Appendix E-2
Alternatives Development
Jamaica Bay Marsh Islands Package

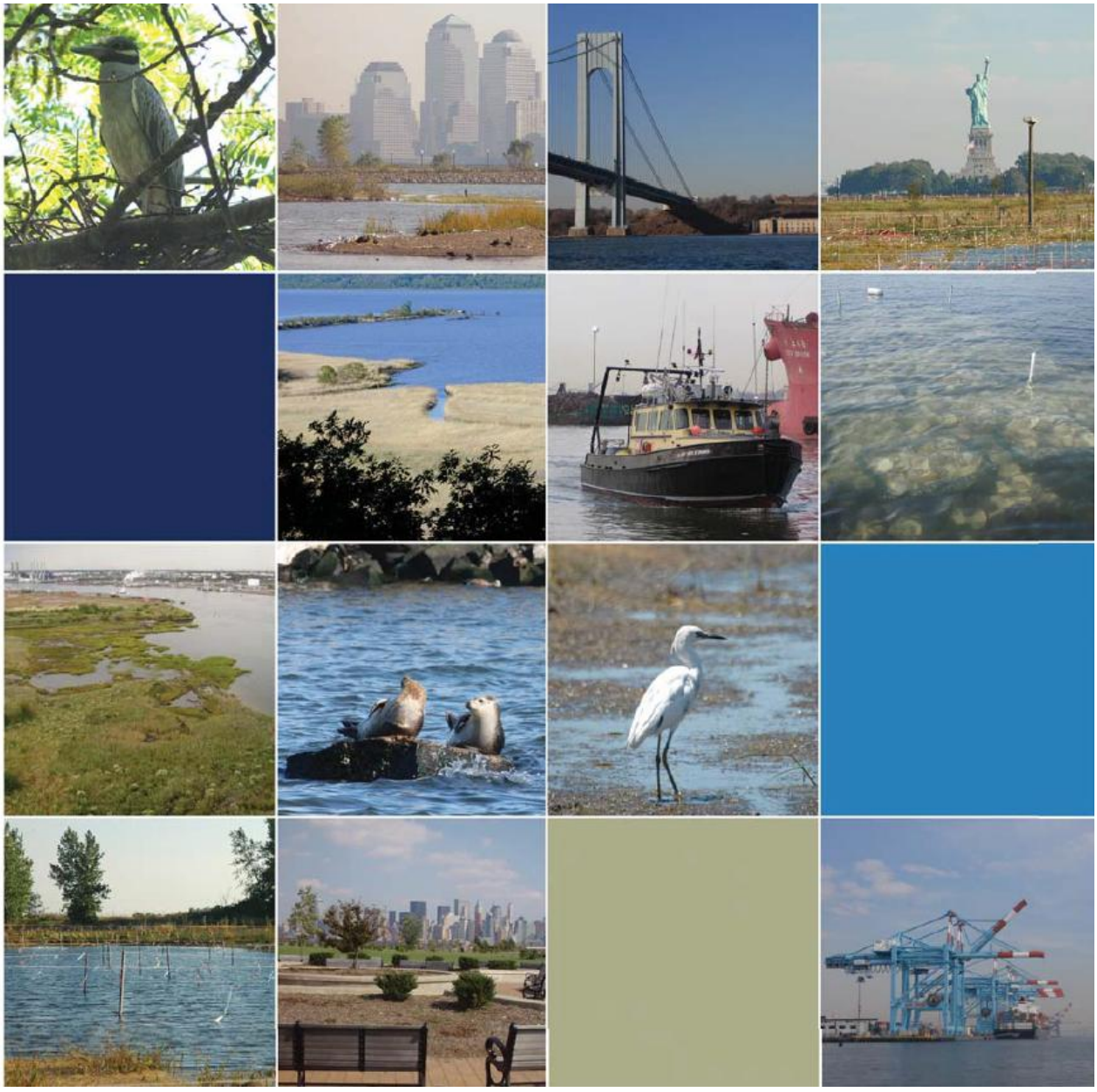
Draft Integrated Feasibility Report & Environmental Assessment
February 2017

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

THE PORT AUTHORITY OF NY & NJ

NYC Environmental Protection

DEPARTMENT OF ENVIRONMENTAL CONSERVATION · NEW YORK STATE



Executive Summary

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

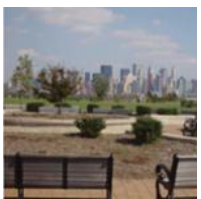
In the 19th and 20th centuries, through a series of human actions, extensive habitat losses resulted in the severe degradation of much of the remaining habitats and the bay's chemical, physical, and biological environment. These actions included the filling of marshes and open water areas, hardening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

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

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

In 1996, USACE initiated study of the Jamaica Bay perimeter sites. During this time, the problems with the loss of marsh islands had not been identified. When the New York State Department of Environmental Conservation (NYSDEC) completed its Geographic Information System-based surveys and actually quantified the extensive losses suffered since only the mid-1970s, the Jamaica Bay study process was already into its detailed investigations of the perimeter sites. The agencies met on several occasions to discuss this new and very serious issue and eventually a consensus evolved that the islands would be investigated under a separate parallel track using the Continuing Authorities Program (CAP) authority and the Hudson Raritan Estuary (HRE) Ecosystem Feasibility Study.



NYSDEC and the New York City Department of Environmental Protection (NYCDEP) requested assistance in implementing several marsh island restoration projects. USACE has already restored five (5) marsh islands amounting to over 160 acres of habitat. These islands include Elders Point East (2007) and West (2010), Yellow Bar Hassock (2012), Black Wall (2012), and Rulers Bar (2012). Lessons learned from these projects have been applied to the alternatives development for the proposed marsh islands recommended in this feasibility report/environmental assessment (FR/EA).

The HRE Draft Integrated FR/EA proposes the restoration of five (5) marsh islands in Jamaica Bay to complement the five (5) marsh islands USACE has already restored in the area. Habitat targets include high marsh, low marsh, and tidal creeks. Due to the substantial marsh island loss, these habitats are quite rare in Jamaica Bay at present.

Evaluation of Planned Wetlands (EPW) technique was used to determine baseline ecosystem function at the each site evaluating the six (6) major wetland functions or functional capacity indexes (FCIs): shoreline bank erosion control (SB); sediment stabilization (SS); water quality (WQ); wildlife (WL); fish (tidal fish [FT], non-tidal stream/river [FS], non-tidal pond/lake [FP]) and uniqueness/heritage (UH). The FCIs are then multiplied by the wetland assessment area (WAA), the approximate acreage of studied wetlands at a site, 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. The EPW baseline scores for the five (5) marsh islands were extrapolated from the EPW assessments conducted at Yellow Bar Hassock and Elders Point in 2003.

Alternative development and alternative concept designs are presented in this appendix. Because anticipated ecological benefits are expected to remain similar regardless of position in the bay, the goal was to create 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. Marsh island restoration cost is related most directly to the volume of material needed to create an acre of marsh island, based on the existing elevation of the area. As such, only one (1) alternative was developed for each marsh island.






Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study
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1 Introduction

The work documented in this appendix focuses on the assessment and alternatives development for the Jamaica Bay marsh islands proposed for restoration. Table 1 lists the Jamaica Bay marsh island sites to be recommended included in the HRE Feasibility Report/Environmental Assessment (FR/EA).

Table 1-1: Jamaica Bay Marsh Island Sites Recommended for Construction

Site
Elders Center
Pumpkin Patch East
Pumpkin Patch West
Duck Point
Stony Creek

Restoration plans for the marsh islands have been evaluated over the past 15 years as pilot and mitigation projects have been developed, recommended, and constructed. The United States Army Corps of Engineers (USACE), in partnership with other agencies and community organizations, has developed an extensive body of data and literature that informs the decisions made in this study process. The 2006 Ecosystem Restoration Report and Environmental Assessment for the Jamaica Bay marsh islands recommended restoration at Elders Point East, Elders Point West, and Yellow Bar Hassock. These three (3) islands were restored in 2007, 2010, and 2012, respectively. Black Wall and Rulers Bar were also restored in 2012 as part of a beneficial use of dredged material in partnership with community organizations and local agencies. Coordination with New York State Department of Environmental Conservation (NYSDEC) and the National Parks Service (NPS) recommended that the maximum perimeter of each of the restored islands should not exceed their 1974 footprints, estimated to be the inflection point at which the existing marsh vegetation began to rapidly deteriorate.

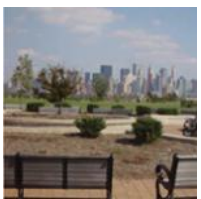
USACE drew from the experiences of researching, designing, and restoring these marsh islands to choose the five (5) proposed islands that comprise the marsh island portion of this report.

This appendix documents the development of alternatives for the marsh island sites, Evaluation of Planned Wetlands (EPW) results (baseline and alternatives) that were projected from prior constructed marsh islands, and the findings of available field investigations and desktop studies. Attachment A contains the EPW summary results.

2 Project Area Context

The Jamaica Bay marsh islands are at the heart of the complex urban ecosystem of Jamaica Bay that is a part of Gateway National Recreation Area, the first urban national park, established in 1972, and a key component of the President's “America's Great Outdoors” initiative. The marsh islands complex is an integral part of the Jamaica Bay ecosystem and has been targeted for restoration by numerous partners. A coalition group, the New York/New Jersey Harbor Estuary Program (HEP), has targeted Jamaica Bay for consideration for restoration and conservation, particularly based on the presence of rare species, size, connectivity, and threat of development.




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

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

In response to these losses, under the USACE's Continuing Authorities Program (CAP), NYSDEC and the New York City Department of Environmental Protection (NYCDEP) requested assistance in implementing several marsh island restoration projects. USACE has already restored five (5) marsh islands amounting to over 160 acres of habitat. These islands include Elders Point East (2007), Elders Point West (2010), Yellow Bar Hassock (2012), Black Wall (2012), and Rulers Bar (2012). Lessons learned from these projects have been applied to the alternatives development for the proposed marsh islands recommended in this FR/EA.





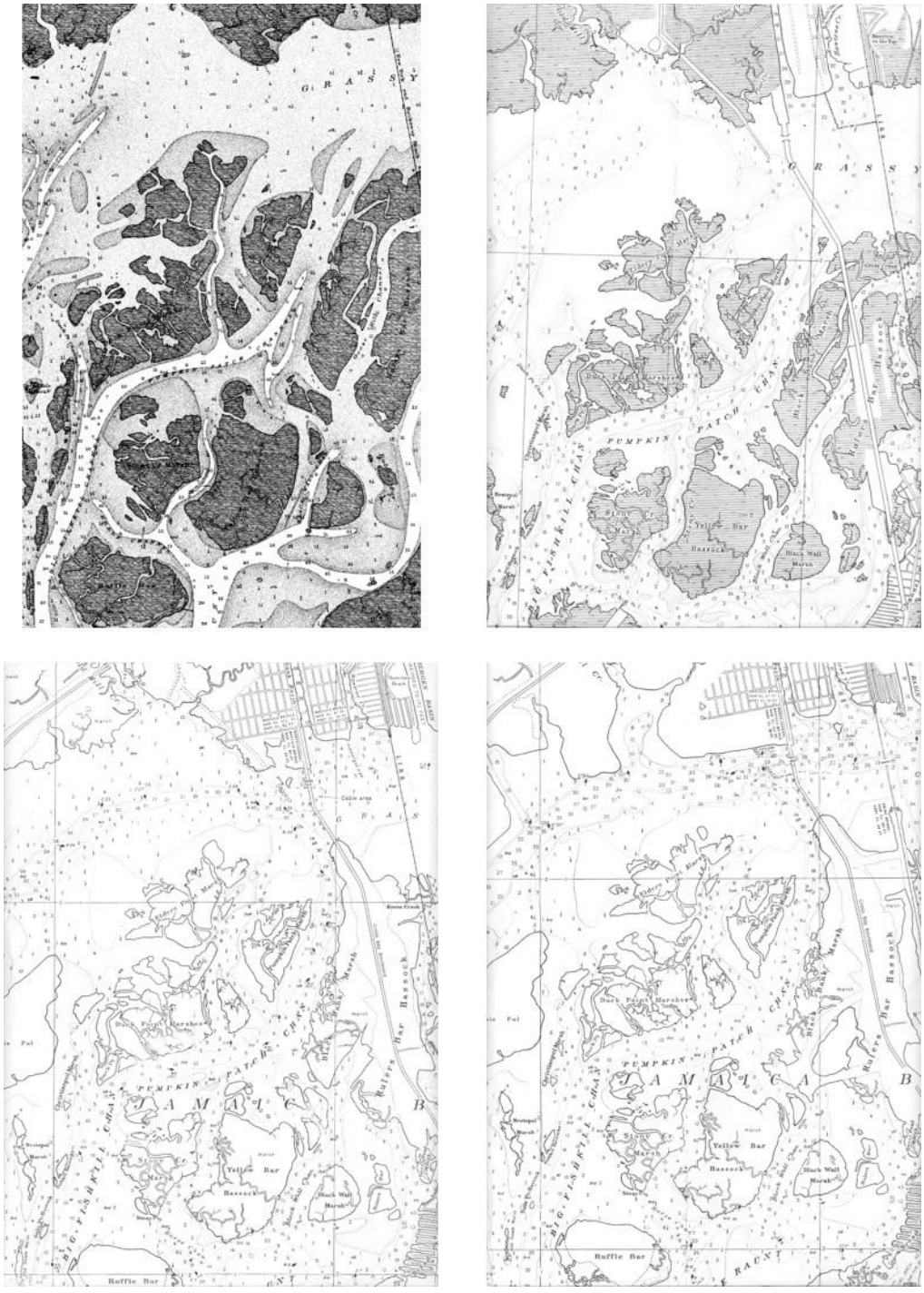



Figure 2-1: Extent of the Jamaica Bay Marsh Islands
Clockwise from top left: A) 1899, B) 1926, C) 1948, and D) 1970.
Source: Ancillary Documentation of the Yellow Bar Hassock Feasibility Report.

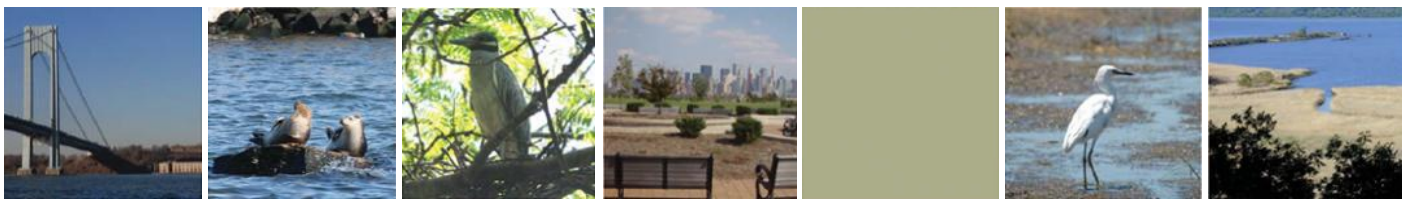


Figure 2-2: Jamaica Bay Marsh Island Extent in 1994. Source: Google Earth.

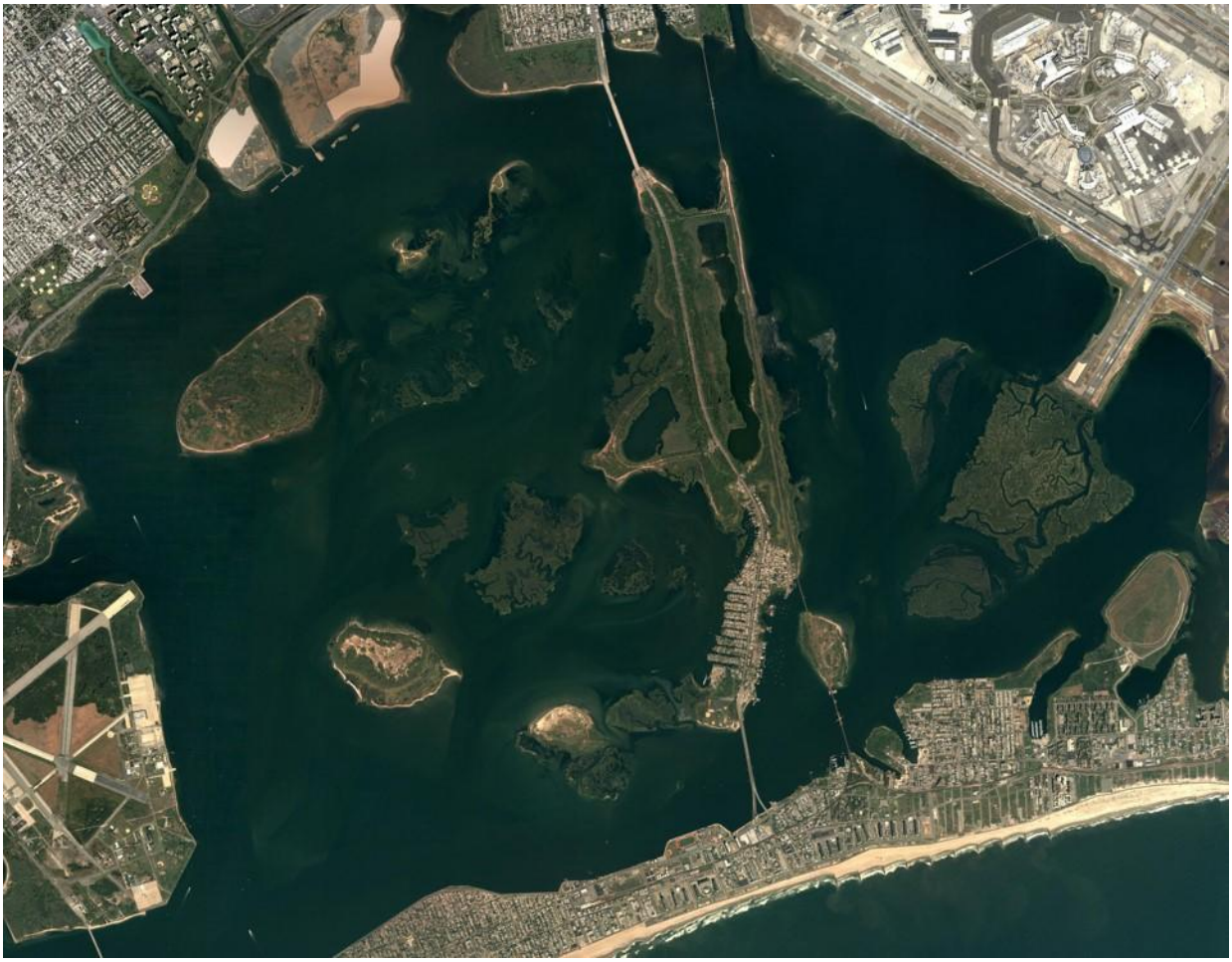


Figure 2-3: Jamaica Bay Marsh Island Extent in 2004. Source: Google Earth.



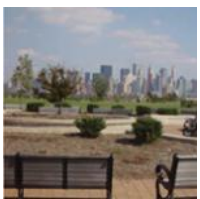




Figure 2-4: Jamaica Bay Marsh Island Extent in 2015. Source: Google Earth.

3 Site Screening

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

- A 2006 Report titled Jamaica Bay Marsh Islands, Jamaica Bay, NY, Integrated Ecosystem Restoration Report included recommendations for restoration of three (3) marsh islands: Elders Point East, Elders Point West and Yellow Bar Hassock.
- Activities at Elders Point East marsh island in 2006-2007 involved restoring 43 acres of marsh constructed for mitigation purposes to offset environmental impacts of the New York and New Jersey Harbor Deepening Project.
- In 2010, the USACE, in partnership with the Port Authority of New York and New Jersey (PANYNJ), the NYSDEC, NYCDEP and NPS restored approximately 40 additional acres at Elders Point West as a result of the beneficial use of dredged material from the Harbor Deepening Project.
- The restoration plan for Elders Point East and Elders Point West included restoring the existing vegetated areas and the sheltered and exposed mudflats by placing dredged sand up to an elevation suitable for low marsh growth. This included hand planting more

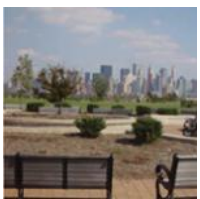
than 700,000 plants (grown from local seed stock by the National Resources Conservation Service on Elders Point East and replanting more than 200,000 plants on Elders Point West.

- A 2015 monitoring report for Elders Point East commissioned by USACE entitled Elders Point East Marsh Island Restoration Monitoring Data Analysis covering the years 2007-2012 detailed lessons learned.
- As part of the NY/NJ Harbor-Jamaica Bay Multi-Project Initiative, sand from the Ambrose Channel was beneficially used from the harbor deepening project to create an additional 87 acres of marsh island habitat within Jamaica Bay. In 2012, 375,000 cubic yards of sand was placed at Yellow Bar Hassock marsh island, resulting in 67 acres of new marsh island and approximately 47 acres of wetlands, including approximately 13.3 acres of hummock relocation, 28 acres of low marsh seeding, 17,175 high marsh plants, and 21,859 high marsh transition plants.
- In 2012, additional Ambrose Channel sand was also beneficially used to restore an additional 30 acres of marsh islands at Black Wall (155,000 cubic yards of sand, 20.5 acres) and Rulers Bar (95,000 cubic yards of sand, 9.8 acres) as part of the USACE's Beneficial Use Program with local partners (NYCDEP, NYSDEC, and PANYNJ). NYCDEP and the NYSDEC with local non-profit organizations (EcoWatchers, Jamaica Bay Guardian and the American Littoral Society) completed a community-based planting effort to vegetate the 30 new acres created at Black Wall and Rulers Bar with the above referenced plants in June 2013.

While Jamaica Bay as a whole represents a rich opportunity for salt-marsh restoration, a number of intractable constraints eliminated candidate sites and resulted in the five (5) restoration sites recommended in the FR/EA. Bird strike concerns by the Federal Aviation Administration resulted in the elimination of all candidate sites east of Cross Bay Boulevard and concerns over accessibility further limited the pool of restoration sites. Limiting depths in the channels of Jamaica Bay render some sites inaccessible to the hopper dredges used to bring material to the site, which greatly impacts the cost of a restoration. An initial screening of marsh island restoration opportunities resulted in nine (9) remaining marsh island sites. A second phase of screening considered the marsh island system as a whole as well as a more focused consideration of issues such as constructability and projected sustainability, resulting in the recommendation of five (5) restoration sites.

Limiting channel depths and the outlines of the historic marsh islands in Jamaica Bay are presented in Figure 3-1. Figure 3-2 illustrates the five (5) selected sites, the five (5) previously constructed sites, and the five (5) sites that were screened out during the second phase of screening.



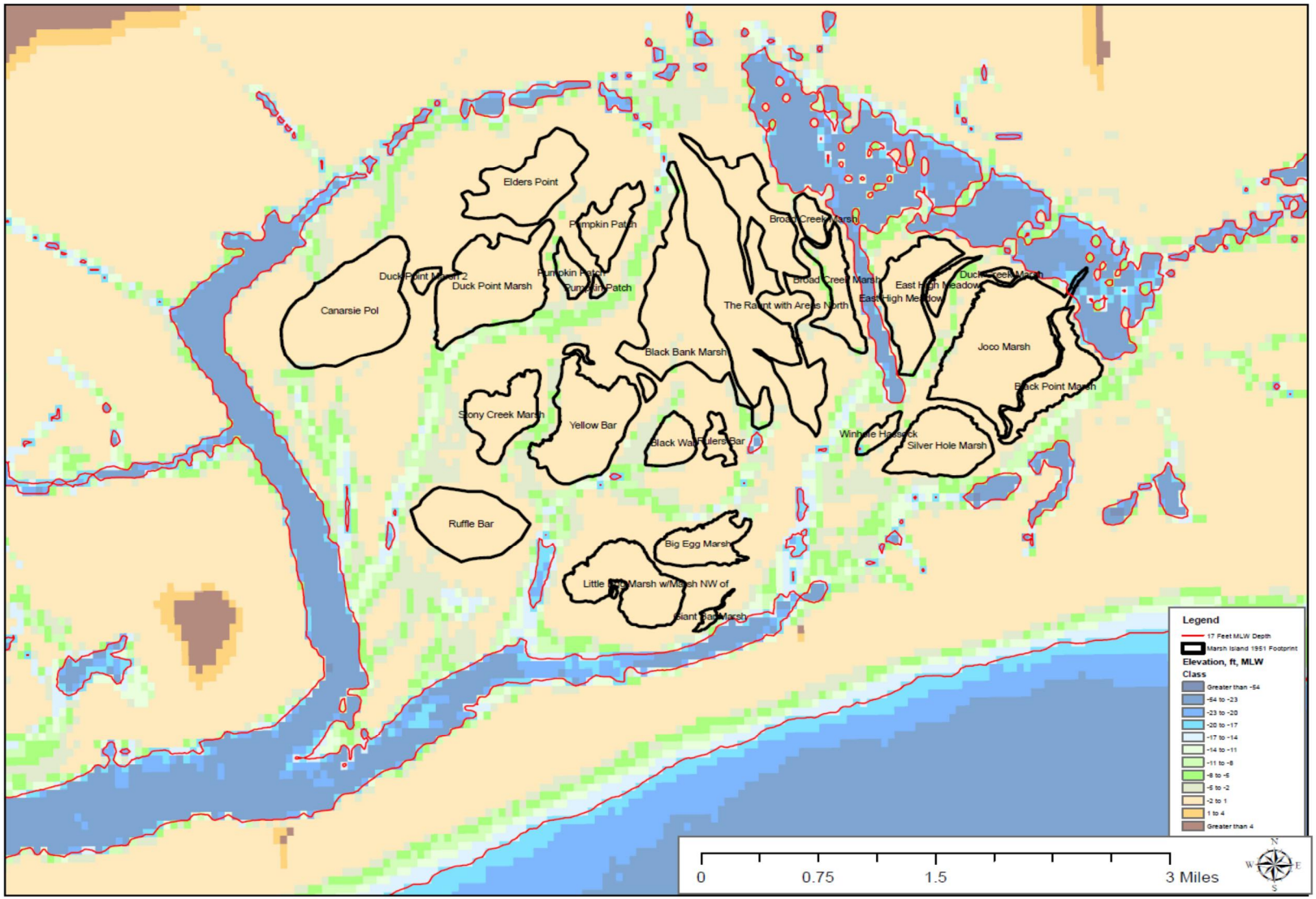



Figure 3-1-: Limiting Channel Depths in Jamaica Bay






The five (5) recommended sites were selected because they will better restore the system as a whole. The proximity of the selected sites will better allow for the recapture of transported sediment and the system as a whole will promote the sustainability of the individual sites.

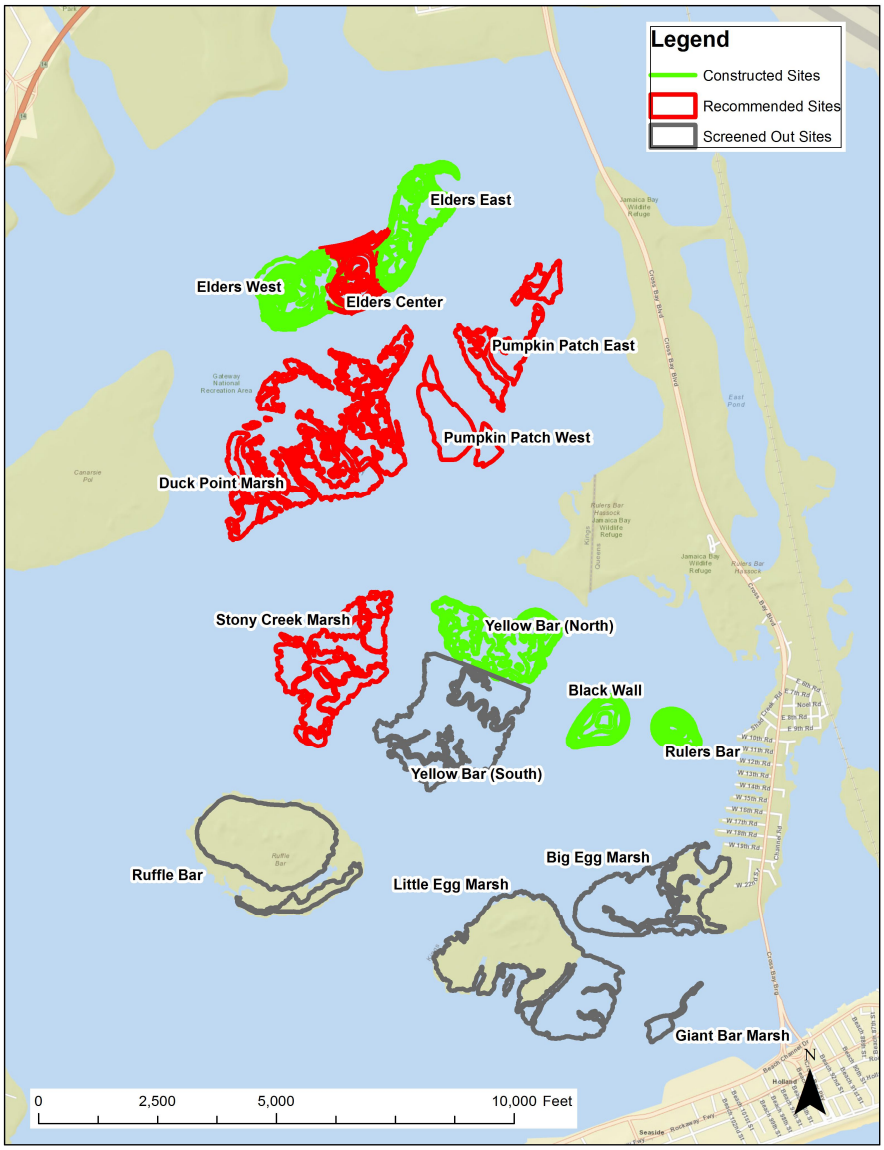


Figure 3-2: Jamaica Bay Marsh Islands – Previously Constructed, Recommended, and Screened-Out Sites

A more thorough understanding of sediment transport and sediment communication between these sites is recommended before proceeding to detailed design in the preconstruction, engineering, and design (PED) phase. This investigation will inform the sequence of construction of the recommended islands, the actual designs of each island, particularly in terms of enhancing sediment stability, as well as the detailed design of the atoll terrace recommended in conjunction with Duck Point Marsh.

4 Assessment Approach for Jamaica Bay Marsh Islands

USACE has extensively surveyed and analyzed the ecological integrity of the Jamaica Bay marsh islands. The reports that informed this assessment are listed in the Ongoing Efforts Appendix (XX). The assessment approach for the marsh islands included studying pre- and post-restoration marsh islands and control islands that have not yet been restored, and reviewing available information on uniqueness and heritage and water quality classifications, such as:

- General field investigations throughout Jamaica Bay; and
- Desktop studies of potential uniqueness and heritage elements and water quality classifications.

5 General Field Investigations

USACE and its partner organizations have conducted many field investigations in the Jamaica Bay Planning Region and on the marsh islands specifically.

The Jamaica Bay Ecosystem Research and Restoration Team (JABERT) and the Jamaica Bay, Marine Park and Plumb Beach Study (Jamaica Bay "source" study) conducted a year-long field study of 12 sites throughout the planning region, including biogeochemistry, vegetation, water quality, soils and sediments, fish, bird, mammal, invertebrate, reptile, and amphibian populations. Although the team focused on identifying shoreline perimeter sites, they also considered some of the marsh islands, including Ruffle Bar, Black Wall and others. The Jamaica Bay "source" study (Appendix E-2 Alternatives Development Jamaica Bay Package) included detailed literature search and inventory of data.

The Jamaica Bay "source" study, among other efforts, have demonstrated the importance of the Jamaica Bay fin fisheries and shellfisheries. Particularly, Atlantic Silverside (*Menidia menidia*), *Fundulus* species, Atlantic Menhaden (*Brevooria tyrannus*), striped mullet (*Mugil cephalus*) winter flounder (*Pseudopleuronectes americanus*), bluefish (*Pomatomus saltatrix*), and striped bass (*Monroe saxatilis*) were particularly prevalent. The most prevalent shellfish species in the area are the northern quahog (*Mercenaria mercenaria*) and the intertidal soft clam (*Mya arenaria*).

The study also focused on the importance of the horseshoe crab (*Limulus polyphemus*). This is particularly important given Jamaica Bay's position in the Atlantic Flyway for migrating birds. Overall, 187 species of birds were observed passing through Jamaica Bay during the course of the study. Six (6) of those species were present for their entire breeding season: clapper rail (*Rallus crepitans*), willet (*Tringa semipalmata*), Forster's tern (*Sterna forsteri*), salt marsh sharp-tailed sparrow (*Ammospiza caudacuta*), seaside sparrow (*Ammospiza maritima*), and boat-tailed grackle (*Quiscalus major*). The area is also home to a great diversity of benthic macroinvertebrates.

In addition to JABERT, the study of Elders Point East, Elders Point West, Yellow Bar Hassock, Black Wall, and Rulers Bar particularly proved helpful in developing alternatives for the proposed marsh islands. The existing conditions, just prior to restoration, of these five (5) islands were similar to the existing conditions of those islands for which restoration is currently proposed.






Elders Point was surveyed by USACE in October of 2003 and representative transects were taken of Yellow Bar Hassock. EPW assessments were also conducted on these two (2) islands with results presented in Section 9.

Pre-restoration, Yellow Bar Hassock and Elders Point were both significantly degraded compared to their original conditions. Elders Point had been reduced to 11 acres by 2005 as compared to 142 acres in 1951, and Yellow Bar Hassock was 80 acres as compared to 184 for the same time period (JBAC, 2007 and NYCDEP, 2007). Elders Point was approximately 50 percent vegetated by mostly smooth cordgrass. Mudflat existed between the smooth cordgrass hummocks. The vegetation was predominantly low marsh with some high marsh, with upland areas dominated by invasive species. Yellow Bar Hassock also consisted of mostly low marsh, with some high marsh and salt pannes.

5.1 Lessons Learned from Elders Point East Restoration (USACE, 2016)

Elders Point East was monitored for five (5) years following construction to collect information on successes and improvements for the next restoration projects. Monitoring of baseline, during-, and post-construction conditions included a variety of physical and biological parameters and performance indicators. Post-construction monitoring was completed in 2012. By that point in time most vegetation structural characteristics (i.e., plant height, stem density, percent cover and aboveground biomass) were comparable values obtained from a reference site (JoCo Marsh). Belowground biomass, however, remained lower than measured reference conditions. This observation was consistent with the longer functional equivalency trajectory associated with mature root system development at other marsh restoration sites in the region. With regard to the development of marsh structural attributes that support fauna, the Elders Point East marsh in 2012 appeared to be providing suitable habitat for characteristic macroinvertebrate and fish assemblages. In particular, the high relative abundance of juvenile fishes indicated that the marsh served as nursery habitat.

The experience gained at the Elders Point East marsh restoration site provides opportunities to transfer knowledge and “lessons learned” to future projects in Jamaica Bay within an adaptive management context. For example, addition of a soil amendment such as fertilizer was deemed only partially successful, and may not necessarily represent the best use of limited project resources and funding in future efforts. In contrast, fencing to limit grazing pressure by geese and other waterfowl was determined to be a valuable management practice, ensuring optimal vegetation establishment conditions, and is strongly recommended for future efforts.

Other specific items of note:

- The average stem count density of *Spartina alterniflora* on Elders Point East increased steadily over the course of the monitoring period.
- Species richness also increased consistently over the monitoring period.
- Total percent cover peaked in 2008, shortly following construction, and declined to a plateau hovering approximately ten percent below that of the reference marsh during the period of 2009 to 2012.
- These results, along with other metrics, suggest that Elders Point East was approaching the condition of JoCo Marsh, the reference marsh, at the end of the monitoring period.
- Benthic macroinvertebrate populations increased notably after restoration at Elders Point East, surpassing the populations at the reference marsh.
- Importantly, Elders Point East became suitable for horseshoe crabs to lay eggs, an






essential food source for many migrating birds. Their presence indicates that the proposed restored islands may also host horseshoe crabs and migratory birds.

6 Desktop Studies

6.1 Uniqueness and Heritage Elements

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.

All of the marsh island sites had previous and ongoing disturbances due to a variety of anthropogenic perturbations (e.g., dredging, placement of combined sewer overflows, overharvesting, etc.). Several species use the marsh island sites, including federally-listed threatened red knot (*Calidris canutus rufa*), American oystercatcher (*Haematopus palliatusi*), black skimmer (*Rhynchops niger*), diamondback terrapin (*Maclemys t. terrapin*) (a federal species of concern), and horseshoe crab (*Limulus polyphemus*).

In compliance with Section 106 of the National Historic Preservation Act and the National Environmental Policy Act, each of the proposed restoration sites would need to be evaluated on a case-by-case basis for archaeological and historic architectural sensitivity based on the actions associated with the restoration techniques chosen to be implemented at each location. If eligible archaeological or historic architectural resources are encountered, recommendations would be made for avoiding such resources. If the eligible resources cannot be avoided, then mitigation measures would be suggested. Mitigation could require the relocation, preservation in place and/or augmentation of project plans to reduce the direct or indirect impact on a resource.

Due to potential impacts to National Register listed or eligible sites, a memorandum of agreement will be developed by the USACE in consultation with the State Historic Preservation Office, the Advisory Council on Historic Preservation, and other interested parties.

6.2 Water Quality Classifications

All waters in New York State are assigned a letter classification that denotes their best uses. Letter classes such as A, B, C, and D are assigned to surface waters. Review of the NYSDEC Enviromapper[1] indicated that all sites in the vicinity of the Jamaica Bay marsh islands were classified as “SB,” surface marine class B waters. The best usages of Class SB waters are swimming, other recreation, and fishing. These waters are designated suitable for fish, shellfish, and wildlife propagation and survival.

[1]http://www.dec.ny.gov/imsmaps/ERM/viewer.htm






7 Evaluation of Planned Wetlands (EPW)

7.1 EPW Process

EPW was conducted as described in Section 2.1.1 of main appendix. While no field investigations of the proposed 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.

7.2 Considerations for EPW for the Jamaica Bay Marsh Islands

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 7-1).

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 (4) wetland assessment area (WAA) locations, including one (1) high marsh and one (1) 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 7-1: Pre-restoration 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
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 the introduction to 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 as a baseline in the average annual functional capacity unit (AAFCU) calculation.

7.3 EPW Results

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 NPS and USACE. Existing acreages for the five (5) proposed marsh islands were estimated from Google Earth aerial imagery.

Table 7-2 presents the EPW FCIs for Elders Point and Yellow Bar Hassock and the FCIs for existing conditions for the marsh islands proposed for restoration. All EPW FCIs are pre-restoration scores.






Table 7-2: Baseline EPW Comparative Table – FCIs for Prior Marsh Island Restoration and Projected Scores for Recommended Marsh Island Restoration

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
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
Stony Creek	0.43	0.75	0.71	0.22	0.26	1.0
Pumpkin Patch East	0.40	0.75	0.71	0.22	0.27	1.0
Pumpkin Patch West	0.36	0.69	0.74	0.22	0.34	1.0
Duck Point	0.42	0.74	0.72	0.22	0.29	1.0
Elders Point Center	0.42	0.73	0.72	0.22	0.29	1.0

8 Proposed Alternatives

Alternatives developed at the five (5) marsh island locations were based on lessons learned and cost-effectiveness evaluations to develop the optimal marsh island size and design. Past construction provided valuable data on how to restore the marsh islands in the most effective and efficient manner. Basic lessons learned that influenced alternative development included the following:

- Ecological output for a given acre of marsh island is constant based on the prior EPW assessments for Elders Point East, Elders Point West and Yellow Bar Hassock and monitoring results of the islands by NPS and USACE.
- The cost of marsh island construction is dependent upon existing condition depth and the cost of the sand material and material transport.
- The size of the marsh island is influenced by the amount of contiguous and sustainable acreage within the 1974 regulatory footprint within a given range of elevations.
- The range of acreage at each marsh island has a minimum area driven by cost constraints of mobilization and demobilization of dredging and placement of sand.
- The maximum area/acreage of the marsh island may be described by the existing depth at which sand placement becomes more expensive and less cost-effective.
- Approximately 50 percent subsidence of sand following placement of dredged material was assumed.






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

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

- Minimum restoration area/volume: a minimum area for each site was defined based on the cost constraints of mobilization and demobilization (mob/demob) and the ratio of mob/demob to the overall project cost such that the cost of mob/demob is estimated to be less than 30 percent. Of the project costs, placement of this minimum area, and to a lesser extent the size of this minimum area, was informed by the location of the highest existing condition elevations and vegetation, the 1974 footprint, and the historic configuration of the marsh island footprint as indicted by historic aerial photography.
- Maximum restoration area: A maximum area for each site was delineated based on existing condition contours. Restoration beyond this contour represents a break point where the per-acre cost of restoration increases considerably. This constraint was well defined at some sites and less so at others and is discussed in detail in the site summaries provided below.
- Sustainability: This constraint consists of a number of related factors including the configuration of the selected plan which is constrained by minimum widths, contiguity, proximity to relatively high velocity currents, and existing channels.

A single alternative was therefore developed for each marsh island based upon these fundamental and governing constraints and the lessons learned from prior efforts. Initial quantity take-offs and costs where then developed and the plans were then further refined based on the guidelines established above. For more detailed engineering information on each of the following alternatives, please refer to the Engineering Appendix (XX). Background and details for the development of each marsh island alternative design are provided below.

8.1 Stony Creek Marsh Island Restoration

The existing condition remnant marsh found at Stony Creek marsh island is well defined and






characterized by relatively high elevations, much like its neighbor Yellow Bar Hassock marsh. The existing marsh is approximately 34 acres.

In the no-action alternative, erosion at Stony Creek marsh would likely continue, though the relatively high elevations may provide better short-to-medium term protection than the remaining Jamaica Bay marsh islands as whole. Geographic Information System analysis estimates that in 1974, the marsh island had an area of approximately 84 acres. Almost 60 percent of the marsh island has been lost in the past 42 years. As with the other marsh islands, it is in danger of sea level rise, continued water quality stressors, and habitat fragmentation.

The minimum restoration area approximately coincides with the +2-foot North American Vertical Datum of 1988 (NAVD88) elevation contour, coincides with the well-defined existing footprint of this marsh island, and encompasses an area of 34 acres. The maximum restoration area coincides with the -1-foot NAVD88 contour and encompasses an area of 72 acres.

The Tentatively Selected Plan (TSP) and these boundaries are shown in Figure 8-1. The TSP restores approximately 51 acres of marsh, with a total of 70 acres of regrading. The TSP is approximately midway between the maximum and minimum boundary. In this case, the actual acres of marsh restored can easily be increased or decreased by approximately 20 percent with only a marginal decrease in efficiency. The maximum boundary in this instance is not well defined; the slope from the island to offshore is relatively consistent. The maximum area is however also constrained by the area of 1974 footprint, which encompasses a total area of approximately 95 acres total and a land area of approximately 85 acres. A total restoration area closer to the minimum boundary of 34 acres is not recommended as this will result in an unacceptably high ratio of mobilization/demobilization costs to the total cost (Figure 8-2).

The TSP for Stony Creek marsh (Figure 8-1) represents the most efficient effort of the five (5) marsh island restorations, with an average of 2,970 cubic yards of material needed per acre of marshland restoration. Sustainability issues for this effort are negligible, with the exception of the proximity of Horse Channel along the southeastern boundary of the site. This plan includes the creation of 26 acres of low marsh, 25.3 acres of high marsh, and five (5) tidal channels that, together, will provide both aquatic and wetland habitat. The proposed alternative also incorporates a minimal amount of scrub/shrub habitat, which will provide habitat diversity for the vegetation and wildlife on the island.





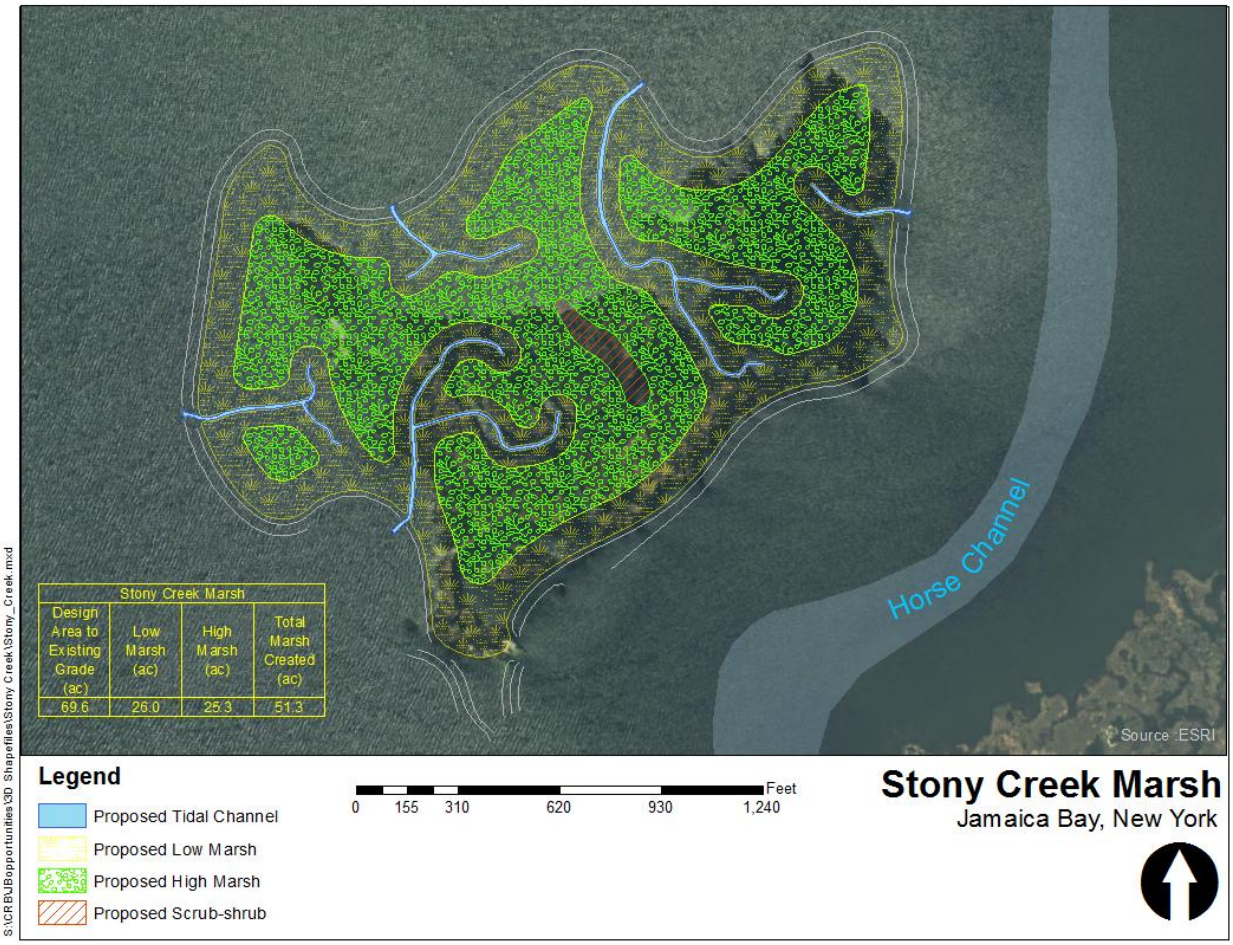
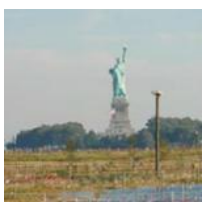



Figure 8-1: Stony Creek Marsh Tentatively Selected Plan







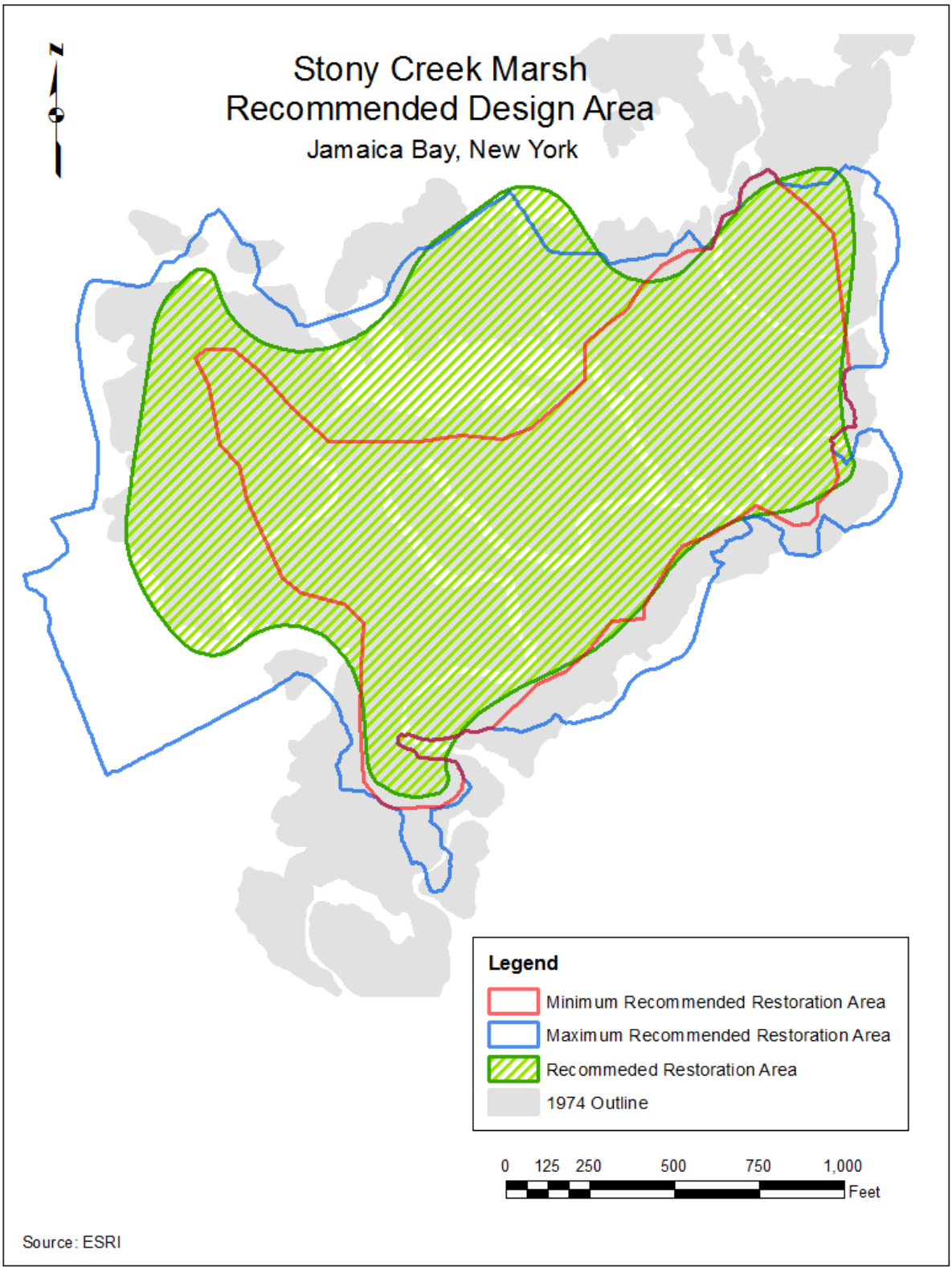



Figure 8-2: Stony Creek Marsh Minimum and Maximum Restoration Area







8.2 Pumpkin Patch East Restoration

Pumpkin Patch East is currently approximately eight (8) acres. The average loss rate for Pumpkin Patch as a whole is approximately 1.3 acres per year between 1974 and 1994, with variation up to 2.5 acres per year between 2003 and 2005. In the no-action alternative, it is feasible that Pumpkin Patch East could disappear altogether.

Site specific planning constraints include:

- Existing bathymetry for sustainable sand placement; and
- NYSDEC regulatory footprint of marsh islands in 1974.

Restoration at Pumpkin Patch initially focused on the restoration of a single large island that would encompass Pumpkin Patch West, Pumpkin Patch East and an area further to the east. The selected plans recommend two (2) separate restoration projects, Pumpkin Patch West and Pumpkin Patch East. Restoration in the area between these two (2) sites and to the east of Pumpkin Patch is not presently recommended due to concerns over sustainability and to the amount of material that would be needed to restore these areas. A future restoration of the area between these two (2) selected plans may be considered after the restoration of Elders Point Center which may have a positive effect on sediment transport and sustainability in this area and could be investigated using hydrodynamic modeling.

The minimum restoration area for Pumpkin Patch East coincides with the -2-foot NAVD88 elevation contour and encompasses an area of 22 acres. The maximum restoration area coincides with the -3-foot NAVD88 contour and encompasses an area of 52 acres (Figure 8-3). Existing condition depths are greater in this location when compared to marsh islands such as Yellow Bar Hassock and Stony Creek marsh, resulting in a significantly greater amount of material per acre needed for restoration. The recommended extent is based on the need to restore an area judged to be sustainable while containing project costs by staying within the higher elevations available at the site. Put another way, restoration to the -2-foot NAVD88 contour would compromise the overall sustainability of the restoration effort while a full build-out to the -3-foot NAVD88 contour would need increasingly greater material to restore the additional acreage beyond the recommended plan. The extent is also informed by the 1974 footprint, which served as a constraint, particularly along the western edge, contributing to concerns of erosion and sustainability.

The TSP (Figure 8-4) restores a total of 35 acres of salt marsh with a total of 52 acres to be graded. This restoration includes 18.6 acres of low marsh, 16.8 acres of high marsh, and six (6) tidal channels. The marsh island will provide significantly more wetland habitat than exists currently, especially when considered with the sister marsh island, Pumpkin Patch West. The restoration of these neighboring marsh islands reduces habitat fragmentation in the area.





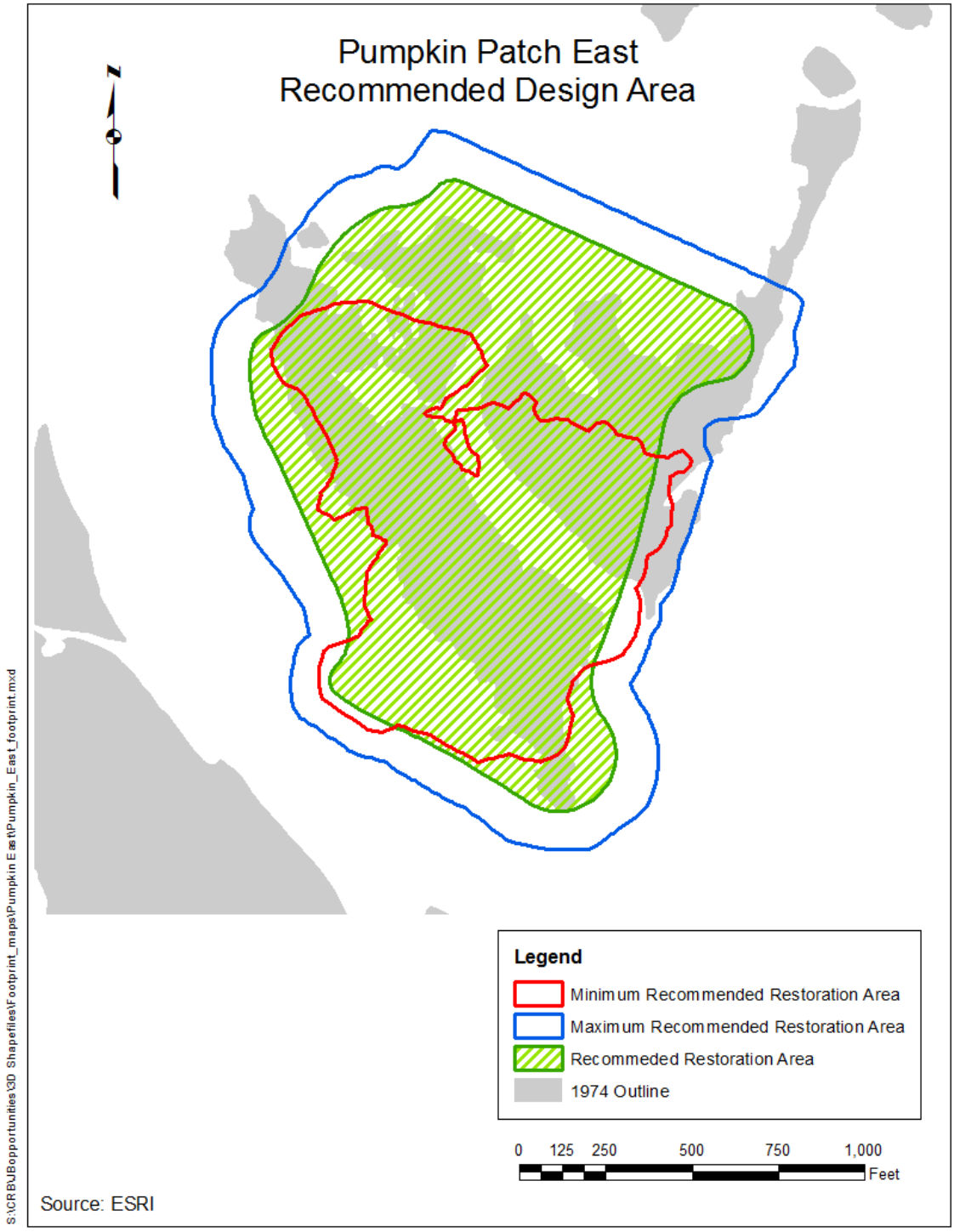



Figure 8-3: Pumpkin Patch East Minimum and Maximum Restoration Area







Figure 8-4: Pumpkin Patch East Tentatively Selected Plan






8.3 Pumpkin Patch West Restoration

Pumpkin Patch West is currently approximately four (4) acres. The average loss rate for Pumpkin Patch as a whole is approximately 1.3 acres per year, with variation up to 2.5 acres per year between 2003 and 2005. In the no-action alternative, it is feasible that Pumpkin Patch West could disappear altogether.

Site specific planning constraints include:

- Existing bathymetry for sustainable sand placement;
- NYSDEC regulatory footprint of marsh islands in 1974; and
- High erosion in portions of the site.

The governing constraint at this site is the minimum area judged necessary to achieve sustainability as well as the exiting condition bathymetry of the site. The minimum area coincides with -3-foot NAVD88 elevation contour and encompasses an area of 20 acres (Figure 8-5). Using this as a basis, the recommended plan was enlarged somewhat to better coincide with the 1974 footprint. A maximum restoration area was not delineated for Pumpkin Patch West as it was clearly evident that the only other option here would be to restore the area between Pumpkin Patch East and Pumpkin Patch West. Doing so would greatly increase the amount of material needed and was judged to be an inefficient approach given the evidence of high erosion in this area.

The TSP for Pumpkin Patch West (Figure 8-6) restores a total of 16.3 acres of salt marsh with a total of 30 acres to be graded. This includes 10.8 acres of low marsh and 5.5 acres of high marsh, returning this portion of Pumpkin Patch Marsh to the approximate dimensions of the 1974 footprint. As noted above, the area between Pumpkin Patch East and Pumpkin Patch West may be a candidate for restoration, but should be considered only after the restoration of Elders Point Center and an investigation of the altered hydrodynamics of this area.







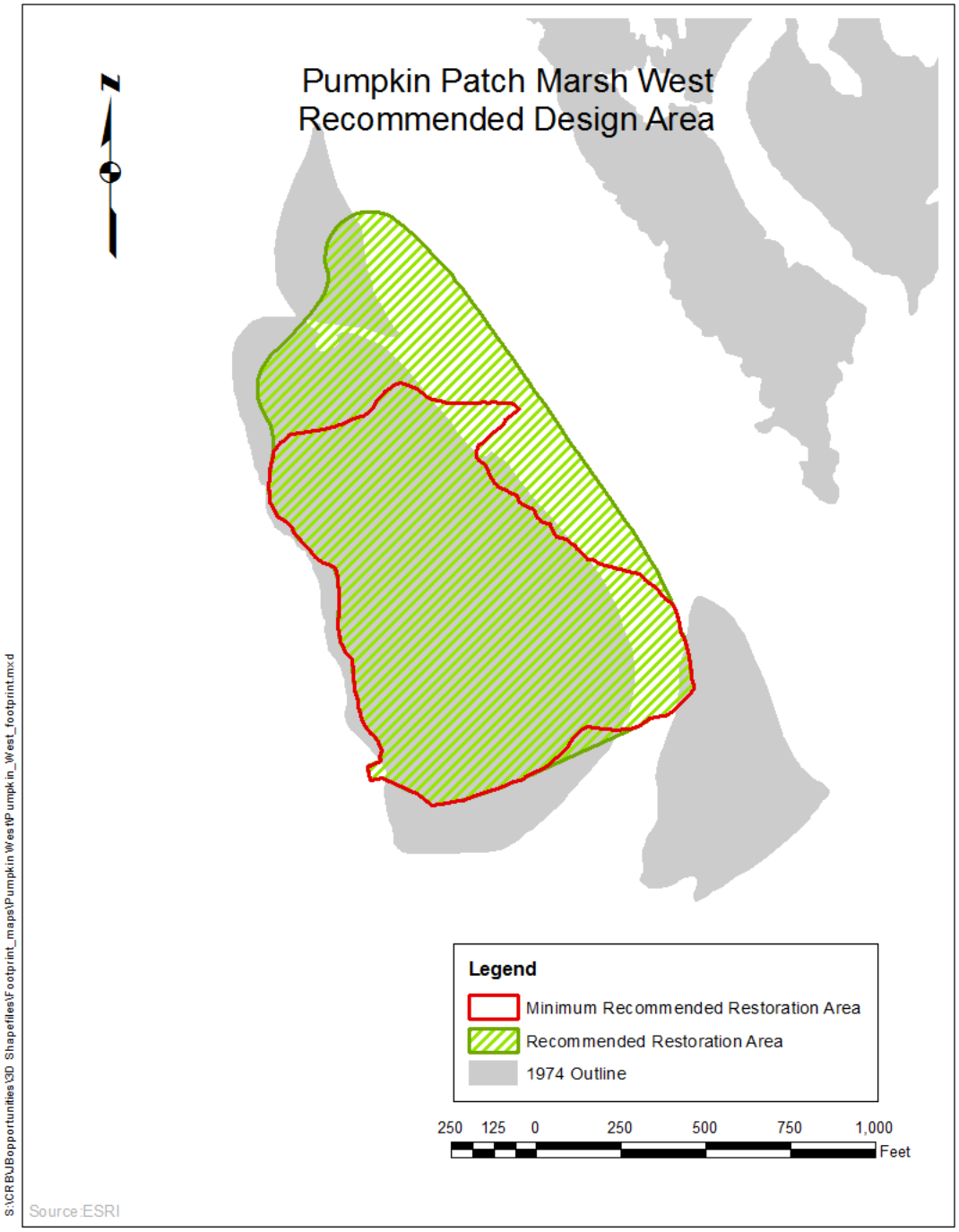


Figure 8-5: Pumpkin Patch West Minimum and Recommended Restoration Area

Figure 8-6: Pumpkin Patch West Tentatively Selected Plan






8.4 Duck Point with Atoll Terrace Restoration

The existing elevations at Duck Point represent approximately 17 acres, more than half of which are at the lower end of the low marsh range. Duck Point has experienced a high rate of marsh loss at approximately 2.8 acres per year between 1974 and 1994. In the no-action alternative, this loss would continue and would disappear over time.

Site specific planning constraints include:

- Existing bathymetry; and
- NYSDEC regulatory footprint from 1974.

Due to the relatively high elevations here, the governing constraint at this site is the maximum recommended restoration area. The minimum recommended restoration area coincides with the +1-foot NAVD88 elevation contour and encompasses an area of 19 acres. The maximum recommended restoration area coincides with the -1-foot NAVD88 elevation contour and encompasses an area of 42 acres (Figure 8-7).

In this instance, the TSP coincides with the maximum recommended restoration area and largely conforms to the 1974 footprint. The only modification made was to widen the center bar that the two (2) lobes of this marsh island so as to promote sustainability. This maximum build-out alternative is recommended due to the well-defined nature of this restoration site. The recommended plan for marsh restoration at Duck Point marsh (Figure 8-8) restores a total of 27.9 acres of salt marsh with a total of 41.5 acres to be graded. Of the 27.9 acres to be restored, 15.4 acres are low marsh and 12.5 acres are high marsh. Much like Stony Creek marsh, this represents an efficient restoration with a relatively small amount of cubic yards of material per acre of restoration.

The marsh restoration at Duck Point marsh is paired with the placement of a nine (9) acre atoll terrace, which is a targeted sand placement feature that resembles a vegetated berm. Extensive research on these features has been conducted by the Structures of Coastal Resilience project at the City University of New York (Figures 8-9 and 8-10). The theory behind the atoll terrace is that harnessing the natural wind and wave processes in Jamaica Bay will promote a continual cycle of recruiting additional material from the bay and then redistributing it, potentially strengthening the marsh's resilience to erosion over time. The atoll is placed in such a manner to capture sediment transported during both times of flood and ebb tide. The atoll terrace is a linking component in the system of completed and recommended projects within this area of Jamaica Bay.





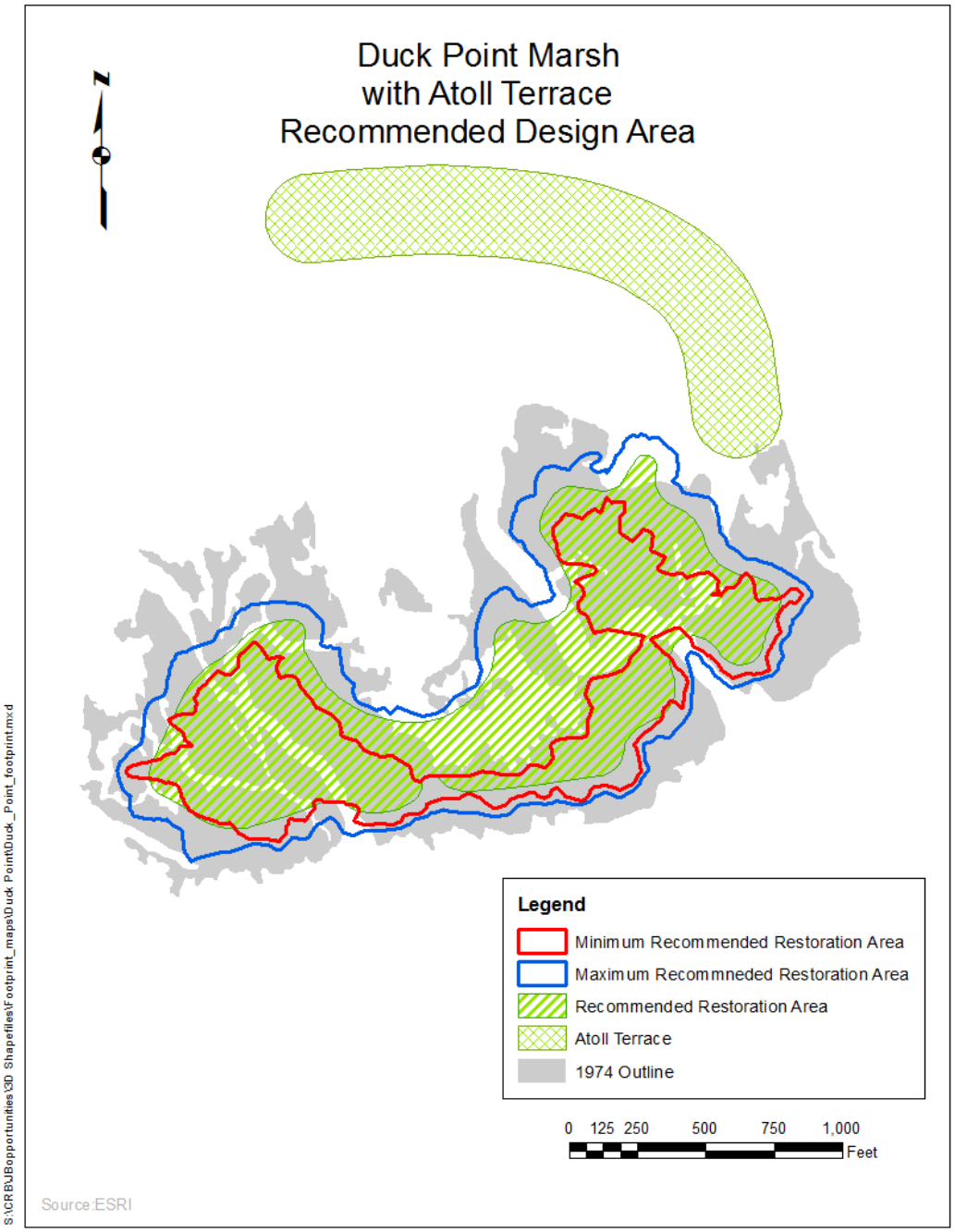



Figure 8-7: Duck Point Marsh Minimum and Maximum Restoration Area







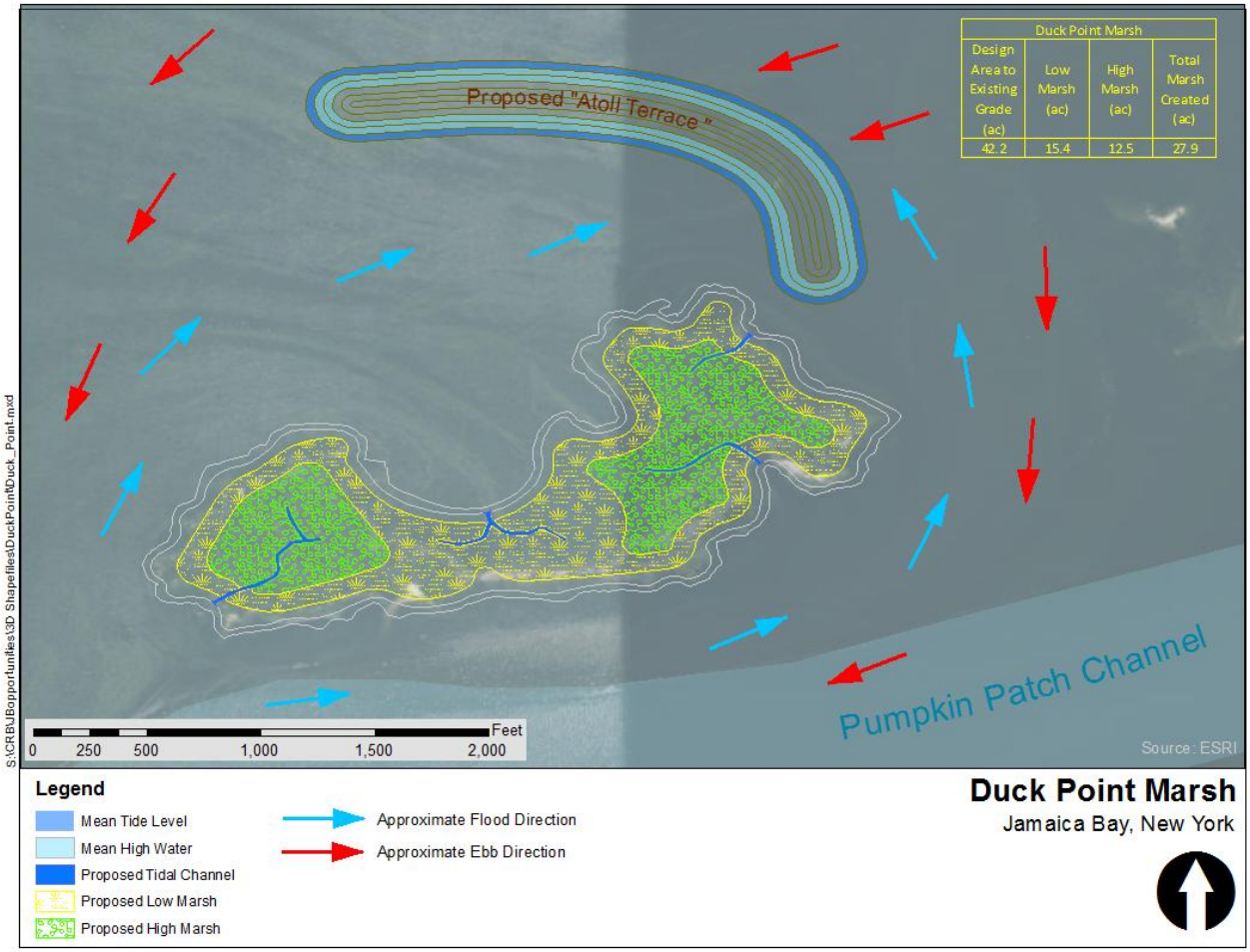


Figure 8-8: Duck Point Marsh with Atoll Terrace Tentatively Selected Plan





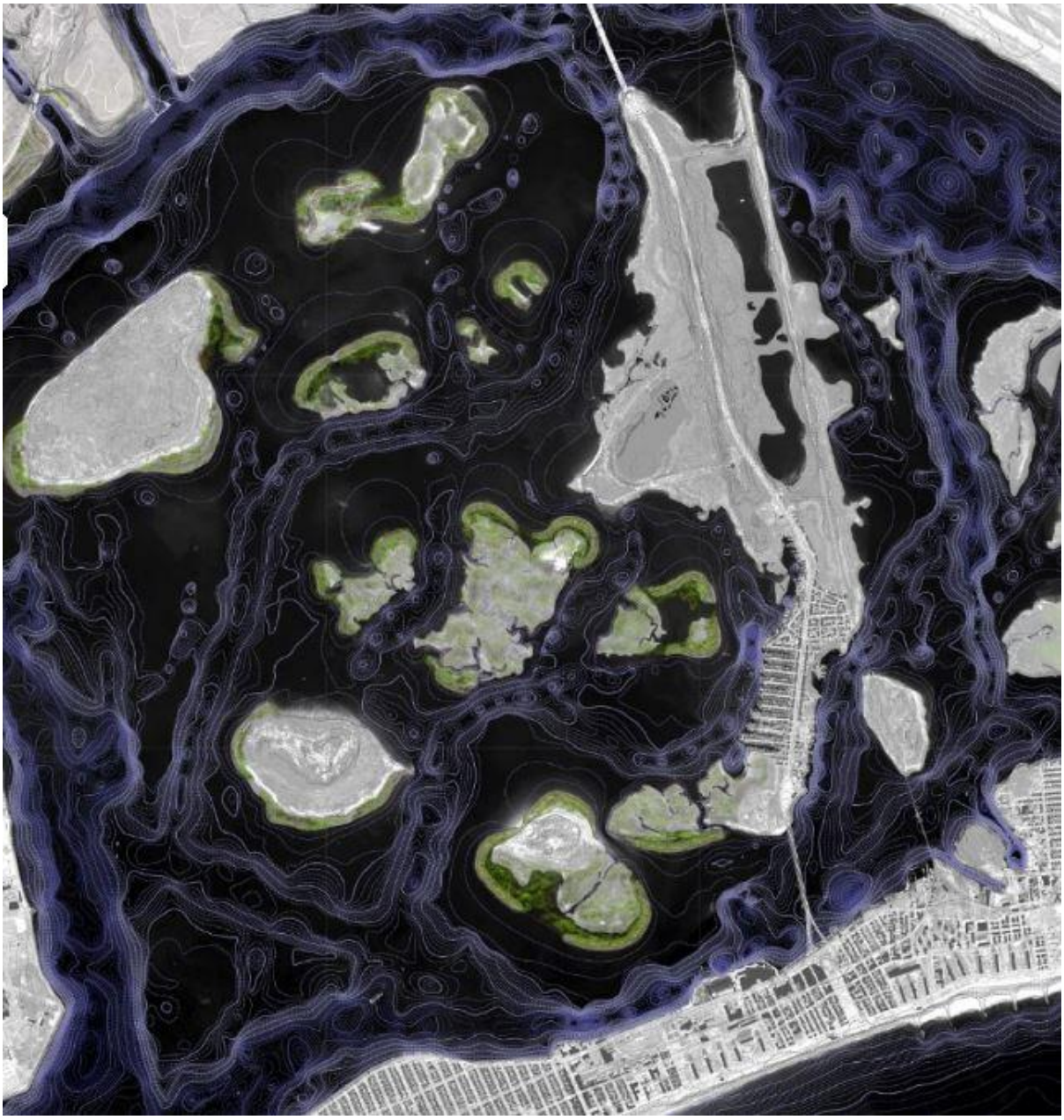



Figure 8-9: Recommended Placement of Atoll Terraces (in green)
Structures of Coastal Resilience, Spitzer School of Architecture, City College of New York







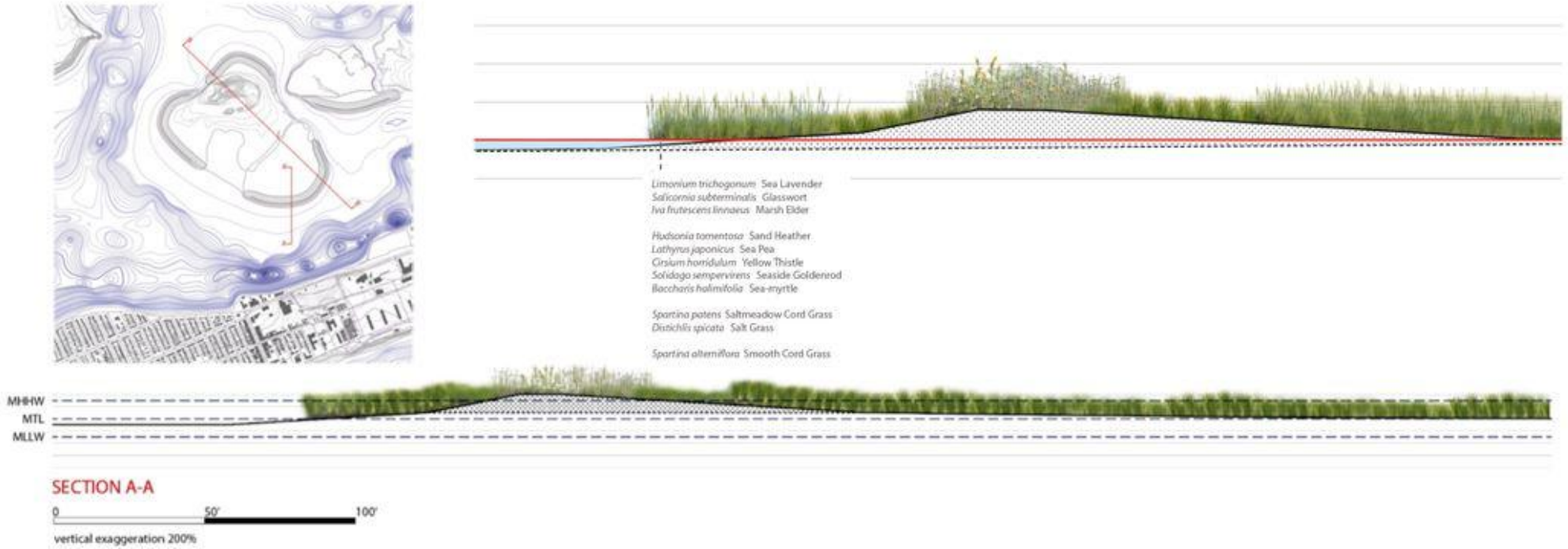


Figure 8-10: Sample Cross-section of an Atoll Terrace (Structures of Coastal Resilience, CUNY).

8.5 Elders Point Center Restoration

Elders Point Marsh was historically one (1) island but marsh loss in the center of the island created two (2) distinct islands separated by a mud flat (USACE, 2006). When the restoration of Elders Point East and Elders Point West were planned and implemented, it was infeasible to restore Elders Point Center based on the depth of the substrate in that area. The restoration was limited to an increase in size of 40 acres of new marsh at Elders Point East (2007) and 43 acres of new marsh at Elders Point West (2010). Presently, no marsh island exists above water between the two (2) islands and Elders Point Center would not exist in the no-action alternative.

However, following the implementation of restoration at Elders Point East (2007) and Elders Point West (2010), sediment has accumulated in the area of Elders Point Center, which has made restoration feasible and cost-effective. The creation of Elders Point Center will result in a continuous marsh island between Elders Point East and Elders Point West, adding benefits such as reduction in habitat fragmentation and the potential for ancillary coastal storm reduction benefits for nearby mainland communities such as Howard Beach.

The TSP at Elders Point Center restores 16 acres of salt marsh with a total of 33.6 acres of graded area (Figure 8-11). Of that, 8.5 acres are high marsh and 7.5 acres are low marsh. The design of the TSP is constrained by the presence of Elders Point East and Elders Point West, two (2) previous restoration projects and by the increasing depths found to the north and the south. As these conditions represent the governing constraints, no minimum or maximum recommended restoration areas were developed. The actual acres of marsh restored can easily be increased or decreased by approximately 20 percent with only a marginal decrease in efficiency at this site.

The restoration of Elders Point Center results in a contiguous Elders Point marsh island, much like it existed in pre-industrial times. This is especially promising, as the effort adds to the 83 acres already restored at Elders Point East and Elders Point West. As detailed in the Elders Point East monitoring report (USACE, 2015), Elders Point East is projected to match the reference marsh conditions. This progression bodes well for the future of Elders Point Center, as it will already have an ecological community on the adjacent marsh islands. A particularly salient point about Elders Point East is that it hosts egg-laying horseshoe crabs, whose eggs are an important source of food for migratory birds along the Atlantic Flyway.





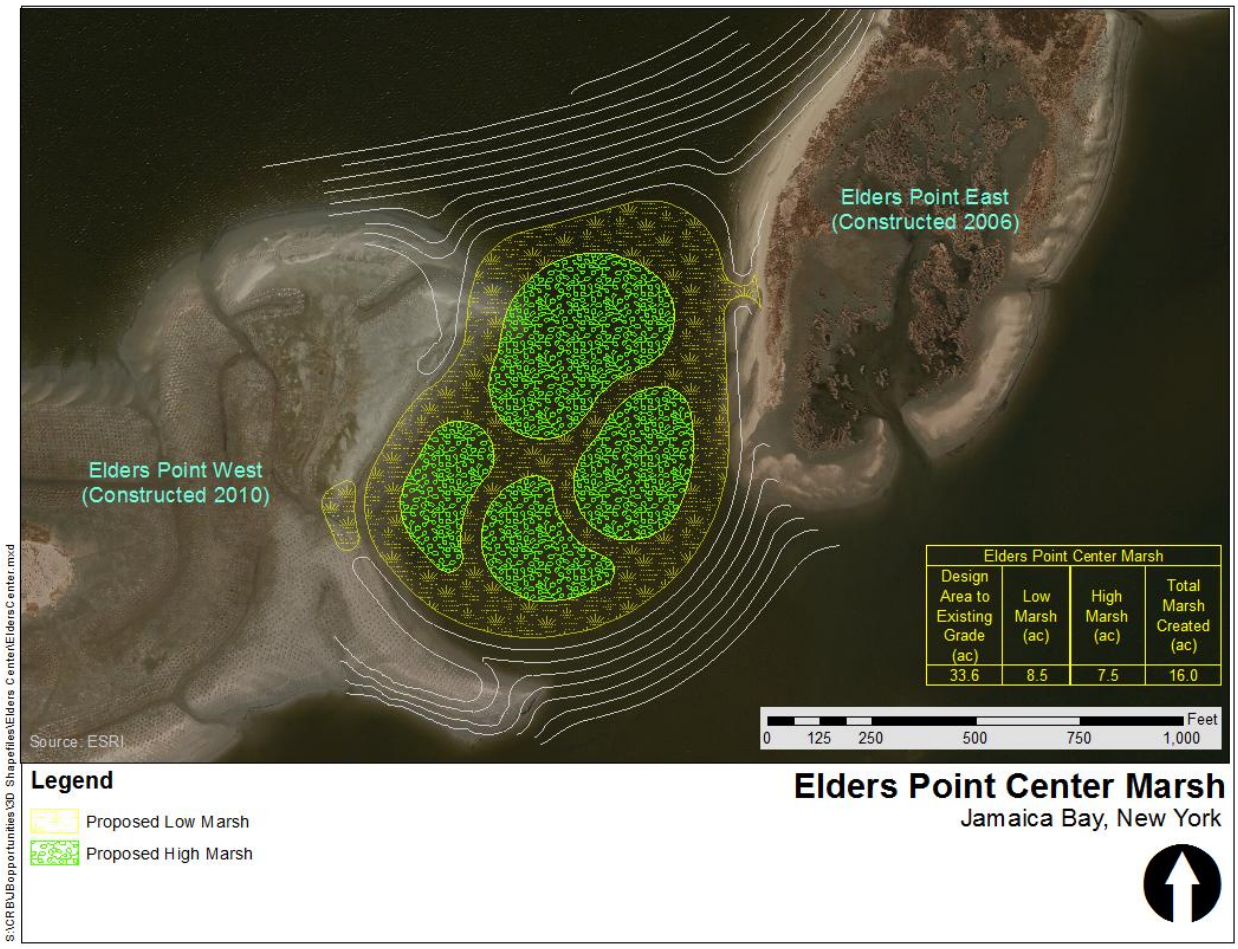



Figure 8-11: Elders Point Center Tentatively Selective Plan

9 EPW Results- Functional Capacity Units (FCUs) for Recommended Marsh Island Alternatives

EPW scores were calculated for alternatives using the FCI predicted from the FCIs measured at Elders Point East, Elders Point West and Yellow Bar Hassock. Table 9-1 presents the FCIs for each of the five (5) EPW functions for each proposed marsh island.






Table 9-1: Predicted EPW FCIs for each Marsh Island

Site	Shoreline Bank Erosion Control	Sediment Stabilization	Water Quality	Wildlife	Fish (Stream/ River)
Stony Creek	0.58	0.75	1.0	0.85	0.41
Pumpkin Patch East	0.57	0.75	1.0	0.85	0.43
Pumpkin Patch West	0.52	0.69	1.0	0.88	0.54
Duck Point	0.56	0.74	1.0	0.86	0.45
Elders Point Center	0.56	0.73	1.0	0.86	0.46

The tables below indicate the existing and proposed alternative FCIs, restoration areas, and FCUs for the separate metrics and total FCUs.

9.1 Stony Creek

At Stony Creek marsh island, the acreage of the recommended marsh island is approximately four (4) times the existing marsh island. As a result, all FCU scores (Table 9-2) increased dramatically.

Shoreline Bank Erosion Control (SB): The FCU score for SB is approximately double in the recommended alternative (27.97) compared to the existing conditions (14.59). This results from an increase in both size and FCI for shoreline bank erosion control.

Sediment Stabilization (SS): The sediment stabilization FCU score is expected to increase by approximately 50 percent (36.78 compared to 25.66 in the existing conditions). This is due to the increase in acreage.

Water Quality (WQ): Water quality is expected to improve from its already relatively high FCI (0.71) to an FCI of 1.0. This, in combination with the increase in acreage, results in a doubling of the FCU score for water quality (24.02 to 48.74).

Wildlife (WL): The recommended alternative improves the wildlife function compared to the existing conditions (FCU = 7.32 to 41.36), mainly due to the increase of functional capacity for each acre (FCI = 0.22 to 0.85).

Fish-Tidal (FT): Current conditions rate a FCI score of 0.26 and an FCU score of 8.96. The recommended alternative results in an increase in both FCI and FCU scores (FCI = 0.41, FCU=20.17).

Based on the EPW assessment, the recommended alternative results in substantial improvements to the functionality of the site from 80.52 total FCUs for existing conditions to 174.92 total FCUs for the TSP.







Table 9-2: EPW FCU Scores - Stony Creek

Function	Existing Conditions WAA			Recommended Alternative		
	FCI	AREA	FCUs	FCI	AREA	FCUs
SB	0.43	34	14.56	0.58	49	27.97
SS	0.75	34	25.66	0.75	49	36.78
WQ	0.71	34	24.02	1.0	49	48.74
WL	0.22	34	7.32	0.85	49	41.26
FS	0.26	34	8.96	0.41	49	20.17
Total FCU			**80.52**			**174.92**

9.2 Pumpkin Patch East

On Pumpkin Patch East, the acreage of the recommended marsh island was increased approximately 10acres, four (4) times the existing marsh island. As a result, all FCU scores (Table 9-3) increased dramatically.

Shoreline Bank Erosion Control (SB): The FCU score for SB is over five (5) times higher in the recommended alternative (19.06) compared to the existing conditions (3.39). This results from an increase in both size and FCI for shoreline bank erosion control.

Sediment Stabilization (SS): The sediment stabilization FCU score is expected to improve substantially (25.07 compared to 5.98 in the existing conditions). This is due to the increase in acreage.

Water Quality (WQ): Water quality is expected to improve from its already relatively high FCI (0.71) to an FCI of 1.0. This, in combination with the increase in acreage, results in dramatic increase in the FCU for water quality (5.68 to 33.54).

Wildlife (WL): The recommended alternative improves the wildlife function compared to the existing conditions (FCU = 1.73 to 28.52), due to the increase of functional capacity for each acre (FCI = 0.22 to 0.85) and the increase in acreage.

Fish-Tidal (FT): Current conditions rate a FCI score of 0.27 and an FCU of 2.18. The recommended alternative results in an increase in both FCI and FCU scores (FCI = 0.43, FCU=14.35).

Based on the EPW assessment, the recommended alternative results in substantial improvements to the functionality of the site from 18.96 total FCUs for existing conditions and 120.54 total FCUs for the TSP.






Table 9-3: EPW FCU Scores – Pumpkin Patch East

Function	Existing Conditions WAA			Recommended Alternative		
	FCI	AREA	FCUs	FCI	AREA	FCUs
SB	0.43	8	3.39	0.57	34	19.06
SS	0.75	8	5.98	0.75	34	25.07
WQ	0.71	8	5.68	1.0	34	33.54
WL	0.22	8	1.73	0.85	34	28.52
FS	0.27	8	2.18	0.43	34	14.35
Total FCU			**18.96**			**120.54**

9.3 Pumpkin Patch West

Similarly to Pumpkin Patch East, the EPW results for the recommended alternative for Pumpkin Patch West (Table 9-4) is almost four (4) times the existing acreage (16 acres recommended, with 15 remaining after 50 years for the EPW estimates).

Shoreline Bank Erosion Control (SB): The FCU score for SB represents a dramatic improvement in the recommended alternative (FCU = 8.11) over the existing conditions (FCU = 1.56) due to increases in both acreage and value per acre.

Sediment Stabilization (SS): The sediment stabilization FCU score is expected to increase substantially (10.68 compared to 2.76 in the existing conditions). This is due to the increase in acreage.

Water Quality (WQ): Water quality is expected to improve from its already relatively high FCI (0.74) to an FCI of 1.0. This, in combination with the increase in acreage, results in a multifold increase in FCU score for water quality (2.96 to 15.49).

Wildlife (WL): The recommended alternative improves the wildlife function compared to the existing conditions (FCU = 0.90 to 13.68), due to the increase of functional capacity for each acre and the increase in acreage (FCI = 0.22 to 0.88).

Fish-Tidal (FT): Current conditions rate a FCI score of 0.34 and an FCU score of 1.38. The recommended alternative results in an increase in both FCI and FCU scores (FCI = 0.54, FCU=8.38).

Based on the EPW assessment, the recommended alternative results in substantial improvements to the functionality of the site from 9.56 total FCUs for the existing conditions of the WAA to 56.34 total FCUs for the proposed recommendation at year 50.







Table 9-4: EPW FCU Scores – Pumpkin Patch West

Function	Existing Conditions WAA			Recommended Alternative		
	FCI	AREA	FCUs	FCI	AREA	FCUs
SB	0.39	4	1.56	0.52	15	8.11
SS	0.69	4	2.76	0.69	15	10.68
WQ	0.74	4	2.96	1.0	15	15.49
WL	0.22	4	0.90	0.88	15	13.68
FS	0.34	4	1.38	0.54	15	8.38
Total FCU			**9.56**			**56.34**

9.4 Duck Point

The recommended alternative for Duck Point EPW results (Table 9-5) is more than twice the existing acreage (27.90 acres recommended, with 26.51 remaining after 50 years for the EPW estimates).

Shoreline Bank Erosion Control (SB): The FCU score for SB is approximately double in the recommended alternative (14.83) compared to the existing conditions (7.26). This results from an increase in both size and FCI for shoreline bank erosion control.

Sediment Stabilization (SS): The sediment stabilization FCU score is expected to increase by approximately 50 percent from 12.81 in the existing conditions to 19.51. This is due to the increase in acreage.

Water Quality (WQ): Water quality is expected to improve from its already relatively high FCI of 0.72 to 1.0. This, in combination with the increase in acreage, results in a doubling of the FCU score for water quality from 12.45 to 26.51.

Wildlife (WL): The recommended alternative improves the wildlife function compared to the existing conditions (FCU = 3.8 to 22.72), due to the increase of functional capacity for each acre (FCI = 0.22 to 0.85) and the increase in acreage.

Fish-Tidal (FT): Current conditions rate a FCI score of 0.29 and an FCU score of 5.00. The recommended alternative results in an increase in both FCI and FCU scores (FCI = 0.45, FCU=11.94).

Based on the EPW assessment, the recommended alternative results in substantial improvements to the functionality of the site with total FCU score of 41.32 for existing conditions and increased to 95.51 for year 50 of the proposed restoration alternative.






Table 9-5: EPW FCU Scores – Duck Point

Function	Existing Conditions WAA			Recommended Alternative		
	FCI	AREA	FCUs	FCI	AREA*	FCUs
SB	0.42	17	7.26	0.56	27	14.83
SS	0.74	17	12.81	0.74	27	19.51
WQ	0.72	17	12.45	1.0	27	26.51
WL	0.22	17	3.80	0.86	27	22.72
FS	0.29	17	5.00	0.45	27	11.94
Total FCU			**41.32**			**95.51**

*Atoll Terrace acreage of 9 additional acres is not included in the benefits calculation.

9.5 Elders Point Center

As Elders Point Center currently does not exist as an above-ground marsh island, the current FCI and FCU scores are zero (Table 9-6). All categories represent a substantial improvement on the current metrics to 54.82 total FCUs.

Table 9-6: EPW FCU Scores – Elders Point Center

Function	Existing Conditions WAA			Recommended Alternative		
	FCI	AREA	FCUs	FCI	AREA	FCUs
SB	0	0	0	0.56	15	8.46
SS	0	0	0	0.73	15	11.13
WQ	0	0	0	1.0	15	15.2
WL	0	0	0	0.86	15	13.06
FS	0	0	0	0.46	15	6.97
Total FCU			**0**			**54.82**

10 Average Annualized Functional Capacity Units (AAFCUs)

AAFCUs for each alternative at each site were calculated for Years 2, 20 and 50 (presented in Attachment A). AAFCUs calculated for Year 50 are presented in Table 10-1 for each marsh island recommended. Year 50 AAFCU assumed that all islands would realize a five (5) percent loss of marsh due to erosion.







The following calculations were used:

AAFCUs = Cumulative FCUs ÷ Number of years in the life of the project, where:
Cumulative FCUs = Sum (T2 -T1)[((A1 F1 +A2 F2) / 3) + ((A2 F1 +A1 F2) / 6)] and where:
T1 = First Target Year time interval;
T2 = Second Target Year time interval;
A1 = Area of available wetland assessment area at beginning of T1
A2 = Area of available wetland assessment area at end of T2;
F1 = FCI at beginning of T1;
F2 = FCI at end of T2

*Rounding results in minor summation and multiplication variability of the presented data.

Table 10-1: AAFCUs Calculated from EPW Results

Site	TEC Type	Acres (Post-restoration)	FCI	Total FCUs	Total AAFCUs
Elders Center	Wetlands	16	3.43	54.82	47.34
Duck Point	Wetlands	27.9	3.43	95.57	82.43
Pumpkin Patch East	Wetlands	35.3	3.41	120.54	103.88
Pumpkin Patch West	Wetlands	16.3	3.46	56.34	48.93
Stony Creek	Wetlands	51	3.43	174.92	150.60

Table 10-1 shows that significant lift to the habitat that would occur, indicating that the health of the Jamaica Bay Marsh Island Complex would be significantly improved if the project were implemented. Use of these scores to populate the cost effectiveness/incremental cost analysis model show that these projects are “best buy” plans, meaning that they are good plans that are worth implementing.






Attachment A







Appendix E-2: Attachment A

Jamaica Bay Marsh Islands - Average Annual Functional Capacity Units for the Tentatively Selected Plan

	EPW Wetland Functions	WAA (Existing)				Year 2				Year 20				Year 50			
		FCI	Area	FCU	Total FCU	Area	Cumulative FCU	AAFCU	Total AAFCU	Area	Cumulative FCU	AAFCU	Total AAFCU	Area	Cumulative FCU	AAFCU	Total AAFCU
Stony Creek	SB	0.43	34	14.56	80.52	51.30	17.59	8.79	54.18	51.30	448.90	22.45	144.98	48.74	1165.35	23.31	150.60
	SS	0.75	34	25.66		51.30	25.66	12.83		51.30	564.40	28.22		48.74	1464.50	29.29	
	WQ	0.71	34	24.02		51.30	34.47	17.24		51.30	875.90	43.80		48.74	2276.29	45.53	
	WL	0.22	34	7.32		51.30	17.97	8.98		51.30	668.37	33.42		48.74	1735.24	34.70	
	FT	0.26	34	8.96		51.30	12.68	6.34		51.30	342.04	17.10		48.74	888.41	17.77	
	UH	1.00	34														
Pumpkin Patch East	SB	0.42	8	3.39	18.96	35.30	8.80	4.40	27.83	35.30	305.95	15.30	100.01	33.54	794.25	15.88	103.88
	SS	0.75	8	5.98		35.30	12.46	6.23		35.30	384.74	19.24		33.54	998.32	19.97	
	WQ	0.71	8	5.68		35.30	17.88	8.94		35.30	604.09	30.20		33.54	1569.94	31.40	
	WL	0.22	8	1.73		35.30	9.76	4.88		35.30	462.09	23.10		33.54	1199.68	23.99	
	FT	0.27	8	2.18		35.30	6.76	3.38		35.30	243.25	12.16		33.54	631.82	12.64	
	UH	1.00	8														
Pumpkin Patch West	SB	0.39	4	1.56	9.55	16.30	3.80	1.90	13.32	16.30	130.17	6.51	47.10	15.49	337.91	6.76	48.93
	SS	0.69	4	2.76		16.30	5.40	2.70		16.30	163.95	8.20		15.49	425.41	8.51	
	WQ	0.74	4	2.95		16.30	8.70	4.35		16.30	284.12	14.21		15.49	738.51	14.77	
	WL	0.22	4	0.90		16.30	4.74	2.37		16.30	221.59	11.08		15.49	575.31	11.51	
	FT	0.34	4	1.38		16.30	4.00	2.00		16.30	142.12	7.11		15.49	369.14	7.38	
	UH	1.00	4														
Duck Point	SB	0.42	17.4	7.26	41.31	27.90	9.10	4.55	28.98	27.90	237.99	11.90	79.36	26.51	617.81	12.36	82.43
	SS	0.74	17.4	12.81		27.90	13.26	6.63		27.90	299.36	14.97		26.51	776.77	15.54	
	WQ	0.72	17.4	12.45		27.90	18.56	9.28		27.90	479.24	23.96		26.51	1245.51	24.91	
	WL	0.22	17.4	3.80		27.90	9.70	4.85		27.90	368.05	18.40		26.51	955.55	19.11	
	FT	0.29	17.4	4.99		27.90	7.34	3.67		27.90	202.53	10.13		26.51	526.06	10.52	
	UH	1.00	17.4														
Elders Point Center	SB	0.00	0	0.00	0.00	16.00	3.17	1.58	10.43	16.00	135.73	6.79	45.57	15.20	352.36	7.05	47.34
	SS	0	0	0.00		16.00	4.37	2.19		16.00	170.76	8.54		15.20	443.07	8.86	
	WQ	0	0	0.00		16.00	6.77	3.39		16.00	275.18	13.76		15.20	715.18	14.30	
	WL	0	0	0.00		16.00	3.84	1.92		16.00	211.62	10.58		15.20	549.42	10.99	
	FT	0	0	0.00		16.00	2.71	1.35		16.00	118.15	5.91		15.20	306.87	6.14	
	UH	0	0														
															TOTAL		**433.17**

For Year 20, it was assumed that stabilized banks would contain 10 percent more wetlands than Year 1.

For Year 50, it was assumed that all wetlands would realize a 5 percent loss due to erosion.

Calculations:

AAFCUs = Cumulative FCUs ÷ Number of years in the life of the project, where:

$$\text{Cumulative FCUs} = (Time_{2} - Time_{1}) \left[\frac{(Area_1 * FCI_1) + (Area_2 * FCI_2)}{3} + \frac{(Area_2 * FCI_1) + (Area_1 * FCI_2)}{6} \right]$$

Cumulative FCUs = Sum (T2 -T1)[((A1 F1 +A2 F2) / 3) + ((A2 F1 +A1 F2) / 6)] and where:

T1 = First Target Year time interval; T2 = Second Target Year time interval; A1 = Area of available wetland assessment area at beginning of T1

A2 = Area of available wetland assessment area at end of T2; F1 = FCI at beginning of T1; F2 = FCI at end of T2

Rounding results in minor summation and multiplication variability of the presented data.

Attachment E-2: Attachment A

Future Without Project Conditions - Average Annual Functional Capacity Units

Alternatives	EPW Wetland Functions	WAA (Existing)				Year 2				Year 20				Year 50			
		FCI	Area	FCU	Total FCU	Area	Cumulative FCU	AAFCU	Total AAFCU	Area	Cumulative FCU	AAFCU	Total AAFCU	Area	Cumulative FCU	AAFCU	Total AAFCU
Stony Creek	SB	0.42832	34	14.56	80.52	34.00	14.56	7.28	40.26	32.30	269.78	13.49	74.59	30.60	677.90	13.56	74.97
	SS	0.754595	34	25.66		34.00	25.66	12.83		32.30	475.28	23.76		30.60	1194.30	23.89	
	WQ	0.7064	34	24.02		34.00	24.02	12.01		32.30	444.93	22.25		30.60	1118.02	22.36	
	WL	0.21542	34	7.32		34.00	7.32	3.66		32.30	135.68	6.78		30.60	340.95	6.82	
	FT	0.26364	34	8.96		34.00	8.96	4.48		32.30	166.05	8.30		30.60	417.26	8.35	
	UH	1	34														
Pumpkin Patch East	SB	0.42424	8	3.39	18.96	8.00	3.39	1.70	9.48	7.60	62.87	3.14	17.57	7.20	157.99	3.16	17.66
	SS	0.74754	8	5.98		8.00	5.98	2.99		7.60	110.79	5.54		7.20	278.38	5.57	
	WQ	0.7098	8	5.68		8.00	5.68	2.84		7.60	105.19	5.26		7.20	264.33	5.29	
	WL	0.21644	8	1.73		8.00	1.73	0.87		7.60	32.08	1.60		7.20	80.60	1.61	
	FT	0.27248	8	2.18		8.00	2.18	1.09		7.60	40.38	2.02		7.20	101.47	2.03	
	UH	1	8														
Pumpkin Patch West	SB	0.39088	4	1.56	9.55	4.00	1.56	0.78	4.78	3.80	28.96	1.45	8.85	3.60	72.78	1.46	8.89
	SS	0.689855	4	2.76		4.00	2.76	1.38		3.80	51.12	2.56		3.60	128.45	2.57	
	WQ	0.7376	4	2.95		4.00	2.95	1.48		3.80	54.66	2.73		3.60	137.34	2.75	
	WL	0.22478	4	0.90		4.00	0.90	0.45		3.80	16.66	0.83		3.60	41.85	0.84	
	FT	0.34476	4	1.38		4.00	1.38	0.69		3.80	25.55	1.28		3.60	64.19	1.28	
	UH	1	4														
Duck Point	SB	0.41752	17.4	7.26	41.31	17.40	7.26	3.63	20.65	16.53	134.58	6.73	38.26	15.66	338.18	6.76	38.46
	SS	0.73592	17.4	12.81		17.40	12.81	6.40		16.53	237.21	11.86		15.66	596.07	11.92	
	WQ	0.7154	17.4	12.45		17.40	12.45	6.22		16.53	230.60	11.53		15.66	579.45	11.59	
	WL	0.21812	17.4	3.80		17.40	3.80	1.90		16.53	70.31	3.52		15.66	176.67	3.53	
	FT	0.28704	17.4	4.99		17.40	4.99	2.50		16.53	92.52	4.63		15.66	232.49	4.65	
	UH	1	17.4														
Elders Point Center	SB	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SS	0	0	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00	
	WQ	0	0	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00	
	WL	0	0	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00	
	FT	0	0	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00	
	UH	0	0														

For year 20, it was assumed that there will be a 5% loss in wetland acreage due to erosion.
For year 50, it was assumed that there will be a 10% loss in wetland acreage due to erosion.