Hudson River Habitat Restoration Ecosystem Restoration Feasibility Study

Draft Integrated Feasibility Report & Environmental Assessment
June 2019

Prepared by the U.S. Army Corps of Engineers,
North Atlantic Division, New York District
in partnership with the
New York State Departments of Environmental Conservation and State

Comments and Questions

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Foyt, S. (2015). Views From Walkway Over The Hudson State Historic Park. https://www.getawaymavens.com/walkway-over-the-hudson/

Executive Summary

The Hudson River Habitat Restoration Ecosystem Restoration Feasibility Study is being conducted by the U.S. Army Corps of Engineers (USACE) with the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of State (NYSDOS), the study's non-Federal sponsors. The study was authorized by section 551 of the Water Resources Development Act of 1996 (P.L. 104-303):

a) *Habitat Restoration – The Secretary shall expedite the feasibility study of the Hudson River Habitat Restoration, Hudson River Basin, New York, and may carry out not fewer than 4 projects for habitat restoration in the Hudson River Basin, to the extent the Secretary determines such work to be advisable and technically feasible. Such projects shall be designed to-*

   a. *assess and improve habitat value and environmental outputs of recommended projects;*
   b. *evaluate various restoration techniques for effectiveness and costs;*
   c. *fill an important local habitat need within a specific portion of the study area; and*
   d. *take advantage of ongoing or planned actions by other agencies, local municipalities, or environmental groups that would increase the effectiveness or decrease the overall cost of implementing one of the recommended restoration project sites.*

The study area includes approximately 125 miles of the Hudson River, from the federal lock and dam at Troy, New York, to the Governor Mario M. Cuomo (formerly Tappan Zee) Bridge. Tributaries in this reach, from the river up to the first natural barrier to migratory fish, are also included. The study area is located entirely in New York State, in Albany, Rensselaer, Greene, Columbia, Ulster, Dutchess, Orange, Putnam, Rockland, and Westchester counties. This area includes Congressional districts 17, 18, 19, and 20.

The Hudson River provides a unique ecosystem with highly diverse habitats. Tidal influence extends from New York-New Jersey Harbor to the federal lock and dam at Troy, and under average runoff conditions the saltwater front can be found 50 to 60 miles north of the Battery, between West Point and the Poughkeepsie area. Approximately 85% of New York State's fish and wildlife species, including over 200 fish species, inhabit the river ecosystem. In the connected estuary complex, there are over 2,000 species of plants and vertebrates.

For more than 200 years, human activities, including federal, state, local, and private development, have degraded the integrity of the Hudson River ecosystem. USACE maintains a federal navigation channel in the study area. In creating the navigation channel, USACE constructed longitudinal dikes and dams along the river, dredged the river bottom, and placed dredge material in between islands in the river as well as in shallow, marshy, side channels. Meanwhile, in the greater Hudson River watershed, approximately 1,600 dams and thousands of culverts were built. Cumulatively, these human activities changed the morphology and hydrology of river.

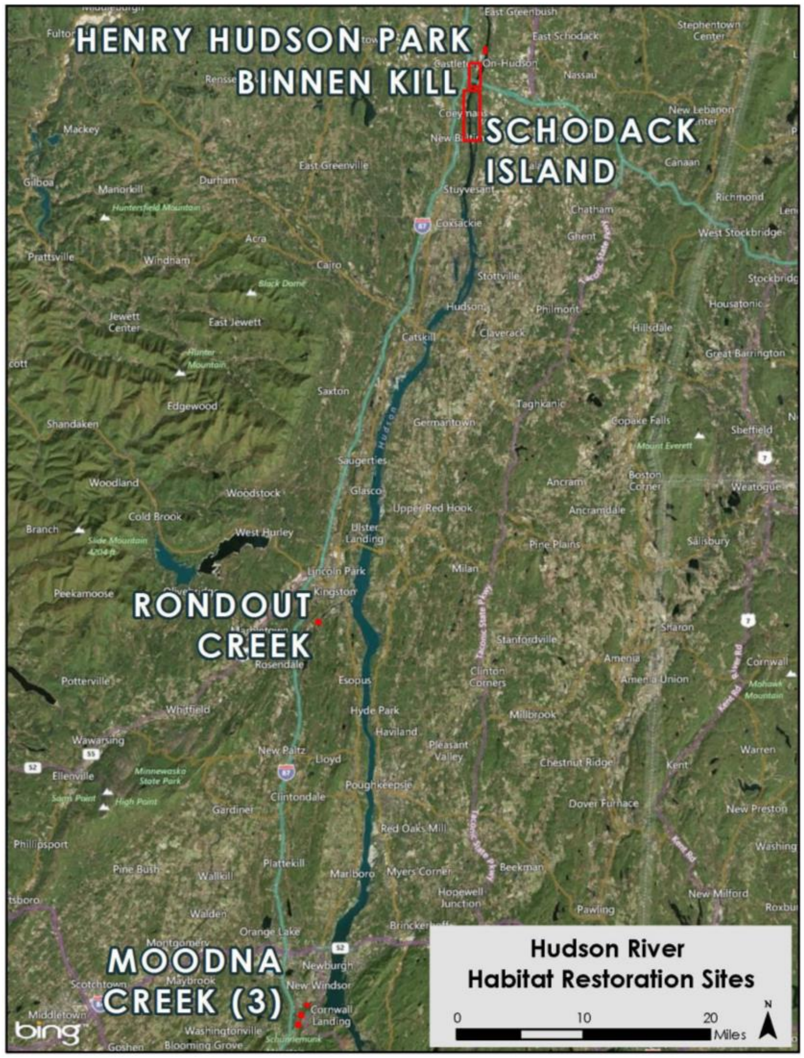

Figure ES-1: Habitat Restoration Sites.

The changes to the Hudson River resulted in large-scale losses of critical shallow water and intertidal wetland habitats, and fragmented and disconnected habitats for migratory and other species. A total of approximately 4,000 acres of aquatic habitats, including shallow, intertidal, and wetland habitats, were lost. Of those, about 3,300 acres were lost to filling, which converted aquatic habitats to upland habitats. The other approximately 700 acres were lost to dredging, which deepened previously shallow waters to more than six feet deep at low tide. In addition, more than 85% of the islands accounting for much of the 71 miles of shoreline were eliminated. Most of this loss and impact occurred in the upper third of the estuary. Additional dredging and filling occurred along the shores of the Hudson River to accommodate transportation and industrial activities, especially around population centers (Miller 2013 and USACE 1996).

Planning objectives developed for the study, to address problems with ecosystem structure, function, and dynamic processes and to take advantage of opportunities for ecosystem restoration in the study area, include:

1. Restoring a mosaic of interconnected, large river habitats, and

2. Restoring lost connectivity within the Hudson River and its tributaries.

Alternatives developed to meet these objectives were evaluated and compared to identify a Tentatively Selected Plan (TSP). The TSP consists of ecosystem restoration at five sites (Figure ES-1).

- Henry Hudson Park is located in the Town of Bethlehem on the western bank of the Hudson River in Albany County.
- Binnen Kill is located on the western bank of the Hudson River on the border of the towns of Bethlehem and Coymanns.
- Schodack Island, which is part of Schodack Island State Park, is located near the eastern bank of the Hudson River, approximately three miles south of Castleton-on-Hudson in the Town of Schodack.
- Eddyville Dam, on Rondout Creek, is approximately 3.6 miles upstream of the creek's confluence with the Hudson River, between the towns of Esopus and Ulster in Ulster County.
- The three areas of interest on Moodna Creek are a sewer utility line, Firth Cliff Dam, and Orr's Mill Dam, which are approximately 1.8, 3.0, and 3.7 miles upstream of the creek's confluence with the Hudson River, respectively, in the towns of New Windsor and Cornwall in Orange County.

The TSP would restore and create a total of approximately 148 acres of wetlands, including 38 acres of intertidal and shallow water habitat associated with two major side channels that would be restored, and reconnect 17 miles of tributary habitat to the Hudson River (Table ES-1). These measures would directly address past impacts of the federal navigation channel and other human activities, including filling shallow water habitat and side channels, hardening and diking shorelines, and fragmenting critical habitat for migratory taxa. Measures at Binnen Kill and Schodack Island would contribute to both of the planning objectives, by restoring subtidal, intertidal, shoreline, and riparian habitats on the Hudson River mainstem, while providing refuges for migratory taxa such as American shad, striped bass, the federally Endangered Atlantic and shortnose sturgeon, and a variety of birds, mammals, and reptiles (Miller, 2013). Measures at Henry Hudson Park would also contribute to restoring a mosaic of interconnected, large river habitats, by creating a living shoreline with intertidal wetland in lieu of a hardened bulkhead. At Rondout and Moodna creeks, measures would contribute to restoring lost connectivity between the Hudson River and its tributaries, by modifying or removing barriers to aquatic organism passage (AOP). This would facilitate the movement of migratory organisms between the river and important headwater habitats and improving the exchange of water, sediment, and nutrients.

Table ES-1: Tentatively Selected Plan Summary.

RESTORATION CATEGORY	SITE	ELEMENT DESCRIPTION OF RECOMMENDED ALTERNATIVES[1]
Large River Mosaic	Binnen Kill	▪ Forested wetland creation (15.5 acres) ▪ Emergent wetland creation (4.3 acres) ▪ Emergent wetland restoration and channel creation (41.2 acres) ▪ Side channel and tidal wetland creation (27.0 acres); ▪ Tidal wetland restoration (7.5 acres) ▪ Other wetland restoration (57.6 acres)
	Schodack Island	▪ Side channel and tidal wetlands (11.4 acres) ▪ Tidal wetland restoration (17.5 acres)
Shoreline Restoration	Henry Hudson Park	▪ Tidal wetland creation (3.6 acres) ▪ Hardened bulkhead replaced with a living shoreline
Tributary Connectivity	Rondout Creek	▪ Removal of Eddyville Dam ▪ Reconnection of 9.0 miles of habitat
	Moodna Creek	▪ Removal of a utility crossing (barrier 1) ▪ Removal of Firth Cliff Dam (barrier 2) ▪ Partial removal of Orr's Mill Dam (barrier 3) ▪ Collectively, reconnection of 7.8 miles of habitat
Total		38 acres of side channels/tidal wetlands restored 148 acres of wetlands in the Hudson River corridor 17 miles of river habitat reconnected

[1] Advancement of each of these sites as part of the TSP is dependent upon landowner consent and local support.

The TSP was identified by comparing the benefits and costs of 23 alternatives, using cost-effectiveness and incremental cost analyses. The alternatives for each site, or site component, were compared to each other, and combinations of alternatives within categories of sites were also compared. The categories: large river mosaic, shoreline restoration, and tributary connectivity derived from the planning objectives and site screening process, in which 1,800 restoration opportunities in the study area were screened and prioritized to select the six sites for which alternatives were developed.

Benefits of the alternatives were quantified using the Evaluation of Planned Wetlands procedure and a Watershed-Scale Upstream Connectivity Toolkit, the units for which are functional capacity units and habitat units, respectively. The TSP provides a total of 218.6 average annual functional capacity units (AAFCUs) and habitat units (AAHUs).

Based on January 2019 price levels, the total estimated first cost of the TSP is $98,386,265, which includes monitoring costs of $1,123,340 and adaptive management costs of $2,739,416. In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the estimated first cost is 75%, or $73,789,700, and the non-federal share is 25%, or $24,596,567. The non-federal costs include the value of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated to be $1,208,741. Table ES-2 summarizes the benefits, costs, and cost apportionment for each restoration site in the TSP.

Although the TSP includes five sites, separate Design Agreements and Project Partnership Agreements (PPAs) may be executed for each site, depending on non-federal sponsor priorities and available funding. Accordingly, Table ES-2 presents cost apportionment on a per site basis, rather than as if the TSP was a single, homogenous suite of activities.

Table ES-2: Tentatively Selected Plan Benefits, Costs, and Cost Apportionment[1].

SITE	AVERAGE ANNUAL COST $	AAFCU OR AAHU [2]	ANNUAL-IZED UNIT COST ($/UNIT)	TOTAL COST ($)	FEDERAL COST ($)	NON-FEDERAL COST ($)	ANNUAL OMRR&R COST ($)[3]
Binnen Kill	2,458,555	33.5 AAFCUs	73,324	57,330,597	42,997,949	14,332,650	231,452
Schodack Island	822,106	7.1 AAFCUs	116,446	19,256,797	14,442,598	4,814,199	73,636
Henry Hudson Park	368,870	2.2 AAFCUs	165,413	8,873,209	6,654,907	2,218,302	29,783
Rondout Creek	157,659	127.4 AAHUs	1,238	3,932,388	2,949,291	983,097	8,429
Moodna Creek	363,771	48.4 AAHUs	7,522	8,993,274	6,744,956	2,248,319	22,664
ALL	**4,170,961**	**218.6 AAFCUs**	**-**	**98,386,265**	**73,789,700**	**24,596,567**	**365,964**

[1] TSP benefits, costs and cost apportionment assume willing landowner participation, local support and availability of funds for all sites.
[2] AAFCUs and AAHUs: Average Annual Functional Capacity Units and Habitat Units
[3] Annual OMRR&R Cost: Operations, Maintenance, Repair, Rehabilitation and Replacement Annual also included in Total Average Annual Cost but NOT included in Total Project Cost. Costs are 100% non-federal funds for up to 10 years after ecological success has been determined.

The total project cost of the TSP assumes willing landowner participation and local support for all projects, which has not been determined for every site at this stage.

Public meetings scheduled in 2019 following the release of this Draft Integrated FR/EA will determine if sites containing private lands will ultimately be recommended for construction. For AOP barrier removal or modification projects with landowner support, additional studies associated with hydrology, hydraulics and flooding will be conducted in the Pre-Construction Engineering Design (PED) phase prior to implementation.

Sites that were not prioritized for this FR/EA may be advanced through the completion of new phase future spin-off feasibility studies carried out under the HRHR study authority or the Continuing Authorities Program. Future new phase studies are dependent upon the availability of federal and local funding, and the willingness of a sponsor to execute a new Feasibility Cost Share Agreements (FCSA).

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Acronyms

AAFCUs – Average Annual Functional Capacity Units

AAHUs – Average Annual Habitat Units

AgACIS – Agricultural Applied Climate Information System

AOP – Aquatic Organism Passage

AM&M – Adaptive Management and Monitoring

CE/ICA – Cost Effectiveness and Incremental Cost Analysis

CEW – Council on Environmental Quality

CMP – Coastal Management Plan

CSC – Climate Smart Communities

CSOs – Combines Sewer Overflows

CZM – Coastal Zone Management

EFH – Essential Fish Habitat

EPW – Evaluation of Planned Wetlands

EQ – Environmental Quality

FCI – Functional Capacity Index

FCU – Functional Capacity Units

FCSA – Feasibility Cost Share Agreement

FIRM – Flood Insurance Rate Map

FR/EA –Feasibility Report and Environmental Assessment

FWOP – Future Without Project Conditions

GIGP – Green Innovation Grant Program

GOSR – Governor's Office of Storm Recovery

HR CRP – Hudson River Comprehensive Restoration Plan

HRHR – Hudson River Habitat Restoration

HTRW – Hazardous Toxic and Radioactive Waste

HU – Habitat Units

LERRD – Lands, Easements, Right-of-Ways, Relocations, and dredge or excavation Disposal areas

LWRP – Local Waterfront Revitalization Program

NAAQS – National Ambient Air Quality Standards

NED – National Economic Development

NEPA – National Environmental Policy Act

NER – National Ecosystem Restoration

NGOs – Non-governmental Organizations

NMFS – National Marine Fisheries Service

NRCS – Natural Resources Conservation Service

NYRCR – New York Rising Community Reconstruction Program

NYSDEC – New York State Department of Environmental Conservation

NYSDOS – New York State Department of State

NYSDOT – New York State Department of Transportation

NWI – National Wetlands Inventory

NWS – National Weather Service

O&M – Operations and Maintenance

OMRR&R – Operations, Maintenance, Repair, Rehabilitation, and Replacement

OSE – Other Social Effects

P&G – Planning and Guidance

PCBs – Polychlorinated biphenyls

PCE – Tetrachloroethene

PEC – Probable Effect Concentration

PED – Pre-construction Engineering and Design

PPA _ Project Partnership Agreement

RCRA – Resource Conservation Recovery Act

RED – Regional Economic Development

SASS – Scenic Areas of Statewide Significance

SCFWH – Significant Coastal Fish and Wildlife Habitats

SPDES – State Pollution Discharge Elimination System

SVOCs – Semi-Volatile Organic Compounds

TEC – Threshold Effect Concentration

TSP – Tentatively Selected Plan

USACE – U.S. Army Corps of Engineers

USCB – U.S. Census Bureau

USFWS – U.S. Fish and Wildlife Service

VOCs – Volatile Organic Compounds

WRDA – Water Resources Development Act

WRRDA – Water Resources Reform and Development Act

WUCT – Watershed-Scale Upstream Connectivity Toolkit

Chapter 1: Introduction

1.1 Overview

In this Draft Integrated Feasibility Report and Environmental Assessment (FR/EA), the U.S. Army Corps of Engineers (USACE) recommends and assesses solutions to restore degraded significant ecosystem function, structure, and dynamic processes in the Hudson River basin. The FR/EA is the decision document for the Hudson River Habitat Restoration (HRHR) Ecosystem Restoration Feasibility Study, and also documents the compliance of the study and recommended solutions with all applicable environmental requirements, including the National Environmental Policy Act (NEPA). The non-federal sponsors of the study are the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of State (NYSDOS).

Figure 1-1: Study Area

This study complements the Hudson River Comprehensive Restoration Plan (Partners Restoring the Hudson, 2018), as well as the Hudson-Raritan Estuary Comprehensive Restoration Plan (USACE, 2016) and Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study (USACE, 2017), within the Harbor & Estuary Program boundaries, and the NYSDEC Hudson River Estuary Habitat Restoration Plan (Miller, 2013). This study considers the Hudson River upstream of the Governor Mario M. Cuomo (formerly Tappan Zee) Bridge, to Troy Lock and Dam, a length of about 125 miles) (Figure 1-1). The Hudson-Raritan Estuary study, for its part, considers the Hudson River and other water bodies downstream of the bridge, in the area encompassed by a 25-mile radius around the Statue of Liberty National Monument.

1.2 Study Authority and History

A reconnaissance study preceded this feasibility study. The reconnaissance study, which USACE conducted from 1994 to 1996, was authorized by section 216 of the Rivers and Harbors Act of 1970 and a resolution of the U.S. Senate Committee on Environment and Public Works dated 21 January 1987, which reads:

Resolved by the Committee on Environment and Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors is requested to review previous reports on the Hudson

> *River Channel, New York City to Albany, contained in House Document No. 228, 83rd Congress, 2nd session, dated September 3, 1954, with a view towards improving the existing Federal navigation project, providing anchorages and necessary spur channels.*

The reconnaissance report identified ecosystem restoration problems and opportunities in the Hudson River basin, identified a federal interest in ecosystem restoration in the river basin, and recommended that the study continue into the feasibility phase.

The feasibility study was authorized by section 551 of the Water Resources Development Act of 1996:

> *(a) Habitat Restoration.–The Secretary shall expedite the feasibility study of the Hudson River Habitat Restoration, Hudson River Basin, New York, and may carry out not fewer than 4 projects for habitat restoration in the Hudson River Basin, to the extent the Secretary determines such work to be advisable and technically feasible. Such projects shall be designed to–*
>
> > *(1) assess and improve habitat value and environmental outputs of recommended projects;*
> > *(2) evaluate various restoration techniques for effectiveness and costs;*
> > *(3) fill an important local habitat need within a specific portion of the study area; and*
> > *(4) take advantage of ongoing or planned actions by other agencies, local municipalities, or environmental groups that would increase the effectiveness or decrease the overall cost of implementing one of the recommended restoration project sites.*
>
> *(b) Non-Federal Share. – Non-Federal interests shall provide 25 percent of the cost of each project undertaken under subsection (a). The non-Federal share may be in the form of cash or in-kind contributions.*
>
> *(c) Authorization of Appropriations. – There is authorized to be appropriated to carry out this section $11,000,000.*

In 1996, USACE executed a Feasibility Cost Sharing Agreement (FCSA) with the non-Federal sponsors for the feasibility study, NYSDEC and NYSDOS, and the study began in 1998. In 2001, the four sites the feasibility study had focused on became unavailable, and the study was put on hold due to lack of consensus on a path forward.

Interest in restoring the Hudson River was renewed in 2012 and the NYSDEC Commissioner Joseph Martens requested that USACE resume the study. In 2013, anticipating the study's resumption, *The Nature Conservancy* organized stakeholders including non-governmental organizations, state and federal agencies (including USACE, NYSDEC, and NYSDOS), and research institutes, as the "Partners Restoring the Hudson," to begin developing a comprehensive restoration plan for the river. A rescoping charette for the feasibility study was held with USACE, NYSDEC, NYSDOS, and partners in March 2014 and the study was resumed in February 2016.

1.3 Purpose and Need

The Hudson River flows southward 315 miles, from Lake Tear of the Clouds in the Adirondack Mountains in northeastern New York, past New York City, to the New York-New Jersey Harbor (**Error! Reference source not found.**). The river basin drains 13,400 square miles. The river is tidally influenced to Troy, with a saltwater front typically detected between West Point and Newburgh, or as far upstream as Poughkeepsie during drought conditions.

The population in the Hudson River valley began to grow at the end of the American Revolution. Navigation improvements to the river and the introduction of railroad travel in 1851 accelerated the valley's development. Industrial development along the river, such as brick and cement manufacturing, was followed by the arrival of vacationers and eventually, commuters.

Error! Reference source not found.**: Hudson River Basin**

The Hudson River has long been used for shipping and transportation. USACE began modifying the river to improve navigability after the Erie Canal, which linked the Hudson River to the Midwest, was completed in 1825. USACE constructed Troy Lock and Dam on the river at Troy, New York in 1915, and currently maintains the river downstream of the lock and dam to the bay for navigation purposes.

As a primary USACE Civil Works mission, the overarching objective of the Corps' ecosystem restoration mission is "to restore significant ecosystem function, structure, and dynamic processes that have been degraded" (ER 1165-2-501), with an intent "to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system" (EP 1165-2-502).

USACE's interest in Hudson River restoration stems from dramatic losses of regional ecosystems, impacts USACE's navigation mission has had on the river's ecosystems, the national significance of those ecosystems, and the potential USACE, working alongside NYSDEC, NYSDOS and other partners, has to measurably improve degraded ecological resources in the river basin. A total of approximately 4,000 acres of aquatic habitats including shallow, intertidal and wetland habitats were lost. Of that, about 3,300 acres were lost to filling (converted to upland habitats) and the remaining were lost to deepening (shallows defined as less than six feet deep at low tide were dredged and deepened). In addition, more than 85% of the islands accounting for much of the 71 miles of shoreline were eliminated. Most of this loss and impact occurred in the upper third of the estuary. Dredging and filling also occurred along the shores of the Hudson to accommodate transportation and industrial activities, especially around population centers. Additionally, there are more than 1,600 dams and thousands of culverts in the Hudson River's 90 tributaries, which have significantly reduced available habitat for American eel and other migratory species (Partners Restoring the Hudson, 2018) and serve as impediments to fish passage. The environment, problems, and opportunities in the study area are described in more detail in Chapter 2: Affected Environment and Chapter 3: Plan Formulation.

This FR/EA recommends five ecosystem restoration projects for USACE involvement in the study area at this time. Ecological degradation in the study area is significant, and additional projects will be needed to address the full scope of ecological challenges. This study and its recommendations are an interim response to the study authority. USACE will continue coordinating with other agencies and organizations to avoid duplication and leverage resources to restore the Hudson River as outlined in the Hudson River Estuary Habitat Restoration Plan and the Hudson River Comprehensive Restoration Plan. The existing study authority allows for new, spin-off feasibility studies with new Feasibility Cost Sharing agreements (FCSAs).

1.4 Study Partners and Stakeholders

NYSDEC and NYSDOS are the non-federal sponsors of this study. The ‘Partners Restoring the Hudson’ (Partners), in addition to USACE, NYSDEC, and NYSDOS, include many public agencies, non-profit organizations, and academic and research institutions that contributed their expertise to this study. The Partners have been involved since the early stages of this study, and together developed the Hudson River Comprehensive Restoration Plan, which was released in August 2018. The recommendations in this FR/EA advance that plan’s restoration goals, as well as the NYSDEC Hudson River Estuary Action Agenda and NYSDEC Hudson River Estuary Habitat Restoration Plan. The following Partners participated in this study:

- NYSDEC Hudson River Estuary Program (HREP) Management Advisory Committee
- Hudson River National Estuarine Research Reserve
- Hudson River Valley Greenway
- New York - New Jersey Harbor and Estuary Program
- NOAA Restoration Center
- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency
- Cornell Cooperative Extension Columbia and Greene Counties
- Cornell Cooperative Extension of Dutchess County
- Historic Hudson River Towns
- Hudson River Boat & Yacht Club Association
- Hudson River Foundation
- Hudson River Watershed Alliance
- Riverkeeper
- Scenic Hudson
- The Nature Conservancy
- Center for International Earth Science Information Network, Columbia University
- Cary Institute of Ecosystem Studies
- Regional Plan Associates

Additional stakeholders are those who live in and visit the study area and others who may be affected by the study’s recommendations, as well as the organizations that represent their interests, including federal, tribal, state, and local governments and various non-governmental organizations. The congressional districts in the study area and their representatives are shown in Table 1-1.

Table 1-1: Study Area's Congressional Districts.

SENATORS	REPRESENTATIVES
Chuck Schumer (D)	Nita Lowey (D) 17th District
Kirsten Gillibrand (D)	Sean Maloney (D) 18th District
	Antonio Delgado (D) 19th District
	Paul Tonko (D) 20th District

1.5 Prior Reports and Existing Water Resource Projects and Programs

Prior reports on the Hudson River related to ecosystem restoration include:

- Hudson River Habitat Restoration, Hudson River Basin, New York Reconnaissance Report (USACE, 1996)
- Rondout Creek and Wallkill River, Watershed Reconnaissance Report (USACE, 2008)
- Esopus and Plattekill Creeks, Watershed Reconnaissance Report (USACE, 2008)
- Hudson River Estuary Habitat Restoration Plan (Miller, 2013)
- Hudson River Estuary Action Agenda (NYSDEC, 2015)
- Hudson River Comprehensive Restoration Plan: Recommendations for the New York–New Jersey Harbor & Estuary Program Action Agenda and the New York State Hudson River Estuary Action Agenda. (Partners Restoring the Hudson, 2018)
- Hudson-Raritan Estuary Comprehensive Restoration Plan (USACE, 2016)

Existing USACE water resources projects in the study area (Figure 1-3) and additional partner programs include:

- Hudson River, New York City to Waterford, New York, Maintenance Dredging
- Hudson River, New York, Operations & Routine Maintenance of Troy Lock & Dam
- Saugerties Harbor, New York, navigation channel
- Rondout Harbor, New York, navigation channel and channel dikes
- City of Kingston Waterfront, Planning Assistance to States
- Wappinger Creek, navigation channel
- Peekskill Harbor, navigation channel
- Tarrytown Harbor, navigation channel
- NY/NJ Harbor and Tributaries Study, coastal storm risk management
- Partner Programs including:
    - NYSDEC Hudson River Estuary Program
    - NYSDEC Hudson River National Estuarine Research Reserve
    - NYSDEC Hudson River Fisheries Unit
    - The Hudson River Valley Greenway
    - The Hudson River Valley National Heritage Area
    - American Heritage River
    - New York-New Jersey Harbor Estuary Program

Figure 1-2: Existing USACE Water Resource Projects

The ongoing navigation projects within the study area do not affect this restoration study. Dredged material is currently placed at a disposal facility on Houghtaling Island south of Schodack Island State Park. The NY/NJ Harbor and Tributaries study (HATS) is currently evaluating solutions for coastal storm risk management within the HRHR study area. These studies are being coordinated and would yield recommendations that are complementary. The HATS study will consider the restoration proposed herein as potential Natural and Nature Based Features (NNBFs) which could provide secondary CSRM benefits to the communities.

1.6 Report Contents

This report describes environmental conditions in the study area, formulation of restoration plans, a Tentatively Selected Plan for USACE action, and the environmental and cumulative impacts of that plan. The EA components of the report (Chapters 5 and 6 and Appendix G) were prepared to comply with NEPA requirements. NEPA requires federal agencies to “provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact” on actions authorized, funded, or carried out by the federal government, to ensure such actions adequately address “environmental consequences, and take actions that protect, restore, and enhance the environment." This report informs decision makers and the public about affected environmental resources and the potential benefits and impacts to those resources that would result from constructing, operating, and maintaining the recommended ecosystem restoration projects.

Chapter 2: Existing Environment in the Hudson River Valley*

2.1 Introduction

This chapter will discuss the existing environment of the Hudson River valley in an overview from Governor Mario Cuomo Bridge to Troy Lock and Dam. For site-specific existing environmental conditions and impacts please see Chapter 5: Existing Environmental Conditions and Environmental Impacts*. In addition, the site-specific Future Without Project Condition (FWOP) for each category is presented in Tables 5-1 through 5-6.

2.2 General Description

The Hudson River's origin is Lake Tear of the Clouds in the Adirondack Mountains at an elevation of 4,322 feet above sea level. From here the river flows southward 315 miles to New York City and the Hudson Raritan Estuary. The Hudson River Valley lies almost entirely within the state of New York, except for its last 22 miles, where it serves as the boundary between New York and New Jersey. Tributaries to the river drain small portions of Connecticut, Massachusetts, New Jersey, and Vermont.

The 125-mile study area concentrates on the environmental habitat restoration problems and opportunities in the Hudson River ecosystem associated with the existing federal channel. The authorized channel extends from New York City, NY upstream to the federal lock and dam at Troy, NY. The river is tidal throughout the study area, with detectable salinity reaching as far north as Poughkeepsie, NY (Hudson River Mile (HRM) 75 – the Battery is HRM 0) during periods of low freshwater discharge.

2.3 Physical Setting

The climate of the study area is characterized by long, cold winters and short warm summers. The mean annual temperature for this region is approximately 40° F. The normal annual temperature during the winter months is about 25° F, and during the summer months it is about 70° F to 75° F. Annual precipitation, in rainfall, for this region is approximately 41 inches. This area receives about 10.5 inches of precipitation during the spring and again in the fall, about 9 inches during the winter, and 11.5 inches during the summer. The mean annual snowfall for the entire Hudson River Basin varies from about 100 inches in the northern regions to about 20 inches in the lower reaches near New York City. Storms occurring in this region are transcontinental and extratropical. The transcontinental storms come from the Gulf of Mexico and the west, often in the spring, while tropical storms generally occur in the fall, from the Atlantic Ocean. Thunderstorms and cloudbursts usually occur during the summer months.

The winds of this region of the Hudson River lie in a belt of prevailing westerlies; however, physiographic features orient a large percentage of the winds in a north-south direction. Direction of the winds during the winter months is from the north and in the summer months from the south. The average wind velocity in the Hudson River Valley is 10 mph. Maximum velocities are experienced during hurricanes, with winds of 75-mph or greater.

The topography of this reach of the Hudson River and its surrounding area is quite different from the basin upstream of the existing federal channel. The stream gradient for this reach of the river is slight, dropping only five feet in 155 miles. Flowing in an almost straight southerly direction, the river basin is bounded on the west by the Catskill Mountains and on the east by the Taconic Mountains. A major topographic feature of the central portion of this region is the Hudson Highlands, the cliffs of which rise directly from the river.

The entire Hudson River drainage basin covers approximately 13,000 sq. mi and includes 3 major sub-basins: Upper Hudson (4,627 sq. mi), Mohawk (3,463 sq. mi) and Lower Hudson (4,940 sq. mi).

2.4 Geotechnical Setting

The Hudson River Valley is a north-south trending linear lowland, extending from New York City to the Adirondack Mountains. The Highlands Gorge in the Peekskill, NY area geographically subdivides the study area into two sections. Both sections are geographically within the Hudson River estuary, but for the purpose of this document the two sections will be called the river valley section and the estuary section. The river valley section extends from Albany to Cornwall-on-the-Hudson, NY. The estuary section extends from Troy Lock and Dam south to the Battery. Although the Hudson River is considered an antecedent stream, many changes in the river's course appear to be controlled by fault zones or by contact with erosion-resistant rocks.

2.4.1 Bedrock

From just south of Albany to Kingston the Hudson River Valley is relatively narrow and steep-walled. The Catskill Mountains lie to the west and the lower Taconic Mountains lie to the east. This section of the river valley is predominantly underlain by Ordovician shale and sandstone with some chert and siltstone. Some Cambrian shale, conglomerate, and limestone are also present.

South of Kingston the valley widens and the river deepens. The Catskill Mountains withdraw to the west. The most common rocks underlying the valley from Kingston to just below Poughkeepsie are Ordovician graywacke, shale, siltstone, chert, and argillite of the Austin Glen, Indian River, Mt. Merino, and Normanskill Formations.

At Cornwall-on-the-Hudson the river valley narrows into a deep steep-sided gorge or fjord with water depths up to 200 feet. Here the river enters the rugged low mountains of the Hudson Highlands. The rocks of the Highlands are predominantly erosion resistant Precambrian and Cambrian metamorphic rocks. Just south of the Highlands, the river passes through the Cortlandt Complex of intrusive rocks.

After passing through the Hudson Highlands the river widens again. As in the Highlands, most of the valley is submerged, forming an estuary. From Stony Point, NY south the river follows the contact between the Triassic rocks of the Newark Basin and the Lower Paleozoic/Precambrian rocks of the Manhattan Prong until it reaches the Hudson Raritan Estuary.

2.4.2 Sediments

Most unconsolidated sediment deposits found in the river valley are the result of glacial and postglacial depositional episodes. Differences in local patterns of deglaciation are responsible for the present location of the various glacial deposits. North of Kingston the river bottom sediments are predominantly sands and sandy silts. A deposit of Quaternary glacial and alluvial deposits conceals the bedrock at Hudson, NY. Clean sands are common in this area. From Saugerties, NY to Kingston the bottom sediments become finer. Between Kingston and Peekskill few streams enter the river and the sediment deposits are generally fine grained. Sediment studies have shown that the river is not carrying coarse grained sediments through the Highlands Gorge. The sediments from Haverstraw Bay to the New Jersey - New York State boundary are clayey silts or sandy clayey silts. From this point south the sediments coarsen appreciably. The coarse fraction of the sediments is probably locally derived, although some may be supplied by the flood tide from New York Bay.

2.5 Water Resources

The Hudson River channel runs nearly straight north and south except for a few sharp bends through the Hudson Highlands. From Troy to Newburgh, the river is generally less than 3/4 mile wide. The river widens at Newburgh Bay, narrows again through the Hudson Highland Gorge, becomes its widest through the shallow bays of Haverstraw Bay and the Governor Mario Cuomo Bridge and remains narrow until it empties into upper New York Harbor at the Battery (Limburg et al., 1986., U.S. of Dept. of Commerce, 1982).

Over the 150 miles from the Troy Lock and Dam to the Battery, New York City, the river gradient is small, only 5 feet, and the river bottom at Albany is at sea level (Limburg et al., 1986, Cooper et al., 1988). This stretch of the river is really a drowned river valley. Intruding sea water flooded the lower river as the last glaciers melted and sea level rose. Tidal freshwater can be found from Troy south to the Poughkeepsie area, however, it is considered saline by regulatory agencies (NOAA, NYSDOS) only downstream of Poughkeepsie.

Freshwater flow in the estuary follows a typical seasonal pattern for temperate climates, with the highest flows occurring during the spring and the lowest flows occurring during late summer, early fall, and mid-winter. Approximately 80% of the fresh water in the estuary enters the river upstream of Troy Lock and Dam, with the remaining 20% being introduced through the estuary's tributaries (Limburg et al., 1986). Hudson River tributaries including Stockport Creek, Catskill Creek, Roeliff Jansen Kill, Esopus Creek, Rondout Creek, Moodna Creek and Wappingers Creek are just a few tributaries that contribute significant freshwater and sediment to the system. Freshwater flow into the estuary is partly regulated through releases from the Sacandaga Reservoir, located in the southern Adirondack Mountains. The average annual freshwater flow at the Green Island Gauging Station, just north of Troy is 13,820 cubic feet/second (cfs). Lower Hudson River freshwater flows have been estimated at 19,000 to 20,000 cfs. In the New York Harbor area, additional freshwater enters the system through New York City's sewage treatment plants and the Hackensack, Passaic and Raritan Rivers. The mean tidal flow varies from 425,000 cfs at the Battery to zero at the Troy Lock and Dam, and can be 10 to 100 times greater than the freshwater flow (Limburg et al., 1986).

The tide is semidiurnal, meaning that two high tides and two low tides occur each day. The average tidal range is greatest at the Battery and Troy (4.4 feet) and is least at West Point, NY (2.5 feet; Limburg et al., 1986). Tidal range and flow are affected by freshwater flow, wind, variations in the lunar cycle and ocean storms. While the tidal regime of the estuary essentially reverses the current direction twice each day, strong winds from the south or north can push water into or out of the estuary, obscuring the true tidal regime (Barnthouse et al., 1988).

The currents in the Hudson River are influenced by the same variables that affect the tides. The times of slack water and the velocities and durations of flood and ebb are subject to extensive changes; the times of strengths are less likely to be affected. Near the Troy Lock and Dam, the current does not flood and the velocity of the downstream flow during ebb tide is 0.7 knots. These values are for the summer when the freshwater discharge is at a minimum.

The interaction between salt water and freshwater is a key feature of the estuary. Dense salt water from the ocean flows up the river where it meets less dense fresh water flowing downstream. Where the two mix, a diffuse wedge of intruding salt water forms. This mixing of salt and freshwater creates a salinity gradient measured in parts per thousand (ppt) which can be grouped into three basic salinity zones within the estuary: polyhaline (18-30 ppt), brackish (includes oligo- and mesohaline 0.5-18ppt) and tidal fresh (<0.5ppt; Limburg et al., 1986). The location of the zones varies with daily tides and seasonally. Under average runoff conditions the limit of salt water intrusion can usually be found 50 to 60 miles north of the Battery, between West Point and the Newburgh area. In general, seasonal patterns in freshwater flow cause saline water to move upriver in the summer and early fall and to move southward in the winter and spring. During periods of very high freshwater flow the salt front can be pushed as far south as the Bronx in New York City (HRM 15) while during drought periods the salt front has approached the Poughkeepsie area (HRM 75). Measurable salt water reached Kingston, 100 miles north of the Battery during the 1965-66 drought (Limburg et al., 1986).

Tidal forces, irregularities in the channel's bottom and river depth affect the mixing of salt and fresh water. The resulting condition is a vertical as well as horizontal salinity gradient. Measurements of vertical gradients of salinity show that during low flow conditions, salt water and fresh water are generally well mixed, while under high flow conditions, freshwater tends to override the denser salt water layer. Parallel shallow areas may receive less salt water, have delayed mixing and experience reduced ranges in salinity (Limburg et al., 1986).

Dissolved oxygen tends to be highest during the late winter and early spring months, when the river is coolest and least saline. During summer, warmer waters contain lower levels of dissolved oxygen due to a lower saturation point throughout much of the estuary. In general, oxygen levels drop south of Albany, recover and peak near Saugerties, decrease slightly through the Highlands, then rise again south of Peekskill and are high in Haverstraw Bay and the Tappan Zee. Levels drop past Yonkers and remain low throughout the New York City area due to biological oxygen demand associated with sewage inputs (Limburg et al., 1986). Typical dissolved oxygen levels are between 5 and 14 milligrams/liter (Barnthouse et al., 1988).

The essential nutrients of phosphorus, nitrogen and carbon play important roles in the productivity of aquatic systems and their sources and fates have been closely studied over the years. Phosphorus enters the Hudson estuary from a variety of sources, including natural ones (organic detritus), non-point source runoff, and sewage discharges. Phosphorus inputs are greatest near the mouth of the river due to combined sewer overflows and sewage treatment plant effluent from the greater NY-NJ metropolitan area (Limburg et al., 1986).

The lower estuary easily meets the phosphorous requirements for the growth of algae and microscopic plants that form the base of an important estuarine food chain. Because natural levels of phosphorous are high relative to demand, phosphorus is not a limiting factor for biological productivity, and biological uptake does not control phosphorus levels. In the freshwater portion of the estuary, although dissolved organic and particulate phosphorus remain high throughout the year, the more usable form, phosphate, varies seasonally, with the lowest values occurring in late summer. Phosphate may, at these times, limit net algal growth in the upper portion of the estuary (Cole, et al., 1991, 1992).

Sources of nitrogen for the estuary include precipitation, decomposition of organic matter, surface and groundwater discharge and nitrogen fixation both in water and in sediments. Nitrogen enters the estuary in the forms of ammonia, nitrate, nitrite and organic nitrogen. Nitrogen is lost from the estuary through outflows from the basin, bacterial denitrification, through burial of nitrogen-containing compounds in the sediments and as water flows into the Atlantic Ocean (Limburg et al., 1986).

The availability of organic carbon drives and controls total food chain productivity. Organic carbon inputs into the Hudson estuary include both autochthonous sources (originating within the river) and allochthonous sources (originating outside the river). The relative contribution of various sources to the overall carbon budget varies with seasonal changes in water flow. During periods of high flow, the allochthonous contribution from both the upper and lower Hudson River watershed areas can be three times the contribution from instream phytoplankton and macrophytes (Howarth, et al., 1991). By contrast, phytoplankton, submerged vegetation, contributions from tidal wetlands and sewage become the major sources of organic carbon during the summer, when river flows decrease and watershed inputs decline (Limburg et al., 1986).

2.6 Ecological Communities

The Hudson River contains many distinct ecological communities, or assemblages of interacting plant and animal populations that share a common environment (Reschke, 1990). The communities are part of the estuarine system which includes the deepwater tidal habitats and adjacent tidal wetlands. Adjacent freshwater creeks and upland forest feed into, and are a part of, the Hudson River ecosystem.

Over 2,400 acres of tidal freshwater wetlands occur along the Hudson estuary between the Troy Lock and Dam and Haverstraw Bay. The Hudson River is one of only a dozen areas in the northeastern U.S. with more than 500 acres of tidal freshwater marsh and is the only such area in New York State. Tidal freshwater wetlands are highly productive biological communities, characterized by near freshwater conditions (average annual salinity of 0.5 ppt or below except during extended periods of drought), plant and animal communities dominated by freshwater species, and a semi-diurnal lunar tidal fluctuation (Swift, 1987).

Over 16,500 acres in the estuary from Albany-Rensselaer to Rockland-Westchester counties have been inventoried and designated `significant coastal fish and wildlife habitat' by NYSDEC and NYSDOS. In addition, the New York Natural Heritage Program has identified numerous significant sites along the estuary where rare species or natural communities occur.

2.6.1 Fishes

Fish common to the estuary can be grouped according to the habitat in which they reproduce. Anadromous species are marine forms that move inshore to spawn in freshwater but will spend most of their lives in salt water. Important species include: Atlantic sturgeon (*Acinpenser oxyrinchus oxyrinchus*), shortnose sturgeon (*Acipenser brevirostrum*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), alewife (*Alosa pseudoharengus*), and blueback herring (*Alosa aestivalis*). One species, the American eel (*Anguilla rostrata*), is catadromous, adults spawn at sea and the young mature in the estuary then travel upriver into the tributaries to live as adults. Marine fish, such as Atlantic menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), winter flounder (*Pseudopleuronectes americanus*), and summer flounder (*Paralichthys dentatus*), hatch and live in the sea but move inshore to feed in low-salinity waters during their first year of life. Resident species include two types: estuarine fishes which are marine but spawn and spend most if not all of their lives in the brackish portion of the estuary, such as white perch (*Morone americana*), bay anchovy (*Anchoa mitchilli*), hogchoker (*Trinectes maculatus*), tomcod (*Microgadus tomcod*) and shortnose sturgeon (*Acipenser brevirostrum*), and freshwater fishes which primarily spend their lives in the freshwater reaches of the river but may spend time in brackish areas as well, such as white bullhead (*Ameiurus catus*), black bass (*Micropterus salmoides*), and brown bullhead (*Ameiurus nebulosus*).

2.6.2 Birds

The Hudson River corridor is part of the Atlantic Flyway, one of four major avian migratory routes in North America. Spring migration occurs along the estuary in February - May; fall migration occurs in September - November. Concentrations of mixed waterfowl can be seen resting and feeding in shallow areas such as Stockport Flats, Tappan Zee, Esopus Meadows, and the flats north of Kingston. Dabbling ducks often congregate in shallows supporting beds of water celery (*Vallisneria americana*). A variety of diving ducks overwinter on open water portions of the estuary, feeding on small fishes such as killifish, shellfish and crustaceans. Herons and egrets commonly feed in sub-tidal shallows during late summer and early fall. Birds of prey are seen circling above the river feeding on fishes and small mammals. The estuary's marshes provide nesting habitat for a limited number of songbirds.

Table 2-1: Common Avian Species in the Hudson River Valley.

Common Name	Scientific Name	Common Name	Scientific Name
Marsh wren	*Cistothorus palustris*	American bittern	*Botaurus lentiginosus*
Red-winged blackbird	*Agelaius phoeniceus*	Spotted sandpiper	*Actitis macularia*
Swamp sparrow	*Melospiza georgiana*	Common snipe	*Gallinago galligano*
Virginia rail	*Rallus limicola*	Greater yellowlegs	*Tringa melanoleuca*
Yellow warbler	*Dendroica petechia*	Belted kingfisher	*Ceryle alcyon*
Song sparrow	*Melospiza melodia*	Eastern kingbird	*Tyrranus tyrannus*
Willow flycatcher	*Empidonax traillii*	Tree swallow	*Tachycineta bicolor*

Common Name	Scientific Name	Common Name	Scientific Name
Common yellowthroat	*Geothylpis trichas*	Grey catbird	*Dumetella carolinensis*
American goldfinch	*Carduelis tristis*	Common grackle	*Quiscalus quiscula*
Mute swan	*Cygnus olor*	Pied-billed grebe	*Podilymbus podiceps*
Canada goose	*Branta canadensis*	Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*	American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*	Least bittern	*Ixobrychus exilis*
Wood duck	*Aix sponsa*	Virginia rail	*Rallus limicola*
Great Blue heron	*Ardea herodias*	King rail	*Rallus elegans*
Green-backed heron	*Butorides striatus*	Sora	*Porzana carolina*
Least bittern	*Ixobrychus exilis*	Common moorhen	*Gallinula chloropus*
Cerulean warbler	*Setophaga cerulea*	Wood thrush	*Hylocichla mustelina*
Hermit thrush	*Catharus guttatus*	Blue jay	*Cyanocitta cristata*
Yellow-throated vireo	*Vireo flavifrons*	American crow	*Corvus brachyrhynchos*
Red-eyed vireo	*Vireo olivaceus*	Black-capped chickadee	*Poecile atricapillus*
Warbling vireo	*Vireo gilvus*	Tuffted titmouse	*Baeolophus bicolor*
Blue-headed vireo	*Vireo solitarius*	White-breasted nuthatch	*Sitta carolinensis*
Carolina wren	*Thryothorus ludovicianus*	Gray catbird	*Dumetella carolinensis*
American robin	*Turdus migratorius*	Cedar waxwing	*Bombycilla cedrorum*
Eastern bluebird	*Sialia sialis*	Ovenbird	*Seiurus aurocapilla*
Yellow-rumped warbler	*Setophaga coronata*	Northern parula	*Setophaga americana*
Blue-winged warbler	*Vermivora cyanoptera*	Yellow warbler	*Setophaga petechia*
Black-throated blue warbler	*Setophaga caerulescens*	Black and white warbler	*Mniotilta varia*
Black-throated green warbler	*Setophaga virens*	Great crested flycatcher	*Myiarchus crinitus*
Olive-sided flycatcher	Contopus cooperi	Alder flycatcher	*Empidonax alnorum*
Eastern wood-pewee	Contopus virens	Willow flycatcher	*Empidonax traillii*
Acadian flycatcher	Empidonax virescens	Eastern phoebe	*Sayornis phoebe*
Yellow-bellied sapsucker	Sphyrapicus thyroideus	Eastern kingbird	*Tyrannus tyrannus*

2.6.3 Reptiles and Amphibians

The most important habitats for reptiles and amphibians are the tidal marshes and shallows, woodland pools and ponds, and adjacent terrestrial forests. Tidal fluctuation and salinity prevent some species from living in the estuary itself. Reptiles found within the estuary include: snapping turtle (*Chelydra serpentina*), northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), spotted turtle (*Clemmys guttata*), common box turtle (*Terrapene Carolina*), wood turtle (*Glyptemys insculpta*), and five-lined skink (*Plestiodon fasciatus*). While amphibians are not abundant in the estuary, freshwater wetland areas provide important breeding habitat for amphibians such as peepers and other tree frogs.

2.6.4 Mammals

Mammals associated with the Hudson River valley include: muskrat (*Ondatra zibethicus*), American mink (*Neovison vison*), North American river otter (*Lontra canadensis*), whitetail deer (*Odocoileus virginianus*), white-footed mouse (*Peromyscus leucopus*), eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), meadow vole (*Microtus pennsylvanicus*), northern shorttail shrew (*Blarina brevicauda*), raccoon (*Procyon lotor*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), Virginia opossum (Didelphis virginiana) and North American beaver (*Castor Canadensis*).

2.6.5 Endangered and Threatened Species

The federal endangered and threatened species that utilize the Hudson River estuary as habitat include the federally endangered Indiana bat (*Myotis sodalis*) and dwarf wedgemussel (*Alasmidonta heterodon*) and the federally threatened Atlantic sturgeon, northern long-eared bat (*Myotis septentrionalis*) and bog turtle (*Clemmys muhlenbergii*). State endangered and threatened species include the Karner blue butterfly (*Lycaeides melissa samuelis*), shortnose sturgeon (*Acipenser brevirostrum*), bog turtle, peregrine falcon (*Falco peregrinus*), black rail (*Laterallus jamaicensis*), Indiana bat, least bittern (*Ixobrychus exilis*), northern harrier (*Circus cyaneus*), bald eagle (*Haliaeetus leucocephalus*) and northern long-eared bat.

2.6.6 Vegetation

Vegetation in the river varies depending on the salinity, depth of water, and currents. Typical submerged aquatic vegetation in the brackish subtidal community consists of native wild celery (*Vallisneria americana*) and clasping pondweed (*Potamogeton perfoliatus)* as well as nonnative Eurasian water milfoil (*Myriophyllum spicatum*) and curly pondweed (*Potamogeton crispus*).

Mudflat plant communities are often characterized with rosette structures (i.e., having leaves in a circular arrangement). The plant communities may include native awl-leaf arrowhead (*Sagittaria subulata*), kidneyleaf mud-plantain (*Heteranthera reniformis*), and soft-stemmed bulrush (*Scirpus validus*), and the non-native spatterdock (*Nuphar advena*).

The freshwater intertidal zone is characterized by native threesquare (Scirpus americanus), wild rice (*Zizania spp*.), pickerelweed (*Pontederia cordata*), cattail (*Typha* spp.), and jewelweed (*Impatiens capensis*), and non-native spatterdock common reed (*Phragmities spp*.) and purple loosetrife (*Lythrum salicaria*).

Terrestrial vegetation along the Hudson River in undeveloped areas is generally deciduous forest. Extensive areas of the river's shores are forested with oaks (*Quercus* spp.), maples (*Acer* spp.*)*, beeches (*Fagus spp.*), birches (*Betula spp.*), and pines (*Pinaceae* spp). Dry rocky slopes such as the Palisades Ridge and Hudson Highlands support oaks. Areas with deeper soils, generally located in the mid-upper reaches of the estuary, as well as moist ravines down river, support oaks, maples, tulips (*Liriodendroidae* spp.), birches, beeches, and dogwood (*Cornaceae* spp.).

2.7 Human Impacts and Ecosystem Degradation

USACE maintains a federal navigation channel in the Hudson River from Troy Lock and Dam to the New York-New Jersey Harbor, and periodically dredges the channel between Albany and New York City to a depth of 32 feet. There is currently an active dredged material placement area on Houghtaling Island on the southern part of Schodack Island State Park. The modifications that were made to the river for navigation, and the ecological impacts of these modifications, are described in Chapter 3: Plan Formulation. Other human impacts to the Hudson River and resulting ecosystem degradation are described below.

Numerous population centers of varying sizes are located along the river in the study area. The north end is flanked by the cities of Albany and Troy. Numerous smaller communities are located along both banks of the river to the southern Rockland-Westchester County lines. From here south, the greater New York Metropolitan area, with its estimated population of nearly 8 million people, dominates the shoreline of the estuary. As a result of the large population and need to protect property and land, over 10,100 acres of shoreline are engineered or hardened to limit erosion of sediment into the channel and prevent bank retreat (Partners Restoring the Hudson, 2018). Approximately 44% of the shoreline is engineered within the study area (http://gis.ny.gov/gisdata/inventories/details.cfm?dsid=1136).

Railroad tracks were constructed along both shores of the estuary, on the east to Rensselaer County and on the west to central Ulster County, during the 19th century (NYSDEC, 1988). The tracks cut off numerous shallow coves and bays at the mouths of tributaries from the river mainstem (Squires, 1992).

The Hudson River provides water for several communities and institutions within the study area. Among the communities which presently withdraw water from the river are the Village of Rhinebeck, NY, the City of Poughkeepsie, and the Highland and Port Ewen Water Districts. A pumping station in Chelsea, New York, which is capable of drawing water from the Hudson River, may be available to augment the water supply by 100 MGD under emergency conditions. The Hudson is also a source of industrial process water or once through cooling systems at power plants, obtained indirectly through municipal systems or from direct withdrawals.

Several major power generating facilities, manufacturing plants, petroleum terminals, cement and aggregate plants, as well as various mining operations, are located along the banks of the river. More recently, several resource recovery facilities that utilize river water for cooling have been built along the river. Many of the river's tributaries were historically dammed for industrial use. The dams eliminated access to spawning habitat for many anadromous fish, notably herring and shad.

Several decades of unregulated discharge of polychlorinated biphenyls (PCBs) from two General Electric capacitor manufacturing plants in the non-tidal river above Troy Lock and Dam contaminated sediments and has resulted in PCB uptake by Hudson Estuary biota, especially striped bass and other commercially and recreationally significant sportfish (Limburg et al., 1986). The U.S. Environmental Protection Agency (EPA) concluded that contaminated sediments in the upper Hudson River are a major source of PCBs for the entire river environment at least as far as New York Harbor (EPA, 1997b). The Contaminant Assessment and Reduction Project (CARP) identified the upper freshwater non-tidal portion of the Hudson River Superfund Site, which includes 200 miles of the Hudson River between Hudson Falls and the Battery, to be the dominant external source of PCBs to the New York/New Jersey Harbor Estuary, contributing about three-quarters of the PCB load below Troy Dam to the Atlantic Ocean, and modeling shows these PCBs are transported throughout the entire estuary, including Newark Bay (Suszkowski and Lodge, 2008). Studies conducted to evaluate the extent of the problem revealed that most of the contaminated sediments were in "hot spots" situated in a 40-mile stretch of the river between the town of Fort Edward and Troy Dam. In February 2002, the EPA issued a Record of Decision (ROD) for the Hudson River Superfund Site that called for targeted dredging of approximately 2.65 million cubic yards of PCB-contaminated sediments from this 40-mile section of the Upper Hudson River. A total of 2.75 million cubic yards of PCB-contaminated sediments were removed from the river bottom between 2009 and 2015 and monitoring is ongoing (USEPA, 2019).

Sewage plants located along tributaries to the river discharge treated effluent into the water. In the lower estuary, combined sewer overflows (CSOs) discharge untreated effluent that the overflowing system cannot handle during storm events, contributing a pulse of nutrients and toxic materials to the water.

Exotic zebra mussel introduced to the river in 1992 depleted the river's standing stock of phytoplankton and impacted other successive food chain components, including zooplankton.

The Hudson River is on the 303(d) List of Impaired Waters: Part 2b – Multiple Segment/Categorical Waterbody Segments Impaired due to Fish Consumption Advisories (USEPA, 2016a). The impairment extends up into the river's tributaries, to the first impassable barrier. The fish consumption advisories (do not eat, or limit consumption) NY State has issued are due to high levels of PCBs in fish in the river.

Despite the fish consumption advisories, the Hudson River is used for commercial and recreational fishing, as well as hunting and trapping along the river banks. The river is also used for boating and swimming, and as an outdoor laboratory for education and research.

Chapter 3: Plan Formulation

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. For the Hudson River Habitat Restoration study, plans were formulated by (1) defining problems, opportunities, objectives, and constraints, (2) identifying and screening restoration sites, (3) developing sets of site-specific management measures to address one or more of the planning objectives, (4) combining measures into alternative plans for each site and/or site component, (5) evaluating the plans' costs and benefits, (6) comparing the alternatives at sites or site components, (7) comparing the site alternatives within a restoration type (large mosaics, shoreline restoration, tributary connectivity), and (6) recommending the Tentatively Selected Plan (TSP).

Plans were formulated for this study in accordance with the requirements of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983); Planning Guidance Notebook (Engineer Regulation [ER] 1105-2-100; USACE 2000a); Project Modification for Improvement of the Environment and Aquatic Ecosystem Restoration (Engineer Circular [EC] 1105-2-214); Civil Works Ecosystem Restoration Policy (ER 1165-2-501); and Ecosystem Restoration Supporting Policy Information (Engineer Pamphlet 1165-2-502).

Supplementing the following description of the plan formulation process for this study is Appendix C - Plan Formulation.

3.1 Problems, Opportunities, Objectives, and Constraints

This section defines the problems and opportunities, objectives and constraints that guided plan formulation for this study.

3.1.1 Problems

As described in Chapter 2, human activity has led to the degradation of the Hudson River ecosystem. Developing and maintaining the Federal navigation project in the river, and development in the Hudson River valley, in particular, have altered the morphology and hydrology of the Hudson River, its side channels, and floodplain, resulting in the loss of valuable habitat for federally endangered fish species (shortnose sturgeon and Atlantic sturgeon), American shad, and striped bass, as well as many birds, mammals, and reptiles. Certain fish, bird and wildlife populations supported by the Hudson River estuary have declined to critically low levels over the past 70 years (Miller, 2013).

Modifications to the Hudson River for navigation began in 1790. USACE became involved in 1834, when Congress authorized a federal navigation project in the river. USACE currently maintains a federal navigation channel in the river between Troy, NY

(HRM 154.8) and the Battery in New York City (HRM 0). Modifications to the river for navigation in the study area, which extends from Troy Lock and Dam to the Governor Mario M. Cuomo Bridge, have generally included:

- Dams and dikes connecting islands to each other and the mainland and closing side channels
- Stone and timber revetments
- Removal of shoals and sandbars
- Channel deepening (1899: 12 feet, 1931: 27 feet, and 1954: 32 feet)
- Channel widening (up to 400 feet between Troy and Kingston and 600 feet between Kingston and New York City)
- Dredged material placement on and along river banks, on and between islands, in side channels, and in the river (creating new islands)
- Troy Lock and Dam
- Saugerties, Rondout, Peekskill, and Tarrytown harbors
- Entrance channels at Catskill and Wappinger creeks

A history of the federal navigation project, including specific alterations that were made to the Hudson River between 1790 and 1954, is contained in the Reconnaissance Report for this study (USACE, 1996). The modifications to the Hudson River that were made for the federal navigation project altered the river's ecosystems in several ways.

Dikes, dams, dredging and the placement of dredged material along river banks changed channel depths (Figure 3-1) and narrowed the river overall. This altered water velocity distributions in the river, disrupting the river's sediment regime, or the transport, supply, and storage of sediments in the river (USACE, 1996).

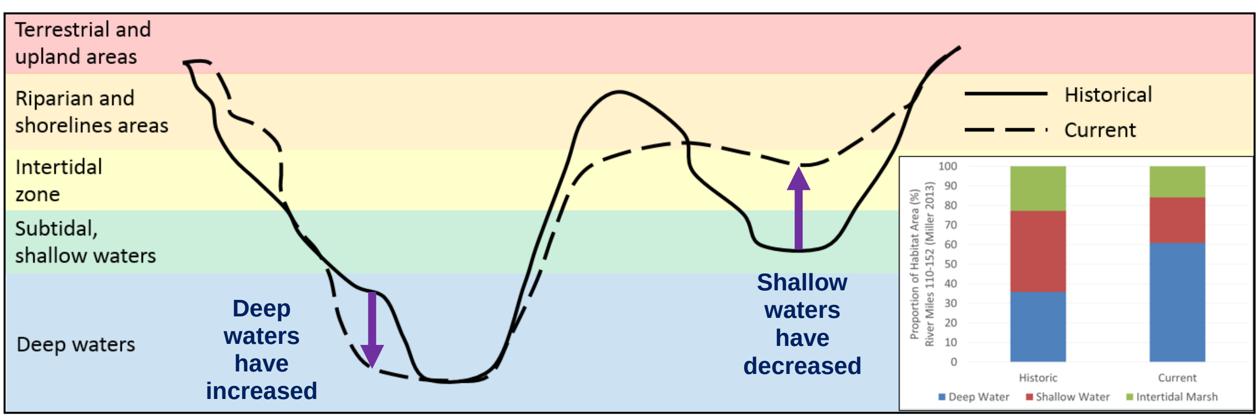


Figure 3-1: Example Historic and Current Cross-Section of the Hudson River.

Dikes, dams, and placement of dredged material along river banks, in between islands and the mainland, and in side channels, reduced both areas of open water and the amount of shallow water habitat in and near the river. The hydrologic connectivity between the river and its floodplain was reduced, over 85% of islands were lost (Figure 3-2) and most of the side channels in the upper portion of the study area were filled in. Placing dredged material in shallow water and marshes often induced habitat transitioning to high marsh or upland systems (USACE, 1996).

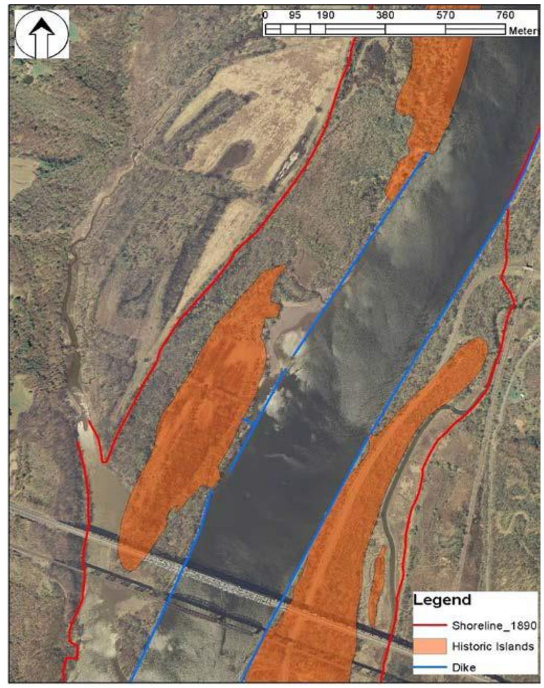


Figure 3-2: Example of Historic Islands Now Part of the Mainland; Castleton, NY (Source: NYSDEC, 2013).

Dikes, dams, dredged material placement, and revetments reduced the amount of shoreline by over 70 miles. Bulkheads and rip-rap were used to harden over 10,100 acres of shoreline (Partners Restoring the Hudson, 2018), which altered or eliminated natural shoreline functions, such as erosion and accretion and the maintenance of a dynamic ecotone between aquatic and riparian areas.

Historical dredging of the federal navigation channel and dredged material placement resulted in negative impacts to over 9,200 acres of habitats in general (Partners Restoring the Hudson, 2018) and the loss of nearly 4,000 acres of shallow water and intertidal habitat, including the near-complete elimination of side channels in the upper third of the estuary (Miller et al., 2006 A; Collins and Miller, 2011).

The extent and magnitude of infrastructure building that accompanied the development of the Hudson River valley also led to unintended ecological consequences. Over 1,600 dams were constructed in the Hudson River watershed, including on tributaries to the Hudson River. Disconnecting the river from its tributaries degraded the river's ecosystem, resulting in problems including the: fragmentation of migratory pathways for aquatic organisms such as river herring, sturgeon, and striped bass; disruption of migratory corridors for riparian and upland taxa; and reduced delivery of water, sediment, and nutrients. In addition, constructing railroad tracks along the Hudson River during the 19th century isolated tidal marshes and shallow estuarine coves from the main channel of the Hudson River, reducing the tidal exchange of water, and inhibiting fluxes of particulate materials and nutrients.

Two problem statements were developed from the problems described above, to guide plan formulation for this study:

1. Intertidal, shallow water, and shoreline habitats connected to the Hudson River have been degraded and reduced in area (e.g., over 9,000 acres of habitat were affected by USACE dredging and dredged material placement, nearly 4,000 acres of shallow water and intertidal habitat have been lost, and 44% of remaining shorelines are hardened).

2. Barriers on Hudson River tributaries have fragmented migration corridors for fish and birds and impaired the exchange of water, sediment, and nutrients.

3.1.2 Opportunities

Opportunities to address problems in the study area include:

- Restoring and/or creating sustainable intertidal, shallow water, and shoreline habitats with hydrologic connectivity to the Hudson River
- Removing barriers on Hudson River tributaries that prevent or impede fish passage and the exchange of water, sediment, and nutrients

Secondary opportunities associated with addressing the problems include using natural and nature-based features for coastal storm risk management and providing passive recreation.

3.1.3 Problems and Opportunities over Time

The period of analysis, or planning horizon, for this study is 50 years, from 2025, when the first construction season is assumed to end, to 2075. The future-without project condition describes how conditions in the study area will change over the period of analysis if no federal action is taken as a result of this study. The future-without project condition is the baseline to which the effects of alternative plans are compared.

The quality and area of some habitats in the Hudson River ecosystem are expected to improve slightly over the 50-year planning horizon. Ongoing, planned, and ad-hoc restoration and conservation projects, including small-scale fish passage projects in the watershed, by government agencies, municipalities, and non-governmental organizations, will result in small habitat gains. Additionally, General Electric's ongoing clean-up of PCBs, associated with the Hudson River Superfund Site, will continue to improve sediment quality in the river.

The degradation of the Hudson River ecosystem as a whole is expected to continue, with losses to the area and quality of riparian, wetland, and aquatic habitats. Periodic maintenance dredging of the federal navigation channel will continue; however, dredge material will be properly placed in designated confined disposal facility (e.g., Houghtailing Island). The Hudson River valley will also continue to be developed. Each time it occurs, dredging and/or filling will negatively impact submerged aquatic vegetation beds by changing water depths in the littoral zone, which also impacts water quality. Similarly, continuing shoreline erosion will negatively affect water quality, increasing turbidity and temperature and altering water depths in littoral zones, wetlands, and streams. Additionally, the range of invasive species already present in the Hudson River valley is expected to continue to expand within many of the Hudson River ecosystem's habitats. This will negatively affect the diversity and abundance of native plant, vertebrate, and invertebrate species in the river's ecosystem, with marsh-nesting birds disproportionately affected.

Rising sea levels may exacerbate the loss and degradation indicated above. Analysis indicates a rise of 6 to 34 inches by the year 2075. The future-without project condition, characterized by extensive reaches of hardened shorelines, reduced shallow water environments, diminished connectivity, and degraded sediment distribution processes will lack the resiliency to adequately adapt to such changes. Areas of wetlands will not be able to migrate due to space constraints. Sediment accretion rates in these wetlands will not be able to keep pace with rising water elevations and shallow waters will deepen, resulting in further habitat loss.

3.1.4 Objectives

Ecosystem restoration is one of the primary missions of USACE's Civil Works program. Guidance document ER 1165-2-501 states:

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

The federal objectives for ecosystem restoration differ slightly from the objectives for other USACE missions, in that the evaluation and comparison of alternative plans for restoration rely heavily on both monetary and non-monetary metrics. As such, ER 1165-2-501 states:

> *Consistent with the analytical framework established by the P&G, plans to address ecosystem restoration should be formulated and recommended, based on their monetary and non-monetary benefits. These measures do not need to exhibit net national economic development (NED) benefits and should be viewed on the basis of non-monetary outputs compatible with the P&G (Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies) selection criteria.*

The planning objectives, or the desired effects of alternative plans, that were developed based on the aforementioned problems and opportunities to guide plan formulation for this study, are to:

1. Restore a mosaic of interconnected, large river habitats, which together host a diversity of native taxa.
    - Increase the extent and quality of *subtidal, shallow water habitats* (e.g., submerged aquatic vegetation, side channels).
    - Increase the extent and quality of *intertidal habitats (*e.g., freshwater tidal marshes, mud/sand flats).
    - Promote *neighboring shoreline, riparian, and upland habitats* contributing to aquatic ecosystem integrity.
    - Promote a balanced *mosaic of habitat types*.
2. Restore lost ecological connectivity within the Hudson River and its tributaries.
    - Increase the connectivity of spawning, foraging, and resting habitats for *migratory fish* (e.g., shad, herring, eel, and sturgeon).
    - Increase the connectivity of stopover, nesting, and foraging habitat for *migratory and resident birds* from freshwater ecosystems to the ocean.
    - Promote actions improving the *transport regime* of water, sediment, and nutrients to the estuary.

3.1.5 Constraints and Other Considerations

Both universal and specific constraints limited the planning process for this study. Universal constraints include legal, regulatory, and policy requirements. Specific constraints (other than resource constraints) that were identified for this study include:

- Navigation: Plans must not significantly impact the federal navigation channel or other existing USACE navigation projects.
- Transportation: Plans must not significantly impact transportation infrastructure or services on, over, or along the Hudson River, including bridges, Amtrak, MetroNorth, and CSX.
- Residential: Plans must not significantly impact existing homes.
- Existing Ecosystem Restoration Projects: Plans must not compromise the function of existing projects.

Other planning considerations, which were used to develop screening criteria and formulate alternative plans, included:

- Public Education Opportunities: Plans should consider opportunities to provide public education on the historical and ecological importance of the Hudson River.

- Consistency with Master Plans: Restoration planning should consider and be complimentary to municipal, site, and park master plans. Restoration projects should be sited and designed in coordination with stakeholders to also meet local planning objectives.
- Fish Consumption Advisories: Because removing barriers could allow fish with potentially harmful levels of chemical contaminants to enter waters where they are currently not present, for any plans that include barrier removal, NYSDEC will be consulted on the need to expand fish consumption advisories, which are issued by the New York State Department of Health (DOH).
- Land Ownership: Plans that involve privately-owned land require the consent of landowners to implement. Sufficient information for landowners to determine whether they may support plans will be developed and provided to landowners as part of this study.

3.1.6 Alignment with State Plans

The NYSDEC Hudson River Estuary Habitat Restoration Plan (Miller, 2013) adapted, and refined for the HRHR Study, restoration objectives identified in USACE’s 1996 Hudson River Habitat Restoration Reconnaissance Report and 2009 Draft Hudson-Raritan Estuary Comprehensive Restoration Plan (finalized in 2016). The four habitat types the NYSDEC Hudson River Estuary Habitat Restoration Plan identified as priorities for restoration in the study area are intertidal, shallow water, shoreline, and tributary stream habitats. To restore these habitat types, the plan proposed five actions:

- *Protect and conserve existing estuary habitat*, including protection of adjacent shore lands
- *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats
- *Promote and implement construction of fish passage structures, dam removal, and culvert right-sizing and placement* in tributaries to the Hudson
- *Promote and implement use of ecologically enhanced shoreline treatments* where shoreline stabilization is required to protect property or other economic assets
- *Implement programs to control invasive plant species*, including preventing new introductions

Table 3-1 shows how the planning objectives for the HRHR study correspond to the NYSDEC Habitat Restoration Plan's proposed actions.

Table 3-1: Correlating HRHR Objectives and NYSDEC Hudson River Estuary Habitat Restoration Plan Actions.

HUDSON RIVER HABITAT RESTORATION OBJECTIVES	CORRESPONDING NYSDEC HUDSON RIVER ESTUARY HABITAT RESTORATION PLAN ACTIONS
1. Restore a mosaic of interconnected, large river habitats ○ Increase the extent and quality of *subtidal, shallow water habitats* ○ Increase the extent and quality of *intertidal habitats* ○ Promote neighboring *shoreline, riparian, and upland habitats* contributing to aquatic ecosystem integrity ○ Promote a balanced mosaic of habitat types	▪ *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats ▪ *Promote and implement use of ecologically enhanced shoreline treatments* ▪ *Implement programs to control invasive plant species*, including preventing new introductions ▪ *Protect and conserve existing estuary habitat*, including protection of adjacent shore lands
2. Restore lost ecological connectivity within the Hudson River and its tributaries ○ Increase the connectivity of spawning, foraging, and resting habitats for *migratory fish* ○ Increase the connectivity of stopover, nesting, and foraging habitat for *migratory and resident birds* from freshwater ecosystems to the ocean ○ Promote actions improving the *transport regime* of water, sediment, and nutrients to the estuary	▪ *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats ▪ *Promote and implement fish passage*, dam removal, and culvert rightsizing in tributaries to the Hudson

3.2 Site Identification and Screening

3.2.1 Site Identification

In 2015, staff from The Nature Conservancy (TNC), Historic Hudson River Towns, Scenic Hudson, Hudson River Watershed Alliance, with funding from the New York State Energy Research and Development Authority and the Hudson River Estuary Program, facilitated five identical workshops in the Hudson River valley to provide a forum for riverfront communities and counties to identify potential habitat restoration, infrastructure, and access projects. Participants from 25 riverfront communities and all

10 estuary planning offices included city managers, mayors, and representatives of economic development councils, conservation action committees, and non-governmental organizations. In 2017 and 2018, additional opportunities were submitted by government agencies and non-profit organizations participating in the Partners Restoring the Hudson. The communities identified a diverse range of project ideas, from green infrastructure, shoreline restoration, bike paths, and fishing piers, to storm water management, combined sewer outfalls, and waste water treatment plants. Organizations affiliated with the Partners Restoring the Hudson also identified project ideas, ranging from dam and culvert removal to side channel and wetland restoration and additional wastewater treatment. The locations associated with each project idea were used to compile a list of sites.

The restoration sites recommended in the 1996 Hudson River Habitat Restoration Reconnaissance Report were added to the list if those sites had not already been included. Additional potential restoration sites were sought out through a desktop ArcGIS exercise called the Ecological Assessment tool produced by The Nature Conservancy (Partners Restoring the Hudson, 2019b). This tool draws on existing GIS data resources and overlays physical habitat characteristics with quality and threat indicators to identify priority areas for preservation or restoration. The Ecological Assessment tool did not identify any additional sites that had not already been identified. The final list contained 1,800 sites.

Sites with opportunities that could not be addressed through USACE's ecosystem restoration mission and the study authority were removed from consideration for further analysis. As they had been identified, sites were categorized based on the type of opportunity they represented: "habitat restoration," "community infrastructure," and/or "access and education." Many sites had been placed in more than one category. The 1,665 sites that were categorized as "habitat restoration" opportunities were retained for further analysis. The sites that were categorized as "community infrastructure" and/or "access and education" opportunities only were dropped from consideration.

The 212 of 1,665 "habitat restoration" sites represented opportunities that aligned with the planning objectives that were developed for this study. Those 212 sites were retained for further analysis.

3.2.2 Site Screening

Site screening was conducted in two stages: preliminary and secondary.

Preliminary Screening

The 212 sites that aligned with the planning objectives for this study were divided into two groups, based on which of the two objectives they most closely aligned with:

restoring a mosaic of interconnected, large river habitats ('mosaic habitat and shoreline restoration sites'), or restoring lost ecological connectivity ('tributary connectivity sites').

Preliminary screening of the 89 mosaic habitat and shoreline restoration sites consisted of screening out sites that met one or more of the following criteria:

- Known contamination: The non-federal sponsor must provide clean sites to USACE before a project can be implemented. Known contamination (i.e., Hazardous Toxic Radioactive Waste [HTRW]) presents a cost and schedule hindrance to feasibility and implementation.
- Landowner has articulated opposition to restoration on his or her property: Landowners who oppose action being taken on their property can prevent a project from being implemented.
- Low potential benefits compared to cost of gathering information needed to develop, evaluate, and compare alternatives: For some sites, for which inadequate information was available, potential benefits appeared low in relation to the cost of collecting additional data needed to develop, evaluate, and compare alternatives for that site.
- Lack of complexity or scale: Simple, small sites were considered better candidates for restoration by other actors and/or organizations.
- Funding for restoration already available: At some of the sites, where restoration was planned, other actors and/or organizations had already secured funding.

The remaining 48 mosaic habitat and shoreline restoration sites were prioritized based on whether the sites had potentially been negatively affected by the federal navigation channel. A total of 17 sites were retained for further analysis to be evaluated in this report. Table C-1 in Appendix C – Plan Formulation contains a list of the 89 sites and shows how they were screened down to 17.

The 123 tributary connectivity sites, located on 41 tributaries to the Hudson River, consisted of dams, utility crossings, and culverts. The sites were first grouped by tributary. The tributaries were then screened, based on the potential benefits removing or modifying the barriers on them could provide for migratory fish communities. Indicators of benefits, developed from previous studies (Schmidt 1996, USFWS 1998, Alderson and Rosman, 2012), used to screen the tributaries included:

- Stream length upstream of barrier(s): Stream length upstream of a barrier, to the next barrier or the tributary's headwaters, was used as a proxy for the potential benefits of removing or modifying that barrier. The amount of habitat that could be opened, or connected to the Hudson River mainstem, was assumed to increase proportionally with stream length. The miles of stream upstream of and between barriers were measured using ArcGIS. Tributaries on which barriers prevent access to more miles of stream were ranked higher than tributaries on which barriers prevent access to fewer miles.

- Number of barriers: Tributaries with fewer barriers, relative to the stream length between and upstream of those barriers, were ranked higher than tributaries with more barriers, due to the potential costs of removing or modifying multiple barriers relative to benefits.
- Natural barriers: Because removing or modifying a barrier upstream or just downstream of a natural barrier, such as a natural waterfall or raised bedrock, would provide few benefits, tributaries with a natural barrier near the first barrier upstream of the tributary's confluence with the Hudson River that could be removed or modified were screened out.
- Access by multiple taxa: Tributaries that, if reconnected to the Hudson River, would not benefit multiple species, such as both river herring and American eel[1], were screened out.

Four tributaries, with a total of 21 sites, were prioritized and retained for further analysis at this time. Table C-2 in Appendix C - Plan Formulation shows how the 41 tributaries were screened down to four.

Desktop analyses of the remaining 17 mosaic habitat and shoreline sites resulted in two of the sites being removed from further consideration. One of the planning constraints for this study is that plans must not significantly impact transportation on, over, or along the Hudson River. Greenpoint Conservation Area & North Bay of Hudson, NY was removed from consideration because a culvert that would need to be modified to restore the site is located under MetroNorth railroad. Bear Mountain State Park, where there may have been opportunities for shoreline restoration, was removed because Amtrak runs along the Hudson River at the park.

Among the 15 other mosaic habitat and shoreline sites, there were a number of sites with overlapping footprints or in very close proximity to each other. Considering hydrologic connectivity and the logistics of mobilization, these sites, in the Albany shoreline, Binnen Kill, and Schodack Island areas, were grouped under one site name each, and thereafter known as 'components.' For instance, in the Binnen Kill area, the Binnen Kill habitat restoration, Schermerhorn Island side channel, and Shad Island side channel sites became components of one Binnen Kill site.

Table 3-2 shows the 17 mosaic habitat and shoreline restoration sites and four tributaries that were retained after preliminary screening. Sites and tributaries are listed in the order of their position on the Hudson River, from upstream to downstream. Tributaries are shaded light blue. The two sites that were removed based on the

[1] River herring is an anadromous fish that migrates up rivers from the sea to spawn, while eel is a catadromous fish that migrates down rivers to the sea to spawn.

transportation constraint are crossed out. Sites in close proximity to each other that were grouped are listed under their new site name.

Table 3-2: Sites Remaining After Preliminary Screening.

	SITE	COUNTY
1	Albany Shorelines: Bulkhead Repairs/ Habitat Restoration	Albany
	Mohawk Hudson Hike Bike Trail	Albany
2	Cow Island Dike	Rensselaer
3	Binnen Kill: Binnen Kill Habitat Restoration	Albany
	Schermerhorn Island Side Channel	Greene
	Shad Island Side Channel	Greene
4	Henry Hudson Park Shoreline	Albany
5	Schodack Island: Channel/ Island Restoration	Rensselaer
	Houghtaling Island Side Channel	Columbia
	Schodack Island State Park Shoreline	Rensselaer
	Upper Schodack Island Side Channel	Columbia
6	Rattlesnake Island Dike Side Channel	Greene
	~~Greenport Conservation Area & North Bay of Hudson, NY~~	~~Columbia~~
7	Claverack Creek (Stockport Creek)	Columbia
8	Roeliff Jansen Kill	Columbia
9	Charles Rider Park	Ulster
10	Rotary Park	Ulster
11	Rondout Creek	Ulster
12	Waryas Park	Dutchess
13	Moodna Creek	Orange
	~~Bear Mountain State Park~~	~~Rockland~~

Figure 3-3 is a map showing the location of the 13 sites that remained after preliminary screening.

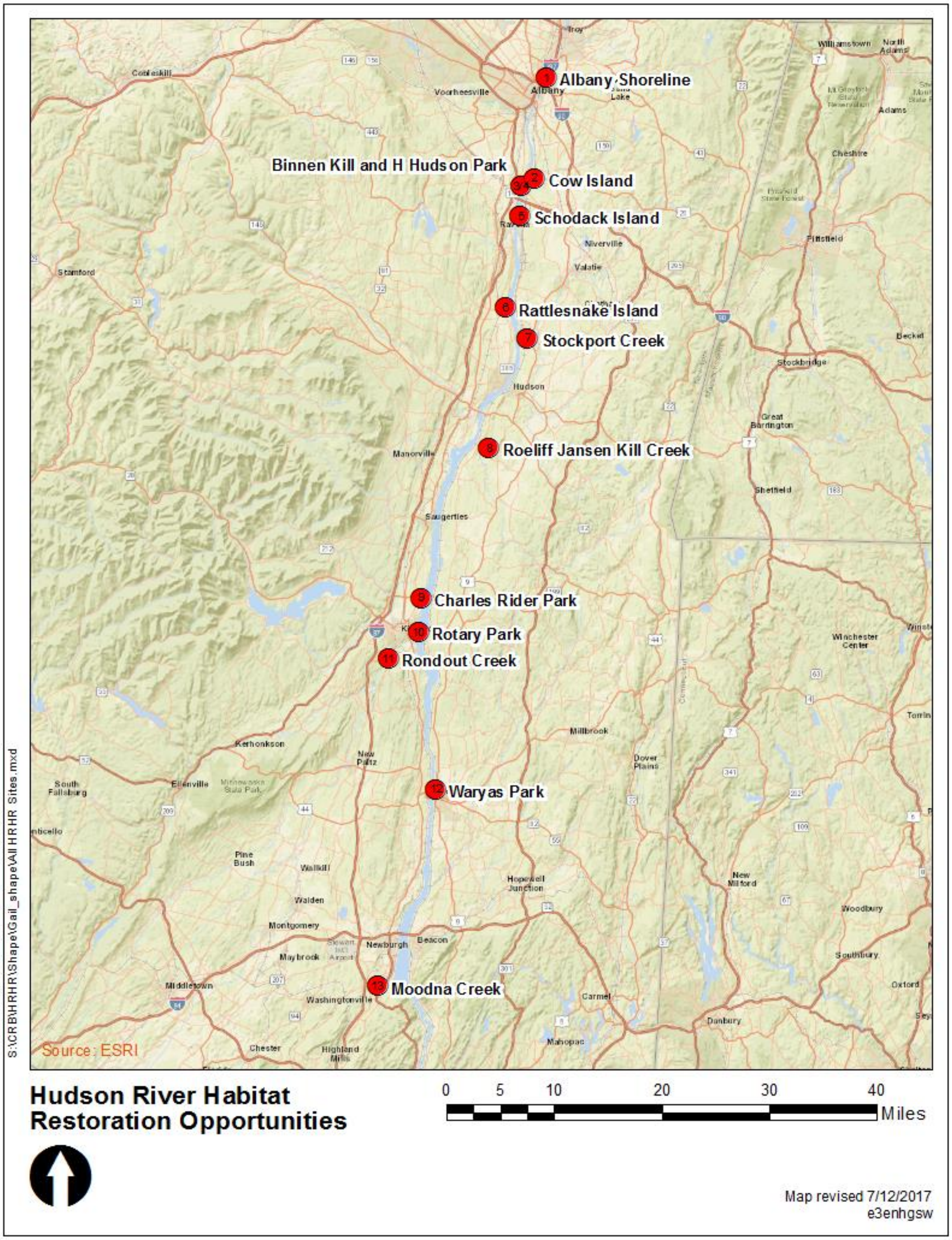


Figure 3-3: Map of Sites Remaining After Preliminary Screening.

Secondary Screening of Sites

The study team visited the remaining 13 sites in September and December 2017, to verify restoration need and potential and to gather preliminary data on site conditions for use in the development of alternatives. Table 3-3 lists the sites and summarizes the reasons for their removal. For two of the tributaries, the presence of previously unknown natural barriers near the site significantly diminish or remove the effectiveness of proposed measures since they would continue to block passage despite any efforts to remove manmade barriers. For the mosaic habitat and shoreline, reasons for removal included potential negative consequences of restoration, unanticipated challenges to restoration, and sites being smaller or in better condition than expected.

Table 3-3: Sites Removed During Secondary Screening.

	SITE	REASON FOR REMOVAL
1	Albany Shoreline	The Hudson River has high energy at the site that causes erosion and scour. The cost to stabilize the river banks with an ecologically restored shoreline and conflicts with the need to preserve park space for patron use would eliminate or significantly diminish the ecological net benefits.
2	Cow Island	Proposed removal of dike may have impacts to the subaquatic vegetation beds.
6	Rattlesnake Island	The NEIWPCC and NYSDEC sponsored report, *Hydrodynamic and Sediment Transport Study of Existing Conditions and Restoration Alternatives at Rattlesnake Island and Coxsackie Cove, Greene County, NY*, found there would be limited benefits from removing the dike. More costly and likely unjustified measures would need to be implemented to obtain significant benefits (NEIWPCC and NYSDEC, 2018).
7	Stockport Creek, Claverack Creek Dam #4	A natural barrier was identified about 0.6 miles upstream of the dam of interest that limits the ecological benefits realized from dam removal, modification, or the installation of an aquatic organism ladder.
8	Roeliff Jansen Kill Dam	A natural barrier downstream of the dam was identified that prevents migratory fish from reaching the dam location even if removed, modified, or an aquatic organism ladder was installed.
10	Rotary Park	Site was found to be in good condition and did not require restoration.
12	Victor Waryas Park	Removed before visiting the site due to small size and lack of potential ecological benefits.

Figure 3-4 summarizes the screening process the study team used to obtain the final array of six sites. These six sites are evaluated further for inclusion in this report. The sites that have not been prioritized at this time, could be included in future new phase feasibility studies.

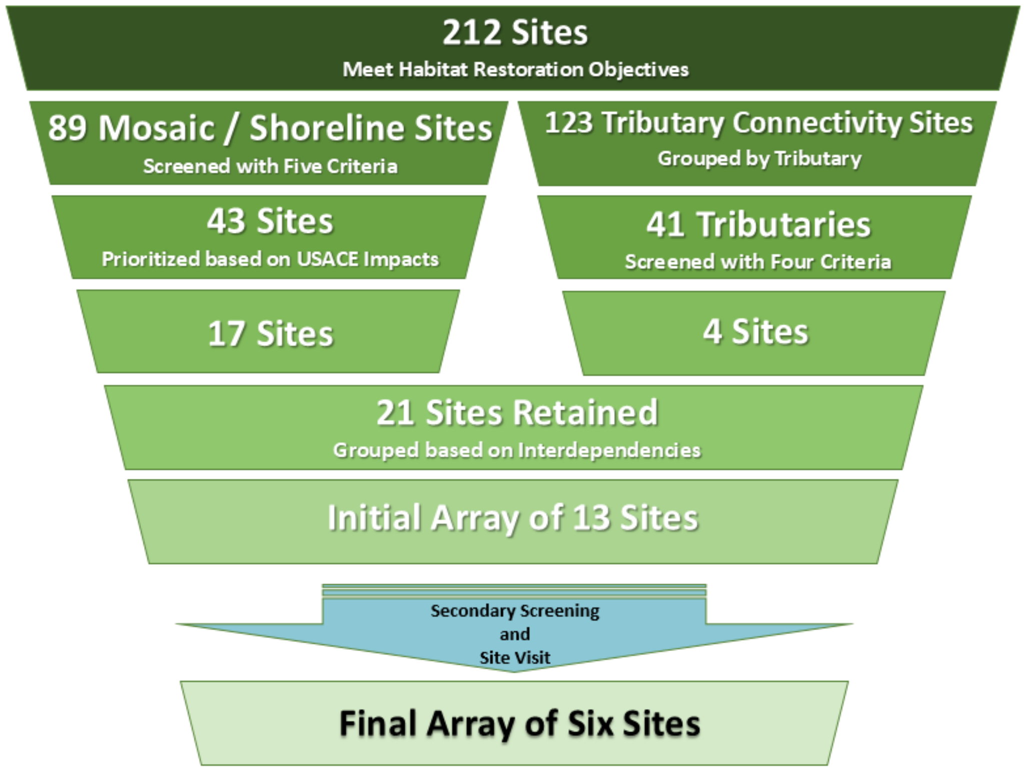


Figure 3-4: Summary of the Site Screening Process.

3.2.3 Final Array of Six Sites

The final array of six sites includes Henry Hudson Park, Binnen Kill, Schodack Island, Charles Rider Park, Rondout Creek, and Moodna Creek. Figure 3-5 is a map of the sites. Brief descriptions of the sites follow. More detailed site summaries are included in Appendix C - Plan Formulation.

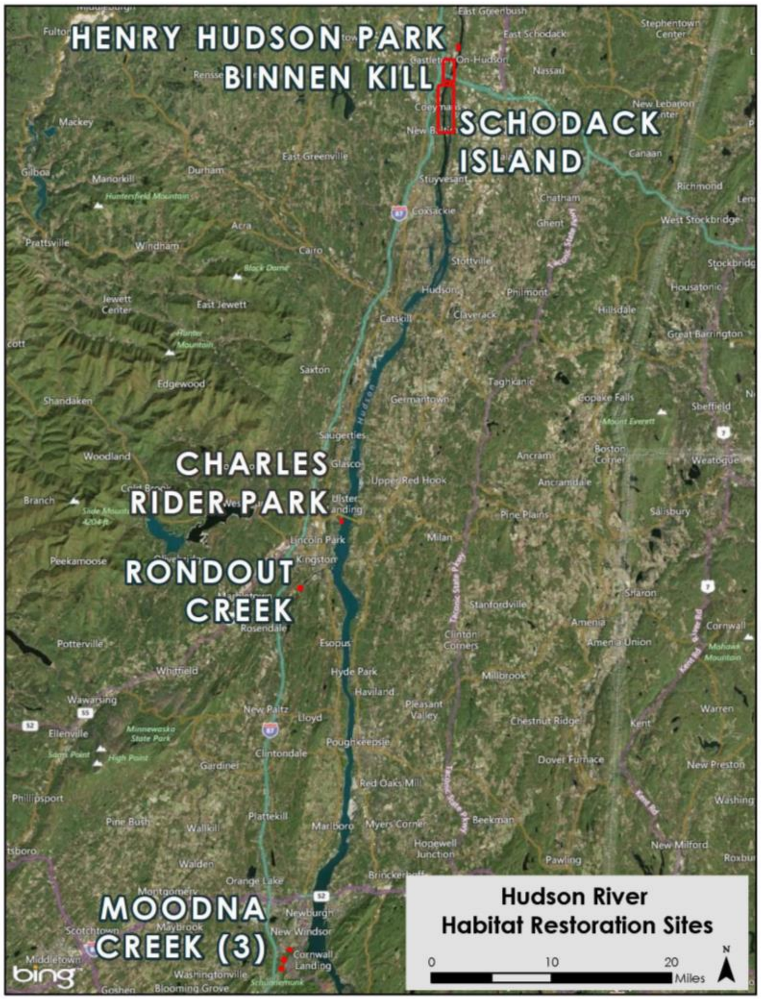


Figure 3-5: Map of Final Array of Sites.

Of the six sites, two – Rondout Creek and Moodna Creek – are tributary connectivity sites. To facilitate the development, evaluation, and comparison of alternative plans, the other four sites were split into two groups: large river mosaic sites, which include Binnen Kill and Schodack Island, and shoreline restoration sites, which include Henry Hudson Park and Charles Rider Park. The differences between large river mosaic sites and shoreline restoration sites pertaining to plan formulation are discussed further in Section 3.3, Alternatives Development.

Henry Hudson Park, located on the western shore of the Hudson River, is public open space owned by the Town of Bethlehem. The park is the only place in Bethlehem where the public can access the river. The southern section of the shoreline consists of a dilapidated timber cribbing structure, filled with riprap between two timber crib walls, and capped with convex concrete segments. Most of the structure has either partially or completely failed; the crib walls are severely decomposed, the concrete cap has detached and been displaced, and riprap has moved from between the crib walls into the river. In sections of complete structural failure, upland areas show signs of erosion and are inundated during high tides.

The **Binnen Kill** site is located on the western shore of the Hudson River, on the border of the Towns of Bethlehem and Selkirk, NY. The site encompasses approximately 1,000 acres of publicly- and privately-owned lands. In the 1800s, there were islands separated from the mainland by side channels on the eastern edge of the site. Due to dredged material infilling, the islands are now contiguous with the mainland. The Binnen Kill is a tidal freshwater tributary surrounded by a complex of on-site tidal wetlands, upland forests, non-tidal wetlands and swamps, farmland, and farm roads. The original islands, Shad and Schermerhorn, are designated a Significant Coastal Fish and Wildlife Habitat by NY State and include resident and migratory fish spawning and nursery habitat, habitat for protected birds, and rare plant species and communities (NYSDEC, 2017; USFWS, 1997).

The Binnen Kill site includes a variety of vital ecological communities and habitats that have been significantly altered by a combination of natural processes and human action, including farming, in addition to dredged material placement. The Binnen Kill site was divided into two components - North and South - for alternatives development, because the site is large and independent action may be taken at its two ends.

The **Schodack Island** site is part of Schodack Island State Park, which sits off the eastern shore of the Hudson River, approximately 10 miles south of Albany, NY. The park is located in the towns of Schodack, New Baltimore, and Stuyvesant. The area of focus for this study is limited to the southern portion of the park, between the river and Schodack Creek. Schodack Island, which is in fact a peninsula, comprised a series of islands in the late 19^{th} to early 20^{th} centuries, but now forms a contiguous landmass due to dredged material infilling. Schodack Creek is a relic side channel of the Hudson River. NY State has designated the original islands, Schodack Island (North and South) and Houghtaling Island, as well as Schodack Creek, a Significant Coastal Fish and Wildlife Habitat, as well as a Bird Conservation Area. The site is considered ecologically significant because it consists of a large undeveloped floodplain wetland ecosystem with diverse ecological communities, including floodplain forests, freshwater tidal wetlands, tidal creeks, littoral zones, submerged aquatic vegetation beds, emergent marshes, and tidal swamp, which support resident and migratory fish spawning and provide nursery and foraging habitat for protected birds (NYSDEC, 2002; NYSDOS, 2012a-c; USFWS, 1997). The Schodack Island site was divided into three components - North, South, and Pocket Wetlands - for alternatives development, because independent action may be taken in different areas of the large site.

Charles Rider Park, which is located on the western shore of the Hudson River, is a 29.6-acre public open space owned by the Town of Ulster. Approximately 5.5 acres of the park are actively managed while the remaining area is primarily forested. The park's shoreline varies in condition. The northern most portion of the shoreline is part of a small cove, partially protected by large rock material at the cove's mouth. The eastern shoreline consists of dilapidated stone-filled timber cribbing that has predominantly failed. Large boulders have been placed along the shoreline adjacent to existing erosional scour in some locations. These boulders appear to have been placed recently, presumably to stabilize the shoreline. Sparse riprap extends riverward of the timber cribbing, mixed with a natural cobble substrate. Heavily worn bricks and water chestnut seeds are common throughout the shoreline.

Rondout Creek contains the Eddyville Dam, the first aquatic organism passage (AOP) barrier approximately 3.6 miles upstream of the creek's confluence with the Hudson River. The dam lies on the boundary between the towns of Esopus and Ulster in Ulster County. The creek has been designated a Significant Coastal Fish and Wildlife Habitat by NY State and is an important migratory habitat for American eel (IUCN listed endangered), blueback herring (IUCN listed threatened), and alewife, a NOAA Fisheries species of concern. The shortnose sturgeon (International Union for Conservation of Nature [IUCN] threatened; federal and state listed endangered) is found in this section of the Hudson River. Brown trout is stocked in the upper portions of the creek. The Eddyville Dam is classified as a Class A – Low Hazard dam, is currently a barrier to tidal flow, serves as the 'head of tide' on Rondout Creek, and is an impediment for resident and migratory fish.

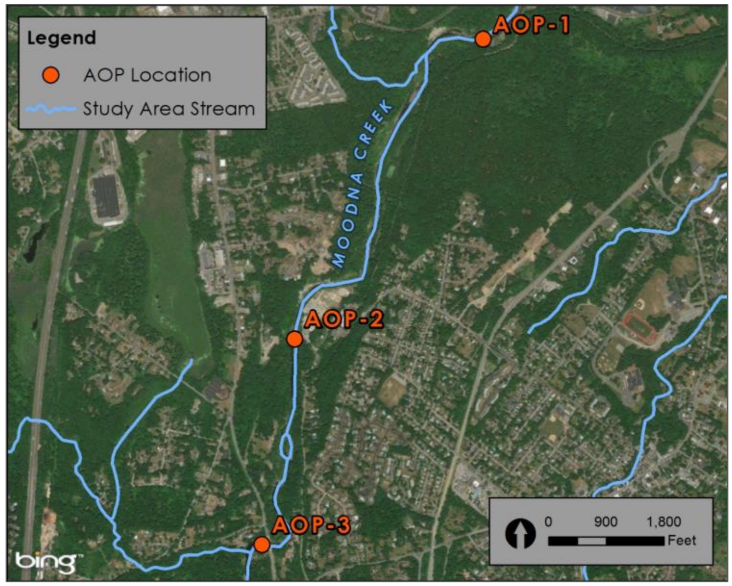
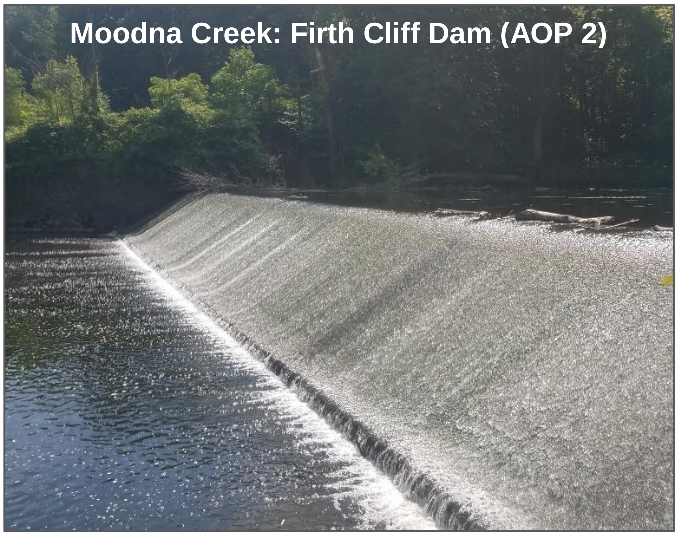
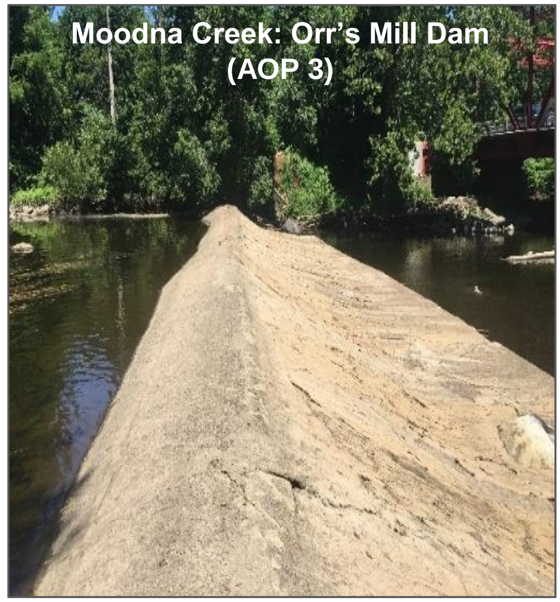


Figure 3-6: Moodna Creek AOP Barriers.

Moodna Creek is a tributary of the Hudson River located in Orange County, NY, approximately 40 miles north of New York City. The creek is used for spawning by anadromous fish such as blueback herring (IUCN listed vulnerable), alewife, a NOAA Fisheries species of concern, and others. The area is also known to be used for breeding by least bitterns (NY State listed threatened). Depending on the location of the salt front in the Hudson River, bluefish (IUCN listed vulnerable) may feed in the creek. Moodna Creek has three AOP barriers, including: a sewer utility line (AOP 1), the Firth Cliff Dam (AOP 2), and Orr's Mill Dam (AOP 3), which are approximately 1.8, 3, and 3.7 miles upstream of the Hudson River confluence, respectively (Figure 3-6). The utility line, which is approximately 5 ft wide, is encased in concrete and forms a weir that creates a vertical drop of water approximately 2 ft-high at normal flows. The Firth Cliff Dam, which is 9 ft high, is classified as a Class A - Low Hazard Dam and is owned by the Moodna Creek Development, Ltd., which is affiliated with the former textile manufacturing factory known originally as Firth Carpet Company and now Majestic Weaving. The Orr's Mill Dam, which is 10 ft high, is a concrete encased cobble/boulder filled crib structure with metal rails running across the crest and down the spillway. The Orr's Mill Dam has been characterized as being in a state of disrepair, structurally unsound, and "could fail at any time," based on prior NYSDEC inspections. The three barriers to, or opportunities for, enhanced tributary connectivity on Moodna Creek (AOP 1, AOP 2, and AOP 3) were considered components of the Moodna Creek site for alternatives development.

Moodna Creek: Utility Line (AOP 1)





3.3 Alternatives Development

In February and April 2018, three design charrettes were held with NYSDEC, to determine field data requirements, management measures, and potential alternatives for the six sites in the final array of sites. Detailed field investigations were conducted in July 2018. For the mosaic habitat and shoreline restoration sites (Binnen Kill, Schodack Island, Henry Hudson Park, and Charles Rider Park), the study team collected shoreline profiles, channel cross-sections, water levels using tide gauges, and input for Evaluation of Planned Wetlands (described in Section 3.4.1, Evaluation and Comparison of Alternatives). For the tributary connectivity sites (Rondout Creek and Moodna Creek), the study team inspected the utility line and dams, explored any associated reservoirs, and collected historical information about the structures. The data collected in July 2018 was used to determine baseline conditions at the sites and to aid in alternatives development.

The identification of management measures, which are features or activities that can be implemented at a specific geographic site to address one or more planning objectives, was informed by the field investigations and derived from a variety of sources. Sources for management measures included the Hudson River Habitat Restoration Reconnaissance Study, prior public scoping process, and U.S. Army Engineer Institute of Water Resources (IWR) Management Measures Digital Library for Ecosystem Restoration. Table 3-4 provides a sample of the management measures that were used alone or in combination to develop alternatives for the sites associated with the planning objectives.

Table 3-4: Objectives and Management Measures.

<table>
<tr><th></th><th colspan="3">MOSAIC HABITAT AND SHORELINE RESTORATION</th><th>TRIBUTARY CONNECTIVITY</th></tr>
<tr><td>OBJECTIVES</td><td colspan="3">Restore a mosaic of interconnected, large river habitats, which together host a diversity of native taxa</td><td>Restore lost ecological connectivity within the Hudson River and its tributaries</td></tr>
<tr><td rowspan="2">SUB-OBJECTIVES</td><td>Increase the extent and quality of subtidal, shallow water habitats (e.g., submerged aquatic vegetation, side channels)</td><td>Increase the extent and quality of intertidal habitats (e.g., freshwater tidal marshes, mud/sand flats)</td><td>Promote neighboring shoreline, riparian, and upland habitats contributing to aquatic ecosystem integrity</td><td rowspan="2">- Increase the connectivity of spawning, foraging, and resting habitats for migratory fish (e.g., shad, herring, eel, and sturgeon)
- Increase the connectivity of stopover, nesting, and foraging habitat for migratory and resident birds from freshwater ecosystems to the ocean
- Promote actions improving the transport regime of water, sediment, and nutrients to the estuary</td></tr>
<tr><td colspan="3">Promote a balanced mosaic of habitat types</td></tr>
<tr><td>MEASURES</td><td>Side channel excavation, dredging, re-contouring</td><td>Excavation, dredging, re-contouring, invasive species removal, bank stabilization, wetland re-vegetation</td><td>Berm or dike removal or modification, modify bank armor, bank stabilization and vegetation, channel modification</td><td>Dam removal, culvert modification, Aquatic Organism Passage (AOP) structures</td></tr>
</table>

To facilitate the development of alternatives, the mosaic habitat and shoreline restoration sites were split into ‘large river mosaics’ and ‘shoreline restoration’ sites. Binnen Kill and Schodack Island, the large river mosaic sites, once included diverse mosaics of subtidal, intertidal, shoreline, and riparian habitats unique to the Hudson River ecosystem. Critical side channel and wetland habitats were lost at these sites as a result of USACE constructing and maintaining a federal navigation channel in the Hudson River. Charles Rider and Henry Hudson parks, the shoreline restoration sites, are characterized by active bank erosion and shoreline retreat along the Hudson River mainstem. Riparian and wetland habitats at these sites were lost as a result of dredged material placement.

Twenty-three alternatives were developed for the six sites, to meet planning objectives and avoid constraints while reasonably maximizing ecosystem restoration benefits. Multiple alternatives were developed for each site or site component (i.e., the North and South components of the Binnen Kill site; the North, South, and Pocket Wetlands components of the Schodack Island site; the Henry Hudson Park site; the Charles Rider Park site; the Rondout Creek site; and the three AOP components of the Moodna Creek site). The measures that compose alternatives were selected to enhance the habitat value for the life stage or stages of the species most likely to be found at a site.

Each alternative includes a “base” measure - that is, a key measure addressing the critical needs of the study area for a balance of more, better-quality shallow water, intertidal, and shoreline habitats, and increased tributary-river connectivity for fish, birds, and the exchange of water, nutrients, and sediment. Alternatives that did not include a base measure would not be considered complete, acceptable, efficient, or effective.

The study team used professional judgment to incrementally add one or more measures to the base measure at a site or site component. These incremental additions increased the amount of habitat restored or created at a site or site component. Preliminary costs and benefits were used to identify alternatives that provide high levels of benefits relative to the costs. The combination of measures to develop alternatives, including the addition of increments to base measures, is further described in Section 3.4, Evaluation and Comparison of Alternatives.

Table 3-5 shows, for each of the 23 alternatives that were developed, what categories of measures (e.g., wetland restoration) the alternative consists of, and the associated acreage of habitat restored or created. Appendix C - Plan Formulation, contains site summaries with descriptions of the alternatives for each site, as well as concept plans for all of the alternatives. Concept plans for the alternatives included in the Tentatively Selected Plan may be found in Chapter 4: Tentatively Selected Plan.

Table 3-5: Alternatives Summary.

SITE	COMP-ONENT	ALTER-NATIVE	ALTERNATIVE DESCRIPTION[1]
LARGE RIVER MOSAICS			
BINNEN KILL	**North**	1	1-Wetland Restoration, 89.94 AC 2-AOP Crossing Enlargement, 0.27 AC
		2	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Creation, 15.52 AC 3-Emergent Wetland Creation, 4.29 AC 4-Emergent Wetland Restoration & Channel Creation, 41.88 AC 5-AOP Crossing Removal, 0.27 AC
		3	1-Wetland Restoration, 89.94 AC
		4	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Creation, 15.52 AC 3-Emergent Wetland Creation, 4.29 AC: 4-Emergent Wetland Restoration & Channel Creation, 41.18 AC
	South	1	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 5-Side Channel and Riparian Corridor Creation, 14.85 AC
		2	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 4-Road Crossing 5-Side Channel and Tidal Wetland Corridor Creation, 27.02 AC
SCHODACK ISLAND	**North**	1	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Riparian Corridor Creation, 2.82 AC 5-Tidal Wetland Restoration South, 15.69 AC
		2	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Tidal Wetland Corridor, 9.09 AC 5-Tidal Wetland Restoration South, 15.69 AC
	South	1	1-Side Channel and Riparian Corridor Creation, 1.45 AC 2-Road Crossing 3-Tidal Wetland Restoration, 2.77 AC
		2	1-Side Channel and Tidal Wetland Corridor Creation, 3.80 AC 2-Road Crossing 3-Tidal Wetland Restoration, 2.77 AC
	Pocket Wetlands	1	1-Tidal Wetland Restoration A, 3.61 AC 2-Non-Tidal Wetland Restoration B, 1.48 AC 3-Tidal Wetland Restoration C, 2.01 AC 4-Tidal Wetland Creation D, 3.85 AC

SITE	COMP-ONENT	ALTER-NATIVE	ALTERNATIVE DESCRIPTION[1]
SHORELINE RESTORATION			
HENRY HUDSON PARK	–	1	1-Western Tidal Wetland Creation, 3.59 AC 2-Vegetated Riprap Creation, 0.43 AC 3-Cove Tidal Wetland Creation, 0.18 AC
		2	1-Northern Tidal Wetland Creation, 0.41 AC 2-Pocket Wetland Creation, 0.09 AC 3-Western Tidal Wetland Creation, 3.59 AC 4-Southern Tidal Wetland Creation, 1.28 AC
CHARLES RIDER PARK	–	1	1-Interstitial Rock Planting Restoration, 0.12 AC 2-Northern Tidal Wetland Creation, 0.29 AC 3-Southern Tidal Wetland Creation, 0.70 AC
TRIBUTARY CONNECTIVITY			
RONDOUT CREEK	–	1	Technical Fishway Construction
		2	Dam Removal
		3	Dam Notching
MOODNA CREEK	AOP 1	1	Sewer Pipe Removal
		2	Roughened Rock Ramp
	AOP 2	1	Dam Removal
		2	Technical Fishway Construction
	AOP 3	1	Dam Removal
		2	Partial Dam Removal/Notching

[1] Alternative number corresponds to concept plan alternative numbers presented in (Figures 4-1 through 4-8; Engineering and Plan Formulation appendices).

3.4 Evaluation and Comparison of Alternatives

In order to evaluate the alternatives presented in Table 3-5, the study team forecasted what environmental benefits the restoration actions would accrue and estimated how much each would cost. Benefits and costs were then used as inputs for the CE/ICA to compare the cost effectiveness of alternatives at a site, as well as among the habitat restoration type (Large Mosaics, Shoreline Restoration and Tributary Connectivity). Additionally, the following factors were also considered:

- How well do the alternatives contribute to the ecosystem restoration mission?
- How well do the alternatives satisfy the planning objectives without violating planning constraints? For instance, are there impacts to habitat, species, cultural resources, or communities not captured by ecological modeling or cost analyses?

- Completeness, effectiveness, efficiency, and acceptability of the actions
- How can the actions be expected to perform over time with Relative Sea Level Change (per ER- 1100-2-8162 and ETL-1100-2-1)?
- Compliance with and embrace of USACE Environmental Operating Principles

3.4.1 Ecological Benefit Forecasting

Ecosystem restoration projects provide benefits to people and the environment that cannot easily be quantified. For example, healthy ecosystems can support biodiversity, resilience, stability, sustainability, and materials cycling, among others. In planning ecosystem restoration projects, USACE uses non-monetary indicators of benefits in cost-effectiveness analysis and incremental analysis, rather than economic benefit-cost analysis. To calculate the non-monetary benefits of the restoration alternatives, two models were used: Evaluation of Planned Wetlands (EPW) and Watershed-Scale Upstream Connectivity Toolkit (WUCT). These benefits were computed based on temporal trajectories and compared to the future-without project condition to determine the ecological lift. Ecological improvement, or lift, is presented as average annual functional capacity units (AAFCUs) for EPW or habitat units (AAHUs) for WUCT. Detailed descriptions of the environmental benefits of each alternative are presented in Appendix D – Habitat Evaluation/ Ecosystem Benefits and a summary of the ecosystem benefit analysis is presented in Table 3-6 for each alternative. The calculation of AAFCUs and AAHUs is presented in the CE/ICA Appendix F.

Evaluation of Planned Wetlands (EPW) was used to quantify benefits for large-scale mosaic and shoreline restoration sites. EPW is a rapid assessment procedure, certified for regional use in July 2016, which provides a method for determining the capacity of a wetland to perform certain ecological and watershed functions by evaluating elements of major wetland functions. EPW evaluates functional categories including shoreline bank erosion, sediment stabilization, water quality, wildlife, and fish (Bartoldus 1994, Bartoldus et al., 1994). EPW scores were calculated for each component/site alternative. Functions of the existing wetlands and uplands slated for restoration were characterized to assess the current functional capacity, establishing a baseline to determine the anticipated increase in functional capacity as a result of implementing the project as proposed. The five functional categories were averaged to obtain a functional capacity index (FCI), which was subsequently multiplied by project area (in acres) to obtain a quality-weighted area metric (functional capacity units [FCUs]).

The Watershed-Scale Upstream Connectivity Toolkit (WUCT) was developed by Engineering Research and Development Center (ERDC) and certified for National use on 29 October 2018. WUCT was utilized for the AOP sites and focuses on upstream movement of migratory organisms such as fish and is intended for application at the watershed scale. The WUCT combines three data sources to estimate quality-weighted, accessible habitat at the watershed scale. The algorithm is based on three primary inputs:

- Habitat Quantity: The area of upstream habitat was computed as the distance from a dam to the next upstream barrier multiplied by the tributary width.
- Habitat Quality: Habitat quality was assessed relative to upstream watershed condition using Colorado State's Environmental Resources Assessment and Management System modeling platform for rapid watershed assessment (https://erams.com/documentation/wrap/).
- Passability: Passability to aquatic species was estimated based on prior research studies elsewhere in the region (Franklin et al. 2012), meta-analyses of fishway efficacy across multiple taxa (Noonan et al. 2011, Bunt et al. 2012), and professional judgment based on two taxa serving as representative keystone species: river herring and American eel.

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

3.4.2 Cost Inputs

Alternatives were compared using standard cost-engineering methods, which are described in Appendix E. First level costs are presented as current year (2019) dollar values and were estimated for each component/site including the following cost categories:

- Real estate
- Cultural resource surveys and mitigation
- Planning, engineering and design for each site
- Construction management
- Monitoring
- Adaptive management

- Contingencies

Costs were also developed for activities associated with operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) efforts for 10 years after construction completion and monitoring activities. Cost estimates are presented in Table 3-6 for each alternative. Please see Appendix E – Cost Engineering for more details and the CE/ICA Appendix F for annualized costs.

Table 3-6: Summary of Benefits and Costs for each Component/Site Alternative [TSP highlighted].

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Annual OMRR&R Cost ($)[6]
Binnen Kill	North	1	1-Wetland Restoration, 89.94 AC 2-AOP Crossing Enlargement, 0.27 AC	5.2	28,928,554	1,233,669	118,211
		2	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Creation, 15.52 AC 3-Emergent Wetland Creation, 4.29 AC 4-Emergent Wetland Restoration & Channel Creation, 41.88 AC 5-AOP Crossing Removal, 0.27 AC	20.8	35,719,261	1,534,710	148,049
		3	1-Wetland Restoration, 89.94 AC	5.2	27,396,882	1,167,621	111,326
		4	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Creation, 15.52 AC 3-Emergent Wetland Creation, 4.29 AC 4-Emergent Wetland Restoration & Channel Creation, 41.18 AC	20.8	35,193,651	1,512,712	145,896
	South	1	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 4-Road Crossing 5-Side Channel and Riparian Corridor Creation, 14.85 AC	2.0	20,118,939	853,720	77,552
		2	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 4-Road Crossing 5-Side Channel and Tidal Wetland Corridor Creation, 27.02 AC	12.7	22,136,946	945,843	85,556

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Annual OMRR&R Cost ($)[6]
Schodack Island	North	1	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Riparian Corridor Creation, 2.82 AC 5-Tidal Wetland Restoration South, 15.69 AC	3.2	13,457,575	568,677	45,836
		2	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Tidal Wetland Corridor, 9.09 AC 5-Tidal Wetland Restoration South, 15.69 AC	7.1	19,256,797	822,106	73,636
	South	1	1-Side Channel and Riparian Corridor Creation, 1.45 AC 2-Road Crossing 3-Tidal Wetland Restoration, 2.77 AC	0.9	7,835,830	323,161	21,062
		2	1-Side Channel and Tidal Wetland Corridor Creation, 3.80 AC 3-Tidal Wetland Restoration, 2.77 AC	1.7	9,715,454	405,123	30,278
	Pocket Wetlands	1	1-Tidal Wetland Restoration A, 3.61 AC 2-Non-Tidal Wetland Restoration B, 1.48 AC 3-Tidal Wetland Restoration C, 2.01 AC 4-Tidal Wetland Creation D, 3.85 AC	2.0	9,072,622	376,249	30,727
Henry Hudson Park (2610 linear feet)	-	1	1-Western Tidal Wetland Creation, 3.59 AC 2-Vegetated Riprap Creation, 0.43 AC 3-Cove Tidal Wetland Creation, 0.18 AC	2.2	8,873,209	368,870	29,783
		2	1-Northern Tidal Wetland Creation, 0.41 AC 2-Pocket Wetland Creation, 0.09 AC 3-Western Tidal Wetland Creation, 3.59 AC 4-Southern Tidal Wetland Creation, 1.28 AC	2.9	15,221,511	638,516	59,173

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Annual OMRR&R Cost ($)[6]
Charles Rider Park	-	1	1-Interstitial Rock Planting Restoration, 0.12 AC 2-Northern Tidal Wetland Creation, 0.29 AC 3-Southern Tidal Wetland Creation, 0.70 AC	0.2	3,585,451	146,099	9,830
Rondout Creek	-	1	Technical Fishway Construction	7.1	4,221,080	183,602	25,000
		2	Dam Removal	127.4	3,932,388	157,659	8,429
		3	Dam Notching	70.8	4,634,670	188,411	12,882
Moodna Creek - AOP 1	-	1	Sewer Pipe Removal	2.8	1,695,631	69,227	5,000
		2	Roughened Rock Ramp	2.2	1,858,694	75,409	5,000
Moodna Creek - AOP 2	-	1	Dam Removal	7.5	5,317,614 (3,621,983)	214,789 (145,562)	7,664
		2	Technical Fishway Construction	3.1	5,745,026 (4,049,395)	246,779 (177,552)	25,000
Moodna Creek - AOP 3	-	1	Dam Removal	48.4	9,597,544 (4,279,930)	387,122 (172,333)	9,523
		2	Partial Dam Removal/Notching	48.4	8,993,274 (3,675,660)	363,771 (148,982)	10,000

[1] Net AAFCU-HU: Average Annual Functional Capacity Unit - Habitat Unit

[2] Net HUs presented for Moodna AOPs 2 and 3 Alternatives represent total maximum HUs including barrier removals at downstream AOPs.

[3] Total First Cost for Moodna AOPs 2 and 3 Alternatives include costs for barrier removal at AOP 1 (costs in parentheses represent cost for that AOP Alternative action only).

[4] Total Average Annual Cost for AOPs 2 and 3 Alternatives include average annual cost for barrier removal at AOP 1 (costs in parentheses represent average/annual cost for that AOP action only).

[6] Annual OMRR&R Cost: Operations and Maintenance Repair and Rehabilitation also included in Total Average Annual Cost and NOT included in Total Project Cost. Costs are 100% non-federal funds for up to 10 years after ecological success has been determined.

3.4.3 Cost Effectiveness and Incremental Cost Analysis

Cost-effectiveness and incremental cost analyses (CE/ICA) are analytical tools for assessing the relative benefits and costs of ecosystem restoration actions and informing decisions. Benefits and costs (Table 3-6) are assessed prior to these analyses using ecological models and cost engineering methods, respectively. CE/ICA may then be conducted at the site scale to compare alternatives at a single location (e.g., no action vs. dam removal vs. fish ladder vs. bypass) or at the system scale to compare relative merits of multiple sites (e.g., no sites vs. Site-A only vs. Site-B only vs. Site-A and Site-B).

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

For each alternative, net benefits were computed over the future without project (FWOP) condition to reflect the change in ecological condition associated with the restoration costs. Notably, EPW and WUCT outputs remain separate throughout these analyses since sites will only be compared within a given type of restoration (i.e., "like with like" comparison).

CE/ICA can be applied multiple ways when examining a multi-site restoration project. First, recommendations can be made at the site-scale and combined logically with other recommended actions to develop different "portfolios" of projects (e.g., Alt-A at Site-1 and Alt-C at Site-2). Second, all permutations of sites and alternative can be assessed to develop project portfolios. Here, we applied CE/ICA using both approaches (Appendix F) with the logic that greater confidence may be placed in a recommendation arrived at through competing methods. The following section only presents CE/ICA for combinations of actions within a restoration type (e.g., mosaic sites) because recommendations were identical using both methods.

Three decision rules were applied when identifying a recommended alternative for each restoration type:

- Does this alternative/plan meet the planning objectives?
- Which alternative/plan has the lowest unit cost (i.e., $/AAFCU or $/AAHU)?
- Which alternative reasonably maximizes environmental benefits in light of non-linearity in cost-benefit data, incremental cost associated with additional investment, cost affordability, and benefits not adequately captured by models (as directed by Appendix E of ER 1105-2-100)?

3.4.3.1 Large River Mosaic Sites

Binnen Kill and Schodack Island both represent large river mosaic restoration sites, and recommendations were developed for this restoration type in isolation of other types (i.e., shoreline, connectivity). System-scale plans were developed examining all possible combinations of sites, components, and alternatives. Mosaic plans represent 270 combinations and are consecutively numbered (i.e., MOS1 – MOS270). For each plan, a time series of ecological benefits was forecast with EPW (Figure 3-7A), benefits of each plan were annualized over the 50-year horizon (Figure 3-7B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-7C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-7D). Based on these analyses, the following system-wide plans for large river mosaic restoration were examined as the final array:

- MOS1 = No action in any sites or components
  - Unit Cost = $0 / AAFCU
  - No action alternative.
- MOS5 = Binnen Kill North-Alternative 4
  - Unit Cost = $72,657 / AAFCU (Incremental Cost / Incremental Unit = $72,657 / AAFCU)
  - No side channels included.
  - Does not meet side channel restoration sub-objective.
- MOS15 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2
  - Unit Cost = $73,324 / AAFCU (Incremental Cost / Incremental Unit = $74,417 / AAFCU)
  - Side channels are not included at both Binnen Kill and Schodack Island.
  - Does not meet side channel restoration sub-objectives.
- MOS45 (**RECOMMENDATION**) = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2
  - Unit Cost = $80,824 / AAFCU (Incremental Cost / Incremental Unit = $116,446 / AAFCU)

  - Side channels are included at both Binnen Kill and Schodack Island.
  - Meets planning objectives.
  - Lowest unit cost of plans meeting planning objectives.
- MOS180 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island Wetlands-Alternative 1
  - Unit Cost = $85,964 / AAFCU (Incremental Cost / Incremental Unit = $192,948 / AAFCU)
  - Meets planning objectives.
  - Moderate unit cost, but increase in incremental cost was very high and was not deemed "worth it" given MOS45's value.
- MOS268 = Binnen Kill North-Alternative 2 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island South-Alternative 1 + Schodack Island Wetlands-Alt1
  - Unit Cost = $91,901 / AAFCU (Incremental Cost / Incremental Unit = $244,050 / AAFCU)
  - Meets planning objectives.
  - High unit cost.
- MOS270 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island South-Alternative 2 + Schodack Island Wetlands-Alternative 1
  - Unit Cost = $92,378 / AAFCU (Incremental Cost / Incremental Unit = $2,199,800 / AAFCU)
  - Meets planning objectives.
  - High unit cost and extremely large incremental cost.

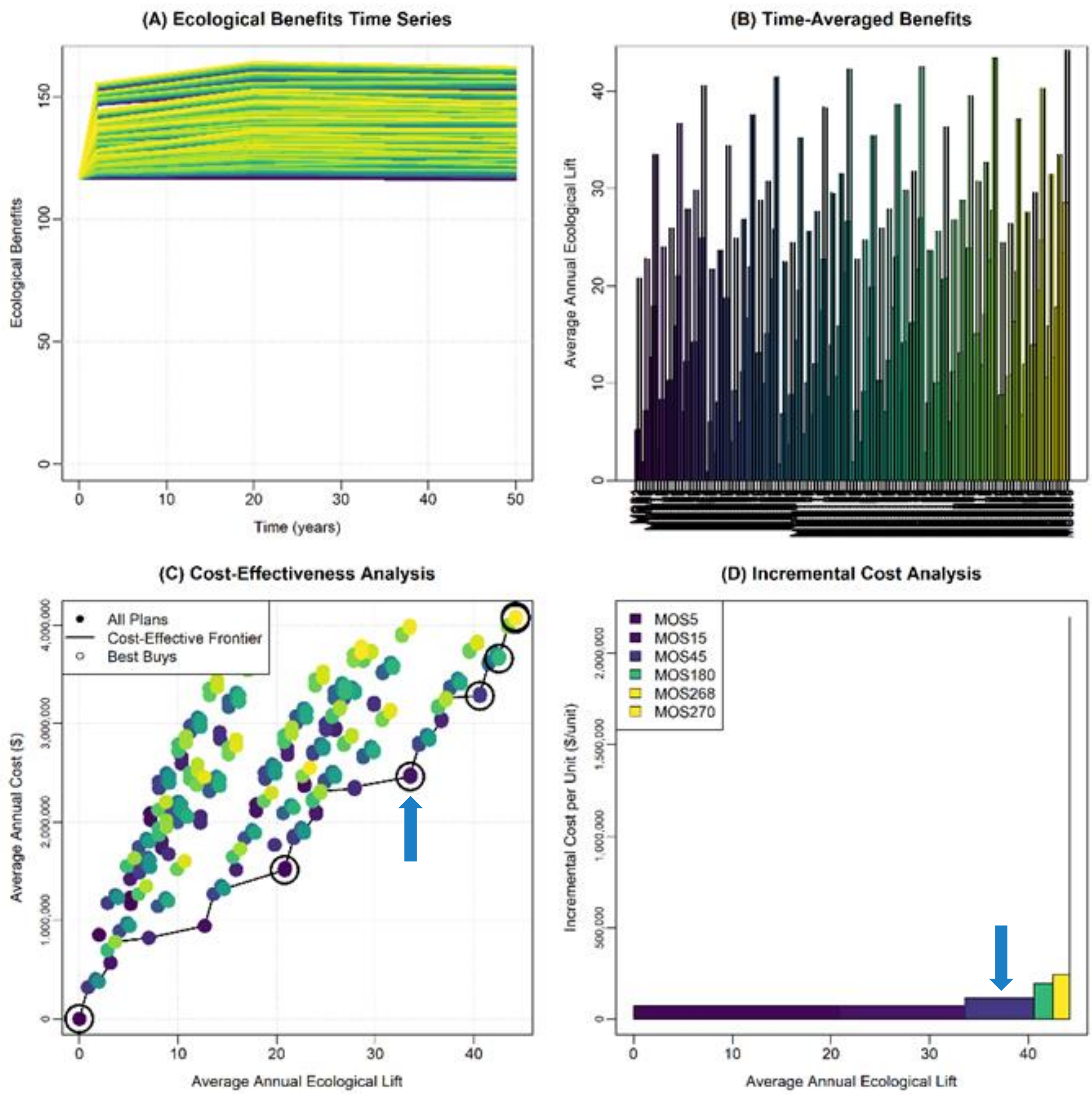


Figure 3-7: CE/ICA Results for Mosaic Sites.

System-wide alternative plan MOS45 was selected for further consideration at Binnen Kill and Schodack Island because it had the lowest unit cost of plans that meet the planning objectives (restoring side channels). The restoration of shallow water habitat through the creation of side channels at both Binnen Kill and Schodack Island was an important objective due to the complete loss of side channels and extensive loss of shallow water habitat resulting from historic USACE activities. This system-wide alternative plan consists of the following components:

- Binnen Kill North Alternative 4: wetland restoration, emergent wetland restoration and channel creation and forested wetland creation;

- Binnen Kill South Alternative 2: wetland restoration, tidal wetland restoration, side channel and tidal wetland corridor creation and road crossing; and
- Schodack Island North Alternative 2: tidal wetland restoration and conversion to side channel connection, side channel and tidal wetland corridor creation.

3.4.3.2 Shoreline Restoration Sites

Henry Hudson and Charles Rider both represent relatively small shoreline restoration sites, and recommendations were developed for this restoration type in isolation of other types (i.e., mosaic, connectivity). System-scale plans were developed examining all possible combinations of sites and alternatives. Shoreline restoration plans represent 6 combinations and are consecutively numbered (i.e., SHO1 – SHO6). For each plan, a time series of ecological benefits was forecast with EPW (Figure 3-8A), benefits of each plan were annualized over the 50-year horizon (Figure 3-8B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-8C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-8D). The following system-wide plans for shoreline restoration were examined as the final array:

- SHO1 = No action in any sites.
  - Unit Cost = $0 / AAFCU
  - No action alternative.
- SHO2 (**RECOMMENDATION**) = Henry Hudson-Alternative 1 and no action at Charles Rider Park
  - Unit Cost = $74,176 / AAFCU (Incremental Cost / Incremental Unit = $74,176 / AAFCU)
  - Lowest unit cost of the best buys.
- SHO3 = Henry Hudson-Alternative 2 and no action at Charles Rider Park
  - Unit Cost = $76,982 / AAFCU (Incremental Cost / Incremental Unit = $86,606 / AAFCU)
  - Large increase in incremental cost not deemed "worth it" due to small increase in project footprint (i.e., 2.88 AAFCUs vs. SHO2’s 2.23 AAFCUs).
- SHO6 = Henry Hudson-Alternative 2 and Charles Rider-Alternative 1
  - Unit Cost = $80,602 / AAFCU (Incremental Cost / Incremental Unit = $124,050 / AAFCU)
  - Highest unit cost and largest incremental cost.

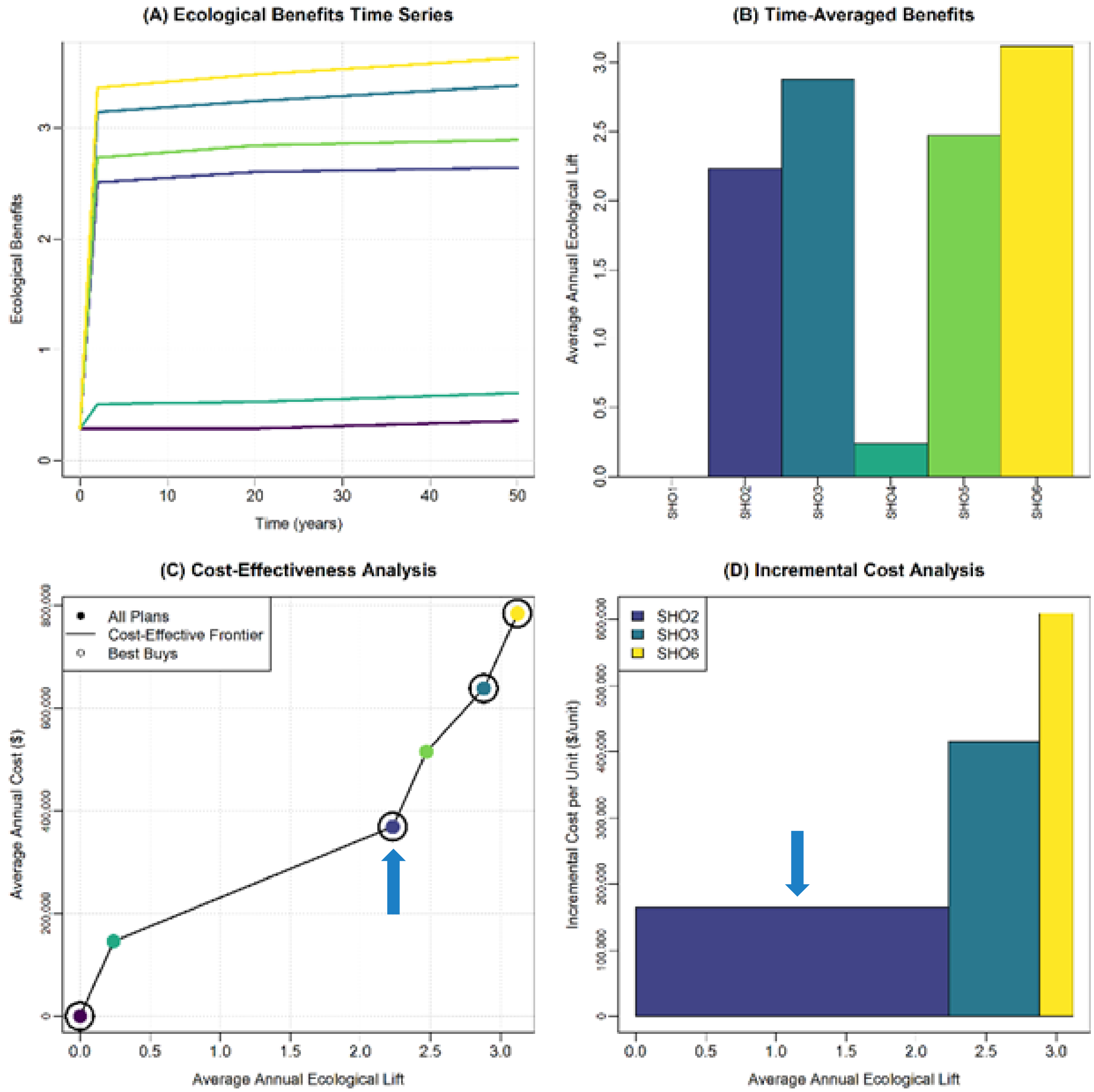


Figure 3-8: CE/ICA Results for Shoreline Restoration Sites.

System-wide alternative plan SHO2 was selected for further consideration for shorelines because it has the lowest unit cost per benefit while meeting the planning objectives. This system-wide alternative plan consists of the Future-Without Project Scenario (FWOP) for Charles Rider and Alternative 1 at Henry Hudson Park (vegetated riprap and tidal wetland restoration).

3.4.3.3 Tributary Connectivity Sites

Rondout and Moodna Creek sites represent tributary connectivity sites, and recommendations were developed for this restoration type in isolation of other types (i.e., mosaic, shoreline). Connectivity projects on Moodna are highly dependent upon activities at downstream sites and represent non-separable elements. System-scale plans were developed examining all possible combinations of sites, components, and alternatives. Tributary connectivity plans represent 108 combinations and are consecutively numbered (i.e., CON1 – CON108). For each plan, a time series of ecological benefits was forecast with WUCT (Figure 3-9A), benefits of each plan were annualized over the 50-year horizon (Figure 3-9B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-9C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-9D). The following “best buy” plans were examined as the final decision array:

- CON1 = No action at any sites
    - Unit Cost = $0 / AAFCU
    - No action alternative.
- CON3 = Rondout-Alternative 2
    - Unit Cost = $1,238 / AAHU (Incremental Cost / Incremental Unit = $1,238 / AAHU)
    - Dam removal at Rondout Creek only.
- CON91 (**RECOMMENDATION**) = Rondout-Alternative 2 + Moodna AOP 1-Alternative 1 + Moodna AOP 2-Alternative 1 + Moodna AOP 3-Alternative 2
    - Unit Cost = $2,967 / AAHU (Incremental Cost / Incremental Unit = $7,522 / AAHU)
    - Full or partial removal of all barriers.
    - A good value for a large amount of environmental benefits ($2,967 / AAHU for 175 AAHUs).

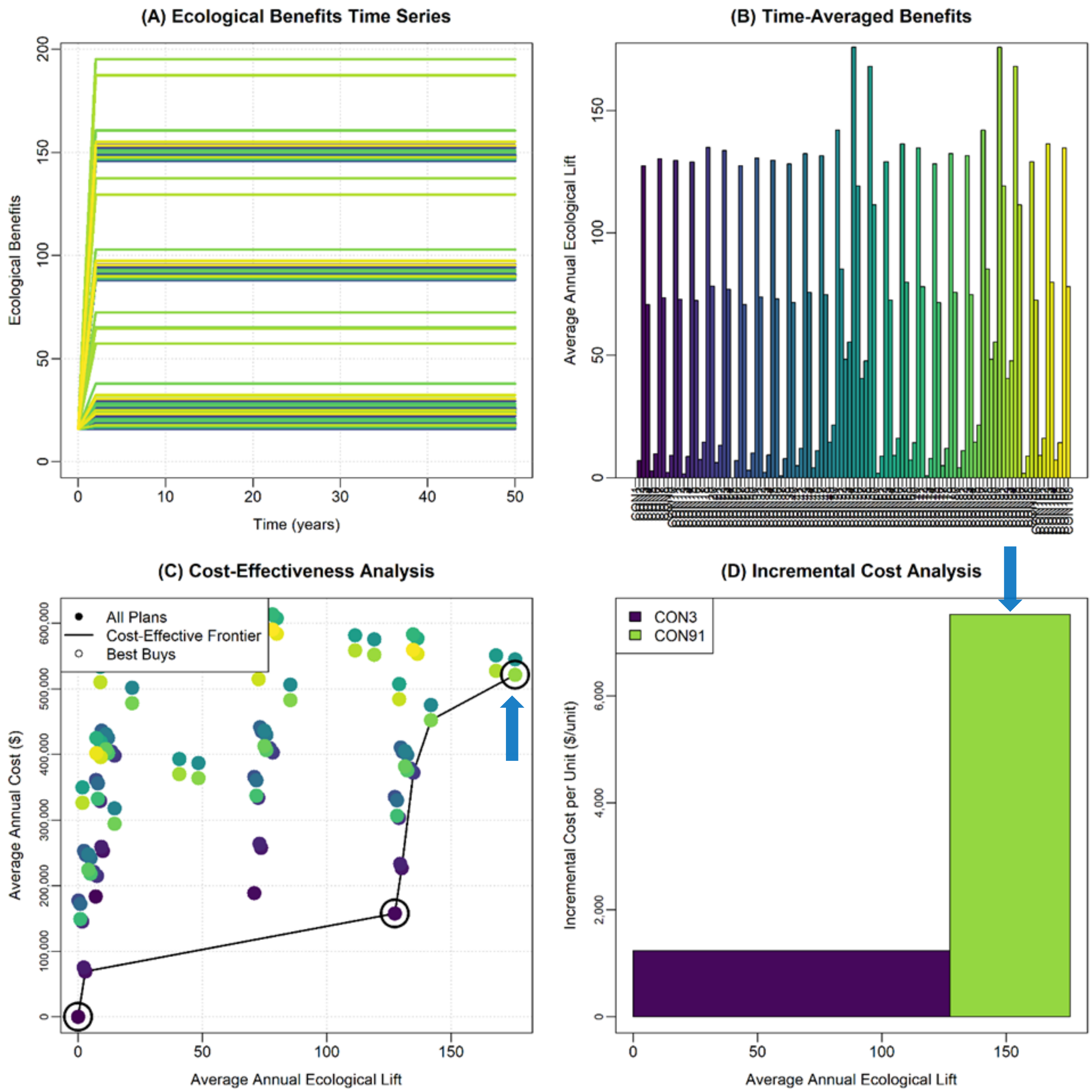


Figure 3-9: CE/ICA for Tributary Connectivity Sites.

System-wide alternative plan CON91 was recommended. Actions are recommended for both tributaries included in the recommendation for further analysis in order to meet our planning objectives and maximize benefits to open up two of the 90 tributaries blocked within the Hudson River watershed. A total of 17 additional miles (9 miles at Rondout and 7.8 miles along Moodna Creek) of high quality spawning habitat would benefit important migratory fish species including American shad, striped bass, alewife, blueback herring, and American eel. This system-wide plan consists of the Rondout Alternative 2 (full removal), Moodna AOP 1 Alternative 1 (full removal), Moodna AOP 2 Alternative 1 (full removal) and Moodna AOP 3 Alternative 2 (partial removal).

3.4.4 Contribution to Objectives and Consideration of Other Decision Factors

Other decision factors commonly influence restoration decision-making, and this section briefly reviews issues related to:

- Contribution to ecosystem restoration mission area and planning objectives
- Adherence to planning constraints
- Completeness, effectiveness, efficiency, and acceptability of the action (per the Principles and Guidelines' Criteria)
- Compliance with and embrace of USACE Environmental Operating Principles

3.4.4.1 Contribution to Objectives Analysis

The objectives for this study and the array of alternatives were formulated in a watershed-wide context. Each category of sites (mosaic, shoreline, connectivity) contributes to the objectives and sub-objectives in different ways. The system-wide alternative plans selected in Section 3.4.3 are further considered for recommendation by considering how they contribute to study's objectives of restoring a mosaic of interconnected habitat and lost connectivity. Due to the vastness and complexity of the study area, restoration activities at one site may not meet all of the objectives. Therefore, the plans are evaluated on how they collectively meet the study's objectives. The text below and Table 4-2 discusses the contributions to objectives expressed qualitatively and as average annual functional capacity units, average annual functional habitat units, and river miles of habitat opened. Collectively, the system-wide alternative plans contribute to all of the study's objectives and sub-objectives.

The large river mosaic sites address the creation of historically prevalent large river ecosystems, which would have included a diverse habitat mosaic of subtidal, intertidal, shoreline, and riparian ecosystems. Sites restore critical side channel and wetland habitat that was lost due to prior USACE activities. Side channels provide moderate velocity, high-biodiversity refuges – nursery ground, resting and feeding shallow water habitat for Federally Endangered Species (shortnose sturgeon and Atlantic sturgeon), American shad, and striped bass, as well as many birds, mammals, and reptiles (Miller, 2013).

Shoreline restoration sites restore riparian and wetland habitat and address active bank erosion and shoreline retreat along the main stem of the Hudson River. These projects restore intertidal habitat that has been impacted and lost due to shoreline hardening to prevent sediment from entering the Federal navigation channel.

Tributary connectivity sites address connectivity between the main stem of the Hudson River and ecologically important tributaries, with a particular emphasis on restoring fish passage to open up significant amounts of high quality habitat to important migratory fish species. Removing impediments to fish passage will allow anadromous fish to spawn and provide protective nursery grounds for larval and juvenile species, including important species like American shad, Hickory shad, striped bass, alewife, and blueback herring. Removing barriers to fish passage will also allow catadromous fish, such as American eel, to return home after spawning at sea to freshwater tributaries where they will spend the rest of their lives. In addition, dam removal benefits other potamodromous (i.e., fish whose migrations occur wholly within fresh water) fish including white sucker, smallmouth bass, white and yellow perch, spottail and golden shiner, carp, northern pike, walley, shorthead redhorse, and gizzard shad.

Dam removal is also anticipated to remove the stagnant backwater conditions that occur during low flows and base flows, and re-create a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. In addition, dam removal will restore the natural transport of bedload sediment, which in turn could rejuvenate benthic habitat conditions for aquatic invertebrates and enhance accretion of wetlands downstream, while partially offsetting any vertical channel degradation that has occurred in the decades and centuries since dam construction.

3.4.4.2 Principles and Guidelines Criteria

The 1983 Principles and Guidelines require that plans are formulated in consideration of four criteria: **completeness**, **effectiveness**, **efficiency**, and **acceptability**.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective. The alternatives in the final array were evaluated with consideration of necessary investments and other actions. The plans were looked at for environmental and cultural resource impacts, as well as the costs associated with the required real estate for implementation. No additional actions by other agencies or private entities are required to produce the benefits associated with the proposed alternatives.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. As described in Section 3.4.4, restoration alternative plans at Binnen Kill, Schodack, Henry Hudson, Rondout Creek, and Moodna Creek collectively meet the objectives.

Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. Efficiency was measured through CE/ICA and additional qualitative benefits from the projects. The incremental cost of the alternative plans' benefits was considered and the lowest unit cost per benefit, while still meeting the planning objectives, was selected. All of the alternative plans selected after the CE/ICA analysis meet the efficiency criteria.

Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. The study team formulated the alternatives in accordance with applicable laws and regulations. One important facet of acceptability is implementability, which is the feasibility of a plan in the technical, environmental, economic, social, and similar senses. All of the 23 evaluated alternatives meet the acceptability criteria.

3.4.4.3 USACE Environmental Operating Principles

The USACE Environmental Operating Principles (EOPs) foster unity of purpose on environmental issues to ensure that conservation, environmental preservation, and restoration is considered in all USACE activities. USACE Environmental Operating Principles have been considered throughout the study process, and will be followed during implementation of the proposed restoration actions, once approved. In coordination with the agencies and other stakeholders, USACE proactively considered the environmental benefits and impacts of the proposed actions. The comprehensive approach of the TSP to meet the study objectives is in accordance with the mandate of the EOPs below:

1. Foster sustainability as a way of life throughout the organization
2. Proactively consider environmental consequences of all USACE activities and act accordingly.
3. Create mutually supporting economic and environmentally sustainable solutions
4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments
5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs
6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner
7. Employ an open, transparent process that respects views of individuals and groups interested in USACE activities

Chapter 4: Tentatively Selected Plan*

This chapter describes the components of the Tentatively Selected Plan (TSP), the plan's benefits and costs, and its implementation. The TSP includes restoration actions at five sites. Shoreline restoration would be conducted at Henry Hudson Park, large river mosaics would be restored at Binnen Kill and Schodack Island, and tributary connectivity restoration would be conducted at Rondout and Moodna creeks. Table 4-1 summarizes the components of the TSP. TSP alternative concept plans for each site/component are presented in Figures 4-1 through 4-8.

Table 4-1: Tentatively Selected Plan Components.

SITE	TENTATIVELY SELECTED PLAN
BINNEN KILL	North: Alternative 4 • Wetland restoration (43.8 acres) • Forested wetland creation (15.5 acres) • Emergent wetland creation (4.3 acres) • Emergent wetland restoration & channel creation (41.9 acres) South: Alternative 2 • Side channel and tidal wetland corridor creation (27 acres) • Tidal wetland restoration (21.3 acres)
SCHODACK ISLAND	North: Alternative 2 • Side channel and tidal wetland corridor (9.1 acres) • Tidal wetland restoration (19.8 acres)
HENRY HUDSON PARK	Alternative 1 • Tidal wetland creation (3.6 acres) • Replacement of the eroding hardened shoreline with a vegetated rip/rap living shoreline
RONDOUT CREEK	Alternative 2 • Eddyville Dam removal (9 miles of upstream habitat)
MOODNA CREEK	AOP 1: Alternative 1 • Utility pipe removal AOP 2: Alternative 1 • Firth Cliff Dam removal AOP 3: Alternative 2 • Orr's Mill Dam partial removal (Collectively, 7.8 miles of upstream habitat)
TOTAL	**• 38 acres of side channels restored** **• 148 acres of wetlands in the Hudson River corridor** **• 17 miles of tributary habitat reconnected**

BINNEN KILL

The TSP at Binnen Kill consists of restoration of Binnen Kill North Alternative 4 (Figure 4-1) and Binnen Kill South Alternative 2 (Figure 4-2) and include NYS property and private parcels with willing landowners (to be confirmed). Binnen Kill North Alternative 4 includes wetland restoration, forested wetland creation, emergent wetland creation and emergent wetland restoration and channel creation.

Wetland Restoration

Almost 44 acres of existing habitat dominated by invasive species such as common reed or reed canary grass would be treated and replanted with native plant species.

Forested Wetland Creation

A portion of the existing hay field would be converted to forested wetland through the excavation of soil. Target ground elevations would need to be one foot above the groundwater table for two weeks during the growing season to ensure wetland hydrology is achieved. It is assumed that twelve inches of material would be excavated, on average. Microtopographic variations would be incorporated within the proposed wetland resulting in hummocks and hollows with elevations plus or minus six inches from the proposed average grade. After soil grading, the area would be planted with native woody vegetation.

Emergent Wetland Creation

This element would include the creation of emergent wetland through the treatment of invasive plant species and excavation of soil. Target ground elevations would need to be within inches of the groundwater table or contain ponded water for two weeks during the growing season to ensure wetland hydrology is achieved. After soil excavation, the area would be planted with native vegetation. It is assumed that twelve inches of material would be excavated, on average, based on existing upland grade elevations and adjacent wetland elevations

Emergent Wetland Restoration and Channel Creation

Restoration would occur in areas that are currently dominated by invasive vegetation such as common reed or reed canary grass. This element would include treatment of invasive plant species and the creation of four connected pools along approximately 3,700 linear feet of new channel with varying widths. The channel would connect diffuse, shallow pools to form areas of ecological diversity. Soil excavation would need to ensure wetland hydrology is met and would be enhanced with hummock-hollow microtopography, which would support both emergent and forested wetland communities. After soil grading, the area would be planted with native vegetation.

Binnen Kill South Alternative 2 includes wetland restoration, tidal wetland restoration and the creation of a side channel with a tidal wetland corridor within NYS property.

Wetland Restoration
Almost 14 acres of existing forested wetland habitat dominated by a common reed understory would be treated and replanted with native plant species.

Tidal Wetland Restoration East
This element includes treatment of invasive plant species and expansion of the existing tidal channel to accommodate increased flows with the proposed side channel connection. Fringe wetlands would be graded as necessary to stabilize the wetland and native vegetation would be planted.

Tidal Wetland Restoration West
Approximately 0.28 acres of common reed would be treated and replanted with native vegetation. Careful attention to rare plants in the stream channel should be adhered to. Restoration would consist of Invasive vegetation treatment followed by native vegetation planting.

Side Channel and Tidal Wetland Corridor Creation
A side channel would be excavated in areas of historic fill placement to hydrologically connect the Binnen Kill and the Hudson River with tidal waters. The channel would convey flow during low tide and higher water levels providing refuge to aquatic species during increased river velocities. A 300-foot tidal wetland corridor would be established adjacent to the channel. To accommodate local vehicular access to Shad Island, a privately-owned property, the channel would be spanned by rectangular reinforced box culverts and road surface.

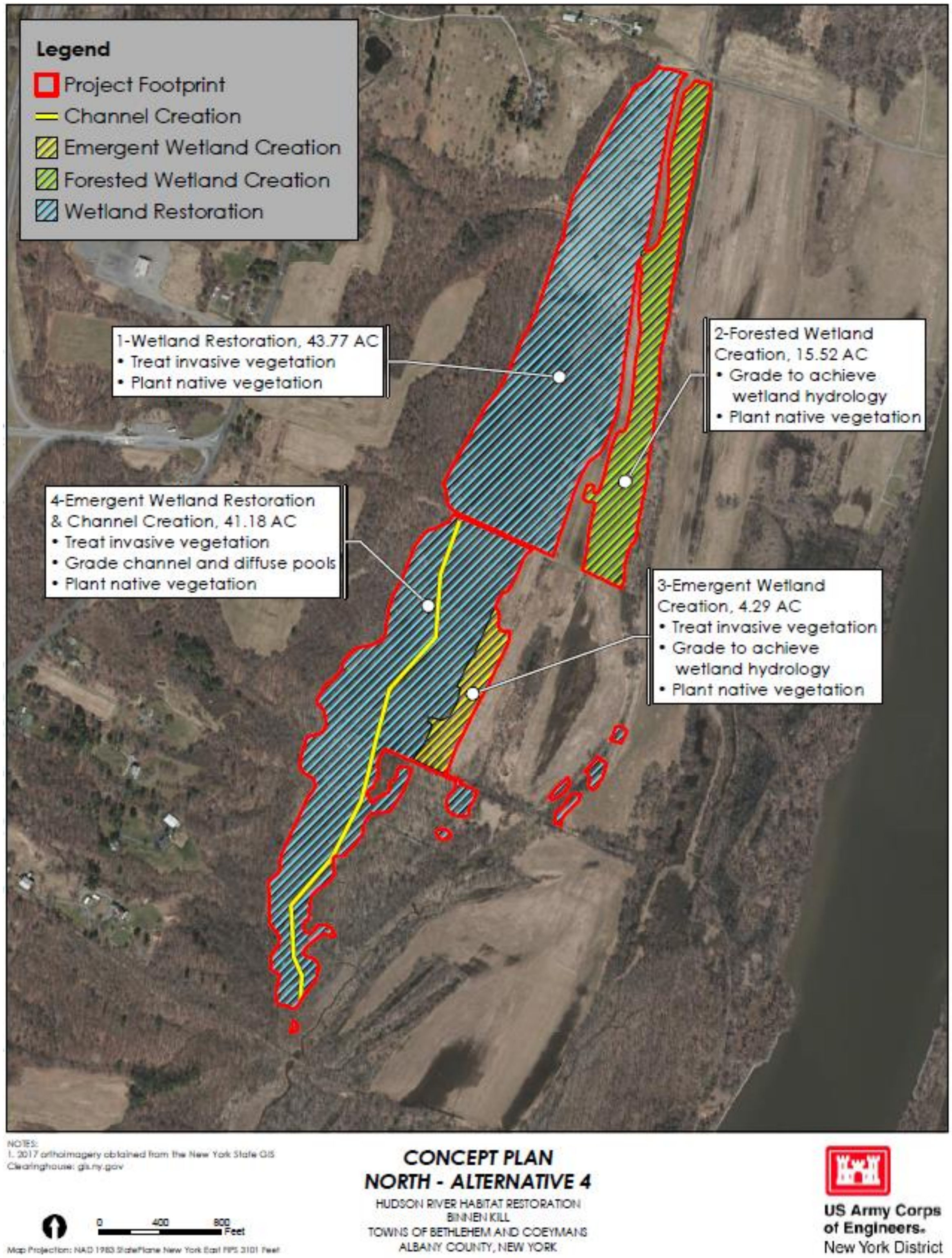


Figure 4-1: TSP at Binnen Kill, North.

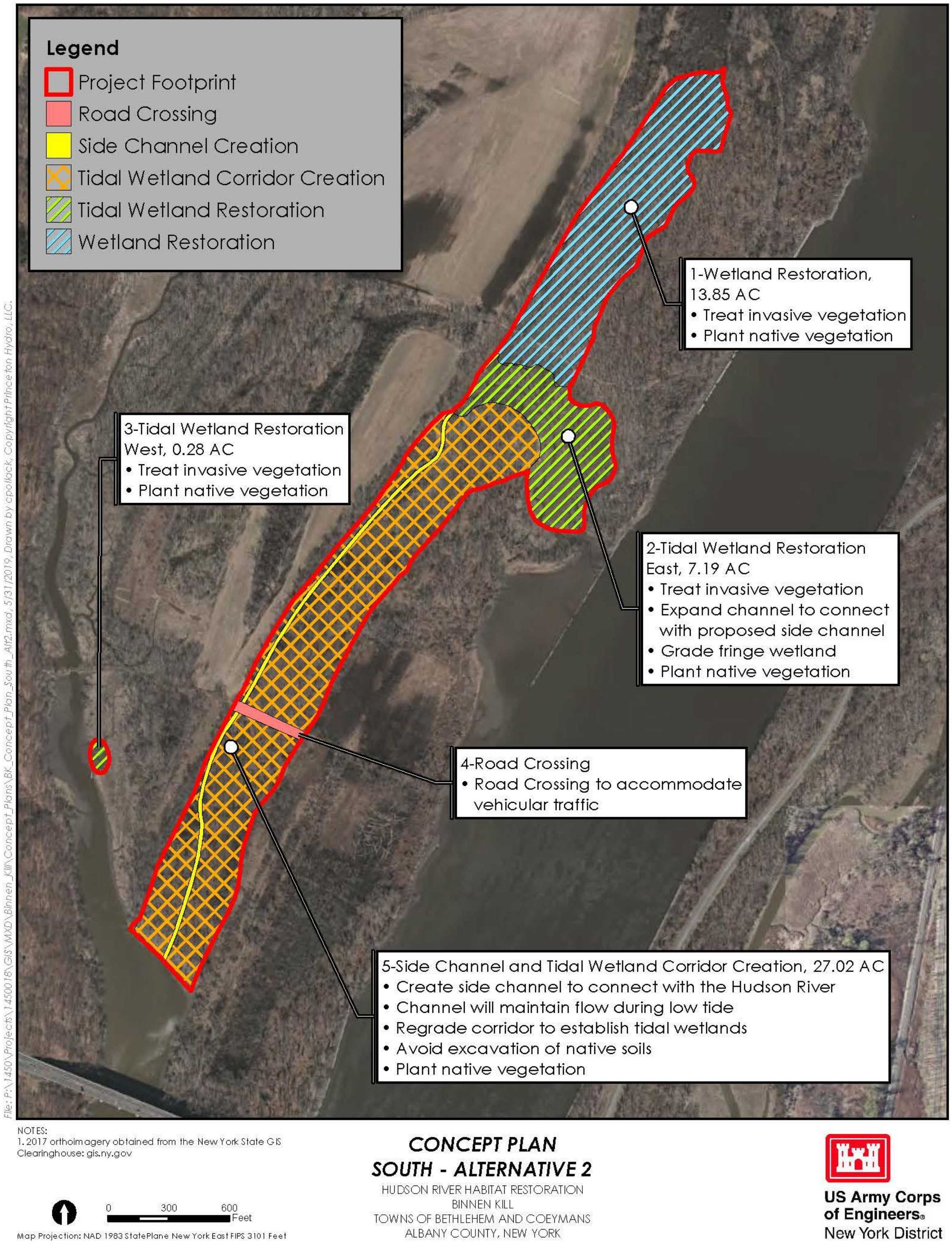


Figure 4-2: TSP at Binnen Kill, South.

SCHODACK ISLAND

The TSP at Schodack Island consists of tidal wetland restoration and side channel restoration with a tidal wetland corridor (Figure 4-3).

Tidal Wetland Restoration North

Approximately 1.8 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species.

Tidal Wetland Restoration & Conversion to Side Channel Connection

Approximately 2.31 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species. Additionally, minor grading would occur to convert wetland to a side channel connection point which would facilitate the conveyance of flow. The shoreline would be stabilized as necessary to accommodate new flows.

Tidal Wetland Enhancement South

Approximately 15.69 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated. Minor grading would expand the existing tidal channel to accommodate increased flows with the proposed side channel connection. Fringe wetlands would be graded as necessary to stabilize the wetland and native vegetation would be planted.

Side Channel and Tidal Wetland Corridor Creation

A side channel would be excavated in areas of historic fill placement to hydrologically connect Schodack Creek and the Hudson River with tidal waters. The channel would convey flow during low tide and higher water levels providing refuge to aquatic species during increased river velocities. A 400-foot tidal wetland corridor would be established adjacent to the channel. To accommodate local vehicular access to the southern portion of the island, the channel would be spanned by a road crossing with rectangular reinforced box culverts. The existing ski trail would also be redirected to this road crossing. The channel would have a 20-foot width and an invert elevation of -2.50 feet based on 2027 tide levels and transition to tidal wetland which would range in elevation from elevation 1.5 to 4.00 feet and then transition to riparian vegetation. The riparian vegetation would transition to existing grade at a maximum slope of 3 feet horizontal to 1 foot vertical. The width of the tidal wetland varied across the sites depending on the location of the historic shoreline or existing grade elevations.

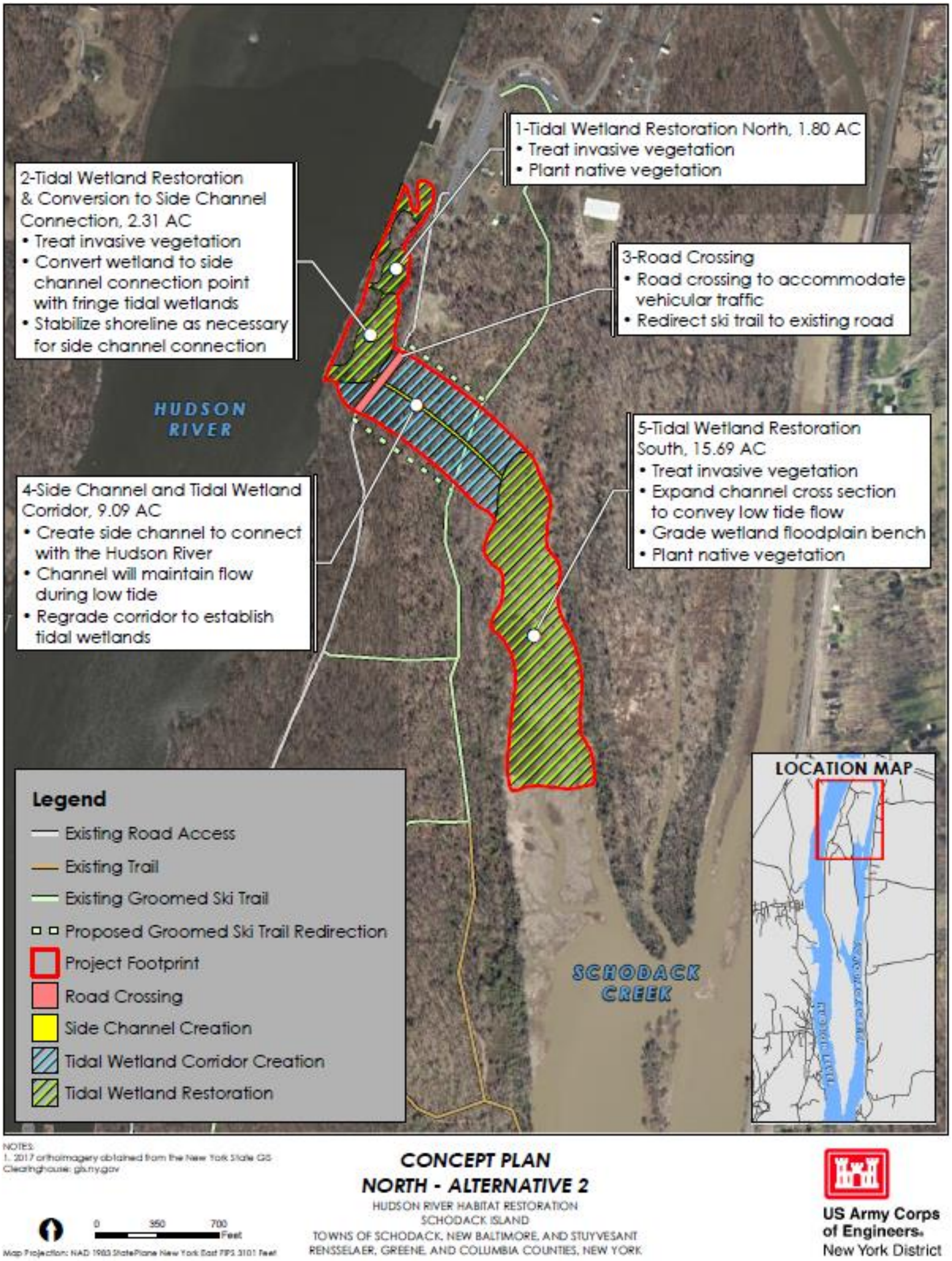


Figure 4-3: TSP at Schodack Island, North.

HENRY HUDSON PARK

The TSP at Henry Hudson Park includes restoration of tidal wetlands and providing a living shoreline with habitat and stability.

<u>Western Tidal Wetland Creation</u>

Approximately 3.6 acres of existing upland will be converted to tidal wetland. Soils would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology. The soils within the wetland area and excavated soil to be placed on site would be amended as necessary and planted with native vegetation. The shoreline would also be stabilized with rock to dissipate erosive forces. Tidal wetlands would be created through the treatment of invasive plant species, excavation of soil, and addition of soil amendments to provide a suitable substrate for native vegetation planting. Target ground elevations would be set to allow daily tidal flushing. The shoreline would also be stabilized with rock to dissipate erosive forces.

<u>Vegetated Riprap Creation</u>

The portion of land available for shoreline restoration at the Park is limited due to the adjacent park amenities, and the bank slopes are generally steep and require stabilization to transition from the shoreline edge to river channel bottom. Due to these conditions, it was necessary to provide a hard-armoring approach using vegetated riprap while balancing the goal to maximize ecological benefits. To breach the transition from the river channel bottom to shoreline edge, reinforcement of the existing timber cribbing toe protection is proposed. Along the Hudson River shoreline, the existing timber cribbing would remain. The cribbing would be reinforced with 12-inch riprap which was sized based on existing rock material located at each site. The concrete cap would be removed and replaced with riprap and graded to achieve a 1V:3H slope. The area of land landward of the reinforced cribbing would be backfilled with soil and planted with native vegetation. It was assumed that the existing timber cribbing is currently stable and would not need to be replaced as the rock and vegetation installed landward of the cribbing would be established and stabilized to withstand the tidal and wave/wake forces if the cribbing further deteriorates. Additionally, stabilization boulders would be placed at the wetland-upland interface. The boulders would be approximately three to four-feet in diameter which is similar in size to boulders on-site that appear to be currently stabilizing the shoreline. These modifications to the structure would not significantly encroach upon the park's upland areas.

<u>Cove Tidal Wetland Creation</u>

Tidal wetland creation would occur within an existing mudflat. Along the northern bank on the Vloman Kill, 20-inch coir log toe protection would be installed at the toe of the slope around the existing mudflat. This diameter coir log was selected to allow six inches to be embedded into the existing substrate and at least 12 inches above grade to retain the substrate, assuming that the coir log will flatten by approximately two inches during installation. Riprap consisting of 36-inch boulders would be installed at the top of slope to stabilize existing scour. These boulders would be embedded a minimum of six inches into the ground. This diameter rock was selected because it is consistent with the size of existing material in stable bank areas. Native wetland vegetation would be planted within the intertidal area.

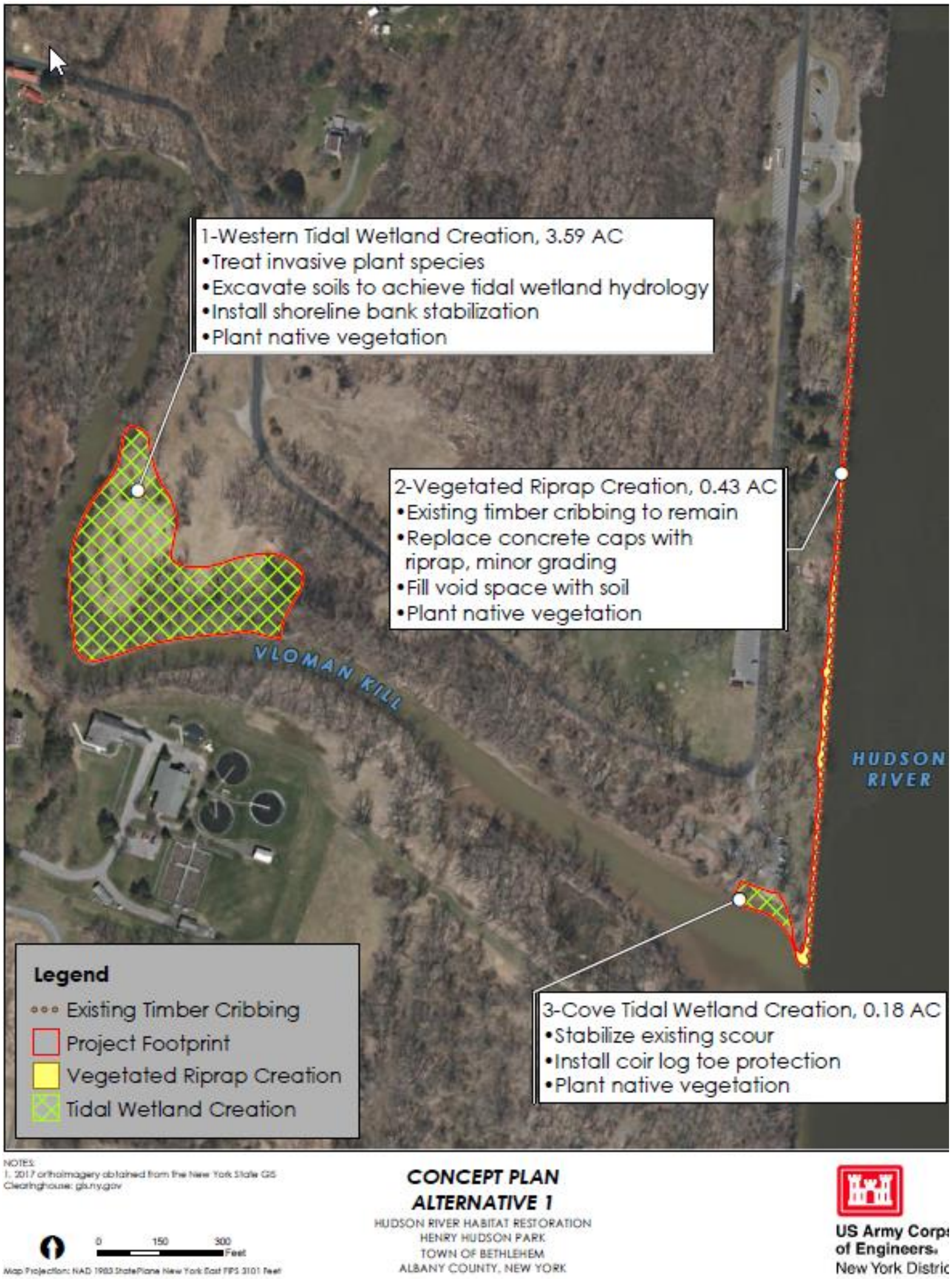


Figure 4-4: TSP at Henry Hudson Park.

RONDOUT CREEK

Alternative 2, the removal of Eddyville Dam, is proposed as the TSP on Rondout Creek. The TSP entails removal of the entire concrete spillway down to the elevation of the underlying bedrock. The free-standing masonry training wall may remain, pending more detailed site investigation and survey. Normal water surface elevation would drop approximately 8 feet in the upstream vicinity of the dam and tidal fluctuation would extend upstream into the impoundment. Despite full removal of the spillway, a bedrock ledge feature would likely remain onsite in some form, separating the deeper portions of the river bed upstream and downstream. This bedrock ledge may still be visible at the surface at some point during the daily tidal fluctuation and variation in river flows; although, more detailed site survey and hydrologic and hydraulic analysis are needed to affirm this with greater specificity.

Dam removal would rely on construction access from the dam owner's property; however, after removal, there would be no need for inspections, maintenance, or repairs. The dam owner would not need to provide ongoing access through his property, and no non-profit or state agency would need to serve as long-term owner and operator of the site. As stated above, it is assumed that adequate shallow bedrock or consolidated river bottom exists immediately upstream and/or downstream of the dam to allow for a rock-lined construction accessway to convey an excavator to the dam and across the spillway.

The bedrock ledge, upon which the dam is founded, and the bedrock valley walls limit the potential for channel instability and geomorphic adjustment at the dam if the dam were to be removed. The deeply mined sections of the river bed upstream of the dam that created pools up to 50 feet deep would still remain if the dam were removed and normal water surface elevation dropped by approximately 8 feet at the dam. Upstream of those deep pools, the river would revert to free-flowing conditions, but with daily tidal fluctuation. Existing shallow areas in the impoundment area are expected to naturally revert to wetlands after the Eddyville Dam is removed.

While tidal fluctuation would extend into the upstream reaches, it is unlikely that water quality conditions would change such that a change in water quality classification would be warranted; although, that decision lies with NYSDEC and the results of ongoing water quality monitoring. With a drop in normal water surface elevation, some narrowing of the normal wetted width would also be expected, both of which would diminish in the upstream direction and would be partially offset or muted by the daily tidal fluctuation. Since the river would remain adjacent to existing riverfront properties, land values related to river views and access to the river are not anticipated to be adversely affected. River navigability upstream of the dam would vary with river flows and tidal fluctuation. The bedrock ledge, which is anticipated to remain in some form, would likely remain as a barrier or deterrent to boat navigation from downstream of the dam to the upstream reaches. Future phases of this study will address this extent and nature of upstream tidal fluctuation and downstream flow.

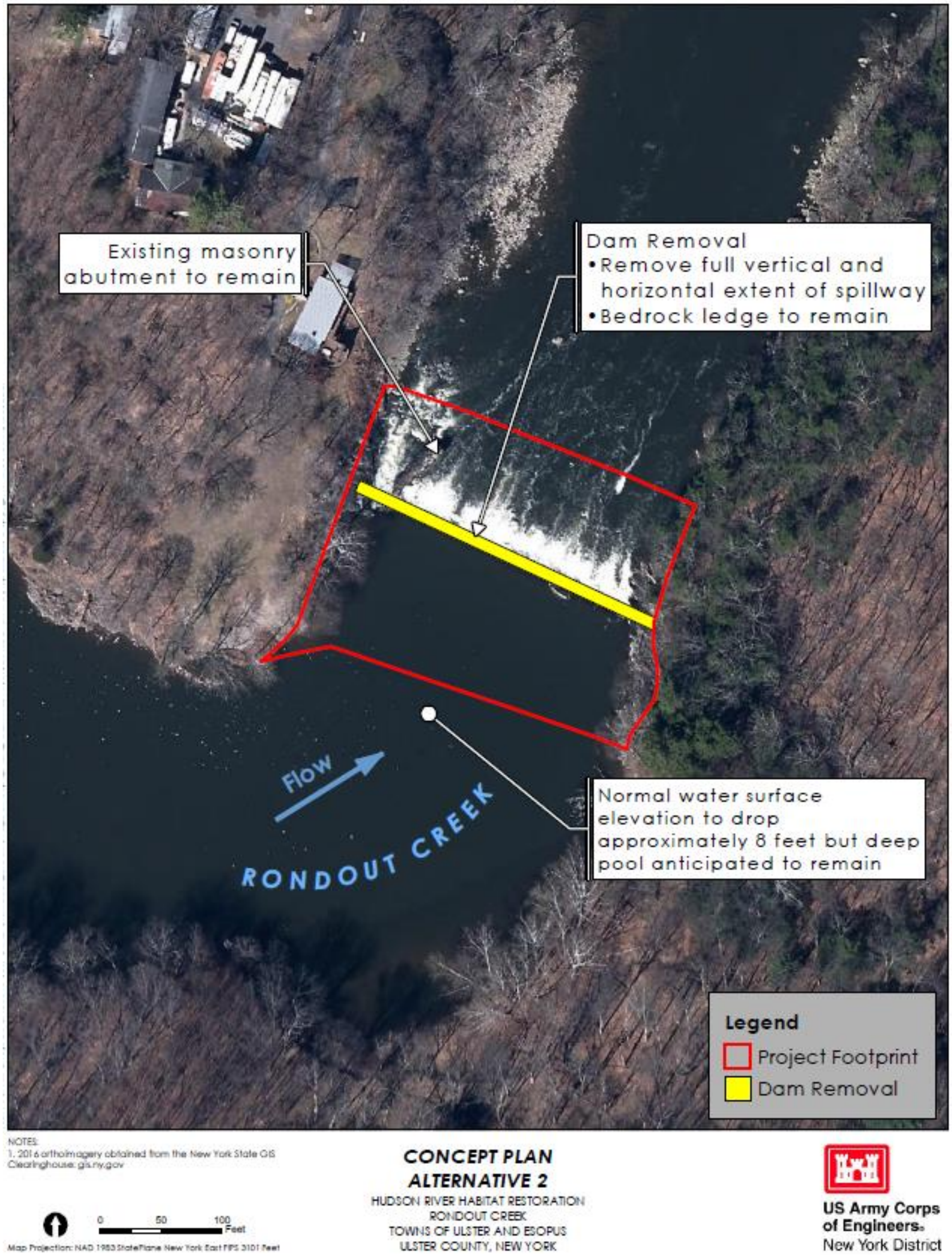


Figure 4-5: TSP at Rondout Creek.

MOODNA CREEK

The TSP for Moodna Creek includes removal of the sewer utility line (AOP 1), removal of Firth Cliff Dam (AOP 2) and breach of Orr's Mill Dam (AOP 3).

AOP 1 Alternative 1 - Utility Removal (Figure 4-6)

This alternative entails decommissioning the dormant utility line and removal of the section that crosses Moodna Creek. The sanitary sewer line is a 16-inch ductile iron pipe (DIP); an approximately 100-foot-long section spans the channel and is contained in a concrete encasement approximately five feet wide and five feet deep. The recommended approach to decommissioning the line includes accessing the existing manhole on the floodplain to the north (i.e. river left side), and sealing-off the incoming sanitary line with concrete or similar means. On the river right bank, where the utility descends steeply from the inactive railroad bed at the top of the slope, the recommended approach to decommissioning this sewer line is to break the existing line at the base of the slope and install a manhole in connection with upgradient line, but with no outlet toward the Creek. The installation of the manhole on river right creates a stable and secure closure to the existing sewer line, and prevents any inadvertent leakage or discharge of fluid into the Creek, in the event of any unknown inflow or infiltration into the sewer line.

A total of 175 feet of sewer line (100-foot concrete encased section and the 75-foot section under floodplain soils leading to the existing manhole) would be excavated and disposed of offsite. The proposed manhole could potentially be used to re-install the line in the future, if necessary. Full removal of the utility line at the channel crossing is proposed as the alternative that most effectively restores fish passage through the site, and also eliminates the structure that is currently exposed, undermined by subsurface flow, and at risk for damage or rupture. Although, removal of the entire utility line extending off-site would not serve the ecological goals of this project, and would likely exceed funding for design, permitting, and construction. Therefore, the off-site segment of the sewer line (75-feet) would remain on-site to reduce costs.

AOP 2 Alternative 1 - Dam Removal (Figure 4-7)

The TSP at Firth Cliff Dam entails demolition and removal of the concrete spillway to the full vertical extent and, pending favorable results of impounded sediment analysis and subsequent passive release of the impounded sediment. The abutments attached to the valley wall on river left and the building foundations on river right may be left in place pending observations from a more detailed site investigation.

Approximately 1,300 feet upstream of the dam, a pronounced boulder riffle indicates the upstream limit of the impoundment and would serve as a natural grade control that would limit the upstream extent of any channel adjustment in the event of dam removal. The well-vegetated banks and narrow valley walls indicate little potential for lateral channel adjustment or meandering. In general, the geomorphic response to dam removal would follow a predictable trajectory: (i) initial water-lowering, (ii) impounded sediment evacuates from the impoundment as head-cut moves upstream from the dam and then widens to the full span of the channel, and (iii) temporary deposition of coarse-grained sediment in the downstream reaches. By the end of the first growing season, herbaceous, annual plants would begin to occupy the newly-exposed upper banks; perennial species would begin to dominate by the end of the second growing season.

This alternative is anticipated to re-create a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. Full fish passage conditions are very likely to re-form; removal of the dam would reconnect two previously disconnected river reaches and restore passage for some resident species and American Eel. In addition, this dam removal is anticipated to restore the natural transport of bedload sediment, which in turn could rejuvenate benthic habitat conditions for aquatic invertebrates downstream, and partially offset any vertical channel degradation that has occurred in the decades and centuries since dam construction.

AOP 3 Alternative 2 - Dam Breach (Figure 4-8)
Alternative 2 entails breaking through the spillway concrete crest, and underlying cobble/boulder-filled timber crib structure, removing the vertical extent of a central portion of the spillway, and leaving the side portions in place. The ends of the spillway could be stabilized at their base with placed boulders, while the upper portions could be left open for visibility of the spillway's interior construction. This alternative effectively removes the dam, but retains a portion of the spillway in place as a physical marker of the former dam if desired by the dam owner; however, similar to current conditions, the remaining spillway would be subject to slow deterioration due to weathering and river conditions (freeze/thaw, ice floes, scour, abrasion, debris impact, etc.

With the full vertical extent of the central portion of the spillway removed, a similar channel response is likely to be triggered as with full removal but with more retention of sediment on the channel margins proximal to the dam. The pronounced boulder riffle approximately 900 feet upstream of the dam would serve as a natural grade control that would limit the upstream extent of any vertical channel adjustment in the main channel if the dam is notched. The multiple extremely large boulders (i.e. five to ten feet in diameter) that are situated immediately upstream of the spillway are anticipated to form boulder-dominated steps or a cascade. Following dam notching, finer sediment would transport downstream, while the larger cobble and boulder may shift position. Due to the steep slope that is anticipated to re-form, full fish passage conditions for the full range of target fish could not be guaranteed to form passively and thus, some active re-grading and re-positioning of boulders may be necessary to facilitate the formation of a stable grade control and fish passability. If *in situ* boulders are insufficient to maintain a stable grade change and/or fish passage conditions, this alternative also includes supplementing this reach with large boulders to establish grade control. Boulder size would be determined during detailed topographic survey, and hydrologic and hydraulic analysis, and rock sizing calculations; however, onsite boulders serve as reasonable estimates. Boulders are an abundant, natural component of Moodna Creek and thus additional use would provide a natural aesthetic that blends with adjacent reaches.

As in the full dam removal alternative, the cobble-dominated tributary confluence requires additional investigation and would likely necessitate a stone grade control structure to prevent undermining of the over-lying residence.

This alternative, much like the full dam removal alternative, is anticipated to remove the stagnant backwater conditions that occur during low flows and base flows, and re-create a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. Full fish passage conditions could not be guaranteed, and are likely to be less passable than the full dam removal option due to the likely steep channel post dam removal; however, removal of the dam would reconnect to previously disconnected river reaches and restore passage for some resident species and American eel. In addition, this dam removal is anticipated to restore the natural transport of bedload sediment, which in turn could rejuvenate benthic habitat conditions for aquatic invertebrates downstream, and offset any vertical channel degradation that has occurred in the decades and centuries since dam construction.

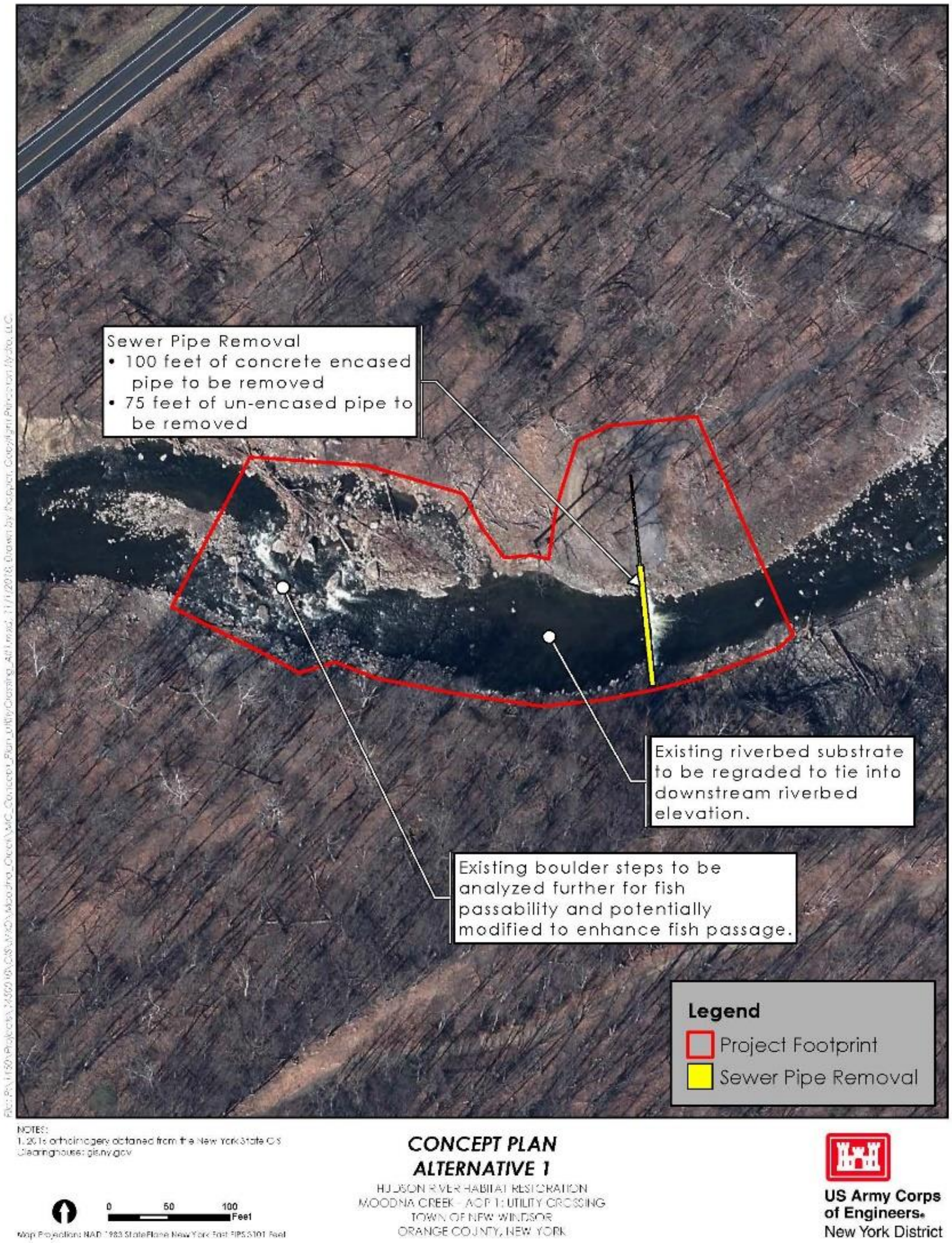


Figure 4-6: TSP at Moodna Creek, AOP Barrier 1.

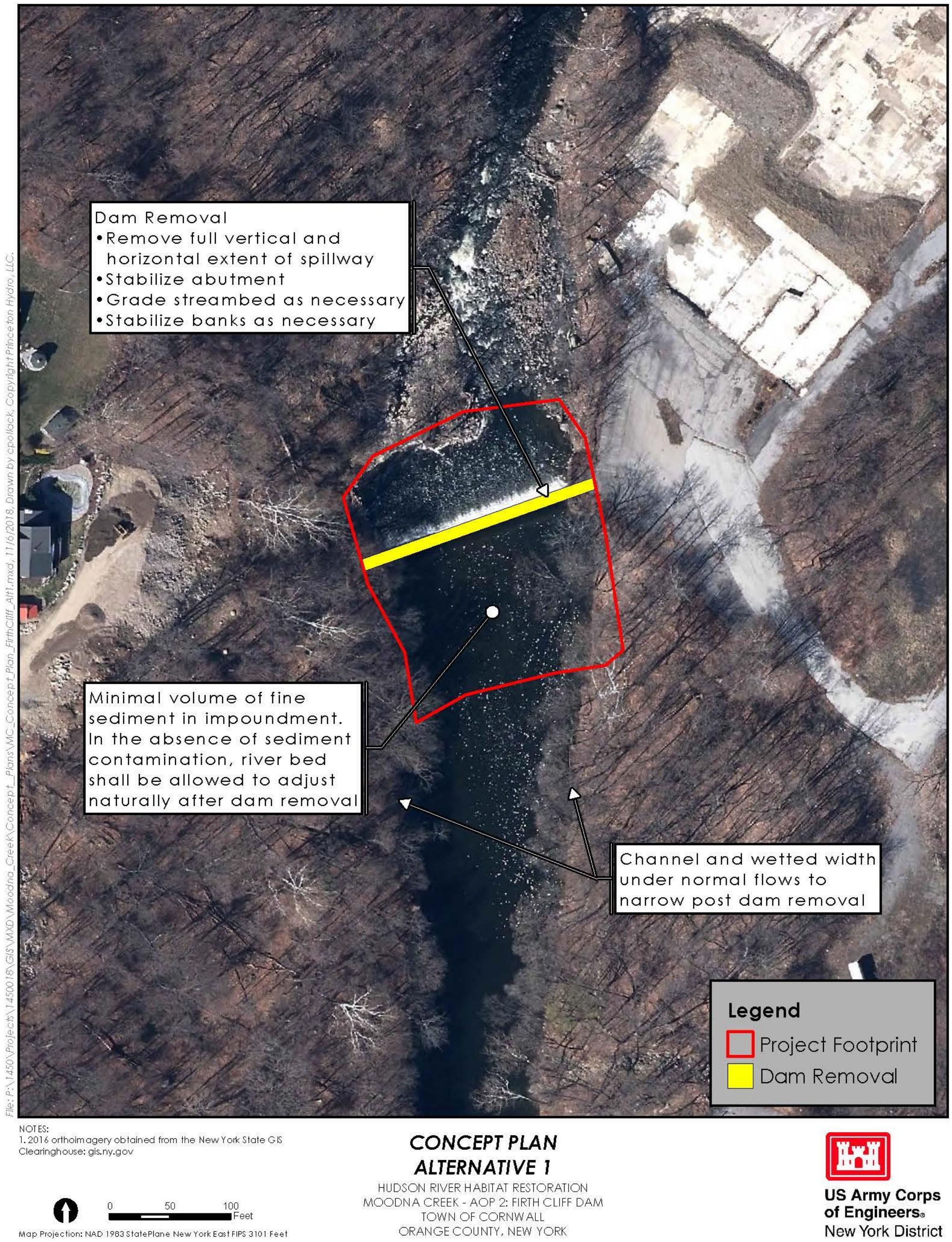


Figure 4-7: TSP at Moodna Creek, AOP Barrier 2.

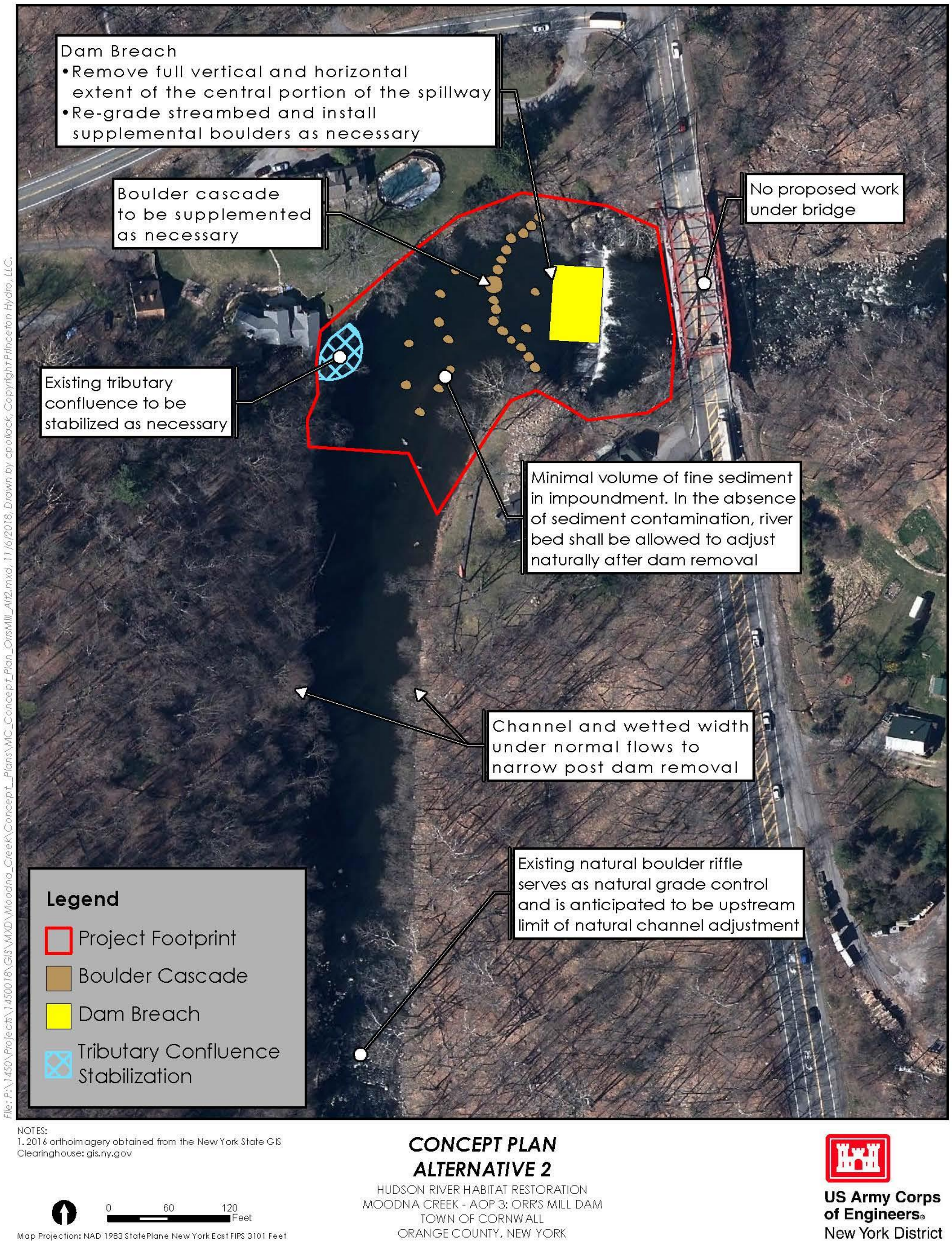


Figure 4-8: TSP at Moodna Creek, AOP Barrier 3.

4.1 Plan Benefits

The TSP meets the planning objectives to restore a mosaic of interconnected, large river habitats and restore lost connectivity within the Hudson River and its tributaries (Table 4-2). The large river mosaic and connectivity benefits of the TSP were calculated as 42.8 AAFCUs and 175.8 AAHUs, respectively. Table 4-2 summarizes quantitative and qualitative benefits of the TSP relative to the planning objectives. Furthermore, activities would directly address past impacts of the USACE navigation project, including filled shallow water habitat, lost side channels, hardened and diked shorelines, and degraded critical habitat for migratory fish species. Further details on TSP benefits are provided below by restoration type.

Proposed activities at Binnen Kill and Schodack Island will partially address the elimination of historically prevalent large river ecosystems, which would have included a diverse habitat mosaic of subtidal, intertidal, shoreline, and riparian habitats. Creating side channels at these sites will restore critical shallow water and wetland habitat that was lost from prior USACE activities. Side channels provide moderate velocity, high-biodiversity refuges, which serve as nursery, resting and feeding habitat for Federally Endangered Species (shortnose sturgeon and Atlantic sturgeon), American shad, striped bass, and many birds, mammals and reptiles (Miller, 2013).

Tidal wetland creation and living shorelines at Henry Hudson Park will create riparian and wetland habitat along the main stem, restoring habitat that has been impacted and lost due to past dredged material placement. The vegetated riprap will address active bank erosion and protect the habitat created, which will provide stable edge habitat for fish, invertebrates, birds, and amphibians.

Proposed activities in Rondout Creek (at Eddyville Dam) and Moodna Creek (at three barriers) will improve connectivity between the main stem of the Hudson River and ecologically important tributaries. The removal and modification of these barriers will open significant amounts of high quality habitat to important migratory fish species. Barrier removal will allow anadromous fish (e.g., American shad, striped bass, alewife, blueback herring) to reach nursery grounds for larval and juvenile life stages and catadromous fish (e.g., American eel) to live out adult life stages. Rondout and Moodna Creeks provide complimentary tributary habitats catering to different species (i.e., Moodna is a relatively narrow small tributary while Rondout is a larger stream). Dam removal also improves hydrologic and sedimentologic processes in the tributary and mainstem and enhances the long-term sustainability of downstream habitat.

Dam or Barrier Removal restores free-flowing conditions to a reach of river, transport of sediment and organic material, movement of resident fish and other aquatic organisms, migration of diadromous species, and typically improves water quality including reduced maximum temperatures and increased dissolved oxygen content. Dam removal often eliminates a threat to public safety and owner liability, and absolves the owner of further regulatory obligations. In addition, the upfront costs for dam removal are typically lower than for dam repair or rebuild, and there are no long-term costs for monitoring, maintenance, and repairs.

One potential positive impact is in the reduction of flood elevations upstream of the dam. It is understood that the upstream riverfront landowners experienced severe river flooding and flood damage during recent flood events. Removal of the dam, and reduction in normal water surface elevation, could result in reduced flooding for neighboring properties. Detailed hydrologic and hydraulic analysis would be required to affirm the extent and magnitude of this effect. Meanwhile, as a run-of-river dam not designed for flood control, the removal of the dam is not anticipated to adversely affect flooding in the downstream reaches.

The multiple papers about the Hudson River and Rondout Creek make a strong case for the potentially profound impacts this dam removal could have on the fishery. With such a diverse fish community immediately downstream in the Hudson River and the lower reaches of Rondout Creek, many fish are poised to benefit from the removal of the dam and reconnection to approximately seven miles of river upstream. They include migratory fish, including catadromous American eel, and anadromous species including American shad, hickory shad, blueback herring, alewife, and striped bass, as well as potamodromous fish including white sucker, smallmouth bass, white and yellow perch, apottail and golden shiner, carp, northern pike, walleye, shorthead redhorse, and gizzard shad. As the first barrier on Rondout Creek, Eddyville Dam is the most important barrier to be considered for removal in the river system.

4.2 Plan Costs

The estimated total cost for the Tentatively Selected Plan is $98,386,265 (FY19 Price Level). Table 4-3 includes the cost estimates and annualized costs.

Table 4-2: System-Wide Alternative Plans Contribution to Objectives.

OBJECTIVE	SUB-OBJECTIVE	MOSAIC		SHORELINE		CONNECTIVITY			
		Binnen Kill	Schodack Island	Henry Hudson	Charles Rider	Rondout Creek	Moodna Creek		
		N4, S2	N2	Alt 1	FWOP	Alt 2	AOP1 Alt 1	AOP2 Alt 1	AOP3 Alt 2
1. Restore a mosaic of interconnected, large river habitats	1.1 Increase extent and quality of subtidal, shallow water habitat	63.9 AAFCU	9.1 AAFCU						
	1.2 Increase extent and quality of intertidal shoreline habitats	↑↑	↑↑	2.2 AAFCU					
	1.3 Promote neighboring riparian habitat contributing to aquatic ecosystem integrity	17.5 AAFCU	2.0 AAFCU						
	1.4 Promote balanced mosaic of habitat types	- 47.9	- 4.1						
2. Restore lost connectivity within Hudson River and its tributaries	2.1 Increase connectivity of spawning, foraging, and resting habitat for migratory fish	↑	↑	↑		127.4 AAHU (9.2 miles)	48.4 AAHU (7.8 miles)		
	2.2 Increase connectivity to stopover, nesting, and foraging habitat for migratory and resident birds	↑↑↑	↑↑	↑					
	2.3 Promote actions improving the transport regime of water sediment and nutrients	↑	↑			↑↑↑	↑↑↑		
Total Average Annual Functional Capacity Units/Habitat Units		33.5	7.1	2.2		127.4	48.4		

Table 4-3: Tentatively Selected Plan Cost Estimates (FY 19 Price Level).

SITE	COMP-ONENT	ALTERN-ATIVE	CONSTRUCTION DURATION (months)	SUB-TOTAL FIRST COST ($)	MONITORING AND ADAPTIVE MANANAGEMENT COST ($)	TOTAL PROJECT FIRST COST ($)	OMRR&R COST ($)	AVERAGE ANNUAL COST ($)
Binnen Kill	North	Alt4	24	33,689,272	1,504,379	35,193,651	145,896	1,512,712
	South	Alt2	24	21,404,501	732,445	22,136,946	85,556	945,843
Schodack Island	North	Alt2	24	18,646,693	610,104	19,256,797	73,636	822,106
Henry Hudson	-	Alt1	12	8,568,894	304,315	8,873,209	29,783	368,870
Rondout	-	Alt2	3	3,821,542	110,846	3,932,388	8,429	157,659
Moodna	AOP1	Alt1	3	1,609,785	85,846	1,695,631	5,000	69,227
	AOP2	Alt1	6	3,511,137	110,846	3,621,983	7,664	145,562
	AOP3	Alt2	6	3,271,685	403,975	3,675,660	10,000	148,982
	ALL Moodna AOPs	ALL	15	8,392,607	600,667	8,993,274	22,664	363,771
TOTAL				94,523,509	3,862,756	98,386,265	365,964	4,170,961

4.3 Economic, Environmental, and Other Social Effects

USACE guidance requires that study alternatives be evaluated under the following accounts: the national economic development (NED), regional economic development (RED), other social effects (OSE), and environmental quality (EQ). Ecosystem restoration projects are also evaluated for NER benefits. The plans formulated and evaluated for this study were all developed to provide ecosystem restoration benefits. There is no evaluation for NED or RED benefits as benefits for ecosystem restoration studies are not monetized.

The Environmental Quality account displays non-monetary effects on significant natural and cultural resources. The expected environmental quality effects of implementing the TSP are primarily beneficial, although there would be short-term adverse effects during construction. Chapter 5 provides a detailed assessment of the potential environmental quality effects that would result from implementing the TSP. In the long term, environmental quality will be greatly enhanced by construction of the five projects.

The major RED impact associated with the implementation of the TSP is the temporary increase in employment and economic activity due to construction expenditures.

OSE include the effects that are not covered in the NED, RED, and EQ accounts. This would include effects on the community, health and safety, displacement, energy conservation, environmental justice, and other non-monetary effects. The expected social effects of implementing the TSP are primarily beneficial (improved outdoor activities based on increased fish and wildlife populations such as fishing, hunting, and bird watching) although there would be short-term adverse effects during construction such as decreased access, noise, and dust in the local vicinity.

4.4 Relative Sea Level Change

Future sea level projections were considered during all phases of design development and will continue to inform this process. The analysis was conducted in accordance with ETL 1100-2-1 (Jun 2014) and ER-1100-2-8162 (Dec 2013). Low, intermediate and high rates of sea level change were calculated. The complete sea level change (SLC) analysis can be found in the Engineering Appendix, Section 3.0 and calculates an increase in water surface elevations of 6 to 34 inches for the study area by the year 2075. The results of this analysis informed the designs of all alternatives (where appropriate) as well as the EPW analyses of baseline and projected with and without project conditions. These results compliment sea level change studies conducted by the City of Albany and the NY State Energy Research and Development Authority (NYSERDA) have also investigated sea level change concluding that water surface elevations along the NY coastlines have increased at an average rate of 1.2 inches per decade since 1900, and that Hudson River water surface elevations at the City of Albany could possibly increase between 8 and 18 inches by the year 2080.

The impact of sea level rise driven changes to the salinity regime in the Hudson River were considered. The HRHR sites where SLC driven changes to the Hudson River salinity gradient could potentially be of concern, Binnen Kill, Schodack, and Henry Hudson Park are located between river miles 133 to 137. The salt front for the Hudson River generally ranges from Mile 27 to Mile 67. During a drought in 1991 saltwater intrusion reached up to Mile 75, and this is generally considered to be the northernmost extent of saltwater intrusion. While studies investigating the impacts of sea level change on Hudson River wetlands are available, no studies that specifically investigated the impact of sea level change on salinity intrusion for the Hudson River were found. Modeling studies that investigate this issue for rivers throughout the world generally calculate changes in the range of one to five miles. Based on the location of the HRHR restoration sites, sea level rise driven changes to salinity intrusion are not a considered a concern for the HRHR restoration sites.

4.5 Resilience and Sustainability

The Sea Level Change Analysis conducted for this study informed the design of alternatives and design were formulated to deliver immediate post-construction benefits and maintain those benefits to the greatest extent possible for the 50 year analysis period for this study. Sea level considerations and need to maximize the resiliency and sustainability of all features will continue to guide design development going forward for features such as the side channels cross-section morphology, flood plain design and habitat/elevation ranges. The proposed actions will increase the resiliency and sustainability of the Hudson River Study area by establishing habitat that will be more resilient to RSLC, restoring system dynamics and processes to more sustainable and self-regulating regimes, and improving anadromous and catadromous species reproduction through the removal of 4 barriers to fish passage and greatly increased access to 17 miles of high quality tributary habitat.

4.5.1 Significance of the Tentatively Selected Plan

The criteria for determining the significance of resources are provided in the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (United States Water Resources Council, 1983), Resource Significance Protocol for Environmental Project Planning, (IWR Report 97-R-4, July1997) and in USACE planning guidance such as the Planning Guidance Notebook (Engineering Regulation 1105-2-100, April 22, 2000). Significance of resources and effects of the TSP are derived from institutional, public, and technical recognition of the ecological, cultural and aesthetic attributes of resources within the study area. As per the USACE Planning Guidance Notebook:

- **Technical recognition** of a resource or an effect is based upon scientific or other technical criteria that establish its significance;

- **Institutional recognition** of a resource or effect means its importance is recognized and acknowledged in the laws, plans, and policies of government and private groups; and
- **Public recognition** means some segment of the general public considers the resource or effect to be important. Public recognition may be manifest in controversy, support, or opposition expressed in any number of formal or informal ways.

In ecosystem restoration planning, the concept of significance of outputs plays an especially important role because of the challenge of dealing with non-monetary outputs. The three (3) sources of significance - institutional, public, and technical recognition - and documentation on the relative scarcity of the resources further illustrates the significance of the resources to be restored. The significance and the relative scarcity of the resources also further establishes a federal interest in the project. The significance of the restoration outputs from the TSP are presented in Table 4-4.

Table 4-4: Significance of the Tentatively Selected Plan.

RESTORATION CATEGORY	TSP	SIGNIFICANCE		
		TECHNICAL	INSITUTIONAL	PUBLIC
Mosaic Habitat and Shoreline Restoration	Binnen Kill, Schodack Island and Henry Hudson Park: • 38 acres of side channels restored • 148 acres of wetlands in the Hudson River corridor	• Habitat Scarcity – Restoration of wetlands and other habitat will address the significant loss of aquatic habitat resulting from urbanization and deepening of the river starting in the 1800s by the USACE (specifically side channels). • Hydrologic and Geographic Connectivity – Wetland areas and side channel restoration will restore the important connectors and habitat for foraging, refugia and nursery grounds for native species which had been severely degraded, destroyed, and fragmented as a result of the USACE's navigation program and historic filling activities. • Fisheries – Habitat restoration will provide important habitat for the life cycle of migratory fish such as river herring, eel, and sturgeon, with direct connection to the Atlantic Ocean. • Habitat will be provided for 51 federally-listed species of special status - Designated Critical Habitat for endangered sturgeon species. • Ecosystem Services – Aquatic habitat restoration will provide lost ecosystem services resulting from development and filling activities. It will provide shoreline habitat and stabilization and species connectivity between the river and riparian habitat.	• Regionally and globally rare tidal communities include freshwater tidal swamp/tidal marsh/intertidal shore. Aquatic restoration would preserve special aquatic sites such as wetlands and vegetated shallows recognized as nationally significant by the Clean Water Act (33 USC 1344) and would preserve exceptionally scarce and declining freshwater tidal marsh as determined by USFWS/NOAA status and trends report. • Stopover point for thousands of birds migrating along the Atlantic Flyway. Aquatic habitat restoration advances the goals and designations within the Hudson River including: • Estuary of National Importance- National Estuary Program (EPA). • National Estuarine Research Reserve System - Hudson River National Estuarine Research Reserve (NOAA) • Hudson River Valley National Heritage Area (NPS) • American Heritage River – Hudson River (EO 13061) • National Recreation Trail - Hudson River Greenway Water Trail (NPS) Restoration builds upon and contributes to the following Regional Plans: • NYS Hudson River Estuary Program Action Agenda • Hudson River Estuary Habitat Restoration Plan • Hudson-Raritan Estuary Comprehensive Restoration Plan • NY-NJ Harbor & Estuary Program	• Restoration in the Hudson benefits 10 New York counties and the waterfront of 21 villages, 41 towns, and 10 cities bookended by two metropolitan areas. • Public river access sites that would benefit from restoration provide recreational activities such as hiking, kayaking, aesthetics, and swimming to local communities. • Restoration at Henry Hudson Park and Schodack Island can provide future opportunities for education and accessibility. • Restoration contributes to the recovery of fisheries and will enhance recreational and commercial fishing. • Restoration contributes to the combined effort of 94 federal and state agencies, academic institutions, and non-profit and community organizations collaborated to draft the Comprehensive Restoration Plan and the efforts of the "Partners Restoring the Hudson"

<table>
<tr><th rowspan="2">RESTORATION CATEGORY</th><th>TSP</th><th colspan="3">SIGNIFICANCE</th></tr>
<tr><th></th><th>TECHNICAL</th><th>INSTITUTIONAL</th><th>PUBLIC</th></tr>
<tr><td>Tributary Connection</td><td><u>Rondout Creek</u>
Eddyville Dam removal (9 miles of upstream habitat)

<u>Moodna Creek</u>
• AOP 1: Utility pipe removal
• AOP 2: Firth Cliff Dam removal
• AOP 3: Orr's Mill Dam partial removal (Collectively, 7.8 miles of upstream habitat)

• Total: 17 miles of tributary habitat reconnected</td><td>• Habitat scarcity – Removal of barriers will allow organisms to access habitat that has been lost in the Hudson resulting from urbanization and deepening of the river starting in the 1800s by the USACE.
• Connectivity – Removal of barriers will fully restore the important direct physical connectors between existing corridor habitats for foraging, refugia and nursery grounds for migratory fish which had been severely degraded, destroyed, and fragmented as a result of the USACE's navigation program and historic filling activities.
• Hydrologic and Geomorphic Character – Removal of these barriers restores the hydrology to the system in order to maintain the ecological function, as well as provide newly accessible habitat structure to migratory species.
• Fisheries – Access to important habitat for the critical life cycle of migratory fish with direct connection to the Atlantic Ocean.
• Habitat will be provided for 51 federally-listed species of special status - Designated Critical Habitat for endangered Sturgeon species as well a state listed least bittern and black rail.
• Ecosystem Services – Aquatic habitat restoration will provide lost ecosystem services such as fish life cycle between river and ocean</td><td>Restoration of tributary connections advances the goals and designations within the Hudson River including:
• Estuary of National Importance- National Estuary Program (EPA).
• National Estuarine Research Reserve System - Hudson River National Estuarine Research Reserve (NOAA)
• Hudson River Valley National Heritage Area (NPS)
• American Heritage River – Hudson River (EO 13061)
• National Recreation Trail - Hudson River Greenway Water Trail (NPS)

Restoration builds upon and contributes to the following Regional Plans:
• NYS Hudson River Estuary Program Action Agenda
• Hudson River Estuary Habitat Restoration Plan
• Hudson-Raritan Estuary Comprehensive Restoration Plan
NY-NJ Harbor Estuary Program</td><td>• Restoration in the Hudson benefits local communities and villages connecting them through river reconnection.
• Removal of the dams would eliminate a safety risk of dam failure.
• Public river access sites that would benefit from restoration provide recreational activities such as hiking, kayaking, and swimming to local communities.
• Restoration contributes to the recovery of fisheries and will enhance recreational and commercial fishing.
• Restoration contributes to the combined effort of 94 federal and state agencies, academic institutions, and non-profit and community organizations collaborated to draft the Comprehensive Restoration Plan and the efforts of the "Partners Restoring the Hudson"</td></tr>
</table>

4.6 Plan Implementation

As a non-federal construction partner, project sponsors must sign a design agreement that will carry the project through the Preconstruction Engineering and Design (PED) phase, which includes development of Plans and Specifications (P&S). The PED phase will be followed by project construction. Funds must be budgeted by the federal government and the non-federal partner to support these activities. A project management plan will be prepared to identify tasks, responsibilities, and financial requirements of the federal government and the non-federal partner during PED. A project schedule will be established based on reasonable assumptions for the detailed design and construction schedules.

Although the TSP includes 5 project sites, design agreements and project partnership agreements may be signed separately for individual sites, depending on non-federal sponsor priorities and available funding. Accordingly, cost apportionment and schedules are presented on a per site basis, rather than as if the tentatively selected plan was a single, homogenous suite of activities.

4.6.1 Real Estate Requirements

In accordance with the Project Partnership Agreement (PPA), the non-Federal sponsor is responsible for fulfilling its Lands, Easements, Right-of-Ways, Relocations and dredge or excavated material Disposal areas (LERRD) responsibilities that are required for the construction, operation and maintenance of the project. The TSP requires the acquisition of approximately 191.25 acres of land. Table 4-5 summarizes the TSP's real estate requirements:

Table 4-5: Real Estate Requirements for the Tentatively Selected Plan.

		Required Acres			Number of Parcels		
Project Site	Site Component	Fee	Temporary Easements	Total	Private	Public	Total
Binnen Kill	North	±89.22	±2.94	±92.16	1	2	3
	South	±36.30	±2.71	±39.01	0	2	2
Schodack Island	North	±42.56	±4.12	±46.68	0	1	1
Henry Hudson Park	-	±4.18	±0.68	±4.86	0	2	2
Moodna Creek	AOP 1	0	±2.16	±2.16	2	1	3
	AOP 2	0	±2.45	±2.45	3	0	3
	AOP 3	0	±2.05	±2.05	2	0	2
Rondout Creek	-	0	±1.88	±1.88	4	0	4
	Totals:	***±172.26***	***±18.99***	***±191.25***	***12***	***8***	***20***

The TSP neither requires relocations of persons or businesses under Public Law 91-646, Uniform Relocation Assistance and Real Property Acquisition Policies Act, nor does it require the physical relocation of public utilities or facilities. Upon the non-Federal sponsor securing all the required real estate for the project and USACE receiving a copy of all easements and deeds recorded with their respective county, USACE will certify the real estate and move the project toward construction.

The non-Federal Sponsor is responsible for all upfront LERRD costs – both direct and indirect costs – for the TSP. The non-Federal Sponsor is eligible to receive credit toward their overall cost-shared amount for the project for LERRD costs incurred that are found to be reasonable, allowable and allocable. Receipts, invoices and other supporting documents on all LERRD costs incurred by the non-Federal Sponsor will be submitted to USACE as part of its claim for credit. LERRD costs incurred that are found to be reasonable, allowable and allocable will be reviewed for credit approval.

4.6.2 Monitoring and Adaptive Management Plan

Monitoring and adaptive management will conform to requirements of section 2039 of WRDA 2007 and subsequent USACE implementation guidance, and monitoring will be conducted until such time as USACE determines that the project has achieved success. USACE Implementation Guidance defines monitoring as the systematic collection and analysis of data for assessing project performance and determining whether adaptive management may be needed. Monitoring includes documenting and diagnosing these results, especially in the early, formative stages of a project. Monitoring reduces the risk of failure and enables effective, responsive management of restoration actions.

Section 1010 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) allows for up to 10 years of monitoring; however, the project assumed 5 years for costing purposes. USACE and the non-Federal sponsor are responsible for carrying out the monitoring and adaptive management plan after construction of each project phase/component until ecological success criteria are met, but for no more than ten years. It is anticipated that the restored habitats can reasonably be expected to achieve success within five years for most or all project components. Upon the determination of the District Engineer that ecological success criteria have been met, cost-shared monitoring will be concluded, and in no case shall cost-shared monitoring extend beyond ten years after construction of each component. Costs for monitoring beyond a 10-year period will be a non-federal responsibility.

See the Monitoring and Adaptive Management Plan (Appendix H) for the specific details regarding the requirements for the TSP. In addition, monitoring and adaptive management activities and costs are presented in the Plan for all evaluated alternatives.

4.6.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation

Per Implementation Guidance for section 1161 of WRDA 2016 (19 October 2017), the responsibility of a non-federal sponsor to conduct Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities on non-structural and nonmechanical elements of an ecosystem restoration project (or component of a project) will cease ten years after ecological success has been determined. There are no structural or mechanical elements within the TSP.

Minimal annual OMRR&R of the completed project is expected. Each project will be inspected once a year after a project is completed. Additional maintenance may be required after major storm events for the removal of possible debris on-site. Post-construction adjustments for purposes of optimization will be performed under the Monitoring and Adaptive Management Plan. OMRR&R will be the responsibility of the non-federal construction sponsor. The OMRR&R costs were included in the annualized first level cost estimates. These estimates and a summary of OMRR&R activities for each site will be refined based on detailed engineering designs during feasibility-level activities for the Final Integrated FR/EA. The OMRR&R cost will include maintenance of all the infrastructure that is included in the project. Although they are being modified, many of these features are already being maintained currently by local entities. Detailed OMRR&R manuals with respective costs will be developed for each site during the PED phase. OMRR&R costs are presented in Table 4-3.

4.6.4 Preconstruction Engineering and Design

Detailed designs and cost estimates will be prepared between the draft and final version of the feasibility study. The study team will more formally identify the necessary studies and data collection to be performed during the PED phase to manage specific risks and uncertainties. A preliminary list of studies identified and considered in the site specific Planning, Engineering and Design cost estimates included:

- Property and utility investigations: Parcel ownership, property boundaries and utility survey, needed to confirm acquisition requirements and refine real estate and relocation costs.
- Data collection: Topography, bathymetry, biobenchmarking, wetland delineation, tidal gauging and soils testing needed to support civil and ecological design as well as hydraulic and hydrologic analyses.
- Hydraulic and hydrologic analysis and modeling: Riverine and sedimentation studies, needed to optimize design features, refine construction cost estimates, confirm areas of environmental benefits, identify areas of induced flooding and predict/minimize actions for operations and maintenance.
- Geotechnical analyses: Foundation design, analysis of settlement and seepage of project features and identification of disposal and borrow sites, needed to finalize design features and refine cost estimates.
- HTRW sampling: Contaminant concentrations in soil and sediment sampling to identify additional activities and costs associated with the restoration action.

- Regulatory compliance and permits.
- Preparation of Plans and Specifications (30, 60, 90, 100 percent)
- Value Engineering

4.6.5 Construction Schedule

A general construction phasing/sequencing of the five projects will be identified during the preparation of fully funded cost estimates for the Final FR/EA. The detailed phasing for the design and construction activities will be developed during the feasibility-level design stage and will be updated as needed during the PED stage of the project. The first project (construction phasing has yet to be determined) is expected to begin construction following the PED Phase in 2025. Specific construction durations are presented in Table 4-3.

The general construction sequence for each restoration type is as follows (see Cost Engineering Appendix E).

<u>Mosaic Habitat and Shoreline Restoration – Construction Sequencing</u>

The general construction sequence for Binnen Kill, Schodack Island and Henry Hudson Park restoration sites will be as follows:

1. Mobilization
2. Installation of soil erosion and sediment control features
3. Installation/modification of temporary work access road(s) and crossings, where applicable
4. Site clearing, including removal of existing vegetation and invasive species treatment, where applicable
5. Installation of water control features, where applicable
6. Earthwork; including excavation, grading, and import of select amended soils, where applicable
7. Installation of site amenities; including removing or modification of existing AOP crossings, floodplain connections, and/or culverts.
8. Installation of herbivory fencing
9. Installation of plants and seed
10. Demobilization

For alternatives that include installation or modifications to aquatic organism passage crossings, floodplain connections, and/or culverts, it was assumed this activity would occur after the bulk of earthwork efforts. Note that construction items may be constructed simultaneously depending on project phasing and construction crews. Also, it was assumed that the construction of Binnen Kill North and South components would occur independent of one another.

Aquatic Organism Passage – Construction Sequencing:

The general construction sequence for dam removal on Rondout Creek and Moodna Creek will be as follows:

1. Mobilization
2. Installation of soil erosion and sediment control features
3. Installation of temporary work access road(s)
4. Site clearing, including removal of existing vegetation, where applicable
5. Installation of water control features
6. Installation of in-water access ramps and pads
7. Demolition of barrier, including excavation and export of material, as applicable
8. Installation of in-stream structures, including import and transport of boulders
9. Stabilization of banks and surrounding areas, as necessary
10. Demobilization

It was assumed that in-stream fish passage or stabilization structures would be constructed after the removal or modification to the barrier at the project site when water surface elevations are shallow enough to drive equipment directly in the stream, eliminating the need for in-stream construction access pads.

4.6.6 Cost Sharing and Non-Federal Partner Responsibilities

The details behind the total first cost of implementing the Tentatively Selected Plan are shown in Table 4-6. The federal share of the project's total first cost is 75-percent of the total. The federal government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of non-federal interests. The non-federal share of the estimated total first cost of the proposed project is 25-percent of the total. The non-federal share consists of a number of components including real estate (of which the non-federal portion is deducted from the non-federal cash contribution). The Total First Project Cost is $98,386,265; with a total federal cost of $73,789,700 and total non-federal cost of $24,596,565.

Table 4-6: Cost Apportionment.

SITE	FEDERAL COST ($)	NON-FEDERAL COST ($)	TOTAL COST ($)
Binnen Kill	42,997,948	14,332,649	57,330,597
Schodack Island	14,442,598	4,814,199	19,256,797
Henry Hudson Park	6,654,907	2,218,302	8,873,209
Moodna Creek	6,744,956	2,248,319	8,993,274
Rondout Creek	2,949,291	983,097	3,932,388
ALL	73,789,700	24,596,565	98,386,265

4.7 Risk and Uncertainty

In a risk-informed decision making framework, the study team has identified risk and uncertainty throughout the plan formulation, performing analysis to reasonably minimize the uncertainty and facilitate effective risk-informed decision making. This section discusses uncertainty and associated potential risk and how it is managed as they pertain to project performance and adaptability, particularly as it relates to future RSLC, real estate considerations in Feasibility, PED, and Construction phases, as well as potential for cultural resources assessments and mitigation and the hazardous and toxic, or radioactive waste. The views of our partners and sister agencies are also discussed as they pertain to risk and uncertainty going forward for implementation.

4.7.1 Performance and Adaptability of the Project with RSLC

As described in Section 3.1.3, while sea levels are expected to change, the rate at which they will rise is uncertain. Sea level change analysis informed the development of the conceptual designs. The USACE "intermediate" sea level change curve was used for the development of the concept alternatives. Analyses using the USACE historic "low", "intermediate" and "high" sea level change scenarios will be conducted for the Final Integrated FR/EA. While the design can be expected to perform well under the "low" and "intermediate" scenarios, they, like much of the Hudson River Habitat, will be challenged if future sea level change rates trend towards the high curve.

Designs were developed so as to yield immediate benefits that were sustainable over the project duration, with minimized loss of habitat or benefit. These considerations will continue to guide the design development process as critical details such as optimized flood plain elevations and channel cross-section morphology will be greatly refined during the detailed design and Pre-Engineering and Design phases. Designs were, and will continue to be, developed to augment both resiliency and adaptability, where critical habitats are afforded the opportunity to migrate in response to rising water surface elevations and natural processes are harnessed to promote adaptability.

4.7.2 Study/ PED/ Implementation

4.7.2.1 Real Estate

The lands where restoration activities are being proposed need to be obtained for the Tentatively Selected Plan to be implemented. Restoration will not be able to be implemented at privately owned parcels at Binnen Kill and at the AOP barriers if the parcels and dams are not acquired (for Binnen Kill) or temporary easements are not obtained (AOP barriers). A non-standard permanent easements may be required if fee acquisition at Binnen Kill is unacceptable and cannot be obtained. However, HQ approval would be required if permanent easements were proposed.

NYSDEC, with assistance from Hudson Riverkeeper, is working with land owners to explain the project's impacts and benefits, and obtain feedback. These meetings with affected landowners occurred in February and March 2019 in preparation of the draft FR/EA release.

4.7.2.2 Cultural Resource Coordination and Costs

Cultural Resources mitigation costs were estimated for each site using existing information. No archaeological or architectural surveys were carried out at this time. The three dams proposed for removal or notching as part of the TSP are historic structures; however, the investigations necessary to determine the National Register eligibility of each structure have not yet been carried out. Cultural mitigation costs assumed the need for mitigation at each site; these costs have the potential to increase or decrease based on future surveys and coordination with the New York State Historic Preservation Office and other interested parties. Data recovery costs that exceed 1-percent of the construction cost must be paid for by the sponsor. Cultural resources surveys carried out during Preconstruction Engineering and Design will determine the need for and level of mitigation.

4.7.2.3 Hazardous Toxic and Radioactive Waste

Hazardous Toxic and Radioactive Waste (HTRW) issues at AOP sites in sediment behind dams may be a concern; however, a literature search yielded no concerns. If required, additional activities associated with remediation will be paid for 100% by the non-federal sponsor. If the non-federal sponsor does not address contamination, the site would not be restored. HTRW data will be collected during the PED Phase. HTRW is not expected to be an issue for mosaic and shoreline sites since dredged material placement occurred from O&M prior to industrialization.

4.8 Views of the Non-Federal Partner and Other Agencies

There has been significant support from federal, state, local, and non-governmental organizations (NGOs) for the restoration of the Hudson River Estuary. NYSDEC and NYSDOS personnel have been fully involved in the study process. Public and private interests have also shown great enthusiasm and attended numerous coordination meetings. Partners Restoring the Hudson, a coalition of more than 30 organizations, has been involved throughout the HRHR Study process. There are frequent meetings hosted by NYSDEC's Hudson River Estuary Program that enhance our coordination and public involvement.

The HRHR Study has generated strong letters of endorsement from members of the New York delegation to the House of Representatives. Other Federal agencies have supported the study by sharing information and providing expertise.

The recommendations outlined in this Draft Integrated FR/EA will advance the NYSDEC Hudson River Estuary Action Agenda 2015-2020, NYSDEC Hudson River Estuary Habitat Restoration Plan, and the partnership's regional Target Ecosystem Characteristics targets and goals that are outlined in the Hudson River Comprehensive Restoration Plan (The Partners Restoring the Hudson, 2018).

Chapter 5: Existing Environmental Conditions and Environmental Impacts*

Sections 1500.1(c) and 1508.9(a)(1) of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321 et seq.) require federal agencies to "provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact" on actions authorized, funded, or conducted by the federal government to insure such actions adequately address "environmental consequences, and take actions that protect, restore, and enhance the environment." This chapter provides an assessment of the potential environmental impacts that would result from implementing the TSP presented in Chapter 4 of this integrated FR/EA for the Hudson River. Table 4-1 and Figures 4-1 through 4-8 (Chapter 4), show the principal restoration measures applied under the TSP at each site to achieve the planning objectives. This chapter also supplements the ecosystem benefits outlined in Chapters 3 and 4 for each project.

As this study includes recommendations for construction of restoration opportunities that are designed at a feasibility level of detail, as well as possible new phase future spin-off studies for restoration opportunities, a qualitative evaluation of impacts resulting from the restoration measures associated with the TSP is discussed in this chapter. This chapter also serves as the baseline for the impact analysis and cumulative impacts of implementing the TSP are discussed in Chapter 6.

For a further detailed discussions of the environmental impacts see Appendix G1 Environmental Assessment.

5.1.1 Tentatively Selected Plan – Overview

The expected environmental impacts of implementing the TSP would be overwhelmingly beneficial to the flora and fauna of the Hudson River, and beneficial to the public living in the surrounding study area. Implementation of the TSP would be a substantial first step in the large-scale restoration of the HRE. Implementation of the TSP would realize habitat restoration and expansion of available habitat for a host of fauna, including anadromous and catadromous species. Secondary benefits would include, but not be limited to, the following:

- Immediate and long-term improvements to water quality and storage of floodwaters;
- Removal of large swathes of invasive species;
- Improved sediment loading and water quality from dam removals;
- Short-term job creation during construction; and
- Educational and "hands on" restoration opportunities for the public and students of the region (for Henry Hudson Park, Binnen Kill and Schodack Island sites).

Impacts can be short-term or long-term. In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only during the time required for construction activities. Long-term impacts are those that are more likely to be persistent and chronic. Impacts of a proposed action can be positive or negative. A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes. A single action might result in positive impacts on one environmental resource and negative impacts on another.

Implementation of the TSP would result in some short-term, negative impacts to the affected environment; however, these impacts would be temporary and localized. All restoration measures would be implemented in accordance with regulatory agency stipulations and construction contractors would employ best management practices (BMPs) at all times—e.g., use of silt curtains and adherence to sediment and erosion control plans.

5.1.2 No Action Alternative (Future Without-Project Condition)

The no action alternative, which is synonymous with the future without-project condition, would be the state of the site under the anticipated future condition if no action were implemented by USACE under the HRHR Feasibility Study. The no action alternative provides a basis upon which a comparison of the potential impacts associated with implementing the TSP can be made. The impacts from the No Action Alternative represents the FWOP condition throughout the planning horizon compared to the existing conditions (Tables 5-1 through 5-5).

Table 5-1: Existing Conditions and Environmental Impacts to the Binnen Kill Site.

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
Geology and Physiography	This section of the Hudson River Valley consists of a narrow inner valley with adjacent terraces approximately 100-200 feet high, bordered by gently rolling terrain and low hills. The valley is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods (NYSDOT, 2013). In general, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. The Hudson River has since reworked these sediments, and the site is currently mapped as alluvium (NYS Museum, 1991). Additionally, the area has been influenced by dredging, and dredge spoils have filled in the areas between islands that historically existed at both sites (Louis Berger, 2017; Friends of Schodack Island State Park, 2018). Specifically, the site is mapped as the Austin Glen Formation, which consists of highly folded, interbedded greywacke sandstone and shale that formed in a deep marine setting from the erosion of pre-existing sedimentary rocks (NYS Museum, 1995).	The No Action Alternatives or TSP would have no impact on geology or physiography.	
Topography	The topography of the site is generally low-lying and gently sloping, with the majority of the site sitting at an elevation of less than 8 feet (NYSDEC, 2011 - 2012). There is an overall slope from north to south, with the shoreline of the Hudson River and Binnen Kill at the lowest elevation, and the site is bounded on the western edge by a steeply sloping hillside.	Under the No Action Alternative, the site would/could be susceptible to topographic change by erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).	Excavation and re-grading under the TSP would result in permanent alterations to on-site topography. Approximately 15.5 acres of land would be excavated to create forested wetland, 4.3 acres to create emergent wetland, and 27 acres to create a side channel/tidal wetland corridor between Binnen Kill and the Hudson River. Diffuse pools and a 3,700 linear foot channel would also be excavated to enhance existing emergent wetlands.

RESOURCE	BINNEN KILL		
	Existing Conditions	NO ACTION ALTERNATIVE (FWOP)	TSP
Soils	The majority of the site was mapped as one of six soils: Hamlin silt loam, Medihemists and Hydraquents, Teel silt loam, Udipsamments (dredged), Wakeland silt loam, and the Wayland soil complex (NRCS, Web Soil Survey).	Under the No Action Alternative, the soils would be subject to minor adverse impacts from soil erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).	In the short-term, the TSP would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. In the long term, implementing the TSP would result in minor beneficial impacts to soil resources through the creation of wetlands, which reduce shoreline erosion by stabilizing sediments and absorbing and dissipating wave energy (Hammer, 1992).
Climate and Weather	A National Weather Service (NWS) station is located approximately 7.8 miles west of the site, at the Alcove Dam. Average monthly temperatures ranged for 21.1°F in January to 69.5°F in July (AgACIS, 2018a). Average annual precipitation was 39.74 inches, with monthly averages ranges from 2.18 inches in February to 3.89 inches in June. Average annual snowfall was 29.5 inches, primarily occurring between December and March.	The No Action Alternatives or TSP would have no impact on the climate no weather at the site.	
Climate Resiliency		Under the No Action Alternative, predicted sea level rise, and increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018b).	Implementing the TSP would result in a moderate beneficial impact to climate resiliency by increasing flood storage along the Hudson River floodplain through the conversion of uplands to tidal wetlands, and excavation of a side channel/tidal wetland corridor between Binnen Kill and the Hudson River.
Floodplains	The site lies within the one percent floodplain (AE Zone) with base flood elevations ranging from 17 to 18 feet (NAVD88), as shown on the Effective Flood Insurance Rate Map. This floodplain is confined between the Hudson River and a steep slope, quickly rising above the floodplain to an elevation of 100 to 150 feet (NAVD88).	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain.	Under the TSP, the site would remain within the Hudson River's one percent floodplain. Implementing the TSP would result in a moderate beneficial impact to floodplains by increasing flood storage along the Hudson River floodplain during precipitation events through the conversion of uplands to tidal wetlands, and excavation of a side channel/tidal

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
			wetland corridor between Binnen Kill and the Hudson River.
Surface Waters	Located within the Middle Hudson Watershed (HUC-8 02020006), the Hudson River and Binnen Kill are the primary surface water bodies at the site, with several small freshwater ponds mapped at the site as well. The Hudson River forms the eastern boundary of the site, while Binnen Kill delineates the southwestern boundary and runs through the middle of the northern portion of the site.	Under the No Action Alternative, the Hudson River and Binnen Kill would continue to constitute the site's only surface water bodies.	Surface water area on the site would be expanded due the excavation of a side channel/tidal wetland corridor between Binnen Kill and the Hudson River.
Water Quality	Binnen Kill and the Hudson River are classified as Class C water bodies, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B). The Hudson River in Albany County is on the 2016 USEPA 303(d) list as "impaired" due to fish consumption advisories from sediment contaminated with polychlorinated biphenyls (PCBs) (USEPA, 2016b).	Soil erosion would increase turbidity in the Hudson River and Binnen Kill, resulting in negligible adverse impacts to water quality	In the short-term, implementing the TSP would result in negligible adverse impacts on water due to increases in turbidity during the construction phase of the project. In the long term, implementing the TSP would result in moderate beneficial impacts to water quality through the creation of approximately 46.8 acres of side channel and the restoration of approximately 106.3 acres of wetland.
Regional Hydrogeology and Groundwater	One aquifer has been identified at the Binnen Kill site by the NYSDEC. This aquifer is described as an unconfined, high yield aquifer with a yield of greater than 100 gallons per minute. The aquifer is composed of sand and gravel deposits, with high transmissivity and a saturated thickness greater than 10 feet.	The No Action Alternative would have no impact on the hydrogeology or the groundwater.	Implementing the TSP may result in minor impacts on local shallow groundwater flows due to alterations to topography and surface water flow.
Tidal Influences	The low and lower low tide levels are -1.42 and -1.62 feet (NAVD88), respectively; while the high and higher high tide levels are 3.39 and 3.59 feet (NAVD88), respectively.	The No Action Alternative would have minor impacts on tidal influences including increasing elevations due to sea level rise.	The TSP would result in moderate beneficial impacts to tidal influence by restoring historically tidal areas that were filled with dredged materials.
Land Use and Zoning	The project area's land use consists primarily of protected open space. This open space consists of a mixture of tidal and nontidal freshwater wetlands,	The No Action Alternatives or TSP would have no impact on the land use or zoning at the site.	

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
	forested wetlands, shrubs, and mixed forest. The open space areas are made up of a mix of properties owned by New York State and by Scenic Hudson Land Trust, a nonprofit land conservation organization. Portions of the project area are also utilized as agricultural fields under private ownership. The project area is located partially within the Town of Bethlehem Rural Riverfront (RR) zoning districts and partially within the Residential & Agricultural (R-A) zoning districts.		
Economics	Ecotourism is an important economic driver in this region, as the natural and scenic resources draw millions of visitors to New York's recreation areas (USFWS, 2006). Many people come from out of town to pursue wildlife-associated recreation, outdoor sporting, angling, hunting, and wildlife watching, bringing with them business for local restaurants, hotels, shops, etc.	The No Action Alternatives or TSP would have no impact on local economic conditions.	
Socio-Economics	The site is located within the Towns of Bethlehem and Coeymans, in Albany County, New York. According to the U.S. Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Bethlehem, NY is an estimated 33,656 people, and is predominantly white. The median age in the Town of Bethlehem, NY is approximately 42.8 years of age and median household income is $96,384. Approximately 97.0% of the population are high school graduates or higher while 58.6% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Bethlehem is 3,119. The civilian employed population 16 and over is an estimated 18,384 people. The population in the Town of Coeymans, NY is an estimated 7,433 people, and is predominantly white. The median age in the Town of New Windsor, NY is approximately 42.4 years of age	The No Action Alternatives or TSP would have no impact on local socio-economic conditions.	

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="3">BINNEN KILL</th></tr>
<tr><th>Existing Conditions</th><th>NO ACTION ALTERNATIVE (FWOP)</th><th>TSP</th></tr>
<tr><td></td><td>and median household income is $60,812. Approximately 91.1% of the population are high school graduates or higher while 24.3% of the population have a bachelor’s degree or higher. The estimated number of companies in the Town of New Windsor is 157. The civilian employed population 16 and over is an estimated 3,980 people</td><td colspan="2"></td></tr>
<tr><td>Environmental Justice</td><td>The site is not located within an Environmental Justice area (NYSDEC, 2018c).</td><td colspan="2">The No Action Alternatives or TSP would have no impact on environmental justice populations.</td></tr>
<tr><td>Coastal Zone Management</td><td>The site is within the NY State Coastal Zone Management Program.</td><td>The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program.</td><td>Implementing the TSP would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat, and Coastal Policy 44.</td></tr>
<tr><td rowspan="2">Wetlands</td><td colspan="3">Specific wetland communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.</td></tr>
<tr><td>USFWS National Wetland Inventory (NWI) map indicates the presence of both freshwater emergent wetlands and freshwater forested/shrub wetlands at the Binnen Kill site. Additionally, tidally influenced wetlands have been mapped by the NYSDEC’s Hudson River Estuary Program as a separate effort in 2007 based off of aerial photographs. Based on the study’s July 2018 Evaluation of Planned Wetlands (EPW), baseline conditions of affected wetlands were considered not functioning at their capacity</td><td>There would be no impact to the extent of wetlands on the site however, the plant communities of those wetlands would likely shift as sea levels rise</td><td>In the short-term, construction activities associated with implementing the TSP would result in moderate adverse impacts to existing wetlands due to site clearing and grading. In the long-term, implementing the TSP would result in major beneficial impacts to wetlands through the creation of approximately 46.8 acres, and restoration of approximately 106.3 acres of tidal wetland.</td></tr>
<tr><td rowspan="2">Vegetation</td><td colspan="3">Specific wetland/vegetation communities were identified in July 2018 using EPW. Wetland/vegetation communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.</td></tr>
<tr><td>A habitat survey conducted by Louis Berger in 2017 revealed a wide variety of habitat types at the Binnen Kill site, with a number of rare plant species identified (Louis Berger, 2017). Approximately half of the site is</td><td>There would be no impact to the extent of vegetation on the site however, the plant</td><td>In the short-term, construction activities associated with implementing the TSP would result in moderate adverse</td></tr>
</table>

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
	occupied by wetland or aquatic habitat. Wetland habitats ranged in elevation and type, including tidal, non-tidal, or both. Tidal areas spanned a range of elevations. A variety of non-tidal wetlands were also present on the site. Other wetland habitats included small ponds, both intermittent and perennial, with sparse emergent vegetation such as common reed (*Phragmites australis*), cattail (*Typha* spp), or river bulrush (*Bolboschoenus fluviatilis***)**. Areas of dominated by the invasive species common reed and reed canary grass (*Phalaris arundinacea*) were observed in both tidal and non-tidal environments. A significant proportion of the upland habitat area on site consisted of current or former agricultural land, including areas under active row cropping (corn) or hayfield cultivation. Non-agricultural upland habitats included upland shrubland and upland hardwood forest. Upland shrubland was found at the transition between meadow and forest, in recently cleared areas such as old fields, artificial berms, and utility corridors. Invasive vegetation was widespread throughout the site. Submerged Aquatic Vegetation (SAV) inventories/mapping in 1997, 2002, 2007, and 2014 documents water celery (Vallisneria americana) present in the lower Binnen Kill, the mouth of the Binnen Kill, and along the shallows of the Hudson River shoreline. Significant SAV loss occurred between 1997 and 2014 especially along the mouth of the Binnen Kill, and the shallows of the Hudson River shoreline. This corresponds with a drastic decline in SAV throughout the Hudson River Estuary following Hurricanes Irene and Lee in 2011(NYSDEC, 2017).	communities would likely shift as sea levels rise.	impacts to vegetation due to site clearing and grading.
Shellfish	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available.	The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial	In the short term, temporary reductions in water quality due to construction activities associated with implementing

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
		impacts to shellfish, as more areas become accessible to shellfish inhabitation.	the TSP would result in negligible adverse impacts to shellfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in moderate beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.
Finfish	The project area is within the designated Significant Coastal Fish and Wildlife Habitat of Shad and Schermerhorn Islands under the New York State Coastal Management Program. According to the Coastal Fish and Wildlife Rating Form associated with this designated habitat, the project area contains habitats serving as a nursery area for blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*) as well as spawning and feeding areas for resident freshwater species in the Hudson River, including white perch (*Morone americana*) (NYSDOS, 2012).	The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to finfish, as more areas become accessible to finfish inhabitation	In the short term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to finfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site and restoration of the historic connection between Binnen Kill and the Hudson River would result in major beneficial impacts to finfish, as more areas become accessible to fish inhabitation.
Benthic Resources	No information regarding the benthic resources on the site is readily available.	The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to benthic resources, as more areas become accessible to benthos inhabitation	Under the TSP, the conversion of approximately 46.8 acres of upland habitat to intertidal habitat on the site would increase the extent of benthic habitat, and therefore provide moderate beneficial impacts to benthic resources.
Reptiles and Amphibians	According to the Coastal Fish and Wildlife Rating Form associated with this designated habitat, the project area supports a variety of amphibians and reptiles including northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), mudpuppy (*Necturus maculosus*), American toad (*Bufo americanas*), bullfrog (*Rana catesbeiana*) and green frog (*Rana clamitans*) (NYSDOS, 2012).	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on reptiles and amphibians, resulting in negligible beneficial impacts to intertidal reptile and amphibian species and negligible adverse	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, improvements to water quality and

RESOURCE	BINNEN KILL		
	Existing Conditions	NO ACTION ALTERNATIVE (FWOP)	TSP
		impacts to non-tidal wetland reptile and amphibian species.	the conversion of approximately 46.8 acres of upland habitat to intertidal habitat on the site would result in moderate beneficial impacts to intertidal reptile and amphibian species and moderate adverse impacts to upland reptile and amphibian species.
Birds	According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018).	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on birds, resulting in negligible beneficial impacts to intertidal bird species and negligible adverse impacts to non-tidal wetland bird species.	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to birds, if present. In the long-term, improvements to water quality and the conversion of approximately 46.8 acres of upland habitat to intertidal habitat on the site would result in moderate beneficial impacts to intertidal bird species and moderate adverse impacts to upland bird species.
Mammals	According to the Coastal Fish and Wildlife Rating Form associated with this designated habitat, the project area supports mammal species including white-tailed deer (*Odocoileus virginianus*) and eastern cottontail (*Sylvilagus floridanus*) (NYSDOS, 2012).	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on mammals, resulting in negligible beneficial impacts to intertidal mammalian species and negligible adverse impacts to non-tidal wetland mammalian species.	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to mammals, if present. In the long-term, improvements to water quality and the conversion of approximately 46.8 acres of upland habitat to intertidal habitat on the site would result in moderate beneficial impacts to aquatic and subaquatic mammalian species and moderate adverse impacts to upland mammalian species.

RESOURCE	BINNEN KILL		
	Existing Conditions	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
Federal Species of Concern	Coordination with the USFWS identified the threatened northern long-eared bat (*Myotis septentrionalis*) as potentially occurring at the site. There are no reports of northern long-eared bats at the Binnen Kill site. Coordination with Greater Atlantic Regional Fisheries Office (GARFO) identified the shortnose sturgeon and Atlantic sturgeon as potentially occur at the site.	The No Action Alternative would have no impact on federal species of concern.	The TSP would have no impact on northern long-eared bats. Implementation of the TSP would have positive benefits to both sturgeon species as it will provide habitat in the side channel for foraging and safety.
State Species of Concern	NYSDEC identified the endangered shortnose sturgeon (*Acipenser brevirostrum*), endangered peregrine falcon (*Falco peregrinus*), and threatened least bittern (*Ixobrychus exilis*) as potentially occurring at the site. The peregrine falcon was observed at the Binnen Kill site in 2016 - 2017 (Kiviat & Samanns, 2017). During the same surveys, least bittern playback calls were utilized with no response. NYSDEC also identified the endangered Hudson River water nymph (*Najas muenscheri*), rare delmarva beggar-ticks (*Bidens bidentoides*), and rare heart-leaved plantain (*Plantago cordata*) plants as observed at the Binnen Kill site. Kiviat & Samanns (2017) observed the Hudson River water nymph and delmarva beggar-ticks at the Binnen Kill site.	The No Action Alternative will have no impact on State species of concern.	The TSP will have positive impacts to shortnose sturgeon resulting from restoration of side channels which will provide high biodiversity refuges – nursery ground, resting and feeding shallow water habitat. Surveys will occur for other listed species prior to construction. Listed plant species areas will be avoided and construction will avoid nesting bird species. Therefore the TSP will have no impact on the other listed species
Designated Critical Habitat	The USFWS has not designated any critical habitat in the site. The GARFO has identified the site as critical habitat for the Atlantic Sturgeon.	The No Action Alternatives would have no impact on Designated Critical Habitat of concern.	Implementation of the TSP would have positive impacts to Atlantic Sturgeon critical habitat as it will provide more habitat with the creation of the side channel.
Essential Fish Habitat	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the Binnen Kill site is potential essential fish habitat for various life stages of winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (*Urophycis chuss*), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*).	The No Action Alternative would have no impact on EFH habitat of concern.	Improvements to water quality and the expansion of intertidal areas on the site and restoration of the historic connection between Binnen Kill and the Hudson River would result in major beneficial impacts to EFH, as more areas become accessible to fish inhabitation. The side channel/tidal wetland corridor would also provide a

RESOURCE	BINNEN KILL		
	Existing Conditions	NO ACTION ALTERNATIVE (FWOP)	TSP
	Kiviat & Samanns (2017) fish survey found none of the above species.		velocity refuge for fish during storm events.
Cultural Resources	There are twelve prehistoric and 18 historic archaeological sites documented within 1 mile of the study area. One prehistoric archaeological site (00102.000198) is located directly within the study area. There is one National Register eligible resource within the study area, the ca. 1958 Castleton-on-Hudson Bridge (08313.000338) which crosses through the southern portion of the site. A recent survey of the study area identified the foundation ruins of a single historic site in the central portion of the study area along the former 1890s shoreline, the remains of the Baker's Ice House. A segment of a historic road was also identified just south of this location, between the former shoreline and Binnen Kill that may have been associated with historic use of the ice house and an un-maintained and unimproved gravel and crushed brick farm road with a deteriorated steel-framed bridge over the Binnen Kill was also identified bisecting the southern portion of the study area. Several areas within the study area have been determined archaeologically sensitive (Miller et. al. 2017). The archaeological and historical record of the surrounding area and information gathered from a walkover survey suggest that there is a high potential for both prehistoric and historic sites to exist within the dry and elevated areas of the study area especially within the vicinity of the historic islands and west of the historic shoreline.	The No Action Alternative will have no adverse impact on cultural resources.	A review of existing information suggests that portions of the project area have a moderate to high probability for prehistoric and historic archaeological resources due to the presence of previously recorded prehistoric sites on similar landforms in the project vicinity, as well as several nineteenth-century map-documented structures in the vicinity of the APE. The remains of a nineteenth century ice house has been identified within the Area of Potential Effect (APE) for the proposed restoration measures and a prehistoric site is documented within 100 feet of the APE at its northernmost extent. Additional cultural resources surveys are recommended to address areas not previously investigated and to test archaeologically sensitive areas to determine the presence or absence of historic properties and archaeological sites within the APE. Geotechnical investigations will be useful in confirming the depth of dredge material and the potential for deeply buried prehistoric archaeological sites to exist within the APE. As plans are further developed additional areas may be considered for staging and access roads and should be assessed for cultural resources. A Programmatic Agreement has been prepared to

RESOURCE	BINNEN KILL		
	Existing Conditions	NO ACTION ALTERNATIVE (FWOP)	TSP
			address adverse effects to cultural resources.
Air Quality	The sites are classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site.	The No Action Alternative would have no impact on air quality.	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period, which would have a projected duration of approximately two years. In the long-term, implementing the TSP would have no impact on air quality.
Noise	The site currently consists of naturalized areas and farm fields. In general, land uses near the site include low density residences and businesses. No known noise pollution monitoring stations are located in vicinity of the site. Potential sources of existing noise pollution on the site may include farming equipment used on the site, and local transportation infrastructure such as the NY Route 912M and the CSX Transportation Railroad located just south of the site.	The No Action Alternative would have no impact on noise levels.	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately two years. In the long-term, implementing the TSP would have no impact on local noise levels.
Recreation	Currently, there are no designated recreational areas located within the site. Initiatives such as Scenic Hudson's campaign for "Saving the Land that Matters Most" have recently protected parcels of land at Binnen Kill and could offer designated outdoor recreation in those areas in the future. The site has the potential to be a bird watching destination.	The No Action Alternative would have no impact on recreation.	In the short-term, no impacts to recreation would occur as there are no designated recreational areas present on the site. In the long-term implementing the TSP would result in minor beneficial impacts to recreation through the restoration of habitat.
Aesthetics and Scenic Resources	The site is not designated as a Scenic Areas of Statewide Significance (SASS) under the New York Coastal Management Program.	The No Action Alternative would have no impact on aesthetics and scenic resources.	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the TSP would result in

RESOURCE	BINNEN KILL		
	Existing Conditions	NO ACTION ALTERNATIVE (FWOP)	TSP
			minor beneficial impacts to the site's aesthetic and scenic resources through the restoration of wetland habitat.
Hazardous, Toxic, and Radioactive Waste (HTRW)	A review of the databases yielded no contaminated sites within or near the Binnen Kill site. There may be remnant agricultural chemicals at the site, as some areas have been used for agriculture since 1940 and older forms of pesticides can result in lead, arsenic, and other contamination.	The No Action Alternatives or TSP would have no impact on HTRW.	
Transportation and Other Infrastructure	The site can be accessed by car off I-87, Exit 22 of the New York State Thruway as well as Route 144, which runs parallel to I-87. Public transportation in the Binnen Kill area is limited, most transit stations are located further north in the City of Albany.	The No Action Alternative would have no impact on transportation or infrastructure	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. In the long-term, implementing the TSP would involve the construction of a road crossing over the proposed side channel/tidal wetland connection.

Table 5-2: Existing Conditions and Environmental Impacts to the Schodack Island Site.

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Geology and Physiography	This section of the Hudson River Valley consists of a narrow inner valley with adjacent terraces approximately 100-200 feet high, bordered by gently rolling terrain and low hills. The valley is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods (NYSDOT, 2013). In general, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. The Hudson	The No Action Alternatives or TSP would have no impact on geology or physiography.	

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
	River has since reworked these sediments, and the site is currently mapped as alluvium (NYS Museum, 1991). Additionally, the area has been influenced by dredging, and dredge spoils have filled in the areas between islands that historically existed at both sites (Louis Berger, 2017; Friends of Schodack Island State Park, 2018). The site is within the Hudson-Mohawk Lowlands physiographic region.		
Topography	The site is located within the inner valley on a peninsula that was previously multiple islands formed from alluvium. The topography of the site is generally low-lying, with the highest elevations on the western edge reaching 22 feet. Portions of the dredge disposal area at the south end of the site reach as high as 50 feet (NYSDEC, 2011 - 2012).	Under the No Action Alternative, the site would/ could to be susceptible to topographic change by erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).	Excavation and regrading under the TSP would result in permanent alterations to on-site topography. Approximately nine acres of land would be excavated to create a side channel/tidal wetland corridor.
Soils	The majority of the Park was mapped as one of eight soils: Udorthents (sandy), Limerick silt loam, Udipsamments (dredged), Medisaprists-Hydraquents (tidal marsh), Fluvaquents-Udifluvents complex, Saprists and Aquents (ponded), Middlebury silt loam, and Hamlin silt loam (NRCS, Web Soil Survey).	Under the No Action Alternative, the soils would be subject to minor adverse impacts from soil erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).	In the short-term, the TSP would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. In the long-term, implementing the TSP would result in minor beneficial impacts to soil resources through the creation of wetlands, which reduce shoreline erosion by stabilizing sediments and absorbing and dissipating wave energy (Hammer, 1992).
Climate and Weather	A National Weather Service (NWS) station is located approximately 7.8 miles west of the site, at the Alcove Dam. Average monthly temperatures ranged for 21.1°F in January to 69.5°F in July (AgACIS, 2018a). Average annual precipitation was 39.74 inches, with monthly averages ranges from 2.18 inches in February to 3.89 inches in June. Average annual snowfall was 29.5 inches, primarily occurring between December and March.	The No Action Alternatives or TSP would have no impact on the climate no weather at the site.	

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Climate Resiliency		Under the No Action Alternative, predicted sea level rise and increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018b).	Implementing the TSP would result in a moderate beneficial impact to climate resiliency by increasing flood storage along the Hudson River floodplain.
Floodplains	The Rensselaer County portion of the site lies completely within the one percent floodplain (A13 Zone) with a base flood elevations of 15.2 to 17.2 feet (NAVD88), as shown on the FEMA Flood Insurance Rate Map. The Greene County portion of the site lies completely within the one percent floodplain (A Zone), as shown on the Flood Insurance Rate Map.	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain.	Under the TSP, the site would remain within the Hudson River's one percent floodplain. Implementing the TSP would result in a moderate beneficial impact to floodplains by increasing flood storage along the Hudson River floodplain during precipitation events through the conversion of uplands to tidal wetlands, and excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River.
Surface Waters	Located within the Middle Hudson Watershed (HUC-8 No.: 02020006), the Hudson River and Schodack Creek are the primary surface water bodies at the site (NYS GIS Clearinghouse, 2018). The Hudson River forms the western boundary of the site, while Schodack Creek delineates the eastern boundary.	The No Action Alternative would have minor impacts on surface waters.	Surface water area on the site would be expanded due the excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River.
Water Quality	Schodack Creek and the Hudson River are classified as Class C water bodies, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B). The Hudson River in Albany County is on the 2016 USEPA 303(d) list as "impaired" due to fish consumption advisories from sediment contaminated with polychlorinated biphenyls (PCBs) (USEPA, 2016b).	Soil erosion on the site, due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b) would increase turbidity in the Hudson River and Schodack Creek, resulting in negligible adverse impacts to water quality.	In the short-term, implementing the TSP would result in negligible adverse impacts on water due to increases in turbidity during the construction phase of the project. In the long term, implementing the TSP would result in moderate beneficial impacts to water quality through the creation of an approximately nine-acre side channel/tidal wetland corridor, and restoration of approximately 19.8 acres of tidal wetland.

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Regional Hydrogeology and Groundwater	One aquifer has been identified at the Schodack Island site by the New York State Department of Conservation Division of Water, Bureau of Water Resources Management. This aquifer is described as an unconfined, high yield aquifer with a yield of greater than 100 gallons per minute. The aquifer is composed of sand and gravel deposits with high transmissivity and a saturated thickness greater than 10 feet. The mapped aquifer generally follows the footprint of the Hudson River and associated alluvium deposits and overlaps with the western edge of the site (for Schodack Island).	The No Action Alternative would have no impact on the hydrogeology or the groundwater.	Implementing the TSP may result in minor impacts on local shallow groundwater flows due to alterations to topography and surface water flow.
Tidal Influences	The low and lower low tide levels are -1.42 and -1.63 feet, (NAVD88), respectively; while the high and higher high tide levels are 3.47 and 3.80 feet (NAVD88), respectively.	The No Action Alternative would have minor impacts on tidal influences resulting in increased tidal elevations due to sea level rise.	The TSP would result in moderate beneficial impacts to tidal influence by restoring historically tidal areas that were filled with dredged materials.
Land Use and Zoning	Schodack Island State Park is within the Town of Schodack and Town of New Baltimore protected open space. This open space consists of extensive forest and wetland areas throughout the southern and central portions of the island, and a recreational area which includes an access road, playgrounds, parking lots, and camping grounds in the northern portion of the island. The site is located entirely Town of Schodack Residential/Agricultural (RA) zoning district. This zone is regulated under Chapter 219 of the Schodack municipal code. This districts generally zones for low-density residential or agricultural-oriented development.	The No Action Alternatives or TSP would have no impact on the land use or zoning at the site.	
Economics	Ecotourism is an important economic driver in this region, as the natural and scenic resources draw millions of visitors to New York's recreation areas (USFWS, 2006). Many people come from out of town to pursue wildlife-associated recreation, outdoor sporting, angling, hunting, and wildlife watching,	The No Action Alternatives or TSP would have no impact on local economic conditions.	

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
	bringing with them business for local restaurants, hotels, shops, etc.		
Socio-Economics	The population in the Town of Schodack, NY is an estimated 12,794 people, and is predominantly white (USCB, 2013-2017). The median age in the Town of Schodack, NY is approximately 44.1 years of age and median household income is $79,740. An estimated 5,324 occupied housing units are present within the town, with a majority of structures being built in 1939 or earlier (1,273structures). Approximately 93.5% of the population are high school graduates or higher while 31.4% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Schodack is 1,053. The civilian employed population 16 and over is an estimated 6,865 people.	The No Action Alternatives or TSP would have no impact on local socio-economic conditions.	
Environmental Justice	The site is not located within an Environmental Justice area (NYSDEC, 2018c).	The No Action Alternatives or TSP would have no impact on environmental justice populations.	
Coastal Zone Management	The site is within the NY State Coastal Zone Management Program.	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program.	Implementing the TSP would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat, and Coastal Policy 44.
Wetlands	Specific wetland communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.		
	USFWS National Wetland Inventory (NWI) map indicates the presence of both freshwater emergent wetlands and freshwater forested/shrub wetlands at the Binnen Kill and Schodack Island sites. Additionally, tidally influenced wetlands have been mapped by the NYSDEC's Hudson River Estuary Program as a separate effort in 2007 based off of aerial photographs. Based on the study's July 2018 EPW, baseline conditions of affected wetlands were considered not functioning at their capacity	There would be no impact to the extent of wetlands on the site however, the plant communities of those wetlands would likely shift as sea levels rise.	In the short-term, construction activities associated with implementing the TSP would result in moderate adverse impacts to existing wetlands due to site clearing and grading. In the long-term, implementing the TSP would result in major beneficial impacts to wetlands through the creation of an approximately nine-acre side channel/tidal wetland corridor and

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="3">SCHODACK ISLAND</th></tr>
<tr><th>EXISTING CONDITIONS</th><th>NO ACTION ALTERNATIVE (FWOP)</th><th>TSP</th></tr>
<tr><td></td><td></td><td></td><td>restoration of approximately 19.8 acres of tidal wetland.</td></tr>
<tr><td rowspan="2">Vegetation</td><td colspan="3">Specific wetland/vegetation communities were identified in July 2018 using EPW. Wetland/vegetation communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.</td></tr>
<tr><td>The Schodack Island site contains a variety of ecological communities including floodplain forests, wooded swamp, scrub shrub wetlands, and emergent wetlands (NYSDOS, 2012).</td><td>There would be no impact to the extent of vegetation on the site however, the plant communities would likely shift as sea levels rise.</td><td>In the short-term, construction activities associated with implementing the TSP would result in moderate adverse impacts to vegetation due to site clearing and grading.</td></tr>
<tr><td>Shellfish</td><td>No information regarding the presence, absence, or composition of shellfish communities on the site is readily available.</td><td>The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.</td><td>In the short term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to shellfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in moderate beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.</td></tr>
<tr><td>Finfish</td><td>The site is in vicinity designated as ‘Significant Anadromous Fish Concentration Area’ by the NYSDEC Environmental Resource Mapper (NYSDEC, Environmental Resource Mapper). Schodack Island in its entirety is also designated as a Significant Coastal Fish and Wildlife Habitat under the NY State Coastal Management Program. Schodack Creek is a significant spawning nursery and feeding area for American shad (Alosa sapidissima), white perch (Morone americana), alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis), largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieui), American eel (Anguilla rostrata) and other freshwater fish species.</td><td>The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to finfish, as more areas become accessible to finfish inhabitation</td><td>In the short term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to finfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site and restoration of the historic connection between Schodack Island and the Hudson River would result in major beneficial impacts to finfish, as more areas become accessible to fish inhabitation.</td></tr>
</table>

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Benthic Resources	The site contains a varied mix of benthic morphology including tidal creeks, freshwater intertidal mud flats, and submerged aquatic vegetation beds predominantly dominated by water celery (*Vallisneria americana*). There is no information on benthic organisms.	The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to benthic resources, as more areas become accessible to benthos inhabitation	Under the TSP, the conversion of approximately 9 acres of upland habitat to intertidal habitat on the site would increase the extent of benthic habitat, and therefore provide moderate beneficial impacts to benthic resources.
Reptiles and Amphibians	No information regarding the presence, absence, or composition of reptile or amphibian communities on the site is readily available.	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on reptiles and amphibians, resulting in negligible beneficial impacts to intertidal reptile and amphibian species and negligible adverse impacts to non-tidal wetland reptile and amphibian species.	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, improvements to water quality and the conversion of approximately 9 acres of upland habitat to intertidal habitat on the site would result in moderate beneficial impacts to intertidal reptile and amphibian species and moderate adverse impacts to upland reptile and amphibian species.
Birds	According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018). Schodack Island State Park has been designated a State Important Bird Area (IBA) by the National Audubon Society (National Audubon Society, 2018a-b), and the New York State Bird Conservation Area Program similarly classifies Schodack Island State Park as a Bird Conservation Area (BCA) (NYSDEC, 2002).	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on birds, resulting in negligible beneficial impacts to intertidal bird species and negligible adverse impacts to non-tidal wetland bird species.	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to birds, if present. In the long-term, improvements to water quality and the conversion of approximately 9 acres of upland habitat to intertidal habitat on the site would result in moderate beneficial impacts to intertidal bird species and moderate adverse impacts to upland bird species.

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Mammals	No information regarding the presence, absence, or composition of mammals on the site is readily available. It is likely that the extensive and varied natural areas contained within Schodack Island State Park provide habitat for numerous mammalian species.	The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on mammals, resulting in negligible beneficial impacts to intertidal mammalian species and negligible adverse impacts to non-tidal wetland mammalian species.	Short-term, temporary disturbances to vegetation and water quality due to construction activities with implementing the TSP would result in negligible adverse impacts to mammals, if present. Long-term, improvements to water quality and the conversion of approximately nine acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to aquatic and subaquatic mammalian species and minor adverse impacts to upland mammalian species.
Federal Species of Concern	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*) and the endangered Indiana bat (*Myotis sodalis*) as potentially occurring at the site. There are no reports of the northern long-eared bat or Indiana bat at the site. Coordination with GARFO identified the shortnose sturgeon and Atlantic sturgeon as potentially occur at the site.	The No Action Alternative would have no impact on federal species of concern.	The TSP would have no impact on bat species. Implementation of the TSP would have positive benefits to both sturgeon species as it will provide habitat in the side channel for foraging and safety.
State Species of Concern	The NYSDEC identified the endangered shortnose sturgeon (*Acipenser brevirostrum*), threatened bald eagle (*Haliaeetus leucocephalus*).	The No Action Alternative would have no impact on state species of concern.	The TSP would have positive impacts on Shortnose Sturgeon.
Designated Critical Habitat	The USFWS has not designated any critical habitat in the site. The GARFO has identified the site as critical habitat for the Atlantic Sturgeon.	The No Action Alternative would have no impact on Designated Critical Habitat of concern.	The TSP would have positive impacts to Atlantic Sturgeon critical habitat
Essential Fish Habitat	The site is potential essential fish habitat for various life stages of summer flounder (Paralichthys dentatus), winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*).	The No Action Alternative would have no impact on EFH habitat of concern.	Improvements to water quality, the expansion of intertidal areas on the site, and restoration of the historic connection between Schodack Creek and the Hudson River would result in beneficial impacts to EFH, as more areas become accessible to fish inhabitation. The side channel/tidal wetland corridor would also provide a

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
	There are no reports of the above EFH species at the site.		velocity refuge for fish during storm events.
Cultural Resources	There is one prehistoric archaeological site documented within the study area, the Mahican Indian Village Site (08313.000238). The location of the site has not been confirmed through archaeological investigations but the existence of the site is documented on several historic maps of the area and historical accounts. Four historic archaeological sites are also located within the boundaries of the study area. These are the Miller and Witbeck Ice House (08313.000242), Ziegler's Ice House (08313.000237), the J.N. Briggs Ice House (08313.000243), and the Horton and Company Ice House (03912.000109). There are no eligible or listed above-ground historic properties located within the study area. The archaeological and historical record of the study area and the results of previous cultural resources surveys suggest that there is potential for both prehistoric and historic sites to exist within the dry and elevated areas of the study area especially within the vicinity of the historic islands.	The No Action Alternative will have no adverse impact on cultural resources.	Of the five sites identified within the study area one is located within the APE for the recommended plan, the map documented Mahican Indian Village (08313.000238). Proposed measures are primarily located within the historic channel that once divided the Islands. A review of previous surveys and other background data indicates that the potential for prehistoric and historic archaeological sites to exist within most of the APE is low, however, the northern portion of the APE overlies the historic Island of Mull's Plaat which is the likely location of the Mahican Indian Village Site. Geotechnical surveys of the APE will be helpful in determining the potential for the proposed project to reach depths below dredge material deposits and additional surveys including limited subsurface testing is recommended once plans are further developed to determine the presence or absence of archaeological sites within the APE. Additional areas identified for staging and access should also be evaluated for impacts to cultural resources. A Programmatic Agreement has been prepared to address adverse effect to cultural resources.
Air Quality	The sites are classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O3), particulate matter (PM10 & PM2.5), sulfur	The No Action Alternative would have no impact on air quality.	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
	dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site.		temporarily during the construction period, which would have a projected duration of approximately two years. In the long-term, implementing the TSP would have no impact on air quality.
Noise	Potential sources of existing noise pollution on the site may include trucking activities, during times when dredged material is being transported for disposal at the southern tip of Schodack Island. Other local sources of noise pollution may include boating activities along the Hudson River and around the Port of Coeymans, which is located just across the river from the site.	The No Action Alternative would have no impact on noise levels.	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately two years. In the long-term, implementing the TSP would have no impact on local noise levels.
Recreation	Currently, eight miles of multi-use trails wind through a variety of ecological communities. In addition, the park has 66 campsites for use, an improved bike trail, volleyball nets, horseshoe and a kayak/canoe launch site. Interpretive signage highlights the park's historic and environmental significance. According to a blog revolving around activities in the town of Schodack, many recreation events are hosted at the Schodack Island State Park, including a Winterfest with cross country ski racing, snow shoeing, nature hikes, ice skating, and dog sledding (Schodack Scene, 2015).	The No Action Alternative would have no impact on recreation.	In the short-term, no impacts to recreation would occur as there are no designated recreational areas present on the site. In the long-term implementing the TSP would result in minor beneficial impacts to recreation through the restoration of habitat.
Aesthetics and Scenic Resources	The site is located within a designated Scenic Area of Statewide Significance (SASS), specifically the Columbia-Greene North SASS, in the CGN-4 Islands subunit (NYSDOS, 1993). According to the Scenic Area Study associated with this SASS (NYSDOS, 1993), the Islands subunit is included in the Columbia-Greene North SASS because "...it links distinctive subunits. The subunit constitutes the middle ground and background of views to the Hudson River from distinctive subunits on both the west and east banks of the Hudson, including views	The No Action Alternative would have no impact on aesthetics and scenic resources.	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the TSP would result in minor beneficial impacts to the site's

RESOURCE	SCHODACK ISLAND		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
	from the trains on the eastern shore and from NY Routes 61 and 9J…”		aesthetic and scenic resources through the restoration of wetland habitat.
Hazardous, Toxic, and Radioactive Waste (HTRW)	A review of the databases yielded no contaminated sites within or near the Schodack Island site.	The No Action Alternatives or TSP would have no impact on HTRW.	
Transportation and Other Infrastructure	Schodack Island State Park is located off of NY-9J, a motor-vehicle road that is also a bicycle route. There is no other infrastructure within the park boundary.	The No Action Alternative would have no impact on transportation or infrastructure.	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. In the long-term, implementing the TSP would involve the construction of a road crossing over the proposed side channel/tidal wetland connection. However, this road crossing would replace an existing access road and therefore have no impact on transportation and site access.

Table 5-3: Existing Conditions and Environmental Impacts to the Henry Hudson Park Site.

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
Geology and Physiography	This section of the Hudson River Valley consists of a narrow inner valley with adjacent terraces approximately 100-200 feet high, bordered by gently rolling terrain and low hills (NYSDOT, 2013). The valley is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods. Specifically, the Binnen Kill site is mapped as underlain by the Austin Glen Formation, which consists of highly folded, interbedded greywacke sandstone and shale that formed in	The No Action Alternative or TSP would have no impact on geology or physiography.	

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE**	**TSP**
	a deep marine setting from the erosion of pre-existing sedimentary rocks (NYS Museum, 1995). In general, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. The Hudson River has since reworked these sediments, and the site is currently mapped as alluvium (NYS Museum, 1991)		
Topography	The topography of the site is generally low-lying and gently sloping, with the majority of the site sitting at an elevation of less than 10 feet (NAVD88) (NYSDEC, 2011 - 2012).	Under the No Action Alternative, the shoreline at the site would continue to be susceptible to topographic change by erosion due to wave and tidal action.	Overall, implementing the TSP would result in moderate impacts to topography. Topographic changes along the shoreline would be minimal. The existing concrete cap would be removed and replaced with vegetated riprap and graded to achieve a 1V:3H slope. Approximately 3.6 acres of existing upland would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology.
Soils	The park was mapped as two soil types: Udipsamments, dredged and Teel silt loam (NRCS, Web Soil Survey).	Under the No Action Alternative, the soils along the site's shoreline would be subject to moderate adverse impacts from soil erosion due to wave and tidal action, the continued deterioration of existing shoreline structures, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).	In the short-term, the TSP would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. In the long term, implementing the TSP would result in moderate beneficial impacts to soil resources through the placement of riprap and creation of wetlands, which reduce shoreline erosion by stabilizing sediments and absorbing and dissipating wave energy (Hammer, 1992).
Climate and Weather	The State's average annual temperature is expected to increase approximately four to six degrees Fahrenheit by mid-century and as	The No Action Alternative or the TSP would have no impact on the climate or weather at the site.	

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE**	**TSP**
	much as 11 degrees Fahrenheit by 2100. The total annual precipitation is expected to increase as much as 11% by mid-century and 18% by 2100. Since 1900, sea level in the lower Hudson has risen 13 inches. Sea level rise along the Hudson River is projected to continue. The Hudson River is projected to rise a minimum of nine additional inches by 2050, with mid-range projections of approximately 10 to 20 inches by 2050.		
Climate Resiliency		Under the No Action Alternative, predicted sea level rise, and increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018b).	Stabilization of the shoreline under the TSP would result in a minor beneficial impact to climate resiliency by enhancing the shoreline's resistance to greater erosive forces associated with climate change.
Floodplains	The site lies completely within the one percent floodplain (AE Zone) with a base flood elevation of 18 feet (NAVD88), as shown on the Flood Insurance Rate Map. Additionally, the shoreline portion of the site, within approximately 30 feet of the Hudson River, is within the regulatory floodway.	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain.	Under the TSP, the site would remain within the Hudson River's one percent floodplain. Excavation along the northern banks of Vloman Kill, associated with tidal wetland creation, would slightly increase local flood storage during precipitation events, resulting in negligible beneficial impacts to the site's floodplain.
Surface Waters	Located within the Middle Hudson Watershed (HUC-8 No.: 02020006), the Hudson River and Vloman Kill are the primary surface water bodies at the site, with the Moordener Kill entering the Hudson River directly across from the site. The Hudson River forms the eastern boundary of the site, while Vloman Kill delineates the southern boundary.	Under the No Action Alternative, the Hudson River would continue to constitute the site's only surface water body.	Implementing the TSP would result in minor impacts to the site's surface waters. Surface water area on the site would be expanded due to excavation along the northern banks of Vloman Kill, associated with tidal wetland creation.
Water Quality	Vloman Kill and the Hudson River are both classified as Class C water bodies, which support fisheries and are suitable for non-contact recreation. The Hudson River is listed in	Under the No Action Alternative, soil erosion along the shoreline would increase turbidity in the Hudson River,	In the short-term, implementing the TSP would result in negligible adverse impacts on water quality due to increases in turbidity during the

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="3">HENRY HUDSON PARK</th></tr>
<tr><th>EXISTING CONDITIONS</th><th>NO ACTION ALTERNATIVE</th><th>TSP</th></tr>
<tr><td></td><td>the 2016 EPA 303(d) list as “impaired” due to fish consumption advisories from sediment contaminated with polychlorinated biphenyls (PCBs)(USEPA, 2016b).</td><td>resulting in negligible adverse impacts to water quality.</td><td>construction phase of the project. In the long-term, implementing the TSP would result in minor beneficial impacts to water quality through the reduction of soil erosion along the shoreline and the creation of approximately 3.6 acres of tidal wetland.</td></tr>
<tr><td>Regional Hydrogeology and Groundwater</td><td>One aquifer has been identified at the Henry Hudson site by the New York State Department of Conservation Division of Water, Bureau of Water Resources Management (NYS GIS Clearinghouse, 2018). This aquifer is described as an unconfined, high yield aquifer with a yield of greater than 100 gallons per minute. The aquifer is composed of sand and gravel deposits, with high transmissivity and a saturated thickness greater than 10 feet.</td><td colspan="2">The No Action Alternatives or TSP would have no impact on the hydrogeology or the groundwater.</td></tr>
<tr><td>Tidal Influences</td><td>The low and lower low tide levels are -1.59 and -1.81 feet (NAVD88), respectively; while the high and higher high tide levels are 3.4 and 3.78 feet (NAVD88), respectively.</td><td>Therefore, the No Action Alternative would have no impact on tidal influences.</td><td>Implementing the TSP would result in minor impacts to tidal influence by increasing the intertidal areas of the park by approximately 3.6 acres through the excavation along the northern banks of Vloman Kill, associated with tidal wetland creation.</td></tr>
<tr><td>Land Use and Zoning</td><td>Henry Hudson Park is within the Town of Bethlehem protected open space. This open space consists of upland forest, riparian habitat, and a recreational area which includes an access road, playground, baseball field, parking lots, and maintained turf. The site is located within the Town of Bethlehem’s Rural Riverfront (RR) zoning district. This zone is regulated under Chapter 128 of the Bethlehem municipal code. This district generally zones for low-density residential, or agricultural-oriented development. Habitat restoration/creation is not explicitly regulated under the town’s municipal zoning code.</td><td colspan="2">The No Action or TSP Alternatives would have no impact on the land use or zoning at the sites</td></tr>
</table>

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
Economics	The Town of Bethlehem has made a strong commitment to fostering economic development and diversification of the Town's tax base. In 2011, the Bethlehem 20/20 Committee prepared the Economic Development Strategy that included several elements to guide economic development initiatives. Several of these initiatives have been addressed or are ongoing.	Under the No Action Alternative, Henry Hudson Town Park would continue to serve as an open space to local residences. However, the shoreline of the park would continue to degrade over time, and the park's recreational functions may become compromised as a result.	Implementing the TSP would have no impact on local economic conditions.
Socio-Economics	According to the U.S. Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Bethlehem, NY is an estimated 33,656 people, and is predominantly white. The median age in the Town of Bethlehem, NY is approximately 42.8 years of age and median household income is $96,384. An estimated 14,485 occupied housing units are present within the town, with a majority of structures being built in 1990 to 1999 (2,154 structures). Approximately 97.0% of the population are high school graduates or higher while 58.6% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Bethlehem is 3,119. The civilian employed population 16 and over is an estimated 18,384 people.	The No Action Alternative or TSP would have no impact on local socio-economic conditions.	
Environmental Justice	The sites are not located within an Environmental Justice area (NYSDEC, 2018c).	The No Action Alternative or TSP would have no impact on environmental justice populations.	
Coastal Zone Management	The sites are within the NY State Coastal Zone Management Program.	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program.	The proposed actions would be consistent with the overall objectives of the Coastal Management Program.
Wetlands	Specific wetland communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.		

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
	The USFWS National Wetland Inventory (NWI) map indicates the presence of both freshwater emergent wetlands and freshwater forested/shrub wetlands at the Henry Hudson site. The Hudson River and Vloman Kill are mapped as riverine environments. Additionally, tidally influenced wetlands have been mapped by the NYSDEC's Hudson River Estuary Program as a separate effort in 2007 based off of aerial photographs (NYSDEC, 2007).	The No Action Alternative would not impact wetlands at the site.	In the short-term, construction activities associated with implementing the TSP would have no impact on any wetlands. In the long term, the TSP would result in moderate beneficial impacts to wetlands through the creation of approximately 3.6 acres of tidal wetland habitat
Vegetation	Specific wetland/vegetation communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland/vegetation communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the TSP are detailed in Appendix D.		
	Approximately 15 acres of the park is managed as recreational open space, containing turf areas, picnic areas, playgrounds, and athletic fields. The remaining area is primarily undisturbed, and have been mapped as emergent wetlands, scrub shrub wetlands, forested wetland, upland deciduous forest, and upland evergreen forest (NYS GIS Clearinghouse, 2018).	Under the No Action Alternative, sea level rise is projected to occur in the tidal Hudson River, which would shift intertidal areas landward of their current extents. As this shift occurs, some of the trees proximate to the sites shoreline may be lost due to increasing groundwater saturation, resulting in negligible adverse impacts to vegetation.	In the short-term, construction activities associated with implementing the TSP would result in minor adverse impacts to vegetation due to site clearing, grading, and the movement of personnel and equipment across the site during construction. In the long-term, implementing the TSP would result in a moderate beneficial impact to vegetation due to the conversion of approximately 0.2 acres of mudflat to tidal wetland at the confluence of Vloman Kill, and the addition of vegetated riprap along the Hudson River shoreline.
Shellfish	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available.	The No Action Alternative would have no impact on shellfish or their habitat.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to shellfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in negligible beneficial impacts to shellfish,

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
			as more areas become accessible to shellfish inhabitation.
Finfish	Henry Hudson Park is adjacent to the area designated as a Significant Coastal Fish and Wildlife Habitats (SCFWH) under the New York State Coastal Management Program, known as 'Shad and Schermerhorn Islands'. According to the Coastal Fish and Wildlife Rating Form (NYSDOS, 2012) associated with this SCFWH, Shad and Schermerhorn Islands contains habitats serving as a nursery area for blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*) as well as spawning and feeding areas for resident freshwater species in the Hudson River, including white perch (*Morone americana*).	The No Action Alternative would have no impact on finfish or their habitat.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to finfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in negligible beneficial impacts to finfish, as more areas become accessible to fish inhabitation.
Benthic Resources	According to Hudson River Estuary Program Benthic Mapping Project (NYSDEC, 2006), the bottom sediment of Vloman Kill is comprised of sandy mud (mud with >10% sand). The bottom sediment of the Hudson River in this area is comprised of muddy sand (sand with >10% mud) along the shoreline, and is part of a thickly lain, depositional sediment region. There is no information on benthic organisms.	The No Action Alternative would have no impact on benthic resources.	Under the TSP, the conversion of approximately 3.6 acres of upland habitat to intertidal habitat would increase the extent of benthic habitat, and therefore provide minor beneficial impacts to benthic resources
Reptiles and Amphibians	Shad and Schermerhorn Islands supports a variety of amphibians and reptiles including northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), mudpuppy (*Necturus maculosus*), American toad (*Bufo americanas*), bullfrog (*Rana catesbeiana*) and green frog (*Rana clamitans*). Given Henry Hudson Park's proximity to this area, these species may also occur in the waters and wetlands within the park, especially in the sheltered Vloman Kill.	The No Action Alternative would have no impact on reptiles, amphibians, or their respective habitats.	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, improvements to water quality and the conversion of approximately 3.6 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to intertidal reptile and amphibian species and minor

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
			adverse impacts to upland reptile and amphibian species.
Birds	According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018). According to the eBird database, managed by Cornell Lab of Ornithology, as January 8, 2019, 155 species of birds have been documented within Henry Hudson Park (eBird, 2012).	The No Action Alternative would have no impact on birds or their habitat.	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to birds, if present. In the long-term, improvements to water quality and the conversion of approximately 3.6 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to intertidal bird species and minor adverse impacts to upland bird species.
Mammals	According to the Coastal Fish and Wildlife Rating Form associated with the designated SCFWH (NYSDOS, 2012), Shad and Schermerhorn Islands supports mammal species including white-tailed deer (*Odocoileus virginianus*) and eastern cottontail (*Sylvilagus floridanus*). Given Henry Hudson Park's proximity to this area, these species may also occur in the park.	The No Action Alternative would have no impact on mammals or their habitat.	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to mammals, if present. In the long-term, improvements to water quality and the conversion of approximately 3.6 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to aquatic mammalian species and minor adverse impacts to upland mammalian species.
Federal Species of Concern	The USFWS iPac system identified the threatened Northern Long-eared Bat (*Myotis septentrionalis*) as potentially occurring at the site. There are no reports of northern long-eared bat at the site. Coordination with GARFO identified the shortnose sturgeon and Atlantic sturgeon as potentially occur at the site.	The No Action Alternative would have no impact on federal species of concern.	Implementation of the TSP would have positive benefits to both sturgeon species as it will provide habitat in the shoreline with the rocky habitat and the creation of the wetlands
State Species of Concern	The NYSDEC identified the endangered shortnose sturgeon (*Acipenser brevirostrum*),	The No Action Alternative or TSP would have no impact on state species of concern.	

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
	threatened bald eagle (*Haliaeetus leucocephalus*). There are no reports of shortnose sturgeon, bald eagles are reported at the site.		
Designated Critical Habitat	The USFWS has not designated any critical habitat in the sites. The GARFO has identified the site as critical habitat for the Atlantic sturgeon.	The No Action Alternative would have no impact on Designated Critical Habitat of concern.	The TSP would have positive impacts to Atlantic sturgeon critical habitat as it will provide more habitat with the creation of the rocky habitat and the creation of the wetlands.
Essential Fish Habitat	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the sites are potential essential fish habitat for various life stages of summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). There are no reports of the above EFH species at the sites.	The No Action Alternative would have no impact on EFH habitat of concern.	Improvements to water quality and the expansion of intertidal areas on the shoreline Hudson River and the Vloman Kill would result in minor beneficial impacts to EFH, as more areas become accessible to fish inhabitation. The side tidal wetland habitat would also provide a velocity refuge for fish during storm events.
Cultural Resources	There are three prehistoric archaeological sites and eight historic archaeological sites documented within one mile of the site. Evidence of a Native American presence in the area has been well documented in the archaeological record and through early historical accounts. The Bethlehem Ancestral Repatriation Site (00102.000892) is a Native American burial that was recovered just 0.2 miles south of the site. The shoreline of Henry Hudson Park has been built up through the years with dredge material and therefore the shoreline has a low potential of containing historic archaeological remains, however, there is moderate potential for deeply buried prehistoric archaeological sites to exist below the dredge material. The northern end of the	The No Action Alternative would have no adverse effect on cultural resources.	The presence of several previously documented historic and prehistoric archaeological sites in the vicinity suggests that the area was utilized heavily both in precontact and contact periods. Considering that the shoreline portion of the study area contains deep dredge material deposits, the potential for historic archaeological remains to exist within the area of proposed shoreline stabilization measures is low with the exception of the northern end where historic maps indicate a dock was once situated. The 3.6 acre proposed wetland area along the bank of the Vloman Kill, however, is believed to have a moderate to high potential for

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
	site is the location of a dock that is depicted in historic maps and labeled "Cedar Hill Landing." Remains of the dock and associates structures may remain within the northern end of the site. Though the shoreline contains deep deposits of dredge material, the wetland area along the Vloman Kill most likely has not been filled to the same extent and is considered sensitive for both prehistoric and historic archaeological remains.		historic and prehistoric remains due to its proximity to a river confluence and the discovery of several historic and prehistoric sites in the vicinity. A pedestrian survey and archaeological testing is recommended for the proposed wetland area to determine the presence or absence of archaeological sites and a geomorphological study is recommended to understand the depositional profile of the shoreline. Additionally, as plans are developed, additional areas including staging and access areas should be subject to a cultural resources assessment. A Programmatic Agreement has been prepared to address adverse effects to cultural resources.
Air Quality	The site is located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site.	The No Action Alternative would have no impact on air quality.	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period, which would have a projected duration of approximately one year. In the long-term, Implementing the TSP would have no impact on air quality.
Noise	The site currently consists of recreational park land. Land in vicinity of the site is largely undeveloped but include some low-density residences and a water treatment plant. Potential sources of existing noise pollution on the site may include recreational activities, such as baseball and boating activities around the site's boat launches.	The No Action Alternative would have no impact on noise levels.	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately one year. In the long-term, implementing the TSP would have no impact on local noise levels.
Recreation	The Henry Hudson Park has many recreation facilities including a boat launch for motorized	Under the No Action Alternative the site would	In the short-term, minor adverse impacts to recreation would occur

RESOURCE	HENRY HUDSON PARK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	TSP
	craft, a boat launch for kayaks, canoes, and other hand-powered craft, picnic areas with grills, a softball field, a playground, a volleyball court, horseshoes area, a gazebo, a pavilion, and an accessible fishing area all for public, recreational use (Town of Bethlehem, 2015).	remain vulnerable to the deterioration of existing shoreline structures and may be subject to the effects of climate change such as sea level rise.	during the construction phase of the project. In the long-term, implementing the TSP would result in minor beneficial impacts to the site's recreational resources.
Aesthetics and Scenic Resources	The Town of Bethlehem's LWRP identified Henry Hudson Park, being the primary local access point to the Hudson River, as a scenic resource (Town of Bethlehem, 2018). The site is not designated as a Scenic Areas of Statewide Significance (SASS) under the New York Coastal Management Program.	Under the No Action Alternative, the site's shoreline would be subject to erosion and the continued deterioration of existing shoreline structures due to wave and tidal action resulting in a minor adverse impact to the shoreline's aesthetics.	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the TSP would result in minor beneficial impacts to the site's aesthetic and scenic resources through the replacement of the dilapidated concrete capping along the shoreline with vegetated riprap.
Hazardous, Toxic, and Radioactive Waste (HTRW)	A review of the databases yields no known contaminated sites within or near the Henry Hudson Park.	The No Action Alternative or TSP would have no impact on HTRW.	
Transportation and Other Infrastructure	Lyons Road loops through Henry Hudson Park, serving as the park's main access road. The park's closest major roadway connections are State Route 114 and Interstate 87. The Town's draft LWRP recommends pedestrian and bicyclist accommodations, such as reduced speed limits and enhanced road crossing, along Route 114 to support access to Henry Hudson Park (Town of Bethlehem, 2018).	The No Action Alternative would have no impact on transportation or infrastructure.	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. In the long-term, implementing the TSP would have no impact on transportation or infrastructure.

Table 5-4: Existing Conditions and Environmental Impacts to Rondout Creek Site.

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Geology and Physiography	The site is within the Hudson-Mohawk Lowlands physiographic region, in the Wallkill River valley. The lowlands in this area are underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods. Specifically, the Rondout Creek site is mapped as underlain by the Austin Glen Formation, which consists of highly folded, interbedded greywacke sandstone and shale that formed in a deep marine setting from the erosion of pre-existing sedimentary rocks (NYS Museum, 1995). The lower Rondout Creek and Wallkill River valley are bounded by the Catskill Mountains to the west\ and the Marlboro Mountains to the east (USGS, 2003).	The No Action Alternative or TSP would have no impact on geology or physiography.	
Topography	Eddyville Dam is situated in a narrow valley with steep bedrock walls. The dam is built on a bedrock ledge, with the dam crest at an elevation of 4 feet (NAVD88). The river bed is highly irregular in the vicinity of the dam, with bed elevations ranging from -45 feet to -14 feet below the dam, and -25 to -6 feet above the dam (FEMA, 2016b). Several pools with water depths up to 48 feet are present above and below the dam, which have been attributed to excavation of rock for use in construction of the nearby Delaware and Hudson Canal.	Under the No Action Alternative, the site could to be susceptible to topographic change by erosion due to wave and tidal action and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018a).	Implementing the TSP would result in negligible impacts to the topography of the site. Direct manipulation of topography would be limited to what is minimally required to remove the dam
Soils	The area around the dam at the Rondout Creek site is composed of various complexes of rock outcrops, Bath gravelly silt loam, and Nassau shaly silt loam soils (NRCS, Web Soil Survey).	Under the No Action Alternative, the soils may be subject to minor adverse impacts from soil erosion due to the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018a).	In the short-term, the TSP would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. In the long-term, The TSP would have no impact on soils at the site.

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Climate and Weather	A National Weather Service (NWS) station is located approximately 10 miles southwest of the site, at Mohonk Lake, New York. Average monthly temperatures ranged for 24.9°F in January to 71.0°F in July (AgACIS, 2018b). Average annual precipitation was 48.4 inches, with monthly averages ranges from 3.30 inches in February to 4.57 inches in July. Average annual snowfall was 61.5 inches, primarily occurring between December and March.	The No Action Alternative or TSP would have no impact on the climate or weather at the site.	
Climate Resiliency		Under the No Action Alternative, increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018a).	Implementing the TSP may result in a beneficial impact to climate resiliency by reducing flood elevations upstream of the Eddyville Dam.
Floodplains	The site lies completely within the one percent floodplain (AE Zone) with a base flood elevations of 17 to 18 feet (NAVD88) above the dam structure and 13 feet below the dam structure, as shown on the FEMA Flood Insurance Rate Map (FIRM), effective as of November 18, 2016 (Firm Panel No.: 36111C0470F)(FEMA, 2016a).	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain	Implementing the TSP would result in a beneficial impact to the floodplain by increasing flood storage along the Rondout Creek floodplain during precipitation and reducing flood elevations upstream of the Eddyville Dam.
Surface Waters	Located within the Rondout Watershed (HUC-8 No.: 02020007), Rondout Creek is the primary surface water body at the site. The site is located approximately 3.5 miles downstream of the confluence of Rondout Creek and the Wallkill River, and approximately 3.6 miles upstream of the Hudson River. Rondout Creek has a drainage area of approximately 1180 square miles (USGS, Streamstats) to the Eddyville Dam site. The dam marks the upstream extent of tidal influence in Rondout Creek.	The No Action Alternative would have no impact on surface waters at the site.	Normal water surface elevation would drop approximately 10 feet in the upstream vicinity of the dam and tidal fluctuation would extend upstream into the impoundment.
Water Quality	Rondout Creek is classified as a Class C water body, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B).	The No Action Alternative would result in minor adverse impacts to water quality.	In the short-term, implementing the TSP would result in negligible adverse impacts on water due to increases in turbidity during the construction phase

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
			of the project. In the long-term, implementing the TSP would result in moderate beneficial impacts to water quality.
Regional Hydrogeology and Groundwater	An unconfined aquifer has been identified at the Rondout Creek site by the New York State Department of Conservation Division of Water, Bureau of Water Resources Management (NYS GIS Clearinghouse, 2018). This aquifer is described as an unconfined, mid-yield aquifer with a yield of 10-100 gallons per minute.	The No Action Alternative would have no impact on hydrogeology or groundwater.	Implementing the TSP may result in minor impacts on local shallow groundwater flows due to alterations to surface water elevations and surface water flow.
Tidal Influences	No tidal stations are located directly in Rondout Creek. A NOAA tide station is located at Hyde Park in the Hudson River, approximately 11 miles downstream of the of the confluence of Rondout Creek and the Hudson River (Station: 8518951, Hyde Park, NY) (NOAA, 2014). At this station, the low and lower low tide levels are -1.78 and -1.58 feet (NAVD88), respectively; while the high and higher high tide levels are 1.93 and 2.32 feet (NAVD88), respectively. Eddyville Dam serves as the upstream limit of tidal influence in Rondout Creek.	The No Action Alternative would have no impact on tidal influences.	Implementing the TSP and restoring historic tidal flow in Rondout Creek upstream of the Eddyville Dam would have major beneficial impacts to tidal influences at the site.
Land Use and Zoning	The Rondout Creek site includes the Eddyville Dam and open waters upstream and downstream along the border of the Town of Ulster and Town of Esopus. Land uses in the vicinity of the site primarily contain a mix of forested land and low-density residential properties. Additionally, an agricultural area and a quarry are located approximately 3,000 feet upstream of the site. The site is located partially within the Town of Ulster's 10,000 square foot minimum lot area, residence zoning district (R-10) and partially within Town of Esopus suburban density residential (R-40) zoning district.	The No Action Alternative or TSP would have no impact on the land use or zoning at the site.	
Economics	The Town of Ulster has economic development projects underway in proximity to the site, including The Hudson Landing Project, located approximately 5 miles northeast of the site, and Tech City Project, located approximately 5 miles north of the site. The Route 9W corridor which houses the Tech City campus also contains a variety of	The No Action Alternative or TSP would have no impact on local economic conditions.	

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="3">RONDOUT CREEK</th></tr>
<tr><th>EXISTING CONDITIONS</th><th>NO ACTION ALTERNATIVE (FWOP)</th><th>TSP</th></tr>
<tr><td></td><td>retailers including the Hudson Valley Mall. The Town of Esopus is in the midst of revising their town comprehensive plan (Kemble, 2018) to help address certain issues and reach new goals such as taking advantage of the Hudson River shoreline. Officials of the Town of Esopus have requested residents weigh in on which waterfront projects to prioritize along Rondout Creek. Among the goals included are to evaluate potential public access on the Rondout Creek in Sleighsburgh and Connelly, including but not limited to a new waterside park and designated area for restaurant dining and recreation.</td><td colspan="2"></td></tr>
<tr><td>Socio-Economics</td><td>According to the US Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Esopus, NY is an estimated 9,041 people, and is predominantly white. The median age in the Town of Esopus, NY is approximately 43.3 years of age and median household income is $69,777. Approximately 89.9% of the Town of Esopus population are high school graduates or higher while 26.9% of the population have a bachelor’s degree or higher. The estimated number of companies in the Town of Esopus is 776. The civilian employed population 16 and over is an estimated 4,917 people. The population in the Town of Ulster, NY is an estimated 12,327 people, and is predominantly white. The median age in the Town of Ulster, NY is approximately 47.7 years of age and median household income is $50,941. Approximately 89.2% of the Town of Ulster population are high school graduates or higher while 25.2% of the population have a bachelor’s degree or higher. The estimated number of companies in the Town of Ulster is 979. The civilian employed population 16 and over is an estimated 5,424 people.</td><td colspan="2">The No Action Alternative or TSP would have no impact on local socio-economic conditions.</td></tr>
<tr><td>Environmental Justice</td><td>The sites are not located within an Environmental Justice area (NYSDEC, 2018b).</td><td colspan="2">The No Action Alternative or TSP would have no impact on environmental justice populations.</td></tr>
</table>

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Coastal Zone Management	The tidal portion of Rondout Creek downstream of the Eddyville Dam is located within a designated Coastal Area, subject to regulation under the federal Coastal Zone Management Act, and managed under the New York Coastal Management Program. The Town of Esopus has developed a Local Waterfront Revitalization Program (LWRP) which was approved by the state Coastal Zone Management Program in 1987 (Town of Esopus, 1987).	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program.	Implementing the TSP would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat
Wetlands	The USFWS National Wetland Inventory (NWI) map indicates the presence of a small freshwater emergent wetland located directly upstream of the dam on the east bank of Rondout Creek.	The No Action Alternative would not impact wetlands at the site.	In the short-term, construction activities associated with implementing the TSP would have no impact on any wetlands. In the long-term, the TSP would result in moderate beneficial impacts to wetlands as existing shallow areas in the impoundment area are expected to naturally revert back to wetlands after the Eddyville Dam is removed.
Vegetation	The area surrounding the Rondout Creek site is mapped as a mixture of upland deciduous forest and upland evergreen forest (NYS GIS Clearinghouse, 2018), in addition to the freshwater emergent wetland noted in the National Wetland Inventory. All community descriptions were acquired from Ecological Communities of New York State, 2nd Edition (Edinger et al., 2014).	The No Action Alternative would have no impact on the vegetation of the site.	In the short-term, construction activities associated with implementing the TSP may result in negligible adverse impacts to vegetation. In the long-term, implementing the TSP would result in a moderate beneficial impact on vegetation due to exposure to previously impounded lands, which are expected to naturally revegetate.
Shellfish	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available.	The No Action Alternative would have no impact on the shellfish.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to shellfish, if present. In the long-term, the restoration of aquatic organism passage to Rondout Creek upstream of Eddyville Dam

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
			would result in moderate beneficial impacts to shellfish.
Finfish	The tidal portion of Rondout Creek, downstream of Eddyville Dam, is designated as a Significant Coastal Fish and Wildlife Habitat under the New York State Coastal Management Program. Rondout Creek has historically supported large concentrations of coastal migratory and resident freshwater fish species. Given its height, Eddyville Dam likely impedes or prevents the upstream migration of fish. The creek is an important spawning area for alewife (*Alosa pseudoharengus*), Blueback Herring (*Alosa aestivalis*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), and striped bass (*Morone saxatilis*) between March and June, and for tomcod (*Microgadus tomcod*) between December and January. American shad (*Alosa sapidissima*) spawn in shallow water areas at the mouth of Rondout Creek. Substantial populations of brown bullhead (*Ameiurus nebulosus*), yellow perch (*Perca flavescens*), American eel (*Anguilla rostrata*), smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*Micropterus salmoides*) occur in the creek throughout the year. The deepwater area near the mouth of the Rondout Creek is one of five known important overwintering areas for largemouth and smallmouth bass.	The No Action Alternative would have no impact on the finfish.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to finfish, if present. In the long-term, the restoration of aquatic organism passage to Rondout Creek upstream of Eddyville Dam would result in major beneficial impacts to finfish.
Benthic Resources	No information regarding the presence, absence, or composition of benthic resources in Moodna Creek is readily available.	The No Action Alternative or TSP would have no impact on the benthic resources.	
Reptiles and Amphibians	The banks of Rondout Creek provides habitat for common snapping turtle (*Chelydra serpentina*), common map turtle (*Graptemys geographica*), water snake (*Nerodia s. sipedon*), red-spotted newt (*Notophthalmus v. viridescens*), redback salamander (*Plethodon cinereus*), common mudpuppy (*Necturus maculosus*), American toad (*Bufo americanas*), gray treefrog (*Hyla versicolor*), spring peeper (*Pseudoacris crucifer*), bullfrog (*Rana*	The No Action Alternative would have no impact on reptiles, amphibians, or their respective habitats.	In the short-term, temporary reductions in water quality. In the long-term, implementing the TSP may result in minor beneficial impacts to wetland reptile and amphibian species and minor adverse impacts to reptile and amphibian species which inhabit slow moving water bodies.

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	**NO ACTION ALTERNATIVE (FWOP)**	**TSP**
	catesbeiana), green frog (*Rana clamitans*), and wood frog (*Rana sylvatica*).		
Birds	According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018). The wetlands located at the mouth of Rondout Creek are productive feeding areas for a variety of waterfowl species during spring and fall migrations including American bittern (*Botaurus lentiginosus*) and osprey (*Pandion haliaetus*). No information regarding the presence, absence, or composition of bird species further upstream, around Eddyville Dam, is readily available.	The No Action Alternative would have no impact on birds or their habitat.	In the short-term, implementing the TSP would result in negligible adverse impacts to birds, if present. In the long-term, implementing the TSP may result in minor beneficial impacts to wetland bird species and minor adverse impacts to bird species which inhabit or forage in slow moving water bodies.
Mammals	No information regarding the presence, absence, or composition of mammals on the site is readily available. It is likely that the floodplains, wetlands, and forested land in vicinity of the site provide habitat for numerous mammalian species.	The No Action Alternative would have no impact on mammals or their habitat.	In the short-term, implementing the TSP would result in negligible adverse impacts to mammals, if present. In the long-term, implementing the TSP may result in minor beneficial impacts to subaquatic mammalian species and minor adverse impacts to aquatic mammalian species which inhabit slow moving water bodies.
Federal Species of Concern	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*) and the endangered Indiana bat (*Myotis sodalis*), and threatened bog turtle (*Clemmys muhlenbergii*) as potentially occurring at the site. There are no reports of the above species occurring at the site. Coordination with GARFO identified the shortnose sturgeon and Atlantic sturgeon as potentially occur at the site.	The No Action Alternative would have no impact on federal species of concern.	The TSP would have positive impacts to the sturgeon as more habitat is opened up. There will be no impacts to the bats and turtle.
State Species of Concern	The NYSDEC identified the endangered Indiana bat (*Myotis sodalis*) as potentially occurring at these sites.	The No Action Alternative would have no impact on state species of concern.	The TSP would have no impact on state species of concern.
Designated Critical Habitat	The USFWS has not designated any critical habitat at this site. The GARFO has identified the site as critical habitat for the Atlantic sturgeon.	The No Action Alternative would have no impact on Designated Critical Habitat of concern.	Implementation of the TSP would have positive impacts to Atlantic Sturgeon critical habitat as it will provide more

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
			habitat with the removal of the dam opening up more habitat.
Essential Fish Habitat	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the site is potential essential fish habitat for various life stages of winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). There are no reports of the above EFH species at the site.	The No Action Alternative would have no impact on EFH habitat of concern.	The expansion of intertidal areas on the site, and restoration of the historic connection between Schodack Creek and the Hudson River would result in beneficial impacts to EFH, as more areas become accessible to fish inhabitation.
Cultural Resources	Two prehistoric archaeological sites are documented within one mile of the site. European settlement in the area began in the early 1600's when the Dutch established a small fortification at the mouth of the Rondout Creek in what is today the City of Kingston. Several mills were operated along the Rondout Creek throughout the 18th and 19th Centuries and the primary industry throughout the area was farming. The construction of the D&H Canal in the 1820s brought more commercial trade to the communities in the Kingston area. The Eddyville Dam takes its name from Eddyville, a small community situated on the Rondout Creek upstream from Kingston. The Eddyville Dam is potentially eligible for the National Register as a component of the historic D&H Canal. There is also potential for underlying remains of previous mill structures and other industrial activities along the Rondout to lie within the area surrounding the dam. The Route 213 Bridge over the Rondout Creek (BIN 1041200) is located just downstream from the dam and within the viewshed of the Eddyville Dam and has been determined eligible for the National Register.	The No Action Alternative would have no adverse effect on cultural resources.	The study area is believed to have a high potential for prehistoric archaeological sites due to the presence of pre-contact archaeological sites in the vicinity and proximity to the Rondout Creek and confluence with the Hudson River however the Area of Potential Effect (APE) for the removal of the Eddyville Dam is likely to have been heavily disturbed as a result of several phases of construction and manipulation of the creek over time. An architectural and historical survey of the Eddyville Dam is recommended to determine whether the dam is eligible for the NRHP either individually or as part of a larger historic district including the historic D&H Canal. A Programmatic Agreement has been prepared to address adverse effects to cultural resources.

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
Air Quality	The site is located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site.	The No Action Alternative would have no impact on air quality.	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period. In the long-term, implementing the TSP would have no impact on air quality.
Noise	Local noise is likely limited to the flow of water over the dam structure, and ambient sounds from the surrounding residential community.	The No Action Alternative would have no impact on noise levels.	In the short-term, minor adverse impacts on local noise levels from construction activities. In the long-term, implementing the TSP would have no impact on local noise levels.
Recreation	The Rondout Creek area has a number of recreation activities available such as bird watching, fishing, kayaking and boating as well as educational spots to visit like the Rondout National Historical District, the Rondout Lighthouse, and the Hudson River Maritime Museum (REConnect, 2018). There are also private recreational opportunities for residents such as the Rondout Bay Marina & Restaurant on the Rondout Creek in Eddyville.	The No Action Alternative would have no impact on recreational resources.	In the short-term, the No Action Alternative would have no impact on recreational resources. In the long-term, implementing the TSP would result in minor impacts to the site's potential recreational uses.
Aesthetics and Scenic Resources	According to the New York State Department of State: Division of Coastal Resources and Waterfront Revitalization, the mouth of Rondout Creek is within a designated Scenic Area of Statewide Significance (SASS) under the New York Coastal Management Program (NYSDOS, 1993). The Eddyville Dam itself is not located within a SASS.	The No Action Alternative would have no impact on aesthetics and scenic resources.	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur. In the long-term, implementing the TSP would result in minor beneficial impacts to the site's aesthetic and scenic resources through the restoration of historic riverine conditions.
Hazardous, Toxic, and Radioactive Waste	A review of the databases yields four Brownfield sites, five New York state Superfund sites, and one NYSDEC sampling report. One of the Brownfield sites has been remediated. Of the remaining three Brownfield sites, one has conducted a Phase II Environmental Site Assessment and has identified heavy metals, semi-volatile organic compounds (SVOCs) and petroleum related volatile organic compounds in the soils. The other two Brownfield sites contain heavy metals and SVOCs as	The No Action Alternative would have no impact on HTRW.	The TSP would have no impact on HTRW. If HTRW soils are identified during further investigations the non-federal sponsor will remove the contaminants prior to the removal of the dam.

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
	well. New York State Superfund Site Code: 356030 is listed for PCB and other contaminants. The site is approximately 4 miles downstream of Eddyville Dam. An interim remedial measure (IRM) was completed in May 2016. The IRM eliminated the potential for contact with, and migration of contaminated soil from the site, and has reduced groundwater contamination in monitored locations within and downgradient of the target area. New York State Superfund Site Code: 356028 was listed for PCBs but site assessment determined PCB levels are below the established hazardous waste threshold and, as such, do not meet the definition of hazardous waste. The State of New York completed a Site Characterization in September 2010 of Superfund Site Code: 356040. The site does not qualify for addition to the Registry of Inactive Hazardous Waste Disposal Sites Current Actions. Based on information gathered to date the site does not qualify for placement on the registry. New York State Superfund Site Code: 356052 is approximately 4 miles downstream of the site and is listed for tetrachloroethene (PCE). Groundwater and soil samples offsite did not detect PCE. New York Superfund Site Code: 356050 is approximately about 5 miles upstream of the Eddyville Dam. Volatile organic compounds are of concern for the site. Downgradient wells that were installed during the Remedial Investigation showed no impacts of the VOCs in the vicinity of the creek. Soil contamination is limited to the site. The NYSDEC (2003) conducted soil sampling in the Rondout Creek. One core and two surficial samples were collected behind the Eddyville Dam and upstream in the Rondout Creek. The metals data from the core sample at R1 indicate that the top five centimeters of sediments had no levels exceeding the Threshold Effect Concentration (TEC). No metals were at concentrations greater than the Probable Effect Concentration (PEC) at any of the sampling sites or depths. The sample from site R3 had lower		

RESOURCE	RONDOUT CREEK		
	EXISTING CONDITIONS	NO ACTION ALTERNATIVE (FWOP)	TSP
	concentrations of metals than site R2, which may be due to the lower organic carbon content of this site. R3 also had much higher solids than the core sample. Metals were detected at very low concentrations, mostly below the conservative TEC and none in excess of the PEC. PCBs (Aroclors) were not detected in any sample; however, detection limits for some samples exceeded the TEC but were well below the PEC. See Appendix G3 for more details.		
Transportation and Other Infrastructure	The transportation system in Ulster County is Ulster County Area Transit or UCAT. UCAT offers reliable transportation services throughout the County (Ulster County, 2018). An attraction is the Catskill Mountain Railroad which is a heritage railroad location in Kingston, New York (Catskill Mountain Railroad, 2018).	The No Action Alternative would have no impact on transportation or infrastructure.	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project. In the long-term, implementing the TSP would have no impact on transportation or infrastructure.

Table 5-5: Existing Conditions and Environmental Impacts to Moodna Creek AOP Sites.

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	**CREEK NO ACTION ALTERNATIVE (FWOP)**	**TSP**
Geology and Physiography	Moodna Creek is located at the transition between the Hudson-Mohawk Lowlands and Hudson Highlands physiographic provinces. The lowlands area situated to the north of Moodna Creek is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods (NYSDOT, 2013). This area is mapped as the Normanskill Formation, which is characterized as dark green to black argillaceous shale containing calcareous and chert beds (NYS Museum, 1995). Additionally, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. Moodna Creek itself is mapped as alluvium, with surrounding areas mapped primarily as till and includes areas of outwash sand and gravel, lacustrine deltas, and kame deposits (NYS Museum, 1991).	The No Action Alternatives or TSP would have no impact on geology or physiography.	
Topography	The main stem of Moodna Creek is generally characterized by moderate gradient, cobble-boulder riffles and rapids, extended pools, and narrow floodplains confined by steep, erodible valley walls. AOP1 is at an elevation of approximately 50 feet (NAVD88), with AOP2 and AOP3 at an elevation of 117 and 163 feet, respectively (NYSDEC, 2011 - 2012).	Under the No Action Alternative, the site could to be susceptible to topographic change by erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change	Implementing the TSP would result in minor impacts to the topography of each site.
Soils	Soils data and soils descriptions for the Moodna Creek site were acquired from the National Resources Conservation Service (NRCS) Web Soil Survey for Orange County, NY. The three barriers at the Moodna Creek site are associated with six different soil types: Mardin gravelly silt loam, Middlebury silt loam, Otisville, Hoosic gravelly sandy loam, Swartswood, and the Udifluvents-Fluvaquents complex (frequently flooded) (NRCS, Web Soil Survey).	Under the No Action Alternative, the soils may be subject to minor adverse impacts from soil erosion due to the projected increase in storm frequency and intensity with climate	In the short-term, the TSP would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase. In the long-term, The TSP would have no impact on soils at the sites.

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
		change (NYSDEC, 2018b).	
Climate and Weather	A National Weather Service (NWS) station is located approximately 6.5 miles southwest of the site, in West Point, New York. Records for this station are available between 1890 and 2018 via the Agricultural Applied Climate Information System (AgACIS). Records at this station indicate that between 1890 and 2018, average monthly temperatures ranged for 27.8°F in January to 74.5°F in July (AgACIS, 2018c). Average annual precipitation was 47.07 inches, with monthly averages ranges from 3.09 inches in February to 4.35 inches in July. Average annual snowfall was 38.3 inches, primarily occurring between December and March.	The No Action Alternatives or TSP would have no impact on the climate or weather at the site.	
Climate Resiliency		Under the No Action Alternative, increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018a).	Implementing the TSP may result in a beneficial impact to climate resiliency by reducing flood elevations upstream of the dams.
Floodplains	All three sites lie primarily within one percent floodplain (AE Zone) and partially in the 0.2 percent floodplain (X Zone) as shown on Flood Insurance Rate Maps (FIRM), effective as of August 3, 2009 (FIRM Panel No.: 36071C0333E and 36071C0341E) (FEMA, 2009a)(FEMA, 2009b).	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain.	Implementing the TSP would result in a beneficial impact to floodplains upstream of AOP2 and AOP3 by increasing flood storage. Implementing the TSP would have no impact on floodplain in the vicinity of AOP1.
Surface Waters	Located within the Hudson-Wappinger Watershed (HUC-8 02020008), Moodna Creek is the primary surface water body at the three sites. AOP1 is located approximately 1.7 miles above the confluence with the Hudson River, and AOP2 and AOP3 are located 2.9 and 3.5 miles upstream of the confluence respectively. Several smaller tributaries join Moodna Creek throughout this reach.	The No Action Alternative would have no impact on surface waters at the sites.	Implementing the TSP would result in moderate beneficial impacts to the site's surface waters.

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
Water Quality	Moodna Creek is classified as a Class C water body, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B).	The No Action Alternative would result in minor adverse impacts to water quality.	In the short-term, implementing the TSP would result in negligible adverse impacts on water quality due to increases in turbidity during the construction phase. In the long-term, implementing the TSP would result in moderate beneficial impacts to water quality in the vicinity of AOP2 and AOP3. Implementing the TSP would have no impact on water quality in the vicinity of AOP1.
Regional Hydrogeology and Groundwater	This area of Moodna Creek is not associated with any major aquifer. Upper Moodna Creek and its tributary Woodbury Creek have extensive confined and unconfined aquifers.	The No Action Alternative would have no impact on hydrogeology nor groundwater.	Implementing the TSP may result in minor impacts on local shallow groundwater flows in the vicinity of AOP2 and AOP3. Implementing the TSP would have no impact on groundwater flows in the vicinity of AOP1.
Tidal Influences	The Moodna Creek is tidal only at the mouth of the creek. There are no tidal influences at the AOP sites.	The No Action Alternative would have no impact on tidal influences.	The TSP would have no impact on tidal influences.
Land Use and Zoning	Land uses in the vicinity of the sites primarily contain a mix of forested land and low to moderate density residential properties. Additionally, there is a vacant, former industrial site adjacent to AOP2. AOP1 is located within the Town of New Windsor's Suburban Residential (R-3) zoning district. AOP2 is split between two zones within the Town of Cornwall, the planned commercial district (PCD) on river right, and suburban residence (SR-1) zoning district on river left. AOP3 lies entirely within the Town of Cornwall suburban residence (SR-1) zoning district.	The No Action Alternative or TSP would have no impact on the land use or zoning at the site.	
Economics	Although much of what was once farmland has since regrown into forest or been developed into urban or suburban uses, agriculture remains a vital component of the economic, scenic, and ecological fabric of the watershed. Today, farmland is largely clustered in the	The No Action Alternative or TSP would have no impact on local economic conditions.	

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
	central, western, and northern reaches of the watershed where the topography is more inviting for grazing of livestock or cultivation of crops.		
Socio-Economics	All three sites are located within the town boundaries of Cornwall and one site is also partially located in the Town of New Windsor, New York in Orange County. According to the US Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Cornwall, NY is an estimated 12,646 people, and is predominantly white. The median age in the Town of Cornwall, NY is approximately 42.8 years of age and median household income is $89,520. Approximately 94.3% of the population are high school graduates or higher while 47.6% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Cornwall is 805. The civilian employed population 16 and over is an estimated 6,250 people. The population in the Town of New Windsor, NY is an estimated 26,799 people and is predominantly white. The median age in the Town of New Windsor, NY is approximately 38.6 years of age and median household income is $77,210 Approximately 94.2% of the population are high school graduates or higher while 30.9% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of New Windsor is 1,962. The civilian employed population 16 and over is an estimated 13,586 people.	The No Action Alternative or TSP would have no impact on local socio-economic conditions.	
Environmental Justice	The site is not located within an Environmental Justice area (NYSDEC, 2018b).	The No Action Alternatives or TSP would have no impact on environmental justice populations.	
Coastal Zone Management	Moodna Creek downstream of AOP3 is located within a designated Coastal Area, subject to regulation under the federal Coastal Zone Management Act, and managed under the New York Coastal Management Program.	The No Action Alternative would have no impact on any areas regulated under the New York Coastal	In particular, implementing the TSP would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat by

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
		Zone Management Program.	removing barriers to the upstream migration of aquatic organisms.
Wetlands	The USFWS National Wetland Inventory (NWI) map does not indicate the presence of wetlands at the Moodna Creek sites. The area around AOP3 is mapped as a freshwater pond. AOP1 and AOP2 are mapped as riverine environments.	The No Action Alternative would have no impact on wetlands.	Implementing the TSP would result in a negligible beneficial impact on wetlands at AOP2 and AOP3. Implementing the TSP would have no impact on wetlands at AOP1.
Vegetation	The area around the Moodna Creek sites is mapped as a mixture of upland deciduous forest and upland evergreen forest (NYS GIS, 2018).	The No Action Alternative would have no impact on vegetation.	In the short-term, construction activities associated with implementing the TSP may result in negligible adverse impacts to vegetation. In the long-term, implementing the TSP would result in a negligible beneficial impact on vegetation at AOP2 and AOP3. Implementing the TSP would have no impact on vegetation at AOP1.
Shellfish	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available.	The No Action Alternative would have no impact on the shellfish.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to shellfish, if present. In the long-term, the restoration of aquatic organism passage to Moodna Creek upstream of the barriers would result in moderate beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.
Finfish	According to the Coastal Fish and Wildlife Rating Form (NYSDOS, 2012) associated with this designated habitat, Moodna Creek tidal portion is an important spawning area for alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), bay anchovy (*Anchoa mitchilli*), American eel (*Anguilla rostrata*), and striped bass (*Morone saxatilis*) between April and June, and for tomcod (*Microgadus tomcod*) between December and January. American Shad (*Alosa sapidissima*) spawn in	The No Action Alternative would have no impact on the finfish.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to finfish, if present. In the long-term, the restoration of aquatic organism passage to Moodna Creek upstream of the barriers would

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
	areas at the mouth of Moodna Creek. The barriers contained within the AOP sites likely impede or prevent the upstream migration of fish. A substantial warmwater fish community occurs in the lower portion of Moodna Creek throughout the year including bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), white catfish (*Ameiurus catus*), yellow perch (*Perca flavescens*), and white perch (*Morone americana*). As the salt front moves up the Hudson during dry periods, bluefish (*Pomatomus saltatrix*), anchovy (*Anchoa mitchilli*), weakfish (*Cynoscion regalis*), silversides (*Menidia menidia*), hogchoker (*Trinectes maculatus*), and blue crab (*Callinectes sapidus*) may enter the area to feed.		result in major beneficial impacts to finfish.
Benthic Resources	No information regarding the presence, absence, or composition of benthic resources in Moodna Creek is readily available.	The No Action Alternative or TSP would have no impact on the benthic resources.	
Reptiles and Amphibians	The banks of Moodna Creek provide habitat for common snapping turtle (*Chelydra serpentina*), water snake (*Nerodia s. sipedon*), red-spotted newt (*Notophthalmus v. viridescens*), redback salamander (*Plethodon cinereus*), American toad (*Bufo americanas*), gray treefrog (*Hyla versicolor*), spring peeper (*Pseudoacris crucifer*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*) and wood frog (*Rana sylvatica*).	The No Action Alternative would have no impact on reptiles, amphibians, or their respective habitats.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, removing the impoundment may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine reptile and amphibian species and negligible adverse impacts to reptile and amphibian species which inhabit slow moving water bodies. Implementing the TSP would have no

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
			impact on reptile or amphibian species in the vicinity of AOP1.
Birds	Moodna Creek provides valuable habitats for many species of shorebirds, wading birds, waterfowl, and songbirds, and is reported to be a major crossing point for raptors migrating through the Hudson Valley. According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018)	The No Action Alternative would have no impact on birds or their habitat.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to birds, if present. In the long-term, may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine bird species and negligible adverse impacts to bird species which inhabit slow moving water bodies. Implementing the TSP would have no impact on bird species in the vicinity of AOP1.
Mammals	No information regarding the presence, absence, or composition of mammals on the site is readily available. It is likely that the floodplains, wetlands, and forested land in vicinity of the site provide habitat for numerous mammalian species.	The No Action Alternative would have no impact on mammals or their habitat.	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the TSP would result in negligible adverse impacts to mammals, if present. In the long-term, removing the impoundment may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine mammalian species and negligible adverse impacts to mammalian species which inhabit slow moving water bodies. Implementing the TSP would have no impact on mammalian species in the vicinity of AOP1.

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
Federal Species of Concern	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*) and the endangered Indiana bat (*Myotis sodalis*), endangered dwarf wedgemussel (*Alasmidonta heterodon*), and threatened small whorled pogonia (*Isotria medeoloides*) as potentially occurring at the site. There are no reports of the northern long-eared bat, Indiana bat, dwarf wedgemussel or small whorled poginia at the site. Coordination with GARFO identified the shortnose sturgeon and Atlantic sturgeon as potentially occur at the site.	The No Action Alternative would have no impact on federal species of concern.	Implementation of the TSP would have positive benefits to both sturgeon species as it will provide more habitat upstream with the removal of the dams. The TSP would have no impact on the bats, wedgemussel, and the poginia.
State Species of Concern	The NYSDEC identified the endangered Indiana Bat (*Myotis sodalis*) as potentially occurring at these sites.	The No Action Alternative would have no impact on state species of concern.	The TSP will not impact the Indiana Bat and a positive impact to sturgeon with the increase of available habitat.
Designated Critical Habitat	The USFWS has not designated any critical habitat at this site. The GARFO has identified the site as critical habitat for the Atlantic Sturgeon.	The No Action Alternative would have no impact on Designated Critical Habitat of concern.	Implementation of the TSP would have positive impacts to Atlantic Sturgeon critical habitat as it will provide more habitat with the removal of the dams.
Essential Fish Habitat	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the site is potential essential fish habitat for various life stages of winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). There are no reports of the above EFH species at the site.	The No Action Alternative would have no impact on EFH habitat of concern.	The restoration of aquatic organism passage to Moodna Creek upstream of the barriers would result in major beneficial impacts to EFH by increasing available habitat.
Cultural Resources	There are no archaeological sites or historic properties recorded within the AOP 1 site, however, the boundaries of the Knox's Headquarters/John Ellison House grounds (90NR02311) lie adjacent to the site. There are no archaeological sites or historic properties documented within the AOP2 site, however the Firthcliff Dam is a historic structure that was associated with the Firth Carpet	The No Action Alternative would not have an adverse effect on cultural resources.	There are no previously documented historic properties within the Area of Potential Effect (APE) for AOP 1. AOPs 2 and 3 are historic dams that are considered potentially eligible for the National Register of Historic Places. There is potential for

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
	Company complex (07149.000103) which has been demolished in recent years. The structure has not yet been evaluated for its National Register eligibility but it is considered potentially eligible. The historical record indicates that the Firth cliff Dam may have been preceded by earlier dam structures associated with predecessor mills and therefore there is potential for archaeological remains of the dams and factory structures to lie below the surface. AOP 3 is known as Orr's Mills Dam and the structure is potentially eligible as an element of a historic district that lies at the intersection of Orr's Mills Road and NYS Route 32 and includes several historic structures. Archaeological remains of the mill features such as the raceway and retaining walls are likely to be located within the immediate vicinity of the dam.		prehistoric and historic archaeological remains to exist within the Area of Potential Effect (APE) at all three AOPs on Moodna Creek. As plans are developed and the APE is better defined a cultural resources survey is recommended to evaluate the National Register eligibility of the Firth cliff Dam and the Orr's Mills Dam and to determine the presence or absence of additional cultural resources within the project area. A Programmatic Agreement has been prepared to address potential adverse effects to cultural resources.
Air Quality	All three sites are located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2).	The No Action Alternative would have no impact on air quality.	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period. In the long-term, implementing the TSP would have no impact on air quality.
Noise	Local noise is likely limited to the flow of water over the dam structure and ambient sounds from the surrounding residential community. AOP3 is also likely subject to traffic noise from the Route 32 crossing.	The No Action Alternative would have no impact on noise levels.	In the short-term, minor adverse impacts on local noise levels from construction activities. In the long-term, implementing the TSP would have no impact on local noise levels.
Recreation	Moodna Creek and its watershed offer a plethora of recreation opportunities for visitors. There are miles of hiking trails, as well as paved trails for walking and biking. In the vicinity, municipal parks are equipped with ballparks and other related amenities. There are 6 known public access points to lakes or streams within the watershed, all of which are located within the town boundaries of Cornwall and New Windsor (OCWA, 2010 a-b).	The No Action Alternative would have no impact on recreational resources.	In the short-term, the No Action Alternative would have no impact on recreational resources. In the long-term, implementing the TSP would result in minor impacts to the site's potential recreational uses.

RESOURCE	MOODNA CREEK		
	EXISTING CONDITIONS	CREEK NO ACTION ALTERNATIVE (FWOP)	TSP
Aesthetics and Scenic Resources	The site is not designated as a Scenic Areas of Statewide Significance (SASS) under the New York Coastal Management Program. The aesthetic and scenic resources provided by the Moodna Creek are locally recognized by stewardship groups.	The No Action Alternative would have no impact on aesthetics and scenic resources.	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase. In the long-term, implementing the TSP would result in minor beneficial impacts to the site's aesthetic and scenic resources.
Hazardous, Toxic, and Radioactive Waste	A review of the databases yields two state Superfund sites. The New York State Superfund Site Number: 336028 is just below AOP 2 for metals, chlorocarbons, and hydrocarbons. Remediation at the site is complete and have removed contamination from the site. The site was delisted in September 2016. The New York State Superfund Site Number: 336008 is located upstream of AOP 3 about 3 miles near Woodbury Creek which flows into Moodna Creek. The site was the subject of numerous environmental investigations and remedial activities, between 1985 and 1997, including a Phase I Investigation of a former landfill and RCRA Facility Assessments and Investigations of several other on-site and off-site release areas. The site was never remediated. Contaminants of concern are lead, chlorinated VOCs, and petroleum hydrocarbons. According to the State the concern is with groundwater and well water contamination. See Appendix G4 for more details.	The No Action Alternative would have no impact on HTRW.	The TSP would have no impact on HTRW. If HTRW soils are identified during further investigations the non-federal sponsor will remove the contaminants prior to the removal of the dam.
Transportation and Other Infrastructure	An important node in the Moodna Watershed is Vails Gate, which consists of the five-point intersection of NYS Routes 32, 300 and 94, and the surrounding area. Along with being a dense commercial and residential area, there are many historic and recreational attractions within a very short distance of the intersection, including trail access to the Moodna itself at Knox's Headquarters State Historic Site.	The No Action Alternative would have no impact on transportation or infrastructure.	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project. In the long-term, implementing the TSP would have no impact on transportation or infrastructure.

Chapter 6: Cumulative Impacts

The Council on Environmental Quality's regulations for implementing NEPA define a cumulative effect "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR §1508.7)."

Consistent with CEQ guidance, this Cumulative Impact analysis focuses on potential cumulative impacts of past and present actions associated with the resources analyzed in Chapters 2 and 5, plus those actions that are in the planning phase—limited to future actions that are reasonably foreseeable (CEQ, 1997). Only actions that have the potential to interact with or be impacted by the Tentatively Selected Plan (TSP) are addressed in this cumulative impact analysis. The analysis evaluates only actions with potential impacts on the environment that are fundamentally similar to the anticipated impacts of the TSP, in terms of the nature of the impacts, the geographical area affected, and the timing of the impacts. In addition, this analysis will also examine instances where two or more individual impacts of the TSP, which, when considered together, are considerable or which compound or increase other environmental impacts.

This analysis covers actions in the study area from the recent past through the 50-year planning period of analysis described in Section 2.2. Assuming the proposed project is expected to begin construction in 2025, the planning period of analysis is 2025 to 2075.

6.1 Recent Past, Present, and Foreseeable Future Actions

A number of actions occurring historically and up to the present time, or reasonably expected to occur in the future, have the potential to influence the resources affected by implementation of the TSP, as identified in Chapter 5. Multiple restoration and conservation programs and development projects were identified. A brief description of these relevant past, present, and reasonably foreseeable future actions follows, with an emphasis on components of the activity that are relevant to the impacts previously identified. When determining whether a particular activity may contribute cumulatively and significantly to the impacts identified in Chapter 5, the following attributes are considered: geographical distribution, intensity, duration, and the historical impacts of similar activities.

6.1.1 Hudson River Estuary Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

The Hudson River Estuary Program (HREP) was established in 1987 through the Hudson River Estuary Management Act and focuses on the tidal Hudson River and adjacent watershed from the federal dam at Troy to the Verrazano Narrows in New York City. The program has developed a Hudson River Estuary Habitat Restoration Plan and the NYSDEC Action Agenda that supports conservation and restoration through grant funding, research, education, training, community planning assistance, land acquisition and restoration projects. These activities are likely to improve water quality and habitat in the future, and encourage future environmental restoration projects similar to those proposed under the TSP.

6.1.2 State Pollutant Discharge Elimination System Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

Article 17 (Water Pollution Control) of the Environmental Conservation Law (ECL) authorized creation of the State Pollutant Discharge Elimination System (SPDES) program to maintain New York's waters with reasonable standards of purity. New York's SPDES program has been approved by the EPA for the control of surface wastewater and stormwater discharges in accordance with the Clean Water Act. The SPDES program regulates water discharges from numerous sources including direct discharges from industrial facilities, combined sewer overflows (CSOs), power plants, and ship ballasts, as well as indirect stormwater discharges from certain industrial activities, in urbanized areas, and from construction sites. Improvements to water quality have occurred and are expected to continue under the SPDES program. Due to the extensive size of the Hudson River's drainage area at the study area, as well as the concentration of industrial sites, shipping ports, urban areas, and CSOs along the Hudson River, the long-term impacts to water quality will be very positive.

6.1.3 Governor's Office of Storm Recovery

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Governor's Office of Storm Recovery

In 2013, New York State established the Governor's Office of Storm Recovery (GOSR) following the occurrence of Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy to centralize recovery and rebuilding efforts in impacted areas of New York State. GOSR is allocating federal funds to support the planning and implementation of community-developed recovery and resiliency projects via the New York Rising Community Reconstruction (NYRCR) Program. The NYRCR Program is currently implementing over 3,000 projects throughout the state, including critical facility/infrastructure hardening, drainage improvements and green infrastructure, economic development, emergency preparedness and recovery operations, housing resiliency, shoreline protection, and transportation infrastructure.

Planned projects under the NYRCR program are located throughout the state, including sites along the Hudson River, Rondout Creek, Moodna Creek, and their respective tributaries. While the program will primarily result in short-term construction impacts from rebuilding on existing developed property, some long-term negative impacts could result from reconstruction or infrastructure projects that have a larger impervious footprint or that alter existing hydrology and habitat. Numerous projects proposed under the NYRCR Program could also result in long-term positive impacts; improvements to waste water treatment infrastructure throughout the state could improve water quality and reduce the risk of accidental water contamination during storm events. Shoreline protection projects, such as the proposed stream bank restoration sites along Rondout Creek and the Hudson River, could reduce erosion and introduce living shorelines, improving water quality and providing intertidal and/or aquatic habitat.

6.1.4 Climate Smart Communities Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

Climate Smart Communities (CSC) is a New York State program that assists local governments (i.e. counties and towns/cities) take action to reduce greenhouse gas emissions and adapt to a changing climate by providing a legal framework to guide their climate action efforts, free technical assistance, grant access, and recognition of achievements via a certification program. Numerous project sites lie within or in vicinity of CSC designated areas. Under the program, these communities have implemented climate programs and policies, including commitments to reduce vulnerability to natural hazards, conserve natural habitats, and support green infrastructure. This may encourage future environmental restoration projects similar to those proposed under the TSP.

6.1.5 Coastal Zone Management Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of State (NYS DOS)

In 1981, the New York State Legislature enacted Article 42 of the Executive Law, the Waterfront Revitalization of Coastal Areas and Inland Waterways Act. In 1982, the New York State Coastal Management Program (NYSCMP) was created, with federal authorization and oversight, to establish the boundaries of the Coastal Area within which the NYSCMP and its policies apply to describe the organizational structure required to implement the NYSCMP, and to provide a set of statewide policies enforceable on all state and federal agencies that manage resources and coordinate actions within the State's federally approved Coastal Area Boundary coastline. Each of the TSP project sites are within the New York State Coastal Area.

6.1.6 Scenic Hudson Conservation and Advocacy

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: Scenic Hudson, Inc.

Scenic Hudson is the largest environmental nonprofit group focused on the Hudson River Valley. Scenic Hudson supports direct conservation via land acquisition, conservation easements, and farming preservation, as well as advocating for environmentally beneficial public policy and opposing environmentally harmful projects. These activities are likely to have a beneficial impact on water quality and habitat in the future.

6.1.7 Hudson River Comprehensive Restoration Plan

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: Partners Restoring the Hudson

In August 2018, a collective group of more than 30 nonprofit organizations, public agencies, and academic institution organizations called “Partners Restoring the Hudson,” released the “Hudson River Comprehensive Restoration Plan: Recommendations for the New York-New Jersey Harbor & Estuary Program Action Agenda and the New York State Hudson River Estuary Action Agenda.” The plan details the current conditions of the Hudson River Estuary, identifies potential restoration sites and recognizes the needs that must be addressed in the coming decades to restore the river and prepare for future conditions, including rising sea levels and increasingly frequent and severe storms (Partners Restoring the Hudson, 2019a).

Four sites (Binnen Kill Watershed, Rondout Creek, Henry Hudson Town Park, and Schodack Island) are included in the Hudson River Comprehensive Restoration Plan, which catalogs ‘restoration progress to date in the Hudson, and sets long-term goals for its future’ (Partners Restoring the Hudson, 2018). The four TSP sites are included as “Candidate Project Opportunities” in the Hudson River Comprehensive Restoration Plan, and are displayed on The Hudson We Share’s “Hudson River Mapper,” an interactive web application that identifies Candidate Project Opportunities, which were established through a participatory community planning process. The four TSP sites currently have physical habitat characterization impacts or ecological assessment threats, which may include items such as a hardened shoreline, aquatic organism barriers, high nutrient pollutant discharge, and/or areas of fill. Implementing the TSPs on the four aforementioned sites would support the goals outlined in the Hudson River Comprehensive Restoration Plan.

While not within the site boundary of the Moodna Creek TSP, the report identifies “Moodna Creek Marsh Protection & Enhancement” as a Candidate Project Opportunity. This area lies at the confluence of Moodna Creek, and therefore implementing the TSP upstream will have a beneficial cumulative impact on the Candidate Project Opportunity identified in the report.

6.1.8 Federal Navigation Project Maintenance Dredging

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: United States Army Corps of Engineers

The Hudson River federal navigation project was authorized by the Rivers and Harbors Acts of 1910 to 1930, and it was modified in 1934, 1935, 1938, and 1954. The United States Army Corps of Engineers perform regular maintenance dredging approximately every three to four years on the Hudson River between New York City and Waterford, New York. The existing navigation project authorizes a channel with a depths ranging from 34 (in rock) to 14 ft feet deep at Federal Lock at Troy. Currently, dredged material from the Operation and Maintenance project is placed at a federally owned upland dredged material placement site on Houghtaling Island, New Baltimore, New York. Channel maintenance activities and the historic subsequent placement of dredged materials as fill has significantly altered the Hudson River and its shoreline in the past, present, and foreseeable future.

6.1.9 Trees for Tribs Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

The Trees for Tribs Program was established in 2007 in an effort to reforest New York's tributaries. The goal of the program is to plant young trees and shrubs along stream corridors in order to prevent erosion, increase flood water retention, improve wildlife and stream habitat, as well as protect water quality. Trees for Tribs has engaged more than 8,751 volunteers in planting more than 101,416 trees and shrubs at 614 sites across New York State. The program also awards grant funding for organizations or municipalities interested in conducting large-scale streamside planting projects in New York State. These activities are likely to have a beneficial impact on water quality and riparian habitats in the future.

6.1.10 Green Innovation Grant Program

Timeframe: Recent past, present, and foreseeable future

Implementing Entity: New York State Environmental Facilities Corporation

The Green Innovation Grant Program (GIGP) supports projects across New York State that utilize stormwater infrastructure design. Eligible projects include floodplain, stream, and wetland restoration, stream daylighting, permeable pavement, bioretention, green roofs, stormwater harvesting and reuse, urban forestry, and downspout disconnection. These activities are likely to have a beneficial impact on water quality and riparian habitats in the future.

6.1.11 Tappan Zee Bridge Environmental Mitigation

Timeframe: Present, and foreseeable future
Implementing Entity: New York State Thruway Authority

As part of the replacement of the Tappan Zee Bridge with the Governor Mario M. Cuomo Bridge, restoration projects will occur to mitigate environmental damages. Restorations projects will include oyster restoration in the Hudson River in proximity to the bridge, wetland restoration and management, and Green Infrastructure and stormwater treatment construction projects.

6.1.12 Smaller Restoration Projects

Timeframe: Recent past, present, and foreseeable future

Many other, smaller restoration projects have been, are, or will be conducted within the study area. Such projects include dam removals, shoreline restoration projects, stormwater management and green infrastructure projects, wetland and flood restoration projects, and other similar projects which seek to restore or enhance natural resources. These projects, although too numerous to enumerate and too early in their planning to ensure their ultimate implementation, could also lead to cumulative impacts.

6.2 Summary of Cumulative Effects Relative to the Tentatively Selected Plan

Environmental impacts associated with the TSP were analyzed in Chapter 5. The proposed alternative at each restoration site will increase the amount of high-quality habitat through restoration measures. All of the alternatives, except the no action alternative, are presumed to improve the habitat and ecological integrity with varying degrees of effectiveness. The alternatives will also mitigate past human actions that harmed habitat and ecological integrity, including the removal of past fill and barriers to aquatic organism passage.

Construction activities associated with the TSP could cause temporary adverse impacts. These impacts listed below were determined individually to be negligible to moderate, or to have no impact. Implementation of the TSP may have cumulative impacts when combined with other similar actions occurring in the region of influence, on the resources discussed below.

The overall cumulative effects of the TSP would be synergistic benefits to all wetland and aquatic species through habitat restoration in the lower Hudson River. The benefits of increasing the number and size of side channels, reconnecting aquatic habitats in the adjacent floodplain, and greatly increasing the acreage of riparian zones and wetlands along the river and its tributaries will provide significant benefits to fish and wildlife species that utilize the habitat, especially for anadromous and catadromous species.

6.2.1 Cumulative Impacts on Wetlands

Short-term, negative impacts to wetlands may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementation, but may become cumulative if larger construction projects that are unrelated to the TSP occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs, such as soil erosion control measures, to protect water quality.

Long-lasting, beneficial cumulative impacts to wetlands may occur as a result of implementing the TSP alongside other ongoing and future wetland restoration projects, wetland conservation via land acquisition, and water pollution control measures. Implementing the TSP would also mitigate past cumulative negative impacts to wetlands by restoring wetlands that were historically filled.

6.2.2 Cumulative Impacts on Water Quality

Short-term, negative impacts to water quality may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementation, but may become cumulative if larger construction projects that are unrelated to the TSP occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs such as soil erosion control measures to protect water quality.

Long-term positive impacts to water quality, as a result of implementing the TSP, would primarily be driven by proposed wetland restoration. Long-lasting, beneficial cumulative impacts to water quality may occur as a result of implementing the TSP alongside other ongoing and future wetland restoration projects, shoreline stabilization projects, land conservation, and water pollution control measures. Implementing the TSP would also mitigate past cumulative negative impacts to water quality by restoring wetlands that were historically filled.

6.2.3 Cumulative Impacts on Biological Resources

Short-term, negative impacts to species diversity and abundance may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementing the TSP alone, but may become cumulative if larger construction projects that are unrelated to the TSP occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs such as soil erosion control measures, to protect water quality, and fencing/tree protection to minimize unnecessary disturbances to vegetation. Ongoing consultation with United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and NYSDEC, will take place over the duration of the project to prevent adverse impacts to federal- or state-listed threatened and endangered species from implementation of the TSP.

Long-term positive impacts to biological resources as a result of implementing the TSP would primarily be driven by proposed wetland restoration, side channel restoration, and aquatic organism passage restoration. Long-lasting, beneficial cumulative impacts to biological resources may occur as a result of implementing the TSP alongside other ongoing and future habitat conservation and restoration projects, hydrological connection restoration, and water pollution control measures. Implementing the TSP would also mitigate past cumulative negative impacts to biological resources by restoring historically disturbed habitats and removing man-made barriers to aquatic organism passage.

6.2.4 Cumulative Impacts on Climate Resilience

Long-term positive impacts to climate resiliency, as a result of implementing the TSP, would primarily be driven by proposed increases in flood storage and stabilization of shorelines. Long-lasting, beneficial cumulative impacts to climate resiliency may occur as a result of implementing the TSP alongside other ongoing and future side channel restoration, shoreline stabilization, and climate-related planning and policies by local, state, and federal entities.

6.2.5 Cumulative Impacts on Coastal Resources

Long-term positive impacts to coastal resources as a result of implementing the TSP would primarily be driven by proposed habitat restoration, aquatic organism passage restoration, and stabilization of shorelines. Proposed actions at each of the TSP sites are consistent with one or more of the objectives of the Coastal Management Program. In particular, implementing the TSP would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat, and Coastal Policy 44, through the restoration and creation of wetland habitat.

Long-lasting, beneficial cumulative impacts to coastal resources may occur as a result of implementing the TSP alongside other ongoing and future habitat restoration, aquatic organism passage restoration, and shoreline stabilization.

6.2.6 Irreversible or Irretrievable Commitments of Resources Involved in the Implementation of the Tentatively Selected Plan

The environmental analysis includes identification of any irreversible and irretrievable commitments of resources, which would be involved in the implementation of the TSP." This clause in NEPA refers to the use of nonrenewable resources and the effects that the use of these resources may have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable period. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored because of the action (e.g., extinction of a species or the disturbance of a cultural site). As an ecosystem restoration project, the proposed Federal action is designed to have little or no irreversible and irretrievable commitment of resources. The TSP would result in:

- a minor irreversible loss of upland areas associated with wetland creation activities
- a negligible irretrievable loss of agricultural resources and products would occur at the Binnen Kill site, as a result of converting an upland farm area to a wetland, an irreversible use of fossil fuels to execute the construction of the habitat restoration.

All construction effects are assumed to be short-term reductions in aquatic and plant resources, which would recover their abundances in a relatively short period.

Chapter 7: Environmental Compliance

The status of the TSP's compliance with applicable Federal environmental requirements is summarized below. Prior to initiation of construction, the work would be in compliance with all applicable Federal laws and Executive Orders.

7.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) (40 C.F.R. §1502.16) commits federal agencies to considering, documenting, and publicly disclosing the environmental impacts of their actions. This integrated Feasibility Report and Environmental Assessment is intended to achieve NEPA compliance for the Tentatively Selected Plan. The Draft Integrated FR/EA will be published for a 30-day public comment period. A Final Integrated FR/EA will take into account all comments received, as well as additional feasibility-level analyses.

7.1.1 Public Involvement

There has been significant support and involvement from federal, state, local, and non-governmental organizations (NGOs) to advance the restoration of the Hudson River Estuary. Since the original initiation of the HRHR Feasibility Study in 1997, USACE has participated in the Hudson River Estuary Program (HREP) with partners to coordinate in the development and advancement of the NYS Hudson River Estuary Action Agenda and the NYSDEC Habitat Restoration Plan. There have been frequent meetings hosted by NYSDEC's HREP that enhance our coordination and public involvement with the HRHR Feasibility Study.

In 2013, USACE worked more closely with NYSDEC, local stakeholders and the 'Partners Restoring the Hudson' (composed of approximately 30 organizations) to successfully resume the HRHR Feasibility Study. USACE coordinated with the partners and NYSDEC during the development of the Hudson River Comprehensive Restoration Plan (HR CRP) (Partners Restoring the Hudson, 2018) to supplement the NYS Hudson River Estuary Action Agenda. The HR CRP provided valuable information to the feasibility study on existing current conditions, regional goals and targets and potential restoration opportunities.

The Feasibility Study has benefited from the dozens of technical and public outreach meetings held to develop the regional targets and goals and identify restoration opportunities throughout the study area. Specifically, USACE and NYSDEC have met with stakeholders, Scenic Hudson, Schodack Island State Park officials, local landowners from the Binnen Kill area (September 2018), and the Town of Bethlehem at Henry Hudson Park (October 2018). NYSDEC has also met with landowners of the AOP barriers, in March and April 2019. Landowners have been notified that their participation is voluntary. Projects will be eliminated from the recommendation and will not be considered further if the landowner does not consent.

7.1.2 Compliance with Executive Order 11988

Executive Order 11988 requires that Agencies avoid, to the extent possible, adverse impacts associated with the occupancy and modification of flood plains and to avoid support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of E.O. 11988, as referenced in ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below in Table 7-1.

Table 7-1: Project Response to E.O. 11988.

EXECUTIVE ORDER 11988 STEP	PROJECT-SPECIFIC RESPONSE
Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).	The proposed action is within the base floodplain.
If the action is in the base floodplain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.	As the primary objective of the project is aquatic ecosystem restoration, no practicable alternatives are completely outside of the base floodplain for the sites that would achieve this objective.
If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.	The Integrated Feasibility Report and Environmental Assessment has been released to public review, and coordination with agency officials and the public have been held throughout the study.
Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base floodplain will affect the base flood plain, impacts resulting from these actions should also be identified.	Potential impacts and benefits were evaluated in Chapter 5. The anticipated impacts associated with the TSP are summarized. While construction of project features would result in mostly minor and temporary adverse impacts to the natural environment, the proposed restoration would result in a substantial and long-term

EXECUTIVE ORDER 11988 STEP	PROJECT-SPECIFIC RESPONSE
	increase in habitat values including an increase in the quantity and quality of riparian and aquatic habitat. For each resource analyzed in Chapter 5, wherever there is a potential for adverse impacts, appropriate best management practices or other environmental considerations were identified.
If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.	The project will not encourage development in the floodplain.
As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.	The project would not induce development in the flood plain. Chapter 4 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.
If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.	The Final Integrated HSGRR/EA documents the final determination.
Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.	The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

7.1.3 Compliance with Federal Law and Regulations

Compliance of the TSP with applicable federal statutes and executive orders is outlined in Table 7-2.

Table 7-2: Summary of Primary Federal Laws and Regulations Applicable to the TSP.

Legislative Title	U.S. Code/Other	Compliance
Bald and Golden Eagle Act of 1940	16 U.S.C. §668-668c	Construction activities with the proposed actions have potential to disturb bald and golden eagles due to the presence of heavy machinery and elevated noise levels. Review USFWS database showed there are no recorded eagle nesting sites within two miles of the project area.
Clean Air Act	42 U.S.C. §§ 7401 7671g	Compliant, project in attainment area. Construction activities associated with the TSP

Legislative Title	U.S. Code/Other	Compliance
		will create air emissions and would have no lasting effect on the study area.
Clean Water Act	33 U.S.C. §§ 1251 et seq.	USACE produced an evaluation complying with the Clean Water Act in Appendix G2
Coastal Zone Management Act	16 U.S.C. §§ 1451-1464 N.J.A.C. 7:7 and N.J.A.C. 7:7E	A CZM Determination was prepared and is located in Appendix G4.
Endangered Species Act of 1973	16 U.S.C. §§ 1531 et seq.	On-going, Appendix G6.
Environmental Justice in Minority and Low Income Populations	Executive Order 12898	USACE performed an analysis and has determined that a disproportionate negative impact on minority or low-income groups in the community is not anticipated; a full evaluation of Environmental Justice issues is not required.
Executive Order 11988, Protection of Floodplains	May 24, 1977rea	TSP will not cause significant changes in future with-project flood conditions compared to future without-project conditions.
Executive Order 11990, Protection of Wetlands	May 24, 1977	TSP has overall effect of enhancing wetlands and increasing their total area. Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	April 21, 1997	Implementation of this project will reduce environmental health risks. Circulation of this report for public and agency review fulfills the requirements of this order
Fish and Wildlife Coordination Act	16 U.S.C. § 661 et seq.	On-going, Appendix G6
Magnuson-Stevens Act Fishery Conservation and Management Act	Section 305(b)(2) 1996 Amendments	As per consultation with GARFO – NJ a letter stating potential impacts to EFH was transmitted. During PED phase a project specific EFH consultations will be conducted. Appendix G7
Migratory Bird Treaty Act of 1918	16 U.S.C. §703-712	TSP will not have any negative effects to migratory bird habitat. Neo-tropical migratory birds that use the riparian zone in the river and tributary corridors will benefit from increase in available habitat.
National Environmental Policy Act of 1969	42 U.S.C. §§ 4321-4347	TSP would have the overall effect of enhancing wetlands and increasing their total area in the lower Hudson River. The circulation of the Draft EA fulfills requirements of this act.

Legislative Title	U.S. Code/Other	Compliance
National Historic Preservation Act of 1966	16 U.S.C. §§ 470 et seq.	On-going. Correspondence and draft PA included in Appendix G5
Prime and Unique Farmlands	CEQ Memorandum of August 1, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA.	Not present in project area.
Wild and Scenic Rivers	Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq.)	Not present in project area.

Chapter 8: Conclusions and Recommendations

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social, and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New York and other non-federal interests.

I recommend that the selected plan for ecosystem restoration for the Hudson River Habitat Restoration, Ecosystem Restoration Feasibility Study, as fully detailed in this draft integrated Feasibility Report and Environmental Assessment, be authorized for construction as a federal project, subject to such modifications as may be prescribed by the Chief of Engineers. The Recommended Plan consists of restoration activities at five sites across the Hudson River watershed and has an estimated first cost of $98,386,265.

<table>
<tr><th>RESTORATION CATEGORY</th><th>SITE</th><th>ELEMENT DESCRIPTION OF RECOMMENDED ALTERNATIVES</th></tr>
<tr><td rowspan="2">Large River Mosaic</td><td>Binnen Kill</td><td>▪ Forested wetland creation (15.5 acres)
▪ Emergent wetland creation (4.3 acres)
▪ Emergent wetland restoration (41.2 acres)
▪ Side channel and tidal wetland creation (27.0 acres);
▪ Tidal wetland restoration (7.5 acres)
▪ Other wetland restoration (57.6 acres)</td></tr>
<tr><td>Schodack Island</td><td>▪ Side channel and tidal wetlands (9.1 acres)
▪ Tidal wetland restoration (19.8 acres)</td></tr>
<tr><td>Shoreline Restoration</td><td>Henry Hudson Park</td><td>▪ Tidal wetland creation (3.6 acres)
▪ Hardened bulkhead replaced with a living shoreline</td></tr>
<tr><td rowspan="2">Tributary Connections</td><td>Rondout Creek</td><td>▪ Removal of Eddyville Dam
▪ Reconnection of 9.0 miles of habitat</td></tr>
<tr><td>Moodna Creek</td><td>▪ Removal of a utility crossing (barrier 1)
▪ Removal of Firth Cliff Dam (barrier 2)
▪ Partial removal of Orr's Mill Dam (barrier 3)
▪ Collectively, reconnection of 7.8 miles of habitat</td></tr>
<tr><td colspan="2">Total</td><td>38 acres of side channels/tidal wetlands restored
148 acres of wetlands in the Hudson River corridor
17 miles of river habitat reconnected</td></tr>
</table>

My recommendation is made with the provisions outlined that the non-federal sponsors will provide the following items of cooperation prior to implementation:

a. Provide, during the periods of design and construction, funds necessary to make its total contribution for ecosystem restoration equal to 25 percent of the total project cost;

b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal government to be required or to be necessary for the construction, operation, and maintenance of the project;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

d. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

h. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction or operation and maintenance of the project;

i. Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction, operation, maintenance, repair, rehabilitation, or replacement of the project;

j. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

k. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

l. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army”; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c));

n. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

o. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch.

Consequently, the recommendations may be modified (by the Chief of Engineers) before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the partner, the State, interested Federal Agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

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Chapter 9: References

AgACIS. 2018a. WETS Station: ALCOVE DAM; Requested years: 1942 - 2018. http://agacis.rcc-acis.org.

AgACIS. 2018b. WETS Station: MOHONK LAKE, NY; Requested years: 1986 - 2018. http://agacis.rcc-acis.org.

AgACIS. 2018c. WETS Station: WEST POINT, NY; Requested years: 1890 - 2018. http://agacis.rcc-acis.org.

Albany County. 2018. Strategic Location of Albany County [webpage]. Accessed November 2018. www.albanycounty.com/Government/Departments/Dept-EconomicDevelopmentConservationandPlaning/EconomicDevelopment/Location.aspx.

Bunt, C.M., T. Castro-Santos, and A. Haro. 2012. Performance of Fish Passage Structures at Upstream Barriers to Migration. River Research and Applications 28: 457-478.

Catskill Mountain Railroad. 2018. Connecting the Hudson Valley with the Catskills [webpage]. Accessed January 2019. https://www.catskillmountainrailroad.com/about-2.

Collins, M. J. and D. Miller. 2011. “Upper Hudson River estuary (USA) floodplain change over the 20th century.” River Research and Applications. doi: 10.1002/rra.1509.

Colorado State University. eRAMS (Environmental Resources Assessment and Management System. https://erams.com.

Cole, J.J., N.F. Caraco, and B. Peierls, 1991. Phytoplankton Primary Production in the Tidal Freshwater Hudson River, NY, USA. Verh. Internat. Verein Limnol. Vol. 24. Pages 1715-1719.

Cole, J.J., N.F. Caraco, and B. Peierls, 1992. Can Phytoplankton Maintain a Positive Carbon Balance in a Turbid Freshwater Tidal Estuary: Limnol. Oceanogr. Vol. 37, Pages 1608-1617.

Cooper, J.C., F.R. Cantelmo, and C. E. Newton. 1988. Overview of the Hudson River estuary. American Fisheries Society Monograph 4:11-24.

Council on Environmental Quality (CEQ). 1997. Considering Cumulative Effects under the National Environmental Policy Act. Executive Office of the President, Electronic.

eBird. 2012. eBird: An online database of bird distribution and abundance [web application]. Accessed January 2019. Ithaca, New York. http://www.ebird.org.

Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2014. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke’s Ecological Communities of

New York State. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

FEMA. 2009a. Flood Insurance Rate Map; Panel Number 36071C0333E. National Flood Insurance Program. https://msc.fema.gov/portal/home.

FEMA. 2009b. Flood Insurance Rate Map; Panel Number 36071C0341E. National Flood Insurance Program. https://msc.fema.gov/portal/home.

FEMA. 2016a. Flood Insurance Rate Map; Panel Number 3611C0480E. National Flood Insurance Program. https://msc.fema.gov/portal/home.

FEMA. 2016b. Flood Insurance Study: Ulster County, New York. FIS Number 36111CV003B.

Foyt, S. 2015. Views from Walkway over the Hudson State Historic Park. https://www.getawaymavens.com/walkway-over-the-hudson.

Franklin, A. E., A. Haro, T. Castro-Santos, and J. Noreika. 2012. Evaluation of Nature-Like and Technical Fishways for the Passage of Alewives at Two Coastal Streams in New England, Transactions of the American Fisheries Society, 141:3, 624-637.

Friends of Schodack Island State Park. 2018. History of Schodack Islands.

Hammer, D.A. 1992. Creating freshwater wetlands. Lewis Publishers, Inc. Chelsea, Michigan. 298 p.

Howarth, R.W., J.R. Fruci and D. Sherman, 1991. Inputs of Sediments and Organic Carbon to an Estuarine Ecosystem: The Hudson River Estuary as a Case Study. Ecological Applications. Vol. 1 pp 27-39.

Hudson River Greenway Water Trail. 2018. Water Trail Sites [webpage]. Accessed December 2018. http://hudsonrivergreenwaywatertrail.org/findaccesssites.php#site58

Kemble, W. J. 22 June 2018. Esopus reviews suggestions for updated comprehensive plan https://www.dailyfreeman.com/news/esopus-reviews-suggestions-for-updated-comprehensive-plan/article_aaf0232b-2af8-5c08-af93-cc5c69e86caf.html.

Kiviat, E., & Samanns, E. 2017. Natural Resource Inventory and Assessment of Conservation. NYSDEC Conservation, Hudson River Estuary Program.

Limburg, K.E., Moran, M.A., and McDowell, W.H. Eds. 1986. *The Hudson River Ecosystem*. Springer-Verlag, NY, NY.

Louis Berger US, Inc. 2017. Natural Resource Inventory and Assessment of Conservation Priorities of the Binnen Kill and its Tidal Habitats. NEIWPCC Agreement No. 2016-021.

Miller, D. E., J. Ladd, and W. Nieder. 2006. “Channel Morphology in the Hudson River Estuary: Historical Changes and Opportunities for Restoration.” In Hudson River

Fishes and Their Environment, ed. J.R. Waldman, K.E. Limburg, and D.L. Strayer, pp. 29-38. Bethesda, Maryland: American Fisheries Society, Symposium 51.

Miller, Daniel E., 2013. Hudson River Estuary Habitat Restoration Plan. New York State Department of Environmental Conservation, Hudson River Estuary Program.

National Audubon Society. 2018a. Important Bird Areas: New York [webpage]. Accessed 15 Aug. 2018. www.audubon.org/important-bird-areas/state/new-york.

National Audubon Society. 2018b. Schodack Island State Park [webpage]. Accessed December 2018. https://www.audubon.org/important-bird-areas/schodack-island-state-park.

New York State Museum. 1991. Surficial Geologic Map of New York. http://www.nysm.nysed.gov/research-collections/geology/gis.

New York State Museum. 1995. Geologic Map of New York. http://www.nysm.nysed.gov/research-collections/geology/gis.

New York State. 2018. Climate Smart Communities Program [webpage]. Accessed December 2018. https://climatesmart.ny.gov.

NOAA. 2014. Station Number 8518951, Hyde Park, NY; Datum Elevations, 1983-2001 Epoch. Center for Operational Oceanographic Products and Services (CO-OPS).

Noonan, M.J., J.W.A. Grant, and C.D. Jackson. 2011. A quantitative assessment of fish passage efficiency. Fish and Fisheries. 1-15.

NRCS. Web Soil Survey [web application]. Accessed December 2018. https://websoilsurvey.sc.egov.usda.gov.

New York State Department of Environmental Conservation, 1988. Hudson River Estuary Management Program: Strategy for the Development of a Fifteen Year Management Program. New Paltz, NY.

NYSDEC. 2002. Schodack Island Bird Conservation Area. https://www.dec.ny.gov/animals/27032.html.

NYSDEC. 2003. Rondout Creek Sampling Results. NYSDEC Division of Water.

NYSDEC. 2006. Hudson River Estuary Program, Benthic Mapping Project [web application]. Accessed January 2019. http://www.dec.ny.gov/imsmaps/benthic/webpages/benthicproject.html.

NYSDEC. 2007. Hudson River Estuary Tidal Wetlands 2007. Accessed December 2018. https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1210.

NYSDEC. 2011 - 2012. New York State Department of Environmental Conservation (NYSDEC) LiDAR: Coastal New York (Long Island and along the Hudson River) [dataset]. NOAA Office for Coastal Management. https://inport.nmfs.noaa.gov/inport/item/49888.

NYSDEC. 2015. Hudson River Estuary Action Agenda.

NYSDEC. 2017 (August). Natural Areas and Wildlife in your Community: A Habitat Summary Prepared for the Town of Bethlehem. http://www.townofbethlehem.org/DocumentCenter/View/10784/Habitat-Summary?bidId.

NYSDEC. 2018a. Boat Launching Sites by County [webpage]. Accessed December 2018. https://www.dec.ny.gov/outdoor/7832.html.

NYSDEC. 2018b. Climate Summary for Communities. Accessed January 2019. http://www.dec.ny.gov/docs/remediation_hudson_pdf/csfc2.pdf.

NYSDEC. 2018c. Maps & Geospatial Information System (GIS) Tools for Environmental Justice. Accessed January 2019. www.dec.ny.gov/public/911.html.

NYSDEC. Environmental Resource Mapper [web application]. Accessed January 2018. http://www.dec.ny.gov/gis/erm.

New York State Department of Environmental Conservation Hudson River Estuary Program and the New England Interstate Water Pollution Control Commission. (March 2018). Hydrodynamic and Sediment Transport Study of Existing Conditions and Restoration Alternatives at Rattlesnake Island and Coxsackie Cove, Greene County, NY. Prepared by O'Brien & Gere, Inc.

NYSDOS. 1993. Scenic Areas of Statewide Significance; Columbia-Greene North, Catskill-Olana, Estates District, Ulster North, Esopos-Lloyd, Hudson Highlands. Reprinted 2004.

NYSDOS. 1995. Town of Schodack and Village of Castleton-on-Hudson Local Waterfront Revitalization Program. Approved: March 17, 1995.

NYSDOS. 2012. Coastal Fish and Wildlife Rating Form, Shad and Schermerhorn Islands. Designated: November 15, 1987. Revised: August 15, 2012.

NYSDOS. 2012a. Coastal Fish and Wildlife Rating Form, Rondout Creek. Designated: November 15, 1987. Revised: August 15, 2012.

NYSDOS. 2012b. Coastal Fish and Wildlife Rating Form, Schodack and Houghtailing Islands and Schodack Creek. Designated: November 15, 1987. Revised: August 15, 2012.

NYSDOS. 2012c. Coastal Fish and Wildlife Rating Form, The Flats. Designated: November 15, 1987. Revised: August 15, 2012.

NYSDOS. 2017. New York State Coastal Management Program and Final Environmental Impact Statement. https://www.dos.ny.gov/opd/programs/pdfs/NY_CMP.pdf

NYSDOT. 2013. Geology of New York State. Geotechnical Design Manual. 3-1-3-35.

NYS GIS Clearinghouse. 2018. Geospatial Data. Accessed December 2018. Available at https://gis.ny.gov/gisdata.

NYS Parks Recreation, and Historic Preservation. 2018. Schodack Island State Park [webpage]. Accessed December 2018. https://parks.ny.gov/parks/146/hunting.aspx.

OCWA. 2010a. Major Aquifers of Orange County. http://waterauthority.orangecountygov.com/aquifers.html.

OCWA. 2010b. Moodna Creek Watershed Atlas. http://waterauthority.orangecountygov.com/moodna.html.

Partners Restoring the Hudson. 2018. Hudson River Comprehensive Restoration Plan: Recommendations for the New York-New Jersey Harbor & Estuary Program Action Agenda and the New York State Hudson River Estuary Action Agenda. The Nature Conservancy. http://thehudsonweshare.org/wp-content/uploads/2018/07/Hudson_River_Report_Final_August-2018_s.pdf

Partners Restoring the Hudson. 2019a. The Hudson We Share: About the Plan (webpage). Accessed 25 January 2019. http://thehudsonweshare.org/about-the-plan.

Partners Restoring the Hudson. 2019b. The Hudson We Share: Hudson River Mapper (webpage). Accessed 25 January 2019. http://thehudsonweshare.org/wp-content/uploads/2018/08/HudsonMapper.html.

REConnect. 2018. REConnect Ulster County Recreation [webpage]. Accessed January 2019. https://ulstercountyny.gov/maps/recreation.

Reschke, C. 1990. Ecological Communities of New York State.

Scenic Hudson. 2016. Wetlands Protected along Binnen Kill. www.scenichudson.org/news/release/wetlands-protected-along-binnen-kill/2016-09-01.

Scenic Hudson. 2018. Sea Level Rise Mapper [web map]. Accessed January 2018. http://www.scenichudson.org/slr/mapper.

Schodack Scene. 2015. Schodack Island to Host Winterfest [Webpage]. Accessed December 2018. https://thescene-thescene.blogspot.com/search?q=schodack+island.

Squires, Donald F. 1992 Quantifying anthropogenic shoreline modification of the Hudson River and Estuary from European contact to modern time, Coastal Management, 20:4, 343-354.

Suszkowski, D.J. and J. Lodge. 2008. CARP: Accomplishments and Findings. In. The Tidal Exchange. Newsletter of the New York - New Jersey Harbor Estuary Program. Spring 2008

Swift, F.L. 1987. An Analysis of Avian Breeding Habitats in Hudson River Tidal Marshes. New York State Department of Environmental Conservation, Albany, NY.

Town of Bethlehem. 2015. Bethlehem's Parks and Recreation Comprehensive Master Plan.

Town of Bethlehem. 2018. Local Waterfront Revitalization Program Update & Henry Hudson Park Master Plan Update; Draft for DOS Legal Review #1.

Town of Esopus. 1987. Local Waterfront Revitalization Program.

Ulster County. 2018. Ulster County Department of Public Transportation Webpage Accessed January 2019. https://ulstercountyny.gov/ucat/ulster-county-area-transit.

USACE. 1996. Hudson River Habitat Restoration, Hudson River Basin, New York Reconnaissance Report.

USACE. 2008. Esopus and Plattekill Creeks Watershed Reconnaissance Report.

USACE. 2008. Rondout Creek and Wallkill River Watershed Reconnaissance Report.

USACE. 2016. Hudson-Raritan Estuary Comprehensive Restoration Plan.

USACE. 2017. Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study Draft Integrated Feasibility Report and Environmental Assessment.

USCB, American FactFinder. 2013-2017. American Community Survey 5-Year Estimates [dataset]. Accessed January 2019. https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml

USEPA. 2016a. September. New York Impaired Waters List. Retrieved from Impaired Waters and TMDLs: https://www.epa.gov/sites/production/files/2017-07/documents/303dproplist2016.pdf.

USEPA. 2016b. New York State 2016 Section 303(d) List of Impaired/TMDL Waters. https://www.epa.gov/tmdl/new-york-impaired-waters-list.

USEPA. 2019. March 20. Hudson River Cleanup. Retrieved from United States Environmental Protection Agency: https://www3.epa.gov/hudson/cleanup.html.

USFWS. 2006. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: New York State. https://www.census.gov/prod/2008pubs/fhw06-ny.pdf.

USFWS. 1997. Significant Habitats and Habitat Complexes of the New York Bight Watershed. https://nctc.fws.gov/resources/knowledge-resources/pubs5/web_link/text/toc.htm.

USFWS. 2018. Flyways [web page]. Accessed December 2018. https://www.fws.gov/birds/management/flyways.php.

USGS. 2003. Geology of the New York City Region. https://3dparks.wr.usgs.gov/nyc.

USGS. 2018. National Water Information System, Station Number 01359139, Hudson River at Albany NY. https://waterdata.usgs.gov/usa/nwis/uv?01359139.

USGS. Streamstats [web application]. Accessed December 2018. https://water.usgs.gov/osw/streamstats.

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