are generally defined as any synthetic or naturally occurring chemical or microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects, may have, in some instances, accumulated in sediments within the HRE study area.

Gowanus Canal and Newtown Creek are also sources of contamination to the HRE study area. These rivers have been named to the National Priorities List. USEPA has completed RI/FS for Gowanus Canal and released a Proposed Plan in

December 2012 (USEPA 2012). In July 2011, EPA issued an administrative Order on Consent to six potentially responsible parties (PRPs), requiring that they perform a RI/FS at Newtown Creek under USEPA oversight.

Currently, every planning region of the HRE study area has exhibited some degree of sediment degradation due to contamination. The Regional Environmental Monitoring and Assessment Program conducted by the USEPA in 1993-1994 and again in 1998, found that pervasive contamination across chemical groups in the HRE study area had declined (Adams and Benyi 2003). Contamination can greatly reduce the biological and recreational value of the HRE study area through fish consumption advisories, human health risks, and economic impacts through restrictions of commercially harvested species. Sediment contamination also affects navigation and commerce within the HRE study area. The port industry is valued at an estimated $53.5 billion annually and directly or indirectly supports approximately 336,600 jobs (NYSA 2015). Contaminated sediments can increase the cost of maintaining navigation channels by as much as four to five times due to the added cost of transporting and processing the material for disposal or reuse (USACE 2008b).

Although sediment and the pollutants that contaminate sediment originate throughout the HRE study area, management of sediment has historically taken a highly localized and narrowly focused approach – one that is largely based on the tightly defined responsibilities of regulatory and resource management agencies and port interests. Sediment management responsibilities are spread among different agencies (e.g., USEPA, NJDEP, NYSDEC, NOAA, USFWS, and USACE), authorities (e.g., CERCLA, RCRA, ISRA, and WRDA Section 312, Navigation), and jurisdictions. In addition, there is no existing regional framework in which to address these cross-jurisdictional issues. As a result, the policy and regulatory framework required to improve regional sediment management throughout the HRE study area does not exist and many sediment related problems remain unaddressed or under-addressed.

In 2008, The New York Academy of Sciences undertook a multi-year study to identify and quantify the flows of specific contaminants into the NY-NJ Harbor from its air and watershed. The project (the Harbor Project) used the methodology of industrial ecology and emphasized outreach and communication in order to encourage implementation of pollution prevention strategies for these contaminants (NYAS 2008). To accomplish the project goals, the New York Academy of Sciences created a regional consortium (the Harbor Consortium), which is able to produce, publish, and promote specific pollution prevention plans for various contaminants (NYAS 2008). The Harbor Project and Consortium have made strides to implement regional actions that address contaminant inputs to the HRE study area (NYAS 2008). In some cases, the recommendations were incorporated into the regulatory process, such as 2002 New York State legislation requiring recycling of all mercury waste in dental offices, and many New York and New Jersey regulations limiting the purchase of products containing mercury, as well as regulating their disposal in municipal solid waste facilities. In other instances, industries were encouraged to implement recommendations on a voluntary basis as a cost-savings measure or to reduce regulatory oversight. Improved recycling and waste management has been identified as the best approach for industrial stewardship, such as promoting proper management of rechargeable batteries.

The potential benefits of managing sediment regionally are:

- Cost savings resulting from a reduced need to dredge navigation channels and dredging cleaner sediments which do not require costly treatment or disposal options;
- Improved habitat quality resulting from the cleanup of contaminated sediments;

- Improved availability of habitat based on reintroduction of sediment into "sand starved" littoral systems;
- Shared regional-scale data management systems, models and other scientific tools to help make sediment management decisions;
- Improved relationships between agencies and the public that produce opportunities for collaboratively leveraging financial and manpower resources; and
- Improved relationships of the regulatory processes resulting from better intergovernmental collaboration and coordination (Tavolaro 2008).

Acknowledging the need for a better management approach, the HEP Regional Sediment Management (RSM) Work Group was formed to develop a plan for a RSM Program that integrates various sediment management activities in the HRE. The HEP Policy Committee charged the Work Group with developing a scope and structure for the RSM Program that includes a plan with specific goals and targets to improve the ecosystem, public health and the economy, sustainability in carrying out future tasks, technical credibility, and regional support.

The RSM Plan (HEP 2008) established a collaborative process that resulted in a plan with three major components: sediment quality, sediment quantity, and dredged material management. Specific objectives for each major component describe the challenges it presents, status of current work, and recommended actions. A total of 8 objectives and 45 specific actions were recommended as the consensus for the Work Group. Primary Sediment Quality Objectives included: ensure new sediments are clean and new sediments entering the system remain clean, reduce toxic exposure, and reduce transport of contaminants to other areas. Specific Sediment Quantity Objectives included; ensure sufficient sediment to support healthy ecosystem and reduce sediment deposition in shipping channels and berths. Dredged Material objectives included the improvement of dredging operations and dredged material management.

Key recommendations of the RSM Plan include:

- Creation of a RSM advocate at the state level in New York and New Jersey;
- Strengthen regional coordination and consistency on regulatory issues, watershed planning, and dredged material management (e.g., dredging windows, beneficial uses, identification of upland placement sites, sedimentation control, etc.);
- Develop a sediment quality map that prioritizes areas for cleanup;
- Focus remedial actions in the Hudson River and lower Passaic River due to the significant impacts contaminated sediments from these areas have on the HRE study area;
- Identify watersheds with excessive sediment loads and develop plans to reduce loads; and
- Update technical information through research, monitoring, and modeling (e.g., develop sediment transport models and CARP model updates).

Target Statement

The TEC for sediment quality was developed to be consistent with the goals of the HEP RSM Plan. In addition to the RSM's specific objectives and recommended actions, short-term and long-term objectives were established through the TEC workshops and subsequent meetings with HEP. The short-term objective for this TEC is to isolate or remove one or more contaminated sediment zone(s) totaling at least 25 acres (0.10 kilometers^2) by 2020. The long-term objective is to isolate or remove at least 25 acres of contaminated sediment every 2 years until 2050 or until all HRE sediments are considered uncontaminated resulting in the removal of fish consumption advisories, lower sediment management and restoration costs, and reduced risk to human health and the environment.

Restoration Opportunities (Maps 3-9 and 3-10)

It has been long documented that the industrial past of the HRE study area has degraded the quality of the sediments. Contaminated sediments are present throughout the HRE study area and there are many opportunities to improve sediment quality. The TEC objective for improvement of sediment quality through isolation or removal of contaminated sediments within the HRE is consistent with the RSM Work Group objectives. A key action recommended by the RSM Plan was to develop a sediment quality map that prioritizes areas for cleanup.

An initial step of this key action was the evaluation of predictions from the CARP model that allow for an estuary-wide assessment of chemical concentrations in the top 10 centimeters (4 inches) of the sediments. To display these contaminant reduction opportunities, current day predictions (or “now-casts”) from the CARP model were incorporated into a GIS framework to display the aerial extent of surface sediment contamination throughout the HRE study area. Two analytes were selected as examples of the contaminants of concern for the analysis: 2,3,7,8-TCDD and Total PCB. Additional analytes are evaluated in Appendix C. The relative concentration of these contaminants throughout the HRE study area is presented as percentiles on Maps 3-9 and 3-10. Established benchmarks are displayed on the maps to enable interpretation of the potential risks associated with contaminant levels. These evaluations will be conducted on a more localized basis through specific follow-up risk assessment activities.

These maps are not at a scale where contaminant “hot spots” can be identified. However, they can be used to understand the extent of contamination in the sediments, and to identify the large areas with the highest concentrations of surficial sediments (top 10 centimeters [4 inches]) within the HRE study area. Detailed evaluations of site-specific cores at depth within individual study areas need to be conducted to identify individual hot spots.

2,3,7,8-TCDD

Map 3-9 displays the predicted concentrations of 2,3,7,8-TCDD for the top 10 centimeters (4 inches) of sediments in the HRE study area. Although there are no Effects Range Medium (ERM) or Effects Range Low (ERL) benchmarks for this type of dioxin, the USFWS derived a benchmark based upon the effects of 2,3,7,8-TCDD tissue concentrations on the egg fertilization and development of eastern oysters (Winterbyer and Cooper 2003). Effects are assumed to occur at sediment concentrations of 0.0032 parts per billion. Predicted concentrations of 2,3,7,8-TCDD range from 0.0003 to 0.1624 parts per billion throughout the HRE study area. The CARP model predicted that approximately 61.2 percent of the surface sediments in the HRE study area have concentrations of 2,3,7,8-TCDD that exceed this benchmark. The highest concentrations were predicted in the lower Passaic River (Inset A) and surrounding waters. The lower Passaic River is the location of many chemical manufacturing plants that produced DDT and other herbicides during the 20th century. As stated in Section 2.4, USEPA issued a Proposed Plan in April 2014 to remove and cap contaminated sediments within the lower

8.3 miles (13.4 kilometers) of the river. In addition, the most contaminated sediments (40,000 cubic yards of debris [CYD]) adjacent the Diamond Alkali Superfund site had been removed in 2012 and surface sediments (16,000 CYD) were removed and capped at River Mile 10.9.

Other areas with very high concentrations in the surface sediments (higher than 0.02 parts per billion) include the eastern portion of Jamaica Bay (Inset C), the Arthur Kill and western Raritan Bay (Inset B). Concentrations above the oyster effects benchmark are predicted for the entire Lower Bay, Sandy Hook Bay, the East River, and the western portion of Jamaica Bay (Inset C). The lowest 2,3,7,8-TCDD concentrations were predicted for the Lower Hudson River and western Long Island Sound.

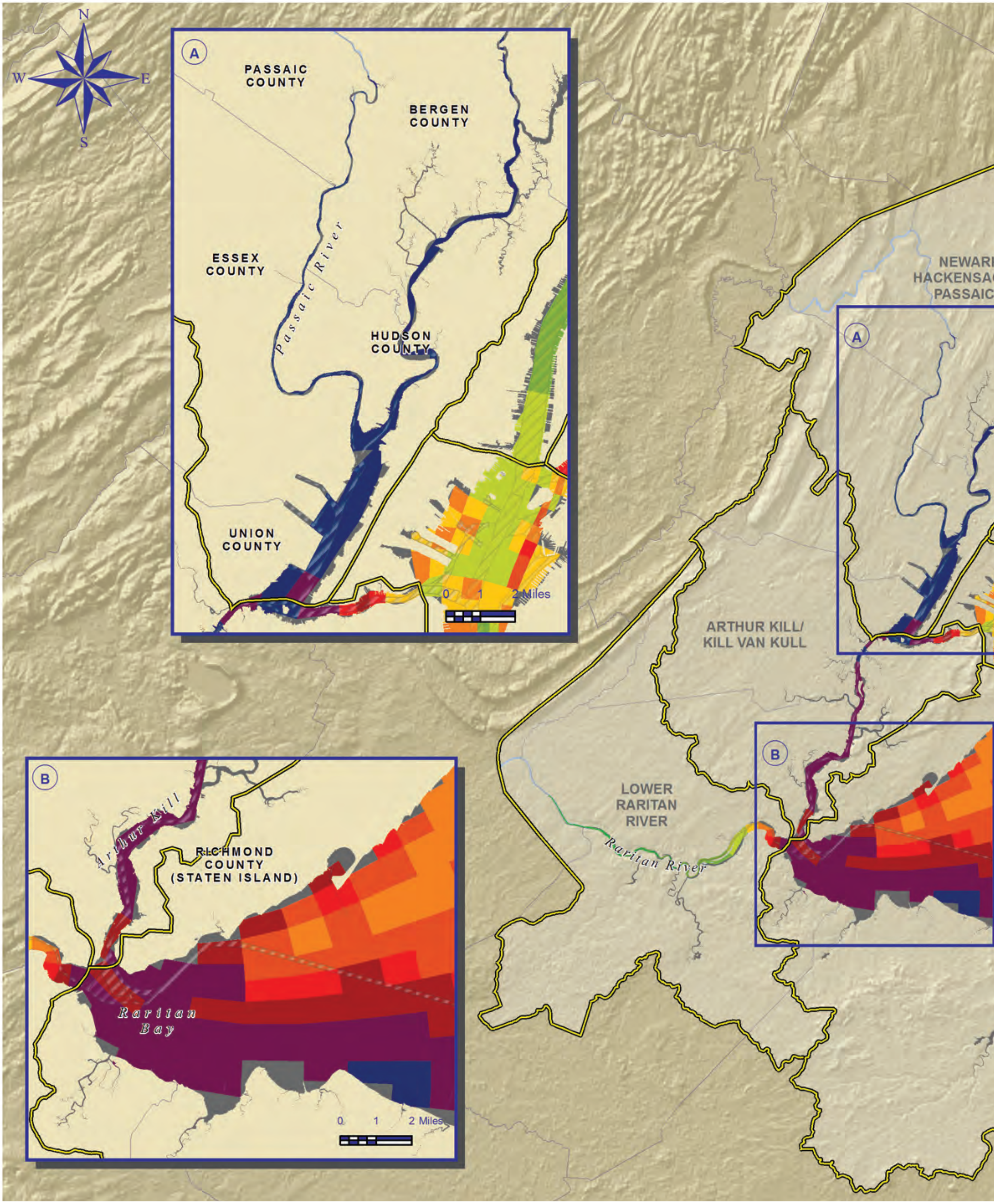
Total PCB

The Total PCB concentrations predicted for the top 10 centimeters of sediment within the HRE study area are displayed on Map 3-10. Concentrations were predicted to range between 14.9 and 11,365.1 parts per billion throughout the HRE study area. PCBs are among the most pervasive contaminant in the HRE study area, with 98.9 percent of the surface sediments predicted to exceed the ERL for Total PCB of 23 parts per billion, and 89.5 percent of the surface sediments predicted to exceed the ERM of 180 parts per billion. The highest concentrations (>879 parts per billion) are predicted in the East River, the Hackensack River (Inset A), the western Raritan River (especially on the shorelines, Inset B) and throughout Jamaica Bay (Inset C). The only area where the sediments were predicted to be below the ERM for Total PCBs was western Long Island Sound.

Summary

Surface sediment contamination is pervasive throughout the HRE study area, but the highest concentrations of several contaminants of concern occur in relatively few places. The Passaic River, Hackensack River, Newark Bay, western Jamaica Bay, and Raritan Bay have nearly the highest predicted concentrations for each contaminant evaluated. This is a concern due to the potential effects of interaction among these contaminants, bioaccumulation, and toxicity. These regions represent opportunities to increase significantly the habitat value by decreasing the effects of contamination. Further evaluation of sediment contamination should be conducted for human health and ecological risk to inform remedial decision-making. Such evaluations are completed on the lower Passaic River, Gowanus Canal, and Newtown Creek and continue in Newark Bay and the Hackensack River. Future evaluation of sediment contamination and recommendations for sediment contaminant reduction for this TEC should be implemented under the auspices of HEP's RSM Work Group (or similar group).

Map 3~9.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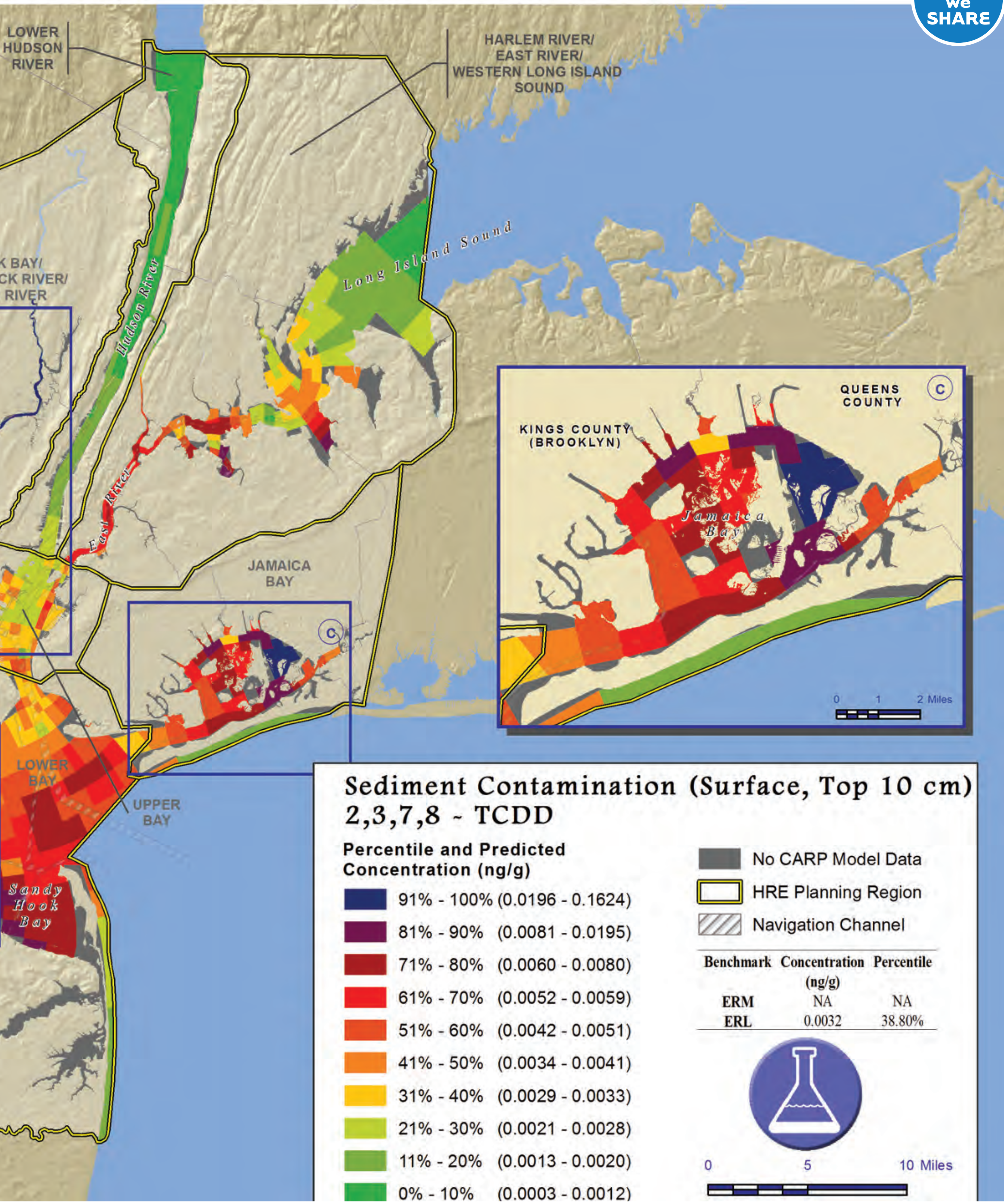
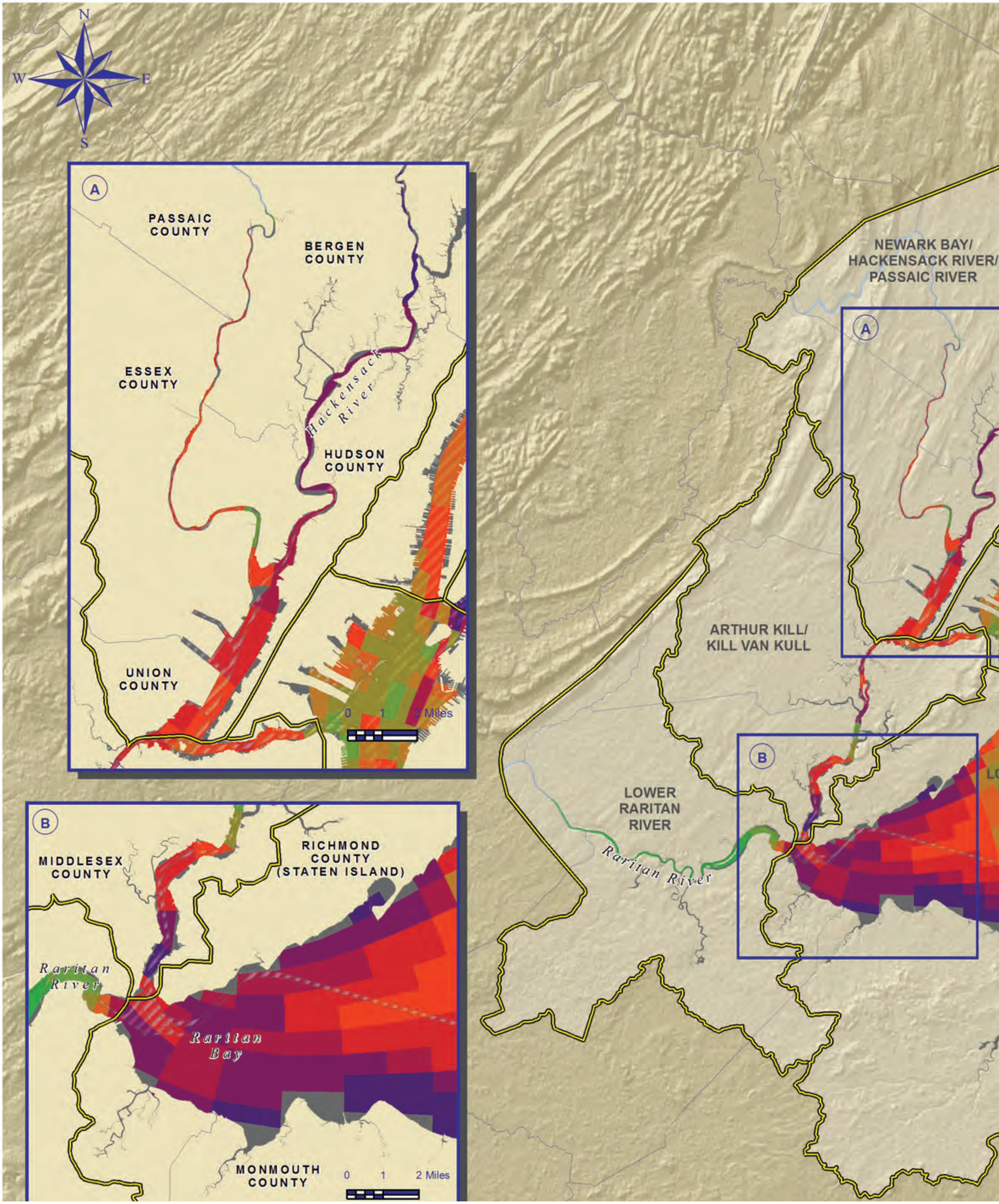


Note: This figure shows predicted surface contamination in 2008, from the Contamination Redcution and Assessment Program (CARP). Legacy chemicals buried below 10 cm are not shown.

Map 3~10.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RICHMOND COUNTY (STATEN ISLAND)
Raritan River
Raritan Bay
MONMOUTH COUNTY
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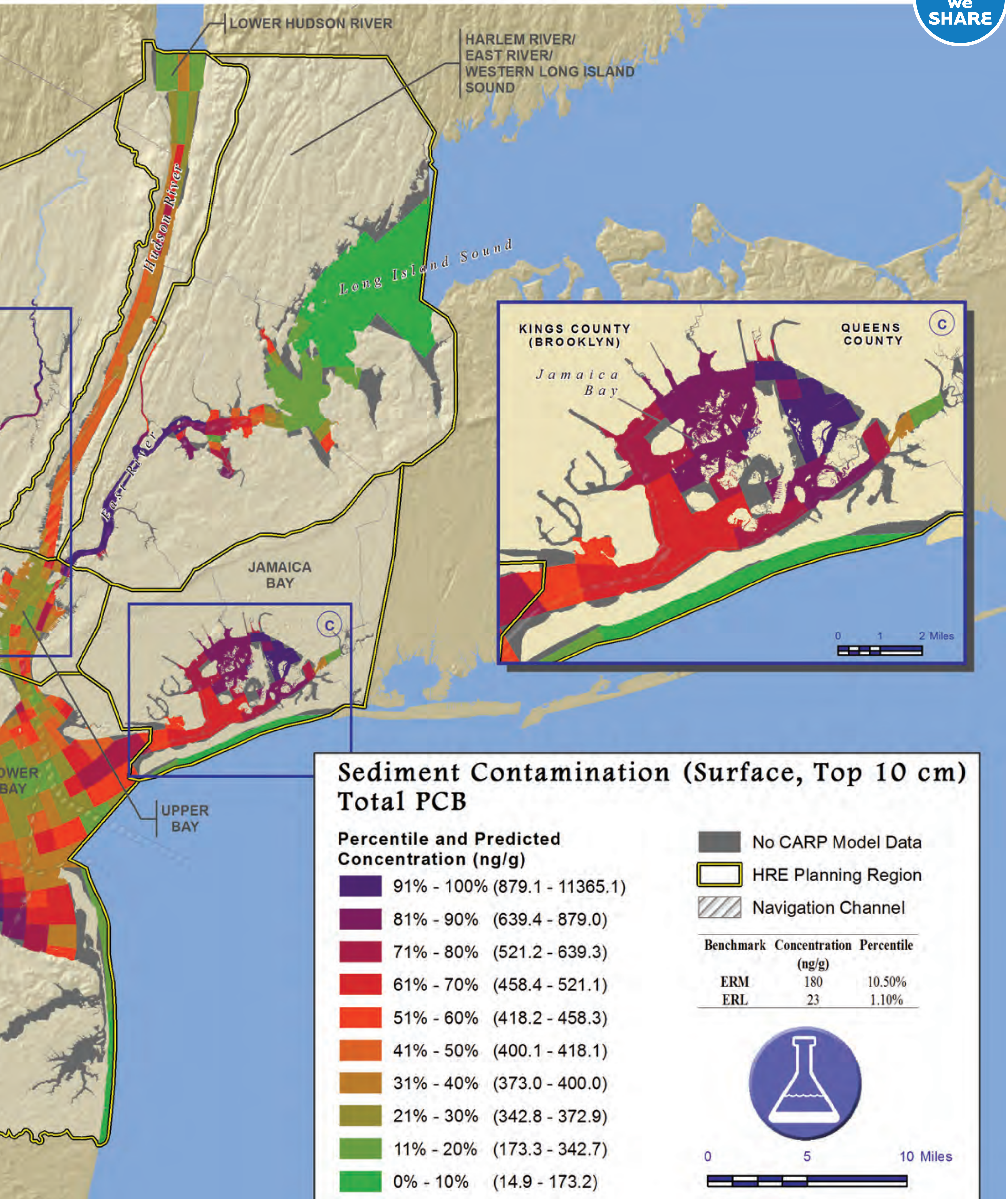
NEWARK BAY/ HACKENSACK RIVER/ PASSAIC RIVER
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER
Raritan River



Note: This figure shows predicted surface contamination in 2008, from the Contamination Redcution and Assessment Program (CARP). Legacy chemicals buried below 10 cm are not shown.

3.5 Societal Values

An important component of this restoration plan is recognition that people are a part of this ecosystem and the plan should incorporate features that will benefit the public. One TEC was designed to promote access to natural areas for the public. The following section describes the public access TEC, its objectives, and potential restoration opportunities within the HRE study area.

3.5.1 Public Access

According to the Public Trust Doctrine, public trust lands, waters, and living resources in a state are held by the state in trust for the benefit of all of the people. The doctrine establishes the right of the public to enjoy these resources for a wide variety of recognized public uses (NYSDOS 2008, NJDEP 2006). Public access to the estuary means providing residents of the HRE study area with accessible routes to natural areas and enabling them to enjoy local scenic, natural, cultural, historic, and recreational resources. Contact with nature can afford numerous public benefits in the form of educational experiences, relaxation, and improved quality of life (Bain et al. 2007). Types of public access points include:

- Direct access (e.g., boat launching, swimming, recreational fishing);
- Indirect access (e.g., waterfront promenade);
- Vistas (e.g., scenic overlook); and
- Upland access routes (e.g., pedestrian route, bike path; Bain et al. 2007).

Throughout the HRE's history, there has been a conflict of interest concerning use of the waterfront. Differing views among government, local communities, and private industries were rarely able to reach a consensus when deciding between urban or natural uses, or some combination thereof, for the waterfront. Often, attempts to create parkland during the 19th century were rejected as inconsistent with economic goals and commercial opportunities for the city. By the mid-20th century, views had changed and the focus became renewal and revitalization of urban waterfronts (Wise et al. 1997).

Since then, water quality improvements and a reanimation of recreational activities along the waterfront and within water bodies of the estuary have occurred (Wise et al. 1997). Since the Draft CRP was released in 2009, many collaborative public access planning initiatives have been developed, spurring the design and construction of innovative new publicly accessible areas. As part of the Mayor's Vision 2020 Plan, NYC released its revised CWP in 2011. While the first plan was released in 1992, the 2011 update reasserts commitments to the priorities of the 1992 plan and expands upon the goals and recommendations to include enlivening the waterfront with a range of attractive uses integrated with adjacent communities and pursuing strategies to increase the City's resilience to climate change and sea level rise.

Between 2009 and 2014, over 500 acres (2.02 kilometers^2) of new parks or public spaces were either acquired and designated or opened for public access purposes along the HRE waterfront (Boicourt et al. 2015). In recent years, in NYC, parks and greenways on the waterfront have opened, expanding recreational opportunities (NYCDCP 2011). An example of this expansion is the 65 acres (0.26 kilometers^2) of public access developed in Brooklyn Bridge Park (to be 85 acres [0.34 kilometers^2] total ultimately) and the 5-acre (0.02 kilometers^2) Paerdegat Basin Ecology Park. In New Jersey, a 12.3-acre (0.05 kilometers^2) waterfront property was developed into the Essex County Riverfront Park (Figure 3-4). The

Figure 3-4. Newark Riverfront Park, located along the Passaic River in Newark, New Jersey, was opened to the public in 2013. Credit: www.newarkriverfront.org, Damon Rich

park was constructed along the Passaic River in Newark, New Jersey in 2011 and opened in 2013, linking the city greenway and Essex County Riverbank Park, stretching the public greenway for nine city blocks (Essex County Department of Parks, Recreation, and Cultural Affairs 2014).

In 2016, HEP conducted a study that assessed public access and stewardship in the New York-New Jersey Harbor in an effort to identify restoration priorities, allocate resources, and refine and track progress toward the public access and stewardship goals established by the CRP. By one measure, only 37 percent of the linear waterfront in the harbor estuary consists of public waterfront spaces. The assessment also recognized the need for additional and improved public access based on current access and socioeconomic characteristics. Multiple areas of higher need for public access exist throughout the harbor that would benefit from both increases in the physical extent and quality of access, as well as resources for programming that foster connections between residents and their waterways (Boicourt et al. 2016).

Concrete Plant Park: A capstone project of the Bronx River Greenway, Concrete Plant Park once housed a concrete batch mix plant located on the western bank of the industrial southern section of the Bronx River. In close partnership with community organizations and public agencies, the Parks Department and the Bronx River Alliance began revitalizing this formerly abandoned site by re-establishing salt marshes along riverbanks once strewn with trash and tires, as well as reintroducing the site to the public through organizing community festivals and leading hundreds of residents out on the Bronx river to canoe and kayak.

Concrete Plant Park covers approximately 7 acres (0.03 kilometers^2) and is situated along the western shore of the Bronx River in the Crotona Park East section of the Bronx, between Westchester Avenue to the north and Bruckner Boulevard to the south. Cement manufacturing began at this site after 1945 and continued until 1987. The silos, hoppers, and conveyor structures built by the Transit Mix Concrete Corporation still stand at Concrete Park today as a reminder of the park's industrial history.

Completed in September 2009 and officially opened to the public October 30th, this once underdeveloped park now contains facilities supporting and linking existing and planned multi–use pedestrian greenways with other off–road, on-road bicycle/pedestrian routes. A new canoe/kayak launch provides an access point to the Bronx River Corridor. The site was also enhanced through the creation of a waterfront promenade, a reading circle, and inviting park entrances at both Westchester Avenue and Bruckner Boulevard.

Source: http://www.nycgovparks.org/parks/concrete-plant-park

View down ramp from Bruckner Boulevard.
Photo by James M. Mituzas, RLA

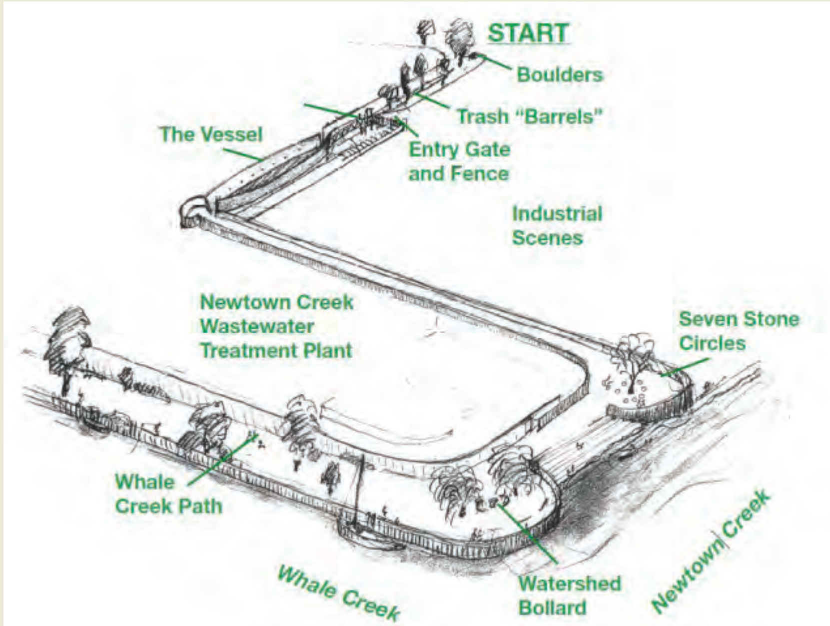
View of concrete lounge chairs.
Photo by James M. Mituzas, RLA

Concrete Plant Park, Phase 1 model.

Public Access Projects

The Newtown Creek Nature Walk was designed by environmental sculpture artist George Trakas. It was built by the New York City Department of Environmental Protection (NYCDEP) through the New York City Department of Cultural Affairs Percent for Art Program in conjunction with the Newtown Creek Wastewater Treatment Plant upgrade. The Nature Walk affords the public its first opportunity in decades to enjoy intimate views of Newtown Creek and to enjoy the local environment and history of the waterfront.

Source: http://www.nyc.gov/html/dep/pdf/newtown_creek_nature_walk_flyer.pdf



The Newtown Creek Nature Walk is open to the public daily from sunrise to sunset, weather permitting.

New Brunswick Landing.

The New Brunswick Landing Project established a new docking area with pedestrian amenities and created a "sense of place" to provide a new front door to the downtown attractions via the river. The project included a 24-slip floating boat dock facility, a pedestrian connection to New Street leading downtown, benches and landscaping, and interpretive signage noting historical and environmental aspects of the area. The modular dock design provides space for up to 24 35-foot-long boats, with end berths accommodating boats up to 45 feet (14 meters) long, and flexibility to expand if slip demand increases. The linear configuration avoids interference with other boat traffic in the channel and only connects to the towpath by existing footbridges in two locations, minimizing effects to the towpath's integrity.

Opening the river for public use and access to new recreational boating amenities has positively affected the quality of life for the residents of New Brunswick and Middlesex County. Additionally, recreational boaters now have direct access to the restaurants, theaters, museums and other recreational activities that downtown New Brunswick provides. The project was funded thru the New Jersey Department of Environmental Protection (NJDEP) Green Acres Program, Middlesex County, and the City of New Brunswick, and was completed in 2007.

Source: http://www.co.middlesex.nj.us/Government/Departments/IM/Documents/Maps/New%20Brunswick%20Landing%20Brochure.pdf

The *Public Access* TEC may encounter more land use trade-offs than other TECs. Industrial or commercial land uses may conflict with public access if they create safety issues for direct access or lack aesthetic quality. Access is currently limited around airports, port terminals, some industrial uses, and other secure areas. Although industrial activity and public access co-exist on separate lots in the Hackensack Meadowlands, Newtown Creek, and the Bronx River, active ports and maritime industries impact the creation of new public access points. Through strategic partnerships, vacant lots, brownfields, and areas shifting from industrial to commercial or residential uses could be restored to offer access opportunities. Similarly, all natural habitats, except for environmentally sensitive areas (e.g., nesting habitat), should be viewed as opportunities to create public access. Providing access creates scenic destinations and peaceful retreats from urban life.

In NYC, waterfront zoning requirements, enacted in 1993, were revised in 2009. These zoning modifications now require new residential and commercial developments on the waterfront to provide both physical and visual access to the water (NYCDCP 2011). With many projects already constructed, under construction, approved, and planned, approximately 8 miles (12.9 kilometers) of publicly accessible waterfront with walkways and visual corridors will be available in a few years (NYCDCP 2011). The devastating effects of Hurricane Sandy also resulted in a revision of the zoning laws. On October 9, 2013, the NYC Council adopted the Flood Resilience Zoning Text Amendment to encourage flood-resilience building construction throughout designated flood zones. Single-and two-family homes are now required to provide 2 feet (0.61 meters) of extra protection, meaning significant changes to structures in flood-prone areas, especially those along the HRE waterfront. Areas like the South Bronx have developed specific plans, such as the South Bronx Greenway that when fully completed will encompass 1.5 miles (1.6 kilometers) of waterfront greenway, 8.5 miles (14 kilometers) of inland green streets, and nearly 12 acres (0.05 kilometers^2) of new waterfront open space (NYCEDC 2016).

The NJDEP promotes public access to waterways under the state's Coastal Zone Management rules, last amended on July 15, 2013. The Coastal Management Rules address public access by defining it as the ability of the public to pass physically and visually to, from, and along lands and waters subject to public trust rights, and to use these lands and waters for activities such as swimming, sunbathing, fishing, surfing, sport diving, bird watching, walking, and boating (NJAC 2013). These regulations set specific standards on provisions for site access, without considering protection of natural habitats, security, fees, parking, liability, and easements along with many other aspects.

Every public access site design should include features to ensure equal enjoyment of the waterfront and waterways regardless of a person's physical condition. The American Disability Act's (ADA) 2010 Standards for Accessible Design are required for all new or altered facilities and public accommodations, including public access sites. Providing ADA access would be required on most paved trails, boardwalks, fishing piers, and boat launches. However, it will be more challenging to provide ADA access to natural areas such as wetlands and stream crossings.

Public access sites must also be consistent with Homeland Security policies and not jeopardize our nation's security. The Office of Homeland Security is responsible for protecting our borders within the rivers and coastal waters around the area, particularly securing the vital economic gateways that handle trade and travel each year (airports, marine ports) and protecting government operations (e.g., United Nations Headquarters). Where industrial land cuts off upland communities from the water in the HRE study area, public access has been granted at specific points where it does not infringe on the activity of the working waterfront or conflict with Homeland Security regulations. Examples in NYC include Barretto Point Park in Hunts Point in the Bronx; Grand Ferry Park in Williamsburg, Brooklyn; and numerous street-end parks in the South

Richmond neighborhood of Staten Island (NYCDCP 2011). On portions of the waterfront where physical access is not feasible due to security restrictions or other safety factors, the focus should be on creating visual access.

Urban settings, such as NYC, represent unique challenges for restoration. Currently, designers are collaborating with ecologists and coastal engineers in New York and other seaside cities to introduce ecological function to high priority areas (e.g., isolated, underutilized, and degraded) (Yozzo et al. 2015). Active collaboration among these disciplines has resulted in sustainable strategies that integrate the built and natural environments, create opportunities for education, and enrich the landscape of the city (Yozzo et al. 2015). Brooklyn Bridge Park, the Randall's Island Salt Marsh Restoration Project, and the Hunter's Point South Project integrate a number of ecological design features with features such as public access, stormwater management, and urban waterfront recreation (Yozzo et al. 2015).

Target Statement

The goal of the ***Public Access*** TEC is to improve direct access to and from the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation. The short-term objective for this TEC is to create one new public access site and one access improvement or upgrade of an existing access site in each of the eight study areas by 2020. By 2050, the objective is to make waters of the HRE and tributary rivers accessible to all residents within a short (approximately 20 minute) walk or public transit trip. The creation of direct access points should be encouraged so that at least 80 percent of access points contain a direct access component (e.g., boat launch, public bathing area). When restoration programs are initiated, siting of new public access areas could be integrated with other TECs and provide informational displays related to those restoration actions.

Restoration Opportunities (Map 3-11)

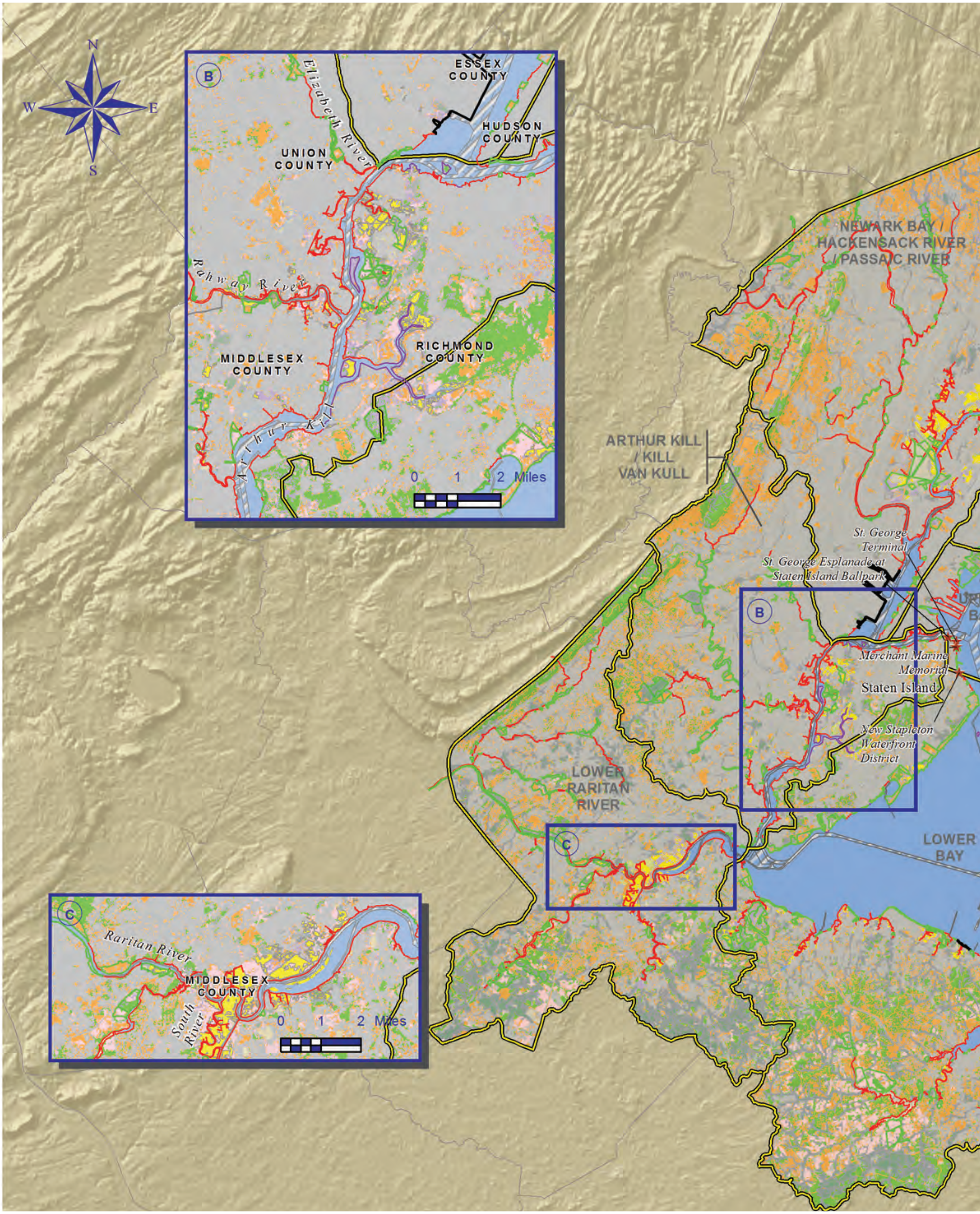
Opportunities for improving existing public access points and creating new public access sites likely exist in every planning region of the HRE study area. HEP developed a data set that includes known public waterfront spaces (Map 3-11). This map can be used as an overview that highlights large expanses of shorelines without access points and to show places where people currently access the water. This data set is available online and includes site-specific information, such as access type, ownership, and acreage.[2]

The available public access displayed on Map 3-11 may be in need of upgrades, facilities, or access improvements, including increases in direct access to and from the water. In the HRE study area, there are 41,078 acres (166.2 kilometers^2) of public waterfront spaces (Boicourt et al. 2016). Fourteen constructed New York City Economic Development Corporation (NYCEDC) projects are highlighted on the map. The restoration opportunities map has several inset maps that provide examples of the distribution of access throughout the region and recently constructed projects:

- *Inset A* – The island of Manhattan is mostly surrounded by waterfront esplanades that have been constructed and provide an interconnected network of paths, piers, and recreational areas. Areas along the Harlem and East

2 See http://www.harborestuary.org/publicaccess.htm.

Map 3~11.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ARTHUR KILL / KILL VAN KULL
St. George Terminal
St. George Esplanade at Staten Island Ballpark
Merchant Marine Memorial
Staten Island
New Stapleton Waterfront District
LOWER RARITAN RIVER
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South River
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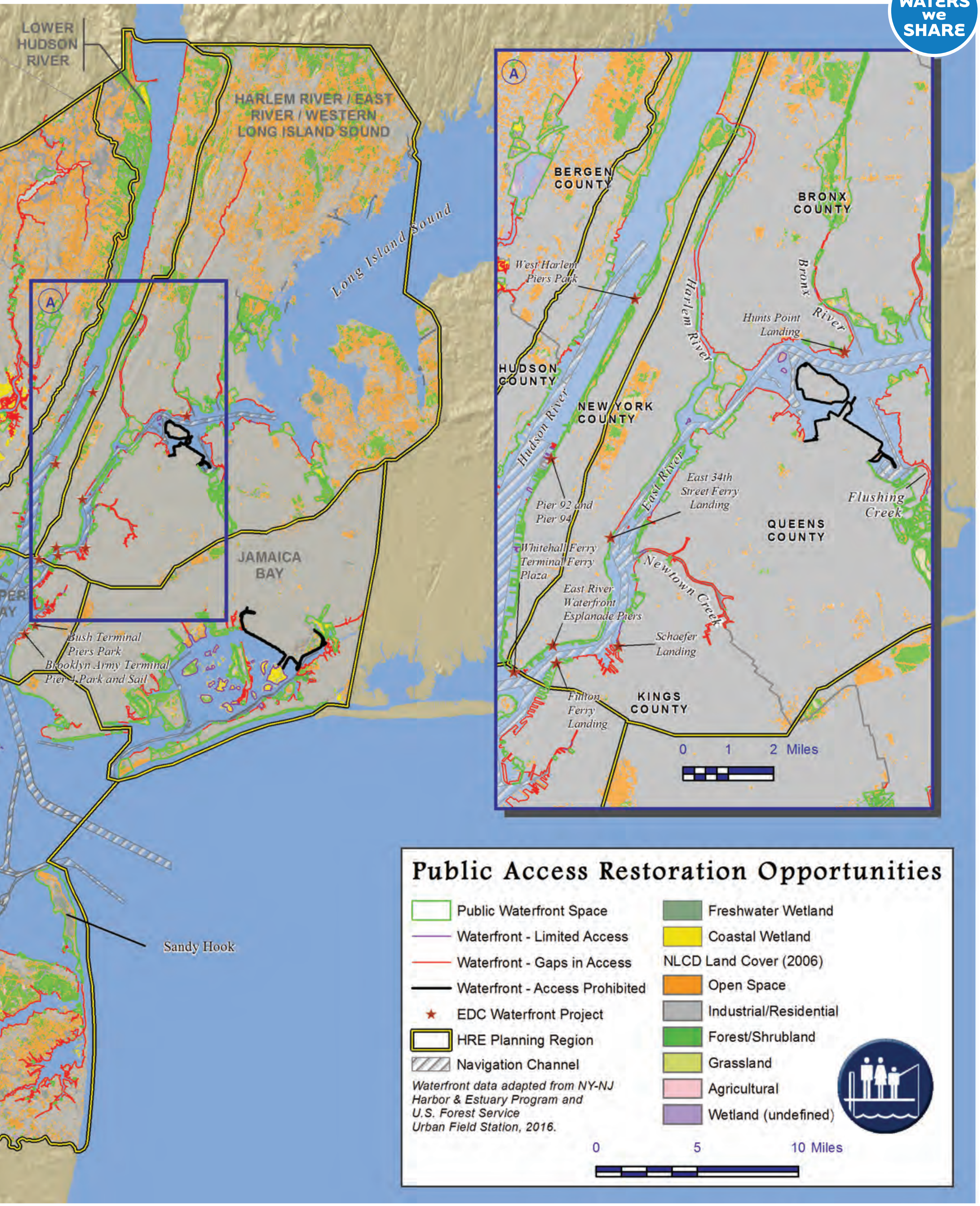

LOWER HUDSON RIVER
HARLEM RIVER / EAST RIVER / WESTERN LONG ISLAND SOUND
Long Island Sound
JAMAICA BAY
A
Bush Terminal Piers Park
Brooklyn Army Terminal
Pier 4 Park and Sail
Sandy Hook
BERGEN COUNTY
BRONX COUNTY
HUDSON COUNTY
NEW YORK COUNTY
QUEENS COUNTY
KINGS COUNTY
West Harlem Piers Park
Hunts Point Landing
Bronx River
Harlem River
Hudson River
East River
Flushing Creek
East 34th Street Ferry Landing
Pier 92 and Pier 94
Whitehall Ferry Terminal Ferry Plaza
Newtown Creek
East River Waterfront Esplanade Piers
Schaefer Landing
Fulton Ferry Landing
0 1 2 Miles
Public Access Restoration Opportunities
Public Waterfront Space
Waterfront - Limited Access
Waterfront - Gaps in Access
Waterfront - Access Prohibited
EDC Waterfront Project
HRE Planning Region
Navigation Channel
Waterfront data adapted from NY-NJ Harbor & Estuary Program and U.S. Forest Service Urban Field Station, 2016.
Freshwater Wetland
Coastal Wetland
NLCD Land Cover (2006)
Open Space
Industrial/Residential
Forest/Shrubland
Grassland
Agricultural
Wetland (undefined)
0 5 10 Miles

Rivers and along Newtown Creek in Brooklyn and Flushing Bay in Queens represent gaps in access that could be created or enhanced to offer additional amenities to the thousands of nearby residents. Despite having many public waterfront areas, including Hunt's Point Landing and Soundview Park, the Bronx and Harlem River in particular were characterized as a higher need area (Boicourt et al. 2016). Safer travel routes should also be considered as many of these access points are separated from residents by large, impassable highways.

- *Inset B* – Shorelines of the Arthur Kill and Rahway River have large gaps in public access and areas with limited access. Dense residential areas are located on the New Jersey side of these rivers and the northern shore of Staten Island. Due to the lack of access, there are opportunities to develop access and increase the connections to existing parks. Although the Arthur Kill and mouth of the Rahway River support industrial uses and have relatively low population densities, important habitats are scattered among them and they may be appropriate for interpretive signage, nature trails, or birding opportunities.
- *Inset C* – Similar to the Arthur Kill, the Lower Raritan River, and South River are characterized by large stretches of gaps in access and are in need of waterfront access development. In particular, growing communities along the south shore of the Lower Raritan River currently have little access.

3.6 Acquisition

In addition to habitat restoration, another fundamental component of the CRP is the acquisition and preservation of existing open and undeveloped lands. Given the intensity of development in the HRE study area, even low quality undeveloped lands should be prioritized for protection.

Target Statement

During the May 2012 TEC meeting, the group agreed to a short-term land acquisition target of 1,000 acres (4.05 kilometers^2) by 2020 to be preserved at an average rate of 200 acres (0.81 kilometers^2) per year for a total of 6,000 acres (24.3 kilometers^2) by 2050. More than likely, land will initially be acquired at faster rates as known sites are purchased, with the rate following a non-linear trajectory as successive opportunities with smaller acreage become scarcer. Therefore, a long-term target has not been developed at this time.

To facilitate progress towards this target, practitioners should seek input from bankers and finance experts to gain better information on how to fund acquisition and encourage development of green infrastructure. Additionally, local governments should investigate zoning and/or policy changes that could provide incentives and accelerate habitat acquisition, such as tax deductions for conservation easements, tradable development rights, or instituting land stewardship zoning. Alternatively, it may be possible to establish in-lieu fee programs where payments are made to offset disturbance to protected habitats, such as wetlands, and use these fees for habitat restoration or site acquisition. Priority should be given to parcels that are adjacent to existing wetlands to allow wetlands to migrate inland and upslope with predicted sea-level rise.

There are local examples of successful acquisition programs in the HRE study area. The PANYNJ has been acquiring properties through HRERP for 15 years. Under the program, the Port Authority provides funds to not-for-profit or public entities for the acquisition of property in the estuary identified as suitable for conservation, ecological enhancement, public access, or environmental mitigation. Between 2001 and 2016, the Port Authority invested $60 million on the acquisition of valuable properties, and in 2014, they authorized an additional $60 million for future acquisitions. New Jersey has the Green Acres Program, which seeks to create a system of interconnected open spaces by preserving and enhancing the state's historic, scenic, and recreational resources for public use and enjoyment. Within the auspices of the Green Acres Program is the Blue Acres Program, which converts properties in flood prone areas that have been or may be subject to storm-related damage into open space. In New York, the state EPF provides funding to the NYSDEC and the State Office of Parks, Recreation and Historic Preservation (OPRHP) to purchase lands to be included in state parks and preserves. In addition, the EPF provides funds to local governments and not-for-profit organizations to purchase lands or historic resources for preservation.

In 2016, the USFWS emphasized the need for acquisition sites by promoting a land preservation-only mitigation strategy for urban settings that focuses on preservation as a restoration strategy in an effort to reduce added contaminant risk to fish and wildlife resources. There are many land trusts in both New York and New Jersey working to acquire and preserve land. Additionally, various local and county bonds and taxes have been instituted within the HRE to promote open space acquisition, which represents a meaningful addition to the overall vision of the HRE study area.

Restoration Opportunities

Acquisition opportunities are included in the restoration opportunities maps found in Chapter 4. These sites, which are currently being acquired or have been identified as acquisition sites, highlight the importance of protection and preservation of existing open and undeveloped lands.

3.7 Other Restoration Actions

Although the TECs are the focused targets of the CRP, habitat restoration opportunities that do not address the TECs can still result in benefits to the HRE study area. For example, there are five vessel graveyards along the Arthur Kill where hundreds of derelict ships scatter the shorelines of Staten Island along with abandoned wooden piers (USACE 2004a). Although these vessels provide some form of artificial intertidal habitat to supplement natural nesting, foraging, and refuge areas, they also smother shoreline vegetation and are a source of dangerous waterborne drift material. Removal of these ships would result in improved intertidal and shoreline habitat.

The restoration of valuable habitat types not included in the TECs can also provide increased benefits to the HRE study area. For example, natural grasslands are a quickly disappearing habitat type that provides critical habitat to many species. The northern harrier (*Circus cyaneus*), which is listed as threatened in New York and endangered in New Jersey, requires maritime grasslands for nesting and foraging. Grasslands are successional habitats that often become overgrown with shrubs and trees unless they are maintained or subject to periodic disturbance. These habitats should be protected and restored wherever practicable.

Other types of restoration and habitat improvements are necessary and underway in the HRE study area. Some of these restoration practices are covered under separate programs, such as the USACE Drift Program that provides for removing abandoned piers, wharves, derelict vessels and debris, and also for repairing in-use deteriorated shore structures throughout the HRE study area. The NYCDEP Floatables Reduction Program focuses on the reduction of waterborne litter and debris that entered the estuary through storm drains and sewers. The program includes the use of catch basins to decrease the amount of floatable debris from entering the waterways and booming and skimming operations to remove debris from the waters. Their CSO abatement program is also improving the water quality of the HRE through the collection and treatment of sewage prior to release into the HRE. The PVSC have several initiatives to improve the waters of Newark Bay and the Passaic River. Their Skimming Program includes one pontoon boat that skims floating debris from the Passaic River. They also sponsor volunteer cleanup programs and have a dedicated cleanup crew that clears large debris from the Passaic River, Newark Bay, and their tributaries (PVSC 2008). NJDEP has issued NJPDES permits to CSO communities requiring the development of CSO Long Term Control Plans (LTCPs). In the HRE region, the permits were issued to Perth Amboy City, Elizabeth City, Town of Guttenberg, Fort Lee Boro, Ridgefield Park Village, Hackensack City, City of Newark, East Newark Borough, Harrison Town, Kearny Town, Paterson City, Bayonne Municipal Utilities Authority, Jersey City Municipal Utilities Authority, Middlesex County Utilities Authority, the Joint Meeting of Essex and Union Counties, North Hudson Sewerage Authority – Adams Street Sewage Treatment Plant, North Hudson Sewerage Authority – River Road Sewage Treatment Plant, North Bergen Municipal Utilities Authority, North Bergen Municipal Utilities Authority – Woodcliff Sewage Treatment Plant, Bergen County Utilities Authority, and the PVSC.

The concept of green building design is becoming increasingly popular throughout the country, and the HRE region is no exception. Many new buildings incorporate features such as rooftop gardens and porous paving blocks that collect stormwater. These features reduce the amount of stormwater that discharges into waterways. The Office of the Mayor's PlaNYC initiative addresses stormwater impacts to the surface waters by incorporating green design features and trees to collect stormwater. The City launched the MillionTreesNYC initiative in 2007 with the goal of planting one million trees on the streets of New York City over the next decade. MillionTreesNYC achieved the goal in late 2015, two years ahead of schedule. PlaNYC also includes incentive programs for the installation of green roofs. The City Council has approved a green parking lot zoning amendment that includes design regulations for new parking lots, regulating the landscaping, perimeter screening, and requirements for canopy trees in planting islands in the lots.

To help promote stormwater control through green infrastructure, HEP supported a local group in Elizabeth, New Jersey in planning and constructing three rain garden demonstrations. These projects were established at local schools where students could get hands-on training with the intention of building additional rain gardens in other areas. HEP also is a partner with the NY/NJ Baykeeper and the Interstate Environmental Commission in working with the City of Newark, New Jersey to identify a location where multiple green technologies can be designed and built. In addition, multiple partners have formed Municipal CSO Action Teams in Newark, Paterson, Jersey City, and Perth Amboy, New Jersey to identify, implement, and promote green infrastructure projects and practices for stormwater management.

4.0 Restoration Opportunities

The overall program goal of the CRP is the restoration of the estuary through the establishment of a mosaic of habitats that provide society with renewed and increased benefits from the estuary environment. To meet the overall goal of the program, multiple TECs should be incorporated into a restoration project in order to achieve the greatest ecological benefits at a single location.

Early in the planning process, several potential restoration sites were identified through HEP's process of nominating sites for acquisition and/or restoration and outreach efforts conducted as a part of the USACE's Needs and Opportunities evaluation. These sites, now known collectively as the CRP Sites, have been cataloged by the USACE and HEP and are included in the NYC OASIS database. More than 400 restoration opportunities have been catalogued and reviewed since the Draft CRP was released in 2009. As of March 2016, a total of 296 CRP Sites have been identified as having opportunities for restoration and/or acquisition that will help to achieve the TEC objectives. Of those sites, 99 have been identified for both acquisition and restoration, 194 sites have been identified for restoration, and 3 sites have been identified for acquisition. Some of the sites are currently undergoing habitat restoration, but most are awaiting funding, collaboration, design, or permits. While hundreds of CRP Sites have been identified, additional sites must be identified and nominated to ensure achievement of the ambitious objectives of the TECs.

Each planning region within the HRE was evaluated for potential restoration opportunities, including CRP Sites and those identified in Chapter 3. The types and quantities of restoration vary greatly among the planning regions, as do the TECs they support, as evidenced by Table 4-1 and the discussion of the opportunities by planning region below.

The USACE's HRE Feasibility Study has evaluated a subset of these CRP restoration opportunities in greater detail. The HRE Feasibility Study sites listed in Table 4-2 reflect the highest priorities of local sponsors and will be recommended for near-term construction. Wherever near-term HRE Feasibility Study sites are described in this chapter, they are highlighted in **blue**.

CRP Sites recommended for near-term construction have been identified in the following planning regions: Jamaica Bay; Newark Bay, Hackensack River, and Passaic River; Harlem River, East River, and Western Long Island; Upper Bay; and Lower Bay. CRP Sites in the Lower Hudson River, Lower Raritan River, and Arthur Kill and Kill Van Kull Planning Regions were not recommended for near-term construction as part of the HRE Feasibility Study. Other CRP Sites are highlighted as sponsor priorities and are advancing within specific programs or are available for future USACE feasibility studies. Together, the implementation of restoration at these sites will collectively contribute to the overall goal of the CRP.

Table 4-1. Comprehensive Restoration Plan (CRP) Sites tallied by Hudson-Raritan Estuary (HRE) planning region and Target Ecosystem Characteristic (TEC).

HRE Planning Region	CRP Sites[1]													TBD[2]
Jamaica Bay	**46**	35	0	28	1	0	23	21	6	16	42	12	8	4
Lower Bay	**52**	33	1	38	1	1	6	4	15	0	38	23	21	7
Lower Raritan River	**26**	6	0	7	0	0	1	3	5	0	9	6	22	16
Arthur Kill/ Kill Van Kull	**31**	19	2	15	0	0	5	7	15	0	23	9	15	5
Newark Bay/ Hackensack River/ Passaic River	**76**	46	0	6	0	0	22	31	41	5	62	36	21	9
Lower Hudson River	**10**	3	0	6	0	0	4	3	1	0	5	7	2	2
Harlem River/ East River/W. Long Island Sound	**48**	21	3	20	2	0	19	21	19	9	21	17	12	25
Upper Bay	**7**	3	0	0	1	0	3	5	0	1	5	4	1	1
TOTAL CRP SITES	**296**	**166**	**6**	**120**	**5**	**1**	**83**	**95**	**102**	**31**	**205**	**114**	**102**	**69**

[1]Special CRP Sites for each planning region are presented in Appendix D: Atlas of Restoration Opportunities.

[2]CRP Sites, for which TEC restoration opportunities are "To Be Determined."

Table 4-2. Comprehensive Restoration Plan (CRP) Sites recommended for near-term construction as part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study.

Site Name	CRP Site	Restoration Opportunities
Jamaica Bay		
Brant Point	102	Protection of tidal fringe marsh and maritime forest; prevent the spread of invasive species into the aquatic habitat; creation of beneficial macroinvertebrate habitat.
Bayswater State Park	148	Creation of beach/dune habitat; removal of invasive/non-native vegetation; creation of a tidal pool; and shoreline protection.
Dubos Point	149	Marsh habitat protection by implementing toe protection (i.e. soldier piles or its equivalent) surrounding the entire western and northern shore.
Hawtree Point	161	Restoration of coastal scrub and grassland habitat; replanting of shrubs and salt marsh hay; and creation of natural barrier to protect newly created habitats and preserve existing marshes.
Fresh Creek	730	Creation of marsh (low and high) and tidal creek habitat; improve flushing and DO; cap contaminated sediment; restoration of tidal marsh system and maritime forest; vegetation plantings; and creation of small detention pond at head of Fresh Creek to filter out CSO output.
Dead Horse Bay	732	Maximize marsh habitat; dune stabilization and creation to avoid erosion; restore maritime forest; beach preservation in the north; and stabilization of tidal creek.
Duck Point Marsh Island	935	Restoration of low marsh and high marsh; atoll terrace design based on Structure of Coastal Resilience research; promote sediment accretion and sustainability.
Pumpkin Patch (East and West Marsh Islands)	936	Restoration of low and high marsh; continued restoration within northeast portion of Jamaica Bay; and increases land above MTL (-0.27 ft NAV88) from existing condition area.
Stoney Creek Marsh Island	937	Restoration of low and high marsh.

Table 4-2 (Cont'd). Comprehensive Restoration Plan (CRP) Sites recommended for near-term construction as part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study.

Site Name	CRP Site	Restoration Opportunities
Elders Center Marsh Island	939	Restoration of low and high marsh; improves sustainability of Elders Marsh complex; and potential area for natural sediment deposition and accretion.
Jamaica Bay	-	Restoration of oyster reefs using: oyster beds (shells, gravel, porcelain) and hanging trays/super trays.
Lower Bay		
Naval Weapons Station Earle	-	Restoration of oyster reefs using: spat on shell, gabion blocks, and reef balls; builds on past success of NY//NJ Baykeeper.
Newark Bay, Hackensack River, and Passaic River		
Meadowlark Marsh	719	Re-establishment of wetlands; invasive species removal and native species plantings; restoration/creation of maritime forest habitat; restore existing mudflats/tidal channels and interior marsh.
Metromedia Tract	721	Reconnect fragmented areas; introduce new tidal channels and improve existing channels; creation of low marsh, high marsh, scrub-shrub, and maritime upland.
Deferred Site: Kearny Point	865	Re-establishment low marsh; new marsh creation; debris and invasive vegetation removal; native plantings; creation of new tidal channels; public overlook; and deepening and/or capping of contaminated sediment.
Deferred Site: Oak Island Yards	866	Restoration and creation of low marsh; creation of tidal channels; debris and invasive vegetation removal; regrading and planting of native vegetation; habitat connectivity along new mudflats/tidal channels; oyster reef habitat; improved public access to water; and deepening and/or capping of contaminated sediment.
Essex County Branch Brook Park	887	Invasive plant removal and planting; channel dredging to restore freshwater stream and floodplain; debris removal and erosion control on banks/shorelines with stormwater control; and support to ongoing public access projects.
Dundee Island Park	900	Debris removal; natural bank vegetation preservation; bank stabilization and shoreline softening; restoration of riparian vegetation.

Table 4-2 (Cont'd). Comprehensive Restoration Plan (CRP) Sites recommended for near-term construction as part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study.

Site Name	CRP Site	Restoration Opportunities
Clifton Dundee Canal Green Acres Purchase and Dundee Island Preserve 	902	Debris and invasive vegetation removal; regrading and planting of native emergent wetland; planting with native trees and shrubs for waterbird habitat creation; restoration/stabilization of riparian forest; reconnecting riparian buffers and floodplains to the estuary; shallow water habitat improvement; and installation of sediment basin to treat stormwater runoff.
Harlem River, East River, and Western Long Island Sound		
Shoelace Park (233rd to 211th Street) 	113	Restoration of Bronx River reach to pre-industrialization conditions; channel modification with instream structures; bank stabilization; select native plantings; sediment load reduction; and public access to the river.
Flushing Creek 	188	Restoration of open water; regrade existing common reed-dominated areas to create low salt marsh; and preserve existing upland forest.
Bronxville Lake (1 Garrett Ave, Tuckahoe) 	851	Native planting of upland trees and shrubs; riprap forebay upstream of lake; channel bed restoration; creation of emergent wetlands forested scrub/shrub wetlands; modification of existing rock weir to facilitate fish passage; removal of invasive vegetation; sediment load reduction; and improved public access to water.
Crestwood Lake 	852	Native planting of upland trees and shrubs; invasive species removal; construction of two riprap forebays with access roads; channel realignment; creation of emergent wetlands; modification of existing rock weir to facilitate fish passage; and improved public access.
Westchester County Center 	854	Channel modification, excavation and replacement of bed material; creation of emergent wetlands; construction of in-stream sediment basins and channel plugs; planting of upland trees and shrubs; removal of invasive vegetation; and bank stabilization.
River Park/West Farm Rapids Park (North of 180th to 177th Street) 	860	Creation of woodland area; shoreline softening; creation of emergent wetlands; river bed restoration between the dam and 180th Street; removal of invasive species; replacement with native upland shrubs and herbaceous vegetation; debris removal; and improved public access.

Table 4-2 (Cont'd). Comprehensive Restoration Plan (CRP) Sites recommended for near-term construction as part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study.

Site Name	CRP Site	Restoration Opportunities
Muskrat Cove	862	Invasive species removal with native plantings; river bank stabilization; removal of debris and log jams from river; and channel modification.
Garth Woods	942	Creation of forested and scrub/shrub wetlands; select native plantings; modification of existing weir to promote fish passage; river channel modification upstream of Harney Road; and invasive species removal.
Harney Road	943	
Bronx Zoo and Dam (South of Fordham Road)	944	Removal of invasive vegetation and native planting; installation of a fish ladder; creation of emergent wetlands; debris removal between dams; sediment load reduction; and improved public access.
Stone Mill Dam	945	Installation of fish ladder and creation of refuge habitats for fish; planting of native vegetation; and removal of invasive vegetation.
Soundview Park	-	Restoration of oyster reefs using: spat on shell and gabion blocks; designed to build on past success and will occur in an area with subtidal rock out crops to form a ~2.75 ac reef/bed complex.
Upper Bay		
Liberty State Park	37	Restoration of coastal and freshwater wetlands and maritime forest, and creation of public access points.
Bush Terminal	-	Restoration of oysters reefs using: spat on shell, gabion blocks, oyster condos, and hanging trays/super trays; would serve as a model for the re-utilization of derelict portions of the harbor shoreline (derelict piers provide wave attenuation and depth variability provide habitat diversity); and provides excellent public access, stewardship, and future study.
Governor's Island	-	Restoration of oysters reefs using: gabion blocks, oyster condos, and hanging trays/super trays; designed to place reproductive stock (hanging trays) in close proximity to suitable hard substrate (condos and gabion blocks) for settlement.

NOTE: " - " indicates a CRP Site has not been assigned.

4.1 Jamaica Bay

The Jamaica Bay Planning Region has tremendous potential for the creation and restoration of a variety of habitats, including wetlands, oyster reefs, eelgrass beds, islands for waterbirds, and coastal and maritime forests. Centered by a national park, Jamaica Bay includes a complex of shallow littoral and intertidal areas as well as marine habitats that offer the potential for aquatic and wetland habitat improvements. Upland restoration opportunities include improvements to island habitats and coastal and maritime forests. In this region, there is potential to reduce the effects of human disturbance by improving water and sediment quality in former tidal creeks that are now enclosed basins and in the bathymetric depressions that experience seasonal hypoxic conditions. Forty-six (46) CRP Sites are within the Jamaica Bay Planning Region; 8 sites have been identified for both acquisition and restoration and 38 have been identified solely for restoration (Table 4-1; Map 4-1).

In the last several years, the Jamaica Bay Planning Region has been the subject of many restoration projects such as pilot projects for eelgrass and oyster bed establishment and the restoration of approximately 160 acres (0.65 kilometers^2) of marsh island habitat (see spotlight project: Jamaica Bay Marsh Islands). Jamaica Bay has also benefited from improved coordination resulting from the creation of Science and Resiliency Institute at Jamaica Bay. However, there are still significant opportunities to increase and improve habitat throughout Jamaica Bay, and 32 of the CRP Sites within this planning region have identified opportunities for coastal wetland restoration and creation. Many of these sites are marshes within the main body of Jamaica Bay. Some of the restoration opportunities located to the east of the main bay include marshes in Idlewild Park (Brookville) (#105), Hook Creek (#601), and Thurston Basin (#634). Others, located along former tidal creeks to the west and north of the main bay, include Hendrix Creek (#168) and Mill Basin (#200).

Idlewild Park (#105) is a complex of nearly 200 acres (0.81 kilometers^2) of wetlands located at the headwaters of Jamaica Bay, containing the largest expanse of high-quality salt marshes that are among the best opportunities to address marsh retreat in the face of sea level rise. Restoration opportunities at this site include restoration of approximately 18 acres (0.07 kilometers^2) of coastal wetlands and approximately 8 acres (0.03 kilometers^2) of maritime forest as a result of the beneficial use of dredged material. Additional restoration opportunities include improving tributary connections and regrading creeks to restore hydrology.

Mill Basin (#200), located along tidal creeks to the west of the main bay, includes: 1 acre (0.004 kilometers^2) of fringe wetlands and mudflats; softening of approximately 950 feet (290 meters) of shoreline; improvements to the intertidal area; potential placement of complex structures along approximately 1 acre (0.004 kilometers^2) of existing habitat; 4 acres (0.02 kilometers^2) of maritime shrubs and dunes; and bathymetric re-contouring of 2,500 feet (762 meters) of the channel. This project would complement the wetland restoration efforts completed at Four Sparrow Marsh, which consisted of several restoration components including 3 acres (0.01 kilometers^2) of salt marsh restoration, 1 acre (0.004 kilometers^2) of adjacent woodlands and restoration of tidal flow to previously filled areas (NYCDPR 2014).

Restoration opportunities at Paerdegat Basin (#731), White Island, and Marine Park are Action Agenda Projects listed in the Vision 2020: NYC CWP. Between 2007 and 2010, the NYCDEP completed several coastal wetland restoration projects that included fill removal and plantings in Paerdegat Basin. Additional opportunities at Paerdegat Basin (#731) include potential stream daylighting of Paerdegat Creek, regrading of approximately 6,500 feet (1,981 meters) of the basin to improve water quality and tidal circulation, and potential remediation of contaminated sediments.

Jamaica Bay Marsh Islands

Over the last century, it is estimated that approximately 1,400 acres (5.67 kilometers^2) of coastal wetlands have been lost within Jamaica Bay. The rate of loss is approximately 44 acres/year (0.18 kilometers^2/year), as calculated by the New York State Department of Environmental Conservation (NYSDEC). In an effort to recover the disappearing marsh islands, several initiatives have been set in place and proposed restoration projects have been implemented by various organizations and government agencies, including the U.S. Army Corps of Engineers (USACE), the Port Authority of New York and New Jersey (PANYNJ), the NYSDEC, the New York City Department of Environmental Protection (NYCDEP), the National Park Service (NPS), and various local non-profit organizations such as Eco Watchers, Jamaica Bay Guardian, and the American Littoral Society (ALS). Restoration efforts began in 2003 with a successful pilot study at Big Egg Marsh and have continued since, with several projects having already been constructed (Elders East, Elders West, Yellow Bar Hassock, Black Wall, and Rulers Bar marshes).

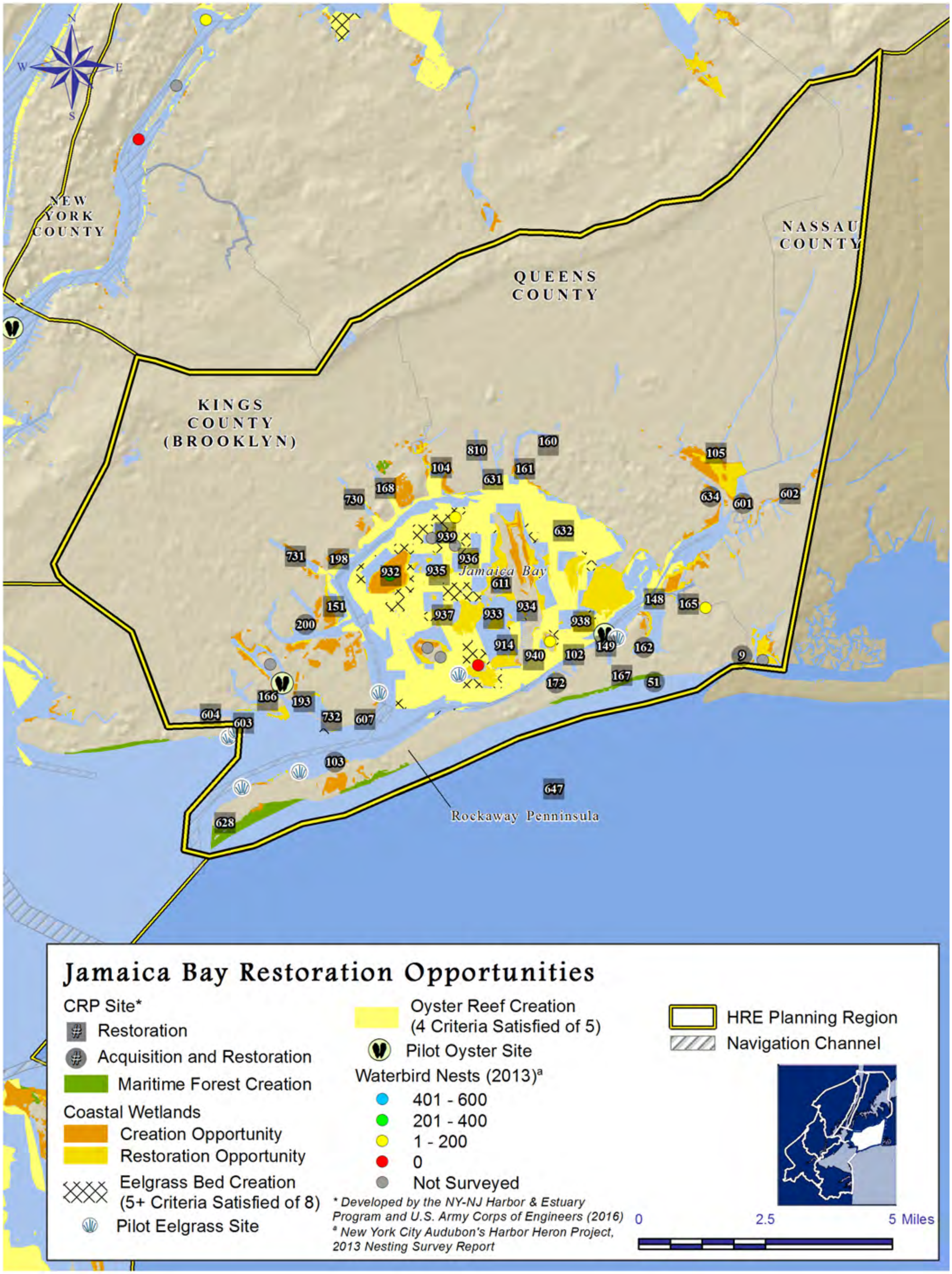
Restoration activities at Yellow Bar Marsh taken by Great Lakes Dredge and Dock.

Despite approximately 160 acres (0.65 kilometers^2) of restored wetlands, additional coastal wetland restoration and creation are needed to recover what has been lost. As such, hundreds of acres of wetland restoration and creation opportunities have been identified at six CRP Sites, including Canarsie Pol, Goose Pond Marsh, Duck Point Marsh, Pumpkin Patch Marsh, Stony Creek Marsh, and Silver Hole Marsh. A total of approximately 356 acres (1.44 kilometers^2) of wetlands and 51,000 feet (15,545 meters) of shoreline and shallows creation is proposed for the Jamaica Bay Marsh Islands.

Under the USACE's Jamaica Bay Marsh Islands Ecosystem Restoration Program, approximately 160 acres (0.65 kilometers^2) of marsh habitat has been restored (USACE 2016). Building upon the tremendous success of these constructed marsh islands, additional marsh island habitat restoration opportunities are being recommended for near-term construction authorization within the HRE Feasibility Study. The next set of marsh islands that will be recommended for construction include the **Elders Center Marsh Island (#939)**, **Duck Point Marsh Island (#935)**, **Pumpkin Patch East and West Marsh Islands (#936)**, **Stoney Point Marsh Island (#937)**. Restoration opportunities at these CRP sites include restoration and creation of coastal wetlands, upland plantings, and the potential for Coastal Storm Risk Management (CSRM) benefits for surrounding communities.

Additional marsh islands include Canarsie Pol (#932), Goose Pond Marsh (#934), Silver Hole Marsh (#938), Big Egg Marsh (#940), and Little Egg Marsh (#941). These projects continue to provide current and future opportunities for wetland restoration and creation, as well as island bird habitat within the Jamaica Bay Planning Region.

Map 4~1.


NEW YORK COUNTY
QUEENS COUNTY
NASSAU COUNTY
KINGS COUNTY (BROOKLYN)
Jamaica Bay
Rockaway Penninsula
Jamaica Bay Restoration Opportunities
CRP Site*
Restoration
Acquisition and Restoration
Maritime Forest Creation
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
Eelgrass Bed Creation (5+ Criteria Satisfied of 8)
Pilot Eelgrass Site
Oyster Reef Creation (4 Criteria Satisfied of 5)
Pilot Oyster Site
Waterbird Nests (2013)a
401 - 600
201 - 400
1 - 200
0
Not Surveyed
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
a New York City Audubon's Harbor Heron Project, 2013 Nesting Survey Report
HRE Planning Region
Navigation Channel
0
2.5
5 Miles

Jamaica Bay also appears to be one of the most suitable regions for oyster and eelgrass restoration projects within the HRE study area. Most of the open waters of Jamaica Bay meet some of the habitat requirements of eelgrass, oysters, and oyster larvae. Although eelgrass restoration has not been identified at the Jamaica Bay CRP Sites and only three sites are identified for oyster restoration, there is potential to include an oyster restoration component or eelgrass restoration component to create multi-TEC habitat complexes suitable for fish, shellfish, and crustaceans (i.e., ***Fish, Crabs, and Lobsters*** TEC). The HRE Feasibility Study plans to recommend an oyster reef restoration project within Jamaica Bay, expanding NYCDEP's current pilot project.

The NYC CWP lists two Action Agenda Projects within the Jamaica Bay Planning Region: a ribbed mussel pilot study and an eelgrass restoration project. The ribbed mussel pilot, located within Fresh Creek, was initiated by NYCDEP to evaluate the potential for ribbed mussels to improve water quality within Jamaica Bay. **Fresh Creek (#730)** involves 93 acres (0.38 kilometers^2) of coastal wetland restoration, maritime forest and shrubland creation, restoration of shallow water habitats, and recontouring of the basin at the mouth of Fresh Creek to improve circulation and decrease the depths of a borrow pit located at the southern portion of the creek.

The eelgrass restoration project was initiated to improve the ecology and water quality of Jamaica Bay. As part of the project, a pilot study was launched at Breezy Point involving the planting of 3,000 eelgrass plants. The initial planting effort was conducted in 2009 and an additional 8,000 plants were planted and monitored in subsequent years as part of the on going effort. Eelgrass in Jamaica Bay continues to experience significant environmental and physical stress, and although the pilot study did not establish a sustainable eelgrass community, it provided a learning opportunity for the overall conditions within the bay. Continued evaluation of the restoration sites will determine the long-term success of the study and feasibility for eelgrass restoration in Jamaica Bay (NYCDEP 2012). The pilot study is proximate to the Breezy Point CRP Site (#103). Restoration opportunities at Breezy Point include approximately 25 acres (0.10 kilometers^2) of beach and dune habitat for shorebirds and wildlife; removal of debris and existing bulkhead along approximately 5,700 feet (1,737 meters) of shoreline; and sediment analysis. The proximity of Action Agenda pilot studies to the CRP sites demonstrates that opportunities to incorporate or pair oyster and eelgrass restoration components with CRP Sites are present within the Jamaica Bay Planning Region.

A relatively rare opportunity to establish maritime forest communities within the HRE study area appears to be possible in the Jamaica Bay Planning Region (Figure 4-1). Breezy Point (#103) and other areas along the Rockaway barrier beach could provide these opportunities. The restoration opportunity at Plumb Beach (#603) was listed as an Action Agenda Project in the NYC CWP and was completed in November 2012. The restoration involved the beneficial use of sand dredged from the NY/NJ Harbor Deepening Project to restore vegetated dunes and sand berms, and marine habitat improvement. The sand was placed on-site days before Hurricane Sandy hit the region, which provided critical protection to the Belt Parkway and NYCDPR infrastructure.

Many of the CRP Sites identify the possibility for maritime forest or other coastal community restoration on uplands adjacent to coastal wetland opportunities. This type of habitat also serves as an important NNBF providing both ecosystem benefits and CSRM benefits to the surrounding communities. Example sites that include both coastal wetlands and associated upland

Sunset Cove Park

In 2009, the New York City Department of Parks and Recreation (NYCDPR) acquired a former marina at Sunset Cove located in the center of Jamaica Bay. The site is adjacent to Big Egg Marsh, a large wetland complex owned and managed by the National Park Service (NPS).The restoration plan for Sunset Cove Park was created by a partnership of NYCDPR, NPS, NY-NJ Harbor & Estuary Program (HEP), New England Interstate Water Pollution Control Commission (NEIWPCC), Jamaica Bay Eco Watchers, Broad Channel Civic Association, and the American Littoral Society (ALS). The plan incorporates approximately 4 acres (0.02 kilometers^2) of salt marsh restoration and preservation, 500 feet (152.4 meters) of shoreline restoration, and approximately 7 acres (0.03 kilometers^2) of upland habitat restoration. Together, these restoration efforts will establish a sustainable salt marsh, remove concrete tailings, debris, and construction fill, expand the existing wetland complex at Big Egg Marsh, and create an upland walking path through a coastal shrubland. In addition, Phase 2 of the plan, in partnership with the Governor's Office of Storm Recovery, proposes enhancements to amenities for public waterfront access, including a boardwalk and access to the water for educational programs. The plan also includes berms along the upland perimeter to provide shoreline protection, enhancing resiliency to climate change and laying the foundation for regional economic growth.

The proposed plan for Sunset Cove Park was released in spring 2014 as part of NYCDPR's Rockaway Parks Conceptual Plan. The design project for the saltwater marsh and coastal upland construction is currently under review by the community board and external agencies.

Source: http://www.nycgovparks.org/facility/beaches/beach-recovery/rockaway-parks-master-plan

Sunset Cove will undergo ecological restoration, including the construction of salt marsh and maritime shrubland and forest, while active uses such as ball fields and play amenities will be featured nearby.

coastal communities that serve as prime examples of NNBFs are Spring Creek (#104) to the north of Jamaica Bay and **Bayswater State Park (#148)**.

Although there is much potential to conduct habitat restoration within the Jamaica Bay Planning Region, contamination issues are pervasive within the bay and its tributaries. The water quality of the eastern end of the bay is degraded and does not currently meet its state-designated best use classification for surface water quality. More than any other planning region, Jamaica Bay provides several opportunities to improve water quality by reducing the human-induced effects of enclosed and confined waters. The shorelines of most of the tributaries of Jamaica Bay have been hardened and straightened, reducing tidal flushing. Opportunities to improve water circulation exist in many of these waterways. In addition, several existing deep borrow pits could be recontoured to improve hydrodynamics and water quality. CRP Sites that involve recontouring of the benthic environment to improve local hydrodynamics include Norton Basin, which is part of Rockaway Peninsula (#628), Bergen Basin (#160), Shellbank Basin (#810), Hendrix Creek (#168), Mill Basin (#200), and Thurston Basin (#634).

Public access opportunities, which can be incorporated into future habitat restoration projects, exist throughout this planning region because much of the region is within the National Park System. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

Spring Creek North and South

The U.S. Army Corps of Engineers (USACE), New York State Department of Environmental Conservation (NYSDEC), New York City Department of Parks and Recreation (NYCDPR), New York City Department of Environmental Protection (NYCDEP), the National Park Service (NPS), the Federal Emergency Management Agency (FEMA), the Governor's Office of Storm Recovery (GOSR), and the U.S. Department of Housing and Urban Development (HUD), among others, have partnered to restore the Spring Creek area located along the north shore of Jamaica Bay. The site consists of two separately funded projects referred to as Spring Creek North and Spring Creek South. Spring Creek North is owned by NYCDPR and the restoration project is being funded by the USACE and NYCDPR pursuant to the Continuing Authorities Program (CAP). Spring Creek South is owned by NPS and the restoration project is funded by a grant provided to NYSDEC under the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP). These projects are also being coordinated with the Governor's Office of Storm Recovery's Howard Beach New York Rising Community Reconstruction Plan (March 2014).

Spring Creek North is a tidal creek that has retained its meandering pattern and has several smaller side channels with exposed mudflats at low tide. The proposed ecosystem restoration project at this site consists of excavating and recontouring uplands to achieve intertidal elevation, as well as removing invasive plant species and replanting the area with native plants. A total of approximately 8 acres (0.03 kilometers^2) of low marsh, 5.5 acres (0.02 kilometers^2) of high marsh, and almost 25 acres (0.1 kilometers^2) of maritime upland habitat would be restored. In addition, NYCDPR received a National Fish and Wildlife Foundation (NFWF) Grant to conduct complementary actions to provide coastal storm risk management (CSRM) features and improve resiliency at the site.

Spring Creek South was originally recommended as a potential restoration opportunity for the USACE's Jamaica Bay, Marine Park, and Plumb Beach Ecosystem Restoration Feasibility Study. As part of FEMA's HMGP, NYSDEC, USACE (as a planning and construction management contractor), and NPS have reevaluated the restoration plans to include Natural/Nature Based Features (NNBFs) providing CSRM benefits and enhanced coastal resiliency to the Howard Beach Community. A protective berm, in conjunction with up to 178 acres (0.72 kilometers^2) of maritime upland habitat and 51 acres (0.21 kilometers^2) of wetlands, could be restored at Spring Creek South, in addition to improved public access and reduction in sediment/soil contamination. In total, the Spring Creek site provides restoration opportunities for six TECs and is an excellent example of leveraging multiple partner programs and funding sources to achieve ecosystem restoration serving as NNBFs within Jamaica Bay Planning Region.

4.2 Lower Bay

Similar to Jamaica Bay, the Lower Bay Planning Region appears to be suitable for the restoration of a variety of habitats, including oyster reefs, wetlands, eelgrass beds, and coastal and maritime forests. The extensive shallow littoral, marine, and intertidal habitats have the potential to offer numerous opportunities for aquatic habitat restoration along southeastern Staten Island and southwestern Brooklyn in New York, and Monmouth County, New Jersey. This region also contains coastal forest restoration opportunities and the potential to reverse the effects of human disturbance. Fifty-two (52) of the CRP Sites are within the Lower Bay Planning Region; 20 sites have been identified for both acquisition and restoration, 31 have been identified for restoration only, and 1 has been identified as acquisition (Table 4-1; Map 4-2).

Large expanses of the Lower Bay meet many of the physical and water quality properties to support the growth of oysters. Oyster restoration projects previously identified in Lower Bay included Matawan Creek/Keyport Harbor (#802), Raritan Bay (Oyster Bed Restoration) (#594), and various other sites in New Jersey. Currently, however, only one oyster restoration project is being conducted in New Jersey, at **NWS Earle**, due to concerns that oysters from contaminated waters would enter the human food chain. In late 2012 however, the NY/NJ Baykeeper was granted permits to conduct oyster research and restoration within a 10-acre (0.04-kilometers^2) area at **NWS Earle** since public access to these waters is restricted and poaching is unlikely. The expansion of the **oyster reef at NWS Earle** is being evaluated through the HRE Feasibility Study (see spotlight project: Oyster Restoration and Research Partnership). In January 2016, the Governor of New Jersey passed bill S2617, requiring NJDEP to revisit existing Shellfish Rules within one year after adoption to provide additional research and restoration opportunities based on public comments.

Many areas within the Lower Bay Planning Region meet several of the habitat requirements of eelgrass beds. Historically, eelgrass beds were found throughout this planning region, but currently only anecdotal reports of remnant beds exist in the tidal rivers of the Shrewsbury River Watershed. Two (2) CRP Sites (Shrewsbury River Watershed [#118] and Shrewsbury/Navesink Rivers [#591]) are located in the Shrewsbury and Navesink Rivers. Currently, eelgrass restoration is not proposed as part of these projects; however, opportunities at the Shrewsbury and Navesink River sites are still under evaluation and eelgrass restoration could be a restoration component based upon future findings. Only one CRP Site (Mt. Loretto [#800]) currently contains opportunities to explore the presence/absence of eelgrass and the potential to develop an eelgrass community.

Substantial coastal wetland creation and restoration opportunities exist along the shorelines of numerous tidal creeks and rivers, harbors, and protected coastlines of Lower Bay. Thirty-four (34) of the CRP Sites in this planning region include plans for coastal wetland restoration.

Due to the variety of aquatic and intertidal habitat types that could be restored in the Lower Bay Planning Region, there is potential to restore habitat complexes to support target fish, crustacean, and shellfish species. There are also opportunities to create two or more complementary habitat types or to restore complementary habitats adjacent to existing wetlands. For example, there are many possibilities for the restoration of oyster or other shellfish beds near coastal wetland restoration opportunities, and in some areas, it may also be possible to incorporate eelgrass restoration into the project. The incorporation of a rock reef or other structural features into other aquatic restoration plans can also increase the benefits of the project. These types of structural features are included in CRP Site plans for Raritan Bay (Submerged Rock Bed

Oyster Restoration Research Partnership

Eastern oysters (*Crassostrea virginica*) were historically found throughout the brackish waters of the Hudson-Raritan Estuary (HRE). Considered a keystone species, oysters are responsible for "engineering" reefs and improving water quality. While naturally occurring oysters are no longer present in the HRE, improved water quality has led to various oyster restoration and research projects. In July 2010, however, all restoration efforts in New Jersey were suspended as the New Jersey Department of Environmental Protection (NJDEP) banned oyster projects in contaminated waters for fear of contaminants entering the human food chain. In an effort to continue oyster research and test the viability of restoring oysters in Raritan Bay, NY/NJ Baykeeper was able to work with Naval Weapons Station (NWS) Earle in Middletown, NJ, to secure use of a restricted access location, thereby reducing poaching risks.

In 2011, NY/NJ Baykeeper and the Rutgers Center for Urban and Environmental Sciences (CUES) initiated preliminary oyster survivability studies at NWS Earle. As part of the study, juvenile oysters were placed in tiered oyster nets deployed below the pier at NWS Earle. In 2012, the oyster nets were recovered, with 90 percent of the oysters surviving the winter. The second phase of the project evaluated three oyster support structures to determine which produced the highest survival and growth rates. Based on the data, one support structure will be selected for more extensive and long-term studies at NWS Earle.

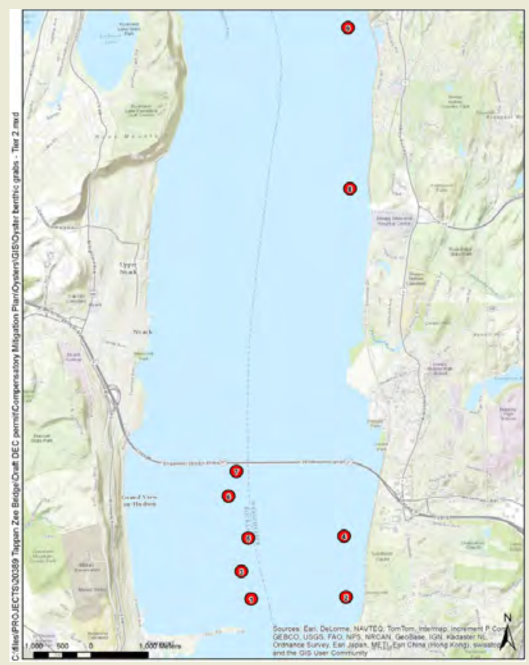
On January 19, 2016, Governor Christie signed bill S2617 that will help protect shellfish research and restoration efforts in New Jersey. The bill requires the NJDEP to revisit acquired Shellfish Rules one year after adoption for revision based on additional research and restoration opportunities introduced via public comment.

Oyster reef restoration and research is also occurring in New York. In 2009, NY/NJ Baykeeper and partners established the Oyster Restoration Research Partnership (ORRP) to study oyster restoration viability in NY Harbor. From 2010 to 2011, ORRP implemented six pilot reefs. In 2013, ORRP established a new oyster reef at Soundview Park in the Bronx. At approximately 1 acre (0.004 kilometers^2), this reef is the largest oyster restoration site in the lower HRE.

Additionally, a two-year oyster restoration pilot study established an oyster restoration site beginning in 2015 near the Tappan Zee Bridge as part of compensatory mitigation associated with construction of the New NY Bridge.

Spat on shell oysters in tanks at Naval Weapons Station Earle.

Spat on shell oysters.



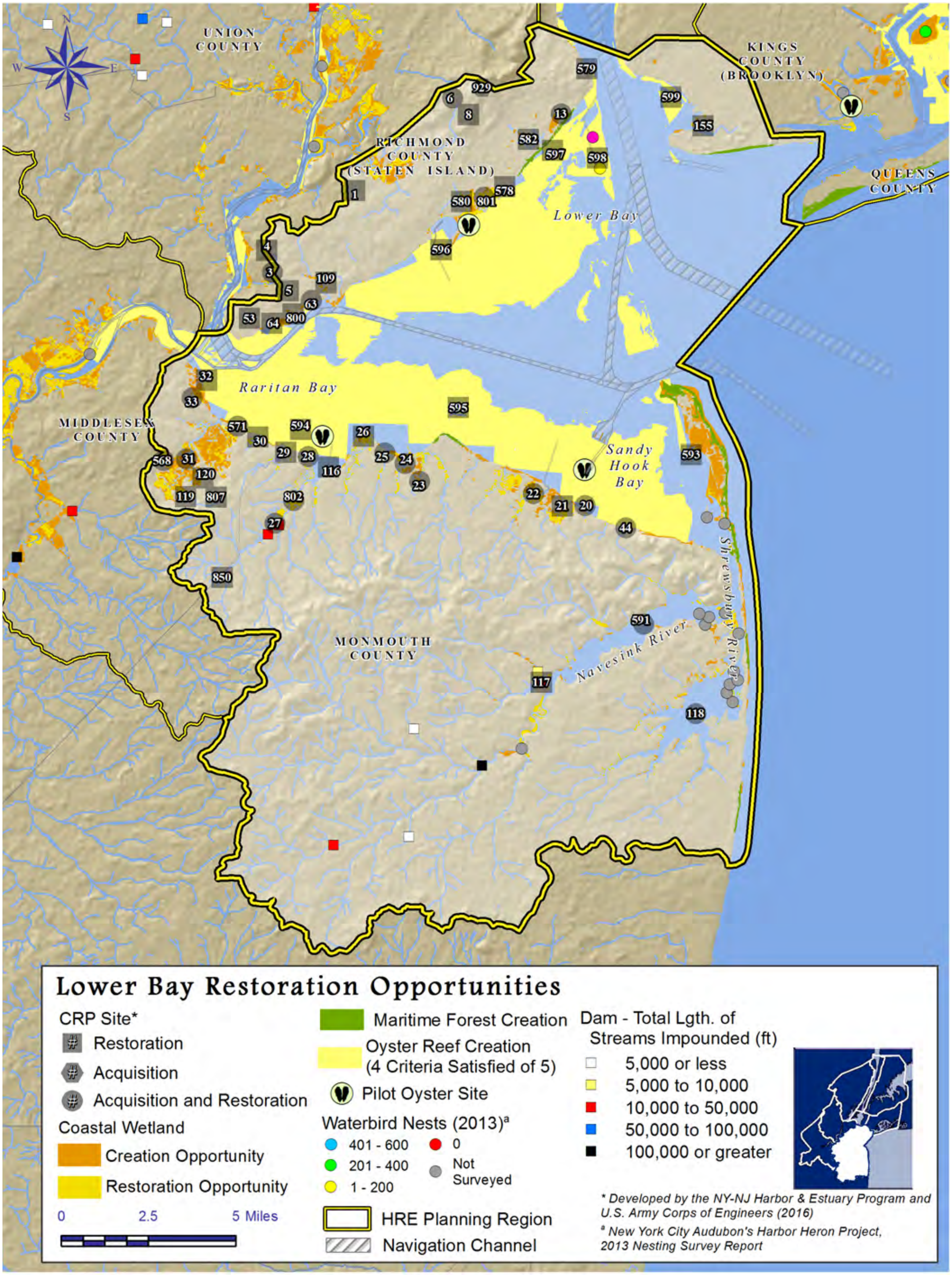
Oyster benthic grab sites.

Source: NY/NJ Baykeeper http://nynjbaykeeper.org/resources-programs/oyster-restoration-program/

[#595]), Gravesend Bay in Brooklyn (#599), and off the shoreline of Staten Island at the Verrazano-Narrows (#597).

The Lower Bay Planning Region also offers the potential for maritime and coastal forest and other upland habitat restoration. Sandy Hook has one of the last remaining stands of maritime forest communities in the HRE study area, and appears to be one of the few areas within the HRE that meets the habitat requirements for these communities. The coasts of Staten

Map 4~2.


UNION COUNTY
KINGS COUNTY (BROOKLYN)
RICHMOND COUNTY (STATEN ISLAND)
QUEENS COUNTY
Lower Bay
Raritan Bay
MIDDLESEX COUNTY
Sandy Hook Bay
MONMOUTH COUNTY
Navesink River
Shrewsbury River
Lower Bay Restoration Opportunities
CRP Site*
Restoration
Acquisition
Acquisition and Restoration
Coastal Wetland
Creation Opportunity
Restoration Opportunity
Maritime Forest Creation
Oyster Reef Creation (4 Criteria Satisfied of 5)
Pilot Oyster Site
Waterbird Nests (2013)a
401 - 600
201 - 400
1 - 200
0
Not Surveyed
HRE Planning Region
Navigation Channel
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
0 2.5 5 Miles
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
a New York City Audubon's Harbor Heron Project, 2013 Nesting Survey Report

Island and Brooklyn within the Lower Bay Planning Region also appear to meet the habitat requirements for maritime forest communities. CRP Sites within this planning region that include plans for the restoration of coastal forest and upland communities are located on the shoreline of Raritan Bay (Treasure Lake [#28], Marquis Creek [#30], Old Morgan Landfill/ Raritan Bay Waterfront Park [#32], and South Amboy [#33]), near Cheesequake Creek in Monmouth County, New Jersey (Global Landfill [#568]), and on Staten Island, New York (Fort Wadsworth Beach [#579], Crookes Point [#596], and Great Kills Park [#801]).

Restoration opportunities at Oakwood Beach (#578) offer the potential to provide CSRM benefits to surrounding communities and coordination with the Sandy South Shore Island project. Over the past 40-50 years, the shoreline has been subjected to significant erosion and major storm damage, including flood damage and loss of property. NY Rising's Enhanced Buyout Program, which sponsors "buy-outs" of property located in sections of Staten Island's East Shore floodplain, will result in restoration opportunities for Oakwood Beach communities. In addition to coastal wetland restoration that would reduce stormwater damage, invasive species removal will also occur at this CRP Site.

Fish passage in the Lower Bay Planning Region could be improved on several tidal rivers impacted by dams, improper culverts, or antiquated tide gates. Several CRP Sites include plans to improve the ability of anadromous fish to swim to upstream spawning areas. These sites include projects such as the installation of a fish ladder at Shadow Lake Dam (#117), and the removal of low-head dams on the Shrewsbury River that would allow for upstream movement of the American eel (#118). An additional opportunity, installation of a fish passage structure on the Swimming River Reservoir dam on Robins Swamp Brook (a tributary to the Navesink River), would provide anadromous fish access to more than 170,000 feet (51,816 meters) of upstream habitat.

Other identified restoration opportunities in this planning region include habitat improvements for the waterbirds on Hoffman-Swinburne Islands (#598) and the restoration of freshwater wetlands near the shore of Raritan Bay (#28 and #33). Shoreline softening opportunities have also been identified in Staten Island (#801), the Shrewsbury River (#118), Natco Lake and Thorns Creek in Monmouth County (#23), and the Navesink River in Redbank, New Jersey. The shoreline softening opportunity along the Navesink River involves replacing debilitated bulkheads at several municipal properties with living shorelines. This shoreline project is being spearheaded by American Littoral Society (ALS), which has collaborated with NOAA to secure project funds though Hurricane Sandy grants. Stevens Institute of Technology assisted ALS by designing the living shoreline.

Many of the habitat creation and improvement opportunities described above, including the living shoreline project proposed along the Navesink River in Redbank, will offer the potential to incorporate a public access component or to improve an existing access point. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

It is important to note that although the Lower Bay Planning Region offers abundant habitat restoration opportunities, the region also has extensive contamination issues. The sediments of Raritan Bay, and to a lesser extent Sandy Hook Bay and Lower Bay, contain relatively high concentrations of DDT, PCBs, dioxins, and furans when compared to other areas in the HRE.

4.3 Lower Raritan River

The Lower Raritan River Planning Region includes the Lower Raritan River and much of its extensive tributary network. The region includes opportunities to restore coastal wetlands, coastal forests, and, potentially, oyster reefs, and to improve tributary connections throughout the planning region. Twenty-six (26) CRP Sites are located within the Lower Raritan River Planning Region; 22 sites have been identified for both acquisition and restoration and 4 sites have been identified for restoration only (Table 4-1; Map 4-3). Specific restoration actions have not been identified for 16 of these sites.

Coastal wetland restoration opportunities are abundant in the Lower Raritan River Planning Region. The extensive coastal wetlands along the Lower Raritan and its southern tributaries represent opportunities to restore and expand this valuable habitat type. Results of the preliminary screening suggest that it may be possible to expand coastal wetlands in this planning region by thousands of acres. CRP Sites that identify coastal wetland restoration opportunities include the Raritan Arsenal (#536), the Kin-Buc and Edison Landfill (#547), and South River (#548). It is likely that future evaluations could reveal additional coastal wetland restoration opportunities.

The South River (#548) CRP Site is located within the Lower Raritan Basin in Middlesex County, New Jersey, along the South River, the first major tributary of the Raritan River. This tidal river system is characterized by wide, meandering channels, dredged material islands, and extensive *Phragmites*-dominated marshes. Portions of the shoreline are bulkheaded or otherwise modified, particularly in urban/residential areas. Habitats at the site include mixed grasslands, forests, and wetlands. This site provides opportunities to restore approximately 152 acres (0.62 kilometers^2) of low emergent marshes, 171 acres (0.69 kilometers^2) of forested and scrub-shrub wetlands, 10 acres (0.04 kilometers ^{2})of tidal creeks, 10 acres (0.04 kilometers^2) of tidal ponds, 19 acres (0.08 kilometers^2) of mudflats that could create habitat for fish, crab and lobsters, and the potential removal and capping of contaminated sediments. This large site offers restoration opportunities for multiple TECs.

No oyster reef restoration opportunities were identified at the CRP Sites; however, a portion of the Lower Raritan River meets many, but not all, of the habitat requirements for this species. Somewhat unique to this planning region is the quality of the sediments in the areas that could support oysters. Although sediments close to the mouth of the Raritan River have relatively high concentrations of many contaminants of concern, concentrations of total dioxins, furans, PCBs, and other contaminants decrease with distance from Raritan Bay.

Although this planning region would likely not support maritime forests, the upper reach of the Lower Raritan River has the potential for other riparian habitat, coastal forest, and grassland restoration opportunities. Former industrial sites, such as National Lead (#537) and the Kin-Buc and Edison Landfill (#547), are examples of sites having the potential for restoration of upland communities. Further evaluations will likely reveal additional opportunities for restoring upland coastal communities.

National Lead (#537) is located adjacent to the Raritan River in Sayreville, New Jersey. The site is part of the Sayreville Waterfront Redevelopment project. Since the site was historically used for industrial purposes, it is undergoing remediation and cleanup efforts. Restoration opportunities at this site include the development of high and low marsh and fringe marsh community, as well as improvements to shallow water habitats through the addition of complex structures to facilitate connectivity with the fringe marsh and establish habitat for fish, crab, and lobsters.

A substantial portion of the upper reaches of the Lower Raritan River shoreline has been hardened, which may present restoration opportunities. Shorelines throughout this planning region should be evaluated to determine the possibility of softening the shorelines or incorporating engineered structures to improve aquatic habitat. Shoreline and shallows restoration opportunities have been identified at the Raritan Arsenal site (#536). There are also several opportunities to improve fish passage and connect habitats along tributaries throughout the Lower Raritan River Planning Region. For example, the installation of fish passage structures on the Duhernal Dam on the South River could open over 170,000 feet (51,816 meters) of stream for fish migration. There are six other dams in this planning region, each of which may present the opportunity to open between 20,000 feet (6,096 meters) and 30,000 feet (9,144 meters) of stream for fish passage. These dams include the Davidsons Mill Pond Dam, New Markets Pond Dam, Tennets Brook Dam, the Farrington Dam, Westons Mill Pond Dam, and Westons Mill Arch Dam.

This planning region represents a substantial opportunity to bring the public to the waterfront. Restoration plans within this planning region should incorporate public access points, such as kayak and canoe launches, nature trails, interpretational materials, and picnicking opportunities. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

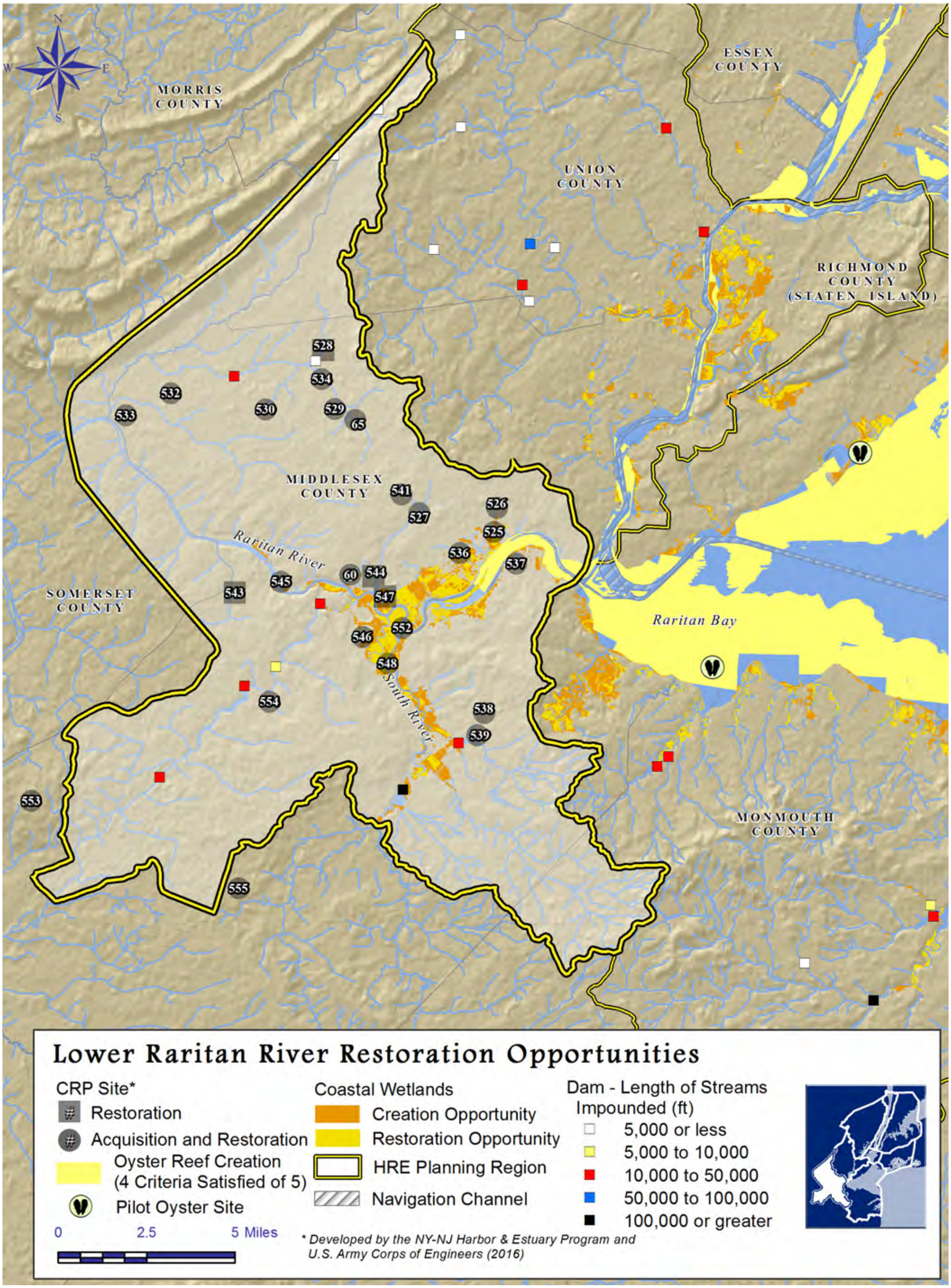
Lawrence Brook Fish Passage

In 2011, through a project funded by the New York-New Jersey Harbor & Estuary Program (HEP) in partnership with New England Interstate Water Pollution Control Commission (NEIWPCC), the Lawrence Brook Watershed Partnership (LBWP) began initial investigations into the possibility of fish passage over two obstructions, Westons Mill Pond Dam and Westons Mill Arch Dam. These obstructions on Lawrence Brook, a tributary to the Raritan River, impound a drinking water supply reservoir owned and operated by the City of New Brunswick. While removal was not seen as viable due to their current function, the installation of fish passage over these dams would open up 3 miles (5 kilometers) of habitat to American shad (*Alosa sapidissima*), blueblack herring (*Alosa aestivalis*), and American eel (*Anguilla rostrata*). If passage were also provided on other upstream blockages, an additional 9 miles (14 kilometers) could be added in the future, for a total of 12 miles (19 kilometers). Furthermore, fish passage has also been proposed for inclusion as part of the City of New Brunswick's developing Municipal Public Access Plan.

Initial fish passage investigations, considering topography, hydrology, safe yield, and habitat, recommended a Denil fish passage structure be considered further. These passage structures are seen as suitable, particularly given the limited space available and desire to provide passage to shad upstream. After the installation of gages and initial readings, LBWP continues to monitor the station for water quality and will be working with partners, including the City of New Brunswick and HEP, to seek opportunities for the next phase of feasibility investigation.

Westons Mill Pond Dam. *Photo courtesy of Kate Boicourt.*

Map 4~3.


MORRIS COUNTY
ESSEX COUNTY
UNION COUNTY
RICHMOND COUNTY (STATEN ISLAND)
MIDDLESEX COUNTY
SOMERSET COUNTY
MONMOUTH COUNTY
Raritan River
South River
Raritan Bay
528
534
532
530
529
65
533
541
527
526
525
536
537
60
544
545
543
547
552
546
548
554
538
539
553
555
Lower Raritan River Restoration Opportunities
CRP Site*
Restoration
Acquisition and Restoration
Oyster Reef Creation
(4 Criteria Satisfied of 5)
Pilot Oyster Site
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
HRE Planning Region
Navigation Channel
Dam - Length of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
0
2.5
5 Miles
* Developed by the NY-NJ Harbor & Estuary Program and
U.S. Army Corps of Engineers (2016)

4.4 Arthur Kill and Kill Van Kull

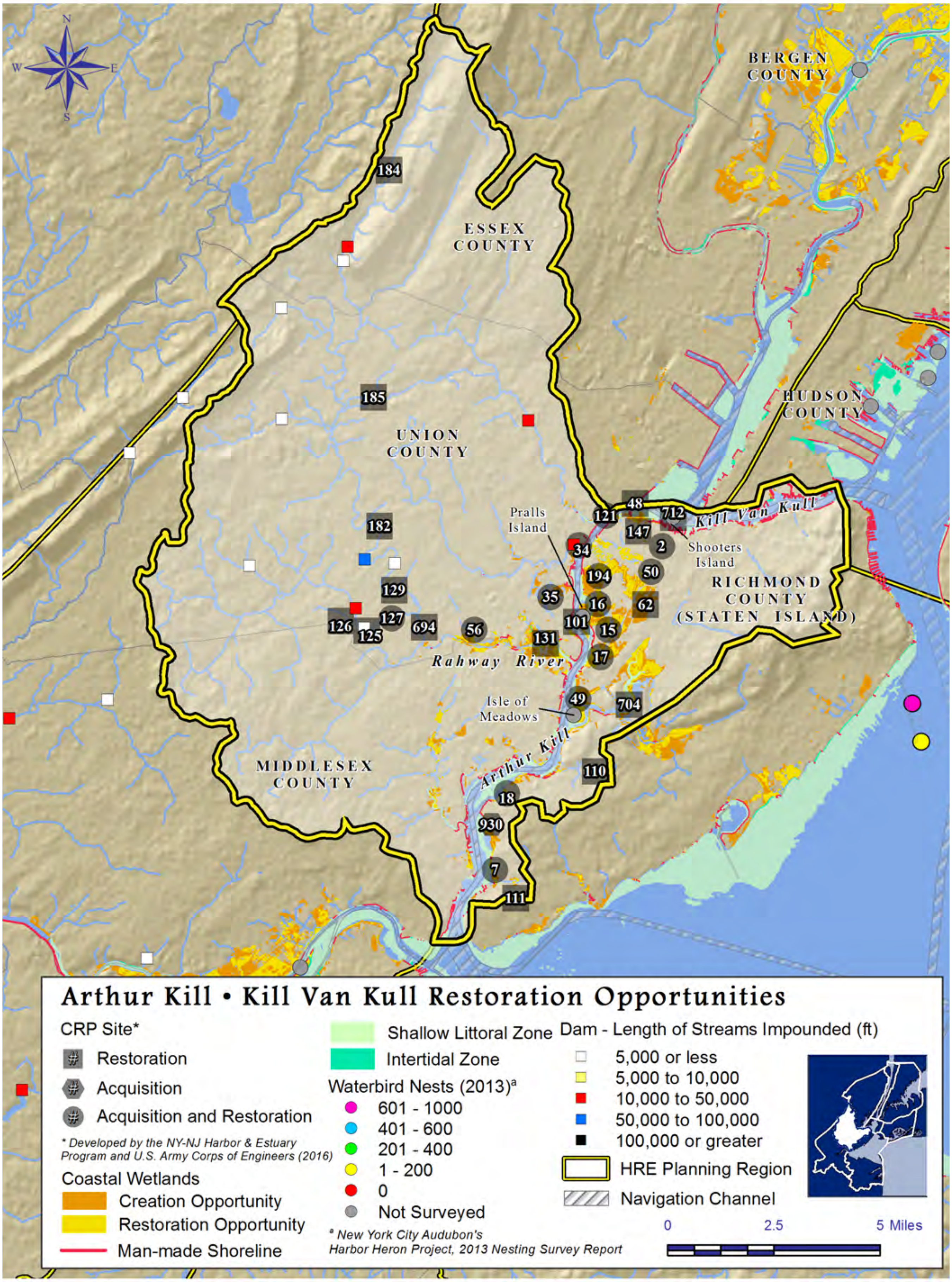
The Arthur Kill and Kill Van Kull Planning Region appears to offer substantial opportunities to restore coastal wetlands, shorelines and shallows, tributary connections, and waterbird habitat. There are large expanses of coastal wetlands along the tributaries to the Arthur Kill that could benefit from restoration activities, and adjacent areas may be appropriate for the creation of additional coastal wetland acreage. The islands of this planning region once supported large colonies of waterbirds, but currently do not support any nesting activities. There are also opportunities within this planning region to reverse human-induced alterations that have led to habitat degradation. Thirty-one (31) CRP Sites are within the Arthur Kill and Kill Van Kull Planning Region; 14 sites have been identified for both acquisition and restoration, 16 have been identified solely for restoration, and 1 has been identified as acquisition (Table 4-1; Map 4-4).

Coastal wetland restoration opportunities are abundant in the Arthur Kill and Kill Van Kull Planning Region. Tidal creeks and rivers on both the New Jersey and New York sides of the Arthur Kill could benefit from the establishment and expansion of native salt marsh vegetation. Twenty-one (21) of the CRP Sites include a coastal wetland component, many of which are located along the Rahway River (e.g., Potter's Island [#131] and Rahway Riverfront Park [#694]), and smaller tributaries in Middlesex County, New Jersey (e.g., Morses Creek [#34] and Piles Creek [#35]). The northwest portion of Staten Island also has several tidal creeks and streams identified as CRP Sites (e.g., Gulfport Marsh [#194] and Graniteville Swamp Woods [#50]). Additional opportunities may be available for coastal wetland creation and restoration in this planning region.

Since the 1990s, waterbird populations no longer use Pralls Island, Shooters Island, or the Isle of Meadows, which once had established colonies of waterbirds in the hundreds. These islands represent an opportunity to restore the habitat in an effort to attract nesting waterbirds again. Current plans on Pralls Island (#101) include restoration of fringe marsh around the perimeter of the entire island, erosion control, restoration of *Phragmites*-dominated wetlands, potential removal and capping of contaminated sediments, restoration of upland forest patches to improve heron habitat, and potential for placement of complex structures to improve habitat connectivity for fish, crab and lobsters, as well as the removal of fill and placement of sand and/or shell to promote waterbird nesting throughout the island. Since the site was nominated as a CRP Site, however, much of the vegetation has been removed in response to an infestation by the Asian longhorned beetle. Restoring the canopy of tree coverage on Pralls Island is part of NYC MillionTrees Initiative and was funded in part by HEP along with a study to facilitate restoration of the island as a nesting habitat for long-legged and wading birds.

Restoration plans at Shooters Island (#712) call for the creation of wetlands along the edges of the island and creation of islands for waterbirds, as well as creation of coastal wetlands and placement of a geotextile tube to control erosion. Additional opportunities for the site include creation of habitat for fish, crustaceans, and lobsters and potential dredging and capping of contaminated sediments. Potter's Island on the Rahway River in Middlesex County, New Jersey (#131) has been identified as another opportunity to enhance habitat for waterbirds, including egrets and heron. Other islands in this planning region may provide opportunities for creating and restoring habitat for waterbirds.

Map 4~4.



N
S
E
W
BERGEN COUNTY
ESSEX COUNTY
UNION COUNTY
HUDSON COUNTY
RICHMOND COUNTY (STATEN ISLAND)
MIDDLESEX COUNTY
Pralls Island
Shooters Island
Isle of Meadows
Kill Van Kull
Rahway River
Arthur Kill
184
185
182
129
127
126
125
694
56
131
35
101
16
15
17
34
194
50
62
121
48
712
147
2
49
704
110
18
930
7
111
Arthur Kill • Kill Van Kull Restoration Opportunities
CRP Site*
Restoration
Acquisition
Acquisition and Restoration
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
Man-made Shoreline
Shallow Littoral Zone
Intertidal Zone
Waterbird Nests (2013)[a]
601 - 1000
401 - 600
201 - 400
1 - 200
0
Not Surveyed
[a] New York City Audubon's Harbor Heron Project, 2013 Nesting Survey Report
Dam - Length of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
HRE Planning Region
Navigation Channel
0
2.5
5 Miles

The Arthur Kill and Kill Van Kull Planning Region has potential for the creation, restoration, and preservation of coastal forests and other uplands. Several CRP Sites include similar actions, although most focus on the protection of existing forests. For example, plans for the Range Road Forest (#56) along the Rahway River, which forms the border of Union and Middlesex counties in New Jersey, include preservation of upland and wetland forests, restoration of coastal wetland habitat, potential enhancements to tidal flats through the addition of complex structures to increase habitat connectivity, potential to enhance tributary connections, and dredging and capping of contaminated sediments. Plans for the Arden Heights Woods (#110) on Staten Island include forested wetland and freshwater wetland preservation. Many other opportunities for coastal upland restoration are present throughout this planning region, as outlined in the Atlas of Restoration Opportunities (Appendix D).

A significant proportion of the coastal shorelines in this region are hardened, though many of these derelict structures could be removed and replaced with habitat of higher ecological function. Several CRP Sites include plans for softening the shorelines or otherwise improving the riparian habitat. Most of these sites are located along the Rahway River in or near the City of Rahway, New Jersey (e.g., Madison/Maple Avenues [#125], Milton Lake [#126], Rahway River Parkway Lake [#129], Central Avenue [#127], and Rahway River Parkway (Sperry Section), The Lagoon [#182]). Farther upstream on the Rahway River, riparian restoration is planned at the Orange Reservoir (#184).

The Arthur Kill and Kill Van Kull Planning Region includes 11 impoundments. Of the dams in the HRE impounding, at least 10,000 feet (3,048 meters) of stream, almost 30 percent, occur in the Arthur Kill and Kill Van Kull Planning Region. Fish passages have been improved at Milton Lake with the placement of a fish ladder at Milton Lake Dam in 2006, which was part of a larger restoration and improvement project that allowed passage along more than 2,000 feet (610 meters) upstream. There may be additional opportunities to provide upstream fish passage to the tributaries to the Arthur Kill. There are several dams in the planning region that should be evaluated for opportunities to improve fish passage and connect the tributaries to other valuable habitats.

Water quality issues and surface sediment contamination are present in the Arthur Kill and Kill Van Kull Planning Region. Dozens of CSOs discharge into the Kill Van Kull, the Elizabeth River, and the Rahway River. Surface sediments of the Arthur Kill and Kill Van Kull have above average concentrations of many contaminants of concern when compared to other planning regions. Predicted concentrations of DDT and PCBs are more than twice the ERM values, and concentrations of 2,3,7,8-TCDD are also well above the predicted effects range for oysters. Concentrations of total dioxins and furans, 2,3,4,7,8-pentachlorodibenzofuran (PeCDF), and total chlordane are also above the median concentrations for the HRE study area.

There is the potential to create new public access areas with almost every intertidal and upland habitat acquisition and restoration site within this planning region. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

4.5 Newark Bay, Hackensack River, and Passaic River

The Newark Bay, Hackensack River, and Passaic River Planning Region offers substantial opportunities to restore coastal and freshwater wetlands, create and restore coastal upland habitats, and repair human induced habitat degradation. In recent years, hundreds of acres of coastal wetland habitat have been restored to serve as mitigation banks and projects in this planning region. The Evergreen MRI3 Wetland Mitigation Bank was constructed in 2012. The 51-acre (0.21-kilometers^2) mitigation bank is adjacent to a newly restored 17-acre (0.07-kilometers^2) mitigation project resulting in about 68 acres (0.28 kilometers^2) of contiguous coastal wetland habitat along the Hackensack River. The Richard P. Kane Mitigation Bank was also constructed in 2012 and consists of 240 acres (0.97 kilometers^2) of contiguous coastal wetland and open water habitat. Although significant progress has been made, there are still many more opportunities to restore degraded habitats. Seventy-six (76) of the CRP Sites are located within the Newark Bay, Hackensack River, and Passaic River Planning Region; 21 sites have been identified for both acquisition and restoration, 54 sites have been identified for restoration only, and 1 site was identified as acquisition (Table 4-1; Map 4-5).

Preliminary screening indicates that this planning region offers more than 2,000 acres (8.09 kilometers^2) of coastal wetland creation opportunities. Thirty-seven (37) coastal wetland restoration opportunities were identified within CRP Sites. Most of these sites are within the Meadowlands District and along the Hackensack River, examples of which include Penhorn Creek (#38), Kearny Marsh (Freshwater) (#39), Berry's Creek Marsh (#803), Bellman's Creek (#42), Anderson Creek Marsh (#715), Lyndhurst Riverside Marsh (#718), Steiners Marsh (#728), and Oritani Marsh (#723). The **Meadowlark Marsh (#719)** and **Metromedia Tract (#721)** are sites that are being recommended for near-term construction authorization as part of the HRE Feasibility Study.

Contamination issues in this planning region are pervasive. Dozens of CSOs are located along the lower Passaic River and within Newark Bay, and poor water quality in Newark Bay fails to meet the NJDEP best use classification for the waterbody. The surface sediments in this planning region have among the highest concentrations of the contaminants of concern evaluated in Chapter 3 and Appendix C, and numerous USEPA Superfund Sites are located within the planning region. Habitat restoration plans will need to take contaminant concentrations, the potential for the transport of contaminants, and attractive nuisance issues into consideration prior to construction.

The restoration opportunities within the lower Passaic River have specific implementation challenges since the river is part of the Diamond Alkali Superfund Site. Restoration opportunities need to be coordinated with USEPA in order to appropriately sequence implementation with remedial investigations and actions. Of the 53 restoration opportunities within the lower Passaic River and tributaries, 28 are located in the lower 14 miles of the lower Passaic River mainstem and are considered "deferred sites," meaning the river must be remediated before the sites can advance. Sites that could advance (without remediation required) and plan to be recommended for near-term construction as part of the HRE Feasibility Study include **Essex County Branch Brook Park (#887)**, **Dundee Island Park/Pulaski Park (#900)**, and **Clifton Dundee Canal Green Acres Purchase and Dundee Island Preserve (#902)**. Restoration opportunities at these sites primarily include removal of invasive species, native plantings, and debris removal.

Other opportunities have been identified along the lower Passaic River (e.g. **Kearny Point [#865]**. Unnamed Tidal Creek – NJ Turnpike [#868], Path Rail Fringe Marsh [#871] and Kearny Marsh (Cedar Creek Marsh) [#869]), and on the shoreline of Newark Bay at Oak Island Yards (#866). The Kearny Point and Oak Island Yards restoration opportunities are considered "deferred sites" recommended for restoration following remediation as part of the HRE Feasibility Study. Although not currently a CRP Site, there are also coastal wetland restoration opportunities at the former Scientific Glass site, located along an unnamed tributary to the Third River in Bloomfield, New Jersey and adjacent to the Desimone property that the Township of Bloomfield acquired in 2012. The former Scientific Glass site is approximately 10 acres (0.04 kilometers^2) and offers wetland and floodplain restoration.

Although this planning region does not appear to provide habitat suitable for maritime forest communities, coastal upland habitat restoration opportunities have been identified for four CRP Sites. Most of these opportunities were identified as part of restoration plans that include a coastal wetland component (e.g., Mehrhof Pond [#720], and Losen Slote Creek Park [#522]). Freshwater wetland restoration and creation opportunities are also present in this planning region. These opportunities have been identified along Penhorn Creek (#38), Kearny Marsh (Freshwater) (#39), and Mehrhof Pond (#720) and within the Teterboro Woods (#729) on the Hackensack River.

There are many opportunities to connect the habitats along tributaries to allow fish passage between valuable habitat types. The installation of a fish ladder at the Oradell Dam (#143) would open more than 110,000 feet (33,528 meters) of stream for anadromous fish migration on the Hackensack River. The Third River (Mouth) (#893), a tributary to the Passaic River, has been identified as an opportunity to construct a fish ladder.

Metromedia Tract

The Metromedia Tract is a candidate for restoration and preservation located in the Hackensack Meadowlands along the Hackensack River and has been identified as a near-term construction site by the HRE Feasibility Study (see Table 4-2). The 74-acre (0.30-kilometers^2) site is undeveloped but dominated by common reed. The site may have received fill from unknown sources during construction of adjacent radio towers, resulting in restricted tidal flow due to high marsh elevations. The conceptual restoration plan includes restoring approximately 53 acres (0.21 kilometers^2) of low marsh and upland buffers through invasive species removal and planting of native species. In addition, 1,862 feet (568 meters) of channel networks could be constructed to restore tidal hydrology and increase habitat connectivity for fish and shellfish. Dredging and capping of contaminated sediments is also a possibility at this site and is dependent on sediment contaminant testing.

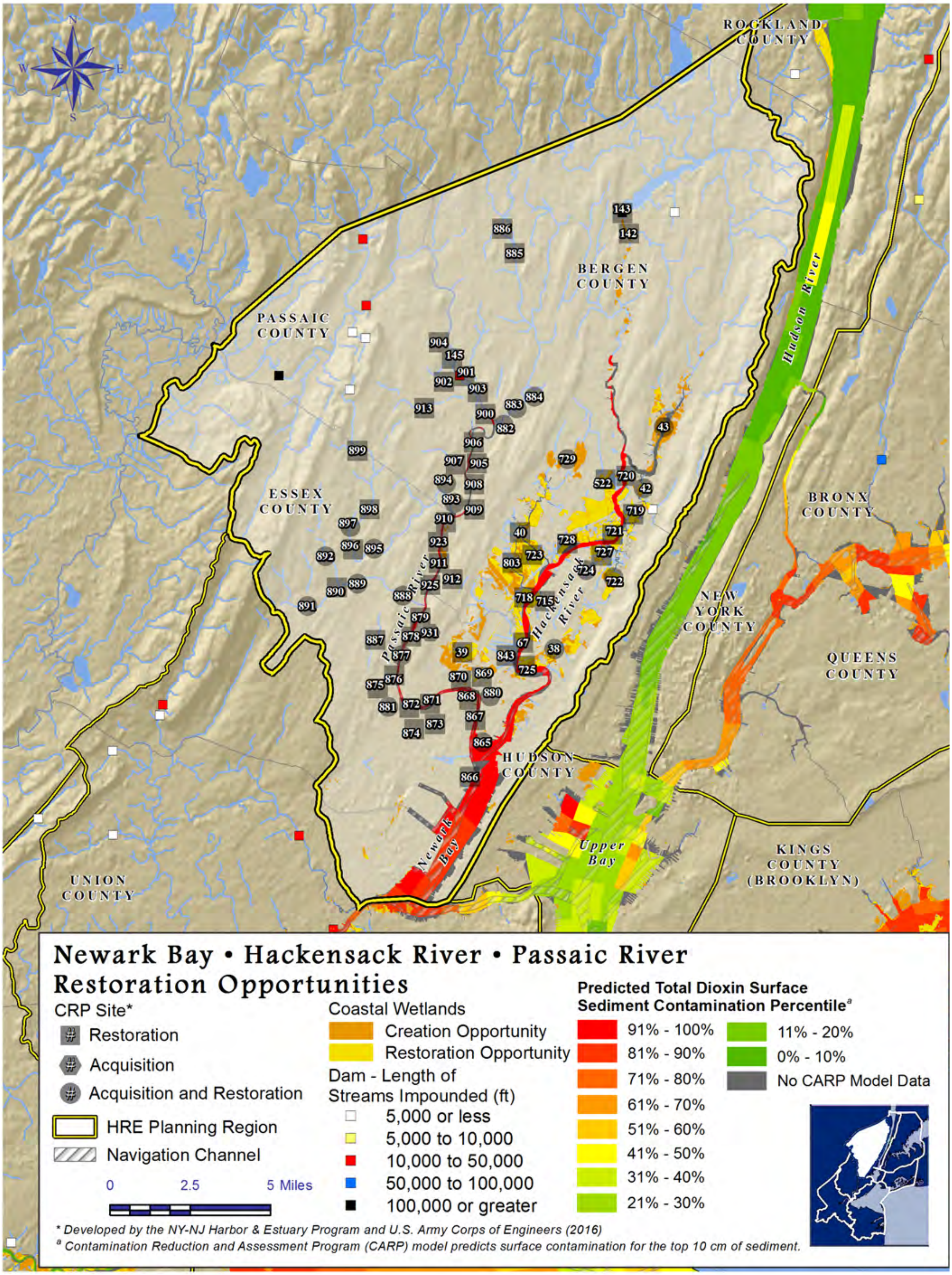
http://meri.njmeadowlands.gov/mesic/sites/candidate-restoration-sites-metro-media-tract-2/

Tidal marsh and Metro Media Broadcast radio towers.

Additional habitat restoration opportunities include softening shorelines and recontouring shallow water habitat along the Passaic River (e.g., Franks Creek Site (1-D Landfill) [#870] and Riverfront Park [#875]) and Hackensack River, and along Newark Bay at Oak Island Yards (#866). This planning region is the location of the HRE Lower Passaic River and the Hackensack Meadowlands Restoration Studies, two ecological restoration feasibility studies that helped identify and prioritize specific restoration actions. Recommendations from these feasibility studies will be included in the HRE Feasibility Study.

This planning region would benefit from the creation of public access points. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

Map 4~5.


ROCKLAND COUNTY
BERGEN COUNTY
PASSAIC COUNTY
ESSEX COUNTY
BRONX COUNTY
NEW YORK COUNTY
QUEENS COUNTY
HUDSON COUNTY
KINGS COUNTY (BROOKLYN)
UNION COUNTY
Hudson River
Hackensack River
Passaic River
Newark Bay
Upper Bay
Newark Bay • Hackensack River • Passaic River
Restoration Opportunities
CRP Site*
Restoration
Acquisition
Acquisition and Restoration
HRE Planning Region
Navigation Channel
0
2.5
5 Miles
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
Dam - Length of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
Predicted Total Dioxin Surface Sediment Contamination Percentile[a]
91% - 100%
81% - 90%
71% - 80%
61% - 70%
51% - 60%
41% - 50%
31% - 40%
21% - 30%
11% - 20%
0% - 10%
No CARP Model Data
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
[a] Contamination Reduction and Assessment Program (CARP) model predicts surface contamination for the top 10 cm of sediment.

4.6 Lower Hudson River

The Lower Hudson River Planning Region includes the brackish and marine waters of the Hudson River, bounded by an extensive shoreline from the Tappan Zee Bridge to lower Manhattan and Hudson County, New Jersey. Coastal wetland and oyster restoration opportunities exist along the Lower Hudson River. The high density urban development along the shorelines in this planning region may offer opportunities to enhance shoreline structures and adjacent waters by incorporating habitat features and structures into their designs. Relatively few CRP Sites are located in this planning region. Ten (10) CRP Sites are within the Lower Hudson River Planning Region; 2 have been identified as both acquisition and restoration and 8 have been identified solely for restoration (Table 4-1; Map 4-6). Eight (8) of these sites are located along the Manhattan and Bronx shorelines in New York, and two are located in New Jersey. Specific restoration actions have not been planned for the sites located in New Jersey.

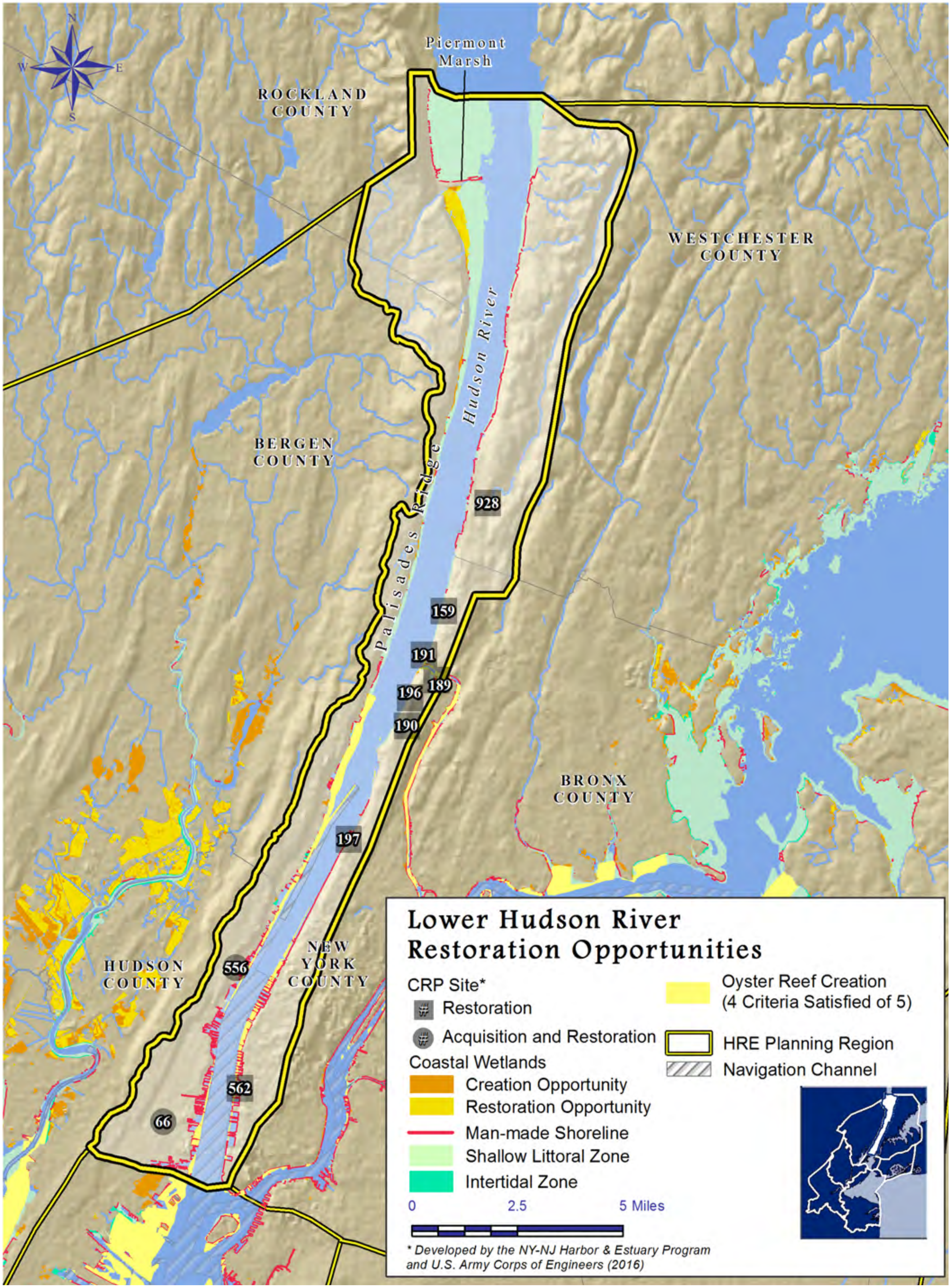
Shorelines of existing parkland in Manhattan and the Bronx have been identified as opportunities to create and restore coastal wetlands. Wetlands near Riverdale Park in the Bronx (#159) provide a wetland restoration opportunity, and it may be possible to create wetlands along the shorelines of Inwood Park (#189), Fort Tryon Park (#190), and Spuyten Duyvil (#191). While specific restoration actions are to be determined at the Hudson/Bergen County Waterfront (#556) in Hudson County, New Jersey, potential plans include creation and restoration of fringe marsh and tidal flats, enhancements to habitat for fish, crab, and lobsters, dredging and capping of contaminated sediments, and construction of a waterfront walkway. Most of these restoration sites are located adjacent to or within parkland, so there is also the potential to restore coastal upland habitat adjacent to the wetlands. In addition to the opportunities identified in the CRP Sites, opportunities to restore and create coastal wetlands may be available adjacent to Piermont Marsh, Rockland County, New York. Plans for restoration of this marsh are proposed as mitigation for the New NY Bridge Project that is being constructed to replace the Tappan Zee Bridge.

The Lower Hudson River Planning Region may offer opportunities for oyster restoration projects. Much of the shallow waters on the western shoreline of the Lower Hudson River meet the chemical and physical parameters for oyster habitat. Opportunities to soften shorelines in this planning region, or to otherwise improve the shoreline habitat for fish and crustacean species, should be further investigated.

The surface sediments of the Lower Hudson Planning Region have the lowest concentrations of nearly all of the contaminants of concern within the HRE study area. Sediment quality is expected to improve as a result of the dredging of PCB contaminated sediments from the Upper Hudson River. However, contaminated sediments are present in localized areas such as interpier basins and around CSOs. Improvements to sediment quality are proposed at most of the CRP Sites within this planning region.

Public access to the waterfront is a very important TEC in this densely populated region. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

Map 4~6.


N
E
S
W
Piermont Marsh
ROCKLAND COUNTY
WESTCHESTER COUNTY
Hudson River
BERGEN COUNTY
Palisades Ridge
928
159
191
196
189
190
BRONX COUNTY
197
HUDSON COUNTY
556
NEW YORK COUNTY
562
66
Lower Hudson River Restoration Opportunities
CRP Site*
Restoration
Acquisition and Restoration
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
Man-made Shoreline
Shallow Littoral Zone
Intertidal Zone
Oyster Reef Creation (4 Criteria Satisfied of 5)
HRE Planning Region
Navigation Channel
0
2.5
5 Miles
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)

Hudson River Park Estuarine Sanctuary

Hudson River Park is located along the western waterfront of Manhattan from Battery Place to 59th Street.The park provides public waterfront access and is home to gardens, scenic overlooks, playgrounds, athletic fields, historic resources, and educational and river research facilities. In the area of the park, the Hudson River experiences a mixing zone of freshwater from the river and seawater from the Hudson Estuary. The area is a regionally significant nursery and wintering habitat for a number of anadromous, estuarine, and marine fish species, and is a migratory and feeding area for birds and fish.

The majority of the shoreline is lined with bulkhead, but the bottom surfaces of the interpier zones are relatively flat and gently sloping. The interpier areas offer opportunities for creating shallow and gradually sloping shorelines and enhancing habitat for fish and other aquatic species. Interpier habitat enhancement and creation includes preservation of high quality habitat at remnant pier structures and placement of rock rip-rap along the water edge to add complex surfaces for cover-seeking fish. Approximately 14 acres (0.06 kilometers^2) of interpier habitat could be created or enhanced and 1,940 feet (591 meters) of gradual sloping shoreline can be created by re-grading at Piers 97, 76, 57, 54, and 40, as well as at Gansevoort Peninsula.

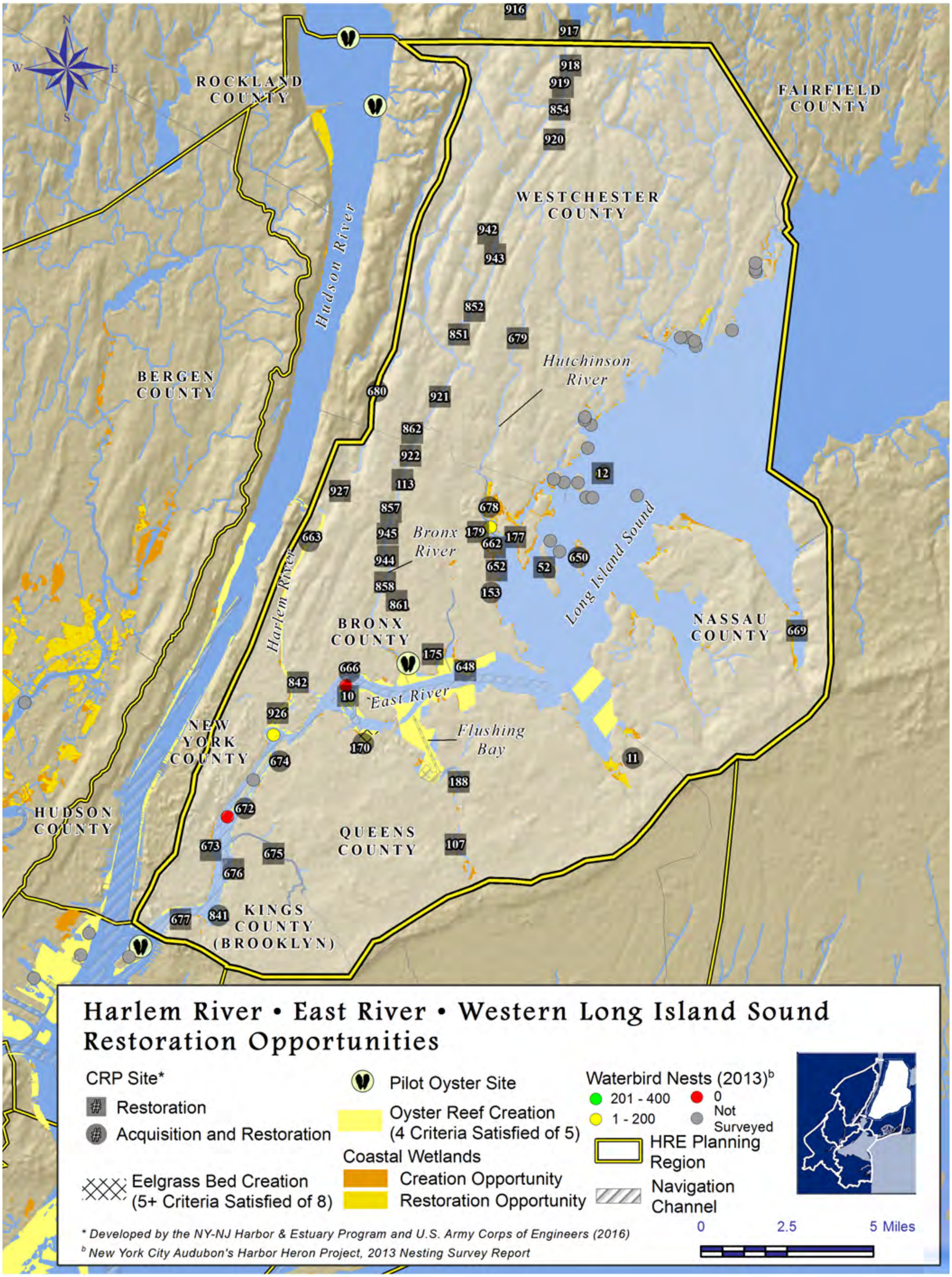
In addition to habitat enhancement and creation, the project offers opportunities to enhance public access at all the piers where interpier habitat is proposed. This would include continuation of the waterfront esplanade, sports and recreation facilities, open and event space, gardens, and commercial revenue generating development, as well as an estuary museum and other educational opportunities.

4.7 Harlem River, East River, and Western Long Island Sound

The Harlem River, East River, and Western Long Island Sound Planning Region offers a variety of opportunities to create and restore each of the TEC habitats. This planning region has extensive shallow littoral and subtidal waters that provide the opportunity to create a variety of aquatic habitat types. Many islands exist within this planning region, representing the potential to improve habitat for waterbirds. There are also many opportunities to reverse human-induced habitat degradation. Forty-eight (48) CRP Sites are located within the Harlem River, East River, and Western Long Island Sound Planning Region; 11 sites have been identified for both acquisition and restoration, and 37 sites have been identified solely for restoration (Table 4-1; Map 4-7).

Of the 48 sites within this planning region, 10 are being recommended for near-term construction authorization as part of the HRE Feasibility Study. Nine (9) sites are on the Bronx River, including **Stone Mill Dam/Anadromous Fish Passage 2 (#945)**, **Bronx Zoo and Dam/Anadromous Fish Passage 1 (#944)**, **Shoelace Park (#113)**, **Muskrat Cove (#862)**, **River Park (#860)**, **Westchester County Center (#854)**, **Bronxville Lake (#851)**, **Crestwood Lake (#852)**, **Garth Woods (#942)**, and **Harney Road (#943)**. One site within **Flushing Creek (#188)** will also be recommended for construction authorization. A common theme among the restoration opportunities at these CRP Sites includes fish passage and shoreline softening, invasive species removal, and native plantings. Coastal wetland creation opportunities are abundant in this planning region. Results of the GIS analyses presented in Chapter 3 suggest that more than 1,000 acres (4.04 kilometers^2) of coastal wetlands could be created. Fourteen (14) of the CRP Sites in this region include a coastal wetland restoration or creation component. These sites include areas located along Pugsley Creek (#175), the Harlem River at Sherman Creek (#663), the Hutchinson River (e.g., Palmer Inlet [#153] and Pelham Bay Park/Tallapoosa West [#179]), on the shoreline of City Island

Map 4~7.



ROCKLAND COUNTY
FAIRFIELD COUNTY
WESTCHESTER COUNTY
BERGEN COUNTY
Hudson River
Hutchinson River
Bronx River
Harlem River
BRONX COUNTY
Long Island Sound
NASSAU COUNTY
East River
Flushing Bay
NEW YORK COUNTY
HUDSON COUNTY
QUEENS COUNTY
KINGS COUNTY (BROOKLYN)
Harlem River • East River • Western Long Island Sound
Restoration Opportunities
CRP Site*
Restoration
Acquisition and Restoration
Eelgrass Bed Creation (5+ Criteria Satisfied of 8)
Pilot Oyster Site
Oyster Reef Creation (4 Criteria Satisfied of 5)
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
Waterbird Nests (2013)b
201 - 400
1 - 200
0
Not Surveyed
HRE Planning Region
Navigation Channel
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
b New York City Audubon's Harbor Heron Project, 2013 Nesting Survey Report
0
2.5
5 Miles

Wetlands (#52), in Brooklyn at Bushwick Inlet (#676), and the coves and harbors of western Long Island Sound (e.g., Hempstead Harbor [#669], Alley Creek Northeast and Hart Island [#650]).

Pugsley Creek Park (#175) is located in the Bronx along Pugsley Creek, a tributary to the East River. The Pugsley Creek Park Project is an Action Agenda Project listed in the NYC CWP and involves the complete restoration of tidal wetlands, including excavation work, sand placement, and the planting of saltmarsh grasses. NYCDPR restored wetlands along the eastern side of the creek, but there are more than 10 acres (0.04 kilometers^2) of degraded upland and wetland habitat that could be restored on the western side of the creek; implementation is planned for 2017.

In addition to wetland restoration, many of the opportunities, such as **Flushing Creek (#188)**, Tibbetts Brook (#680), and several sites listed above, include a coastal upland habitat restoration component. Tibbetts Brook (#680), which drains approximately 2,300 acres (9.30 kilometers^2) of parts of Westchester County and the Bronx, currently drains into the combined sewer system and thus contributes to CSOs to the Harlem River. In the existing floodplains of the brook, there are stream and wetland restoration and creation opportunities that extend from Tibbetts Brook Park in Yonkers to Van Cortlandt Park in the Bronx. There is also an opportunity for restoration of coastal forests in the floodplain fringe. The forest community would link to the existing established upland forest to create a larger and more contiguous forest stand. Other restoration opportunities at Tibbetts Brook include wetland restoration and daylighting a section of stream within Van Cortlandt Park, a planning project that is currently in the contracting phase with NYCDPR. The long-term vision is to remove the brook from the combined sewer system and reconnect it to the Harlem River. This reconnection, through stream daylighting where possible, would improve overall awareness of urban streams, improve downstream water quality, and serve as a model project for daylighting other streams in the HRE.

Alley Creek also provides both wetland and coastal forest restoration opportunities. The site is located within Alley Pond Park in northeast Queens, between the LIRR and Northern Boulevard to the east of Alley Creek. Although not currently a CRP Site, opportunities at the site include approximately five acres (0.02 kilometers^2) of coastal forest restoration and four acres (0.016 kilometers^2) of salt marsh restoration. The site is dominated by low elevation concrete and asphalt fill and is suitable for low marsh restoration through the removal of fill materials and *Phragmites*.

The Pelham Bay Park/Tallapoosa West Site (#179) provides wetland restoration opportunities along an inlet located south of the Pelham Bay Landfill in Eastchester Bay. Opportunities include coastal wetland restoration, including *Phragmites* removal, replanting with *Spartina*, and regrading wetland elevations along approximately 1.7 acres (0.006 kilometers^2) of existing wetlands. Additional opportunities exist to restore tributary connections and flushing to a brook that was diverted, dredge the inlet, and remove debris along approximately 1,288 feet (392 meters) of the brook to restore flow, and a potential opportunity to dredge and cap contaminated sediments.

Although only two CRP Sites (Hempstead Harbor [#669] and Sherman Creek [#663]) include plans for oyster restoration and eelgrass restoration within this planning region, there are opportunities to create these habitats. Areas protected from wave action and navigation channels along the upper East River have physical and chemical properties that meet requirements for oyster habitat. A large-scale (one-acre [0.004 kilometer^2]) oyster restoration pilot study was constructed off the shore of Soundview Park. This study is an Action Agenda Project listed in the NYC CWP and involves oyster planting, evaluating ecological and water quality effects resulting from oyster restoration, and determining the feasibility of large scale oyster restoration projects within the HRE. In addition, the expansion of the oyster reef at Soundview Park is planned to be recommended for near-term construction as part of the HRE Feasibility Study. It may also be possible to include an oyster restoration component to current restoration plans in Bowery Bay (#170). Eelgrass restoration opportunities may exist in many of these areas as well. Restoring two or more complementary habitat types for fish, shellfish, and crustacean appears to be possible in the upper East River and western Long Island Sound.

The majority of islands in the HRE study area are located within the Harlem River, East River, and Western Long Island Sound Planning Region. Uninhabited islands in the East River include North and South Brother Islands, Mill Rock, Roosevelt Island, and U Thant Island. Islands in western Long Island Sound include David's Island, Huckleberry Island, Pea Island, Hart Island, City Island, and Goose Island. Reports of invasive vine and tree species on many of these islands suggest that there are numerous opportunities to improve habitat for roosting and nesting waterbirds. The CRP Sites that include opportunities to restore island habitat for waterbirds include South Brother Island (#10), Hart Island (#650), and Huckleberry Island (#12). There are likely additional opportunities to restore waterbird habitat in this planning region that will be identified during future evaluations.

Opportunities to improve the connectivity of habitats along tributaries and to improve the ability for fish to move between these habitats exist in this planning region. The Hutchinson River Marsh Restoration (#678) includes plans for the installation of a fish ladder to allow passage for anadromous fish. There are also four dams in this planning region that may block access to more than 10,000 feet (3,048 meters) of upstream waters. In particular, the Bronx River Double-Dam Fish Passage (see spotlight project: Bronx River Double-Dam Fish Passage) and Stone Mill Dam may represent an opportunity to restore fish passage to more than 63,000 feet (19,202 meters) of stream. Freshwater wetland restoration opportunities have been identified at Meadow Lake and are being implemented (#107).

This planning region provides opportunities to improve water quality in the bays and harbors of western Long Island Sound. The surface waters of Flushing Bay, Little Neck Bay, Manhasset Bay, and Hempstead Harbor fail to meet the water quality requirements for their state-designated best use classifications. CSOs line the shorelines of eastern Manhattan, along Brooklyn, as well as many rivers draining into the upper East River and western Long Island Sound. Two CRP Sites include plans to improve local water quality habitat: Sherman Creek (#663) and Newtown Creek (#675). Newtown Creek was listed as a Superfund Site on the NPL in 2010. Potential restoration opportunities at Newtown Creek (#675) will be on hold until site remediation is completed by USEPA and water quality is improved through CSO regulations and upgrades. Future evaluations will likely identify many more opportunities to improve water quality in this planning region.

Surface sediment contamination issues are pervasive along the East River in this planning region. In particular, predicted concentrations of PCBs in the sediments along the entire East River are among the highest in the HRE study area. Relatively high concentrations (above the ERL) of benzo(a)pyrene were also predicted for the upper East River. Predicted dioxin and furan concentrations were also high when compared to the Lower Hudson and Lower Raritan River Planning Regions.

Bronx River Dams Fish Passage

Dams on the Bronx River create a series of impediments to anadromous fish passage. The dams have caused a significant buildup of sediments and the formation of a bar within the channel that is dominated by invasive species. Upstream of the dams in the Bronx Zoo, the Bronx River channel has lost most of the natural riverine geomorphology and has formed a lacustrine community surrounded by steep banks with several point sources of sediment and areas of bank instability. Restoration potential at the site includes the removal of invasive plants and replanting with native species within the upland buffers and floodplain to increase bank stability, as well as the installation of in-stream structures to increase fish habitat function. To improve habitat connectivity, a fish ladder is proposed at the Bronx Zoo Dam to extend anadromous fish passage and use of riverine habitat by approximately 0.67 miles (1.0 kilometers). Another fish ladder is proposed at the Stone Mill Dam, to extend fish passage upstream approximately 7 more miles (11 kilometers) into Westchester. Several dams are located farther upstream in Westchester; therefore, it is recommended that fish passages be constructed at all the dams for the system to be most effective. These two sites at Bronx Zoo and Stone Mill Dam will be recommended for near-term construction authorization with New York City Department of Parks and Recreation (NYCDPR) (non-Federal sponsor) as part of the HRE Feasibility Study.

Bronx Zoo Dam. *Photo courtesy of New York City Department of Parks and Recreation.*

4.8 Upper Bay

The Upper Bay Planning Region is the smallest and among the most urbanized of the HRE planning regions. Seven (7) CRP Sites are within the Upper Bay Planning Region; one has been identified for both acquisition and restoration and six sites have been identified solely for restoration only (Table 4-1; Map 4-8). Despite the fact that so few CRP Sites are in this planning region, opportunities exist for many TECs.

The northeastern shoreline of Staten Island, the shorelines of Hudson County, New Jersey, Governor's Island, and a portion of Brooklyn (including Red Hook) are within this planning region. Shallow littoral and intertidal habitat occurs along the western shorelines, and there are existing coastal wetlands on the New Jersey side of this planning region. Restoration opportunities for shorelines and shallows exist at **Bush Terminal/Brooklyn Sunset Park (#154)** and **Governor's Island (#864)**. The shorelines of the region are heavily lined with piers and bulkheads, and a network of navigation channels runs throughout the subtidal waters of this planning region. In addition, habitat restoration opportunities for fish, crabs, and lobster have been identified for this planning region at all CRP Sites except Gowanus Canal (#503).

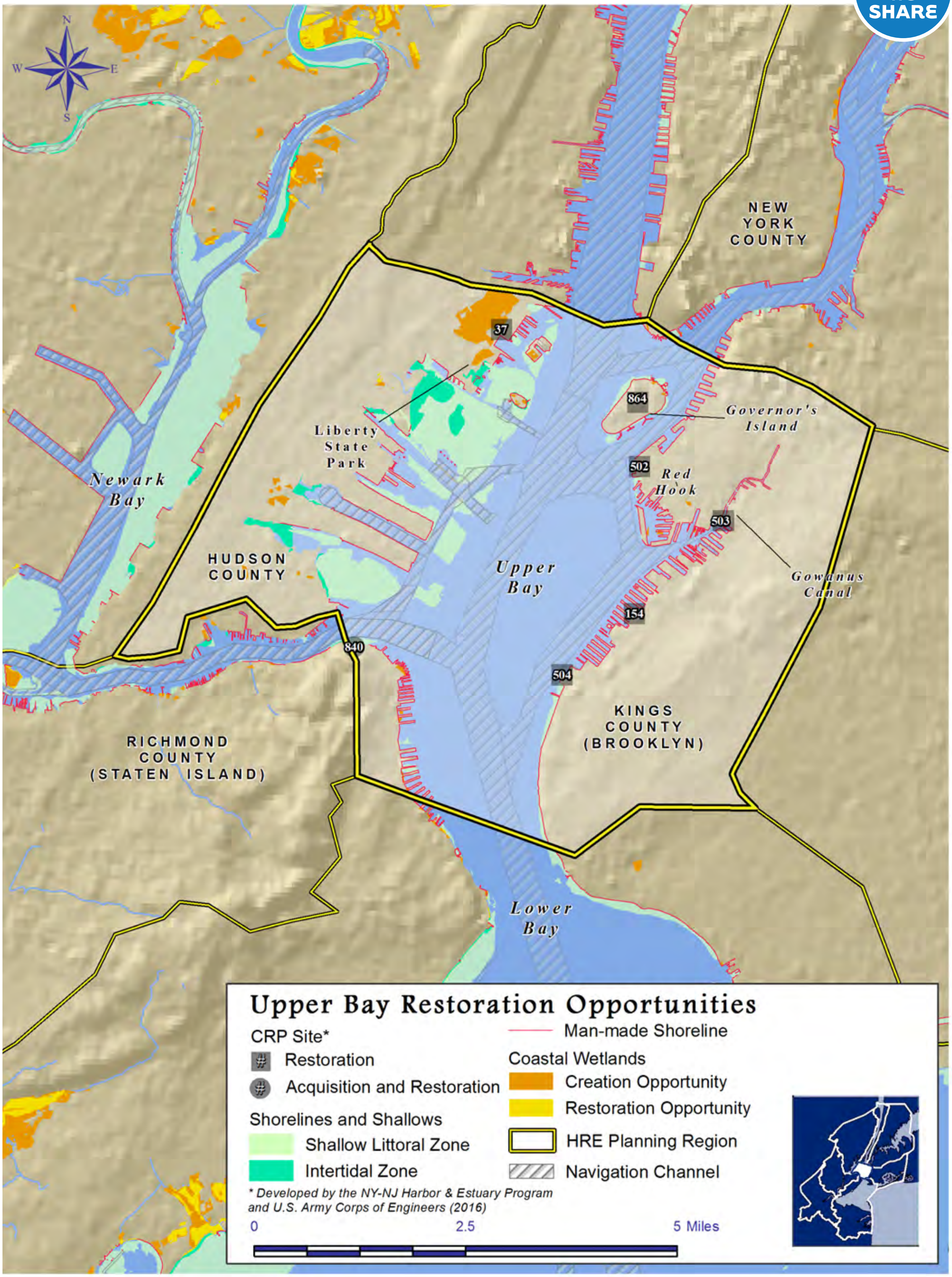
In addition to the CRP Sites discussed above, the Lincoln Park Restoration Project has been successful in restoring a native salt marsh community in an urban ecological area. Restoration of the tidal wetland hydrology at the site was accomplished by excavating previously placed fill material and re-contouring the site to create intertidal habitat and tidal creeks. This project restored 42 acres (0.17 $kilometers^2$) of wetland, stream, and salt marsh habitat along the Hackensack River. The tidal marsh, which was originally designed to offset damage from a 1990 oil spill in the Arthur Kill channel, has been incorporated into the 270-acre (1.09-$kilometers^2$) site. Some additional wetland restoration opportunities currently exist in the park.

Existing coastal wetlands are relatively rare within the Upper Bay Planning Region, occurring in only a few areas in Bayonne and Jersey City, New Jersey. One CRP Site includes plans for coastal wetland creation, **Liberty State Park (#37)**. The major restoration action planned for **Liberty State Park** includes more than 224 acres (0.91 $kilometers^2$) of restoration with a more than 40-acre (0.16- $kilometers^2$) tidal marsh complex. Plans to improve upland coastal habitat (including a maritime forest community) and freshwater wetlands are also included in this project (USACE 2004c). This will substantially increase the overall acreage of habitat available in this planning region.

The shallow littoral waters of the planning region may have the potential to support oyster reefs. These regions meet the physical and chemical parameters necessary for oyster habitat. One CRP Site at **Governors Island (#864)** has been identified as an oyster restoration opportunity. A pilot study for oyster growing has been initiated with hopes of increasing the size of the project and the volume of oysters grown, based on the success of the pilot. Further evaluations of the Upper Bay Planning Region may demonstrate that more oyster restoration opportunities are feasible in the areas where relatively shallow waters occur. The expansion of oyster pilots at **Bush Terminal/Brooklyn Sunset Park (#154)** and **Governors Island (#864)** are recommended for near-term construction authorization for the HRE Feasibility Study.

Water quality in the Upper Bay is somewhat degraded and does not meet its best use classification for either New York or New Jersey surface water quality standards. Although surface sediment contamination is present throughout the HRE study area, sediments in the middle of Upper Bay generally have contaminant concentrations below the median for the HRE study area. However, predicted total DDT concentrations are well above the ERM of 46 parts per billion on the eastern side of

Map 4~8.



N
W
E
S
NEW YORK COUNTY
37
864
Governor's Island
Liberty State Park
502
Red Hook
Newark Bay
503
HUDSON COUNTY
Upper Bay
Gowanus Canal
154
840
504
KINGS COUNTY (BROOKLYN)
RICHMOND COUNTY (STATEN ISLAND)
Lower Bay
Upper Bay Restoration Opportunities
CRP Site*
Restoration
Acquisition and Restoration
Shorelines and Shallows
Shallow Littoral Zone
Intertidal Zone
Man-made Shoreline
Coastal Wetlands
Creation Opportunity
Restoration Opportunity
HRE Planning Region
Navigation Channel
* Developed by the NY-NJ Harbor & Estuary Program and U.S. Army Corps of Engineers (2016)
0
2.5
5 Miles

Liberty State Park Restoration Project

Liberty State Park is one of the first restoration studies conducted under the HRE study authority. The 40-year old park, located on a 1,122-acre (4.5-kilometers^2) plot by the water's edge in Jersey City, New Jersey, is in the Upper Bay Planning Region (USACE 2004c). It offers spectacular views of the Manhattan skyline, the Statue of Liberty, and Ellis Island, as well as a green oasis amidst dense development. An estimated 4.3 million visitors a year enjoy its man-made walkways, open spaces, and educational center (USACE 2004c).`

Human-induced disturbances have re-shaped the ecological community and conditions within the park. This site was originally an intertidal mud flat and salt marsh that was filled and stabilized, then used by the Central Railroad of New Jersey Terminal for freight and passenger services (USACE 2004c). Once rail operations ended and the terminal facilities were removed, natural succession resulted in ecological communities dominated by invasive species and low animal diversity, which is indicative of a highly disturbed area that is isolated from surrounding natural areas. Currently, a large undeveloped section located at the center of the park is inaccessible to the public due to high concentrations of sediment-borne toxins (USACE 2004c).

In 2007, the New Jersey Department of Environmental Protection (NJDEP) implemented a 10-acre (0.04-kilometers^2) freshwater State Natural Resource Damage (NRD) wetland mitigation project. The primary restoration activities included fill removal followed by plantings of native species.

Continued opportunities at the 240-acre (0.97-kilometers^2) Liberty State Park restoration site will provide substantial benefits by linking previously developed and restored, but isolated, components of the park into one cohesive whole. Approximately 46 acres (0.19 kilometers^2) of salt marsh will be created. Salt marshes that once lined the harbor were gradually eliminated during the industrial revolution. Remnant pocket marshes exist primarily between piers throughout the harbor and provide invaluable wildlife habitat in the center of the most densely populated area of the country. The salt marsh will add an entirely new host of functions and values that are not present in the park, particularly aquatic habitat for fish and waterfowl. A system of walkways and observation platforms are planned, which will add educational and aesthetic value to the inherent ecological value of Liberty State Park.

In addition to the salt marsh, 26 acres (0.12 kilometers^2) of freshwater wetlands will be created and/or enhanced, 50 acres (0.20 kilometers^2) of grasslands will be created, and 100 acres (0.40 kilometers^2) of hardwoods and maritime shrublands will be enhanced. A narrow channel will connect the tidal marsh to the North Cove. This site has been recommended for near-term construction as part of the HRE Feasibility Study (Table 4-2).

A view of the Manhattan skyline from Liberty State Park.

Two hundred fifty (250) acres of Liberty State Park are inaccessible to the public due to contaminated sediments.

Sources:
NJDEP. 2015. The Future of Liberty State Park: Creating a World Class Destination.
USACE. 2004a. Hudson-Raritan Estuary Environmental Restoration Feasibility Study. Study Area Reports. U.S. Army Corps of Engineers, New York District, New York, NY.

the bay along the shoreline of Brooklyn. This area also has predicted concentrations of PCBs well above the ERM of 180 parts per billion. Predicted concentrations of total dioxin and furan on the northwestern side of the bay along the shoreline of Jersey City, New Jersey were among the highest in the HRE study area. In addition, localized areas of degraded sediment and water quality likely exist in areas with restricted water circulation, such as interpier basins and modified tidal creeks.

The Gowanus Canal (#503) Restoration Project is an example of a CRP Site where the plan focuses on localized improvements that will benefit the larger estuary. The plan calls for the removal of contaminated sediments within the canal, shoreline softening and stabilization, the installation of measures to improve water circulation to minimize future contamination issues, and the creation of coastal wetlands along the shoreline to further improve the habitat. The USEPA designated the Gowanus Canal a Superfund site on the NPL in 2010. All restoration plans for the Gowanus Canal Restoration Project are on hold and will be reevaluated when remediation is completed by USEPA and water quality is improved through the CSO regulations and/ or upgrades.

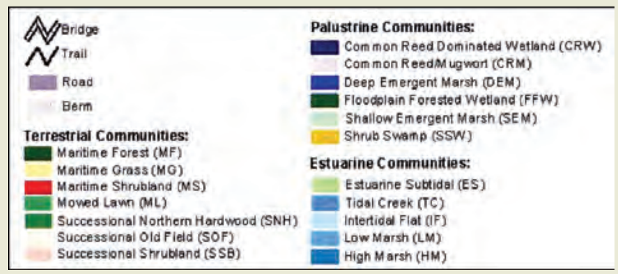
Relatively few public access points have been identified in the Upper Bay Planning Region. Planned and existing public access points, as described in Chapter 3, will be identified as a result of future coordination and outreach efforts.

4.9 Summary

Opportunities to restore habitats and reduce the effects of human disturbance are abundant throughout the HRE study area. As highlighted in this chapter, and in the Atlas of Restoration Opportunities provided as Appendix D, many site-specific opportunities have been identified. However,

Liberty State Park Restoration Project (Cont'd)

In addition to the salt marsh, 26 acres (0.12 kilometers^2) of freshwater wetlands will be created and/or enhanced, 50 acres (0.20 kilometers^2) of grasslands will be created, and 100 acres (0.40 kilometers^2) of hardwoods and maritime shrublands will be enhanced. A narrow channel will connect the tidal marsh to the North Cove. This site has been recommended for near-term construction as part of the HRE Feasibility Study (Table 4-2).



Liberty State Park legend.


Existing conditions at Liberty State Park.


Proposed communities for the Liberty State Park Salt Marsh Restoration.

this is not a comprehensive list. It is likely that these restoration actions represent only a small fraction of those possible. As discussed in Chapter 3, additional zones of restoration opportunities were identified through a series of GIS analyses. These estuary-wide analyses were used to estimate whether the TEC objectives are achievable and to identify zones where successful restoration projects may be likely.

HRE stakeholders are encouraged to identify and nominate additional restoration opportunities to increase the number of CRP Sites. In addition to listing more sites, each existing site was evaluated using GIS for specific restoration opportunities and potential projects with details such as available TECs, acreages of restoration opportunities, and the status of each site. Site reconnaissance is required to verify the findings of these evaluations and the restoration opportunities present at each site.

The original list of CRP Sites has evolved to include new sites that have been nominated, and many sites have been removed for various reasons including successful project completion. As the list of sites is modified, the existing CRP Site information on the NYC OASIS database continues to be updated. OASIS provides an interactive approach for those seeking restoration opportunities within the HRE and allows users to obtain site information from a standard set of attributes including the acreage, TECs with potential to be restored on the site, major habitat class, acreage, planning region, watershed, and general notes regarding restoration potential. The continued evaluation of restoration opportunities, nomination of new sites, and evolution of the Atlas of Opportunities will help to guide restoration efforts throughout the estuary, allowing all stakeholders to work toward a series of common restoration goals that provide benefits to the estuary.

5.0 Comprehensive Restoration Plan Management and Implementation

Habitat restoration requires coordination among agencies and organizations since restoration opportunities do not always follow property boundaries, or state or county lines. While virtually any stakeholder with financial and logistical support can plan, implement, and monitor a habitat restoration project, smaller groups and community organizations are better suited for more localized actions. Federal agencies are strategically positioned to provide leadership and hold key partnership roles in large-scale ecological restoration, protection, and resiliency programs that span geographical and political boundaries. Many Federal agencies, such as USACE, NOAA, and USEPA, are charged with protecting, restoring, and sustaining our natural environments.

Federal, state, and municipal agencies and organizations that may have an interest in ecosystem restoration in the HRE either through their existing programs or through actions requiring mitigation include (but are not limited to): USACE, USEPA, NOAA, NPS, PANYNJ, NJDEP, NYSDEC, NYCDPR, NYCDEP, NJDOT, New York State Department of Transportation (NYSDOT), NYCEDC, New Jersey Sports & Exposition Authority (formerly NJMC), Environmental Defense Fund, NY/NJ Baykeeper, Hackensack Riverkeeper, Hudson Riverkeeper, Passaic River Coalition, HRF, the Trust for Public Land, Clean Ocean Action, the Natural Areas Conservancy of NYC, and the National Parks Conservation Association. Restoration and preservation of ecologically valuable habitat is extremely important to New York and New Jersey. State agencies and organizations are encouraged to exchange information and expertise and undertake joint projects with their Federal partners. Municipalities also partner on many of these projects.

Given the large number of stakeholders conducting habitat restoration within the HRE study area under a variety of programs, it is important to identify funding sources and strategic partnerships that will effectively achieve the TEC objectives. Restoration projects are typically planned on a site-by-site basis, without measuring or demonstrating the benefits achieved within the context of the entire HRE. Coordinated planning of what are often discrete projects to leverage cooperative funding opportunities and cumulatively advance CRP goals and objectives will be challenging. Successful CRP implementation requires a management structure that can coordinate and evaluate restoration activities among a vast group of stakeholders. The following sections identify potential restoration funding opportunities and potential CRP management strategies.

5.1 Management

Pursuant to the HRE Ecosystem Restoration Feasibility Study, USACE and PANYNJ provided the funding and staff for developing the CRP. USACE, through the HEP process, has brought together agencies, stakeholders, and institutions for important contributions to the CRP development. This collaborative process resulted in an inclusive restoration agenda, setting stakeholders' objectives on a common path, and increasing support and visibility of the program.

In 2010, following release of the 2009 Draft CRP, HEP formed the RWG, whose mission incorporated the role of what had been the Habitat Work Group, to steer development and implementation of the CRP per the management framework described in Section 5.2. The RWG also provides guidance for HEP's research and actions regarding restoration, acquisition, and habitats that address priorities in HEP's Action Plan, CCMP, and this CRP (described herein).

The success of the CRP in improving the estuary ecosystem directly relates to and depends upon continued successful collaboration and cooperation among stakeholders. CRP management must accommodate the dynamic process of long-term environmental restoration. Ecological changes brought about by CRP implementation, as well as ongoing changes to the physical and chemical environment from sea level rise and human activities, will require adjustments to the CRP. The CRP management framework must accommodate the major roles of the plan:

- Tracking Progress. The HEP RWG will continue to play a key role in advising activities of the CRP implementation. This includes its significant contributions to CRP development, evaluating goals or targets, and reviewing conceptual plans for acquisition and restoration sites. Lessons learned will be documented as restoration projects advance and move toward achieving TEC objectives. Successes and failures provide information that can improve restoration in the HRE study area at existing sites through adaptive management as well as aid in the design and construction of new sites. The RWG will also track progress toward achieving goals by providing regular updates of progress toward the specific restoration objectives and recommend or redirect efforts or change management strategies to more effectively meet restoration targets.
- Approving New CRP Restoration Opportunities. The RWG will identify and approve new CRP sites proposed by partners and regional stakeholders through the HEP nomination process.
- Advancing TEC Science. Environmental restoration within the HRE study area is an emerging science that will evolve as the CRP is implemented. Data, insights gained, and challenges overcome through implementing the restoration objectives (i.e., TECs) in the HRE study area should be readily available to restoration practitioners and provide a valuable resource to all stakeholders. The RWG should continue to monitor HEP's CRP and CCMP planning efforts and strive to close information gaps regarding the successful implementation of restoration projects in the region. The lessons learned and practical experience gained from ongoing and completed restoration projects have already led to advances in restoration and to modification of such TECs as ***Oyster Reefs***, ***Habitat for Waterbirds***, ***Wetlands***, and ***Tributary Connections***. Continued revisions to the TECs, based on advances in restoration, will contribute to the success of the CRP and improving the estuary ecosystem.
- Streamlining Policy and Management. As described in Section 5.2.2, policy considerations affect implementation of the TECs, specifically as they pertain to habitat exchange, beneficial use of dredged material, attractive nuisances, and sediment contamination (among others). The RWG can provide a forum to advance relevant policy and regulatory or management concerns that affect restoration, acquisition, species, and habitat. Through targeted meetings with regulatory agencies, it may be possible to improve overall success and provide for regional consistency in implementation.
- Identifying Funding Strategies. Funding for restoration projects has been primarily envisioned as a partnering process, but many sources of funding are needed to achieve major progress. The role of the RWG is to identify and leverage resources and programs to advance priority environmental restoration and acquisition opportunities.

- Prioritizing Restoration Projects. The RWG must work together to develop strategies and approaches to prioritize CRP acquisition and restoration sites in order to inform stakeholders of the relative importance and value of each CRP site within each planning region and within the overall HRE study area.
- Public Involvement. Long-term support for the program can be achieved if stakeholders and the public have direct involvement and strong awareness of the plan's progress. Management and implementation of the CRP should be an inclusive process and should foster this dedicated support.

5.1.1 Program Management Team

Members of the HEP RWG represent organizations or agencies with a broad geography and expertise within the HRE. Current RWG participants include representatives from the following agencies and organizations:

- New York-New Jersey Harbor & Estuary Program
- U.S. Army Corps of Engineers
- National Oceanic and Atmospheric Administration
- The Port Authority of New York and New Jersey
- New Jersey Department of Environmental Protection
- New York State Department of Environmental Conservation
- New York City Department of Parks and Recreation
- New York City Department of Environmental Protection
- New York/New Jersey Baykeeper
- Hudson River Foundation
- National Park Service
- The Nature Conservancy
- The Trust for Public Land
- New Jersey Harbor Dischargers Group

Among the organizations directly involved in the RWG, those listed below have a major stake in guiding or managing aspects of the CRP's implementation:

New York-New Jersey Harbor & Estuary Program (HEP)

HEP was authorized in 1987 by USEPA and had been located at the USEPA Region 2 office in NYC for over 25 years. In 2013, USEPA selected HRF as the new host for HEP in order to enhance the program's opportunities for partnerships and align it with the organization of estuary programs throughout the country. HEP is comprised of stakeholders from agency groups, scientists, citizens, business interests, and non-government organizations. The program represents a multi-year effort to develop and implement a plan to protect, conserve, and restore the HRE. Over the years, HEP has played an integral role in the development of the CRP working with USACE and PANYNJ, and continues to play a major role in environmental stakeholder coordination within the HRE study area, enabling these organizations to advance their objectives. HEP's work groups consist of representatives from local, state, and Federal agencies, scientists, citizens, business interests, and environmentalists, among others. These work group meetings and additional outreach meetings have helped develop and advance implementation of the CRP by providing tools to understand stakeholders' interests and needs. HEP has partnered with the CUNY, which manages a centralized, online information center, the NYC OASIS database, whereby stakeholders can obtain information on activities at CRP sites throughout the HRE study area.

HEP is poised to oversee the long-term management and implementation of the CRP. In December of 2009, the HEP Policy Committee agreed to adopt the CRP as the blueprint and regional agenda for future restoration in the HRE study area. Additionally, the HEP Policy Committee, Management Committee, and the active work groups (Restoration, Water Quality [formerly Nutrients, Pathogens, Toxics, and TMDL], and Public Access) maintain a list of goals and priority actions in the estuary. The Citizens Advisory Committee (CAC) shares program-specific information with the public. The HEP Policy Committee is comprised of representatives from USEPA, USACE, NJDEP, NYSDEC, NYCDEP, PANYNJ, a representative of local government in New Jersey (LGNJ), the Citizens Advisory Committee, the Science and Technical Advisory Committee (STAC), and the HRF or host entity. The RWG provides direction for site acquisition and restoration in the HRE study area. The Harbor Herons and Oyster Restoration sub-committees fall under the RWG. HEP also distributes mini-grants to applicants annually, supporting HRE-specific programs. Many of these grant-funded programs focus on environmental education and providing stewardship opportunities, while others seek to gain information for planning public access and open spaces in the estuary.

Regulatory Agencies

Through their permitting authorities, regulatory agencies (e.g., USACE, NOAA, USFWS, NYSDEC, NYCDEP, and NJDEP) have been working to conserve and protect natural resources from degradation. Over time, these programs have created an essential baseline for environmental restoration. Regulatory programs have improved water quality, stopped the loss of wetland and other shoreline habitats, and regulated activities that in the past degraded the estuary. Regulatory agencies will play a critical and multifaceted role implementing the CRP through their permitting of individual restoration projects, ongoing efforts to address residual pollution and contamination, management of aquatic resources, and technical expertise applied directly to restoration projects.

Regulatory agencies also play an integral part in the management of aquatic habitats through their mitigation programs. These programs dictate and enforce the creation or restoration of habitat to mitigate for filling or dredging activities. Future mitigation projects should be consistent with the goals of the CRP. Restoration opportunities identified through the CRP process could be advanced through mitigation.

Beyond these standard programs implemented by the respective state and Federal agencies, many of these agencies have a non-regulatory environmental restoration mission and funding mechanisms to support the CRP. Having appointed representatives on the RWG provides added benefit by providing technical expertise on the state of the science, regulatory expertise needed to permit certain restoration activities, and awareness of restrictions that may be hindering restoration activities, as well as funds allocated to advance projects. For example, USACE has mechanisms to utilize Federal funding and has an established history of conducting large-scale habitat restoration projects in the HRE and throughout the country. Alternative funding for a bi-state management effort would require complex political action for implementation. NYCDPR and its NRG division are important partners in the HRE study area. NRG is the steward of 12,000 acres (48.57 kilometers^2) of natural areas within NYC's park system across the five boroughs and implements many stewardship, preservation, and restoration programs.

Hudson River Foundation (HRF)

HRF was established in 1981 under the terms of an agreement among environmental groups, government regulatory agencies, and utility companies seeking resolution of a series of legal controversies concerning the environmental impacts of power plants on the Hudson River. HRF's mission is to make science-based decisions that support the stewardship of the Hudson River and its watershed. HRF has been sponsoring ecological research focused on the Hudson River and HRE study area and providing technical information for all segments of the environmental community. Under HEP's direction, HRF has coordinated major environmental investigations such as the CARP, and the development of the TECs (in coordination with the Center for the Environment at Cornell University funded by USACE and PANYNJ from the HRE Ecosystem Restoration Feasibility Study) as a science-based method for identifying the ecological objectives of the CRP. HRF had brought together technical teams to help refine the TECs. These teams represented diverse expertise that provided guidance in achieving each of the TECs and will continue to participate with technical aspects of restoration as well as administering grant funding in the HRE study area. In 2013, USEPA selected the HRF as the new host for HEP. As the new host, HRF has assumed a leadership role within HEP and will continue a long history of collaboration with HEP and its many partners on numerous programs to support stewardship of the Harbor Estuary and improve the scientific understanding of issues that directly impact management decisions and policies.

Other Stakeholders

Various local organizations are active in many aspects of environmental protection and restoration in the HRE study area. These groups may represent local areas and issues, lobby and petition for regulatory change, acquire and manage areas with important ecological values, and actively undertake restoration efforts. These groups have diverse objectives and are comprised of individuals with different experiences, needs, values, and beliefs, but collectively have an interest in improving environmental conditions.

The Waterfront Alliance is an umbrella organization representing more than 900 entities and has become a focal point for many stakeholder groups in the HRE study area. The organization represents all facets of interest in the waterfront, with particular attention paid to waterfront development and opening the waterfront for public access and recreational use of the water. In order to integrate restoration, public access, resiliency, and environmental sustainability within the planning and development of NY and NJ's waterfront and coastal shorelines, the Waterfront Alliance's involvement in CRP management will be critical. The Waterfront Alliance's efforts on the WEDG program is an example of this important integration (WA 2015).

The New York-New Jersey Harbor Coalition is a campaign of local and national advocacy organizations focused on improving the New York-New Jersey Harbor. The coalition works to raise awareness and public support for the harbor and to advocate

Figure 5-1. Katerli Bounds and Leila Mougoui of New York City Parks paddle through the Arthur Kill to Pralls Island to restore heron nesting habitat. Photo Credit: Gabriela Munoz

for the adoption of legislation and policies in Federal, state, and local agencies to secure funds for programs that enhance and improve the harbor.

The NY/NJ Baykeeper, established in 1990, conducts many important habitat restoration and preservation projects and represents environmental concerns of those residing in the HRE. The Baykeeper, which is also an active member of HEP's committees, has been a prominent figure in many pollution prevention and habitat restoration projects. Many of these projects would not be as successful without the support from the hundreds of devoted NY/NJ Baykeeper volunteers. They conduct many of the HRE study area's oyster gardening and restoration programs and, as members of the RWG, are important players in developing and reviewing the CRP.

The Natural Areas Conservancy works with NYCDPR's NRG, through a private-public partnership, to bring additional resources for natural areas throughout the city, and collaborates with additional partners to expand the impact of research and conservation to support sound natural resource management decision-making. For example, NAC funded the development of a Coastal Restoration Opportunities Inventory that serves as a resource to inform planning and implementation of coastal restoration in the City.

The ALS, established in 1961, restores habitats important to the coast in the northeast from Jamaica Bay south to Delaware Bay and in the southeast in Sarasota Bay. The ALS works with community stewards and public agencies to implement hands-on, community-based projects.

NYC Audubon Society is the lead organization for the Harbor Herons Project and protecting the uninhabited islands of NYC. They have provided valuable information about the species and habitats discussed in the ***Habitat for Waterbirds*** TEC, and should play a role in the ***Coastal and Maritime Forests*** TECs.

The National Parks Conservation Association is a national non-profit organization committed to protecting the country's national parks. The northeast regional office, located in NYC, has taken a prominent role in improving parks in the HRE study area, including those within the Gateway National Recreation Area (i.e., Sandy Hook, Jamaica Bay). The National Parks Conservation Association will continue their role in refining the TECs and assist in their implementation.

Dozens of community-based organizations take an active role in environmental outreach, environmental improvement, and stewardship within the HRE study area. These organizations represent a collective voice of the local communities, and it is important they support the restoration agenda of the CRP. These organizations include the Bronx River Alliance, Friends of Liberty State Park, Lower Passaic Watershed Alliance, Passaic River Coalition, Riverkeeper, Rockaway Waterfront Alliance, the River Project, and the Waterkeeper Alliance, among others.

Several universities and colleges have played large roles in the development and refinement of the TECs and may continue their high levels of involvement by monitoring individual projects or evaluating progress of the TECs. For instance, the Center for the Environment at Cornell University and the HRF helped develop and write the TECs and coordinated workshops to gather local input and acceptance (Bain et al. 2007). Many academic institutions have participated in the TEC development process: Cornell University, Rutgers University, Virginia Institute of Marine Science, City University of New York (Manhattan College, Brooklyn College, Queens College, Hunter College), and State University of New York (College of Environmental Science and Forestry, Stony Brook University), among others. More recently, the Consortium of the Science and Resilience Institute at Jamaica Bay, comprised of several academic institutions, is advancing the state of the science in resiliency in Jamaica Bay that may be applied throughout the HRE.

5.1.2 Plan Management Mechanisms

The many environmental agencies and groups referenced in this report provide a diverse and complex set of management skills and options to implement the CRP. To be effective, agency personnel must be organized in a way that takes advantage of their respective skills and builds on their interests, authorities, mandates, expertise, and availability. The management framework of the involved agencies must have mechanisms built around the major roles (i.e., tracking progress, approving restoration opportunities, advancing science, streamlining policy, identifying financial strategies, and public involvement) of the CRP that can operate with long-term continuity. The management framework must accommodate change over time, as the CRP is intended to be a "living document" that will continue to evolve as it is periodically reviewed and additional information is collected from its implementation.

For the management strategy to be successful, it should be implemented by the existing program management team (e.g., RWG), with roles and responsibilities of each team member clearly defined. The management team must work together to ensure that the CRP will continue to address changes in technical knowledge, funding sources, and regulatory climate. CRP management must also have a mechanism to track progress in meeting program goals and to document lessons learned during implementation.

HEP's RWG provides an organization that can work together to ensure projects identified in the CRP are implemented in a coordinated manner and track progress. The HEP has directly addressed objectives of the CCMP and now also addresses the specific restoration objectives represented by the TECs. Regulatory agencies, while dealing with aquatic resource management for many decades, have recently recognized the need for mechanisms to approve permit applications specific to the CRP objectives or to proactively integrate TECs into permit applications. Most stakeholder groups have limited staff or are staffed by volunteers and do not typically address harbor-wide restoration efforts. Permanent staff associated with larger organizations in the RWG are best equipped to manage CRP implementation and could give the CRP permanence and prominence by managing aquatic and terrestrial resources in the HRE study area. Achieving the CRP's objectives could bring profound changes to the ecology of the estuary; change of this magnitude cannot be attained and managed without a dedicated staff.

Federal funding, with local partnering, is supporting ongoing restoration work in the HRE study area. This mechanism is expected to be a major source of funding for future large-scale restoration projects. In the future, some project sponsors may obtain funding independently, but others may need alternative funds to implement their projects. CRP management must provide guidance on funding opportunities to potential project sponsors and will need to emphasize the critical need to fund projects on an ongoing basis. The RWG has committed to developing and managing an annual budget that will be used to competitively award grants and contracts.

A significant advantage of HEP and the RWG for leadership in CRP management is their well-established history of coordinating stakeholders and gaining public support. HEP's former HWG is the foundation of the CRP; the CRP furthers the goals of establishing and maintaining a healthy ecosystem with full beneficial uses, as defined in HEP's CCMP. The HEP has identified restoration sites and provided funding for the acquisition of sites for protection and restoration. Many programs and work groups in HEP have already played and will continue to play major roles in furthering the restoration agenda of the CRP.

The HEP RWG, comprised of senior staff from Federal, state, bi-state, and municipal agencies and non-profit organizations, has membership with specific expertise in the HRE study area and a willingness to spend time and effort reviewing documents and addressing critical issues. RWG bylaws lend additional transparency to this organization. These bylaws include membership roles and responsibilities, and affirm that they are active participants in CRP management and are to comment on the program and disseminate information to their agencies and organizations. The RWG was integral in the evolution of the CRP, and members will be tasked with helping identify new acquisition and restoration sites, successes and lessons learned, and potential regulatory hurdles; develop strategies to prioritize acquisition and restoration sites; and periodically re-evaluate the appropriateness of the program goals. The RWG will help guide the management of the CRP going into the future and will be integrated into the adaptive management strategy for the CRP.

5.1.3 Tracking Performance at the Estuary-Scale

The TECs provide a means to measure existing and future environmental conditions in the HRE study area. Tracking TEC performance and maintaining an accurate, comprehensive database of project sites and estuary-wide changes should be a priority of the CRP management team. However, collecting and tracking project specific data depends on restoration practitioners voluntarily providing information and project updates to a central location. To ensure that information is collected, the management team also needs to actively seek and retrieve information.

To effectively track and provide environmental data, the RWG should solicit, summarize, and make information from restoration practitioners available to the broader community. HEP's annual report process can be modified to track CRP progress. HEP currently gathers and compiles information from regional organizations involved in restoration or acquisition, producing a yearly update that tracks progress toward achieving program goals compared to the prior year. As the HEP collects annual information for the National Estuary Program Online Reporting Tool (NEPORT), reporting progress toward CRP goals will join this annual cycle. The RWG anticipates the annual reporting cycle will include annual requests for information, compilation of site lists with acreages, fact-checking, and wide distribution of the annual report. The acreages will be categorized by near-term (2020) and long-term objectives (2050). When possible, TECs will be tracked quantitatively. For example, ***Wetlands***, ***Coastal and Maritime Forests*** and ***Oyster Reefs*** will be tracked in acres created/restored per year, while TECs like ***Habitat for Waterbirds***, ***Enclosed and Confined Waters***, ***Public Access***, and ***Acquisition*** will be tracked in number of sites established or enhanced per year. Details of sites per planning region for each TEC will also be reported. Other projects to be tracked include mitigation banks, mitigation projects, and acquisition sites.

Similar to all CRP sites within the database, additional information for each project would include (if available):

- Project location and, if possible, a mapped perimeter with GPS coordinates;
- TECs and restoration actions proposed or implemented;
- Total project cost;
- Assessing functions and values provided over pre-restoration conditions;
- Status updates: Planning/Feasibility, Construction, Post-Construction Monitoring, Construction Completed, and Acquisition Completed. Projects will not be counted toward the TEC objective until construction is completed; and
- Project Sponsors.

Ideally, restoration practitioners would also be able to provide photographs, data, graphics, or any reports generated from the construction or monitoring phases. Guidelines may be established to standardize the data collection and reporting process to facilitate comparability among different programs and their many datasets. These reports would be highly valuable to those interested in conducting restoration and seeking guidance. This type of documentation would also help the CRP management team determine project success and assess functional performance of the TECs, thus assisting in planning further restoration efforts.

Regular reporting of acreages restored per TEC by planning region, as well as a cumulative total per TEC for the HRE study area, will help maintain interest in the program and track success in meeting its short and long-term goals. The reporting process will be designed to be easily reviewed and understood by the public. Regular reports will help determine if current actions and resources are sufficient and how the HRE study area is contributing to national restoration efforts.

Data from the environmental monitoring programs should be summarized periodically in "Health of the Harbor" reports for the estuary, similar to the ones published in 2004 and in 2012. Generating reports helps to identify data gaps and information needs. Currently, determining trends in environmental health in the HRE study area is difficult or impossible for some categories, most of which correspond to a TEC, because detailed information is incomplete. Future monitoring programs may help to fill these gaps, especially if government or stakeholder programs are initiated on an estuary-wide scale and data collection methods are kept consistent throughout the program.

The OASIS database will be an end-point for placing any new or updated restoration and acquisition information, and will be expanded to more completely include the data for coastal New Jersey counties in the HRE study area and for Westchester County, New York.

As described above, programmatic monitoring will address planning region and estuary-wide trends, evaluating whether TEC target statements and objectives are being met, and determining what steps should be taken to achieve them. Programmatic monitoring can also include communicating work group and committee activities, outreach activities completed, research and restoration milestones, the amount of committee funding spent, and changes in public awareness and perception of the program (USEPA 2005). It may be beneficial to monitor whether partners follow through on their commitments and what might be preventing them from doing so (USEPA 2005).

General recommendations to consider during plan implementation include:

- Build upon existing monitoring efforts, and use the HEP RWG and possibly other HEP work groups or organizations as a coordinating body to fill data gaps;
- Adopt monitoring protocols to provide a consistent means for comparing information across geographical and temporal scales; and
- Continue efforts to develop an estuarine-wide database from which to share data.

5.1.4 Adaptive Management

Adaptive management, based on the approach of "learning by doing" (Walters and Holling 1990), has been an important planning and assessment tool in ecosystem restoration. Adaptive management is critical to success in a developing science that depends on many factors that may be unpredictable. 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. When the goals or performance criteria are not met, corrective actions based on the monitoring should be implemented. Other actions include doing nothing or modifying the goal to a different but equally acceptable state. The final component of an adaptive management program involves incorporating successful techniques and lessons learned into successive projects within the same program or geographic range. Adaptive management recognizes and prepares for uncertain outcomes and, if established early in the planning phase and correctly implemented through the assessment phase, adaptive management can be a valuable tool for efficiently improving program performance.

Adaptive management can also help reduce potential adverse effects of restoration. Adverse effects may be present because restoration involves the alteration or enhancement of existing habitats in the effort to restore or enhance selected species and habitat types. Although existing habitats may be degraded, they do support some level of aquatic life production. Adaptive management can be used to reduce adverse effects of implementing selected restoration actions through refinement of restoration techniques and increasing the knowledge applied to selecting acquisition and restoration sites.

All facets of the CRP and TEC implementation can be adaptively managed. Each restoration project implemented as part of the CRP should incorporate a monitoring element sufficient to support adaptive management options. This approach will ensure the highest probability of success and verify that sites have been set on a trajectory to meet the project's goals. By employing these corrective measures at future acquisition and restoration sites throughout the estuary, the likelihood of success will be improved (compared to no action) and lessons learned can be used to improve success of the next project, thereby bringing the HRE study area closer to its restoration goal more quickly and efficiently.

5.2 Implementation

5.2.1 Potential Funding Opportunities

Meeting the restoration targets described in Chapters 3 and 4 depends upon planning, constructing, and monitoring many restoration projects. These efforts will have substantial costs. Economies of scale will benefit from larger, coordinated efforts where the average unit cost decreases as the project size increases or where cumulative benefits from adjacent areas add to the overall restoration value. Volunteers can also help reduce costs, typically through assistance with planting and monitoring. For example, the ALS regularly engages hundreds of volunteers in habitat restoration activities, such as removing debris from smothered marshes, planting native dune plants, removing invasive plants, and bagging shell for oyster reef restoration. In June 2013, the ALS, EcoWatchers, and the Jamaica Bay Guardian mobilized volunteers and planted 30 acres (0.13 kilometers^2) of wetlands at the Black Wall and Rulers Bar Marsh Islands within Jamaica Bay.

For projects that depend upon Federal or state funding mechanisms, it should be recognized that Congress and State Legislatures' funding decisions are made over a period of months or years following plan adoption. The recommendations made in this plan have been crafted to recognize these limitations.

Even when restoration practitioners efficiently and resourcefully plan their projects, the thousands of acres of upland, intertidal, and subtidal habitat necessary to meet the short- and long-term TEC goals will require a large investment (Table 5-1). For example, the cost to meet the short-term objective for the ***Wetlands*** TEC (i.e., creation and restoration of 1,000 acres [4.05 kilometers^2] by 2020) is estimated at between $218 and $713 million. Meeting the long-term objective (i.e., creation of 5,000 acres [20.24 kilometers^2] by 2050) is estimated to cost $1.0 to $3.5 billion. Considering that these are only the costs associated with one of the twelve TECs, funding to implement all TECs will be difficult to secure over the timeframes identified. It is therefore important to take great care to ensure these projects are in the best interest of the local community. Investing in natural resources brings major returns to the region as ecosystem services, by promoting the region's culture, and by benefiting local economies.

Table 5-1. Observed high, median, and low costs of conducting restoration of selected TECs.

TEC	Unit of restoration	Low observed ($/unit)	Median observed ($/unit)	High observed ($/unit)	# of data sets used	Data sources and references
Coastal Wetlands	Acre of wetlands restored	$218,587	$292,000	$713,569	6	USACE, New York District cost estimates for Brooklyn Union Gas, Staten Island, NY; Elders Point East and Yellow Bar Hassock, Jamaica Bay, NY; Medwick Park Restoration, NJ; Woodbridge Creek Restoration & Mitigation (+ Option), NJ
	Cubic yard of material excavated or filled	$49	$53	$144		
Oyster Reefs	Acre of habitat restored	$51,457	$52,478	$109,776	3	USACE, Baltimore District cost estimate for Cheapeake Bay Oyster Restoration, MD, and USACE, Norfolk District cost estimates for the Great Wicomico and Lynnhaven rivers oyster restoration projects, VA.
	Cubic yard of shell placed for habitat[1]	$30	$65	$75		
Eelgrass	Acre of habitat restored[2]	$1,080	$16,600	$170,083	8	Shafer, D., & Bergstrom, P. (USACE-ERDC & NOAA Chesapeake Bay Office, 2007). Large-Scale Submerged Aquatic Vegetation Restoration in Chesapeake Bay: Status Report, 2003-2006.
Habitat for Fish, Crabs & Lobsters	Cubic yard of rock placed for habitat	$38	N/A	$621	2	(1) USACE, New York District cost estimate for proposed lobster habitat restoration, New York Harbor. (2) Massachusetts Division of Marine Fisheries, cost estimate for hard-bottom habitat mitigation project, Boston Harbor, MA.
Tributary Connections[3]	Dam removal: square feet of dam removed	$32	$180	$378	8	University of Rhode Island, The Costs for Environmental Restoration Projects. Retreived from: http://www.edc.uri.edu/restoration/html/tech_sci/socio/costs.htm
	Fish ladders: river miles accessible	$7,069	$26,772	$280,900	7	
Enclosed & Confined Waters	Cubic yard of material excavated or filled[4]	$17	$43	$61	3	USACE, New York District cost estimates for Norton Basin, Fresh Creek and Paerdegat basins, Jamaica Bay, NY.
Sediment Contamination	Cubic yard of sediment excavated[5]	$184	$296	$1,003	12	Lower Passaic River, NJ Draft Focused Feasibility Study. (2007) Appendix J, Cost Estimates. Retrieved from http://www.ourpassaic.org

Notes: Actual construction costs are escalated to January 2008 price levels and adjusted for New York City locality. Construction management costs are included and determined by NY District USACE methodology. Management costs are a function of total construction cost. Engineering and design costs were approximated at 2% of total construction cost. Where applicable, monitoring costs are assumed based on complexity and frequency and generally for a period of five years. Contingency costs were estimated at approximately 20% for projects not yet constructed (assumed contingencies were included for constructed projects).

1 Lower unit costs based on shell material provided by state-owned (Virginia) fossil shell bed, including transportation to restoration site.

2 Lower unit costs based on passive seed dispersal methods; higher unit costs based on intensive hand-planting by divers, including storage of plant material and monitoring. All costs normalized to a common 8.4% survival rate.

3 Costs for dam removals dependent on construction materials of dam, debris removal, complexity of disassembly. Costs for fish ladders dependent on type of ladder installed, height, complexity of installation.

4 Costs based on net volume of material cut and filled.

5 Includes costs for excavation and placement.

Table 5-2. U.S. Army Corps of Engineers Restoration Authorities in the Hudson-Raritan Estuary study area.

Type	Authority	Program/Authority Description	Funding Opportunities
Environmental Restoration	Section 306 of the Water Resources Development Act (WRDA) 1990	Environmental Restoration was added as one of USACE's primary missions.	
	Estuary Restoration Act of 2000	Promote restoration of estuary habitat; develop a national Estuary Habitat Restoration Strategy; provide Federal assistance for and promote efficient financing of estuary habitat restoration; and develop and enhance monitoring, data sharing, and research capabilities.	
	Section 1135, WRDA 1986 and Water Resource Reform and Development Act (WRRDA) 2014	Continuing authority to modify USACE structures and operations built or to perform restoration at other locations affected by construction or operation of USACE projects.	Program authorization cap $35 million; with up to $10 million allowed as Federal share. Cost shared: 75/25 (Federal/ sponsor).
	Section 206, WRDA 1996	USACE carries out ecosystem restoration and protection projects if the project will improve environmental quality, is in public interest, and cost effective.	Federal limit: $5 million. Cost shared: 65/35 (Federal/ sponsor).
	Individual Project Authorizations	Project-specific authorizations to address aquatic ecosystem restoration.	Feasibility studies cost shared: 50/50 Construction cost shared: 65/35 (Federal/sponsor).
Beneficial Use of Dredged Material to Restore Aquatic Ecosystems	Section 204 of the WRDA 1992, as amended, and Section 207 of WRDA 1996	Continuing authority that allows the USACE to carry out ecosystem restoration and protection projects in connection with new or maintenance dredging of Federal projects.	Study and construction cost shared: 75/25 (Federal/sponsor).
	Federal Standard	State under Coastal Zone Management or CWA recommends use of the dredged material for a state beneficial use.	
Environmental Dredging	Section 312 of WRDA 1990	Provides authority for the USACE to participate in the removal of contaminated sediments (a) outside of the boundaries of and adjacent to Federal navigation projects as part of operations and maintenance, and (b) for the purposes of ecosystem restoration, not related to operations and maintenance of navigation channels. This authority requires coordination with USEPA.	The cost-sharing formula for this authority is condition-specific.
Regulatory Programs		Protection of aquatic ecosystems under avoidance, minimization, and mitigation; use of special area and general permits to encourage environmental preferred activities.	Opportunity for multi-agency and public resource management.
Aquatic Plant Control	Section 104 of the Rivers & Harbors Act of 1958, Section 103 of WRDA 1986, Section 225 of WRDA 1996, Section 540 of WRDA 1996	USACE may cooperate with non-Federal agencies for authorized plant control on navigable waters not under jurisdiction of USACE or other Federal agencies.	Cost shared: 50/50.
Planning Assistance to the States	Section 22 of WRDA 1974, Section 605 (Public Law 96-597), Section 221 of WRDA 1996	General authority to cooperate with states providing technical assistance.	Cost shared: 50/50; not more than $500,000 to any one state per year.

Finance planning is time-consuming but necessary for long-term success and progress toward the CRP's goal and restoration targets. Securing funds to support program operations and implement restoration programs represents a challenge, but one that may be facilitated by the CRP as it provides for the first time a common restoration agenda that the region can collectively support. It is important to establish base funding sources to support ongoing programmatic components (e.g., newsletters, website, and data management, tracking progress) and to later enhance and expand the program by increasing the base funding. Moreover, funding to implement the CRP should not interfere or conflict with existing restoration efforts by drawing money away from successful programs. Instead, a complementary finance plan should be developed to identify and evaluate:

- Funding sources for managing and implementing restoration in the HRE study area;
- How these mechanisms will be executed; and
- During what time period implementation should occur (USEPA 2005).

A variety of Federal, state, local, and private funding opportunities should be evaluated when developing the finance plan. For many endeavors, it may be beneficial to develop strategic partnerships with other organizations, whether formal or informal. Examples of these partnerships include the Long Island Sound Habitat Restoration Initiative, HEP, and the Urban Waters Federal Partnerships on the Lower Passaic, Bronx, and Harlem Rivers, which include a combination of Federal, state, and local partners. Developing cost-sharing agreements and partnerships can result in larger programs that benefit from economies of scale. Several funding opportunities that may be used for habitat restoration in the HRE study area are described below.

5.2.1.1 U.S. Army Corps of Engineers Programs

There are partnering opportunities with the USACE to restore habitats through the Continuing Authorities Program (CAP), General Investigation (GI) studies, and Construction General (CG) funds. These programs require a cost-share agreement between the USACE and the non-Federal sponsor. The non-Federal share can be contributed with matching funds or as in-kind products or services (Table 5-2).

Continuing Authorities Program and General Investigation Studies

- Under the CAP, small-scale ecosystem restoration projects can be conducted under several standing authorities, including the beneficial use of dredged material (Sections 204 of WRDA 1992 and 207 of WRDA 1996), environmental restoration (Sections 206 of WRDA 1996 and 1135 of WRDA 1986), and estuary habitat restoration (Sections 102-110 of the Estuary Restoration Act of 2000). These projects are undertaken by the USACE at the request of local partners, such as state agencies, county governments, and municipalities. CAP projects are cost-shared between the Federal government and a non-Federal sponsor, and are generally funded with 65 percent to 75 percent Federal funds.
- GI studies are the common way for the USACE to help a community solve a complex or large-scale water resource problem such as habitat restoration within a large system. Specific Congressional authorization and appropriations are necessary, such as the HRE Ecosystem Restoration Study resolution and appropriations under which this report was developed. The costs for those feasibility studies are evenly shared between the Federal and non-

Federal partners, while project implementation is typically funded with 65 percent Federal funds. Recommendations stemming from the feasibility studies must then be approved by Congress and funded for construction via CG accounts.

Both CAP and GI studies require formal requests for assistance from a non-Federal project sponsor. All potential non-Federal partners must be able to provide any required lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas. Depending on the program and type of project, a non-Federal partner can be:

- A legally constituted public body with full authority and capability to perform the terms of its agreement;
- A national non-profit organization that is capable of undertaking future requirements for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R); or
- Any non-profit organization if there is no future requirement for OMRR&R.

Construction General Funds

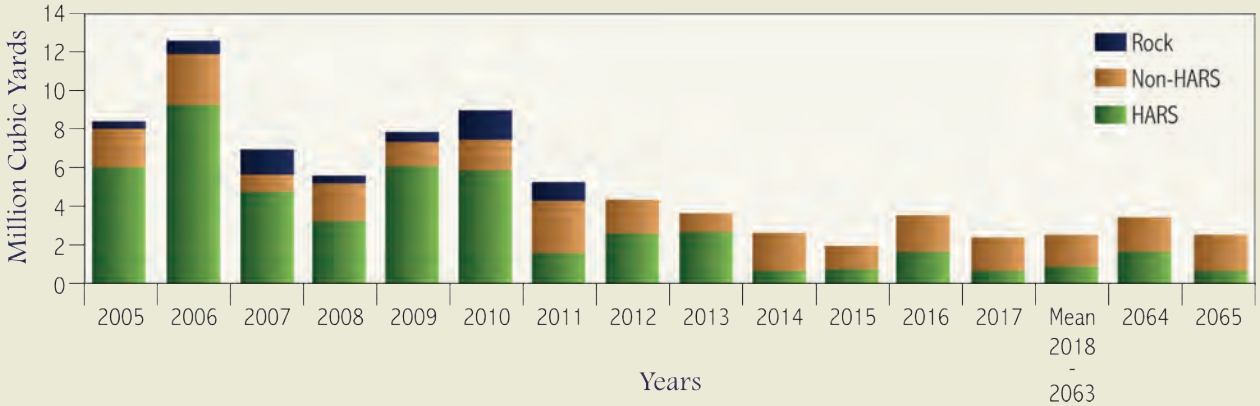
Demonstration projects are eligible for funding through USACE's Engineer Research and Development Center (formerly, the Waterways Experiment Station) in Vicksburg, Mississippi. The Center annually issues requests for proposals for research and demonstration projects, with a funding limit of approximately $200,000, which approximates the estimated construction cost. In addition, smaller projects can be nominated to an interagency committee for funding under the National Estuary Restoration Act, implemented by USACE and NOAA, such as the creation of wetlands, oysters and seagrass beds within Cedar Beach Creek in Suffolk County with the Cornell Extension Station as grantee and Suffolk County Parks as landowner.

Beneficial use of dredged material for habitat restoration, a primary goal of the USACE Dredged Material Management Plan (USACE 2008b), is another potential strategy to decrease overall project costs. Large-scale projects in the HRE study area use dredged material for a number of projects that contribute to the TECS, such as offshore reefs, capping contaminated sediments and restoring coastal *Wetland* habitat (e.g., the Lincoln Park West Wetland Restoration Project in Jersey City, New Jersey), and restoring vanishing marsh islands (e.g., Jamaica Bay Marsh Islands), as well as recreation and beach nourishment, and remediation (USACE 2008a). Diverting uses of dredged materials to restore habitat is a valuable, cost-effective method that can also reduce the need for mining virgin materials to complete these restoration projects.

The NY/NJ Harbor Deepening Project presented a well-timed, ample supply of dredged material for beneficial use around the estuary (USACE 2008b), placing more than 60,000,000 CY of dredged material in the region. Managing future dredged material during the operations and maintenance (O&M) of the 50-foot (15-meter) channels will be a challenge. Several considerations and challenges in the beneficial use of O&M dredged material include the need to assess demand, relative benefits, timing of availability, ability for the local sponsor to pay 100 percent of any increased differential costs, synchronizing the need and placement of sites with O&M projects, developing suitable plans, and specification and negotiations of contributed funds agreements with sponsors. Although most aquatic restoration projects require relatively little material, recontouring subaqueous borrow pits, creating upland habitat, creating artificial reefs, and restoring wetland islands present opportunities in the estuary to use large amounts of clean dredged material and rock for restoration.

DREDGED MATERIAL MANAGEMENT PLAN (2005 – 2065)

DATA SOURCE: USACE 2008B



The Dredged Material Management Plan for the Port of New York and New Jersey forecasts future dredged material volumes and management options over a 60-year planning horizon. An estimated total of 195 million cubic yards (MCY) of material will be dredged from the HRE study area between 2005 and 2065, which includes both maintenance dredging and the authorized harbor deepening.

In the HRE study area, dredged material is categorized as either suitable or unsuitable for placement at the Historic Area Remediation Sites (HARS). The HARS, a past ocean disposal site for dredged material and refuse, is located in the NY Bight outside of the HRE study area. Only suitable, tested cap material (estimated to be a total of 89 MCY) can be used in the remediation of the HARS. Since 1997, a total of 112 Federal navigation and Federally permitted dredging projects have been placed at the HARS, representing approximately 71.9 MCY of Remediation Material. All other material unsuitable for HARS will be managed in the future: Non-HARS estimated at 101 MCY; rock estimated at 5 MCY. Beneficial use of dredged materials is a priority within the region. HARS, non-HARS material, and rock can all be used beneficially for habitat restoration, nourishment, land remediation, and decontamination technologies.

The restoration of upland habitat presents another opportunity to use dredged material for restoration and improving the resiliency of the estuary's coastline. The coordination of restoration projects and O&M dredging projects will present a challenge for the beneficial use of dredged material. During the duration of the Harbor Deepening Project, the quantity and types of material varied; however, through timely, coordinated planning, restoration programs benefitted from reusing dredged materials.

In addition to ongoing authorities, the intent of the HRE Ecosystem Restoration Feasibility Study is to obtain authorization and appropriations for projects that will be recommended for near-term construction. Funding is hopeful for the subset of sites that will be recommended in the USACE Chief's Report, and there are opportunities to advance "Spin-Off" Feasibility Studies in the future as "New Phases" of the program are developed.

5.2.1.2 Federal Grant Programs

Many Federal grant programs can assist with funding restoration. The following sections describe examples of these programs.

U.S. Environmental Protection Agency (USEPA)

USEPA has many grant programs that can aid in implementation of restoration:

- The NEP provides grants in support of habitat restoration projects. These grants are provided through the CWA and require a match commitment from a local sponsor;
- Wetlands Program Development Grants in support of developing new or refining existing comprehensive wetland protection, management, or restoration programs;
- Community Action for a Renewed Environment is a competitive grant program offering financial and technical assistance to communities to reduce pollution in their local environment;
- The Environmental Justice Small Grant Programs assists local organizations to identify and/or address environmental/public health issues in their community;
- The Environmental Education Grants Program supports environmental education projects that increase the public awareness about environmental issues and increase people's ability to make informed decisions that affect environmental quality;
- The Five Star Restoration Program brings together various stakeholder groups (e.g., students, citizen groups, corporations, landowners, government agencies) to provide environmental education and training through projects that restore wetlands and streams;
- The Clean Water State Revolving Fund assists states wanting to implement water quality protection projects for wastewater treatment, non-point source pollution control, and watershed and estuary management;
- Section 319 of the CWA provides grants to states with comprehensive watershed projects aimed at protecting or enhancing water quality from non-point source pollution. The Section 319 Nonpoint Source Management Program currently awards over $200 million annually to watersheds nationwide. While generally not applied to habitat restoration, they are instrumental in setting the stage for establishing the water criteria necessary for restoration project success; and
- The Targeted Watershed Grants Program encourages successful community-based approaches and management techniques to return real environmental results in improved and sustained water quality.

National Oceanic and Atmospheric Administration (NOAA)

NOAA is dedicated to improving and preserving coastal and riverine habitats throughout the nation. NOAA offers funding opportunities through several of their programs.

- The Community-based Restoration Program provides funding to local communities from NOAA-Fisheries. These grants require 1:1 matching funds or in-kind services on restoration projects. There are a few spin-offs of this program, where partnerships have been formed with the NEP and with the National Association of Counties. The

NEP/Community-based Restoration Partnership funds citizen-driven habitat restoration projects within watersheds of the NEPs.

- NOAA's National Sea Grant Program offers funding for marine and estuarine research programs. Sea Grant is NOAA's primary university-based program in support of coastal resource use and conservation. The New York Sea Grant, administered from the State University of New York, focuses on coastal-dependent businesses, fisheries, seafood products, coastal hazards and processes, coastal water quality, coastal habitats, and aquatic nuisance species. The New Jersey Sea Grant is managed by the New Jersey Marine Science Consortium. The program supports research, education, and information sharing to foster sustainable use of marine resources and provide solutions to coastal management and policy issues. Other NOAA programs include the Estuary Habitat Restoration Program, the Climate Program, and the Marine Debris Prevention and Removal Program.

U.S. Fish and Wildlife Service (USFWS)

The USFWS funds restoration and conservation under many separate programs, including:

- The National Coastal Wetlands Conservation Grants, which are available to state agencies;
- The Coastal Program provides incentives for voluntary species protection;
- The Partners for Fish and Wildlife Program assists private landowners with habitat improvement projects that benefit Federal Trust Species (e.g., migratory birds, inter-jurisdictional fish, threatened and endangered species);
- Restoration programs specific to enhancing marine or anadromous fisheries, including constructing artificial reefs, salt marshes, and freshwater habitats, can be funded through the 1988 USFWS Federal Aid in Sport Fish Restoration Act, 16 U.S.C. Sec. 777; and
- Further fisheries restoration support from the Wallop-Breaux Act amendments, in which an excise tax was extended to previously untaxed fishing equipment.

U.S. Department of Agriculture (USDA)

The U.S. Department of Agriculture-Natural Resources Conservation Service offers technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat through its Wildlife Habitat Incentives Program. These funds are available to private landowners, agencies, and non-government organizations.

5.2.1.3 State Programs

Both New York and New Jersey offer a funding mechanism to implement ecosystem restoration that can be used to advance the HRE goals.

New York

The NYSDEC offers a number of assistance programs to their municipalities and community-based organizations, including ecological restoration, brownfields restoration, and water quality improvement projects. Many of these programs are appropriated through the 1996 Clean Water/Clean Air Bond Act, which provides millions of dollars each year for qualified restoration programs in New York. Other New York grant programs were established through different means.

NYSDEC also manages the Hudson River Estuary Program, whose mission is to conserve the river's natural resources, promote full public use and enjoyment of the river, and clean up the pollution that affects our ability to use and enjoy it. The Estuary Program implements its Hudson River Estuary Action Agenda through numerous partners in government, the non-profit and business sectors, and concerned citizens (NYSDEC 2013), as well as the NYSDEC Habitat Restoration Plan (Miller 2013). In addition, NYSDEC and New York State Department of State (NYSDOS) are local sponsors for the recently resumed USACE Hudson River Restoration Feasibility Study. This study is also anticipated to result in new construction authorization and appropriations for restoration above the Tappan Zee Bridge to the Federal Troy Lock and Dam.

In fall 2001, Federal legislation established the State Wildlife Grants (SWG) program to provide funds from offshore oil and gas leasing to state wildlife agencies for conservation of fish and wildlife species and their associated habitats in greatest need of conservation. In New York, this program is implemented by NYSDEC's Division of Fish, Wildlife and Marine Resources with funding from "Teaming with Wildlife," a national organization dedicated to fish and wildlife conservation.

The SWG program is unique in that it provides funds for conservation of species not traditionally hunted or fished. Within the geographic extent of the HRE, there are 267 species of greatest conservation need eligible for funding through the New York SWG program.

New Jersey

The NJDEP maintains several grant and loan programs under the themes of environmental regulation, land use management, brownfields restoration, and natural and historic resources, among others. Through these programs, the state offers low-interest loans for dam restorations, assists municipalities in implementing Forestry Management Plans, and offers funds to develop and maintain trails and trail facilities.

New Jersey Department of Transportation/Office of Maritime Resources manages the National Boating Infrastructure Grant Program, funded by the DOI, USFWS, are distributed annually to states "to construct, renovate, and maintain tie-up facilities" for recreational vessels. With these funds, there are numerous opportunities to develop purposeful and objective projects to fulfill the program's mission and enhance New Jersey's ***Public Access*** facilities.

5.2.1.4 Sandy Recovery Funds

The emergency Federal funding allocated as part of the Hurricane Sandy Recovery effort will be shared among several Federal and state agencies to aid in current recovery and future flood protection projects. These projects include infrastructure repairs, upgrades, and maintenance; construction of coastal storm risk management projects; restoring and increasing resiliency of coastal communities; monitoring; and research. Many of the CRP sites outlined in this document can serve as NNBFs that should be integrated into ongoing and future Coastal Storm Risk Management projects. A detailed list of funding opportunities supporting coastal restoration efforts is in Chapter 2.

5.2.1.5 Natural Resource Damage Assessment

The Natural Resource Damage Assessment (NRDA) process pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) can also provide opportunities and funding for Federal and state agencies and private entities to implement ecosystem restoration projects. NOAA and USFWS have programs to provide funds for habitat restoration in areas that have experienced environmental degradation as a result of oil spills and other losses of ecological resources. These funds derive from litigation and financial settlement with the responsible parties, with oversight of a committee of trustees pursuant to CERCLA/Superfund. In New Jersey, the Natural Resource Restoration is administered by the Office of Natural Resource Restoration, which was established to ameliorate environmental injury caused by multiple oil spills and discharges. The Commissioner of the NJDEP is the designated "trustee" charged with administering and protecting the State's natural resources. In New York State, the Governor has designated the NYSDEC as the trustee for New York trust resources.

In addition to seeking funding from "natural resource damage" claims from natural resource trustees, it may also be possible to coordinate with PRPs of Superfund sites to identify habitat restoration actions. Implementation of potential restoration opportunities, restoring specific natural resource losses, could fulfill a PRP's liability with the Federal and state trustees. In all cases, projects should attempt to maximize the ecological value of the site and be designed to be self-maintaining. A recent example of a NRDA project that resulted in a net increase of habitat is the Lincoln Park West Wetland Restoration Project, which resulted in the creation of 32 acres (0.13 kilometers^2) of intertidal and coastal ***Wetland*** habitat.

5.2.1.6 Mitigation

For several TECs, it may be possible to obtain mitigation funding to support restoration projects. Agencies (e.g., USACE, PANYNJ, NJDOT, NYCDEP, and NYCEDC) and private entities are often required to mitigate for unavoidable project impacts. The USACE and USEPA 2008 Final Compensatory Mitigation Rule emphasizes that the process of selecting locations for compensation sites should be driven by a watershed approach and watershed needs identified within the analysis (USACE and USEPA 2008). Specific wetland creation, restoration, preservation, and protection projects should best address those needs. Mitigation actions could be selected based on recommendations within the CRP to ensure that the mitigation projects benefit the HRE watershed while also meeting mitigation requirements. Sites identified through the HEP nomination process could also be considered as mitigation sites.

The 2008 Mitigation Rule also indicates a preference for mitigation banking in order to fulfill a permitee's mitigation requirements. Mitigation banks are sites where a wetland has been created by a public or private entity and permit applicants purchase credits (corresponding to a specific wetland type and area) to offset project impacts. These banks are generally larger in scale than permittee-responsible mitigation projects and they provide large expanses of contiguous habitat. This provides greater certainty for long-term ecological success and eliminates the temporal loss of wetland habitat that can occur before a permittee-responsible mitigation site is constructed or achieves its performance standards. As discussed in Section 2.4, two mitigation banks were established in the Hackensack Meadowlands, along the Hackensack River within the Newark Bay, Hackensack River, Passaic River Planning Region in 2012. Additionally, NYCEDC has initiated planning for the Saw Mill Creek Wetland Bank under the Mitigation and Restoration Strategies for Habitat and Ecological Sustainability (MARSHES) initiative in the Arthur Kill/Kill Van Kull planning region. The restoration opportunities identified within the CRP could focus site selection for the creation of one or more additional wetland mitigation banks within the HRE. In addition to mitigation banks, in-lieu fee fund management and other fund management strategies should be among the options explored.

In the HRE study area, mitigation banks are uniquely positioned to provide programmatic benefits for the CRP. Mitigation banks offer opportunities for interagency collaboration during the project-planning phase; agencies work together to develop standardized functional assessment and sampling methodologies as well as standardized measures of restoration success. For example, the NYCEDC's proposed mitigation bank will be used as a platform to establish regional mitigation monitoring and success criteria in NYC through consensus-building with USACE-New York District, NYSDEC Region 2, and several city agencies, including NYCDPR. The standardized requirements will be designed to be realistic, without putting undue hardship on the project sponsor, and can serve as the blueprint for other TECs being implemented in the HRE study area.

While banks offer a relatively simple solution to the mitigation needs in the HRE, the market price for credits is steep and will continue to increase as credits become scarce. Project sponsors can reduce their mitigation needs by implementing the TECs and incorporating restoration measures and approved design and development guidelines in the planning, design, and pre-application phases of a project. For example, NYC's Waterfront Revitalization Plan (WRP), updated in 2016, provides opportunities to incorporate restoration into the planning and permitting framework of a project. To more effectively implement the city's waterfront planning goals, several policies were created, including policy four of the WRP, which is specific to the protection and restoration of ecological systems within the coastal area. Project sponsors can also benefit from adopting a new approach to design by utilizing tools such as the Waterfront Alliance's WEDG. WEDG provides a set of guidelines and an incentive-based ratings system intended for developing waterfront properties in a way that promotes ecological restoration, access, and resiliency. Additional information and examples of projects that proactively incorporate restoration in the early phases of project planning and design are discussed in Chapter 2.

5.2.1.7 Non-Profit Organizations

Coordination with non-profit organizations actively engaged in restoration/preservation activities may be another opportunity to raise funds for restoration. Non-profit organizations are ideally suited to receive contributions from the public and private sectors and disburse funds for research studies, environmental monitoring, and educational programs. It may also be possible to solicit non-profit organizations to identify actions they can implement that would correspond to their missions. In addition, several non-profit organizations have grant programs, including:

- HRF awards grants that focus on capital construction, development, and improvement, including public access facilities, habitat preservation/restoration, and educational facilities.
- American Rivers is a non-profit organization that funds many community-based environmental restoration programs ranging from restoring natural river function (including barrier removal projects), floodplains, and wetlands to establishing public access opportunities near rivers.
- NFWF has keystone initiatives that focus on bird conservation, fish conservation, marine and coastal conservation, and wildlife and habitat conservation. The NFWF also has many special grant programs that range from water

quality improvements to innovative conservation practice, in addition to the significant grant funding provided as part of the Hurricane Sandy Coastal Resiliency Competitive Grant Program, which supports projects that reduce communities' vulnerability to coastal storms, sea level rise, flooding, and erosion through strengthening natural ecosystems and benefitting fish and wildlife.

5.2.1.8 Additional Funding Sources

Private partnerships, such as Coastal America's Corporate Wetlands Partnership, provide another avenue for project funding. Through these partnerships, private companies help their communities make the required local match for Federal funds for community-based restoration projects. Other creative methods for funding implementation projects can occur through affinity credit cards, specialty license plate fees (e.g., Conserve Wildlife license plates), capital giving campaigns, or utility fees (USEPA 2005).

5.2.2 Policy Considerations for Implementation

As an organization, agency, municipality, or other group begins the process of conducting restoration within the HRE study area, there may be critical policy considerations that should be discussed with regulatory agencies to improve overall success and encourage consistency in operation. Some critical policy issues include:

- Habitat Exchange
- Placement of Fill (for creation of wetlands and shallow water habitat)
- Beneficial Use of Dredged Material
- Attractive Nuisances
- Oyster Reef Creation/Restoration
- Lobster Habitat Creation
- Sediment Contamination

Overarching Regulatory Issues

Currently, there are differences in the regulatory approach and policies among agencies with the statutory authority to regulate restoration activities. The CRP provides an opportunity to open a dialogue among these agencies. Limited funding and staff have been ongoing challenges for regulatory agencies as they attempt to accomplish their goals within mandated administrative procedures and project review times. Setting the administrative issues aside, there are broad policy issues that should be addressed.

The HRE is a highly urbanized environment with significant legacy impacts (e.g., chemical contaminants, sedimentation, and loss of habitat). The current regulatory framework is geared to protect existing resources and is likely to dominate management of the HRE's ecological resources in the future. However, as environmental restoration is incorporated into habitat management, goals for the protection of existing resources and the restoration of the ecosystem should converge. This convergence could be facilitated with policies that integrate environmental protection, ecosystem restoration, and economic development. Some proponents for restoration argue that restoration projects should have priority during regulatory actions and that policies should be changed to favor restoration. However, this action may require legislative action resulting in changes in New York and New Jersey state laws. One purpose of the CRP is to identify such issues and encourage dialogue among regulatory agencies and restoration practitioners in an effort to facilitate practical policy changes and developments.

Habitat Exchange

While there is no specific regulation stating that habitat exchange (creating one type of habitat in an area that is presently a functional habitat of another type) cannot be permitted, regulatory agencies interpret their rules regarding the placement of fill and/or dredging to encompass the habitat exchange issue. This generally occurs because some alteration of the physical environment, through either filling or dredging, has to take place in order to change the habitat type. NYSDEC, NJDEP, NYSDOS, and USACE all have jurisdiction in regulating these types of activities.

All of these policies and their supporting laws have implications when initiating a restoration effort that may involve exchanging one habitat type for another. This may be most prevalent in the case of the ***Wetland*** TEC, the ***Shorelines and Shallows*** TEC, and the ***Oyster*** TEC. Regulatory agencies tend to place preservation of existing aquatic habitat above its alteration, possibly due to uncertainty of success or the absence of an overriding comprehensive plan. Current regulations require alternatives analyses, studies or modeling of existing habitat quality or diversity, justification for the proposed exchange of habitats, and monitoring the success of the restoration effort if permitted. Mitigation for the impacts associated with habitat restoration can also be required. All of this is reasonable if the evaluations occur with an open mind and in the context of the larger restoration agenda. Cooperation with the regulatory agencies through the CRP should encourage an appreciation of the need for a diversity of habitat types and the desire to support potential actions that at first may appear to be undesirable changes. It is important to note that habitat distribution and vulnerability may change over time with sea level rise and events associated with climate change. In addition to improving habitat diversity, this bigger-picture approach should aid the restoration community in achieving the TEC goals identified in this CRP.

Placement of Fill

While there may be opportunities when fill placement would have a positive effect on the aquatic environment, many regulatory agencies routinely view this type of effort negatively. Fill placement activities can be involved in the creation of ***Wetlands*** (such as in the Jamaica Bay Marsh Islands), ***Shorelines and Shallows***, and ***Oyster Reefs*** (including Rebuild By Design's Living Breakwater off the coast of Staten Island), all of which advance the TECs and may serve as NNBFs by providing coastal storm risk management benefits. Another example of "fill" is the placement of new pile fields, such as those in the Hudson River at the Hudson River Park. This activity has the potential to create foraging habitat for fish, shield juvenile fish from predators, and provide habitat for sessile invertebrate species. NYSDEC, NJDEP, NYSDOS, and USACE have jurisdiction in regulating these types of activities. The applicants worked extensively with these agencies, along with the NOAA-Fisheries, to obtain the requisite permits. In a similar manner, an extensive interagency team worked with NYSDEC to permit the fill of shallow water/mudflat habitat to create marshes that were being lost at an accelerating rate. These examples suggest a growing trend or at least willingness to examine this important issue on individual merit.

Placement of dredged material has become a policy issue over the years. According to the 2008 Dredged Material Management Plan, the beneficial use of dredged material is a priority for the NY/NJ Regional Dredging Team. Policy issues for using dredged materials are similar to those raised for the placement of fill and are regulated by NYSDEC, NJDEP, NYSDOS, and USACE. While there have been opportunities to use dredged material for restoration projects (e.g., Jamaica Bay Marsh Islands) and projects that provide coastal storm risk management (e.g., Plumb Beach), use of the material is limited based on the specific policies of the agencies involved.

Attractive Nuisances

An attractive nuisance is something that causes, or is perceived to cause, an unintended problem. Attractive nuisance problems pose human health or ecological health risk due to exposure to unacceptable levels of contaminants or pathogens. An attractive nuisance (e.g., area, habitat, or feature) has, or has the potential to have, waste or contaminants on site that are harmful to plants or animals. Therefore, an attractive nuisance can potentially cause harm to wildlife and subsequently humans, if an exposure pathway exists from contaminants or pathogens on site that could directly harm wildlife or could then travel up the food chain. Several types of attractive nuisances affect the HRE throughout its regions. These nuisances present themselves within restoration opportunities such as ***Wetland*** restoration and creation, creation of shellfish habitat including ***Oyster Reefs***, and creation of habitat for wildlife such as ***Habitat for Waterbirds*** and ***Fish, Crab, and Lobster Habitat***.

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, creation of both ***Oyster Reefs*** and artificial reefs for lobsters (i.e., ***Fish, Crab, and Lobster Habitat***) has regulatory implications, as oyster 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 restoration in New Jersey is currently permitted only in closed waters with continuous security to prevent poaching (e.g., NY/NJ Baykeeper's reef at Naval Weapons Station Earle). There are concerns about the potential for economic repercussions that 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 NJDEP to adopt new Shellfish Rules to provide improved and expanded research and restoration opportunities by September 2016. Other potential policy issues stemming from creation of reefs would be considered under both the habitat exchange and placement of fill sections. The NYSDEC, NJDEP, NYSDOS, and USACE have jurisdiction in regulating these types of activities. Blanket restrictions on oyster reef restoration will prevent implementation of the ***Oyster Reefs*** TEC and achieving the agreed upon TEC goals. The CRP and its comprehensive evaluation of habitat will encourage future dialogue on this issue to encourage integration of safety and economic needs and not oppose any TEC goal.

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 (eight-kilometer)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, like 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 (eight-kilometer) 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.

Sediment Contamination

Sediment contaminant activities are also regulated by USEPA, NYSDEC, NJDEP, NYSDOS, and USACE. While removing or capping contaminated sediments is an important part of HRE restoration, there is no definition of how clean the sediments must be for the restoration to be considered successful. Due to the urban nature of the HRE, it is unlikely that the entire estuary would be cleaned up to acceptable risk guidance benchmarks. These benchmarks are defined by the USEPA and other regulatory agencies as levels of contaminants that are known to cause harmful effects in plants or animals. Restoration implementation in the HRE requires that agencies discuss the concept of "acceptable" for this urban estuary. While policy makers and restoration practitioners realize that it is impossible to remove all contaminated sediments from the HRE study area, the level of residual contamination in acquisition and restoration sites or the recontamination of the sites due to surrounding sediment and water quality needs to be addressed.

There are many policy issues that should be considered when planning a restoration project. The appropriate regulatory agency should be consulted early in the planning process in order to resolve issues and work toward a mutually agreeable restoration plan. More importantly, the resolution of these policy considerations is critical to implement the CRP and achieve the consensus restoration goals set forth by the regional stakeholders.

5.2.3 Public Involvement and Support

The public has been an important proponent and source of support for an aquatic resources restoration agenda for the HRE study area. To maintain their interests and "hands-on" involvement, any public involvement program should (1) make the public's desires, needs, and concerns known to decision-makers and incorporate them into the CRP; (2) provide a forum for consultation prior to reaching planning decisions; (3) inform the public about proposed restoration activities (especially on a site specific basis); and (4) consider the public's views in restoration plans. Participation in the CRP public outreach should occur on three levels: elected officials, stakeholders/organizations, and the general public.

The region's stakeholders, such as the NY/NJ Harbor Coalition, should reach out to elected officials and engage them in the planning process. These relationships should be forged as a means to solidify a commitment to restoration in the HRE study area and could translate into funding opportunities for program implementation, especially as it relates to individual constituencies.

Environmental stakeholder groups have been active participants in the HEP and have taken a variety of individual actions to strengthen environmental protection regulations and initiate restoration programs for selected species and local sites. Continued coordination with well-established stakeholder groups in the HRE study area will increase program visibility and support, as well as increase the number of sites that might help meet TEC goals.

Goal: Implement CRP

Our goal is to inspire everyone reading this document to become actively involved in implementing the CRP and ensuring the restoration as well as the long-term health and preservation of the estuary. Restoration efforts as ambitious as the ones described herein can be costly and will require commitment and funding from multiple sources, including government programs and grants, large donors, local municipalities, corporate sponsorship programs, and many more. We encourage each person to take ownership of their role in implementing the CRP by contacting their elected officials to voice support for the restoration plan, volunteering within the HRE with one of the many stakeholder organizations supporting the CRP, and identifying restoration, acquisition, or public access opportunities by nominating new sites using the online form. *To find out how else you can support restoration and to see what activities are taking place near you, visit www.TheWatersWeShare.org.*

In the transition of the CRP to an action plan, it is essential to promote the program and raise the public awareness necessary to achieve long-term plan objectives. The Waterfront Alliance, NY/NJ Harbor Coalition, and HEP represent existing advocacy organizations and work groups that can provide an outlet and forum for environmental restoration discussions by focusing on the estuary and the waterfront. Since the Draft CRP was released in 2009, these organizations have promoted the CRP's restoration goals, with the Waterfront Alliance partnering and promoting common objectives (e.g., ***Public Access, Shorelines and Shallows***), and HEP through its newsletters and biannual restoration conference. The HEP's Restoration Conference is a recurring event open to the public that highlights the advancement of restoration, acquisition, and public access efforts throughout the harbor estuary. Implementation of the CRP has also drawn on professional public outreach expertise to extend interest in environmental restoration beyond the stakeholders already engaged in HRE study area-specific issues. This has been initiated through branding, with the Waters We Share logo, website (http://www.harborestuary.org/watersweshare/index.htm), and brochures.

Public support for the CRP is more engaged in habitat restoration programs and outreach at the local level. Restoration of ***Wetlands*** and ***Oyster Reefs*** and environmental education programs, which have been underway in the HRE study area for many years, are attempts to reverse the degradation of the estuary's aquatic resources. Many of these efforts are conducted independently as isolated, local activities and are not perceived as constituent elements in a larger framework to restore the entire estuarine ecosystem. A public involvement campaign should attempt to connect these "isolated" programs and demonstrate the potential estuary-wide benefits of collective restoration activities.

Strong public interest in habitat restoration and coastal resiliency is evident from participation in various waterfront and restoration programs in the estuary. This interest has been communicated to resource management agencies. The public needs to be aware of the potential long-term benefits of a comprehensive approach to ecosystem restoration and how it can support that effort. This is especially critical, as the CRP is a long-term program that will need continuing funding.

The following components could improve public participation and support.

- Newsletters, brochures, and fact sheets should document the status of the CRP. Written materials provide continuity to the planning process for participants and help to maintain interest and hold public attention during the intervals between outreach events. The HEP newsletter, the Tidal Exchange, provides estuary-wide and region/site-specific information in an engaging format with many graphics. Photographs of work in progress and interviews with community leaders involved in projects also provide planning region identification and demonstrate involvement at the local level. For the foreseeable future, the HEP newsletter will function as the CRP newsletter and will be distributed quarterly. Brochures and fact sheets can describe the history and goals of the program or be single-topic discussions on individual acquisition and restoration sites or on technical matters, such as contaminated sediments management. The format and graphic look of all materials should be consistent with the CRP to maintain estuary-wide identification with the project and project materials. As funding permits, these publications should also be translated into the languages of prominent minority groups (e.g., Spanish) to promote public participation of all socioeconomic groups in the HRE study area. An introductory brochure developed for the CRP and updates like the 2014 Restoration Report are available for download on the Waters We Share website. New brochures should be developed to acknowledge important milestones, and fact sheets or other promotional materials should be developed and posted to the Waters We Share website.
- The Waters We Share website should be managed regularly to serve as a two-way communication vehicle, as well as an electronic newsletter to disseminate project-related materials. The internet is an immediate source of information for the public and may become the first exposure residents of the HRE study area have to the program. The website is currently seamlessly accessible from HEP's website.
- The NYC OASIS program is an online, interactive mapping tool that offers an engaging format that relays specific information on jurisdictional boundaries, land use (including wetlands, parks, and protected areas), and locations of acquisition and restoration sites to the public. With support from HEP and the USACE, the HRE study area will be integrated into this mapping tool to help communicate project-related information and will continue to be updated. The OASIS database can serve as the restoration mapping clearinghouse for the CRP.
- Periodically, TEC-specific workshops should be conducted to discuss lessons learned and include stakeholder groups in the decision-making process. These workshops will be held on an as-needed basis, based on stakeholder interest, to advance near-term objectives. Because stakeholder groups will be initiating many restoration programs, their input is imperative after the initial restoration strategy is approved and throughout the CRP implementation. Technical members should be invited to provide information on the latest research developments. However, the selection of workshop topics could be driven by the regional areas of the CRP and the specific acquisition and restoration sites/needs. Regional area boundaries correspond to watershed drainage basins and jurisdictional boundaries, and may not reflect the way communities define themselves. For the purpose of public outreach, planning region-specific programs should reflect the most appropriate way to reach local communities and therefore

may cross planning region boundaries, as appropriate. These gatherings can create a mechanism for involving the public in early planning stages, thereby obtaining a clear understanding of the public's needs and concerns and hopefully generating enthusiasm for planning efforts, future sponsors, and future projects.

- It may also be beneficial to establish Planning Region Work Groups (similar to the Science and Resilience Institute at Jamaica Bay, but for other planning regions) through HEP to regularly update interested residents and regional stakeholder groups on the status of the CRP, lessons learned, upcoming events or projects, and ways to get involved within their specific regional areas. The Planning Region Work Groups can meet periodically and informally, which will serve as a platform for exchanging ideas, information, and addressing concerns in a non-technical, engaging manner. This regional coordination will ensure consideration of municipalities' planning efforts in overall regional restoration planning within the CRP study area.

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Comprehensive Restoration Plan (CRP) Sites and Associated Target Ecosystem Characteristics (TECs)

Planning Region	CRP ID	Site Name	Wetlands	Islands for Waterbirds	Coastal & Maritime Forest	Oyster Reefs	EelgrassBeds	Shorelines and Shallows	Habitat for Fish, Crab and Lobsters	Tributary Connections	Enclosed and Confined Waters	Sediment Contamination	Public Access	Acquisition	To Be Determined
Jamaica Bay	9	Seagirt Avenue Wetlands	●		●					●	●	●		●	
	51	Arvene Urban Renewal Area			●							●	●	●	
	102	Brant Point	●		●				●			●			
	103	Breezy Point			●			●				●	●	●	
	104	Spring Creek	●		●			●	●			●	●		
	105	Idlewild Park (Brookville)	●		●					●	●	●	●		
	148	Bayswater Park	●		●				●			●			
	149	Dubos Point	●		●				●			●			
	151	Bergen Beach	●		●			●				●			
	160	Bergen Basin	●		●				●		●	●			
	161	Hawtree Point	●		●							●			
	162	Conch Basin	●						●		●	●		●	
	165	Mott Basin	●		●				●		●	●			
	166	Shell Bank Creek	●		●				●		●	●			
	167	Somerville Basin	●		●				●			●			
	168	Hendrix Creek	●		●	●		●	●		●	●			
	172	Vernam Barabadoes	●		●				●			●		●	
	193	Gerritsen Inlet (deadhorse bay)	●		●				●			●			
	198	Canarsie Beach	●		●			●	●			●	●		
	200	Mill Basin	●		●			●	●		●	●	●	●	
	601	Hook Creek	●		●				●		●	●		●	
	602	Doxey Creek													1

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Jamaica Bay	603	Plumb Beach			●				●			●	●		
	604	Sheepshead Bay						●			●	●			
	607	Floyd Bennett Field			●			●				●	●		
	611	West Pond	●		●			●	●			●	●		
	628	Rockaway Peninsula													1
	631	Frank Charles Park	●		●			●	●		●	●	●		
	632	Grassy Bay						●		●	●	●			
	634	Thurston Basin	●		●				●	●	●	●		●	
	647	Rockaway Reef													1
	730	Fresh Creek	●		●			●		●	●	●	●		
	731	Paerdegat Basin	●		●			●	●	●	●	●	●		
	732	Dead Horse Bay	●		●				●			●			
	810	Shellbank Basin									●	●			
	914	Sunset Cove- Broad Channel Marina													1
	932	Carnasie Pol	●					●				●			
	933	Black Wall Marsh	●					●				●			
	934	Goose Pond Marsh	●					●				●			
	935	Duck Point Marsh	●					●				●			
	936	Pumpkin Patch Marsh	●					●				●			
	937	Stoney Creek Marsh	●					●				●			
	938	Silver Hole Marsh	●					●				●			
	939	Center of Elders East/West	●					●				●			
	940	Big Egg Marsh	●					●				●			

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Jamaica Bay	941	Little Egg Marsh	●					●				●			
Jamaica Bay Total	**46**	**N/A**	**35**	**0**	**28**	**1**	**0**	**23**	**21**	**6**	**16**	**42**	**12**	**8**	**4**
Lower Bay	1	Additons to Arden Woods	●		●								●		
	3	Canada Hill Forest	●		●							●		●	
	4	Charleston/Kreischer Hill Woods	●		●							●	●		
	5	North Mount Loretto Woods	●		●					●		●	●		
	6	Northern Sea View			●									●	
	8	Pouch Camp	●		●								●		
	13	South Beach Wetlands, Northern Section	●		●							●	●	●	
	20	Leonardo (Middletown Township)	●		●							●		●	
	21	Ware Creek	●		●					●		●			
	22	Compton Creek	●		●							●		●	
	23	Natco Lake/Thorns Creek	●		●					●		●		●	
	24	East Creek	●		●					●		●		●	
	25	Flat Creek	●		●					●		●		●	
	26	Conaskonk Point	●		●			●							
	27	Matawan Creek	●		●					●		●		●	
	28	Treasure Lake	●		●							●	●	●	
	29	Whale Creek/Long Neck Creek	●		●					●		●	●		
	30	Marquis Creek	●		●					●		●			
	31	Cheesequake Marsh	●		●							●		●	
	32	Old Morgan Landfill/Raritan Bay Waterfront Park	●		●			●				●			

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Lower Bay	33	South Amboy	●		●							●		●	
	44	Many Mind Creek	●		●					●		●	●	●	
	53	Paw-Paw Hybrid Oak Coastal Woods	●		●							●	●		
	63	St. Edward's Campground			●							●	●	●	
	64	Butler Manor Woods	●		●					●		●	●		
	109	Lemon Creek	●		●			●		●		●	●		
	116	Matawan Creek/Keyport Harbor Mouth													1
	117	Shadow Lake Dam								●					
	118	Shrewsbury River Watershed (Multiple Sites)												●	1
	119	Cheesequake State Park (Atlantic White CedarForest)			●										
	120	Cheesequake State Park (Hook Lake)								●		●	●		
	155	Dreier Offerman													1
	568	Global Landfill			●							●	●	●	
	571	Laurence Harbor	●		●			●				●	●	●	
	578	Oakwood Beach	●		●							●	●		
	579	Fort Wadsworth Beach			●			●				●	●		
	580	Great Kills, Gateway NRA	●		●							●	●		
	582	Seaview Avenue Wetlands	●		●							●	●		
	591	Shrewsbury/Navesink Rivers												●	1
	593	Sandy Hook (Shellfish Restoration)													1
	594	Raritan Bay (Oyster Bed Restoration)													1

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Lower Bay	595	Raritan Bay (Submerged Rock Bed)							●			●			
	596	Crookes Point	●		●							●	●		
	597	Verrazano Narrows							●			●			
	598	Hoffman-Swinburne Islands		●					●			●			
	599	Gravesend Bay							●			●			
	800	Mt. Loretto	●		●	●	●	●		●		●	●		
	801	Great Kills Park	●		●							●	●	●	
	802	Matawan Creek/Keyport Harbor	●		●							●		●	
	807	Cheesequake State Park	●		●					●		●	●		
	850	Matawan Creek: Freneau Fields/Hauser Farm													1
	929	St. Francis Friary driveway												●	
Lower Bay Total	**52**	**N/A**	**33**	**1**	**38**	**1**	**1**	**6**	**4**	**15**	**0**	**38**	**23**	**21**	**7**
Lower Raritan River	60	Silver Lake	●		●				●	●		●		●	
	65	Dismal Swamp	●		●					●		●	●	●	
	525	Former Nuodex Corporation Facility												●	1
	526	Hatco Chemical	●		●							●		●	
	527	Renora, Inc.								●		●		●	
	528	South Plainfield Veterans Memorial Park								●			●		
	529	Woodbrook Road												●	1
	530	Chemsol, Inc.												●	1
	532	Middlesex Sampling Plant												●	1
	533	Factory Lane												●	1

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Lower Raritan River	534	Cornell Dubilier Superfund Site												●	1
	536	Raritan Arsenal	●		●			●				●	●	●	
	537	National Lead	●						●			●	●	●	
	538	Evor Phillips Leasing Company												●	1
	539	CPS/Madison Industries												●	1
	541	Chemical Insectiside Superfund Site												●	1
	543	131 Jersey Avenue													1
	544	Iron Leaf													1
	545	Kents Neck			●					●		●	●	●	
	546	Edgeboro Landfill												●	1
	547	Kin-Buc & Edison Landfills													1
	548	South Rivers	●		●				●			●		●	
	552	Raritan River Waterfront												●	1
	553	South Brunswick Landfill			●							●	●	●	
	554	Fried Industries												●	1
	555	Jones Industrial Service Landfill												●	1
Lower Raritan River Total	**26**	**N/A**	**6**	**0**	**7**	**0**	**0**	**1**	**3**	**5**	**0**	**9**	**6**	**22**	**16**
Arthur Kill & Kill Van Kull	2	Cable Avenue Woods	●		●							●		●	
	7	Outerbridge Ponds and Woods	●		●							●		●	
	15	Sawmill Park Addition	●		●							●		●	
	16	Merrill's Creek	●		●					●		●		●	
	17	Neck Creek	●							●				●	

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Arthur Kill & Kill Van Kull	18	Port Mobile Swamp Forest and Tidal Flats	●		●				●			●		●	
	34	Morses Creek												●	1
	35	Piles Creek	●							●		●		●	
	48	Arlington Marsh	●						●	●		●			
	49	Little Fresh Kills, Arthur Kill Peninsula	●		●				●			●		●	
	50	Graniteville Swamp Woods	●		●					●		●		●	
	56	Range Road Forest	●		●				●	●		●		●	
	62	Teleport Magnolia Forest	●		●					●		●			
	101	Prall's Island	●	●	●				●			●			
	110	Arden Heights Woods	●		●								●		
	111	Long Pond Park	●		●					●		●	●		
	121	Elizabeth River												●	1
	125	Madison/Maple Avenues								●		●	●		
	126	Milton Lake						●		●		●	●		
	127	Central Avenue								●		●	●	●	
	129	Rahway River Parkway Lake						●		●		●	●		
	131	Potter's Island		●				●							
	147	Mariner's Marsh	●		●					●		●			
	182	Rahway River Parkway (Sperry Section), TheLagoon						●		●		●	●		
	184	Orange Reservoir						●				●	●		
	185	Vauxhall Creek													1
	194	Gulfport Marsh	●		●				●			●		●	

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Arthur Kill & Kill Van Kull	694	Rahway Riverfront Park	●						●			●			
	704	Fresh Kills Landfill	●		●					●		●	●		
	712	Shooter's Island													1
	930	Sharrots Shoreline												●	1
Arthur Kill & Kill Van Kull Total	**31**	**N/A**	**19**	**2**	**15**	**0**	**0**	**5**	**7**	**15**	**0**	**23**	**9**	**15**	**5**
Lower Hudson	66	Pennsylvania Railroad Harsimus Stem Embankment											●	●	
	159	Riverdale Park	●		●					●		●	●		
	189	Inwood Park	●		●			●	●			●	●		
	190	Fort Tryon Park			●								●		
Lower Hudson	191	Spuyten Duyvil	●		●			●				●			
	196	Fort Washington Park			●								●		
	197	Riverside Park			●			●	●			●	●		
	556	Hudson/Bergen County Waterfront												●	1
	562	Hudson River Park Estuarine Sanctuary						●	●			●	●		
	928	Sawmill River Daylighting-Chicken Island													1
Lower Hudson Total	**10**	**N/A**	**3**	**0**	**6**	**0**	**0**	**4**	**3**	**1**	**0**	**5**	**7**	**2**	**2**
Newark Bay, Passaic River, & Hackensack River	38	Penhorn Creek	●						●	●		●	●	●	
	39	Kearny Marsh (Freshwater)	●		●				●		●	●	●		
	40	Berry's Creek													1
	42	Bellman's Creek	●						●	●		●		●	
	43	Overpeck Creek												●	1
	67	Laurel Hill Park Wetlands	●						●			●	●		

Appendix D: Atlas of Restoration Opportunities

Comprehensive Restoration Plan (CRP) Sites and Associated Target Ecosystem Characteristics (TECs)

Planning Region	CRP ID	Site Name	Wetlands	Islands for Waterbirds	Coastal & Maritime Forest	Oyster Reefs	EelgrassBeds	Shorelines and Shallows	Habitat for Fish, Crab and Lobsters	Tributary Connections	Enclosed and Confined Waters	Sediment Contamination	Public Access	Acquisition	To Be Determined
Newark Bay, Passaic River, & Hackensack River	142	Van Buskirk Island													1
	143	Oradell Dam								●					
	145	Dundee Dam								●		●			
	522	Losen Slote Creek Park	●		●							●	●		
	715	Anderson Creek Marsh													1
	718	Lyndhurst Riverside Marsh	●						●			●			
	719	Meadowlark Marsh	●		●				●			●	●		
	720	Mehrhof Pond	●		●							●	●		
	721	Metro Media Tract	●		●				●			●	●		
	722	Mori Tract	●						●			●	●	●	
	723	Oritani Marsh	●					●	●	●		●	●		
	724	Petrillo Tract	●					●	●			●		●	
	725	Riverbend Wetlands Preserve	●					●	●			●			
	727	Secaucus Tract	●					●	●			●			
	728	Steiners Marsh	●					●	●			●			
	729	Teterboro Woods	●									●		●	
	803	Berry's Creek Marsh	●						●	●		●			
	843	Kearny Marsh (Brackish)	●						●			●			
	865	Kearny Point	●					●	●			●	●		
	866	Oak Island Yards	●		●				●	●		●	●		
	867	Unnamed Tidal Creek Pulaski Skyway (LawyersCreek)	●							●	●	●			
	868	Un-named Tidal Creek-NJ Turnpike	●					●	●	●	●	●			

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Planning Region	CRP ID	Site Name	Wetlands	Islands for Waterbirds	Coastal & Maritime Forest	Oyster Reefs	EelgrassBeds	Shorelines and Shallows	Habitat for Fish, Crab and Lobsters	Tributary Connections	Enclosed and Confined Waters	Sediment Contamination	Public Access	Acquisition	To Be Determined
Newark Bay, Passaic River, & Hackensack River	869	Kearny Marsh (Cedar Creek Marsh)	●						●		●	●			
	870	Franks Creek Site (1-D Landfill)	●						●	●	●	●			
	871	Path Rail Fringe Marsh	●						●			●		●	
	872	Harrison Shoreline Redevelopment	●						●			●			
	873	Newark Riverbank Park/Joe G. Minish Park (Portion)	●					●	●			●	●		
	874	Gateway Park/ Joseph G. Minish Park (Portion)											●	●	
	875	Riverfront Park	●					●	●			●		●	
	876	Clay Street Lot										●	●	●	
	877	Franklin- Burlington Plastics	●					●	●			●		●	
	878	Frank Vincent Park and Boat Ramp	●					●	●			●	●	●	
	879	Kearny Riverbank Park	●					●	●			●			
	880	Jacobus Avenue-Kearny													1
	881	PSE&G Shoreline													1
	882	Saddle River Ox Bow								●		●		●	
	883	Saddle River Felician College South								●		●		●	
	884	Saddle River Lodi Cemeteries								●		●			
	885	Saddle River Arcola Pool Site								●		●		●	
	886	Saddle River County Park	●							●		●		●	
	887	First River Branchbrook Park	●					●		●			●	●	
	888	Second River Passaic/ Belleville								●		●	●	●	
	889	Second River Bloomfield								●		●	●	●	

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Newark Bay, Passaic River, & Hackensack River	890	Second River Watsessing Park								●		●	●		
	891	Second River Wigwam Brook Industrial								●		●		●	
	892	Second River Mills								●		●			
	893	Third River (Mouth)								●		●	●		
	894	Third River Clifton Pond	●							●		●	●		
	895	Third River Forest Hills Field Club								●		●			
	896	Third River JFK Parkway								●		●	●		
	897	Third River Glen Ridge Country Club								●		●			
	898	Thid River Clarks Pond	●							●			●		
	899	Third River Alonzo F. Bonsal Wildlife Preserve								●		●	●		
	900	Dundee Island Park/Pulaski Park						●		●		●	●		
	901	Semel Avenue & River Road Parcel	●					●		●		●	●		
	902	Clifton Dundee Canal Green Acres Purchase andDundee Island Preserve	●					●	●	●		●	●		
	903	Botany Street Small Islands	●					●	●	●		●			
	904	Dundee Lake Islands at Clifton and Elmwood Park													1
	905	Joe Sesselman Park	●					●		●		●	●		
	906	Joe Sesselman Park Annex	●					●		●		●	●		
	907	Waterfront Access in the City of Passaic	●					●		●		●	●		
	908	Rutherford Memorial Field	●					●		●		●	●		
	909	Route 3 Bridge (PRC) parcels	●							●		●	●		

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Newark Bay, Passaic River, & Hackensack River	910	Riverside Co.Park North Joe Carucci Park/LyndtPark	●						●	●		●	●		
	911	River Bank Edge Parcels	●							●		●			
	912	Riverside Park (Bergen Co.South Pk.)	●						●	●		●	●		
	913	Weasel Brook Park						●		●		●	●		
	923	Nutley Boat Ramp											●		
	925	Stonewall													1
	931	Rapp's Boatyard												●	1
Newark Bay, Passaic River, & Hackensack River Total	**76**	**N/A**	**46**	**0**	**6**	**0**	**0**	**22**	**31**	**41**	**5**	**62**	**36**	**21**	**9**
Harlem River, East River, & Western Long Island Sound	10	South Brother Island		●	●			●				●			
	11	Udalls Cove Ravine			●					●		●	●	●	
	12	Huckleberry Island		●											
	52	City Island Wetlands	●		●				●	●		●			
	107	Meadow Lake	●								●	●	●		
	113	Bronx River/Shoelace Park	●		●			●	●	●			●		1
	153	Palmer Inlet	●							●	●	●		●	
	170	Bowery Bay	●		●			●		●	●	●		●	
	175	Pugsley Creek	●		●						●	●	●		
	177	Turtle Cove													1
	179	Pelham Bay Park/Tallapoosa West													1
	188	Flushing Creek	●		●			●		●		●			
	648	Ferry Point Park	●		●			●	●			●	●		

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Harlem River, East River, & Western Long Island Sound	650	Hart Island	●	●	●			●						●	
	652	Rice Stadium Wetlands													1
	662	Pelham Bay Landfill			●							●	●		
	663	Sherman Creek	●			●		●	●			●	●	●	
	666	Oak Point Rail Yard						●	●	●		●		●	
	669	Hempstead Harbor	●		●	●			●	●	●	●			
	672	Anable Cove	●		●				●			●	●	●	
	673	Stuyvesant Cove						●	●			●	●		
	674	Hallet's Cove	●					●	●			●	●	●	
	675	Newtown Creek						●			●	●			
	676	Bushwick Inlet	●		●			●	●		●	●	●		
	677	Cove Between the Bridges (part of Brooklyn Bridge)						●	●			●	●		
	678	Hutchinson River Marsh Restoration	●		●				●	●		●	●	●	
	679	Hutchinson River Fish Impediment Removal								●					
	680	Tibbetts Brook												●	1
	841	Brooklyn Navy Yard Wallabout Channel												●	1
	842	Bronx Kill Shoreline-Randall's Island													1
	851	Bronxville Lake	●		●			●	●	●	●		●		1
	852	Crestwood Lake	●		●			●	●	●	●		●		1
	854	Westchester County Center	●		●			●	●	●			●		1
	857	Bronx River Forest			●				●						1
	858	182nd St. Dam							●	●				●	1

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	860	Bronx River Park	●		●			●	●	●		●	●		1
	862	Muskrat Cove	●					●	●	●					1
	918	North White Plains													1
	919	287 Crossing													1
	920	Bronx River Invasives Upper													1
	921	Bronx River Invasives Lower													1
Harlem River, East River, & Western Long Island Sound	922	Woodlawn													1
	926	East Harlem Ecological Edge													1
	927	Tibbetts Brook Daylighting and Putnam Greenway													1
	942	Garth Woods	●		●			●	●	●					1
	943	Harney Road													1
	944	Anadromous Fish Passage (Bronx Zoo)							●	●					1
	945	Anadromous Fish Passage (Stone Mill)								●					1
Harlem River, East River, & Western Long Island Sound Total	**48**	**N/A**	**21**	**3**	**20**	**2**	**0**	**19**	**21**	**19**	**9**	**21**	**17**	**12**	**25**
	37	Liberty State Park	●						●			●	●		
	154	Bush Terminal/Brooklyn Sunset Park	●					●	●			●	●		
	502	Coffey Street Park							●				●		
Upper Bay	503	Gowanus Canal						●			●	●			
	504	Lower Bay Reef							●			●			
	840	Northshore Waterfront Greenway Trail												●	1
	864	Governors Island	●			●		●	●			●	●		

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Upper Bay Total	**7**	**N/A**	**3**	**0**	**0**	**1**	**0**	**3**	**5**	**0**	**1**	**5**	**4**		**1**
OUTSIDE HRE	916	Westchester County DPW Grasslands Facility													1
	917	Valhalla Station													1
Grand Total	**296**	**N/A**	**166**	**6**	**120**	**5**	**1**	**83**	**95**	**102**	**31**	**205**	**114**	**102**	**69**

Notes:

At the time of publication in June 2016, there were 296 sites approved by the RWG. The following sites are not included: Conference House Park freshwater wetland, Crescent Beach, Depot Place, Hammond Cove, Idlewild Cove, City Island Ambrosini fields, and Snug Harbor.

Symbol indicates that TEC is planned for the project; Blank in column indicates that TEC is not associated with project.

N/A: Not Applicable