Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study

Appendix E
Benefits

Final Integrated Feasibility Report &
Environmental Assessment
March 2020

Prepared by the New York District
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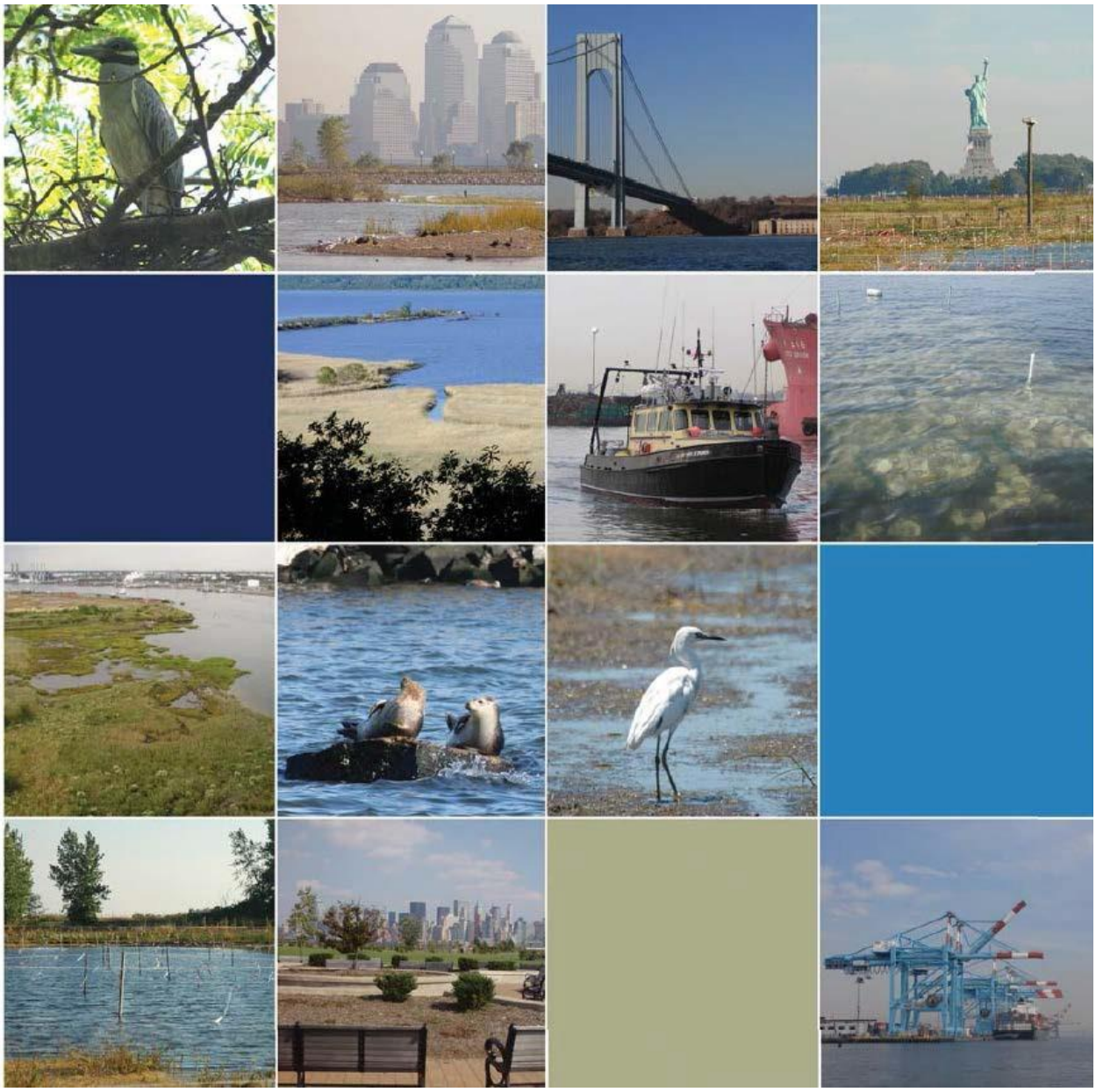
THE PORT AUTHORITY OF NY & NJ



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1. Introduction

This appendix presents the details for the assessment of baseline existing conditions and Future Without Project (FWOP) conditions; it describes the habitat evaluation assessment approach applied in the formulation, evaluation, and comparison of alternatives for sites included in this Integrated Feasibility Report/Environmental Assessment (FR/EA) within the Hudson Raritan Estuary (HRE). In providing the inputs for the Cost Effective and Incremental Cost Analysis (CE/ICA), it was determined that the assessment approach would need to: (1) provide an equitable evaluation that adequately distinguishes between all increments, and (2) be based in the U.S. Army Corps of Engineers' SMART planning principals. The first consideration was satisfied by developing an assessment approach that would produce a broadly applicable output (habitat units) based on a multi-species/multihabitat evaluation. The second consideration resulted in a number of assumptions and simplifications that streamlined the overall assessment approach and maximized the use of existing information. The Project Delivery Team (PDT) identified the Evaluation of Planned Wetland (EPW) assessment framework as meeting the needs for an assessment approach. The assessment approach would provide an evaluation in terms of acre-based habitat units.

As discussed in the Plan Formulation Appendix D, analyses completed as part of six separate "source" studies were incorporated into this FR/EA and quantitative assessment of benefits. For discussion purposes, this appendix has been divided into Sections based on formulation (Planning Region, "source" study or habitat type).

Table E-1. Alternative Assessment Package for each Waterbody, "Source" Study or Restoration Type

Package	Site Name
Jamaica Bay Perimeter	Dead Horse Bay
	Fresh Creek
	Brant Point
	Dubos Point
	Hawtree Point
	Bayswater State Park
Jamaica Bay Marsh Islands	Stony Creek
	Duck Point
	Elders Point Center
	Pumpkin Patch West
	Pumpkin Patch East
Flushing Creek	Flushing Creek
Bronx River	Bronx Zoo and Dam
	Stone Mill Dam
	Shoelace Park
	Bronxville Lake
	Garth Woods/Harney Road
	Muskrat Cove
	River Park/West Farm Rapids Park
	Crestwood Lake

Package	Site Name
	Westchester County Center
Lower Passaic River and Hackensack River	Metromedia Tract
	Meadowlark Marsh
	Oak Island Yards
	Essex County Branch Brook Park
	Kearny Point
	Dundee Canal
HRE Oyster Restoration	Jamaica Bay, Head of Bay
	Bush Terminal
	Naval Weapons Station Earle

2. Detailed Assessment - Overview

2.1. Baseline Conditions

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

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

2.2. Evaluation of Planned Wetlands Process

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

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

Table E-2. Definitions of EPW Functions

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

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

The FCI is a dimensionless number ranging from 0.0 to 1.0 that describes a wetland's relative capacity to perform a function, where 0.0 indicates no functional capacity and 1.0 indicates optimal function capacity. The FCI and WAA are then used to derive the functional capacity units (FCUs). The FCIs represents the "quality" of functional capacity per unit area, whereas the FCUs represent the "quantity" of functional capacity. FCUs are calculated by multiplying FCI times the area of the planned/anticipated impacts. The WAA was evaluated by completing the data sheets, and calculating the FCI and FCUs for the existing conditions at each site. Each alternative was evaluated by completing the data sheets with the predicted conditions at each time interval. The total EPW score for a given alternative was calculated using averaged functional capacity indices/units rather than summation.

The following assumptions were applied to this analysis:

As a result of coordination with USACE's National Ecosystem Planning Center of Expertise (ECO-PCX), the EPW scores for the Final FR/EA were calculated using averaged functional

capacity indices/units. In the Draft FR/EA the summation of functional capacity indices/units were used to calculate the EPW scores, resulting in an EPW score that was 5 times greater.

The approach used in this study assessed the restored and the unrestored areas within the project footprint to gain a full picture of the benefits. Existing condition FCIs were used to represent the unrestored areas. This accounting approach prevented a site from appearing to have an existing condition area that was larger than the fully restored area.

It was assumed that during the construction period, no net benefits or net impacts would occur and that benefits would begin to accrue in the year following construction. In practical application the assumption of a 12-18 month construction period will result in benefits reflecting an initial construction response being accrued following year 2. Benefits were assessed at four time intervals for all alternatives: Target Year-0 (existing condition), Target Year-2 (reflecting initial ecological response), Target Year-20 (estimating long-term outcomes), and Target Year-50 (end of the planning horizon). This appendix presents the EPW Outputs, FCIs and calculated FCUs, for these referenced time intervals, these values were subsequently utilized to calculate Average Annual Functional Capacity Units (AAFCUs), which are presented in the CE/ICA Appendix J.

Sea Level Change (SLC) analysis of the FWOP and initial alternatives was conducted for all estuarine sites in all habitat types for each alternative in Target Years 0, 2, 20, and 50. At this stage of the feasibility study, many of the proposed alternatives did not have grading plans. The SLC analysis therefore involved the development of concept level grading plans for each alternative and only the intermediate curve was used for this initial alternatives analysis. The resulting outputs were then used to model future benefits, an important element in the screening of the alternatives. The results of this initial analysis also greatly informed the detailed design of the selected alternatives as the resiliency of the designs were improved as a result of the insights gained (see Engineering Appendix C). For freshwater riverine sites an assumptions of diminishing ecological value and erosion in year 50 was taken into account through a 10% decrease in habitat area from year 20-50.

Optimization of the selected alternative was conducted for all estuarine sites once detailed grading plans were completed. Through this optimization, habitat areas were assessed through a Relative Sea Level Change analysis (decrease in vegetated wetland, increase in open water, and change in wetland community type) which evaluated all habitat types for each alternative and FWOP for Target Years 0, 2, 20, and 50 (see Engineering Appendix C). Optimization also occurred for sites not affected by SLC due to design or planning issues.

Investigation of the Draft FR/EA EPW analyses, in coordination with the Eco-PCX, revealed that the area acreage had been underestimated. The proposed habitat acreage was recalculated utilizing Geographic Information Systems (GIS) to capture additional appropriate benefits. The current EPW analysis incorporates habitats adjacent to emergent wetlands, low marsh, and high marsh such as riparian buffers and shoreline/ shallow water habitat. These adjacent habitats are integral components of wetland systems acting as transitional zones between habitats, providing water quality and wildlife benefits; as well as functional and structural support to hydraulic, sediment transport, and bank stability conditions of the restored wetland. In their 2000 publication Fischer and Fischenich provide a synopsis of design recommendations for riparian

corridors and vegetated buffer strips[1]. These recommendations vary based on the desired habitat function or target species; however, due to limited space in the urban setting of the Hudson Raritan Estuary, buffer habitat was generally restricted to under 30m width.

General width guidelines from Fischer and Fischenich:

- Water Quality Protection: 5 - 30m
- Riparian Habitat: 30-500m+
- Stream Stabilization: 10-20m
- Flood Attenuation: 20-150m

The shallow water portion of the wetlands were included in the analysis in alignment with federal and state classifications. New York State[2] classifications for coastal, tidal, and freshwater wetlands includes inundated areas such as intertidal marsh, high marsh, fresh water marsh, formerly connected, coastal shoals bars and mudflats, littoral zones, and adjacent areas. Similarly, USFWS[3] defines the boundary between wetland and deepwater habitat in the Riverine and Lacustrine Systems at a depth of 2m below low water; however, if emergents, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

2.3. Oyster Habitat Suitability Index Model (OHSIM)

Oyster reef benefits were assessed using a certified, spatially explicit, flexible, 4-parameter habitat suitability index model developed by Swannack et al.[4]. This model was used to determine locations suitable for restoration of eastern oyster reefs throughout the western Atlantic and Gulf coasts. The model captures the minimum environmental parameters required for successful restoration suitability.

2.4. Watershed-Scale Upstream Connectivity Toolkit (WUCT)

Fish passage connectivity benefits (assessed as the total amount of accessible, quality-weighted habitat available upstream for migratory fishes) were applied to the Bronx Zoo Dam and Stone Mill Dam sites. A Watershed-Scale Upstream Connectivity Toolkit (WUCT) was developed to assess these benefits (based on prior work in McKay et al. 2013, 2016, and 2017) and was approved for model certification (October2018). Habitat units were combined with EPW FCUs at each site by summation.

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

[2] New York State Department of Environmental Conservation. Tidal Wetland Categories. www.dec.ny.gov/lands/5120.html

[3] Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31, U.S. Department of Interior, Fish and Wildlife Service, Washington D.C.

[4] Swannack T.M., Reif M., Soniat T.M. 2014. A Robust, Spatially Explicit Model for Identifying Oyster Restoration Sites: Case Studies on the Atlantic and Gulf Coasts. Journal of Shellfish Research 33(2):395-408.

2.5. Relative Sea Level Change Analysis

Relative Sea Level Change Analysis (Appendix C) was considered for the FWOP and for the future benefits calculations for years 2, 20 and 50. Habitat acreage (low marsh, high marsh, floodplain) were projected 50 years beyond the design year (based on the annual elevation datum) for the intermediate scenario. With the exception of oyster reefs, all benefits for estuarine sites in CE/ICA include the effects of sea level rise. These sites include: Duck Point, Elders Center, Pumpkin Patch East Marsh, Pumpkin Patch West Marsh, Stony Creek Marsh, Dead Horse Bay, Metromedia, Meadowlark, Flushing Creek, Fresh Creek, and Oak Island Yards.

2.6. Development of Site-Specific Alternatives

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

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

Restoration concept designs were discussed with non-federal study sponsors and potential construction sponsors at design charrettes or coordination meetings. Alternatives ranging from one to six were developed for each Jamaica Bay site as part of the Jamaica Bay "source" study (Appendix D-2).

The three alternatives that were developed as part of HRE were optimized from the previously selected preferred alternative as part of the Flushing Creek and Bay "source" study. Appendix D-4 contains additional site screening and alternatives development conducted in order to identify the original Flushing Creek preferred alternative in 2007.

The development of alternatives for the Jamaica Bay marsh islands and oyster restoration are specifically outlined in Appendices D-3 and D-7, respectively.

3. Jamaica Bay Perimeter

3.1. Background

The EPW assessment for the Jamaica Bay Perimeter Sites was conducted in two parts:

Part 1 (2004**)** of this section documents the outcome of a system wide CE/ICA assessment conducted as part of the draft Jamaica Bay, Marine Park, and Plumb Beach New York Ecosystem Restoration Feasibility Report and Environmental Assessment. Results are presented for baseline conditions and alternatives, highlighting the recommended alternative for the following sites: Dead Horse Bay, Fresh Creek, Brant Point, Hawtree Point, Bayswater Point State Park, and Dubos Point. Prior to finalizing the report, Hurricane Sandy devastated the region and this study was named in Interim Report 2 of Sandy Recovery Act (PL-135). The sites were subsequently included in the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study for consideration as natural or nature-based features for coastal storm risk management (CSRM) benefits.

In 2015, as part of the East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study, USACE Published Memorandum for Record #8[5] (MFR #8) Ecological Valuation of Alternatives & Assessment of Mitigation Requirements. This document performed field work post Hurricane Sandy at 33 sites in Jamaica Bay, including the proposed restoration sites. Using EPW methodology, the USACE scored the potential wetlands and exiting uplands at each site. During the formulation and finalization of the proposed alternatives for the HRE projects, the scores from the USACE's 2015 study were reviewed. The scores showed that the habitats within the proposed restoration sites had not dramatically changed in physical composition pre- and post-Sandy, that the wetlands, near shore tidal habitats and uplands would all benefit from the proposed restoration, and that the costs for the selected restoration plans are warranted as they would provide substantial uplift. The 2015 assessment (MFR#8) verified that existing conditions had not significantly changed, validating the 2004 baseline EPW results.

Part 2 (2018) of this section documents the EPW results of the FWOP and the 2004 recommended alternative only. In the 2018 assessment, the areas were re-calculated to account for Relative Sea Level Change as described in Section 2.6.

Habitat types calculated in the EPW analysis for the Jamaica Bay Perimeter sites included: low marsh, high marsh, scrub/shrub, meadow, and tidal channels/basin recontouring. For projects that did not have a scrub shrub habitat buffering the wetland, all or a portion of the habitat adjacent to the high marsh was included and considered buffer habitat. These special cases include; the entire (< 2 acre) maritime forest habitat at Dubos Point and 10% of the grassland at Hawtree Point. The unrestored area for the alternatives and the FWOP were assumed to be a continuation of the existing condition and the values for the above listed habitat types, from the 2004 analyses were used in the current analysis. The FWOP areas for the restored areas were assumed to be zero.

3.2. Methods

Part 1

An EPW assessment for Jamaica Bay was conducted in the spring of 2004 and was verified in August 2015 (MFR#8). The EPW process is described in Section 2.2. In 2004, functional capacity index (FCI) calculations were performed in a Microsoft Excel© spreadsheet using the

[5] U.S. Army Corps of Engineers (USACE). 2015. East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Reformulation Study- Memorandum for the Record #8 Ecological Valuation of Alternatives & Assessment of Mitigation Requirements.

equations presented in the EPW manual (Bartoldus et al., 1994); all equations and spreadsheet cell references were validated.

Part 2

The EPW results of the FWOP and the 2004 recommended alternative only were recalculated for using the functional capacity index (FCI) from the 2004 analysis for the WAA and the Planned Wetland FCIs applied to each alternative. In the Part 2 assessment the areas were also optimized to account for Relative Sea Level Change as described in Sections 2.6. FCI calculations were performed in a Microsoft Excel© spreadsheet using the equations presented in the EPW manual (Bartoldus et al., 1994); all equations and spreadsheet cell references were validated.

3.2.1. Results

Part 1

Dead Horse Bay

The FWOP and five (5) alternatives were considered for the Dead Horse Bay restoration site:

- FWOP: No action alternative.
- Alternative 1: Fringe marsh system in the north, shoreline erosion control and landfill capping in the south.
- Alternative 2: All elements of Alternative 1 plus excavation and on-site re-use of 31 acres of landfill in the south.
- Alternative 3: Tidal channel marsh system and creek stabilization with training structures in the north, placement of clean fill and sand from the north to create dunes along the edge of the water and to restore the maritime forest in the south.
- Alternative 4: All elements of Alternative 3 plus excavation and on-site re-use of 31 acres of landfill in the southern portion.

Table E-3. The functional capacity units for each alternative at Dead Horse Bay

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/River)	Total
FWOP	76.61	47.81	55.36	54.05	69.26	303.09
1	120.72	79.44	79.15	100.52	84.20	464.03
2	123.57	113.60	98.51	100.52	97.49	533.69
3	156.54	106.83	144.55	133.87	119.92	661.71
4	159.36	149.14	151.60	133.87	153.30	747.27

Based on the EPW assessment (2004), all four (4) alternative restoration plans create improvements to the functionality of the site. However, Alternative 4 was identified as the

Tentatively Selected Plan (TSP) based on the 2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 Alternative Formulation Brief (AFB).

3.2.2. Fresh Creek

The FWOP and six (6) alternatives have been considered for the Fresh Creek restoration site:

- FWOP: No action alternative.
- Alternative 1: Tidal marsh system continuous around basin with no bottom filling.
- Alternative 2: Tidal marsh system continuous around basin with bottom filled from head to edge of deep dredged channel.
- Alternative 3: Tidal marsh system continuous around basin with head of basin filled to intertidal elevations and tidal channel marsh system established.
- Alternative 4: Tidal marsh system continuous around basin with bottom filled from head to Jamaica Bay.
- Alternative 5: Tidal marsh system continuous around basin with head of basin filled to intertidal elevations and tidal channel marsh system established and with the remainder of the basin filled to Jamaica Bay.

Table E-4. The functional capacity units for each alternative at Fresh Creek

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream / River)	Uniqueness / Heritage	Total
FWOP	30.80	22.42	35.92	13.51	22.62	52.43	125.27
1	91.55	66.27	72.04	60.71	64.30	95.53	354.87
2	67.27	46.07	51.19	44.61	44.77	70.20	253.91
3	67.29	40.81	45.35	34.09	33.86	58.51	221.39
4	65.94	47.73	51.89	54.05	42.18	68.81	261.80
5	90.97	71.20	79.11	74.57	75.02	94.93	390.86

Based on the EPW assessment (2004), all five (5) alternative restoration plans create improvements to the functionality of the site. However, Alternative 5 was identified as the TSP based on the 2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 AFB.

3.2.3. Brant Point

The FWOP and three (3) alternatives have been considered for the Brant Point restoration site:

- FWOP: No action alternative.
- Alternative 1: Tidal fringe marsh system transitioning into maritime forest without shore protections.
- Alternative 2: Tidal fringe marsh system transitioning into maritime forest with offshore breakwaters.

Table E-5. The functional capacity units for each alternative at Brant Point

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water quality	Wildlife	Fish (Stream/River)	Total
FWOP	3.31	2.35	4.25	1.73	5.02	16.67
1	9.26	7.31	9.34	7.65	8.90	42.47
2	4.55	5.12	8.24	7.65	7.77	33.33

Based on the EPW assessment (2004), both alternative restoration plans create improvements to the functionality of the site. However, Alternative 2 was identified as the TSP based on the 2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 AFB.

3.2.4. Hawtree Point

The FWOP and two (2) alternatives have been considered for the Hawtree Point restoration site:

- FWOP: No action alternative.
- Alternative 1: Coastal dune restoration in invasive dominated areas.

Table E-6. The functional capacity units for the no action and action alternatives at the Hawtree Point

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/River)	Uniqueness/ Heritage	Total
FWOP	5.07	3.10	5.24	1.55	4.18	6.68	25.80
1	5.19	6.16	5.24	5.34	4.68	6.68	33.29

This site, compared to the other Jamaica Bay shoreline sites, is relatively small and the restoration planned is not large. However, it was determined that the action alternative would improve the overall functionality of the site. Alternative 1 was advanced as the TSP based on the 2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 AFB.

3.2.5. Bayswater Point State Park

The FWOP and four (4) alternative scenarios were developed for the Bayswater Point State Park restoration site:

- FWOP: No action alternative
- Alternative 1: Tidal channel marsh system with coastal dune system.

- Alternative 2: Tidal channel marsh system with coastal protection tidal pool approach system.
- Alternative 3: Tidal channel marsh system with coastal protection buried T-groin system.

Table E-7. The functional capacity units for each alternative at Bayswater Point State Park

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/ River)	Total
FWOP	18.00	15.57	22.01	7.57	22.27	85.42
1	28.35	24.84	32.98	28.13	28.02	142.32
2	33.01	28.56	37.90	32.33	35.62	167.43
3	31.52	27.26	36.19	30.87	33.98	159.81

Based on the EPW assessment, all three (3) alternative restoration plans create improvements to the functionality of the site. However, Alternative 2 was identified as the TSP based on the 2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 AFB.

3.2.6. Dubos Point

The FWOP and four (4) alternatives have been considered for the Dubos Point restoration site:

- FWOP: No action alternative.
- Alternative 1: Tidal channel marsh system in invasive dominated areas without any coastal protection measures implemented.
- Alternative 2: Tidal channel marsh system in invasive dominated areas with toe protection installed at failed locations.
- Alternative 3: Tidal channel marsh system in invasive dominated areas with continuous toe dike protection along the western and northern shorelines.

Table E-8. The functional capacity units for each alternative at Dubos Point

Alternative	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream / River)	Uniqueness / Heritage	Total
FWOP	16.40	14.82	23.31	8.56	21.54	31.61	84.63
1	17.96	16.90	26.60	28.33	27.43	36.06	117.21
2	22.16	16.90	26.60	28.33	28.63	36.06	122.62
3	34.94	25.02	28.70	28.33	30.13	36.06	147.11

Based on the EPW assessment, all three (3) alternative restoration plans create improvements to the functionality of the site. However, Alternative 3 was identified as the TSP based on the

2004 system wide CE/ICA for Jamaica Bay perimeter sites and approval at the January 2010 AFB.

Part 2

3.2.7. Dead Horse Bay

Dead Horse Bay TY50 comprises approximately 37.4 acres of restored wetland habitat analyzed in the EPW assessment. One restoration alternative was evaluated for this site. The FWOP and optimized Alternative 4 FCUs after 50 years are 1.21 and 34.23. Table E-9 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

3.2.8. Fresh Creek

Fresh Creek TY50 comprises approximately 72.4 acres of restored wetland habitat analyzed in the EPW assessment. One restoration alternative was evaluated for this site. The FWOP and optimized Alternative 5 FCUs after 50 years are 19.8 and 59.69. Table E-10 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

3.2.9. Brant Point

Brant Point TY50 comprises approximately 5.1 acres of restored wetland habitat analyzed in the EPW assessment. One restoration alternative was evaluated for this site. The FWOP and Alternative 2 FCUs after 50 years are 0.4 and 3.92. Table E-11 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

3.2.10. Hawtree Point

In TY50 comprises approximately 0.21 acres of restored wetland habitat analyzed in this EPW assessment. One restoration alternative was evaluated for this site. The FWOP and Alternative 1 FCUs after 50 years are 0.94 and 0.99. Table E-12 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

3.2.11. Bayswater Point State Park

In TY50 comprises approximately 3.7 acres of restored wetland habitat analyzed in this EPW assessment. One restoration alternative was evaluated for this site. The FWOP and Alternative 2 FCUs after 50 years are 3.7 and 4.86. Table E-13 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

3.2.12. Dubos Point

In TY50 comprises approximately 6.8 acres of restored wetland habitat analyzed in this EPW assessment. One restoration alternative was evaluated for this site. The FWOP and Alternative 3 FCUs after 50 years are 7.32 and 9.22. Table E-14 presents a summary of the EPW output for the FWOP and recommended alternative in the preliminary and optimized design, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

Table E-9. EPW Output Summary Dead Horse Bay

	Year	Output	FWOP	Alt 4	Optimized FWOP	Optimized Alt 4
Unrestored	T0	FCI-SB	0.57	0.57	0.57	0.57
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.41	0.41	0.41	0.41
		FCI-WL	0.4	0.4	0.4	0.4
		FCI-FS	0.52	0.52	0.52	0.52
		Area	2.67	2.67	2.67	2.67
	T2	FCI-SB	0.57	0.57	0.57	0.57
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.41	0.41	0.41	0.41
		FCI-WL	0.4	0.4	0.4	0.4
		FCI-FS	0.52	0.52	0.52	0.52
		Area	2.7	2.7	2.7	2.7
	T20	FCI-SB	0.57	0.57	0.57	0.57
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.41	0.41	0.41	0.41
		FCI-WL	0.4	0.4	0.4	0.4
		FCI-FS	0.52	0.52	0.52	0.52
		Area	2.7	2.7	2.7	2.7
	T50	FCI-SB	0.57	0.57	0.57	0.57
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.41	0.41	0.41	0.41
		FCI-WL	0.4	0.4	0.4	0.4
		FCI-FS	0.52	0.52	0.52	0.52
		Area	2.67	2.67	2.67	2.67
Restored	T0	FCI-SB	0.57	0.57	0.57	0.57
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.41	0.41	0.41	0.41
		FCI-WL	0.4	0.4	0.4	0.4
		FCI-FS	0.52	0.52	0.52	0.52
		Area	0	0	0	0
	T2	FCI-SB	0.57	0.94	0.57	0.94
		FCI-SS	0.36	0.88	0.36	0.88
		FCI-WQ	0.41	0.9	0.41	0.9
		FCI-WL	0.4	0.79	0.4	0.79
		FCI-FS	0.52	0.91	0.52	0.91
		Area	0	42	0	32.91
	T20	FCI-SB	0.57	0.94	0.57	0.94
		FCI-SS	0.36	0.88	0.36	0.88
		FCI-WQ	0.41	0.9	0.41	0.9
		FCI-WL	0.4	0.79	0.4	0.79
		FCI-FS	0.52	0.91	0.52	0.91
		Area	0	41.94	0	34.25
	T50	FCI-SB	0.57	0.94	0.57	0.94
		FCI-SS	0.36	0.88	0.36	0.88
		FCI-WQ	0.41	0.9	0.41	0.9
		FCI-WL	0.4	0.79	0.4	0.79
		FCI-FS	0.52	0.91	0.52	0.91
		Area	0	40.04	0	37.36
Total	**T0**	**FCU**	**1.21**	**1.21**	**1.21**	**1.21**
	T2	**FCU**	**1.22**	**38.35**	**1.22**	**30.31**
	T20	**FCU**	**1.22**	**38.3**	**1.22**	**31.5**
	T50	**FCU**	**1.21**	**36.6**	**1.21**	**34.23**

Table E-10. EPW Output Summary Fresh Creek

	Year	Output	FWOP	Alt 5	Optimized FWOP	Optimized Alt 5
Unrestored	T0	FCI-SB	0.49	0.49	0.49	0.49
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.21	0.21	0.21	0.21
		FCI-FS	0.36	0.36	0.36	0.36
		Area	56.6	56.6	56.6	56.6
	T2	FCI-SB	0.49	0.49	0.49	0.49
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.21	0.21	0.21	0.21
		FCI-FS	0.36	0.36	0.36	0.36
		Area	54.18	0	54.18	0
	T20	FCI-SB	0.49	0.49	0.49	0.49
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.21	0.21	0.21	0.21
		FCI-FS	0.36	0.36	0.36	0.36
		Area	51.98	0	51.98	0
	T50	FCI-SB	0.49	0.49	0.49	0.49
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.21	0.21	0.21	0.21
		FCI-FS	0.36	0.36	0.36	0.36
		Area	49.76	0	49.76	0
Restored	T0	FCI-SB	0.49	0.49	0.49	0.49
		FCI-SS	0.36	0.36	0.36	0.36
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.21	0.21	0.21	0.21
		FCI-FS	0.36	0.36	0.36	0.36
		Area	0	0	0	0
	T2	FCI-SB	0.49	0.96	0.49	0.96
		FCI-SS	0.36	0.75	0.36	0.75
		FCI-WQ	0.57	0.83	0.57	0.83
		FCI-WL	0.21	0.79	0.21	0.79
		FCI-FS	0.36	0.79	0.36	0.79
		Area	0	71.6	0	69.18
	T20	FCI-SB	0.49	0.96	0.49	0.96
		FCI-SS	0.36	0.75	0.36	0.75
		FCI-WQ	0.57	0.83	0.57	0.83
		FCI-WL	0.21	0.79	0.21	0.79
		FCI-FS	0.36	0.79	0.36	0.79
		Area	0	70.35	0	70.26
	T50	FCI-SB	0.49	0.96	0.49	0.96
		FCI-SS	0.36	0.75	0.36	0.75
		FCI-WQ	0.57	0.83	0.57	0.83
		FCI-WL	0.21	0.79	0.21	0.79
		FCI-FS	0.36	0.79	0.36	0.79
		Area	0	70.15	0	72.44
Total	**T0**	**FCU**	**22.53**	**22.53**	**22.53**	**22.53**
	T2	**FCU**	**21.57**	**59**	**21.57**	**57**
	T20	**FCU**	**20.69**	**57.97**	**20.69**	**57.89**
	T50	**FCU**	**19.8**	**57.8**	**19.8**	**59.69**

Table E-11. EPW Output Summary Brant Point

	Year	Output	FWOP	Alt 2
Unrestored	T0	FCI-SB	0.46	0.46
		FCI-SS	0.33	0.33
		FCI-WQ	0.59	0.59
		FCI-WL	0.24	0.24
		FCI-FS	0.69	0.69
		Area	1.24	1.24
	T2	FCI-SB	0.46	0.46
		FCI-SS	0.33	0.33
		FCI-WQ	0.59	0.59
		FCI-WL	0.24	0.24
		FCI-FS	0.69	0.69
		Area	1.24	1.24
	T20	FCI-SB	0.46	0.46
		FCI-SS	0.33	0.33
		FCI-WQ	0.59	0.59
		FCI-WL	0.24	0.24
		FCI-FS	0.69	0.69
		Area	1.28	1.28
	T50	FCI-SB	0.46	0.46
		FCI-SS	0.33	0.33
		FCI-WQ	0.59	0.59
		FCI-WL	0.24	0.24
		FCI-FS	0.69	0.69
		Area	0.87	0.87
Restored	T0	FCI-SB	0.46	0.46
		FCI-SS	0.33	0.33
		FCI-WQ	0.59	0.59
		FCI-WL	0.24	0.24
		FCI-FS	0.69	0.69
		Area	0	0
	T2	FCI-SB	0.46	0.47
		FCI-SS	0.33	0.53
		FCI-WQ	0.59	0.85
		FCI-WL	0.24	0.79
		FCI-FS	0.69	0.8
		Area	0	5.1
	T20	FCI-SB	0.46	0.47
		FCI-SS	0.33	0.53
		FCI-WQ	0.59	0.85
		FCI-WL	0.24	0.79
		FCI-FS	0.69	0.8
		Area	0	5.12
	T50	FCI-SB	0.46	0.47
		FCI-SS	0.33	0.53
		FCI-WQ	0.59	0.85
		FCI-WL	0.24	0.79
		FCI-FS	0.69	0.8
		Area	0	5.11
Total	**T0**	**FCU**	**0.57**	**0.57**
	T2	**FCU**	**0.57**	**4.08**
	T20	**FCU**	**0.59**	**4.11**
	T50	**FCU**	**0.4**	**3.92**

Table E-12. EPW Output Summary Hawtree Point

	Year	Output	FWOP	Alt 1
Unrestored	T0	FCI-SB	0.75	0.75
		FCI-SS	0.46	0.46
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.23
		FCI-FS	0.61	0.61
		Area	1.57	1.57
	T2	FCI-SB	0.75	0.75
		FCI-SS	0.46	0.46
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.23
		FCI-FS	0.61	0.61
		Area	1.57	1.36
	T20	FCI-SB	0.75	0.75
		FCI-SS	0.46	0.46
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.23
		FCI-FS	0.61	0.61
		Area	1.6	1.39
	T50	FCI-SB	0.75	0.75
		FCI-SS	0.46	0.46
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.23
		FCI-FS	0.61	0.61
		Area	1.67	1.46
Restored	T0	FCI-SB	0.75	0.75
		FCI-SS	0.46	0.46
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.23
		FCI-FS	0.61	0.61
		Area	0	0
	T2	FCI-SB	0.75	0.76
		FCI-SS	0.46	0.91
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.79
		FCI-FS	0.61	0.69
		Area	0	0.21
	T20	FCI-SB	0.75	0.76
		FCI-SS	0.46	0.91
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.79
		FCI-FS	0.61	0.69
		Area	0	0.21
	T50	FCI-SB	0.75	0.76
		FCI-SS	0.46	0.91
		FCI-WQ	0.77	0.77
		FCI-WL	0.23	0.79
		FCI-FS	0.61	0.69
		Area	0	0.21
Total	**T0**	**FCU**	**0.89**	**0.89**
	T2	**FCU**	**0.89**	**0.93**
	T20	**FCU**	**0.9**	**0.95**
	T50	**FCU**	**0.94**	**0.99**

Table E-13. EPW Output Summary Bayswater Point State Park

	Year	Output	FWOP	Alt 2
Unrestored	T0	FCI-SB	0.54	0.54
		FCI-SS	0.47	0.47
		FCI-WQ	0.66	0.66
		FCI-WL	0.23	0.23
		FCI-FS	0.67	0.67
		Area	5.96	5.96
	T2	FCI-SB	0.54	0.54
		FCI-SS	0.47	0.47
		FCI-WQ	0.66	0.66
		FCI-WL	0.23	0.23
		FCI-FS	0.67	0.67
		Area	5.96	2.05
	T20	FCI-SB	0.54	0.54
		FCI-SS	0.47	0.47
		FCI-WQ	0.66	0.66
		FCI-WL	0.23	0.23
		FCI-FS	0.67	0.67
		Area	6.43	2.57
	T50	FCI-SB	0.54	0.54
		FCI-SS	0.47	0.47
		FCI-WQ	0.66	0.66
		FCI-WL	0.23	0.23
		FCI-FS	0.67	0.67
		Area	7.2	3.34
Restored	T0	FCI-SB	0.54	0.54
		FCI-SS	0.47	0.47
		FCI-WQ	0.66	0.66
		FCI-WL	0.23	0.23
		FCI-FS	0.67	0.67
		Area	0	0
	T2	FCI-SB	0.54	0.8
		FCI-SS	0.47	0.69
		FCI-WQ	0.66	0.92
		FCI-WL	0.23	0.79
		FCI-FS	0.67	0.87
		Area	0	3.91
	T20	FCI-SB	0.54	0.8
		FCI-SS	0.47	0.69
		FCI-WQ	0.66	0.92
		FCI-WL	0.23	0.79
		FCI-FS	0.67	0.87
		Area	0	3.86
	T50	FCI-SB	0.54	0.8
		FCI-SS	0.47	0.69
		FCI-WQ	0.66	0.92
		FCI-WL	0.23	0.79
		FCI-FS	0.67	0.87
		Area	0	3.86
Total	**T0**	**FCU**	**3.06**	**3.06**
	T2	**FCU**	**3.06**	**4.24**
	T20	**FCU**	**3.31**	**4.46**
	T50	**FCU**	**3.7**	**4.86**

Table E-14. EPW Output Summary Dubos Point

	Year	Output	FWOP	Alt 3
Unrestored	T0	FCI-SB	0.52	0.52
		FCI-SS	0.47	0.47
		FCI-WQ	0.74	0.74
		FCI-WL	0.27	0.27
		FCI-FS	0.68	0.68
		Area	10.68	10.68
	T2	FCI-SB	0.52	0.52
		FCI-SS	0.47	0.47
		FCI-WQ	0.74	0.74
		FCI-WL	0.27	0.27
		FCI-FS	0.68	0.68
		Area	10.68	3.78
	T20	FCI-SB	0.52	0.52
		FCI-SS	0.47	0.47
		FCI-WQ	0.74	0.74
		FCI-WL	0.27	0.27
		FCI-FS	0.68	0.68
		Area	11.48	4.55
	T50	FCI-SB	0.52	0.52
		FCI-SS	0.47	0.47
		FCI-WQ	0.74	0.74
		FCI-WL	0.27	0.27
		FCI-FS	0.68	0.68
		Area	13.65	6.9
Restored	T0	FCI-SB	0.52	0.52
		FCI-SS	0.47	0.47
		FCI-WQ	0.74	0.74
		FCI-WL	0.27	0.27
		FCI-FS	0.68	0.68
		Area	0	0
	T2	FCI-SB	0.52	0.97
		FCI-SS	0.47	0.69
		FCI-WQ	0.74	0.8
		FCI-WL	0.27	0.79
		FCI-FS	0.68	0.84
		Area	0	6.9
	T20	FCI-SB	0.52	0.97
		FCI-SS	0.47	0.69
		FCI-WQ	0.74	0.8
		FCI-WL	0.27	0.79
		FCI-FS	0.68	0.84
		Area	0	6.93
	T50	FCI-SB	0.52	0.97
		FCI-SS	0.47	0.69
		FCI-WQ	0.74	0.8
		FCI-WL	0.27	0.79
		FCI-FS	0.68	0.84
		Area	0	6.75
Total	**T0**	**FCU**	**5.72**	**5.72**
	T2	**FCU**	**5.72**	**7.67**
	T20	**FCU**	**6.15**	**8.11**
	T50	**FCU**	**7.32**	**9.22**

4. Jamaica Bay Marsh Islands

4.1. Background

The Jamaica Bay marsh islands environmental benefits assessment includes an EPW assessment for baseline and three alternatives at each of the five proposed restoration sites: Elders Center, Pumpkin Patch East, Pumpkin Patch West, Duck Point, and Stony Creek. The alternatives development at Jamaica Bay marsh islands are based on the lessons learned from successful construction of five other marsh islands: Elders Point East, Elders Point West, Yellow Bar, Black Wall, and Rulers Bar and the findings of available field investigations and desktop studies. The EPW assessment conducted for the five already constructed marsh islands were assumed to be similar to the marsh islands proposed in this FR/EA with similar ecological benefits for every acre of wetland restored. The EPW baseline scores for the five proposed marsh islands were extrapolated from the EPW assessments conducted at Yellow Bar Hassock and Elders Point in 2003. No new field work was conducted for the current analysis.

Because anticipated ecological benefits are expected to remain similar regardless of position in the bay, the goal was to restore the maximum acreage of marsh islands for the minimum cost while ensuring critical issues such as overall sustainability and sediment stability and the restoration of the marsh island as a complex, interdependent system were adequately considered.

Uniqueness and heritage elements have been assessed for many proposed sites in the HRE study area and for other areas within Jamaica Bay that have been previously restored. Jamaica Bay has been designated as a Special Natural Waterfront Area by the New York City Waterfront Revitalization Program, and each site is located on parkland. The functional capacity index (FCI) of the existing condition as well as the recommended alternative is 1.0. The Functional Capacity Unit (FCU) was not calculated, as the uniqueness of the site was not considered to be a function of the size of the wetland habitats at the site.

Habitat types that were calculated in the EPW analysis for the Jamaica Bay Marsh Islands included: low marsh, high marsh, and scrub/shrub. The FWOP for the Jamaica Bay Marsh Islands sites were assumed to be a continuation of the existing condition with consideration for RSLC. For the restored areas the FWOP area is zero in all years. The unrestored areas FWOP for Elders Center, Pumpkin East, and Pumpkin West are zero in all years, as they are currently below surface; Duck and Stony do currently have some acreage above surface water. The FWOP for the unrestored areas of the two marsh islands were developed using a GIS analysis and based on existing topography, engineering judgment, and lessons learned from previous marsh island work.

4.2. Methods

Scoring Existing Conditions

EPW was conducted as described in Section 2.2. While no field investigations of the recommended marsh islands were conducted, the PDT utilized the prior field investigations conducted on the neighboring marsh islands to obtain a close approximation of the functions of the existing wetlands. The existing conditions of the marsh islands are assumed to be similar to

the prior existing conditions of Elders Point East, Elders Point West, Yellow Bar Hassock, Black Wall, and Rulers Bar.

The baseline acreages were derived from measurement of aerial imagery taken from Google Earth. The baseline EPW FCIs were derived from an average of the pre-restoration FCIs from the Elders Point and Yellow Bar Hassock marsh islands (USACE, 2006). For Elders Point and Yellow Bar Hassock, these FCIs were evaluated separately for high and low marsh (Table E-15).

As detailed in the Elders Point and Yellow Bar Hassock Ecosystem Restoration Report/Environmental Assessment (ERR/EA) (USACE 2007), EPW assessments were conducted at four wetland assessment area (WAA) locations, including one high marsh and one low marsh per island, at the Yellow Bar Hassock and Elders Point marshes in October of 2003.

The following is excerpted from the Yellow Bar Hassock and Elders Point ERR/EA:

> *With exception for the wildlife scores, the FCI scores for low marsh on Elders Point and Yellow Bar are essentially the same. The difference in wildlife scores is attributed to the higher degree of island fragmentation at Elders Point as opposed to Yellow Bar, which is relatively intact.*
>
> *For the high marsh systems, Yellow Bar is different from Elders Point in the wildlife functions and the shoreline bank erosion control function. The high marsh wildlife FCI was higher at Elders Point due to the more complex vegetation structure compared to Yellow Bar. Even though common reed is present in the high marsh at Elders Point, a greater amount of herbaceous and woody plant cover types provides more complex horizontal and vertical habitat structure as opposed to the salt marsh hay/salt spike grass system present on Yellow Bar. Yellow Bar does not have a shoreline bank (defined as mean high water elevation) therefore, this function was not assessed at Yellow Bar. Elders Point does have a defined shore line bank so was assessed. The tidal fish function was not assessed for the high marsh systems on either island, as high marsh does not provide tidal fish habitat.*

Table E-15. Existing Conditions Functional Capacity Indices for Elders Point and Yellow Bar Hassock

Site	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/ River)	Uniqueness/ Heritage
Elders Point low marsh	0.31	0.55	0.72	0.18	0.52	1.0
Elders Point high marsh	0.55	0.93	0.68	0.24	N/A	1.0

Site	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/ River)	Uniqueness/ Heritage
Yellow Bar Hassock low marsh	0.31	0.55	0.89	0.31	0.52	1.0
Yellow Bar Hassock high marsh	-	1.0	0.53	0.13	-	1.0

For each proposed island, the FCIs were weighted by the island's high to low marsh ratios to capture each FCI accurately. These baseline acreages and FCIs were used to calculate EPW scores in the same manner as described in Section 2.2 of this appendix. Proportional changes in each FCI over time were derived from the EPW assessments for the Meadowlark Marsh and Metromedia Tract restoration sites. For Elders Point Center, which has no existing above-water acreage, an average of the other islands' existing FCIs was used.

Ecological output for a given acre of marsh island is expected to be similar within Jamaica Bay, based on the prior EPW assessments for Elders Point East, Elders Point West, and Yellow Bar Hassock and the results of monitoring of the islands by the National Parks Service (NPS) and USACE. Existing acreages for the five (5) proposed marsh islands were estimated from Google Earth aerial imagery.

Table E-16. Existing Conditions Functional Capacity Indices for Recommended Marsh Island Restoration

Site	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream /River)	Uniqueness/ Heritage
Duck Point	0.42	0.74	0.72	0.22	0.29	1.0
Stony Creek	0.43	0.75	0.71	0.22	0.26	1.0
Pumpkin Patch West	0.36	0.69	0.74	0.22	0.34	1.0
Pumpkin Patch East	0.40	0.75	0.71	0.22	0.27	1.0
Elders Center	0.42	0.73	0.72	0.22	0.29	1.0

Scoring the Planned Wetlands

The EPW results of the FWOP and the proposed marsh islands were calculated using the functional capacity index (FCI) extrapolated from the 2004 analysis for the WAA (existing) and the Planned Wetland FCIs applied to each alternative. In the 2018 assessment (MFR#8), the areas were also re-calculated to account for Relative Sea Level Change as described in Sections 2.6. FCI calculations were performed in a Microsoft Excel© spreadsheet using the equations presented in the EPW manual (Bartoldus et al., 1994); all equations and spreadsheet cell references were validated.

Table E-17. Planned Wetland Functional Capacity Indices for Recommended Marsh Island Restoration

Site	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/ River)	Uniqueness/ Heritage
Duck Point	0.42	0.74	0.72	0.22	0.29	1.0
Stony Creek	0.43	0.75	0.71	0.22	0.26	1.0
Pumpkin Patch West	0.36	0.69	0.74	0.22	0.34	1.0
Pumpkin Patch East	0.40	0.75	0.71	0.22	0.27	1.0
Elders Center	0.42	0.73	0.72	0.22	0.29	1.0

4.3. Results

A relative sea level change analysis (RSLC) was conducted to aid ecosystem restoration planning and impact assessment of the recommended projects in the Planning Region (see Engineering Appendix C). All recommended sites in Jamaica Bay are expected to be effected by SLC; however, within the 50 year period of analysis results under the intermediate SLC curve show that sites will see a growth of low marsh due to high marsh to low marsh conversion and no loss of low marsh at the lower end until the years 40-50. This is because the low end of the low marsh elevation ranges have been designed at 1 foot above mean tide level (MTL) so there is no impact until sea level rises 1 foot. After 50 years, the analysis predicts that measures would need to put into place to prevent drowning of the marsh islands from continued SLR because there would be no room to migrate.

4.3.1. Duck Point

Duck Point TY50 comprises approximately 43 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and optimized Alternative 2 FCUs after 50 years are 0 and 31. Table E-18 presents a summary of

the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

4.3.2. Stony Creek

Stony Creek TY50 comprises approximately 57.5 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and optimized Alternative 1 FCUs after 50 years are 0 and 41.14. Table E-19 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

4.3.3. Pumpkin Patch West

Pumpkin Patch West TY50 comprises approximately 26.7 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and optimized Alternative 2 FCUs after 50 years are 0 and 19.4. Table E-20 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

4.3.4. Pumpkin Patch East

Pumpkin Patch East TY50 comprises approximately 31.8 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and optimized Alternative 3 FCUs after 50 years are 0 and 22.86. Table E-21 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

4.3.5. Elders Center

Elders Center TY50 comprises approximately 29.4 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and optimized Alternative 3 FCUs after 50 years are 0 and 21.23. Table E-22 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

Table E-18. EPW Output Summary Duck Point

	Year	Output	FWOP	Alt 1	Alt 2	Alt 3	Optimized FWOP	Optimized Alt 2
Unrestored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.74	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	7	7	7	7	7	7
	T2	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	7	0	0	0	7	0
	T20	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	5	0	0	0	5	0
	T50	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.74	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.42	0.39	0.39	0.39	0.42	0.39
		FCI-SS	0.73	0.46	0.46	0.46	0.73	0.46
		FCI-WQ	0.72	0.91	0.91	0.91	0.72	0.91
		FCI-WL	0.22	0.61	0.61	0.61	0.22	0.61
		FCI-FS	0.29	0.36	0.36	0.36	0.29	0.36
		Area	0	27.9	39	44.41	0	47.2
	T20	FCI-SB	0.42	0.56	0.56	0.56	0.42	0.56
		FCI-SS	0.73	0.74	0.74	0.74	0.73	0.74
		FCI-WQ	0.72	1	1	1	0.72	1
		FCI-WL	0.22	0.86	0.86	0.86	0.22	0.86
		FCI-FS	0.29	0.45	0.45	0.45	0.29	0.45
		Area	0	25.6	38.12	44.29	0	45.52
	T50	FCI-SB	0.42	0.56	0.56	0.56	0.42	0.56
		FCI-SS	0.73	0.74	0.74	0.74	0.73	0.74
		FCI-WQ	0.72	1	1	1	0.72	1
		FCI-WL	0.22	0.86	0.86	0.86	0.22	0.86
		FCI-FS	0.29	0.45	0.45	0.45	0.29	0.45
		Area	0	21.8	30.72	36.59	0	42.93
Total	**T0**	**FCU**	**3.33**	**3.33**	**3.33**	**3.33**	**3.35**	**3.33**
	T2	**FCU**	**3.33**	**15.23**	**21.29**	**24.25**	**3.33**	**25.77**
	T20	**FCU**	**2.38**	**18.48**	**27.52**	**31.98**	**2.38**	**32.87**
	T50	**FCU**	**0**	**15.74**	**22.18**	**26.42**	**0**	**31**

Table E-19. EPW Output Summary Stony Creek

	Year	Output	FWOP	Alt 1	Alt 2	Alt 3	Optimized FWOP	Optimized Alt 1
Unrestored	T0	FCI-SB	0.43	0.43	0.43	0.43	0.43	0.43
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.26	0.26	0.26	0.26	0.26	0.26
		Area	10	10	10	10	10	10
	T2	FCI-SB	0.43	0.43	0.43	0.43	0.43	0.43
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.26	0.26	0.26	0.26	0.26	0.26
		Area	10	0	0	0	10	0
	T20	FCI-SB	0.43	0.43	0.43	0.43	0.43	0.43
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.26	0.26	0.26	0.26	0.26	0.26
		Area	7	0	0	0	7	0
	T50	FCI-SB	0.43	0.43	0.43	0.43	0.43	0.43
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.26	0.26	0.26	0.26	0.26	0.26
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.43	0.43	0.43	0.43	0.43	0.43
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.26	0.26	0.26	0.26	0.26	0.26
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.43	0.4	0.4	0.4	0.43	0.4
		FCI-SS	0.75	0.47	0.47	0.47	0.75	0.47
		FCI-WQ	0.71	0.9	0.9	0.9	0.71	0.9
		FCI-WL	0.22	0.6	0.6	0.6	0.22	0.6
		FCI-FS	0.26	0.33	0.33	0.33	0.26	0.33
		Area	0	49.2	39.65	31.34	0	62.09
	T20	FCI-SB	0.43	0.57	0.57	0.57	0.43	0.57
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	1	1	1	0.71	1
		FCI-WL	0.22	0.85	0.85	0.85	0.22	0.85
		FCI-FS	0.26	0.41	0.41	0.41	0.26	0.41
		Area	0	49	34.3	27.7	0	60.55
	T50	FCI-SB	0.43	0.57	0.57	0.57	0.43	0.57
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	1	1	1	0.71	1
		FCI-WL	0.22	0.85	0.85	0.85	0.22	0.85
		FCI-FS	0.26	0.41	0.41	0.41	0.26	0.41
		Area	0	44.9	25.2	21.3	0	57.46
Total	**T0**	**FCU**	**4.74**	**4.74**	**4.74**	**4.74**	**4.74**	**4.74**
	T2	**FCU**	**4.74**	**26.57**	**21.41**	**16.92**	**4.74**	**33.53**
	T20	**FCU**	**3.32**	**35.08**	**24.56**	**19.83**	**3.32**	**43.35**
	T50	**FCU**	**0**	**32.15**	**18.04**	**15.25**	**0**	**41.14**

Table E-20. EPW Output Summary Pumpkin Patch West

	Year	Output	FWOP	Alt 1	Alt 2	Alt 3	Optimized FWOP	Optimized Alt 2
Unrestored	T0	FCI-SB	0.39	0.39	0.39	0.39	0.36	0.39
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	0.74	0.74	0.74	0.74	0.74
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.34	0.34	0.34	0.34	0.34	0.34
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.39	0.39	0.39	0.39	0.39	0.39
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	0.74	0.74	0.74	0.74	0.74
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.34	0.34	0.34	0.34	0.34	0.34
		Area	0	0	0	0	0	0
	T20	FCI-SB	0.39	0.39	0.39	0.39	0.39	0.39
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	0.74	0.74	0.74	0.74	0.74
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.34	0.34	0.34	0.34	0.34	0.34
		Area	0	0	0	0	0	0
	T50	FCI-SB	0.39	0.39	0.39	0.39	0.39	0.39
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	0.74	0.74	0.74	0.74	0.74
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.34	0.34	0.34	0.34	0.34	0.34
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.39	0.39	0.39	0.39	0.36	0.39
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	0.74	0.74	0.74	0.74	0.74
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.34	0.34	0.34	0.34	0.34	0.34
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.39	0.36	0.36	0.36	0.39	0.36
		FCI-SS	0.69	0.43	0.43	0.43	0.69	0.43
		FCI-WQ	0.74	0.94	0.94	0.94	0.74	0.94
		FCI-WL	0.22	0.63	0.63	0.63	0.22	0.63
		FCI-FS	0.34	0.43	0.43	0.43	0.34	0.43
		Area	0	16.3	23.22	29.6	0	27.83
	T20	FCI-SB	0.39	0.52	0.52	0.52	0.39	0.52
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	1	1	1	0.74	1
		FCI-WL	0.22	0.88	0.88	0.88	0.22	0.88
		FCI-FS	0.34	0.54	0.54	0.54	0.34	0.54
		Area	0	15.2	18.2	28.2	0	27.28
	T50	FCI-SB	0.39	0.52	0.52	0.52	0.39	0.52
		FCI-SS	0.69	0.69	0.69	0.69	0.69	0.69
		FCI-WQ	0.74	1	1	1	0.74	1
		FCI-WL	0.22	0.88	0.88	0.88	0.22	0.88
		FCI-FS	0.34	0.54	0.54	0.54	0.34	0.54
		Area	0	12.8	17.2	22.7	0	26.72
Total	**T0**	**FCU**	**0**	**0**	**0**	**0**	**0**	**0**
	T2	**FCU**	**0**	**9.1**	**12.96**	**16.52**	**0**	**15.53**
	T20	**FCU**	**0**	**11.04**	**13.21**	**20.47**	**0**	**19.81**
	T50	**FCU**	**0**	**9.29**	**12.49**	**16.48**	**0**	**19.4**

Table E-21. EPW Output Summary Pumpkin Patch East

	Year	Output	FWOP	Alt 1	Alt 2	Alt 3	Optimized FWOP	Optimized Alt 3
Unrestored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.4	0.42
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.27	0.27	0.27	0.27	0.27	0.27
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.27	0.27	0.27	0.27	0.27	0.27
		Area	0	0	0	0	0	0
	T20	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.27	0.27	0.27	0.27	0.27	0.27
		Area	0	0	0	0	0	0
	T50	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.27	0.27	0.27	0.27	0.27	0.27
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.4	0.42
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	0.71	0.71	0.71	0.71	0.71
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.27	0.27	0.27	0.27	0.27	0.27
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.42	0.39	0.39	0.39	0.42	0.39
		FCI-SS	0.75	0.46	0.46	0.46	0.75	0.46
		FCI-WQ	0.71	0.9	0.9	0.9	0.71	0.9
		FCI-WL	0.22	0.6	0.6	0.6	0.22	0.6
		FCI-FS	0.27	0.34	0.34	0.34	0.27	0.34
		Area	0	33.9	21.39	28.86	0	34.6
	T20	FCI-SB	0.42	0.57	0.57	0.57	0.42	0.57
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	1	1	1	0.71	1
		FCI-WL	0.22	0.85	0.85	0.85	0.22	0.85
		FCI-FS	0.27	0.43	0.43	0.43	0.27	0.43
		Area	0	33.7	21.23	27.23	0	33.33
	T50	FCI-SB	0.42	0.57	0.57	0.57	0.42	0.57
		FCI-SS	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WQ	0.71	1	1	1	0.71	1
		FCI-WL	0.22	0.85	0.85	0.85	0.22	0.85
		FCI-FS	0.27	0.43	0.43	0.43	0.27	0.43
		Area	0	30	17.93	23.03	0	31.75
Total	**T0**	**FCU**	**0**	**0**	**0**	**0**	**0**	**0**
	T2	**FCU**	**0**	**18.24**	**11.51**	**15.53**	**0**	**18.61**
	T20	**FCU**	**0**	**24.26**	**15.29**	**19.61**	**0**	**24**
	T50	**FCU**	**0**	**21.6**	**12.91**	**16.58**	**0**	**22.86**

Table E-22. EPW Output Summary Elders Center

	Year	Output	FWOP	Alt 1	Alt 2	Alt 3	Optimized FWOP	Optimized Alt 3
Unrestored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
	T20	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
	T50	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.42	0.42	0.42	0.42	0.42	0.42
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	0.72	0.72	0.72	0.72	0.72
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.29	0.29	0.29	0.29	0.29	0.29
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.42	0.39	0.39	0.39	0.42	0.39
		FCI-SS	0.73	0.45	0.45	0.45	0.73	0.45
		FCI-WQ	0.72	0.91	0.91	0.91	0.72	0.91
		FCI-WL	0.22	0.61	0.61	0.61	0.22	0.61
		FCI-FS	0.29	0.36	0.36	0.36	0.29	0.36
		Area	0	15.1	18.28	29.28	0	33.94
	T20	FCI-SB	0.42	0.56	0.56	0.56	0.42	0.56
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	1	1	1	0.72	1
		FCI-WL	0.22	0.86	0.86	0.86	0.22	0.86
		FCI-FS	0.29	0.46	0.46	0.46	0.29	0.46
		Area	0	15.2	18.96	32.11	0	33.28
	T50	FCI-SB	0.42	0.56	0.56	0.56	0.42	0.56
		FCI-SS	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-WQ	0.72	1	1	1	0.72	1
		FCI-WL	0.22	0.86	0.86	0.86	0.22	0.86
		FCI-FS	0.29	0.46	0.46	0.46	0.29	0.46
		Area	0	13.8	16.06	27.31	0	29.41
Total	**T0**	**FCU**	**0**	**0**	**0**	**0**	**0**	**0**
	T2	**FCU**	**0**	**8.21**	**9.94**	**15.93**	**0**	**18.46**
	T20	**FCU**	**0**	**10.97**	**13.69**	**23.18**	**0**	**24.03**
	T50	**FCU**	**0**	**9.96**	**11.6**	**19.72**	**0**	**21.23**

5. Flushing Creek

5.1. Background

The Flushing Creek environmental benefits assessment includes a site screening evaluation and EPW assessment for Flushing Creek. As part of the initial Flushing Creek and Bay "source" study, problems and opportunities were identified, alternatives were developed and a recommended alternative was identified within the study area in 2007. New York City Department of Environmental Protection (NYCDEP) did not concur with the recommended plan given there was an intent to better coordinate NYCDEP's Long Term Control Plan and environmental dredging. Subsequently, NYCDEP conducted additional field investigations in Flushing Creek and three additional conceptual alternatives were developed optimizing the 2007 alternative. These alternatives and acreages were used as the basis for an EPW assessment conducted by the NYCDEP in 2014 as part of the HRE Study.

The first set of alternatives developed under HRE were based on the FWOP assumptions (during 2013-2018) that NYCDEP would environmentally dredge the creek adjacent the restoration site. In 2018, following the release of the draft FR/EA, NYCDEP indicated their agency no longer had plans to conduct dredging in the creek. Given the change in FWOP, the HRE alternatives were reformulated with the assumption that no dredging would occur in the future without project conditions. The three new reformulated alternatives are presented in the analysis below. FCI data assigned to the 2014 single planned wetland alternative was applied to the three alternatives as the projected habitat benefits were assumed to be the same in similar habitats, only the areas had changed.

Habitat types that were calculated in the EPW analysis for Flushing Creek included: shallows, low marsh, high marsh, and scrub/shrub. The FWOP for the unrestored areas at the Flushing Creek site was assumed to be a continuation of the existing condition, therefore, existing areas of the above listed habitat types were summed through a GIS analysis to develop the FWOP area. Existing condition FCI scores from the 2014 field effort were used and an assumption was made that although the footprint expanded, it was similar habitat quality. For the restored areas, the FWOP area is zero in all years.

5.2. Methods

The EPW results of the FWOP and 2019 alternatives were recalculated for using the functional capacity index (FCI) from the 2014 WAA and the Planned Wetland FCIs. The recommended alternative was optimized to account for Relative Sea Level Change as described in Sections 2.6. FCI calculations were performed in a Microsoft Excel© spreadsheet using the equations presented in the EPW manual (Bartoldus et al., 1994); all equations and spreadsheet cell references were validated

5.3. Results

Flushing Creek TY50 comprises approximately 15.4 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternative were evaluated for this site. The FWOP and Alt B Optimized FCUs for this alternative after 50 years are 4.38 and 12.87. Table E-23 presents a summary of the EPW output for the FWOP and three alternatives, the optimized

FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

Table E-23. EPW Output Summary Flushing Creek

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt B
Unrestored	T0	FCI-SB	0.27	0.27	0.27	0.27	0.27	0.27
		FCI-SS	0.55	0.55	0.55	0.55	0.55	0.55
		FCI-WQ	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WL	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-FS	0.28	0.28	0.28	0.28	0.28	0.28
		Area	9.91	9.91	9.91	9.91	9.91	9.91
	T2	FCI-SB	0.27	0.27	0.27	0.27	0.27	0.27
		FCI-SS	0.55	0.55	0.55	0.55	0.55	0.55
		FCI-WQ	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WL	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-FS	0.28	0.28	0.28	0.28	0.28	0.28
		Area	9.91	3.58	1.12	0	9.91	1.12
	T20	FCI-SB	0.27	0.27	0.27	0.27	0.27	0.27
		FCI-SS	0.55	0.55	0.55	0.55	0.55	0.55
		FCI-WQ	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WL	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-FS	0.28	0.28	0.28	0.28	0.28	0.28
		Area	9.91	3.58	1.12	0	9.91	1.12
	T50	FCI-SB	0.27	0.27	0.27	0.27	0.27	0.27
		FCI-SS	0.55	0.55	0.55	0.55	0.55	0.55
		FCI-WQ	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WL	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-FS	0.28	0.28	0.28	0.28	0.28	0.28
		Area	9.91	3.58	1.12	0	9.91	1.12
Restored	T0	FCI-SB	0.27	0.27	0.27	0.27	0.27	0.27
		FCI-SS	0.55	0.55	0.55	0.55	0.55	0.55
		FCI-WQ	0.75	0.75	0.75	0.75	0.75	0.75
		FCI-WL	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-FS	0.28	0.28	0.28	0.28	0.28	0.28
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.27	0.89	0.89	0.89	0.27	0.89
		FCI-SS	0.55	1	1	1	0.55	1
		FCI-WQ	0.75	0.98	0.98	0.98	0.75	0.98
		FCI-WL	0.36	0.52	0.52	0.52	0.36	0.52
		FCI-FS	0.28	0.62	0.62	0.62	0.28	0.62
		Area	0	10.07	14.3	15.42	0	15.4
	T20	FCI-SB	0.27	0.89	0.89	0.89	0.27	0.89
		FCI-SS	0.55	1	1	1	0.55	1
		FCI-WQ	0.75	0.98	0.98	0.98	0.75	0.98
		FCI-WL	0.36	0.52	0.52	0.52	0.36	0.52
		FCI-FS	0.28	0.62	0.62	0.62	0.28	0.62
		Area	0	10.07	14.3	15.42	0	15.27
	T50	FCI-SB	0.27	0.89	0.89	0.89	0.27	0.89
		FCI-SS	0.55	1	1	1	0.55	1
		FCI-WQ	0.75	0.98	0.98	0.98	0.75	0.98
		FCI-WL	0.36	0.52	0.52	0.52	0.36	0.52
		FCI-FS	0.28	0.62	0.62	0.62	0.28	0.62
		Area	0	9.57	13.59	14.65	0	15.43
Total	**T0**	**FCU**	**4.38**	**4.38**	**4.38**	**4.38**	**4.38**	**4.38**
	T2	**FCU**	**4.38**	**9.66**	**11.96**	**12.37**	**4.38**	**12.85**
	T20	**FCU**	**4.38**	**9.66**	**11.96**	**12.37**	**4.38**	**12.74**
	T50	**FCU**	**4.38**	**9.25**	**11.39**	**11.75**	**4.38**	**12.87**

6. Bronx River

6.1. Background

The Bronx River environmental benefits assessment includes a site screening evaluation and EPW assessment for the following sites along the Bronx River; Bronx Zoo and Dam, Stone Mill Dam, Shoelace Park, Bronxville Lake, Garth Harney, West Farm Rapids Park, Muskrat Cove, Crestwood Lake, and Westchester County Center. The EPW assessment was performed on each site for existing and proposed conditions for each of the three alternatives as well as future without project conditions.

Habitat types that were calculated in the EPW analysis for Bronx River sites included: emergent wetland, wet meadow, forest scrub/shrub, native plantings, forebay, bed restoration, and streambank restoration. As described in Section 2.2, riparian buffer and shallow water habitat directly supporting the wetland were included in this analysis. The FWOP for the unrestored areas of the Bronx River sites was assumed to be a continuation of the existing condition and areas were determined through EPW field work investigations conducted in 2014. For the restored areas, the FWOP area for the restored areas is zero in all years.

6.2. Methods

EPW was conducted as described in Section 2.2. Field work to establish existing conditions and inform alternatives formulation was conducted in June 2014.

Upon arrival at each site, the team started the investigation at the downstream location and traversed upstream examining the stream channel, any adjacent wetlands, and the surrounding upland buffers on both sides of the river. Specific field data collection included GPS information for specific features, photographs, and hand-sketches of existing terrestrial and aquatic habitats and vegetative communities within the site's project boundary. Habitats were classified as per the *Ecological Communities of New York State*[6], although, due to the high degree of disturbance identified at most sites, many habitats were urban in nature.

To support the EPW during the field investigations, the team identified various conditions and features including:

- stream channel/bank and riparian buffer/upland conditions;
- dominant vegetation in each habitat/vegetative community;
- anticipated fauna usage within each habitat;
- outfalls and other conveyances of hydrology;
- human-induced and natural/wildlife impacts; and
- evidence of flooding and water level fluctuations.

[6]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.

Concurrent with the field investigations, desktop studies of potential uniqueness and heritage elements, as well as water quality classifications, were gathered for each site.

Following the field investigations, the senior ecologist and senior ecological engineer met together to complete the EPW data sheets and subsequently scored the alternatives. Following the completion of the baseline sheets for all the sites, the sheets and the resulting Functional Capacity Index (FCIs) scores were re-reviewed and compared to ensure that the various elements were scored consistently across the sites.

As per the EPW handbook, for each element, there are certain rationale and assumptions that need to be considered during the assessment procedure. In general, the typical metrics (e.g. contact once annually or less, Slope <10:1, etc.) in the handbook and on field data sheets were followed. However, there were a few elements for which the condition assessment metric given on the field data sheet was not applicable to this project. For these instances, the field team selected more appropriate condition assessments on which to base the EPW scoring. These include:

- *10. Vegetation Characteristics During Growing Season (note differences in definitions for upper shore zone, lower shore zone, and entire wetland) – Due to the fact that the wetlands assessed at most sites were very narrow and in most cases, quite steep (2:1 or steeper), an assumption was made for the evaluation of the 'lower" and 'upper' shore zones. The 'lower shore zone' was designated as the portion of the bank that was typically wetted and/or saturated under normal water level conditions; the 'upper shore zone' was designated as the higher portion of the bank that was rarely inundated but could still support wetland vegetation and/or exhibit signs of wetland hydrology.*
- *11a. Number of Layer in Banks – Determination was made to include 'water column, open water below 25cm (10in) in depth' in the wetland layers only at sites where the water flow did not prohibit the growth of hydrophytic vascular vegetation.*
- *14a. Steepness of Existing Shore & 14b Steepness of Planned Wetland Shore –For these project sites, the potential for shoreline stabilization is not based upon whether or not existing conditions would allow for the construction of a shallow-sloped wetland, but rather whether or not existing infrastructure would prevent shoreline improvements. Therefore, the field team applied the metric "Constructible" and "Not Constructible" in lieu of specific slope ratios.*
- *27a. Spawning Substrate, Accessible During Spawning Periods – Assumed substrate dominated by large, anthropogenic construction debris (e.g. bricks, concrete blocks, etc.) fell under choice 'c. Boulders, bedrock or fines (e.g., silt, mud, clay).'*

6.3. Results

6.3.1. Bronx Zoo and Dam

Bronx Zoo and Dam TY50 comprises approximately 1.98 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative A FCUs after 50 years are 0.16 and 1.01, respectively. Table E-24 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0),

following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. Additional benefits at this site are quantified in Section 9 of this Appendix.

6.3.2. Stone Mill Dam

Stone Mill Dam TY50 comprises approximately 0.5 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative A FCUs after 50 years are 0 and 0.25, respectively. Table E-25 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. Additional benefits at this site are quantified in Section 9 of this Appendix.

6.3.3. Shoelace Park

Shoelace Park TY50 comprises approximately 18 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative B FCUs after 50 years are 0 and 9.5, respectively. Table E-26 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

6.3.4. Bronxville Lake

Bronxville Lake TY50 comprises approximately 5.8 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative B FCUs after 50 years are 0.13 and 3.89, respectively. Table E-27 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

6.3.5. Garth Harney

Garth Harney TY50 comprises approximately 6.6 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative A FCUs after 50 years are 0.24 and 4.46, respectively. Table E-28 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

6.3.6. West Farm Rapids Park

West Farms Rapids Park TY50 comprises approximately 0.94 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and recommended Alternative A FCUs after 50 years are 0 and 0.48, respectively. Table E-29 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

6.3.7. Muskrat Cove

Muskrat Cove TY50 comprises approximately 1.26 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and recommended Alternative A FCUs after 50 years are 0.01 and 0.65, respectively. Table E-30 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

6.3.8. Crestwood Lake

Crestwood Lake TY50 comprises approximately 7.5 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and recommended Alternative A FCUs after 50 years are 1.03 and 5.87, respectively. Table E-31 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

6.3.9. Westchester County Center

Westchester Count Center TY50 comprises approximately 6.7 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and recommended Alternative A FCUs after 50 years are 0.6 and 4.93, respectively. Table E-32 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

Table E-24. EPW Output Summary Bronx Zoo and Dam

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt A
Unrestored	T0	FCI-SB	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-SS	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0.43	0.43	0.43	0.43	0.43	0.43
	T2	FCI-SB	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-SS	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0.43	0	0	0	0.43	0
	T20	FCI-SB	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-SS	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0.43	0	0	0	0.43	0
	T50	FCI-SB	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-SS	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0.41	0	0	0	0.41	0
Restored	T0	FCI-SB	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-SS	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.22	0.22	0.22	0.22	0.22	0.22
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.35	0.53	0.52	0.35	0.35	0.53
		FCI-SS	0.63	0.84	0.84	0.77	0.63	0.84
		FCI-WQ	0.36	0.43	0.43	0.42	0.36	0.43
		FCI-WL	0.22	0.34	0.26	0.25	0.22	0.34
		FCI-FS	0.37	0.41	0.41	0.39	0.37	0.41
		Area	0	1.69	1.12	0.56	0	2.09
	T20	FCI-SB	0.35	0.53	0.52	0.35	0.35	0.53
		FCI-SS	0.63	0.84	0.84	0.77	0.63	0.84
		FCI-WQ	0.36	0.43	0.43	0.42	0.36	0.43
		FCI-WL	0.22	0.34	0.26	0.25	0.22	0.34
		FCI-FS	0.37	0.41	0.41	0.39	0.37	0.41
		Area	0	1.69	1.12	0.56	0	2.09
	T50	FCI-SB	0.35	0.53	0.52	0.35	0.35	0.53
		FCI-SS	0.63	0.84	0.84	0.77	0.63	0.84
		FCI-WQ	0.36	0.43	0.43	0.42	0.36	0.43
		FCI-WL	0.22	0.34	0.26	0.25	0.22	0.34
		FCI-FS	0.37	0.41	0.41	0.39	0.37	0.41
		Area	0	1.61	1.06	0.53	0	1.98
Total	**T0**	**FCU**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**
	T2	**FCU**	**0.17**	**0.86**	**0.55**	**0.24**	**0.17**	**1.06**
	T20	**FCU**	**0.17**	**0.86**	**0.55**	**0.24**	**0.17**	**1.06**
	T50	**FCU**	**0.16**	**0.82**	**0.52**	**0.23**	**0.16**	**1.01**

Table E-25. EPW Output Summary Stone Mill Dam

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt A
Unrestored	T0	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.4	0.4	0.4	0.4	0.4
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.4	0.4	0.4	0.4	0.4
		Area	0	0	0	0	0	0
	T20	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.4	0.4	0.4	0.4	0.4
		Area	0	0	0	0	0	0
	T50	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.4	0.4	0.4	0.4	0.4
		Area	0	0	0	0	0	0
Restored	T0	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.36	0.36	0.36	0.36	0.36
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.4	0.4	0.4	0.4	0.4
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.39	0.38	0.46	0.36	0.39
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.58	0.61	0.58	0.4	0.58
		Area	0	0.02	0.02	0.09	0	0.53
	T20	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.39	0.38	0.46	0.36	0.39
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.58	0.61	0.58	0.4	0.58
		Area	0	0.02	0.02	0.09	0	0.53
	T50	FCI-SB	0.8	0.8	0.8	0.8	0.8	0.8
		FCI-SS	0.56	0.56	0.56	0.56	0.56	0.56
		FCI-WQ	0.36	0.39	0.38	0.46	0.36	0.39
		FCI-WL	0.12	0.12	0.12	0.12	0.12	0.12
		FCI-FS	0.4	0.58	0.61	0.58	0.4	0.58
		Area	0	0.02	0.02	0.08	0	0.51
Total	**T0**	**FCU**	**0**	**0**	**0**	**0**	**0**	**0**
	T2	**FCU**	**0**	**0.01**	**0.01**	**0.04**	**0**	**0.26**
	T20	**FCU**	**0**	**0.01**	**0.01**	**0.04**	**0**	**0.26**
	T50	**FCU**	**0**	**0.01**	**0.01**	**0.04**	**0**	**0.25**

Table E-26. EPW Output Summary Shoelace Park

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt B
Unrestored	T0	FCI-SB	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-SS	0.16	0.16	0.16	0.16	0.16	0.16
		FCI-WQ	0.28	0.28	0.28	0.28	0.28	0.28
		FCI-WL	0.15	0.15	0.15	0.15	0.15	0.15
		FCI-FS	0.35	0.35	0.35	0.35	0.35	0.35
		Area	0.02	0.02	0.02	0.02	0.02	0.02
	T2	FCI-SB	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-SS	0.16	0.16	0.16	0.16	0.16	0.16
		FCI-WQ	0.28	0.28	0.28	0.28	0.28	0.28
		FCI-WL	0.15	0.15	0.15	0.15	0.15	0.15
		FCI-FS	0.35	0.35	0.35	0.35	0.35	0.35
		Area	0.02	0	0	0	0.02	0
	T20	FCI-SB	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-SS	0.16	0.16	0.16	0.16	0.16	0.16
		FCI-WQ	0.28	0.28	0.28	0.28	0.28	0.28
		FCI-WL	0.15	0.15	0.15	0.15	0.15	0.15
		FCI-FS	0.35	0.35	0.35	0.35	0.35	0.35
		Area	0.02	0	0	0	0.02	0
	T50	FCI-SB	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-SS	0.16	0.16	0.16	0.16	0.16	0.16
		FCI-WQ	0.28	0.28	0.28	0.28	0.28	0.28
		FCI-WL	0.15	0.15	0.15	0.15	0.15	0.15
		FCI-FS	0.35	0.35	0.35	0.35	0.35	0.35
		Area	0.02	0	0	0	0.02	0
Restored	T0	FCI-SB	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-SS	0.16	0.16	0.16	0.16	0.16	0.16
		FCI-WQ	0.28	0.28	0.28	0.28	0.28	0.28
		FCI-WL	0.15	0.15	0.15	0.15	0.15	0.15
		FCI-FS	0.35	0.35	0.35	0.35	0.35	0.35
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.32	0.71	0.71	0.61	0.32	0.71
		FCI-SS	0.16	0.86	0.86	0.48	0.16	0.86
		FCI-WQ	0.28	0.4	0.4	0.33	0.28	0.4
		FCI-WL	0.15	0.22	0.22	0.22	0.15	0.22
		FCI-FS	0.35	0.46	0.46	0.47	0.35	0.46
		Area	0	11.21	9.73	4.09	0	18.86
	T20	FCI-SB	0.32	0.71	0.71	0.61	0.32	0.71
		FCI-SS	0.16	0.86	0.86	0.48	0.16	0.86
		FCI-WQ	0.28	0.4	0.4	0.33	0.28	0.4
		FCI-WL	0.15	0.22	0.22	0.22	0.15	0.22
		FCI-FS	0.35	0.46	0.46	0.47	0.35	0.46
		Area	0	11.21	9.73	4.09	0	18.86
	T50	FCI-SB	0.32	0.71	0.71	0.61	0.32	0.71
		FCI-SS	0.16	0.86	0.86	0.48	0.16	0.86
		FCI-WQ	0.28	0.4	0.4	0.33	0.28	0.4
		FCI-WL	0.15	0.22	0.22	0.22	0.15	0.22
		FCI-FS	0.35	0.46	0.46	0.47	0.35	0.46
		Area	0	10.65	9.25	3.89	0	17.92
Total	**T0**	**FCU**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
	T2	**FCU**	**0.01**	**5.94**	**5.16**	**1.73**	**0.01**	**10**
	T20	**FCU**	**0.01**	**5.94**	**5.16**	**1.73**	**0.01**	**10**
	T50	**FCU**	**0**	**5.64**	**4.9**	**1.64**	**0**	**9.5**

Table E-27. EPW Output Summary Bronxville Lake

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt B
Unrestored	T0	FCI-SB	0.54	0.54	0.54	0.54	0.54	0.54
		FCI-SS	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-WQ	0.51	0.51	0.51	0.51	0.51	0.51
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0.3	0.3	0.3	0.3	0.3	0.3
	T2	FCI-SB	0.54	0.54	0.54	0.54	0.54	0.54
		FCI-SS	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-WQ	0.51	0.51	0.51	0.51	0.51	0.51
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0.3	0	0	0	0.3	0
	T20	FCI-SB	0.54	0.54	0.54	0.54	0.54	0.54
		FCI-SS	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-WQ	0.51	0.51	0.51	0.51	0.51	0.51
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0.3	0	0	0	0.3	0
	T50	FCI-SB	0.54	0.54	0.54	0.54	0.54	0.54
		FCI-SS	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-WQ	0.51	0.51	0.51	0.51	0.51	0.51
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0.28	0	0	0	0.28	0
Restored	T0	FCI-SB	0.54	0.54	0.54	0.54	0.54	0.54
		FCI-SS	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-WQ	0.51	0.51	0.51	0.51	0.51	0.51
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.54	0.92	0.9	0.75	0.54	0.9
		FCI-SS	0.53	0.82	0.82	0.58	0.53	0.82
		FCI-WQ	0.51	0.84	0.8	0.6	0.51	0.8
		FCI-WL	0.23	0.41	0.41	0.37	0.23	0.41
		FCI-FS	0.43	0.53	0.43	0.59	0.43	0.43
		Area	0	6.74	6.1	5.14	0	6.1
	T20	FCI-SB	0.54	0.92	0.9	0.75	0.54	0.9
		FCI-SS	0.53	0.82	0.82	0.58	0.53	0.82
		FCI-WQ	0.51	0.84	0.8	0.6	0.51	0.8
		FCI-WL	0.23	0.41	0.41	0.37	0.23	0.41
		FCI-FS	0.43	0.53	0.43	0.59	0.43	0.43
		Area	0	6.74	6.1	5.14	0	6.1
	T50	FCI-SB	0.54	0.92	0.9	0.75	0.54	0.9
		FCI-SS	0.53	0.82	0.82	0.58	0.53	0.82
		FCI-WQ	0.51	0.84	0.8	0.6	0.51	0.8
		FCI-WL	0.23	0.51	0.41	0.37	0.23	0.41
		FCI-FS	0.43	0.53	0.43	0.59	0.43	0.43
		Area	0	6.4	5.79	4.88	0	5.79
Total	**T0**	**FCU**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
	T2	**FCU**	**0.13**	**4.74**	**4.1**	**2.97**	**0.13**	**4.1**
	T20	**FCU**	**0.13**	**4.74**	**4.1**	**2.97**	**0.13**	**4.1**
	T50	**FCU**	**0.13**	**4.63**	**3.89**	**2.82**	**0.13**	**3.89**

Table E-28. EPW Output Summary Garth Harney

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt A
Unrestored	T0	FCI-SB	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-SS	0.11	0.11	0.11	0.11	0.11	0.11
		FCI-WQ	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-WL	0.18	0.18	0.18	0.18	0.18	0.18
		FCI-FS	0.42	0.42	0.42	0.42	0.42	0.42
		Area	0.8	0.8	0.8	0.8	0.8	0.8
	T2	FCI-SB	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-SS	0.11	0.11	0.11	0.11	0.11	0.11
		FCI-WQ	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-WL	0.18	0.18	0.18	0.18	0.18	0.18
		FCI-FS	0.42	0.42	0.42	0.42	0.42	0.42
		Area	0.8	0	0	0	0.8	0
	T20	FCI-SB	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-SS	0.11	0.11	0.11	0.11	0.11	0.11
		FCI-WQ	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-WL	0.18	0.18	0.18	0.18	0.18	0.18
		FCI-FS	0.42	0.42	0.42	0.42	0.42	0.42
		Area	0.8	0	0	0	0.8	0
	T50	FCI-SB	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-SS	0.11	0.11	0.11	0.11	0.11	0.11
		FCI-WQ	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-WL	0.18	0.18	0.18	0.18	0.18	0.18
		FCI-FS	0.42	0.42	0.42	0.42	0.42	0.42
		Area	0.76	0	0	0	0.76	0
Restored	T0	FCI-SB	0.53	0.53	0.53	0.53	0.53	0.53
		FCI-SS	0.11	0.11	0.11	0.11	0.11	0.11
		FCI-WQ	0.32	0.32	0.32	0.32	0.32	0.32
		FCI-WL	0.18	0.18	0.18	0.18	0.18	0.18
		FCI-FS	0.42	0.42	0.42	0.42	0.42	0.42
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.53	0.93	0.74	0.74	0.53	0.93
		FCI-SS	0.11	0.73	0.81	0.58	0.11	0.73
		FCI-WQ	0.32	0.68	0.55	0.55	0.32	0.68
		FCI-WL	0.18	0.39	0.39	0.32	0.18	0.39
		FCI-FS	0.42	0.65	0.81	0.6	0.42	0.65
		Area	0	4.13	2.32	0.98	0	6.89
	T20	FCI-SB	0.53	0.93	0.74	0.74	0.53	0.93
		FCI-SS	0.11	0.73	0.81	0.58	0.11	0.73
		FCI-WQ	0.32	0.68	0.55	0.55	0.32	0.68
		FCI-WL	0.18	0.39	0.4	0.36	0.18	0.39
		FCI-FS	0.42	0.65	0.81	0.6	0.42	0.65
		Area	0	4.13	2.32	0.98	0	6.89
	T50	FCI-SB	0.53	0.93	0.74	0.74	0.53	0.93
		FCI-SS	0.11	0.75	0.85	0.68	0.11	0.75
		FCI-WQ	0.32	0.68	0.55	0.55	0.32	0.68
		FCI-WL	0.18	0.39	0.4	0.36	0.18	0.39
		FCI-FS	0.42	0.65	0.81	0.6	0.42	0.65
		Area	0	3.93	2.21	0.93	0	6.55
Total	**T0**	**FCU**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**
	T2	**FCU**	**0.25**	**2.79**	**1.53**	**0.55**	**0.25**	**4.66**
	T20	**FCU**	**0.25**	**2.79**	**1.54**	**0.56**	**0.25**	**4.66**
	T50	**FCU**	**0.24**	**2.67**	**1.48**	**0.55**	**0.24**	**4.46**

Table E-29. EPW Output Summary West Farm Rapids Park

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.66	0.66	0.66	0.66
		FCI-SS	0.51	0.51	0.51	0.51
		FCI-WQ	0.4	0.4	0.4	0.4
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.26	0.26	0.26	0.26
		Area	0	0	0	0
	T2	FCI-SB	0.66	0.66	0.66	0.66
		FCI-SS	0.51	0.51	0.51	0.51
		FCI-WQ	0.4	0.4	0.4	0.4
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.26	0.26	0.26	0.26
		Area	0	0	0	0
	T20	FCI-SB	0.66	0.66	0.66	0.66
		FCI-SS	0.51	0.51	0.51	0.51
		FCI-WQ	0.4	0.4	0.4	0.4
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.26	0.26	0.26	0.26
		Area	0	0	0	0
	T50	FCI-SB	0.66	0.66	0.66	0.66
		FCI-SS	0.51	0.51	0.51	0.51
		FCI-WQ	0.4	0.4	0.4	0.4
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.26	0.26	0.26	0.26
		Area	0	0	0	0
Restored	T0	FCI-SB	0.66	0.66	0.66	0.66
		FCI-SS	0.51	0.51	0.51	0.51
		FCI-WQ	0.4	0.4	0.4	0.4
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.26	0.26	0.26	0.26
		Area	0	0	0	0
	T2	FCI-SB	0.66	0.7	0.69	0.7
		FCI-SS	0.51	0.67	0.67	0.53
		FCI-WQ	0.4	0.46	0.46	0.36
		FCI-WL	0.11	0.18	0.17	0.16
		FCI-FS	0.26	0.53	0.53	0.44
		Area	0	0.99	0.85	0.43
	T20	FCI-SB	0.66	0.7	0.69	0.7
		FCI-SS	0.51	0.67	0.67	0.53
		FCI-WQ	0.4	0.46	0.46	0.36
		FCI-WL	0.11	0.18	0.17	0.16
		FCI-FS	0.26	0.53	0.53	0.44
		Area	0	0.99	0.85	0.43
	T50	FCI-SB	0.66	0.7	0.69	0.7
		FCI-SS	0.51	0.67	0.67	0.53
		FCI-WQ	0.4	0.46	0.46	0.41
		FCI-WL	0.11	0.18	0.17	0.16
		FCI-FS	0.26	0.53	0.53	0.44
		Area	0	0.94	0.81	0.41
Total	**T0**	**FCU**	**0**	**0**	**0**	**0**
	T2	**FCU**	**0**	**0.5**	**0.43**	**0.19**
	T20	**FCU**	**0**	**0.5**	**0.43**	**0.19**
	T50	**FCU**	**0**	**0.48**	**0.41**	**0.18**

Table E-30. EPW Output Summary Muskrat Cove

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.55	0.55	0.55	0.55
		FCI-SS	0.53	0.53	0.53	0.53
		FCI-WQ	0.34	0.34	0.34	0.34
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.44	0.44	0.44	0.44
		Area	0.02	0.02	0.02	0.02
	T2	FCI-SB	0.55	0.55	0.55	0.55
		FCI-SS	0.53	0.53	0.53	0.53
		FCI-WQ	0.34	0.34	0.34	0.34
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.44	0.44	0.44	0.44
		Area	0.02	0	0	0
	T20	FCI-SB	0.55	0.55	0.55	0.55
		FCI-SS	0.53	0.53	0.53	0.53
		FCI-WQ	0.34	0.34	0.34	0.34
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.44	0.44	0.44	0.44
		Area	0.02	0	0	0
	T50	FCI-SB	0.55	0.55	0.55	0.55
		FCI-SS	0.53	0.53	0.53	0.53
		FCI-WQ	0.34	0.34	0.34	0.34
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.44	0.44	0.44	0.44
		Area	0.02	0	0	0
Restored	T0	FCI-SB	0.55	0.55	0.55	0.55
		FCI-SS	0.53	0.53	0.53	0.53
		FCI-WQ	0.34	0.34	0.34	0.34
		FCI-WL	0.11	0.11	0.11	0.11
		FCI-FS	0.44	0.44	0.44	0.44
		Area	0	0	0	0
	T2	FCI-SB	0.55	0.74	0.74	0.59
		FCI-SS	0.53	0.67	0.67	0.67
		FCI-WQ	0.34	0.38	0.46	0.37
		FCI-WL	0.11	0.23	0.19	0.19
		FCI-FS	0.44	0.55	0.55	0.45
		Area	0	1.33	1.33	0.37
	T20	FCI-SB	0.55	0.74	0.74	0.59
		FCI-SS	0.53	0.67	0.67	0.67
		FCI-WQ	0.34	0.38	0.46	0.37
		FCI-WL	0.11	0.23	0.19	0.19
		FCI-FS	0.44	0.55	0.55	0.45
		Area	0	1.33	1.33	0.37
	T50	FCI-SB	0.55	0.74	0.74	0.59
		FCI-SS	0.53	0.67	0.67	0.67
		FCI-WQ	0.34	0.38	0.46	0.37
		FCI-WL	0.11	0.23	0.19	0.19
		FCI-FS	0.44	0.55	0.55	0.45
		Area	0	1.26	1.26	0.35
Total	**T0**	**FCU**	**0.01**	**0.01**	**0.01**	**0.01**
	T2	**FCU**	**0.01**	**0.68**	**0.69**	**0.17**
	T20	**FCU**	**0.01**	**0.68**	**0.69**	**0.17**
	T50	**FCU**	**0.01**	**0.65**	**0.66**	**0.16**

Table E-31. EPW Output Summary Crestwood Lake

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.85	0.85	0.85	0.85
		FCI-SS	0.57	0.57	0.57	0.57
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.35	0.35	0.35	0.35
		FCI-FS	0.36	0.36	0.36	0.36
		Area	2	2	2	2
	T2	FCI-SB	0.85	0.85	0.85	0.85
		FCI-SS	0.57	0.57	0.57	0.57
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.35	0.35	0.35	0.35
		FCI-FS	0.36	0.36	0.36	0.36
		Area	2	0	0	0
	T20	FCI-SB	0.85	0.85	0.85	0.85
		FCI-SS	0.57	0.57	0.57	0.57
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.35	0.35	0.35	0.35
		FCI-FS	0.36	0.36	0.36	0.36
		Area	2	0	0	0
	T50	FCI-SB	0.85	0.85	0.85	0.85
		FCI-SS	0.57	0.57	0.57	0.57
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.35	0.35	0.35	0.35
		FCI-FS	0.36	0.36	0.36	0.36
		Area	1.9	0	0	0
Restored	T0	FCI-SB	0.85	0.85	0.85	0.85
		FCI-SS	0.57	0.57	0.57	0.57
		FCI-WQ	0.57	0.57	0.57	0.57
		FCI-WL	0.35	0.35	0.35	0.35
		FCI-FS	0.36	0.36	0.36	0.36
		Area	0	0	0	0
	T2	FCI-SB	0.85	0.95	0.95	0.96
		FCI-SS	0.57	0.87	0.82	0.67
		FCI-WQ	0.57	0.81	0.62	0.57
		FCI-WL	0.35	0.6	0.35	0.35
		FCI-FS	0.36	0.67	0.38	0.49
		Area	0	7.92	4.07	3.42
	T20	FCI-SB	0.85	0.95	0.95	0.96
		FCI-SS	0.57	0.87	0.82	0.67
		FCI-WQ	0.57	0.81	0.62	0.57
		FCI-WL	0.35	0.6	0.35	0.35
		FCI-FS	0.36	0.67	0.38	0.49
		Area	0	7.92	4.07	3.42
	T50	FCI-SB	0.85	0.95	0.95	0.96
		FCI-SS	0.57	0.87	0.82	0.67
		FCI-WQ	0.57	0.81	0.62	0.57
		FCI-WL	0.35	0.6	0.35	0.35
		FCI-FS	0.36	0.67	0.38	0.49
		Area	0	7.53	3.87	3.25
Total	**T0**	**FCU**	**1.08**	**1.08**	**1.08**	**1.08**
	T2	**FCU**	**1.08**	**6.18**	**2.54**	**2.08**
	T20	**FCU**	**1.08**	**6.18**	**2.54**	**2.08**
	T50	**FCU**	**1.03**	**5.87**	**2.41**	**1.98**

Table E-32. EPW Output Summary Westchester County Center

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.53	0.53	0.53	0.53
		FCI-SS	0.14	0.14	0.14	0.14
		FCI-WQ	0.3	0.3	0.3	0.3
		FCI-WL	0.15	0.15	0.15	0.15
		FCI-FS	0.45	0.45	0.45	0.45
		Area	2	2	2	2
	T2	FCI-SB	0.53	0.53	0.53	0.53
		FCI-SS	0.14	0.14	0.14	0.14
		FCI-WQ	0.3	0.3	0.3	0.3
		FCI-WL	0.15	0.15	0.15	0.15
		FCI-FS	0.45	0.45	0.45	0.45
		Area	2	0	0	0
	T20	FCI-SB	0.53	0.53	0.53	0.53
		FCI-SS	0.14	0.14	0.14	0.14
		FCI-WQ	0.3	0.3	0.3	0.3
		FCI-WL	0.15	0.15	0.15	0.15
		FCI-FS	0.45	0.45	0.45	0.45
		Area	2	0	0	0
	T50	FCI-SB	0.53	0.53	0.53	0.53
		FCI-SS	0.14	0.14	0.14	0.14
		FCI-WQ	0.3	0.3	0.3	0.3
		FCI-WL	0.15	0.15	0.15	0.15
		FCI-FS	0.45	0.45	0.45	0.45
		Area	1.9	0	0	0
Restored	T0	FCI-SB	0.53	0.89	0.89	0.73
		FCI-SS	0.14	0.95	0.84	0.47
		FCI-WQ	0.3	0.61	0.46	0.41
		FCI-WL	0.15	0.53	0.38	0.24
		FCI-FS	0.45	0.69	0.86	0.86
		Area	0	0	0	0
	T2	FCI-SB	0.53	0.89	0.89	0.73
		FCI-SS	0.14	0.95	0.84	0.47
		FCI-WQ	0.3	0.61	0.46	0.41
		FCI-WL	0.15	0.53	0.38	0.24
		FCI-FS	0.45	0.69	0.86	0.86
		Area	0	7.08	3.78	2.85
	T20	FCI-SB	0.53	0.89	0.89	0.73
		FCI-SS	0.14	0.95	0.84	0.47
		FCI-WQ	0.3	0.61	0.46	0.41
		FCI-WL	0.15	0.53	0.38	0.24
		FCI-FS	0.45	0.69	0.86	0.86
		Area	0	7.08	3.78	2.85
	T50	FCI-SB	0.53	0.89	0.89	0.73
		FCI-SS	0.14	0.95	0.84	0.47
		FCI-WQ	0.3	0.61	0.46	0.41
		FCI-WL	0.15	0.53	0.38	0.24
		FCI-FS	0.45	0.69	0.86	0.86
		Area	0	6.72	3.59	2.71
Total	**T0**	**FCU**	**0.63**	**0.63**	**0.63**	**0.63**
	T2	**FCU**	**0.63**	**5.19**	**2.59**	**1.54**
	T20	**FCU**	**0.63**	**5.19**	**2.59**	**1.54**
	T50	**FCU**	**0.6**	**4.93**	**2.46**	**1.47**

7. Lower Passaic River and Hackensack River

7.1. Background

The Lower Passaic River and Hackensack River environmental benefits assessment includes a site screening evaluation and EPW assessment for the following sites along the Lower Passaic River; Oak Island Yards, Essex County Branch Brook Park, Clifton Dundee Canal Green Acres, Dundee Island Park, and Kearny Point. Hackensack River sites include Metromedia Tract and Meadowlark Marsh. The EPW assessment was performed on each site for existing and proposed conditions for each of the three alternatives as well as future without project conditions.

Habitat types that were calculated in the EPW analysis for Lower Passaic and Hackensack River sites included: low marsh, high marsh, scrub/shrub, shallows, tidal channels, emergent wetland, streambank restoration, and stream bed and channelrestoration. As described in Section 2.2, riparian buffer and shallow water habitat directly supporting the wetland were included in this analysis. The FWOP for the unrestored areas of the Lower Passaic and Hackensack River sites was assumed to be a continuation of the existing condition and areas were determined through EPW field work investigations conducted in 2015. For the restored areas, the FWOP area is zero in all years.

7.2. Methods

EPW was conducted as described in Section 2.2. Field work to establish existing conditions and inform alternatives formulation was conducted in spring of 2015.

Upon arrival at each site, the team started the investigation at the downstream location and traversed upstream examining the stream channel, any adjacent wetlands, and the surrounding upland buffers on both sides. Specific field data collection included GPS information for specific features, photographs, and hand-sketches of existing terrestrial and aquatic habitats and vegetative communities within the site's project boundary. Habitats were classified as per the *Ecological Communities of New York State*[7], although, due to the high degree of disturbance identified at most sites, many habitats were urban in nature.
To support the EPW during the field investigations, the team identified various conditions and features including:

- Stream channel/bank and riparian buffer/upland conditions;
- Dominant vegetation in each habitat/vegetative community;
- Anticipated fauna usage within each habitat;
- Outfalls and other conveyances of hydrology;
- Human-induced and natural/wildlife impacts; and
- Evidence of flooding and water level fluctuations.

[7]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.

Concurrent with the field investigations, desktop studies of potential uniqueness and heritage elements, as well as water quality classifications, were gathered for each site.
Following the field investigations, the senior ecologist and senior ecological engineer met together to complete the EPW data sheets and subsequently scored the alternatives. Following the completion of the baseline sheets for all the sites, the sheets and the resulting Functional Capacity Indicators (FCIs) were re-reviewed and compared to ensure that the various elements were scored consistently across the sites.

As per the EPW handbook, for each element, there are certain rationale and assumptions that need to be considered during the assessment procedure. In general, the typical metrics (e.g. contact once annually or less, Slope <10:1, etc.) in the handbook and on field data sheets were followed. However, there were a few elements for which the condition assessment metric given on the field data sheet was not applicable to this project. For these instances, the field team selected more appropriate condition assessments on which to base the EPW scoring. These include:

- *10. Vegetation Characteristics During Growing Season (note differences in definitions for upper shore zone, lower shore zone, and entire wetland) – Due to the fact that the wetlands assessed at most sites were very narrow and in most cases, quite steep (2:1 or steeper), an assumption was made for the evaluation of the 'lower" and 'upper' shore zones. The 'lower shore zone' was designated as the portion of the bank that was typically wetted and/or saturated under normal water level conditions; the 'upper shore zone' was designated as the higher portion of the bank that was rarely inundated but could still support wetland vegetation and/or exhibit signs of wetland hydrology.*
- *11a. Number of Layer in Banks – Determination was made to include 'water column, open water below 25cm (10in) in depth' in the wetland layers only at sites where the water flow did not prohibit the growth of hydrophytic vascular vegetation.*
- *27a. Spawning Substrate, Accessible During Spawning Periods – Assumed substrate dominated by large, anthropogenic construction debris (e.g. bricks, concrete blocks, etc.) fell under choice 'c. Boulders, bedrock or fines (e.g., silt, mud, clay).'*

7.3. Results

7.3.1. Oak Island Yards

Oak Island Yards TY50 comprises approximately 8.1 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative A FCUs after 50 years are 3.762 and 6.94, respectively. Table E-33 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

7.3.2. Essex County Branch Brook Park

Essex County Branch Brook Park TY50 comprises approximately 43.8 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative D FCUs after 50 years are 19.05 and 45.91,

respectively. Table E-34 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

7.3.3. Clifton Dundee Canal Green Acres

Clifton Dundee Canal Green Acres TY50 comprises approximately 3.15 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and Alternative A FCUs after 50 years are 1.37 and 2.69, respectively. Table E-35 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

7.3.4. Dundee Island Park

Dundee Island Park TY50 comprises approximately 0.71 acres of restored wetland habitat analyzed in the EPW assessment. One restoration alternative was evaluated for this site. The FWOP and Alternative A FCUs after 50 years are 0.19 and 0.66, respectively. Table E-36 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

7.3.5. Kearny Point

Kearny Point TY50 comprises approximately 28.54 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and Alternative C FCUs after 50 years are 14.97 and 21.86, respectively. Table E-37 presents a summary of the EPW output for the FWOP and three alternatives, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction. This site was deleted from the recommended plan and was not analyzed further.

7.3.6. Metromedia Tract

Metromedia Tract TY50 comprises approximately 62.5 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative A FCUs after 50 years are 36.99 and 58.49, respectively. Table E-38 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0), following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

7.3.7. Meadowlark Marsh

Metromedia Marsh TY50 comprises approximately 72.9 acres of restored wetland habitat analyzed in the EPW assessment. Three restoration alternatives were evaluated for this site. The FWOP and optimized Alternative C FCUs after 50 years are 42.83 and 62.25, respectively. Table E-39 presents a summary of the EPW output for the FWOP and three alternatives, the optimized FWOP and recommended alternative, as well as the total FCUs for existing (TY0),

following construction (TY2), 20 (TY20), and 50 (TY50) years following construction.

Table E-33. EPW Output Summary Oak Island Yards

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt A
Unrestored	T0	FCI-SB	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-SS	0.48	0.48	0.48	0.48	0.48	0.48
		FCI-WQ	0.45	0.45	0.45	0.45	0.45	0.45
		FCI-WL	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-FS	0.44	0.44	0.44	0.44	0.44	0.44
		Area	7.8	7.8	7.8	7.8	7.97	7.97
	T2	FCI-SB	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-SS	0.48	0.48	0.48	0.48	0.48	0.48
		FCI-WQ	0.45	0.45	0.45	0.45	0.45	0.45
		FCI-WL	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-FS	0.44	0.44	0.44	0.44	0.44	0.44
		Area	7.8	0	0	0	7.97	0
	T20	FCI-SB	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-SS	0.48	0.48	0.48	0.48	0.48	0.48
		FCI-WQ	0.45	0.45	0.45	0.45	0.45	0.45
		FCI-WL	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-FS	0.44	0.44	0.44	0.44	0.44	0.44
		Area	7.82	0	0	0	8.08	0
	T50	FCI-SB	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-SS	0.48	0.48	0.48	0.48	0.48	0.48
		FCI-WQ	0.45	0.45	0.45	0.45	0.45	0.45
		FCI-WL	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-FS	0.44	0.44	0.44	0.44	0.44	0.44
		Area	7.83	0	0	0	8.07	0
Restored	T0	FCI-SB	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-SS	0.48	0.48	0.48	0.48	0.48	0.48
		FCI-WQ	0.45	0.45	0.45	0.45	0.45	0.45
		FCI-WL	0.35	0.35	0.35	0.35	0.35	0.35
		FCI-FS	0.44	0.44	0.44	0.44	0.44	0.44
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.59	0.6	0.56	0.71	0.59	0.6
		FCI-SS	0.48	0.67	0.7	0.71	0.48	0.67
		FCI-WQ	0.45	0.78	0.65	0.62	0.45	0.78
		FCI-WL	0.35	0.37	0.35	0.32	0.35	0.37
		FCI-FS	0.44	0.53	0.57	0.45	0.44	0.53
		Area	0	11.34	11.33	11.33	0	7.97
	T20	FCI-SB	0.59	0.83	0.83	0.83	0.59	0.83
		FCI-SS	0.48	1	0.75	0.75	0.48	1
		FCI-WQ	0.45	1	0.96	0.89	0.45	1
		FCI-WL	0.35	0.89	0.71	0.87	0.35	0.89
		FCI-FS	0.44	0.75	0.65	0.65	0.44	0.75
		Area	0	10.32	9.55	10.75	0	8.08
	T50	FCI-SB	0.59	0.83	0.83	0.83	0.59	0.83
		FCI-SS	0.48	1	0.75	0.75	0.48	1
		FCI-WQ	0.45	0.82	0.96	0.96	0.45	0.82
		FCI-WL	0.35	0.9	0.72	0.83	0.35	0.9
		FCI-FS	0.44	0.75	0.69	0.69	0.44	0.75
		Area	0	9.97	9.27	10.57	0	8.07
Total	**T0**	**FCU**	**3.6**	**3.6**	**3.6**	**3.6**	**3.68**	**3.68**
	T2	**FCU**	**3.6**	**6.69**	**6.41**	**6.37**	**3.68**	**4.7**

	T20	FCU	3.61	9.23	7.45	8.58	3.73	7.22
	T50	FCU	3.62	8.58	7.33	8.58	3.73	6.94

Table E-34. EPW Output Summary Essex County Branch Brook Park

	Year	Output	FWOP	Alt A	Alt B	Alt C	Alt D	Optimized FWOP	Optimized Alt D
Unrestored	T0	FCI-SB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
		FCI-SS	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.52	0.52	0.52	0.52	0.52	0.52
		FCI-WL	0.47	0.47	0.47	0.47	0.47	0.47	0.47
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37	0.37
		Area	35.8	35.8	35.8	35.8	35.8	35.8	35.8
	T2	FCI-SB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
		FCI-SS	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.52	0.52	0.52	0.52	0.52	0.52
		FCI-WL	0.47	0.47	0.47	0.47	0.47	0.47	0.47
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37	0.37
		Area	35.8	35.8	35.8	35.8	35.8	35.8	35.8
	T20	FCI-SB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
		FCI-SS	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.52	0.52	0.52	0.52	0.52	0.52
		FCI-WL	0.47	0.47	0.47	0.47	0.47	0.47	0.47
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37	0.37
		Area	35.8	35.8	35.8	35.8	35.8	35.8	35.8
	T50	FCI-SB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
		FCI-SS	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.52	0.52	0.52	0.52	0.52	0.52
		FCI-WL	0.47	0.47	0.47	0.47	0.47	0.47	0.47
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37	0.37
		Area	35.8	35.8	35.8	35.8	35.8	35.8	35.8
Restored	T0	FCI-SB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
		FCI-SS	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.52	0.52	0.52	0.52	0.52	0.52
		FCI-WL	0.47	0.47	0.47	0.47	0.47	0.47	0.47
		FCI-FS	0.37	0.37	0.37	0.37	0.37	0.37	0.37
		Area	0	0	0	0	0	0	0
	T2	FCI-SB	0.64	0.82	0.65	0.66	0.65	0.64	0.65
		FCI-SS	0.66	0.66	0.95	0.66	0.66	0.66	0.66
		FCI-WQ	0.52	0.66	0.57	0.58	0.57	0.52	0.57
		FCI-WL	0.47	0.32	0.34	0.47	0.32	0.47	0.32
		FCI-FS	0.37	0.36	0.4	0.39	0.36	0.37	0.36
		Area	0	64.21	53.91	23.77	38.28	0	46.05
	T20	FCI-SB	0.64	0.97	0.97	0.66	0.66	0.64	0.66
		FCI-SS	0.66	0.95	1	0.84	0.84	0.66	0.84
		FCI-WQ	0.52	0.89	0.84	0.61	0.61	0.52	0.61
		FCI-WL	0.47	0.82	0.58	0.69	0.69	0.47	0.69
		FCI-FS	0.37	0.48	0.43	0.39	0.39	0.37	0.39
		Area	0	64.21	53.91	23.77	38.28	0	46.05
	T50	FCI-SB	0.64	0.9	0.97	0.66	0.66	0.64	0.66
		FCI-SS	0.66	0.88	1	0.84	0.84	0.66	0.84
		FCI-WQ	0.52	0.88	0.76	0.6	0.6	0.52	0.6
		FCI-WL	0.47	0.82	0.58	0.69	0.58	0.47	0.58
		FCI-FS	0.37	0.52	0.43	0.39	0.39	0.37	0.39
		Area	0	61	51.22	22.58	36.37	0	43.75
Total	**T0**	**FCU**	**19.05**	**19.05**	**19.05**	**19.05**	**19.05**	**19.05**	**19.05**
	T2	**FCU**	**19.05**	**55.26**	**50.42**	**32.17**	**38.64**	**19.05**	**42.62**
	T20	**FCU**	**19.05**	**71.83**	**60.24**	**34.21**	**43.47**	**19.05**	**48.43**
	T50	**FCU**	**19.05**	**67.85**	**57.36**	**33.41**	**41.38**	**19.05**	**45.91**

Table E-35. EPW Output Summary Clifton Dundee Canal Green Acres

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.54	0.54	0.54	0.54
		FCI-SS	0.62	0.62	0.62	0.62
		FCI-WQ	0.5	0.5	0.5	0.5
		FCI-WL	0.41	0.41	0.41	0.41
		FCI-FS	0.37	0.37	0.37	0.37
		Area	2.81	2.81	2.81	2.81
	T2	FCI-SB	0.54	0.54	0.54	0.54
		FCI-SS	0.62	0.62	0.62	0.62
		FCI-WQ	0.5	0.5	0.5	0.5
		FCI-WL	0.41	0.41	0.41	0.41
		FCI-FS	0.37	0.37	0.37	0.37
		Area	2.81	0	2.34	2.81
	T20	FCI-SB	0.54	0.54	0.54	0.54
		FCI-SS	0.62	0.62	0.62	0.62
		FCI-WQ	0.5	0.5	0.5	0.5
		FCI-WL	0.41	0.41	0.41	0.41
		FCI-FS	0.37	0.37	0.37	0.37
		Area	2.81	0	2.34	2.81
	T50	FCI-SB	0.54	0.54	0.54	0.54
		FCI-SS	0.62	0.62	0.62	0.62
		FCI-WQ	0.5	0.5	0.5	0.5
		FCI-WL	0.41	0.41	0.41	0.41
		FCI-FS	0.37	0.37	0.37	0.37
		Area	2.81	0	2.36	2.81
Restored	T0	FCI-SB	0.54	0.54	0.54	0.54
		FCI-SS	0.62	0.62	0.62	0.62
		FCI-WQ	0.5	0.5	0.5	0.5
		FCI-WL	0.41	0.41	0.41	0.41
		FCI-FS	0.37	0.37	0.37	0.37
		Area	0	0	0	0
	T2	FCI-SB	0.54	0.83	0.56	0.64
		FCI-SS	0.62	0.66	0.66	0.62
		FCI-WQ	0.5	0.84	0.62	0.65
		FCI-WL	0.41	0.4	0.6	0.46
		FCI-FS	0.37	0.47	0.42	0.37
		Area	0	3.31	0.47	0
	T20	FCI-SB	0.54	0.91	0.72	0.64
		FCI-SS	0.62	0.95	0.87	0.62
		FCI-WQ	0.5	1	0.89	0.7
		FCI-WL	0.41	0.73	0.66	0.48
		FCI-FS	0.37	0.69	0.45	0.31
		Area	0	3.31	0.47	0
	T50	FCI-SB	0.54	0.91	0.71	0.56
		FCI-SS	0.62	0.95	1	0.62
		FCI-WQ	0.5	1	0.89	0.61
		FCI-WL	0.41	0.73	0.62	0.48
		FCI-FS	0.37	0.69	0.5	0.31
		Area	0	3.15	0.45	0
Total	**T0**	**FCU**	**1.37**	**1.37**	**1.37**	**1.37**
	T2	**FCU**	**1.37**	**2.12**	**1.41**	**1.37**
	T20	**FCU**	**1.37**	**2.84**	**1.48**	**1.37**
	T50	**FCU**	**1.37**	**2.69**	**1.49**	**1.37**

Table E-36. EPW Output Summary Dundee Island Park

	Year	Output	FWOP	Alt A
Unrestored	T0	FCI-SB	0.52	0.52
		FCI-SS	0.46	0.46
		FCI-WQ	0.45	0.45
		FCI-WL	0.22	0.22
		FCI-FS	0.38	0.38
		Area	0.47	0.47
	T2	FCI-SB	0.52	0.52
		FCI-SS	0.46	0.46
		FCI-WQ	0.45	0.45
		FCI-WL	0.22	0.22
		FCI-FS	0.38	0.38
		Area	0.47	0.47
	T20	FCI-SB	0.52	0.52
		FCI-SS	0.46	0.46
		FCI-WQ	0.45	0.45
		FCI-WL	0.22	0.22
		FCI-FS	0.38	0.38
		Area	0.47	0.47
	T50	FCI-SB	0.52	0.52
		FCI-SS	0.46	0.46
		FCI-WQ	0.45	0.45
		FCI-WL	0.22	0.22
		FCI-FS	0.38	0.38
		Area	0.47	0.47
Restored	T0	FCI-SB	0.52	0.52
		FCI-SS	0.46	0.46
		FCI-WQ	0.45	0.45
		FCI-WL	0.22	0.22
		FCI-FS	0.38	0.38
		Area	0	0
	T2	FCI-SB	0.52	0.53
		FCI-SS	0.46	0.62
		FCI-WQ	0.45	0.5
		FCI-WL	0.22	0.29
		FCI-FS	0.38	0.37
		Area	0	0.71
	T20	FCI-SB	0.52	0.88
		FCI-SS	0.46	0.89
		FCI-WQ	0.45	0.81
		FCI-WL	0.22	0.35
		FCI-FS	0.38	0.42
		Area	0	0.71
	T50	FCI-SB	0.52	0.73
		FCI-SS	0.46	0.95
		FCI-WQ	0.45	0.81
		FCI-WL	0.22	0.38
		FCI-FS	0.38	0.44
		Area	0	0.71
Total	T0	FCU	0.19	0.19
	T2	FCU	0.19	0.52
	T20	FCU	0.19	0.66
	T50	FCU	0.19	0.66

Table E-37. EPW Output Summary Kearny Point

	Year	Output	FWOP	Alt A	Alt B	Alt C
Unrestored	T0	FCI-SB	0.58	0.58	0.58	0.58
		FCI-SS	0.49	0.49	0.49	0.49
		FCI-WQ	0.45	0.45	0.45	0.45
		FCI-WL	0.31	0.31	0.31	0.31
		FCI-FS	0.34	0.34	0.34	0.34
		Area	34.7	34.7	34.7	34.7
	T2	FCI-SB	0.58	0.58	0.58	0.58
		FCI-SS	0.49	0.49	0.49	0.49
		FCI-WQ	0.45	0.45	0.45	0.45
		FCI-WL	0.31	0.31	0.31	0.31
		FCI-FS	0.34	0.34	0.34	0.34
		Area	34.48	0	0	0
	T20	FCI-SB	0.58	0.58	0.58	0.58
		FCI-SS	0.49	0.49	0.49	0.49
		FCI-WQ	0.45	0.45	0.45	0.45
		FCI-WL	0.31	0.31	0.31	0.31
		FCI-FS	0.34	0.34	0.34	0.34
		Area	34.48	0	0	0
	T50	FCI-SB	0.58	0.58	0.58	0.58
		FCI-SS	0.49	0.49	0.49	0.49
		FCI-WQ	0.45	0.45	0.45	0.45
		FCI-WL	0.31	0.31	0.31	0.31
		FCI-FS	0.34	0.34	0.34	0.34
		Area	34.49	0	0	0
Restored	T0	FCI-SB	0.58	0.58	0.58	0.58
		FCI-SS	0.49	0.49	0.49	0.49
		FCI-WQ	0.45	0.45	0.45	0.45
		FCI-WL	0.31	0.31	0.31	0.31
		FCI-FS	0.34	0.34	0.34	0.34
		Area	0	0	0	0
	T2	FCI-SB	0.58	0.53	0.52	0.58
		FCI-SS	0.49	0.6	0.6	0.49
		FCI-WQ	0.45	0.76	0.76	0.62
		FCI-WL	0.31	0.46	0.32	0.31
		FCI-FS	0.34	0.43	0.43	0.34
		Area	0	36.11	32.2	29.98
	T20	FCI-SB	0.58	0.68	0.68	0.6
		FCI-SS	0.49	1	1	1
		FCI-WQ	0.45	0.96	0.89	0.89
		FCI-WL	0.31	0.94	0.81	0.71
		FCI-FS	0.34	0.69	0.65	0.59
		Area	0	31.51	27.77	28.9
	T50	FCI-SB	0.58	0.68	0.68	0.6
		FCI-SS	0.49	1	1	1
		FCI-WQ	0.45	0.96	0.96	0.89
		FCI-WL	0.31	0.94	0.82	0.71
		FCI-FS	0.34	0.69	0.65	0.63
		Area	0	30.35	26.4	28.54
Total	**T0**	**FCU**	**15.06**	**15.06**	**15.06**	**15.06**
	T2	**FCU**	**14.96**	**20.08**	**16.94**	**14.03**
	T20	**FCU**	**14.96**	**26.91**	**22.39**	**21.91**
	T50	**FCU**	**14.97**	**25.92**	**21.7**	**21.86**

Table E-38. EPW Output Summary Metromedia Tract

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt A
Unrestored	T0	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.41	0.41	0.41	0.41	0.41	0.41
		Area	59.5	59.5	59.5	59.5	59.5	59.5
	T2	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.41	0.41	0.41	0.41	0.41	0.41
		Area	62.67	12.14	0	0	62.67	12.14
	T20	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.41	0.41	0.41	0.41	0.41	0.41
		Area	63.58	10.05	0	0	63.58	10.05
	T50	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.41	0.41	0.41	0.41	0.41	0.41
		Area	64.67	4.53	0	0	64.67	4.53
Restored	T0	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.59	0.59	0.59	0.59	0.59
		FCI-WL	0.23	0.23	0.23	0.23	0.23	0.23
		FCI-FS	0.41	0.41	0.41	0.41	0.41	0.41
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.63	0.63	0.63	0.63	0.63	0.63
		FCI-SS	1	0.64	0.64	0.64	1	0.64
		FCI-WQ	0.59	0.76	0.76	0.76	0.59	0.76
		FCI-WL	0.23	0.62	0.49	0.62	0.23	0.62
		FCI-FS	0.41	0.56	0.45	0.56	0.41	0.56
		Area	0	50.53	61.78	60.58	0	57.2
	T20	FCI-SB	0.63	0.82	0.82	0.83	0.63	0.82
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	0.96	0.89	0.96	0.59	0.96
		FCI-WL	0.23	0.8	0.69	0.74	0.23	0.8
		FCI-FS	0.41	0.63	0.63	0.63	0.41	0.63
		Area	0	53.53	65.18	62.86	0	61.88
	T50	FCI-SB	0.63	0.98	0.98	0.83	0.63	0.98
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.59	1	0.93	1	0.59	1
		FCI-WL	0.23	0.86	0.75	0.75	0.23	0.86
		FCI-FS	0.41	0.63	0.63	0.63	0.41	0.63
		Area	0	60.14	65.62	64.45	0	62.53
Total	**T0**	**FCU**	**34.03**	**34.03**	**34.03**	**34.03**	**34.03**	**34.03**
	T2	**FCU**	**35.85**	**39.38**	**36.7**	**38.89**	**35.85**	**43.67**
	T20	**FCU**	**36.37**	**50.82**	**52.54**	**52.3**	**36.37**	**57.85**
	T50	**FCU**	**36.99**	**56.36**	**56.3**	**54.27**	**36.99**	**58.49**

Table E-39. EPW Output Summary Meadowlark Marsh

	Year	Output	FWOP	Alt A	Alt B	Alt C	Optimized FWOP	Optimized Alt C
Unrestored	T0	FCI-SB	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	0.61	0.61	0.61	0.61	0.61
		FCI-WL	0.81	0.81	0.81	0.81	0.18	0.81
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	85.43	85.43	85.43	85.43	72.7	72.7
	T2	FCI-SB	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	0.61	0.61	0.61	0.61	0.61
		FCI-WL	0.81	0.81	0.81	0.81	0.18	0.81
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	77.88	0	0	0	72.7	0
	T20	FCI-SB	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	0.61	0.61	0.61	0.61	0.61
		FCI-WL	0.81	0.81	0.81	0.81	0.18	0.81
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	78.47	0	0	0	72.5	0
	T50	FCI-SB	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	0.61	0.61	0.61	0.61	0.61
		FCI-WL	0.81	0.81	0.81	0.81	0.18	0.81
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	79.17	0	0	0	72.6	0
Restored	T0	FCI-SB	0.73	0.73	0.73	0.73	0.73	0.73
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	0.61	0.61	0.61	0.61	0.61
		FCI-WL	0.81	0.81	0.81	0.81	0.18	0.81
		FCI-FS	0.43	0.43	0.43	0.43	0.43	0.43
		Area	0	0	0	0	0	0
	T2	FCI-SB	0.73	0.63	0.63	0.63	0.73	0.63
		FCI-SS	1	0.6	0.6	0.64	1	0.64
		FCI-WQ	0.61	0.76	0.83	0.76	0.61	0.76
		FCI-WL	0.81	0.52	0.48	0.42	0.18	0.42
		FCI-FS	0.43	0.48	0.48	0.55	0.43	0.55
		Area	0	80.02	82.13	92.18	0	72.7
	T20	FCI-SB	0.73	1	1	0.98	0.73	0.98
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	1	1	1	0.61	1
		FCI-WL	0.81	0.79	0.74	0.58	0.18	0.58
		FCI-FS	0.43	0.69	0.69	0.58	0.43	0.58
		Area	0	79.17	81.31	91.79	0	72.93
	T50	FCI-SB	0.73	1	1	0.98	0.73	0.98
		FCI-SS	1	1	1	1	1	1
		FCI-WQ	0.61	1	1	1	0.61	1
		FCI-WL	0.81	0.79	0.82	0.65	0.18	0.65
		FCI-FS	0.43	0.69	0.69	0.64	0.43	0.64
		Area	0	76.56	78.51	89.99	0	72.89
Total	**T0**	**FCU**	**61.17**	**61.17**	**61.17**	**61.17**	**42.89**	**52.05**
	T2	**FCU**	**55.76**	**47.85**	**49.6**	**55.31**	**42.89**	**43.62**
	T20	**FCU**	**56.18**	**70.93**	**72.04**	**76**	**42.77**	**60.39**
	T50	**FCU**	**56.69**	**68.59**	**70.82**	**76.85**	**42.83**	**62.25**

8. Small Scale Oyster Restoration

8.1. Background

The HRE oyster sites environmental benefits assessment includes a quantification of oyster restoration benefits assessed as the total area of installed reef features. Habitat units were quantified using the certified Oyster Habitat Suitability Index Model (OHSIM)[8]. The OHSIM model is a modification of an eastern oyster (*Crassostrea virginica*) habitat suitability index model[9] which followed previously established methodology[10][11]. The model uses four variables: three are related to salinity, and one related to substrate. Each variable is used to calculate a dimensionless oyster suitability index (OSI) value representing the relationship between an environmental variable and a stage of the oyster's life history. Each OSI is represented by a linear suitability curve, with a minimum value of 0 for unsuitable to 1.0 for optimal habitats. A restoration suitability index (RSI) is calculated as the geometric mean of the four OSI values to represent the overall suitability of a particular location. The details and suitability curves of the model are discussed in the paper, A Robust, Spatially Explicit Model for Identifying Oyster Restoration Sites: Case Studies on the Atlantic and Gulf Coasts[12]. The model was applied to three Eastern oyster restoration designs at Naval Station Earle, Bush Terminal, and Head of Jamaica Bay. The OHSIM was used to evaluate the candidate sites in terms of whether oyster restoration at each of the sites is expected to be successful and, in concert with anticipated relative cost of the restoration techniques to be employed at each of the sites.

Three alternatives per site were developed to provide ecological and functional uplift in terms of habitat improvement, shoreline stabilization, water quality improvements, and carbon sequestration.

8.2. Methods

For the HRE project, the model was applied as a spatially-implicit version that considered each site separately. The model uses a series of linear equations to calculate habitat suitability for *C. virginica* under different restoration scenarios. The overarching assumption of the OHSIM is that substrate and salinity variables can be used to quantitatively estimate area suitable for oyster

[8] Swannack T.M., Reif M., Soniat T.M. 2014. A Robust, Spatially Explicit Model for Identifying Oyster Restoration Sites: Case Studies on the Atlantic and Gulf Coasts. Journal of Shellfish Research 33(2):395-408.
[9] Soniat T.M. 2012. Eastern Oyster Habitat Suitability Index (appendix D-13). In: Louisiana's comprehensive master plan for a sustainable coast. Baton Rouge, LA: Coastal Protection and Restoration Authority. 18pp. Available at: www.coastalmasterplan.louisiana.gov/2012-master-plan/master-plan-appendices/.
[10] Cake E.W., JR. Habitat Suitability Index Model: Gulf of Mexico American Oyster. U.S. Fish and Wildlife Service. FWS/OBS-82/10.57.37p.
[11] Soniat T.M. and Brody M. Field Validation of a Habitat Suitability Index Model for the American Oyster. 1988. Estuaries and Coasts 11(2):87-95.
[12] Swannack et al. 2014

habitat. The OHSIM model captures the minimum environmental parameters required for successful restoration suitability:

- % Clutch – Percentage of the bottom covered with hard substrate (e.g., oyster shell or other suitable bottom) or other hard surfaces (e.g., limestone, concrete, granite, etc.).
- MSSS – Mean salinity during the spawning season calculated by averaging daily values of salinity from May 1 through September 30th.
- Habitat Modeling Report and CE/ICA
- MAS – Minimum annual salinity is the minimum value of the 12 monthly mean salinities.
- AS – Annual mean salinity is calculated by averaging mean monthly salinity values

Each variable has a corresponding range of dimensionless Oyster Suitability Index (OSI) values that quantifies the relationship between an environmental variable and a stage of the oyster's life history. For example, minimum annual salinity is used to represent the relationship between adult oysters and salinity due to freshwater inflow. Each OSI value is quantified as a series of step-functions with linear approximations between each step, ranging from a minimum value of 0 for unsuitable conditions to 1.0 for optimal habitats for oysters. An overall Habitat Suitability Index (HSI) value is calculated as the geometric mean of all the OSI values and represents the overall suitability of a location that may vary under different restoration scenarios. Refer to Swannack et al. 2012[13] for a complete description of variable selection, quantification, and model evaluation.

For this study, three sites were considered: Naval Weapons Station Earle, Head of Jamaica Bay, and Bush Terminal. For each of those sites, the model was applied under four alternatives: a FWOP and three restoration scenarios, where the addition of substrate type in the form of various oyster features (i.e., super trays, gabion baskets and/or oyster castles) was considered as part of the alternative. Vertical and horizontal surface areas were calculated for each oyster feature. Horizontal surface areas were considered as the area of the site that would be planted with spat-on-shell and vertical surface area was calculated as the additional surface area gained by the complexity of the feature. Surface areas for each feature type were as follows: Super Trays: 7.85 ft^2/unit, Gabion Baskets: 20 ft^2/unit and Oyster Castles: 53.34 ft^2/unit. Surface areas were summed and used as total area for the calculation of habitat units.

Salinity data were gathered for each site from gage stations and summarized to generate the required metric (e.g., mean annual salinity) to calculate OSI values for each of the three sites. Data sources and summarized values are provided for each site as follows:

[13] Swannack T.M., Fischenich J.C., Tazik D.J. 2012. Ecological Modeling Guide for Ecosystem Restoration and Management. ERDC TR-12-18. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

1) **Naval Weapons Station Earle**
    a. Data from 2015 Sonde collections (provided by University of Rutgers). Salinity values were only available from May to July, so we assumed that mean annual and mean salinity during spawning season are the same value.
    b. **Summary Values:**
        i. Mean Annual Salinity (ppt): 18.76
        ii. Minimum Annual Salinity (ppt): 9.06
        iii. Mean Salinity during Spawning Season (ppt): 18.76

2) **Jamaica Bay**
    a. Data from NY harbor station HOB for 2016 (11 total values from August to December). Station map is presented in Plan Formulation Appendix D-7.
    b. **Summary Values**
        i. Mean Annual Salinity (ppt): 28.00
        ii. Minimum Annual Salinity (ppt): 27.06
        iii. Mean Salinity during Spawning Season (ppt): 28.12

3) **Bush Terminal**
    a. Data from NY harbor station G1 for 1999 (17 values from February to December) and 2000 (4 values from February to June). Station map is presented in Plan Formulation Appendix D-7.
    b. **Summary Values**
        i. Mean Annual Salinity (ppt): 24.24
        ii. Minimum Annual Salinity (ppt): 6.79
        iii. Mean Salinity during Spawning Season (ppt): 23.49

For each site, the summarized value was used to calculate an OSI value for each of the three salinity metrics following the methods described in Swannack et al. 2012. An overall HSI was calculated for each alternative and for a future-without-project. Habitat units were calculated for each alternative following standard procedures.

8.3. Results

Salinity values varied among sites, but no sites were completely unsuitable for *C. virginica* (Table E-40). Habitat units increased as the surface area of hard substrate resulting from oyster features increased. The largest habitat lift for each site was Alternative 3, which had the largest amount surface area of oyster features.

Table E-40. Results of the application of OHSIM for each of the three sites in the Hudson Raritan Estuary Project (A) Naval Weapons Station Earle (B) Bush Terminal, and (C) Jamaica Bay. Abbreviations: Acres (ac), Square Feet (ft2), Spat on Shell (SOS); Oyster Suitability Index (OSI), Mean Annual Salinity (AS), Annual Minimum Salinity (AMS), Mean Salinity during Spawning Season (MSSS), SA: Surface Area; Super Trays (ST; Surface Area per unit: 7.85 ft2), Gabion Baskets (GB; Surface Area per unit: 20 ft2), Oyster Castles (OC; Surface Area per unit: 53.34 ft2), Overall Habitat Suitability Index (HSI), and Habitat Units (HU).

(A) Naval Weapons Station Earle

					Suitability (OSI)					Vertical Features				Area & Habitat Units				
	Project area		SOS		Substrate	AS	MSSS	AMS	HSI	Count				Area (ft^2)			HU	
Alt.	ac	ft^2	ac	ft^2						ST	GB	OC	Total Vertical SA	Plan	Vert.	Tot.	ft^2	ac
0	0	0	0	0	0	0.7	1	1	0	0	0	0	0	0	0	0	0	0
1	3.3	143748	11	479160	1	0.7	1	1	0.91	0	32	306	11867.64	479160	11867.6	491028	446687	10.25
2	16.2	705672	16.2	705672	1	0.7	1	1	0.91	0	62	612	23554.68	705672	23554.7	729227	663377	15.23
3	32	1393920	32	1393920	1	0.7	1	1	0.91	0	102	1010	38844	1393920	38844	1432764	1303384	29.92

(B) Bush Terminal

					Suitability (OSI)					Vertical Features				Area & Habitat Units				
	Project area		SOS		Substrate	AS	MSSS	AMS	HSI	Count				Area (ft^2)			HU	
Alt.	ac	ft^2	ac	ft^2						ST	GB	OC	Total Vertical SA	Plan	Vert.	Tot.	ft^2	ac
0	0	0	0	0	0	0.31	0.66	0.698	0.000	0	0	0	0	0	0	0	0	0
1	11	479160	11	479160	1	0.31	0.66	0.698	0.615	0	376	0	7520	4.79E+05	7.52E+03	4.87E+05	2.99E+05	6.867
2	16.2	705672	16.2	705672	1	0.31	0.66	0.698	0.615	0	554	0	11080	7.06E+05	1.11E+04	7.17E+05	4.41E+05	10.113
3	32	1393920	32	1393920	1	0.31	0.66	0.698	0.615	0	1094	0	21880	1.39E+06	2.19E+04	1.42E+06	8.70E+05	19.977

(C) Head of Jamaica Bay

					Suitability (OSI)					Vertical Features				Area & Habitat Units				
	Project area		SOS		Substrate	AS	MSSS	AMS	HSI	Count				Area (ft^2)			HU	
Alt.	ac	ft^2	ac	ft^2						ST	GB	OC	Total Vertical SA	Plan	Vert.	Tot.	ft^2	ac
0	0	0	0	0	0	0.16	0.46	1	0	0	0	0	0	0	0	0	0	0
1	3.3	143748	11	479160	1	0.16	0.46	1	0.07	10	112	50	4985.5	479160	4985.5	484146	0.07	0.818
2	16.2	705672	16.2	705672	1	0.16	0.46	1	0.07	16	224	100	9939.6	705672	9939.6	715612	0.07	1.209
3	32	1393920	32	1393920	1	0.16	0.46	1	0.07	24	337	150	14929.4	1393920	14929.4	1408849	0.07	2.38

9. Watershed-Scale Upstream Connectivity Toolkit (WUCT)

9.1. Background

The Watershed-Scale Upstream Connectivity Toolkit (WUCT) provides a procedure for quantifying benefits associated with removal of organism movement barriers within a watershed (e.g., dam removal, culvert repair, fish ladder installation). The model focuses on upstream movement of migratory organisms such as fish and is intended for application at the watershed-scale. The algorithm is based on four primary components: habitat quantity upstream of a dam, habitat quality upstream of a dam, the passability of a structure for a given taxa, and the shape (i.e., topology) of the watershed. The WUCT combines these data to estimate quality-weighted,

accessible habitat at the watershed scale. This model was certified according to USACE procedures[14] in Fall 2018, and additional model documentation is available elsewhere[15].

This model application examines HRE fish passage prioritization. Specifically, this application quantifies fish passage benefits associated with two sites in the Bronx River watershed, which were proposed in the Draft Feasibility Report[16] and supported by the Comprehensive Restoration Plan[17]. Fish passage outputs are quantified in terms of "accessible habitat" using the Watershed-Scale Upstream Connectivity Toolkit (WUCT) with river herring as the focal taxa.

Three dams are of interest in the Bronx River system moving from downstream to upstream. First, the East 182nd Street Dam is the first barrier encountered, where a fish ladder (Alaskan Steep pass) has been constructed by partners including NYC Parks, the Bronx Borough, the Wildlife Conservation Society, the National Oceanic and Atmospheric Administration, the US Fish and Wildlife Service, New York State, and the National Fish and Wildlife Foundation[18]. Second, the Bronx Zoo Dam is the next structure, where USACE has proposed three restoration alternatives as part of this feasibility study (all including a fish ladder, Appendix D). Third, the Stone Mill Dam (aka. Snuff Mill Dam) is the next structure, where USACE has proposed three restoration alternatives as part of this feasibility study (one with a fish ladder + attractors, one with a fish ladder, and one without a fish ladder). A significant amount of habitat is accessible above the Stone Mill Dam, when considering both main stem and tributary habitats. The Bronx River has been shown to support river herring populations, where accessibility is not limiting[19], and the 182nd St Dam fish ladder has subsequently demonstrated that river herring will utilize technical fishways in this region.

9.2. Methods

The WUCT requires four general types of inputs, which are parameterized as follows for HRE (summarized in Table E-41):

[14] U.S. Army Corps of Engineers (USACE). 2011. Assuring quality of planning models. EC-1105-2-412. Washington, DC.

[15] McKay S.K., Reif M., Conyngham J.N., and Kohtio D. 2017. Barrier prioritization in the tributaries of the Hudson-Raritan Estuary. ERDC TN-EMRRP-SR-82. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

McKay S.K. 2018. Watershed-Scale Upstream Connectivity Toolkit (WUCT). Model Certification Documentation. Ecosystem Restoration Planning Center of Expertise. U.S. Army Corps of Engineers. September 2018.

[16] U.S. Army Corps of Engineers (USACE). 2017. Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study. February 2017. New York District, U.S. Army Corps of Engineers, New York, New York.

[17] U.S. Army Corps of Engineers (USACE). 2016. Hudson-Raritan Estuary: Comprehensive restoration plan. Volume 1, Version 1.0. New York District, U.S. Army Corps of Engineers, New York, New York.

[18] Lumbian S. and Larson M. 2015. Final report on fish passage construction at the East 182nd Street Dam, Bronx River. New York City Parks.

[19] Larson M. and Sugar D. 2004. Phase 1 final report: Fish passage needs and feasibility assessment. Natural Resources Group, Parks and Recreation, City of New York.

- *Habitat Quantity*: For each barrier, an area of upstream habitat opened is used as the primary basis for habitat quantity. First, the length of upstream habitat was computed (i.e., the distance between the dam and the next upstream barrier) and included tributary habitats that would be newly accessible. River width was estimated from aerial photos in Google Earth as the smallest observable width upstream of the structure (i.e., an extremely conservative estimate). Length of river was multiplied by width to obtain an area-based metric.
- *Habitat Quality*: Habitat quality was predicted based on a watershed-scale, geospatial analysis of all upstream habitat. The model included three metrics accounting for land use development, water quality, and the proportion of the basin in conservation status[20].
- *Passability*: Local studies of fish passage rates (i.e., passability) were unavailable in the Bronx River during project planning. As such, passability was estimated based on studies elsewhere on the efficacy of technical fishways in general and for river herring specifically. Prior to restoration actions, all structures are assumed to have zero passage of river herring. Alewife studies in New England[21] report high overall passage rates of 64-99% passage in the East River, Massachusetts with particularly high rates for technical steep passes of 94-97%. These values are in line with a meta-analysis of 65 published fish passage studies[22], which indicated that fish passage efforts typically result in 42% fish passage on average across a variety of taxa. Based on the Massachusetts data, we used 80% passability for all fish ladders as a conservative estimate of passage efficiency. The 182nd Street Dam and Ladder were included in all analyses as part of the future without project condition. At Stone Mill Dam, Alternative-A includes fish attractors to increase utilization of the ladder, which were assumed to increase passability by 10% (i.e., to 88% total).
- *Watershed Topology*: Watershed shape was summarized by an adjacency matrix detailing connectivity between any two reaches of river[23].

Sixteen combinations of potential actions were simulated (e.g., Alt-A at Bronx Zoo + Alt-B at Stone Mill). For each simulation, total accessible habitat for the watershed was assessed, which represents a quality- and connectivity-weighted metric of riverine habitat. Per WUCT procedure, all analyses were conducted in the R Statistical Software[24].

[20] McKay et al. (2017).
[21] Franklin A.E., Haro A., Castro-Santos T., and Noreika J. 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, 624-637.
[22] Noonan M.J., Grant J.W.A., and Jackson C.D. 2011. A quantitative assessment of fish passage efficiency. Fish and Fisheries, doi: 10.1111/j.1467-2979.2011.00445.x.
[23] McKay et al. (2017).
[24] R Development Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. www.R-project.org.

Table E-41. Bronx River WUCT input data. Each node specifies the existing condition (shown as Alt+0), and multiple restoration alternatives are also specified for each node (shown as Alt = A, B, or C).

Barrier ID	Alternative	Quantity of Upstream Habitat (ac)	Quality of Upstream Habitat (0 to 1)	Structure Passability (0 to 1)
Estuary Outlet	0	0.01	1.00	1.00
182nd St	0	1.80	0.20	0.80
BronxZoo	0	3.96	0.41	0.00
BronxZoo	A	3.96	0.41	0.80
BronxZoo	B	3.96	0.41	0.80
BronxZoo	C	3.96	0.41	0.80
StoneMill	0	98.66	0.33	0.00
StoneMill	A	98.66	0.33	0.88
StoneMill	B	98.66	0.33	0.80
StoneMill	C	98.66	0.33	0.80

9.3. Results

Table E-42 presents outputs of the Bronx River WUCT application. As shown, this assessment incorporates future without project conditions at the estuary outlet and the 182nd Street Dam. Actions at Stone Mill Dam result in the greatest increases in accessible habitat, particularly under Alternative-A (which includes the fish attraction structures). Notably, these benefits cannot be realized without parallel actions at the Bronx Zoo and Dam. Although benefits of the Bronx Dam fish ladder are minimal on their own, the dependency between these actions makes joint restoration at both structures crucial to the success of either restoration action.

Table E-42. Alternatives analysis using the WUCT in the Bronx River Watershed. Competing restoration alternatives are shown as rows, and the alternative used in the plan is denoted by the number shown.

Simulation Number	Estuary Outlet	182nd St Dam	Bronx Zoo and Dam	Stone Mill Dam	Accessible Habitat (AH)
1	0	0	0	0	0.298
2	0	0	A	0	1.337
3	0	0	B	0	1.337
4	0	0	C	0	1.337
5	0	0	0	A	0.298
6	0	0	A	A	19.674

Simulation Number	Estuary Outlet	182nd St Dam	Bronx Zoo and Dam	Stone Mill Dam	Accessible Habitat (AH)
7	0	0	B	A	19.674
8	0	0	C	A	19.674
9	0	0	0	B	0.298
10	0	0	A	B	18.007
11	0	0	B	B	18.007
12	0	0	C	B	18.007
13	0	0	0	C	0.298
14	0	0	A	C	18.007
15	0	0	B	C	18.007
16	0	0	C	C	18.007