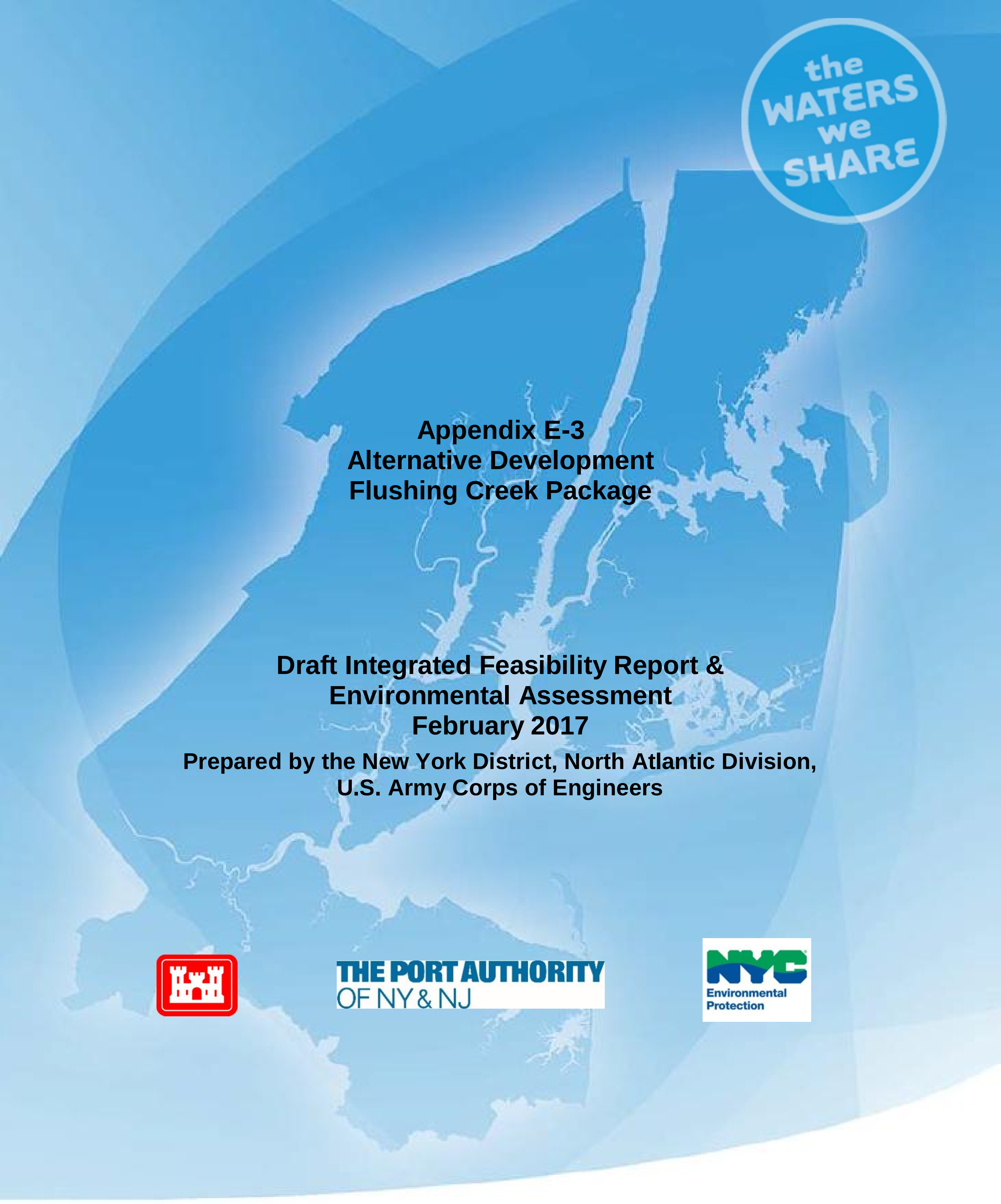


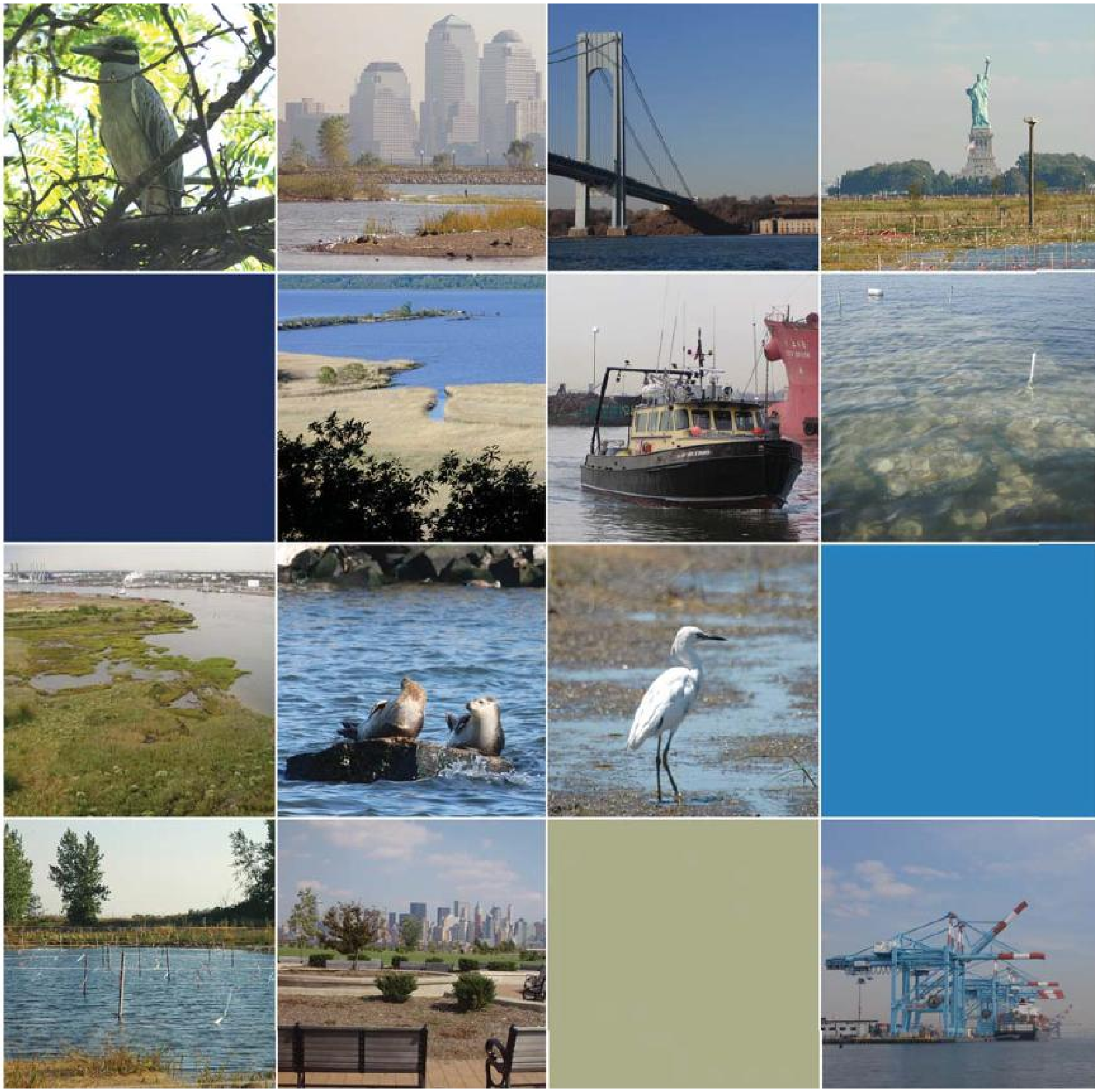
Appendix E-3
Alternative Development
Flushing Creek Package

Draft Integrated Feasibility Report & Environmental Assessment
February 2017

Prepared by the New York District, North Atlantic Division, U.S. Army Corps of Engineers

THE PORT AUTHORITY OF NY & NJ

NYC Environmental Protection



Executive Summary

The Flushing Bay and Creek Ecosystem Restoration Feasibility Study (“source” study) was initiated in 1999 based on the recommendations of the 1996 reconnaissance report that proposed six (6) measures for ecosystem restoration and water quality improvements in Flushing Bay and Creek (USACE, 1996) including:

- Measure 1 - Tidal Wetland Restoration;
- Measure 2 - Freshwater Wetland Restoration;
- Measure 3 - Dredging in Flushing Bay and Creek;
- Measure 4 - Partial or Total Removal of Breakwater at LaGuardia Airport;
- Measure 5 - Reorientation of the Federal Navigation Channel; and
- Measure 6 - Bank Stabilization, Site Cleanup and Debris Removal.

The “source” study developed preliminary plans that were screened out from further consideration:

- Breakwater at LaGuardia Airport;
- Tidal wetland alternatives at Western Shore of College Point;
- Freshwater wetland restoration at former Flushing Airport;
- Tidal wetland restoration in Inner Flushing Bay;
- Tidal/freshwater wetland restoration in Upper Flushing Creek and Flushing Meadows-Corona Park;
- Tidal wetland restoration at College Point Northern Shoreline;
- Tidal wetland restoration at Tallman Island adjacent to Powell’s Cove;
- Reconstruction and daylighting of Flushing Creek;
- Tidal/freshwater wetland restoration at Meadow Lake;
- Wetland restoration and rehabilitation at Willow Lake;
- Reorientation of the federal navigation channel; and
- Bank stabilization, site cleanup and debris removal along the west side of the College Point shoreline.

These plans were not advanced due to a variety of reasons such as real estate requirements, lack of non-federal support, heavy recreational use of land, water quality modeling results, or small size.

Two restoration alternatives were recommended for full feasibility analysis:

- Tidal wetland restoration in Lower Flushing Creek between the Van Wyck Expressway (Route 678) crossing at the mouth, to the tidal gates at Porpoise Bridge beyond the New York City Transit Authority yard and rail crossing. An opportunity exists to restore about 6.5 acres of low tidal marsh, where currently scattered areas total about one (1) acre, and create forest along 2,000 linear feet of the creek.
- Dredging in selected areas of the Inner Bay and Flushing Creek, including the removal of the top two (2) to eight (8) feet of sediments, coupled with replacement of clean sediments (possibly beneficial use of dredged material) would reduce concentrations of total organic carbon in the sediments and improve substrate quality, while also reducing the oppressive hydrogen sulfide odor. The dredging alternative could also include re-contouring the bay bottom in the vicinity of high velocity combined sewer overflow (CSO) discharges to reduce localized scouring, turbidity, and the conveyance of sediments downstream. Coarse substrate materials could be used to attract fish into the interbay and creek.

A total of 17 alternatives were developed that focused on variations of Flushing Creek dredging, capping and adjacent habitat restoration within the riparian, tidal wetland, and benthic zones of the project area. The specific project area was located between the Long Island Railroad (LIRR) and the Interborough Rapid Transit Railroad (IRTRR). Alternatives were evaluated using a study specific three-part model which assessed benefits in three distinct restoration zones, a benthic zone, a tidal wetland zone and a riparian zone using concepts from Benthic Index Integrity (B-IBI); terrestrial coefficient of conservatism assessment approaches; wetland variables from the Evaluation of Planned Wetlands (EPW) (Bartoldus et al, 1994) and standard forestry metrics. Costs for each alternative were estimated using rough order of magnitude costs which were sufficient to scale and select a restoration alternative.

The cost effectiveness and incremental cost analysis (CE/ICA) (IWR-PLAN Beta Version 3.33 software) was used to evaluate 490 alternative plans. Screening identified 22 cost-effective plans and eight (8) best buy plans. Incremental cost analysis was conducted on the best buy plans resulting in the selection of the Tentatively Selected Plan (TSP) in 2007 focused on Flushing Creek dredging and adjacent marsh restoration, including 4.4 acres of riparian restoration, 1.8 acres of wetland restoration on the left descending bank of Flushing Creek, and 4.2 acres of wetland restoration on the right descending bank.

The TSP was not supported by the New York City Department of Environmental Protection (NYCDEP) at the time, as the agency wanted the United States Army Corps of Engineers (USACE) to include additional environmental dredging activities in the TSP in coordination with NYCDEP's own environmental dredging activities and Long Term Control Plan. Progress was then suspended due to lack of funding, and the study was inactivated and subsequently rolled into the Hudson-Raritan Estuary (HRE) Feasibility Study in 2013. USACE evaluated subsequent opportunities to integrate additional dredging into the restoration plans; however the dredging measures were not advanced due to cost. NYCDEP planned to advance the environmental dredging activities in Flushing Creek in parallel with 100 percent of the costs borne by NYCDEP.

As part of the HRE Feasibility Study process, the selected 2007 restoration alternative was then optimized further. Additional field investigations were conducted in 2012 and 2013 within the potential proposed project area and adjacent Flushing Creek. Based on the updated information, three (3) additional restoration alternatives were developed that included restoration measures to restore low marsh, high marsh, scrub/shrub wetlands and upland maritime forest. These measures were designed to be complimentary to any future NYCEP dredging activities adjacent proposed for Flushing Creek. In 2014, an EPW assessment was conducted to account for the updated baseline existing conditions and determine ecological benefits of each proposed alternative. The EPW scores were utilized for CE/ICA (Appendix M) to determine the most cost effective best buy plan to be recommended as the TSP within the HRE FR/EA.

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1 Introduction

The Flushing Creek and Bay Ecosystem Restoration Feasibility Study (“source study”) was initiated in 1999 and included within the larger East River, Harlem River, and Western Long Island Sound Planning Region. During the ”source study”, an array of preliminary alternatives including tidal and freshwater wetland restoration, breakwaters, reorientation of the federal navigation channel, daylighting of portions of Flushing Creek and bank stabilization were identified at various locations throughout the Flushing Bay and Creek Study Area. The screening of initial alternatives and sites resulted on the focus of tidal wetland restoration in Lower Flushing Creek and dredging in selected areas of the Inner Bay and Flushing Creek for full feasibility analysis.

A total of 17 restoration alternatives were developed that focused on variations of Flushing Creek dredging, capping and adjacent habitat restoration within the riparian, tidal wetland, and benthic zones of the project area. The specific project area was located between the Long Island Railroad (LIRR) and the Interborough Rapid Transit Railroad (IRTRR) (Figure 1-1). Alternatives were evaluated using ecological functional assessments and rough order of magnitude costs for use in cost effectiveness and incremental cost analysis (CE/ICA). CE/ICA was used in 2007 to evaluate 490 alternative plans where screening identified 22 cost-effective plans and eight (8) best buy plans. Incremental analysis on the best buy plans resulted in the selection of a recommended plan focused on Flushing Creek dredging and adjacent marsh restoration, including 4.4 acres of riparian restoration, 1.8 acres of wetland restoration on the left descending bank of Flushing Creek, and 4.2 acres of wetland restoration on the right descending bank (Table 1).

The recommended restoration plan was not supported by New York City Department of Environmental Protection (NYCDEP) at the time, as the agency wanted the United States Army Corps of Engineers (USACE) to include additional environmental dredging activities in the TSP in coordination with NYCDEP’s own environmental dredging activities and Long Term Control Plan. Progress was then suspended due to lack of funding, and the study was inactivated and subsequently rolled into the Hudson-Raritan Estuary (HRE) Feasibility Study in 2013. The USACE evaluated subsequent opportunities to integrate additional dredging into the restoration plans; however the dredging measures were not advanced due to cost. NYCDEP planned to advance the environmental dredging activities in Flushing Creek in parallel with 100 percent of the costs borne by NYCDEP.

Table 1-1: Flushing Creek Ecosystem Feasibility Study Project Site

Site	County
Flushing Creek – CRP Site 188 (between the LIRR and IRTRR)	Queens County

The recommended restoration plan selected in 2007 was then optimized further with NYCDEP as part of the HRE Feasibility Study. Modification of the selected design was conducted using data collected on behalf of NYCDEP in 2012 through 2014 to re-evaluate baseline function, document existing conditions at the site and develop three (3) additional restoration alternatives. Field investigations included functional assessments, utilizing Evaluation of Planned Wetlands (EPW) technique to determine baseline conditions and ecological benefits of each alternative.

This appendix documents baseline conditions, preliminary alternative plan development, site screening, selection of the restoration plan in 2007, modification of that plan through the preparation of three (3) new alternatives, EPW methodology results, average annual functional capacity units scores (AAFCUs)

calculated from the EPW scores, as well as the findings of the field investigations and desktop studies. Attachment A contains the sustainability evaluation and Attachment B contains the EPW summary results.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Figure 1-1: Ecosystem Restoration Project Area

2 Project Area Context

The Flushing Bay and Creek watershed, located in the Borough of Queens, New York City, is highly urbanized with a dense mixture of residential, transportation, commercial, industrial and institutional development. The watershed includes approximately 20,577 acres, of which 16,700 acres are densely developed lands that comprise portions of the Borough of Queens and all or parts of the communities of College Point, Bayside, Flushing, Willets Point, Queensboro Hill, Kew Gardens, Rego Park, Forest Hills, Corona, North Corona, and East Elmhurst. The study area extends from the northern end of College Point south to approximately Atlantic Avenue and the LIRR. From west to east, the study area extends from East Elmhurst to Bayside. Significant features within the study area include the former Flushing Airport, the eastern shoreline of LaGuardia Airport, and Flushing Meadows-Corona Park. The major area of parkland is Flushing Meadows-Corona Park, which was the site of the 1939 and 1964 World’s Fair.

Flushing Bay is an embayment of the East River consisting of approximately 6,200 acres of open water. The project area contains an existing federal navigation project consisting of a 15-foot channel into Flushing Bay and Creek and a six (6)-foot anchorage basin in the back bay. A 1,400-foot sheet pile breakwater was recommended by the USACE in a 1962 Chief’s Report, but was never constructed. A 2,800-foot earthen breakwater was constructed in 1964 by the New York City Department of Parks and Recreation (NYC Parks) and the World’s Fair Corporation. The earthen breakwater functioned to protect the marinas located in the back bay. The outermost 1,400 feet of the earthen breakwater were accepted for maintenance and operations by the USACE in 1967 from the City of New York, in lieu of a federally authorized 1,400-foot steel sheet pile breakwater. The breakwater was deauthorized as a federal project in the Water Resources Development Act (WRDA) of 1992.

In 1995, the top portion of the breakwater was removed to 3.2 feet above mean low water (MLW), approximately to the level of the existing mudflats. The breakwater was removed by the Port Authority of New York and New Jersey in conjunction with construction of a runway safety overrun at LaGuardia Airport. The material removed from the top of the dike was used as fill for the safety overrun. The bay bottom impacted by the overrun was mitigated for by reestablishing wetlands on the north shoreline of the airport as well as offsite at Alley Pond Park in Little Neck Bay. The New York State Department of Environmental Protection (NYSDEC) specified the 3.2-foot MLW remaining dike elevation as requirement for the permit.

The main tributary to Flushing Bay is Flushing Creek. Flushing Creek flows approximately 7,000 feet from the outlet of Meadow Lake before entering Flushing Bay. Prior to landfills and development in preparation for the 1939 World’s Fair, Flushing Creek was a sinuous tidal creek that supported an extensive tidal wetland system. Development of the World’s Fair site included significant straightening of the stream, filling in wetland areas, and reconfiguring the headwaters of Flushing Creek into two man-made freshwater lakes. Willow Lake (40 acres) and Meadow Lake (100 acres) were created to support World Fair activities.

Present land use in the Flushing Creek watershed is mainly residential, followed by open space and outdoor recreational uses. A small fraction of the land accounts for industrial and transportation-designated areas. The majority of the land used for industrial purposes lies close to the eastern shore of the creek. Figure 2-1 presents an aerial view of Flushing Creek, including surrounding waterbodies (Flushing Bay and Meadow and Willow Lakes) and communities in Queens. Figure 2-2 presents the land use within one (1) quarter-mile of the creek. Flushing Creek was also diverted through

underground culverts to flow through a fountain structure prior to reaching the tide gates at Porpoise Bridge.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Figure 2-1: Aerial of Flushing Creek and Surrounding Waterbodies and Communities

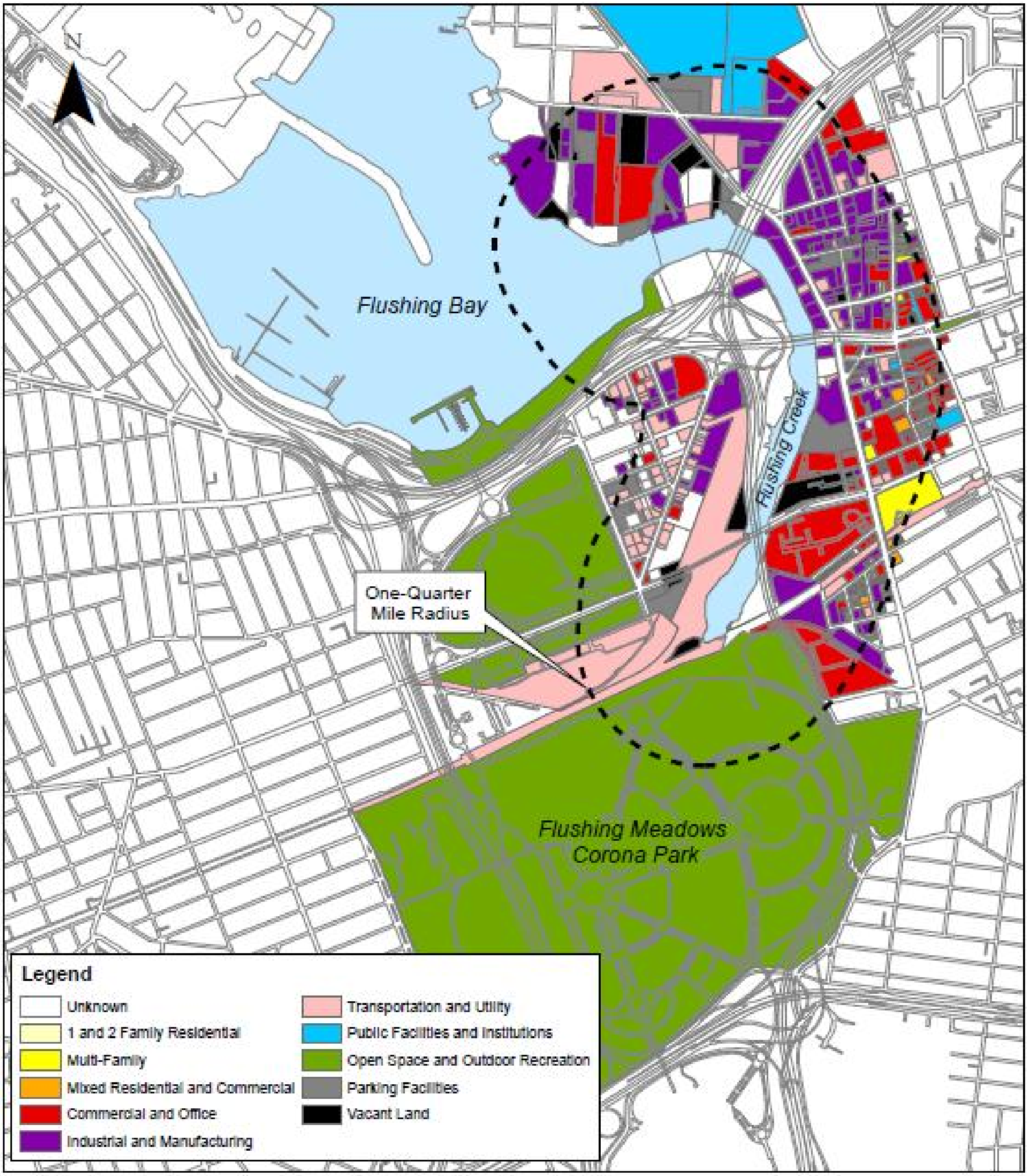

Figure 2-2: Land Use within One-Quarter-Mile of Flushing Creek

Within Flushing Meadows-Corona Park, Willow Lake drains into Meadow Lake which discharges to Flushing Creek. Immediately downstream of Meadow Lake, the creek flows under the elevated highway infrastructure for approximately 2,500 feet. When it reaches a culvert, the flows are directed underground for 1,000 feet to the fountain structure. Below fountain structure, the creek reenters an underground culvert that directs flow for another 1,000 feet at which point the creek is discharged to a pond. This is at the head of the tide gates. The Flushing Creek watershed is small. The low freshwater

flows are not sufficient to open the tidal gate. Flushing Creek therefore contributes only a small portion of the total inflow to Flushing Bay.

Development activities in the watershed exhibit a continuous pattern of loss and degradation of tidal wetlands. Development continually has encroached into the natural tidal wetlands complex which originally bounded Flushing Bay and Creek. The remaining wetlands in the area are significantly degraded and are limited to fringe areas. The fringe areas are generally unsuitable for development. Operation of the retention facility and other combined sewer overflow (CSO) abatement measures completed by NYCDEP will significantly improve water quality in Flushing Creek. The abatement facilities will improve adjacent stream reaches, and adjacent areas of the bay.

2.1 NYCDEP Improvements

NYCDEP has dredged several areas within Flushing Bay and had planned to dredge areas of Flushing Creek west of and adjacent to the Van Wyck Expressway and north of the LIRR. Dredging supports upland restoration and also serves to remove mounds of accumulated sediment that are exposed at low tide that contribute to nuisance odors. The accumulated sediment mounds would be dredged to a depth of four (4) feet below mean lower low water, resulting in removal of approximately 54,000 cubic yards of sediment. Placement of a one (1)-foot sand cap over the dredged area would provide clean substrate for benthic habitat. Figure 2-3 presents an aerial view of Flushing Creek, including the proposed project area, the three (3) CSO outfalls that are located in Flushing Creek, and the extent of the USACE federal navigation channel.

Specifically, over the past several decades NYCDEP has developed a comprehensive watershed based approach to abate CSO discharges and improve water quality in the New York Harbor. Currently, long term CSO control is enforced by an Order on Consent between NYCDEP and the NYSDEC (Case #CO2-20110512-25). Flushing Creek is one of several waterbodies that is included in the Order on Consent. Water quality in Flushing Creek has been improved through the following NYCDEP projects[1]:

- Construction of the Flushing Creek CSO Retention Facility: The 43 million-gallon Flushing Creek CSO Retention Facility was certified by NYCDEP as complete and operational in May 2007, and is designed to store and capture combined sewage that previously discharged to Flushing Creek via outfall TI-010.
- Tallman Island Conveyance Enhancements: NYCDEP has initiated work on a number of Tallman Island system conveyance enhancements to maximize the flow delivered to the Tallman Island Waste Water Treatment Plant and reduce CSO discharge to Flushing Creek as well as the East River.

NYCDEP is currently evaluating additional improvements in Flushing Creek in development of the Long Term Control Plan for the waterbody. Dredging of Flushing Creek was required by an early draft of the CSO Order on Consent but was subsequently removed. Under the ecosystem restoration, dredging may be completed in the vicinity of TI-010 and potentially fulfill the intent of the dredging requirements of the Order on Consent.

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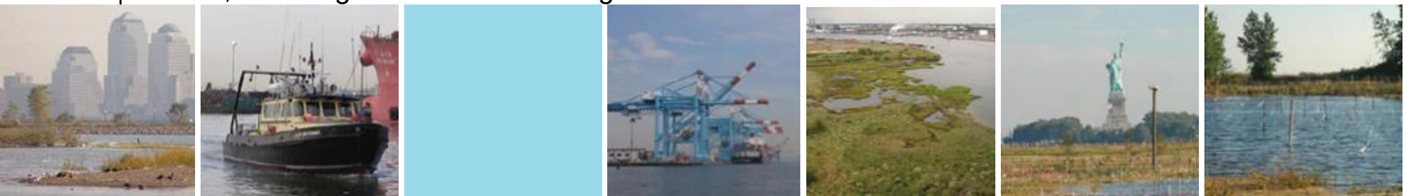
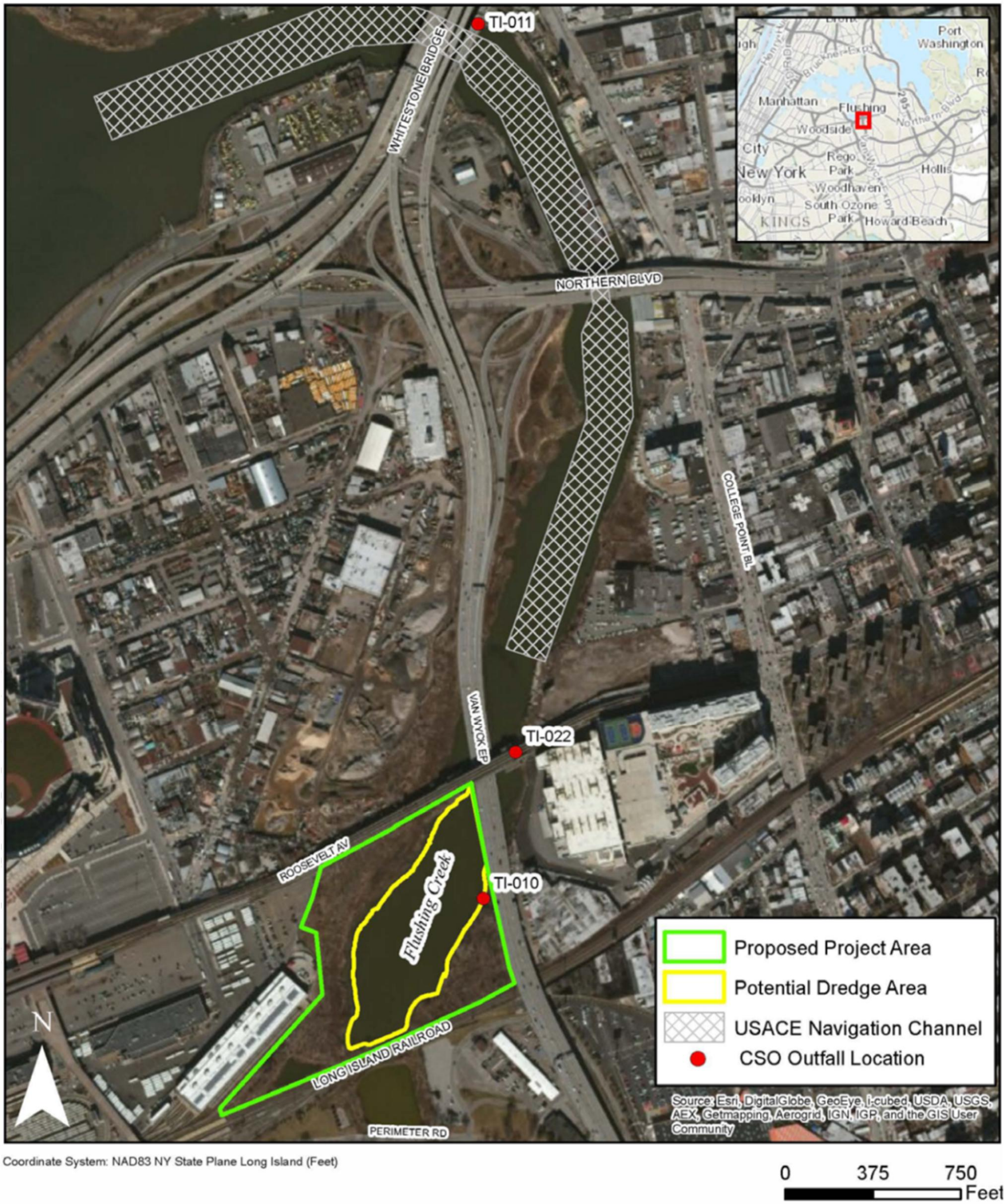
[1] DEP, Flushing Creek WWFP. August 2011.





Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Coordinate System: NAD83 NY State Plane Long Island (Feet)

Figure 2-3: Flushing Creek Project Area, CSO Outfalls and USACE Navigation Channel

In addition, NYCDEP is implementing green infrastructure plans to help mitigate stormwater from entering the sewer system by installing hundreds of street-side bioswales to manage stormwater on the streets and sidewalks. By 2030, NYCDEP intends to manage eight (8) percent of Flushing Creek's watershed and 13 percent of Flushing Bay's watershed impervious cover with green infrastructure.

2.2 Adjacent Site Brownfield Cleanup Program

An ongoing brownfield remediation site marks the northeast extent of the project area where the Van Wyck Expressway crosses the creek. The Flushing Industrial Park was historically owned by Con Edison and used as a service center to support electrical and gas utility operations. Upon being sold to C.E. Flushing, LLC, investigations revealed that soil and groundwater on the property contained polychlorinated biphenyls (PCBs), volatile organic compounds, semi-volatile organic compounds, pesticides, and metals. As a result, C.E. Flushing entered a Voluntary Cleanup Agreement with the NYSDEC where subsequent investigations placed Flushing Industrial Park into the NYSDEC Brownfield Cleanup Program.

Under the program, the property was divided into sections (operable units) and parcels. Parcel 4 in Operable Unit 1 extends into Flushing Creek. In 2005, a separate investigation was conducted on Parcel 4 (Site ID C241078A). The investigation revealed the presence of PCBs, polycyclic aromatic hydrocarbons, pesticides, and metals in the sediment that exceeded NYSDEC sediment screening levels presented in the Technical Guidance for Screening Contaminated Sediments[2]. Alternatives analysis was subsequently conducted to determine the most effective solution to address the PCB-affected sediment in Parcel 4. The selected alternative includes dredging the approximately 1,200 cubic yards of PCB-affected sediment from Parcel 4, which would result in a reduction of both volume and toxicity of PCB-impacted sediments in the creek[3]. The dredged material would be permanently removed and the area backfilled to restore the habitat.

Figure 2-4 shows the Parcel 4 boundary of the remediation project. The Feasibility Study for the remediation project was issued in August 2013. As the design for the Brownfield Remediation Program is ongoing, and due to the PCB contamination, the proposed ecosystem restoration project will not overlap with the C.E. Flushing site.

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[2] ARCADIS, RIR, Section 1.1. March 2011.

[3] ARCADIS, Feasibility Study Report: Flushing Industrial Park Operable Unit 2, Section 7. August 2013.

Figure 2-4: Brownfield Remediation Site, Parcel 4 Boundary

3 Assessment of Flushing Bay and Creek

NYCDEP and USACE have extensively surveyed and analyzed the ecological integrity of Flushing Bay and Creek. The reports that informed this assessment are listed in the Ongoing Efforts Appendix (B). Prior reports, field investigations conducted for the "source" study, and desktop studies identified the water resource problems and existing conditions of the Flushing Bay and Creek.

3.1 Water and Sediment Quality

See Engineering Appendix D.

3.2 Habitat

The history of land use and development activities in the area shows a continuous pattern of loss and degradation of tidal wetlands throughout the New York Harbor area. Consistent with the rest of the New York Harbor region, development has encroached into the natural tidal wetlands complexes. Wetland complexes originally bounded Flushing Bay and Creek. Historic navigation maps from 1909 showing the Flushing Bay and Creek tidal wetlands complex show 157 acres of tidal wetlands present in the early 1900s.

Aerial photographs from 1994 were evaluated to determine the acreage of remaining tidal wetlands in the Flushing Bay and Creek watershed. Approximately 21 acres of tidal wetlands were identified along Flushing Creek, the back bay shoreline, and the southeast corner of the College Point shoreline. This represents a reduction of tidal wetlands of approximately 87 percent from the early 1900s to the present. The remaining tidal wetlands in the area are significantly degraded, dominated by invasive species, and limited to fringe areas. Fringe areas are present because they are unsuitable for development.

The estuarine environment of the project area consists of the tidal habitats of Flushing Bay and Creek, adjacent tidal marsh wetlands, and mudflats. The low marsh area is comprised of the upper 50 percent of the inter-tidal zone adjacent to open water and mudflats. This area is dominated by salt marsh cordgrass (*Spartina alterniflora*). The tidal zone from mean high tide to the spring tide elevation is dominated by salt grass (*Distichlis spicata*) and salt marsh hay (*Spartina patens*). The invasive common reed (*Phragmites australis*) is the dominant species in much of these marsh areas. Common reed is an aggressive invasive and displaces most native high marsh vegetation.

The project area is located in a highly disturbed urban setting. Portions of the project area not occupied by buildings or paved surfaces are weed-dominated fill. Areas adjacent near the project are sparsely vegetated with low herbaceous weeds. Some areas have begun to succeed to shrubs and trees. No threatened or endangered species are known to inhabit the study area.

3.2.1 Flushing Bay Habitats

Flushing Bay is estuarine environment that consists of the deepwater tidal habitats and adjacent tidal marsh wetlands, and mudflats. The intertidal mudflats of Flushing Bay are found behind the breakwater. The substrate is rich in organic matter and is poorly drained. Benthic organisms present include polychaetes and mud snail.

The fisheries resources of Flushing Bay and Creek are limited. The species diversity and abundance of fish species varies with seasonal temperature changes and pollutant loads. Many fish species are transient or migratory species. Trawls conducted in Flushing Bay by NYCDEP in 1986 show a fish population of winter flounder (*Pseudopleuronectes americanus*), northern sea robin (*Prionotus carolinus*), weakfish (*Cynoscion regalis*), tomcod (*Microgadus tomcod*), butterfish (*Peprilus triacanthus*), windowpane flounder (*Scopthalmus aquosus*) and bluefish (*Pomatomus saltatrix*).

The benthic communities in and around Flushing Bay are comprised of species that are tolerant to fine gained organics-rich sediments and low concentrations of dissolved oxygen. The benthic habitat of Flushing Bay and Creek was degraded and does not support species found in local healthy estuaries. A total of 40 invertebrate taxa were found in Flushing Bay. Nematoda and Annelida Oligochaeta were the most abundant taxa found in 23 of 24 sites sampled.

Estuarine environments typically attract many species of seasonally migrating birds. Bird species were observed in the tidal marsh and open water habitat in Flushing Bay for loafing and feeding. Many species of waterfowl such as American black duck (*Anas rubripes*), Canada goose (*Branta canadensis*), American widgeon (*Anas americana*), mallard (*Anas platyrhynchos*), canvasback (*Aythya valisineria*), lesser scaup (*Aythya affinis*), coot (*Fulica americana*), common merganser (*Mergus merganser*) were identified. Wading birds including great blue heron (*Ardea herodias*), cattle egret (*Bubulcus ibis*), snowy egret (*Egretta thula*), great egret (*Ardea alba*), and black-crowned night heron (*Nycticorax nycticorax*), and various passerines including red-winged blackbird (*Agelaius phoeniceus*), song sparrow (*Melospiza melodia*) were identified.

Tidal wetlands are located along the shoreline of Flushing Bay associated with mudflat areas of the back bay. The shoreline adjacent to LaGuardia Airport, other areas along the north and east sides of the College Point shoreline, and along the tidally influenced sections of Flushing Creek, also provided tidal wetland habitat. Common reed with narrow bands of salt marsh cordgrass was present along the tidal fringe. Filling and dumping in the intertidal zone occurred extensively along the waterfront of Flushing Bay and the mouth of the Creek. This encroaches on many wetland areas. Filling has raised elevations to a level unsuitable for the growth of beneficial plant species. There is very little natural grade change from wetland or aquatic habitat to upland areas. Very abrupt boundary conditions are common. This severely degrades the value of existing habitats.

3.2.2 Meadow and Willow Lake Habitats

Willow and Meadow Lakes are located above the tidal gate and below the head of Flushing Creek. The 100-acre Meadow Lake is surrounded by an intensively used recreation area. The intensive use of Meadow Lake and the surrounding maintained areas (e.g., picnicking, recreation, boating) limit habitat to a narrow (0 to 10 feet) wetland fringe along the lake's shoreline. A well-defined transition from uplands to the open water depicts relatively consistent water levels. The fringe habitat is dominated by purple loosetrife (*Lythrum salicaria*), common reed, and broad-leaf cattail (*Typha latifolia*). A muskrat hut was found in at least one (1) stand of broad-leaf cattail. No other mammal evidence was observed. Glass shrimp were observed in Meadow Lake. Meadow Lake is above the tide gate but the water is at the lower end of brackish. Salinity levels are as high as a few parts per thousand.

Birds observed at Meadow Lake include waterfowl such as Canada goose, American black duck, mallard, ruddy duck (*Oxyura jamaicensis*), and red-breasted merganser (*Mergus serrator*). Gulls identified included greater black-backed gull (*Larus marinus*), herring gull (*Larus smithsonianus*), laughing gull (*Leucophaeus atricilla*), ring-billed gull (*Larus delawarensis*), and glaucous gull (*Larus hyperboreus*). Wading birds such as the great blue heron, spotted sandpiper (*Actitis macularius*), least sandpiper (*Calidris minutilla*), and great egret were identified. Swallows were seen feeding on insects over the water's surface (barn swallow [*Hirundo rustica*], tree swallow [*Tachycineta bicolor*], rough winged swallow [*Stelgidopteryx serripennis*]), and a number of other species (rock dove [*Columba livia*], mourning dove [*Zenaida macroura*], European starling [*Sturnus vulgaris*], house sparrow [*Passer domesticus*]) were noted. Red-winged blackbird, common yellowthroat (*Geothlypis trichas*), yellow warbler (*Setophaga petechial*), and belted kingfisher (*Megaceryle alcyon*) were observed using the wetland fringe.

The open waters of Meadow Lake provide refuge and feeding opportunities for the waterfowl and gulls. Wading birds forage at the wetland fringe, but are frequently disturbed by people using walking trails. Other birds utilized the wetland fringe for foraging. Nesting is of low success due to the limited locations secluded enough to provide protection.

The 40-acre Willow Lake is upstream of Meadow Lake. Meadow Lake is fresh water. No public access to the trails and walking paths are adjacent to the lake. This adds value, leaving Meadow Lake largely undisturbed. Within the upland areas surrounding Willow Lake are isolated sedge meadows, shallow emergent marsh, small shrub swamp, open meadow fields and small woodlands. The transition from upland to open water surrounding Willow Lake is dominated by a monoculture of common reed. Willow Lake provides a more diverse combination of habitats and transitions between habitats than Meadow Lake.

The Willow Lake area provides habitat for wading birds, waterfowl, and passerines. Wading birds observed include glossy ibis (*Plegadis falcinellus*), great egret, and black-crowned night heron. Waterfowl species observed include mallard, American black duck, bufflehead (*Bucephala albeola*), red-breasted merganser, double-crested cormorant (*Phalacrocorax auritus*), brant (*Branta bernicla*), mute swan (*Cygnus olor*), and coot. Birds of prey include red-tailed hawk (*Buteo jamaicensis*) and Cooper's hawk (*Accipiter cooperii*). Passerines include downy woodpecker (*Picoides pubescens*), common flicker (*Colaptes auratus*), Eastern Phoebe (*Sayornis phoebe*), Eastern Pewee (*Contopus virens*), gray catbird (*Dumetella carolinensis*), northern mockingbird (*Mimus polyglottos*), cedar waxwing (*Bombycilla cedrorum*), yellow warbler, yellow-rumped warbler (*Setophaga coronate*), common yellowthroat, swamp sparrow (*Melospiza georgiana*), song sparrow, and field sparrow (*Spizella pusilla*).

Probable breeding bird species in the area include Canada goose, mallard, common moorhen (*Gallinula chloropus*), American kestrel (*Falco sparverius*), red-winged blackbird, and swamp sparrow. Adult and juvenile ring-necked pheasant (*Phasianus colchicus*) were observed in the upland areas. This indicates breeding success for the ring-necked pheasants. Cattail lodges confirm the presence of muskrats (*Ondatra zibethicus*). Meadow and Willow Lakes also reportedly support a warm-water fishery dominated by large-mouth bass (*Micropterus salmoides*), panfish, and carp (*Cyprinus carpio*).

Freshwater wetlands are associated with the fringes of Willow and Meadow Lakes. These lakes are experiencing advanced eutrophication due to low freshwater flows. Limited outflows and herbicide runoff from the surrounding park also contribute to eutrophication. Willow Lake has a small supply of fresh water from springs located at the upper end of the lake. Meadow Lake does not have springs. Meadow Lake gets fresh water from Willow Lake, Flushing Meadows-Corona Park, and surrounding road surfaces. Limited fresh water flows hampers the effective operations of the tidal gates. Insufficient flow to open the gates during low tide does not allow flushing of the lake systems. The waters in Willow and Meadow Lakes are relatively stagnant.

3.2.3 Flushing Creek Habitats

Tide gates on Flushing Creek reduce the connection between Flushing Bay, Flushing Creek and Meadow Lake. The tidal gates affect the frequency, volume and duration of tidal flooding. This degrades the upstream water quality and creates conditions that favor invasive plant species. The banks of the Flushing Creek are organically rich muck that slowly erodes into the creek at low tide. Flushing Creek once had a sinuous pattern. This sinuous pattern was lost when the Flushing Creek was straightened to support the World's Fair. The lower portion of Flushing Creek is predominantly bulk headed. The bulkheads support development, mostly commercial and industrial.

Inter-tidal emergent marshlands persist along the western bank of Flushing Creek. These areas are dominated by disturbed species such as common reed, field horsetail (*Equisetum arvense*), chicory

(*Chichorium intybus*), and common plantain (*Plantago major*). A native shrub marsh elder (*Iva frutescens*) is present in the high tide to spring tide range. Native salt marsh cordgrass is present along a narrow band. Birds observed in lower Flushing Creek include waterfowl (mallard, canvasback, lesser scaup, wood duck [*Aix sponsa*]) and wading birds (cattle egret, snowy egret, great egret).

3.2.4 Wetlands and Shoreline Habitat Delineation in Entire Study Area

Tidal and non-tidal wetlands and tidal shore habitats within the study area have been sampled and delineated. Where feasible, the non-tidal wetlands were GPS-located or sketched. Photo-interpretations were conducted based on photos taken at low tide on March 19, 2001. Non-tidal wetlands are associated with Meadow and Willow Lakes in Flushing Meadows-Corona Park. Much of these areas were historically tidal marshes that were filled since the 1939 World's Fair. Those associated with Willow Lake are strongly dominated by common reed. Common cattail is more important in deeper waters. Hydrophytic trees and shrubs are developing in the upper wetland fringe.

Wetlands associated with Meadow Lake appear to be subsiding into the underlying marsh and assuming wetland hydrology. These areas are frequently mowed and remain dominated by ruderal vegetation. Meadow Lake also has a narrow fringe of mixed common reed, cattail and occasional big cordgrass (*Spartina cynosuroides*). Table 2 lists the non-tidal wetlands identified in the study area.

Table 3-1: Non-tidal Wetlands in the Flushing Bay and Creek Project Area

Wetland ID	Type	Location	Area (acres)
WL-1	Mixed palustrine scrub/shrub (PSS) and palustrine emergent (PEM)	Northeast shore of Willow Lake	0.58
WL-2	PEM/PSS	East side Willow Lake	5.15
WL-3	PEM/PSS	East side Willow Lake near foot bridge	0.32
WL-4	Mixed palustrine forested (PFO), PSS, PEM, and open water	South side Willow Lake around train yard	7.45
WL-5	PEM/PSS	South side Willow Lake shoreline	1.17
WL-6	PEM/PSS/PFO	West side Willow Lake	3.1
WL-7	PEM/PSS	North shoreline Willow Lake	1.42
ML-1	PEM-Ruderal	North shore Meadow Lake	1.05
ML-2	PEM-Ruderal	North of Meadow Lake	0.14
ML-3	PEM-Ruderal	Along central east side Meadow Lake	0.36
		Total	**20.74**

Tidal wetlands and shoreline habitats identified in the project area are listed on Table 3. Vegetated wetlands include those dominated by big cordgrass and common reed. Cordgrass is typically monotypic in low marsh, while common reed has taken over most high marsh sites. Mud flats and tidal shores are areas exposed at low tide and composed of soft sediments and organic accumulations.

Table 3-2: Tidal Wetlands and Shoreline Aquatic Habitats in the Project Area

Wetland ID	Feature	Location	Area (acres)	Length (feet)
CP-2	Cordgrass fringe/low marsh	West of McNeil Park	0.5	1045
CP-3	Cordgrass fringe/low marsh	East of McNeil Park	0.9	1000
CP-5	Cordgrass fringe/low marsh	End of Capstan Ct. development	0.7	760
CP-8	Cordgrass fringe/low marsh	Old marina west of Tallman Island	0.25	1100
CP-9	Cordgrass fringe/low marsh	Old marina west of Tallman Island	0.04	200
CP-10	Cordgrass fringe/low marsh	Powell’s Cove West	1.06	1260
CP-14	Cordgrass fringe/low marsh	Powell’s Cove East	0.15	650
LG-1	Cordgrass fringe/low marsh	North side of LaGuardia Airport	2.48	2700
LG-3	Cordgrass fringe/low marsh	North side of Jetty	1.65	1200
LG-5	Cordgrass fringe/low marsh	South side of Jetty	2.4	2090
LG-10	Cordgrass fringe/low marsh	Flushing Bay Marina West	0.2	200
LG-11	Cordgrass fringe/low marsh	Flushing Bay Marina West	0.67	580
FC-2	Cordgrass fringe/low marsh	RDB Flushing Creek	0.29	250
FC-3	Cordgrass fringe/low marsh	RDB Flushing Creek at 678 bridge	1.82	1350
FC-6	Cordgrass fringe/low marsh	LDB Flushing Creek along Van Wyck	0.16	340
FC-7	Cordgrass fringe/low marsh	LDB Flushing Creek along Van Wyck	0.09	380
FC-10	Cordgrass fringe/low marsh	LDB Flushing Creek along Van Wyck	0.44	760
FC-14	Cordgrass fringe/low marsh	RDB south of Porpoise Bridge	0.11	480
FC-15	Cordgrass fringe/low marsh	LDB north of Porpoise Bridge	0.13	230
Cordgrass fringe/low marsh total:			**14.04**	**16,575**
LG-8	Jetty	Jetty	4.5	1820
Jetty total:			**4.5**	**1820**
CP-1	Mud flat/tidal shore	West of McNeil Park	0.8	780
CP-4	Mud flat/tidal shore	End of Capstan Ct. development	1.53	1760
CP-6	Mud flat/tidal shore	Old marina west of Tallman Island	3.25	985
CP-7	Mud flat/tidal shore	Old marina west of Tallman Island	1.17	750
CP-11	Mud flat/tidal shore	Powell’s Cove West	2.04	985
CP-12	Mud flat/tidal shore	Powell’s Cove East	4.6	945
CP-13	Mud flat/tidal shore	NYC Parks restoration site	1.53	750
CP-16	Mud flat/tidal shore	College Point West, end of 20th Ave.	0.14	150
CP-17	Mud flat/tidal shore	College Point West, end of 22nd Ave.	0.11	100
CP-18	Mud flat/tidal shore	College Point West, end of 25th Ave.	0.21	845
CP-19	Mud flat/tidal shore	College Point West, Grahm Court	1.16	725
LG-2	Mud flat/tidal shore	North side of Jetty	8.32	2010
LG-4	Mud flat/tidal shore	South side of Jetty	13.51	4000
LG-7	Mud flat/tidal shore	Flushing Bay Marina West	0.2	250

Wetland ID	Feature	Location	Area (acres)	Length (feet)
LG-9	Mud flat/tidal shore	Flushing Bay Marina West	0.25	200
LG-12	Mud flat/tidal shore	Flushing Bay Marina West	0.2	280
FC-1	Mud flat/tidal shore	RDB Flushing Creek at 123rd St.	1.28	1400
FC-5	Mud flat/tidal shore	LDB Flushing Creek along Van Wyck	1.31	975
FC-12	Mud flat/tidal shore	LDB Flushing Creek along Van Wyck	1.13	720
Mud flat/tidal shore total:			**42.74**	**18,610**
CP-15	*Phragmites* monoculture	Powell's Cove East	1.31	750
LG-6	*Phragmites* monoculture	South side of Jetty	1.81	1215
FC-4	*Phragmites* monoculture	LDB Flushing Creek along Van Wyck	0.54	620
FC-8	*Phragmites* monoculture	Along Roosevelt Ave.	1.64	600
FC-9	*Phragmites* monoculture	LDB Flushing Creek along Van Wyck	2.96	1230
FC-11	*Phragmites* monoculture	RDB near rail line	1.42	580
FC-13	*Phragmites* monoculture	RDB north of Porpoise Bridge	0.73	270
***Phragmites* monoculture total:**			**10.41**	**5,265**
Grand total:			**71.69**	**42,270**

4 Future Without-Project Conditions

The future without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis. In the absence of federal action, it is anticipated that the degraded condition of the study area ecosystem will continue into the future. Non-federal improvements include water quality improvements associated with the operation of the CS4 retention facility and the New York City waterfront zoning laws that cover 36 acres of Flushing waterfront. The zoning change requires waterfront access and waterfront viewing corridors. These planned improvements may have an effect on ecosystem restoration. Without supporting structural measures, including dredging, improved water quality the future degradation of bay and creek sediments will continue. In short, without significant federal involvement a degraded ecosystem will continue throughout the 50 year planning horizon.

5 Problems and Opportunities

5.1 Planning Goal

The planning goal is to restore the degraded aquatic ecosystem of Flushing Bay and Creek.

5.2 Planning Objectives

The objective for the Flushing Bay and Creek project is to develop and recommend the optimal plan to restore the degraded structures, functions, and dynamic processes of the local and regional ecosystems to a less degraded, more natural condition. Achieving this objective will involve consideration of the ecosystem's natural integrity, productivity, stability, and biological diversity.

The specific objectives used to guide the plan formulation process for the Flushing Bay and Creek "source" study included:

- Restore and enhance inter-tidal marsh habitat at selected sites along the shorelines of Flushing Bay and Creek to encourage the re-introduction of beneficial flora, such as salt marsh cordgrass, salt grass and salt marsh hay.
- Restore and improve vegetated and non-vegetated sub-tidal habitats for use by migrating waterfowl, invertebrates (including shellfish) and fish.
- Improve water quality in Flushing Bay and Creek to improve existing habitats and support restoration activities through a variety of non-structural measures including:
  - ✓ reduction in sedimentation rates;
  - ✓ comprehensive watershed management planning;
  - ✓ natural filtration through creation of wetlands near CSO outfalls;
  - ✓ fringe plantings in non-point source runoff areas;
  - ✓ reduction in residual combined sewer overflows; and
  - ✓ control of non-point source runoff.
- Decrease water quality and sediment related odor problems in the vicinity of the mudflats in the back bay and upper reaches of Flushing Creek.
- Potentially dredge to remove toxins from contact with benthic habitat.
- Improve the suitability of bottom substrate thereby improving the structure and value of the macrobenthic population that support higher trophic level species such as fish.
- Reduce surface runoff, erosion and sedimentation in Flushing Bay and Creek.
- Remove debris along the shoreline in support of habitat restoration measures.
- Increase transparency of water increasing the potential for photosynthesis by stream producers.
- Select alternatives or combinations of alternatives that facilitate the maximum improvement to the overall aquatic ecosystem.

Site-specific planning constraints include:

- Avoid impacts to residential and commercial properties;
- Minimize impacts to existing infrastructure (*e.g*., roads, bridges, etc.);
- Limit induced flooding; and
- Limit re-vegetation of riparian areas to species native to the region.

6 Preliminary Alternatives/Site Screening

A range of preliminary plan formulation alternatives were developed from the measures that focus on areas and resources of Flushing Bay and Creek. These preliminary plans were screened and refined in subsequent iterations throughout the planning process.

6.1 Preliminary Plans/Alternatives

6.1.1 Tidal Wetland Restoration Alternatives

Opportunities for tidal wetland restoration exist at a variety of locations in the back bay of Flushing Creek and the College Point waterfront. Approximately 21 acres of potential tidal wetland restoration sites were identified in the reconnaissance study. Fourteen (14) acres along the west bank of Flushing Creek and seven (7) acres along the western College Point shoreline were identified. Investigations and site visits identified restoration opportunities for tidal wetlands including 12 acres at Tallman Island on the Powells Cove (eastern) side of College Point and eight (8) acres on the northern side of College Point facing the East River. Restoration would involve the removal and eradication (i.e., excavation and grading or chemical treatment) of common reed (including the root stock), removal of fill material, re-grading to elevations suitable for inter-tidal wetlands, and planting with appropriate wetland species.

6.1.2 Freshwater Wetland Restoration

Non-tidal wetlands within the Flushing Bay and Creek watershed are located in at Willow and Meadow Lakes at Flushing Meadows-Corona Park and the former Flushing Airport site. These sites are located in areas which were formerly tidal wetlands, but were removed from tidal influence through extensive land filling. The constructions of the tidal gates are now inoperative because of the reduced freshwater flow.

The reconnaissance study identified approximately 25 acres of restoration opportunities at Willow and Meadow Lakes. This would double the size of the existing wetland complex. The restoration of wetlands at Willow and Meadow Lakes would enhance forage and cover for wildlife and improve water quality by filtering contaminants in the runoff from Flushing Meadows-Corona Park. Installation of aeration devices in the lakes, currently being considered by NYC Parks, could aid in reducing eutrophication of the lakes.

The reconnaissance study identified approximately 19 acres of restoration opportunities at Flushing Airport. This would increase the size of the existing wetland complex by over 70 percent. Restoration activities would involve removal and eradication (i.e., excavation and grading or chemical treatment) of common reed (including the root stock), and planting with suitable non-tidal wetland species. The site would be lowered to ensure that sufficient hydrological conditions exist to create forested, scrub/shrub, emergent sedge meadow and grass meadow wetland habitats. A common reed control program would be implemented to help ensure the success of these restored wetlands.

6.1.3 Dredging in Flushing Bay and Creek

The reconnaissance study recommended that dredging Flushing Bay and Creek be further analyzed in the feasibility study. Components of the dredging alternative could include re-contouring of the bay bottom to improve circulation patterns and water quality in the inner bay and creek. Fine grained organics-rich sediments and capping dredged areas with clean sediments to improve overall benthic habitat, plus the lowering the elevation of existing mudflats to reduce hydrogen sulfide flux would be accomplished.

6.1.4 Partial or Total Removal of the Breakwater at LaGuardia Airport

In 1995, the Port Authority of New York and New Jersey removed the top portion of the earthen breakwater to the level of the exposed mudflats above two (2) feet MLW in conjunction with construction of the LaGuardia Airport runway overrun project. In 1996, a floating breakwater was constructed to protect the World’s Fair marina, which had previously been protected by the earthen breakwater. Reduction of the earthen breakwater elevation was performed at the request of the Borough of Queens. The Borough perceived benefits in allowing additional inflows into the back bay during high tides. Hydrodynamic and water quality modeling studies conducted before the reconnaissance study indicate that removal of the earthen breakwater alone will not result in significant water quality improvements in the back bay. This is in large part due to the distance from the earthen breakwater to the shoreline and the presence of three (3) CSO outfalls just offshore in the back bay. However, the reconnaissance study did recommend that removal of the breakwater be assessed for potential habitat improvements that would result from improved circulation and flushing, restoration of the former bay bottom, and for impacts on odor reduction in the back bay.

6.1.5 Reorientation of the Federal Navigation Channel

In analyses conducted prior to the reconnaissance study, deepening of the federal navigation channel was evaluated as an option. Deepening the navigation channel was found to have limited effect on increasing circulation in the back bay. Due to problems identified in the past modeling efforts (WES, 1992), recent and planned CSO abatement activities, and the construction of a floating breakwater in the back bay, additional modeling of the impacts of reorienting or deepening the federal channel was recommended in the reconnaissance study.

6.1.6 Bank Stabilization, Site Cleanup and Debris Removal

A number of sources of surface erosion were identified during the reconnaissance phase. Eroded banks were observed at numerous locations along the west bank of College Point in Flushing Bay. Some of these sites were also being used for illegal dumping of refuse and construction and demolition material. Erosion control, site cleanup, and debris removal could support tidal wetland restoration efforts in this area.

6.2 Preliminary Screening of Alternatives

Four (4) evaluation criteria are identified in the Economic and Environmental Principles for Water and Land Resources Implementation Studies (Principles and Guidelines): completeness, effectiveness, efficiency, and acceptability. EP 1165-2-500 (30Sep99) “Ecosystem Restoration Supporting Policy Information” identifies three (3) additional evaluation criteria: significance, cost and benefit evaluation, and cost reasonableness. The preliminary screening of alternative plans conducted for this analysis was based on all evaluation criteria. A cost and benefit evaluation criteria had not yet been developed for any of the alternatives identified above.

Completeness is defined as accounting for all actions that may be required to support the alternative plan. In this preliminary screening process, hazardous, toxic, and radioactive waste (HTRW) phase I assessments, preliminary cultural resource impact assessments, and property ownership were used as benchmarks for the completeness criterion. Any preliminary plan with identified HTRW, cultural, or property ownership concerns would require additional investigation and planning resources to address these concerns and would need to be reconsidered with respect to its potential for ecological benefits prior to advancement to more detailed analysis.

The effectiveness of an alternative plan is determined by how fully the plan achieves the objective. Preliminary plans that do not achieve the planning objectives will not be advanced to more detailed analysis. The efficiency criterion assesses whether the plan achieves the objective at a reasonable cost and includes a preliminary assessment of whether the objective can be achieved by a less costly plan. Preliminary plans that require unreasonably intensive use of resources or that appear to be far more costly than other alternative plans that achieve the same objective may not be advanced in the planning process. The acceptability criterion is used to identify community, property owner, and regulatory agency support or concern for the plan. Preliminary plans that do not have community or property owner support or that raise significant concern by a regulatory agency would need to be reconsidered prior to advancement to more detailed analysis.

Significance refers to the institutional, public, or technical importance of the resource. This perspective on resource significance includes contributions the alternative plan may provide to local restoration initiatives or local interests. Also included under the significance criterion would be any coordination

with, or advancement of, local or regional programs, such as the New York/New Jersey Harbor or the Long Island Sound National Estuary Programs.

6.3 Alternatives Not Receiving Further Consideration

6.3.1 Breakwater Removal

Phase I and Phase II water and sediment quality modeling efforts, as described in Section 3: Water and Sediment Quality, have been conducted in order to identify the benefits of breakwater removal. The results of these modeling efforts are conclusive in that removal of the breakwater would not improve dissolved oxygen levels in the bay or creek nor would removal decrease the deposition of fine grained organic-rich sediments in inner Flushing Bay. After many model refinements, reviews and reassessments, the conclusion is that breakwater removal will not provide ecological benefits in terms of sediment or water quality improvement. It would return a small portion of bay bottom that the dike was built on but this too would suffer from poor water and sediment quality. Breakwater removal would be ineffective as a restoration activity. The breakwater removal was not carried forward into more detailed analysis.

6.3.2 Tidal Wetland Restoration Alternatives – Western Shore of College Point

During reconnaissance two short stretches of beach/eroded headlands along the western side of College Point were considered for vegetative stabilization by the planting of low marsh vegetation. Investigations revealed that these sites face into the prevailing winds and are subjected to very high-energy storm-driven wave surges, due to the long, uninterrupted fetch to the west that preclude the natural establishment of low marsh. The establishment of vegetation in these locations would require the construction of breakwaters or jetties to reduce wave energy. The effectiveness of this alternative would be extremely limited without the construction of energy attenuation structures. These structures would greatly increase costs for the same small area of restored wetland. It was also assumed that the construction of hardened structures in the bay would not be accepted by the public, given the public's desire for removal of the existing breakwater.

Also on the western side of College Point two areas located between steeply sloped headlands created by the accumulation of construction and demolition fill were considered for restoration. This area is 15 acres of fill, rubble, scrub brush, low trees and ruderal vegetation that was considered for restoration and rehabilitation as forest, low marsh, and tidal shore mud flats. Since the reconnaissance study, the area surrounding these sites has undergone preliminary excavations for residential development. The configuration of the steeply sloped banks would require landward excavation to establish a grade suitable for tidal wetlands. With residential development underway, an opportunity for landward excavation no longer exists. Tidal wetland restoration at these sites would not be effective and is assumed to not be acceptable to the landowner. This restoration activity was removed from further consideration.

6.3.3 Freshwater Wetland Restoration Alternatives – Former Flushing Airport

During initial feasibility level investigations of freshwater wetland restoration potential at the former Flushing Airport, the property owner and potential non-federal partner for construction, New York City Economic Development Corporation, formally requested the USACE to initiate an ecosystem restoration study of the former Flushing Airport pursuant to Section 206 of the WRDA of 1996. In a letter dated August 1, 2009, the USACE informed the New York City Economic Development Corporation of its intention to initiate the requested study under the authority of Section 206 WRDA

1996. Restoration at the former Flushing Airport will be pursued under separate authority and is no longer within the scope of this feasibility study.

6.3.4 Tidal Wetland Restoration – Inner Flushing Bay

This restoration opportunity would involve rehabilitating the 1.81 acres of common reed high marsh to cordgrass low marsh and expanding the existing cordgrass and tidal mud flat areas. This project would require the placement of additional substrate material at elevations suitable to support low marsh and tidal shoreline. Fill materials could come from removal of the breakwater or from other dredging sites in the New York Harbor vicinity. Total wetlands created and rehabilitated could be as much as six (6) acres of low marsh and another six (6) acres of new tidal shore mud flat, effectively increasing wetland coverage in the inner bay six-fold.

This potential restoration area is located at the outfall of three (3) CSOs (CSOs 1, 2, and 3). The success of this restoration opportunity would largely depend on the water quality impacts of these CSOs. Existing wetlands and mudflats in this area are highly degraded because of these CSOs. Restoration of additional wetlands and mudflats in this area would include the placement of clean material in the construction of additional wetlands and mudflats. The effects of the CSOs would degrade this material to a level equivalent with existing conditions. This degradation would occur over only a few years because these three (3) CSOs are not scheduled to receive abatement treatment similar to the abatement of overflow from CSO 4. The unabated outflow from CSOs 1, 2, and 3 make any wetland and mudflat restoration ineffective. Therefore restoration in the inner Flushing Bay was not considered for further detailed analysis.

6.3.5 Tidal/Freshwater Wetland Restoration - Upper Flushing Creek

During the time that restoration opportunities were being first identified, the NYC Parks was formulating a master plan for Flushing Meadows-Corona Park. NYC Parks expressed interest in the feasibility of restoring tidal and freshwater wetlands along Flushing Creek. This alternative considers improvements to tidal flushing in the upper portion of Flushing Creek enlarging the connection to Lower Flushing Creek. This would be accomplished through modification of the culverts under the railroad bridge and tidal gates at Porpoise Bridge near northern end of Flushing Meadows-Corona Park.

Opportunities exist along both banks of the stream to restore and widen low and high marsh communities into and through the golf area. The project would include excavation, grading, selective filling, planting of low and high marsh, and planting of native upland trees and shrubs species. Wetland restoration opportunities in Flushing Meadows-Corona Park would displace very intensively used recreational areas such as picnic grounds, soccer fields, and areas of the golf course. The loss of highly valued and heavily used recreation land areas likely will be opposed the community.

Further complicating this restoration alternative is the uncertainty of future plans for the park. Alternative plans were being developed that would convert much of Flushing Meadows-Corona park into a venue for future Olympic Games. (See www.Nyc2012.com for a description of venues tentatively planned for Flushing Meadows-Corona Park). Although New York City was not selected as the site of the 2012 Olympics, this alternative was dropped from consideration because of the intensity of existing use and the uncertainty of alternative future uses.

6.3.6 Tidal Wetland Restoration - College Point Northern Shoreline

This project would restore and create tidal low marsh, high marsh wetlands and tidal shoreline to several derelict sections of tidal shoreline between and possibly including some of Herman McNeil Park and the abandoned marina north of Powell's Cove Boulevard and 125th Street. This restoration area is located along the East River. This area periodically receives strong wind driven waves from Long Island Sound. Restoration activities would include placement of structures to reduce wave energy gradients. Restoration would require grading to improve circulation or increase tidal flushing of weed-dominated sections of high marsh, filling of some presently deeper areas and planting. This project area could create up to six (6) acres of tidal marsh where there is currently less than one (1) acre, and about eight (8) acres of transitional and upland woody habitat. Wetland restoration in this area was removed from further consideration because of the need to place energy abatement structures in the bay and lack of non-federal interest.

6.3.7 Tidal Wetland Restoration - Tallman Island Adjacent to Powell's Cove

This project includes wetland creation by lowering the grade of the presently ruderal fill area. The project area is located just south of Tallman Island Waste Water Treatment Plant. Elevations would be developed to support low and high tidal marsh, and with planting graded uplands with native trees and shrubs. The project area can continue south and link with the tidal wetlands creation/restoration project recently constructed by the NYC Parks in Powell's Cove Park. This project would double existing tidal marsh acreage up to 3.2 acres of tidal marsh, extend tidal shoreline, and create about 1.6 acres of transitional and upland woody habitat.

Tidal wetland and upland woody habitat restoration at this location is complicated by the real estate requirements of the restoration and lack of non-federal sponsor support in potential restoration of this area. Potential restoration of this area was not carried forward to more detailed analysis.

6.3.8 Reconstruction and Daylighting of Flushing Creek

Construction of the circular fountain at the eastern terminus of the Fountain of the Planets for the 1964 World's Fair placed approximately 2,400 linear feet of Flushing Creek underground. While probably maintaining a groundwater, or perhaps piped, connection, Meadow Lake and the above ground sections of Flushing Creek remain somewhat brackish. Flushing Creek flushes poorly and suffers frequent summer oxygen depletion due to eutrophic conditions, which lead to algal blooms. A significant nutrient source supporting eutrophication is the extremely high usage of, and defecation in, the wetland fringe by large resident populations of Canada geese. An approximately 4.5 acre fountain basin sits between the two underground sections of Flushing Creek. This area has minimal circulation and becomes an algae-clotted foul-smelling nuisance each summer that requires expenditures by NYC Parks to clean and maintain. NYC Parks expressed interest in dealing with these issues and assessing the feasibility of restoring ecosystem functionality to the creek through Flushing Meadow-Corona Park.

A project directed toward resolving these problems would include the construction of an open channel reconnecting sections of Flushing Creek and Meadow Lake and the establishment of a riparian buffer zone. The channel could continue to be aligned through the fountain, or the channel could be converted into a braided-drainage marsh. Effective restoration may require as much as 2,000 linear feet of stream channel within the park, about five (5) acres of low tidal or freshwater marsh around or in place of the old fountain, and eight (8) acres of riparian buffer habitat. This alternative was not considered further because of existing alternative land uses (heavy recreational use), the uncertainty regarding potential

re-development of the park into an Olympic Games or other athletic venue, and the potential uncertainty associated with historical significance of the surrounding World’s fair area.

6.3.9 Tidal/Freshwater Wetland Restoration at Meadow Lake

Flushing Creek and Meadow Lake would be restored to a more saline condition under a tidal wetland design. This would facilitate the reestablishment of marine and estuarine biotic communities into the formerly extensive tidal marsh. Improvements in circulation and the creation of conditions less suitable for freshwater algae infestation would be supported. A reduction in the goose problem would also be realized. The reconstructed channel connecting Flushing Creek to Meadow Lake would be designed to allow diurnal tidal cycling, with a maximized (sinuous) channel length. This would support the ability to accommodate tidal ebb and flow timing.

Under a freshwater wetland design, the limited wetland and buffer habitat restoration planned by the NYC Parks would be enhanced by the construction of approximately 20 acres of additional fringe wetlands, grading and planting of floating leaf aquatic plants, and restoration of deep and shallow water emergent marsh.

The effectiveness of restoration alternatives at Meadow Lake would require a buffer zone to protect fringing wetlands. The availability of land is very limited along the lake because picnicking regularly takes place right at the water’s edge. The expected strong community opposition to the loss of valuable and heavily used recreation land and the uncertainty concerning future plans for the park caused this alternative to be removed from further consideration.

6.3.10 Wetland Restoration and Rehabilitation at Willow Lake

Willow Lake is presently managed as a minimal public access nature preserve. Formerly part of the World's Fair grounds, the lake and its environs have been allowed to proceed through natural successional processes to its present low feral state. Wetlands have accrued on former paved areas and in abandoned pools. Much of the site is, however, dominated by ruderal herbaceous vegetation, scattered stands of wind propagated trees and shrubs and over grown decorative trees. An ecosystem restoration project would take the form of minor grading, removal of weedy vegetation (particularly common reed), the planting and seeding of native vegetation and construction of wildlife habitat structures such as bird, squirrel and wood duck boxes, bat houses, and osprey (*Pandion haliaetus*) perch. The restoration project would include design and construction of trails and signage for a nature interpretive program. This project could rehabilitate 20 acres of non-tidal isolated and lake shore wetlands and improve up to 30 acres of upland forest wildlife habitat.

This alternative was not considered further in the feasibility study because of the uncertainty concerning future plans for Olympic Games or other athletic venue development.

6.3.11 Reorientation of the Federal Navigation Channel

The hydrodynamic model (RMA-10), which had been previously calibrated and verified for work being conducted by NYCDEP, was used to produce the transport data for the water quality model (RMA-11). The water quality model calibration was performed in two stages. The first stage is the calibration of the constituents that primarily affect hydrogen sulfide flux. The second stage is the calibration of dissolved oxygen and the other water quality constituents that primarily affect dissolved oxygen. Model development, calibration, and verification has been reviewed and approved by the Waterways Experiment Station.

Model results indicate that dredging or widening the existing navigation channels to improve circulation will increase the transfer of East River water into the inner bay. Although Flushing Bay and Creek exhibit low levels of dissolved oxygen, improvements to bay and creek dissolved oxygen levels due to the effects of the CSO holding tank to be completed in 2004 will raise bay and creek dissolved oxygen levels above East River dissolved oxygen levels. Expanding the channel would be counter-productive to improving dissolved oxygen levels in the inner bay because future without-project condition dissolved oxygen levels in the bay are better than future without-project condition dissolved oxygen levels in the East River. Channel expansion would increase tidal flushing but would decrease dissolved oxygen levels in the inner bay. Dredging or widening the navigation channel was not recommended for further consideration.

6.3.12 Bank Stabilization, Site Cleanup and Debris Removal

Bank stabilization, site cleanup, and debris removal are measures associated with potential wetland restoration sites along the west side of the College Point shoreline. Wetland restoration at this location is not being carried forward for more detailed analysis in the feasibility study. Small areas of one (1) acre or less, identified for site cleanup and debris removal along the shoreline, are being used as illegal dumping areas where household and construction debris have been deposited. Feasibility level analysis of these alternatives indicates that limited ecological significance is associated with these measures at the west side of College Point and that the completeness of these alternatives would require measures to maintain site cleanliness and to prevent debris placement. This alternative was not carried forward for more detailed feasibility level analysis.

6.4 Alternatives Recommended For Full Feasibility Analysis

The following ecosystem restoration alternatives are discrete projects that could be designed and constructed independently, with independent value. The cumulative ecosystem benefits could exceed the individual project benefits if they were implemented as part of a single project or as part of a sequential set of linked projects. When possible, projects would be linked to existing parks and natural areas to enhance connectivity of habitats along the water and land interface in the New York metropolitan area.

6.4.1 Tidal Wetland Restoration - Lower Flushing Creek

This site would include restoration and rehabilitation activities designed to widen the existing low tidal marsh and high tidal marsh, by lowering the grade through the presently common reed-dominated high marsh wetlands and adjacent ruderal uplands. The site for this restoration project includes sections of the left descending bank of Flushing Creek between the Van Wyck Expressway (Route 678) crossing at the mouth, to the tidal gates at Porpoise Bridge beyond the New York City Transit Authority yard and rail crossing. An opportunity exists here to restore about 6.5 acres of low tidal marsh where currently scattered areas total about one (1) acre, and to create forest along 2,000 linear feet of the creek. This restoration opportunity has been included in plan formulation for more detailed analysis.

6.4.2 Dredging in the Inner Bay and Flushing Creek

Dredging selected areas of the inner bay and creek, including removal of the top two (2) to eight (8) feet of sediments, coupled with replacement of clean sediments (possibly beneficial use of dredged material), would reduce concentrations of total organic carbon in the sediments and improve substrate

quality. As discussed in Section 3: Water and Sediment Quality, reductions in concentrations of total organic carbon would increase benthic diversity. The dredging alternative could also include re-contouring the bay bottom in the vicinity of high velocity CSO discharges to reduce localized scouring, turbidity, and the conveyance of sediments downstream. Coarse substrate materials could be used to attract fish into the inner bay and creek.

An analysis of future CSO loadings would be required to determine the best areas to dredge and cap in order to maximize the duration of improvements, before concentrations of total organic carbon revert to baseline levels. An assessment of the beneficial impacts from other planned water and sediment quality improvements in the study area and in the East River will be conducted to determine the expected duration of sediment improvements. This restoration opportunity has been included in plan formulation for more detailed analysis.

6.5 Plan Formulation of Feasibility Level Alternatives

The initial formulation task during the “source” study was to identify, inventory and evaluate the sources of potential impacts to Flushing Bay and Creek. CSOs are one the most significant effects on Flushing Bay and Creek. Fourteen (14) CSO were identified in the upper portions of the Flushing Creek. A 40 million gallon CSO retention facility was constructed by the NYCDEP and has been in use since 2006.

A second major impact to the Flushing Creek is the hydrogen sulfide smell associated with Flushing Creek during the summer month. The odor is significant in the summer months. As tides flow out of the creek, mud flats are exposed and hydrogen sulfide is emitted. These odors can be very oppressive during summer.

6.6 Key Assumptions Guiding Plan Formulation

Several key assumptions provided the framework to develop alternative measures and compare and screen alternative plans. The following are the key assumptions used to guide the plan formulation process:

- Develop measures to restore the aquatic habitat of Flushing Bay and Creek to a less degraded, more natural condition.
- Develop measures to facilitate the recovery of the overall aquatic ecosystems.
- Dredge where appropriate to support the recovery of the aquatic ecosystem.
- Provide restoration of tidal wetlands including salt marsh cordgrass and within the tidal zone from mean high tide to the spring tide elevation, salt grass and salt marsh hay.
- Provide freshwater wetland restoration and enhancement as appropriate.
- Minimizing long-term operations and maintenance to ensure a self-sustaining aquatic ecosystem.

6.6.1 Alternative Formulation

The estuarine environment of the project area consists of the tidal habitats of Flushing Bay and Creek, adjacent tidal marsh wetlands, and mudflats. In the low marsh area, the upper 50 percent of the inter-tidal zone adjacent to open water and mudflats, salt marsh cordgrass would typically be present. Within the tidal zone from mean high tide to the spring tide elevation, salt grass and salt marsh hay would be present. In most of these marsh areas, the invasive common reed is the dominant species. Common reed is displacing most of the native high marsh vegetation. The majority of non-wetland environments in the bay and project vicinity are highly disturbed, urban settings. Areas not currently occupied by buildings, other structures or paved surfaces are generally weed-dominated fill materials. While most

such areas are sparsely vegetated with low herbaceous weeds, some untended areas have begun to succeed to shrubs and trees. No threatened or endangered species are known to inhabit the study area.

Alternatives for restoration focus on Flushing Creek Dredging and adjacent marsh restoration. The project area is located between the LIRR and the IRTRR.

The wetland areas adjacent to this reach are of a disturbed nature and are dominated by common reed, field horsetail, chicory, common plantain with a trace of glasswort (*Salicornia*) and mugwort (Artemisia vulgaris) within the upper tidal and upland areas. A native shrub marsh elder is present in the high tide to spring tide range. The native salt marsh cordgrass is also present along a narrow band in places that range from one (1) to 20 feet wide.

6.6.2 Restoration Techniques

The following are measures which were considered to restore the aquatic ecosystem of the Flushing Creek.

6.6.2.1 Dredging

- Dredge to recreate existing depth: This would entail dredging three (3) to four (4) feet. Minor over dredge volumes from six (6) inches to a foot would be anticipated.
- Dredging four (4) feet: This would entail dredging four (4) feet. Minor over dredge volumes from six (6) inches to a foot would be anticipated.

6.6.2.2 Capping

- Existing depth with sand: One (1) to two (2) feet of medium to fine sand would be used to cap the dredged areas. The sand would be used to provide a barrier from the potentially contaminated sediments below the sand.
- Dredge three (3) feet with sand: One (1) to two (2) feet of medium to fine sand would be used to cap the dredged areas.
- Dredging four (4) feet with sand: One (1) to two (2) feet of medium to fine sand would be used to cap the dredged areas.

6.6.2.3 *Spartina* Restoration/Creation

The existing areas are shown in Table 6-1. Restored areas for the following are provided later in the Feasibility Report.

- *Spartina* restoration left bank: This would entail *Spartina* restoration on the left bank of Flushing Creek.
- *Spartina* restoration/creation left bank and island: This would encompass restoration of the left bank and *Spartina* restoration on the right descending bank.
- *Spartina* restoration/creation left bank, island, and right bank: This would entail *Spartina* restoration on the left bank, island, and the right bank.
- Restore the riparian corridor of Flushing Creek: Three (3) scales of riparian corridor restoration are envisioned as follows:
    - ✓ Riparian corridor restoration scale 1: Riparian corridor restoration on the left bank would be accomplished in association with the *Spartina* creation.

- ✓ Riparian corridor restoration scale 2: Riparian corridor restoration on the left bank would be accomplished in association with the *Spartina* creation. Common reed eradication would be provided for the left side of the project area.
- ✓ Riparian corridor restoration scale 3: Riparian corridor restoration would occur on the left bank and right bank in association with the *Spartina* creation. *Spartina* island creation and *Spartina* creation above CS-4 would be done. Common reed eradication would be provided for the left and right sides of the project area.

Table 6-1: Existing Acreage of Habitats or Communities

Habitat or Community	Area (Acres)
Estuarine benthic habitat/open water	4.7
Mud flat	4.3
Spartina low marsh	0.5
Common reed (*Phragmites)* high marsh	1.7
Successional upland herbs	0.4
Successional sedge wetland	0.4
Cottonwood forest	1.2
Mixed riparian forest	1.9
Rip-rap/concrete	0.3
Total	**15.4**

6.6.3 Evaluation of Restoration Techniques

The highly degraded nature of the project site offers opportunities to conduct the following restoration activities. These are considered individually and in various combinations for economic and ecosystem benefits assessments.

6.6.3.1 Benthic Community Restoration: Dredging and Capping

This opportunity would include removal of three (3) to four (4) feet of upper contaminated substrate material, remove it from the site for disposal and replace it with two (2) feet of clean fill consisting of medium to fine sand. For achieving odor reduction, final substrate grade would be consistently below MLW elevation. This would require excavation of all mud flats and hardened bank protection of shorelines to allow transition to Spartina marsh within the intervening mudflat. This opportunity provides a persistence of restored conditions.

6.6.3.2 Expansion of Low Marsh by Excavating Uplands on Left Descending Bank to Eliminate Common Reed (*Phragmites*)

The left descending bank shoreline would be excavated landward from the approximate existing *Spartina* edge, to the approximate elevation of 12.0 MLW. The finished grade would be maintained within the local daily tidal range of the approximate elevation of five (5) to seven (7) feet MLW. This would be done to support the establishment of a *Spartina* low marsh. The common reed stand would be

eliminated by complete removal of stem and root structures and re-introduction of daily tidal influences. Common reed root masses would be buried locally below low tide to provide organic matter to the restored low marsh. Existing *Spartina* root masses and peat would be moved and replaced as the project progresses. Marsh subgrade would be one (1) foot below final grade to accommodate imported peat or organic material. The area would be planted with locally obtained potted or sprig Spartina and other low marsh species. A steep (>1:1) transition between new low marsh and upland forests would be prepared to minimize the potential for common reed recolonization. The transition slope would be protected using jute matting. New plantings would be stimulated by the application of high nitrogen fertilizer.

6.6.3.3 Expansion of Low Marsh to Recreated Mudflats along Both Banks

Using techniques similar to the left bank low marsh creation opportunity, *Spartina* low marsh would be created at the existing mud flats along both stream banks. The existing mud flat locations are representative of low energy, depositional conditions that occur in response to existing sewer and culvert in-flows. Fringing mudflats banks would stabilize the marsh edge.

6.6.3.4 Enhancement of Species Diversity in Forested Uplands

This opportunity includes supplementary planting of coastal-adapted trees and shrubs in existing forests to improve the forest habitat. Inclusion of native seed and berry producing species would improve value to wildlife. Enhanced planting is particularly important along the transition to low marsh banks for the prevention by canopy shading of common reed. Re-soiling to a depth of 0.5 to one (1) feet and mulching would be conducted where it would not interfere with existing trees. Areas would be fertilized to stimulate rapid growth and organic layer build up.

6.6.3.5 Planting Forest on Non-forested Uplands and Conversion of Herbaceous Wetlands to Forested Wetlands to Suppress Common Reed (*Phragmite*s) Invasion

Native coastal tree and shrub species would be planted in successional habitat types. This type of planting would aid in suppression of common reed and increase the area of locally rare shoreline forest. Topsoil would be placed to a depth of 0.5 to one (1) feet, fertilized and mulched. Native woodland herbaceous species would be seeded.

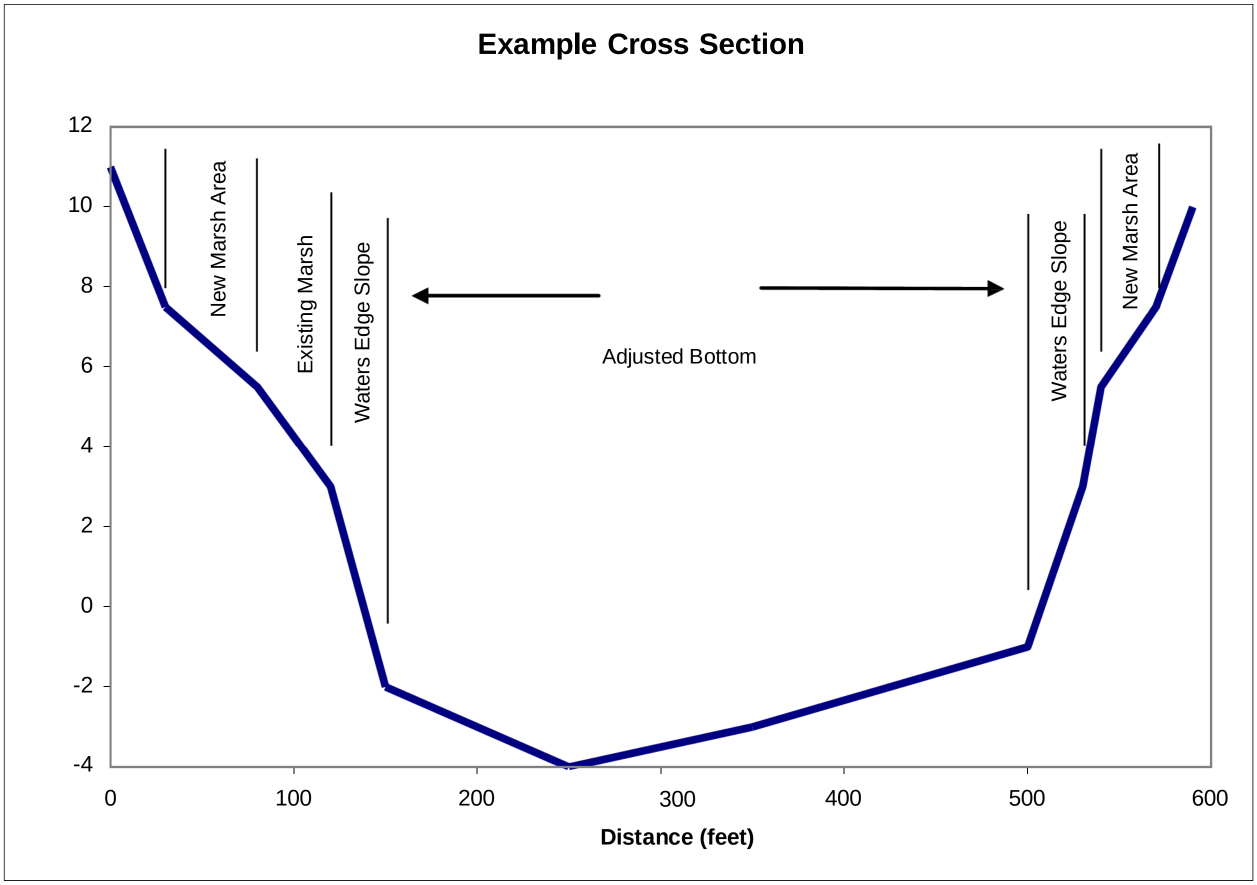


Figure 6-1: Proposed Cross-Section

6.6.4 Restoration Plan Alternatives

A total of 17 alternatives were developed that focused on variations of Flushing Creek dredging, capping, and adjacent habitat restoration within the riparian, tidal wetland, and benthic zones of the project area. The specific project area was located between the LIRR and the IRTRR. Table 6-2 lists the potential opportunities for restoration on the Flushing Bay and Creek Sites.

Table 6-2: Restoration Alternatives

	Dredging to Recreate Existing Depth	Dredging Three (3) Feet	Capping	Dredging and Capping to Existing Depth	Dredging Three (3) Feet and Capping	Full *Spartina* Restoration /Creation	*Spartina* Restoration /Creation Left Bank	*Spartina* Restoration /Creation Left Bank and Island	*Spartina* Restoration /Creation Left Bank, Island, and Right Bank	Riparian Corridor Restoration
Alternative 1	X									
Alternative 2		X								
Alternative 3			X							
Alternative 4	X			X						
Alternative 5		X			X					
Alternative 6				X		X				
Alternative 7		X			X	X				
Alternative 8	X			X		X				X
Alternative 9		X			X	X				X
Alternative 10	X			X			X			
Alternative 11	X			X				X		
Alternative 12	X			X					X	
Alternative 13	X			X					X	X
Alternative 14		X			X		X			
Alternative 15		X			X			X		
Alternative 16		X			X				X	
Alternative 17		X			X				X	X

6.7 “Source” Study Ecological Benefits Evaluation for Original 17 Alternatives

The benefits derived from proposed alternative ecosystem restoration for an approximately 16-acre project area(in and immediately adjacent to a 1,200-foot reach of Flushing Creek), were calculated using a three (3)-part model . The three (3)-part model was used to independently assess benefits in three (3) distinct, adjacent restoration zones (benthic, tidal wetland, and riparian zones). The benthic zone is the non-vegetated, sub-tidal to mean sea level, topographic region of the Flushing Creek bed that is composed of an organic and inorganic sedimentary substrate that supports typical estuarine fauna. The wetland zone is the vegetated area between mean sea level and mean high tide inundated or saturated to the surface periodically each day. The riparian zone is the vegetated area above mean high tide to the outboard limits of the project area. The restoration benefits calculated for each of the three (3) parts were summed to yield a single numeric restoration benefit value for each restoration alternative or restoration measure assessed.

A calculation of restoration benefits was necessary to support an incremental cost analysis and identify best buy plans for various levels of restoration activity. The calculation of restoration benefits was premised on demonstration that the area to be restored was in an ecologically degraded condition. Restoration will result in a less-degraded condition and that the less-degraded condition resulting from restoration actions will be self-sustaining.

Reference areas were used to support development of the model. Components of this model include elements and concepts from various benthic biota-based indices of biotic integrity. Terrestrial coefficient of conservatism assessment approaches, EPW evaluation (Bartoldus et al, 1994), and standard forestry metrics were used to develop the model.

6.7.1 Functional Capacity Units

Riparian buffer habitat was assessed using a forest growth model. Assumptions concerning the biotic and abiotic changes that occur during natural succession drove the successional model. Outputs from the three (3) component methods were normalized for summation of a single positive value. The Functional Capacity Units (FCUs) were calculated similarly to the Hydrogeomorphic (HGM) approach to assessing wetland functions.. The FCU is the product of spatial area measurements within an ecosystem where improvement is presumed to occur. The quantification of the assumed degree of improvements are assigned to each ecosystem function. While the restoration area is always a measurable unit that is calculated, the degree of ecosystem improvement is an ordinal. Value-based ranking of one or more factors intended to express the improvements in relative function or the reduction in impairment.

The use of FCUs in the benefit model provided the normalization needed to evaluate various approaches and scales for ecosystem restoration against restoration costs. The FCU became the input value for the Cost Effective and Incremental Cost Analysis (CE/ICA) model used to assist in plan selection. The FCU output for a restoration measure or cluster of measures were used to compare the cost effectiveness between different approaches to solving the problem or to different degrees of restoration effort. This would mean selecting the least cost measure when two measures provide an equal FCU output. The FCU output of a particular restoration measure was used to evaluate the relationship between the ecosystem lift gained and the incremental cost of different degrees of restoration effort.

FCUs for discrete or parallel restoration measures were also combined in various incremental ways to evaluate the effect of various plan scales. This allowed for degrees of ecosystem lift and cost for identifying the most cost-effective set of measures. The scale (absolute area) of a measure and the degree of lift expected for a measure can be varied and combined with other measures to identify one (1) or more "best buy" plans for ecosystem restoration. The restoration area and relative ecosystem functional lift was varied.

6.8 Restoration Concept

Such an array of communities and diversity of composing species might have occurred within and around the formerly large area of undisturbed Flushing Meadows. It would be impractical to fully restore this project site. The present confined conditions might support a limited array of natural communities, composed of native species, as may have occurred along a steep transect from a sandy or till-plain bluff that plunged to tidal waters. Because of the continued disturbance in adjacent surrounding areas and the very limited space available, the restoration concept for this site included only three (3) community zones.

- <u>Riparian Zone</u>: Species occurring in terrestrial system communities would be established in areas that rarely flood or become exposed to saline waters, which, for this concept of a restored ecosystem, was construed as the riparian zone. The low fringe of the riparian zone would be occupied by species of the estuarine intertidal salt shrub community.
- <u>Tidal Wetland Zone</u>: Plant species from the upper tidally influenced edge through the edaphic zone found in estuarine subtidal systems would be established in a tidal wetland zone. The salt shrub banks of the riparian zone would transition quickly to tidal middle marsh and low marsh. Middle marsh would be relatively narrow and composed of several halophytic (salt tolerant) herbs and grasses. Low marsh would be dominated by smooth cordgrass from mean high tide to mean sea level. Down the topographic gradient from the smooth cordgrass community to mean low water elevation, would occur the nearly non-vegetated marine intertidal mudflat community.
- <u>Benthic Zone</u>: The lowest zone, the area below mean low tide, would be a restored, unconsolidated-bottom, marine subtidal benthic zone.

Restoration alternatives that were evaluated focused on variations in the relative area of each zone, and variations in the measures and the materials used to implement restoration. Table 6-3 shows sample functional capacity index (FCI) calculations for an alternative that dredges and caps 4.66 acres, creates 4.27 acres of wetland, and improves 0.84 acres of riparian habitat. FCUs were calculated by adjusting raw FCI scores for total improved acreage, changes in habitat quality over time (improvements for wetland and riparian habitats or degradation for benthic habitats), and summed over the 50-year study period.

Table 6-3: Sample Benefit Calculations

Benthic Zone Parameter	DEI	Wetland Zone Parameter	DEI	Riparian Zone Parameter	DEI
Total benthic taxa	3	Bank erosion control	15.5	Habitat diversity	5
Tolerant taxa ration	4	Sediment stability	8	Natural succession	3
		Wildlife	19.5	Nativity	4
		Fish (tidal)	15	Soil fecundity	2

Benthic Zone Parameter	DEI	Wetland Zone Parameter	DEI	Riparian Zone Parameter	DEI
				Native fauna	2
Raw total benthic FCIs	7	Raw total wetland FCIs	58	Raw total riparian FCIs	16
Acres improved	**4.66**	**Acres improved**	**4.27**	**Acres improved**	**0.84**

Note: DEI = Degree of Ecosystem Improvement

6.9 Selection of Recommended Restoration Plan in the "Source" Study

CE/ICA (IWR-PLAN Beta Version 3.33 software) was used to evaluate 490 alternative plans. The ecological benefits and rough order of magnitude costs were used for the CE/ICA which identified 22 cost-effective plans and eight (8) best buy plans. Incremental cost analysis was conducted on the best buy plans resulting in the selection of the recommended restoration plan focused on Flushing Creek dredging and adjacent marsh restoration. The selected alternative included 4.4 acres of riparian restoration, 1.8 acres of wetland restoration on the left descending bank of Flushing Creek, and 4.2 acres of wetland restoration on the right descending bank (Figure 6-2).

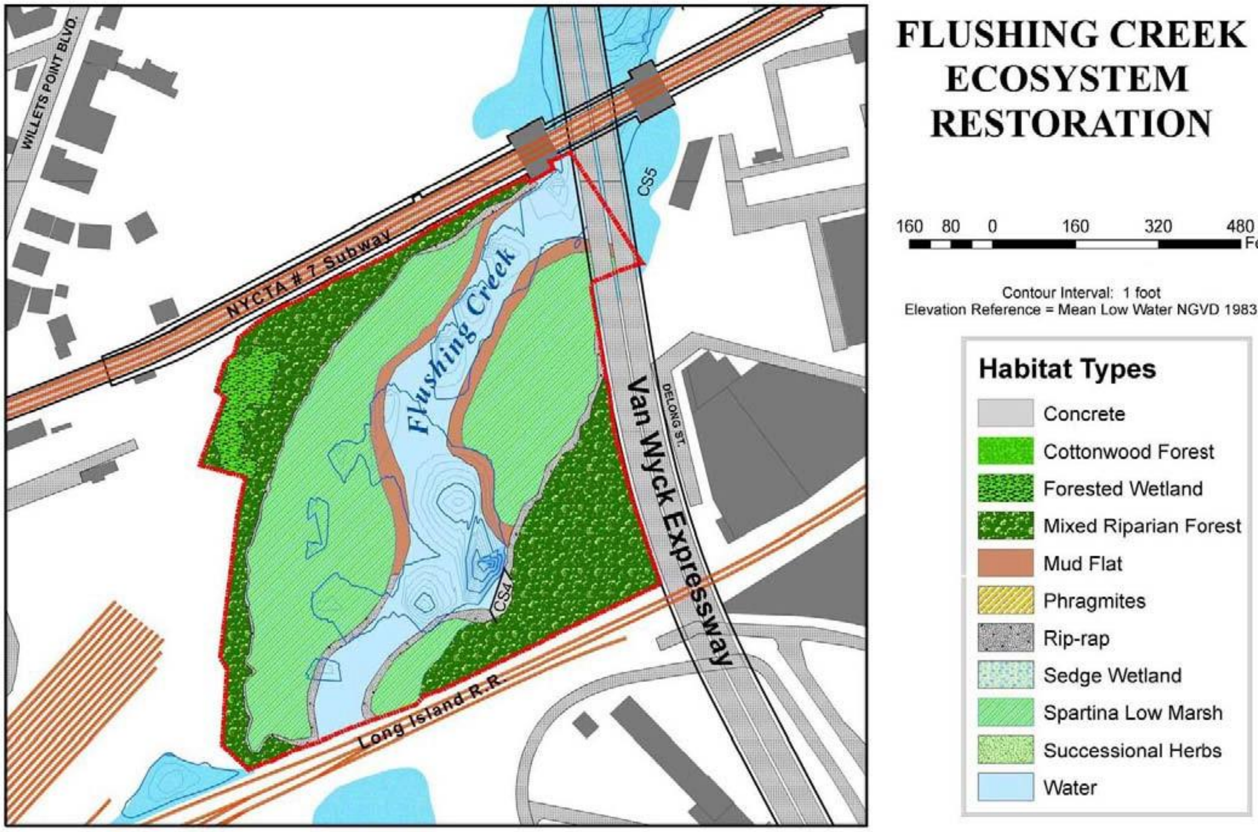


Figure 6-2: The Recommended Restoration Plan Selected as Part of the "Source" Study in 2007

The recommended restoration plan was not supported by NYCDEP at the time, as the agency wanted the USACE to include additional environmental dredging activities in coordination with NYCDEP's own environmental dredging activities and Long Term Control Plan. Progress was then suspended due to lack of funding, and the study was inactivated and subsequently rolled into the HRE Feasibility Study in 2013. The USACE evaluated subsequent opportunities to integrate additional dredging into the restoration plans; however the dredging measures were not advanced due to cost. NYCDEP planned to advance the environmental dredging activities in Flushing Creek in parallel with 100 percent of the costs borne by NYCDEP.

The recommended restoration plan selected in 2007 was then optimized further with NYCDEP as part of the HRE Feasibility Study.

7 Optimized Selected Restoration Alternative

In addition to the field investigations that were conducted within the "source" study area, NYCDEP conducted field investigations to re-evaluate the recommended alternative in an area of approximately 17.36 acres between the Roosevelt Avenue Bridge to the north, LIRR bridge to the south and the Van Wyck Expressway to the east. NYCDEP also investigated adjacent areas along Flushing Creek. The recommended restoration plan from 2007 was then re-evaluated based on data collected in 2012 and 2013. Three (3) additional restoration alternatives were developed that would complement NYCDEP's dredging activities within Flushing Creek. NYCDEP plans to dredge portions of Flushing Creek to a target depth of 3.28 feet MLW) funded 100 percent by the NYCDEP. The dredging will be conducted by NYCDEP to remove accumulated sediments that are exposed at low tide and contribute to nuisance odors with subsequent placement of a sand cap over the newly dredged area to provide a clean substrate for benthic habitat.

7.1 Baseline Conditions

Baseline conditions of fish, benthic invertebrates and vegetation communities as well as EPW within the project area were most recently surveyed in 2012 through 2014 by NYCDEP (NYCDEP, 2014).

7.1.1 Fish and Benthos

A benthic and fisheries sampling program was conducted during fall 2012 and spring 2013 to determine the nature of the existing communities within the proposed restoration area. This sampling effort was intended to provide an assessment of overall habitat quality. The sampling design and methods were carried out in accordance with a benthic and fisheries sampling work plan approved by NYSDEC on October 4, 2012.

This study compared benthic communities between intertidal and subtidal habitats at the proposed project and reference locations, and revealed few marked differences in abundance or other community parameters. The invertebrate communities were dominated by common, widely-distributed, pollution-tolerant marine annelids.

The fisheries sampling program represented a unique assessment of the current finfish community inhabiting the upper reaches of Flushing Creek and generally confirmed that the fisheries resources within Flushing Creek are somewhat limited in species diversity and abundance when compared to the nearby larger and more complex East River and Hudson River estuaries. Over the course of the fall 2012 and spring 2013 surveys, 477 finfish representing 12 different species and 31 blue crabs were collected. The most commonly collected species were typical estuary inhabitants and included

mummichog (*Fundulus heteroclitus*) at 62.5 percent of the total collection, Atlantic silverside (*Menidia menidia*) at 14.9 percent, gizzard shad (*Dorosoma cepedianum*) at 10.7 percent, and Atlantic menhaden (*Brevoortia tyrannus*) at 8.6 percent. Mummichog, is ubiquitous among shallow estuarine habitats including open shorelines and is a species highly tolerant of low dissolved oxygen conditions.

7.1.2 Wetland and Upland Habitat Characterization

Intertidal and non-tidal wetlands within the Flushing Creek project area were delineated on October 9, 15, and 24, and November 8, in 2013. Four (4) distinct wetland communities (vegetated intertidal wetlands, intertidal mudflats, ephemeral pond, and subtidal shallows) and one (1) upland community (maritime forest) were identified in the proposed project area. Existing conditions are presented in Figure 7-1.

The vegetated intertidal wetlands consisted of common reed and saltmarsh cordgrass; the cordgrass typically being found in the lower portion of the tidal regime and in depressions on the westerly side of Flushing Creek. The stands of saltmarsh cordgrass appeared to be healthy and vigorous, although about 90 percent of the vegetated wetlands were a very dense common reed monoculture. The intertidal mudflats consisted of silt, sand, cinders and gravel interspersed with very soft and deep organic sediments. Extensive mudflats are exposed at low tide along the easterly shoreline downgradient of the existing vegetated wetlands. These near-level areas dewater and flood very rapidly during the tidal cycle. A shallow ephemeral pond is located north of the LIRR tracks and west of Flushing Creek. The pond had no defined inlet or outlet and appears to be no more than two (2) feet deep at full pool. The pond apparently fills from sheet flow from the uplands to the west and north and the LIRR tracks to the south. The littoral zone/subtidal shallows consisted of the inundated portions of Flushing Creek within the project area and appeared to be less than six (6) feet in depth at MLW.

The maritime forest comprised the sparse to moderately dense forested upland areas on the west and easterly sides of Flushing Creek, respectively. The two forested areas appeared to be the result of natural colonization and not the result of any intentional planting or landscaping. The forested area on the easterly side of Flushing Creek featured a moderately dense tree canopy and dense shrub cover in some areas. Dominant trees were honey locust (*Gleditsia triacanthos*), black cherry (*Prunus serotina*) and box elder (*Acer negundo*). Areas beneath the highway overpasses were sparsely vegetated with herbaceous weeds. The forested area on the westerly side of Flushing Creek consisted of a sparse canopy of small (less than six (6) inch diameter) black locust (*Robinia pseudoacacia*) and Eastern cottonwood (*Populus deltoides*) trees with a mugwort and common reed herbaceous layer. Many of the cottonwood saplings and small trees were dead or had extensive dieback of the major branches. This forested area provides sparse cover and a very limited food supply for wildlife.

7.1.3 Sustainability

An assessment of the sustainability of the proposed project was conducted from the perspective of the rate of future discharges of solids and contaminants to the creek. A fine grid hydrodynamic model of Flushing Creek in the area upstream of Northern Boulevard was developed to assist in the sustainability evaluation. The model is capable of calculating bottom shear stresses, which are the forces that determine the ultimate fate of CSO solids within Flushing Creek. The model was tested and evaluations considered the following inputs including:

- Historical contaminants in Flushing Creek sediments and historical levels of contaminants being treated at city wastewater treatment plants;
- The impact of facilities recently constructed to reduce CSOs; and

- Future facilities planned to further reduce CSOs.

As presented in Attachment B, the findings of this assessment are that current and future anticipated discharges to the creek tend to favor sustainability; i.e., that contaminated sediment mounds are not likely to form. In addition, the NYCDEP water quality improvements, green infrastructure and environmental dredging that has been completed and planned will ensure the sustainability of the proposed ecosystem restoration.

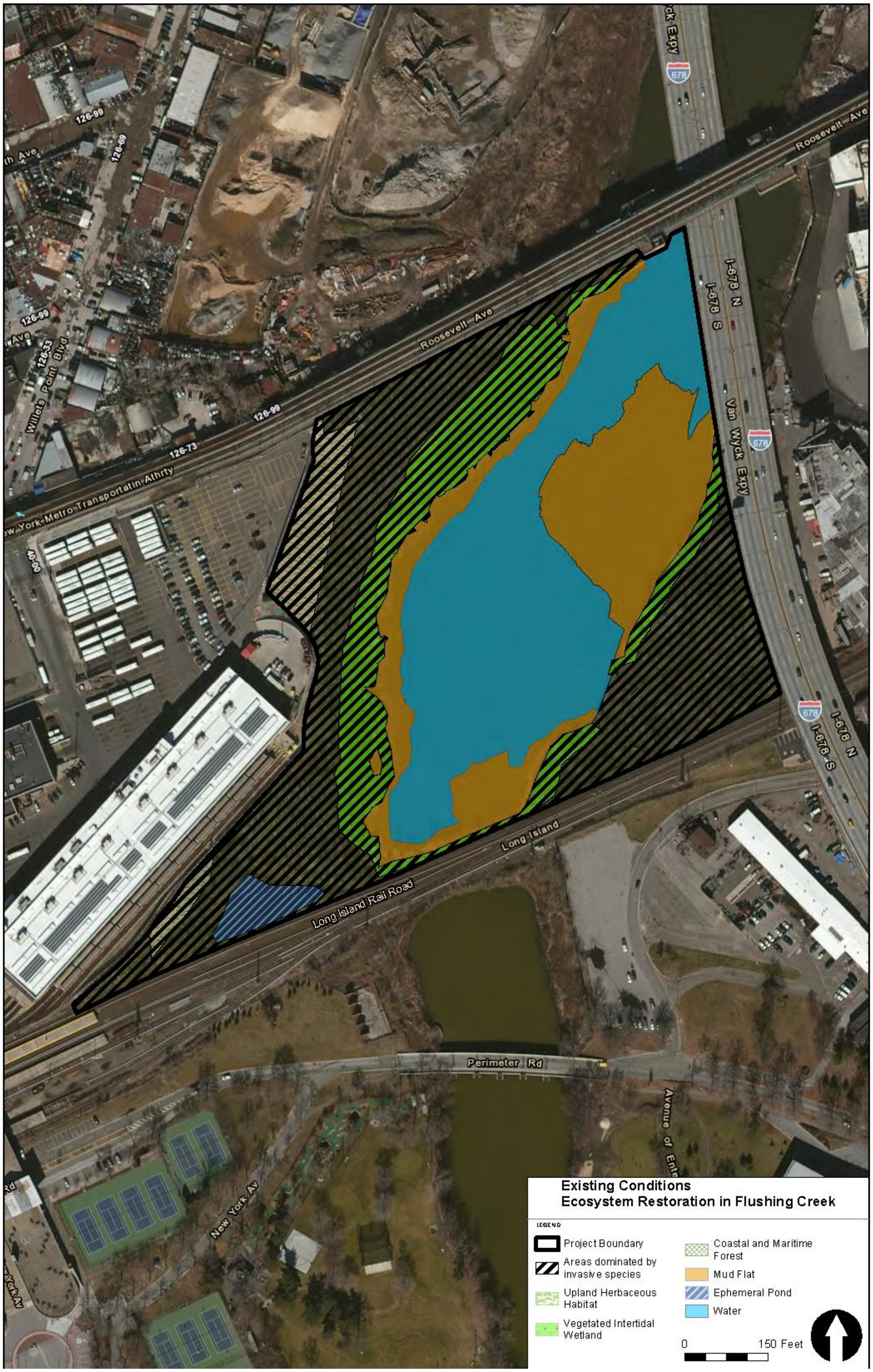


Figure 7-1: Existing Baseline Conditions at Flushing Creek

7.2 Proposed Modified Alternatives

The original recommended alternative identified in 2007 was re-evaluated in order to coordinate better with the NYCDEP's environmental dredging of the creek. Three (3) additional restoration alternatives were developed for Flushing Creek within the proposed restoration footprint. The restoration measures proposed for the site alternatives are based off target ecosystem characteristics. Table 7-1 categorizes and explains each restoration measure and technique proposed for Flushing Creek alternatives. Provided below is a brief overview of the three (3) alternative conceptual plans and what these plans would include:

7.2.1 Alternative A

Alternative A (Figure 7-2) would restore habitat through the creation of a low salt marsh community and improve water quality within Flushing Creek. The concept plan includes:

- Low salt marsh (2.42 acres): Re-grading existing common reed-dominated areas to create low salt marsh consisting of saltmarsh cordgrass.
- Ephemeral pond (0.28 acres): Preserving the ephemeral pond.
- Existing upland (6.56 acres): Preserving existing upland forest with no re-grading or replanting proposed.

7.2.2 Alternative B

Alternative B (Figure 7-3) would restore and improve several habitat types within the system and improve water quality within Flushing Creek. The concept plan includes:

- Mudflat (1.16 acres): Re-grading the tidal creek edges to establish mudflats with a target elevation between MLW and mean tide line).
- Ephemeral pond (0.28 acres): Preserving the ephemeral pond.
- Low salt marsh (3.67 acres): Re-grading existing common reed-dominated areas to create low salt marsh consisting of saltmarsh cordgrass.
- High salt marsh (0.44 acres): Establishing transitional high marsh/shrub swamp area between low marsh and upland maritime forest consisting of salt meadow cordgrass, salt grass, switchgrass *(Panicum virgatum)*, marsh elder, and groundsel bush (*Baccharis halimifolia)*.
- Maritime forest (6.77 acres): Restoring the existing upland forest to a maritime forest community with post oak (*Quercus stellata)* and black oak *(Q. velutina*).

Table 7-1: Ecological Restoration Measures for Flushing Creek

TEC	Measure	Description	Techniques
Wetlands (Coastal Wetlands)	Mudflat restoration	Re-grade tidal creek edges to establish mudflats at elevations between MLW and mean tidal elevation.	
	Emergent wetland creation	Excavate and re-grade areas to appropriate elevations between mean tidal elevation and mean high water (MHW) and plant saltmarsh cordgrass to create an emergent wetland to replace upland invasive areas to provide a habitat that is less likely to become revegetated with the same upland invasive species.	• Low marsh wetlands • High marsh wetlands
	Scrub/shrub wetland creation	Excavate and regrade areas to elevations between MHW and mean higher-high water (MHHW) to create a scrub/shrub wetland to provide continuous fringe habitat and shade for fish habitat from trees/shrubs. Plant salt meadow cordgrass mixed with salt grass and switch grass *(Panicum virgatum).* At the upper edge of this area, marsh elder and groundsel bush (*Baccharis halimifolia)* would be planted*.*	• Coastal scrub/shrub
	Invasive species removal with native plantings	Remove non-native plants and replant those areas with plants native to the ecosystem. Invasive species removal will be in coordination with other ecological restoration measures	
Maritime Forest	Upland forest restoration	Establish or maintain grades above MHHW, and restore with post oak (*Quercus stellata)* and black oak *(Q. velutina*).	
Shorelines and Shallows	Bank stabilization	Establish and implement measures to prevent and/or fix erosion and stabilize the embankment.	• Stacked rock wall with brush layers • Tiered rock slope with native plant benches/pockets • Vegetated crib wall
Fish, Shellfish and Benthic Habitat & Sediment Control/ Nutrient Load Reduction (Habitat for Fish, Crab, & Lobsters)	Tidal creek/channels	Create small tidal creek/channels to support low and high marsh wetland communities.	
	Channel plug with select native plantings (realign channel with instream structures)	Block water from entering the secondary channel to create a more adequate stream morphology in the main channel section.	
	Debris removal	Remove debris surrounding the marsh.	
	Sediment load reduction	Reduce sediment erosion in specified location.	• Wetland plantings • Protective atoll

Figure 7-2: Flushing Creek Ecosystem Restoration Alternative A

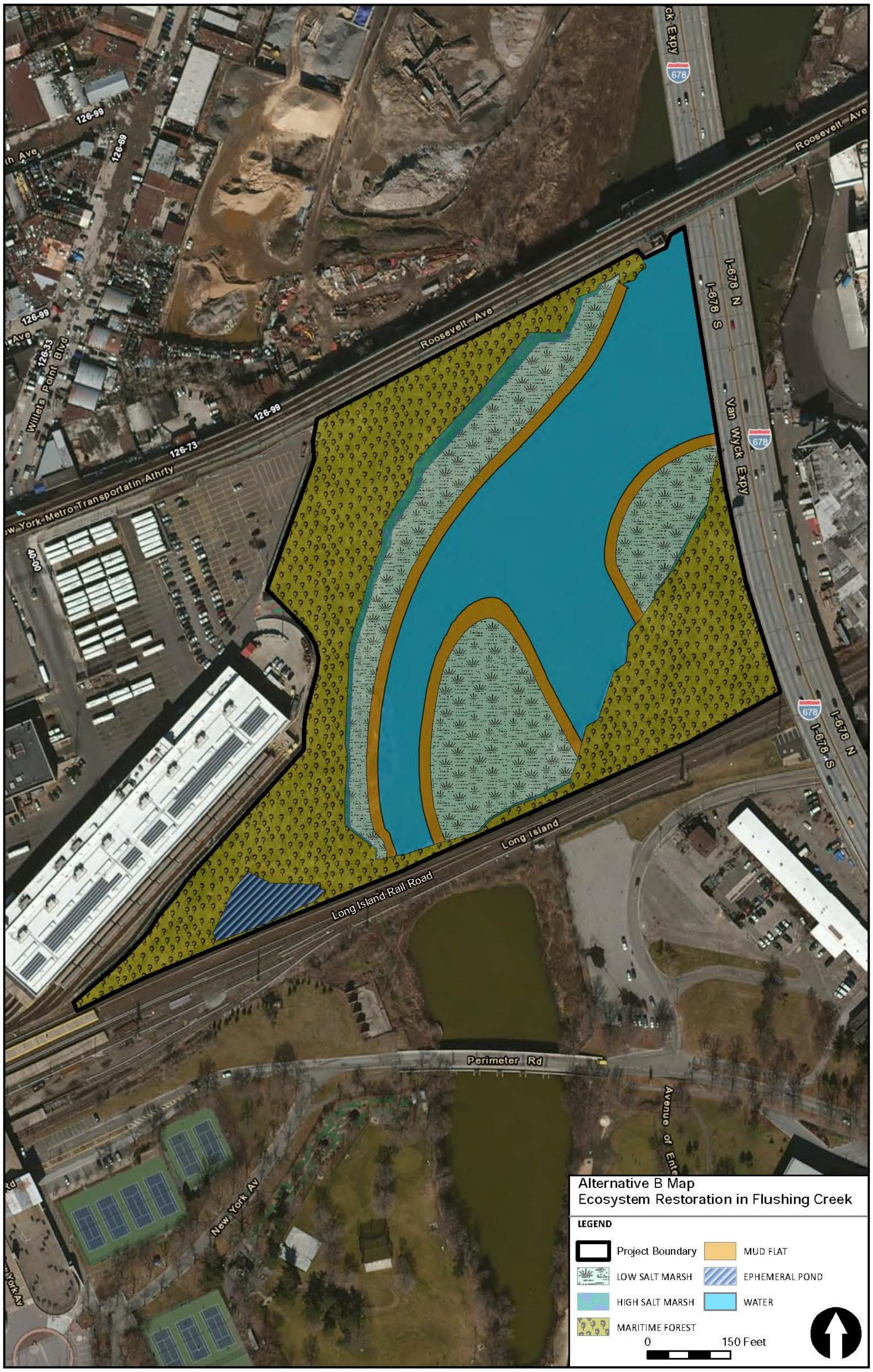


Figure 7-3: Flushing Creek Ecosystem Restoration Alternative B

7.2.2 Alternative C

Alternative C (Figure 7-4) contains the same type of habitat and water quality improvement features as Alternative B, but also further enhances water quality through active stormwater capture and filtration systems. The conceptual plan includes:

- Mudflat (1.25 acres): Eliminating or minimizing mudflats by raising the elevation of the low salt marsh surface and using a coir log or other tidal bank revetment to protect the edge from erosion.
- Ephemeral pond (0.28 acres) – Preserve ephemeral pond.
- Low salt marsh (4.01 acres): Re-grading existing common reed-dominated areas to create low salt marsh through the planting of saltmarsh cordgrass.
- High salt marsh (0.41 acres): Establishing transitional salt shrub/high marsh area between low marsh and upland maritime forest consisting of salt meadow cordgrass, salt grass, switchgrass, marsh elder, and groundsel bush.
- Maritime forest (6.85 acres): Restoring the existing upland forest area to a maritime forest community with post oak and black oak.
- Stormwater infiltration features would be located to collect runoff from adjacent areas and roads to improve stormwater quality.
- Addition of habitat enhancement to the bulkhead along the eastern edge of creek would also be included as part of this alternative.

Figure 7-4: Flushing Creek Ecosystem Restoration Alternative C

8 Evaluation for Planned Wetlands (EPW)

The existing functions and values of the wetlands in upper Flushing Creek were assessed using the EPW technique as a baseline for future dredging and habitat restoration activities. The EPW technique for Flushing Creek used five (5) variables (shoreline bank erosion control, sediment stabilization, water quality, wildlife, and fish) to assess wetland health and value, and to provide a benchmark for created or restored wetlands. Within the EPW framework, the wetlands assessment area (WAA) consists of the entire proposed project area and the identified wetland habitats. The 17.36-acre project area was therefore considered to be the limits for the WAA used in the EPW assessment. The EPW summary tables and flow diagrams are presented in Attachment A. The completed EPW field assessment sheets for the baseline condition and each of the three (3) alternatives are available upon request.

8.1 EPW Baseline Assessment Results of Flushing Creek

In general, the value of the existing wetlands in the WAA is diminished by invasive plant species, limited connection to other wetland or upland habitats, poor water quality, and poor water circulation. The wetlands do provide a haven for area wildlife, which is accentuated by the connection to the fields and forested areas of Flushing Meadows-Corona Park. A baseline summary of the five (5) EPW functions currently provided by the Flushing Creek wetlands, and any limiting factors on performance of those functions, are described in the paragraphs below.

- **Shoreline Bank Erosion Control –** The tidal shorelines within the WAA are generally steep and vegetated with either saltmarsh cordgrass or common reed; the roots and rhizomes appear to be stabilizing the bank in many locations. In several areas on the westerly side of Flushing Creek and downstream (north) of the LIRR embankment, recent bank slippage had occurred. Vegetated banks had been undermined and collapsed or slumped into the lower intertidal area. No evidence of scouring or channeling from upland water sources was noted. While wind fetch is assumed to be minimal based on the EPW criteria (i.e. maximum fetch distance within the WAA was estimated to be just over 1,000 feet) the area with the greatest fetch distance (westerly shore near the LIRR embankment), was where the most bank slippage and undercutting was observed. The shoreline damage appeared to be relatively recent and may have been caused by the winds and storm surge from Superstorm Sandy (October 2012). Due to the shallow water depths and intervening bridge supports, vessel wakes are not expected to be an issue in upper Flushing Creek. The bridge supports themselves may alter water exchange, tidal current velocities, and sedimentation patterns. Exposure to sunlight is adequate except near and beneath the roadway and rail overpasses.

- **Sediment Stabilization –** While the sediments in the interior portions of the herbaceous wetlands appear stable, the meadow mat and banks at the vegetated wetland/mudflat interface is slumping or eroding in several locations. On some portions of the westerly shoreline, there is a near-vertical bank of three (3) feet where the vegetated wetland is actively sloughing into the mudflat area. The lack of any rooted vascular plants in the subtidal shallows or on the intertidal flats promotes sediment scouring and movement during high-flow events. The wetland delineation data sheets indicated an absolute percent cover of 60 to 100 percent for the herbaceous layer in the vegetated intertidal wetlands, indicating a good to excellent capacity to stabilize and hold the banks and further trap solids carried by the tidal exchange.

- ***Water Quality* –** Flushing Bay is classified by NYSDEC as a Class I waterbody, which has water quality standards established to maintain uses such as fishing or boating (NYSDEC Part

935.6). NYSDEC's best usage criteria for Class I waterbodies is that the waters shall be suitable for fish propagation and survival (NYSDEC Part 701.13). Water quality in upper Flushing Creek is generally poor with depressed dissolved oxygen levels, particularly in the summer months. Hypoxic and anoxic conditions have been documented in the upper creek during the summer. Contributions from CSOs as well as stormwater flows from the adjoining roadways and intensively developed residential and commercial areas further contributes to compromised water quality. Water circulation and exchange to Flushing Bay and ultimately the East River is limited by the linear nature of upper Flushing Creek. The low dissolved oxygen levels and hydrogen sulfide emitted from the organic sediments may also limit fish and benthic invertebrate use of Flushing Creek. Recent benthic invertebrate collections in the project area were dominated by pollution-tolerant species (*Streblospio benedicti* and *Capitella capitata*). The soft organic sediments deposited during low flow conditions are probably scoured and redeposited and/or exported to Flushing Bay during high flow/storm events. Upper Flushing Creek, due to poor tidal flushing, is very effective in trapping fine-grained organic sediments. Extensive intertidal and subtidal mudflats have formed in upper Flushing Creek between the LIRR embankment and Roosevelt Avenue.

Flushing Creek most closely resembles "Condition F," as illustrated in Figure A.4 in the EPW manual, in that the open water/stream is bordered by upgradient, linear wetlands and fringed by uplands. The annual growth of common reed and saltmarsh cordgrass represent a large annual biomass production, uptake of nutrients and evapotranspiration. Plant height ranges from three (3) to four (4) feet in the cordgrass areas, to 10 to 12 feet in the common reed-dominated areas. The wetlands would be considered as low marsh/intertidal and the vegetation as persistent. Based on observations during the field studies, it appears that much of the plant debris derived from the wetlands (chiefly reed grass stems) gets deposited back in the wetlands during storm events. Detention time to allow for sequestering and assimilation of nutrients in the WAA is assumed to be minimal due to the linear nature of the watercourse and wetlands and tidal exchange. Flocculation of suspended solids is expected to occur in Flushing Creek and adjacent Flushing Bay due to the salinity interfaces between fresh, brackish, and marine waters.

- ***Wildlife* –** A total of 27 bird species were observed in the upland forest, vegetated intertidal wetlands, open waters, and mudflats in upper Flushing Creek during the wetland delineation and habitat assessment studies in October and November 2013. The protected nature of upper Flushing Creek was observed to provide a refuge for waterfowl and other shoreline-oriented birds on windy days. The presence and dominance (approximately 80 percent of the vegetated wetlands are a common reed monoculture) of a low wildlife value plant species may reduce wildlife use though the dense stands of common reed do provide cover for birds. The regular contours of the five (5) identified habitats and sparse cover in the upland maritime forest may diminish wildlife use; birds foraging in the subtidal shallows and unvegetated mudflats were visible from distances of several hundred feet. Raccoon tracks (*Procyon lotor*) were commonly observed on the tidal flats; one (1) dead opossum (*Didelphis marsupialis*) was observed near the LIRR tracks on October 24, 2013.

- ***Fish* –** Predominant fish species collected during recent sampling events (October 2012 and May 2013) consisted of Atlantic silverside, mummichog, gizzard shad, and Atlantic menhaden. Smaller forage fish (silversides and/or mummichogs) were observed in the shallows downstream and upstream of the LIRR embankment during the delineation surveys. The shallow waters provide a feeding area for forage fish that in turn probably provide a food source for larger predatory fish, and thus may contribute to the commercial/recreational fishery. In-

water structure is limited to about 15 old wooden piles located north of the LIRR embankment. Upper Flushing Creek is not expected to serve as significant habitat for striped bass (*Morone saxitilis*) and winter flounder.

Some evidence of angling (fishing line, bait and lure containers) was observed along the northern side of the LIRR embankment and along the east and west shores of the area between the embankment and the Porpoise Bridge. Poor water quality may be a limiting factor for some species of fish, particularly during the summer months, in upper Flushing Creek; lack of aquatic vegetation and submerged structures/cover may also be limiting factors. While fish can pass both upstream and downstream via the twin concrete culverts at the LIRR embankment, the tide gate on the Porpoise Bridge represents the upstream limit for fish passage, except during extreme tidal/storm events.

8.2 EPW Assessment of Proposed Restoration Alternatives

8.2.1 Functional Capacity Units

Figures 7-2 to 7-4 illustrate the three (3) proposed restoration concepts – Alternatives A, B and C respectively. Table 8-1 provides a summary of the anticipated acreages by habitat type for each of the three (3) alternatives. These acreages were used to calculate the EPW FCU for each of the alternatives. A summary of each alternative and the estimated habitat gains are summarized in the following sections.

Based on the three (3) restoration alternatives, EPW data sheets were scored and summarized. The FCUs were based on the 17.36-acre study area, less the acreage of upland habitat to be preserved (Alternative A) or enhanced as maritime forest (Alternatives B and C) and the acreage of open water.

Table 8-1: Flushing Creek Alternatives by Habitat Types

Habitat Type	Existing (acres)	Alternatives (acres)		
		A	B	C
Ephemeral pond	0.28	0.28	0.28	0.28
Mud flat	3.46		1.16	1.25
Low salt marsh		2.42	3.67	4.01
High salt marsh			0.44	0.41
Vegetative intertidal wetland	2.39			
Successional maritime forest	5.32			
Maritime forest			6.77	6.85
Upland herbaceous habitat	0.74			
Existing upland		6.56		
Total	**12.19**	**9.26**	**12.32**	**12.80**

Results of the assessment for each of the baseline conditions and the three (3) alternatives for the five (5) assessed EPW functions are calculated in Attachment A EPW Table A-1: Comparison of WAA and

planned wetland: calculations of FCIs and FCUs. Year 2 scores are summarized in Table 8-2. Pursuant to discussions with the HRE consultant team, the target FCI was set at the calculated EPW value, and the R value (i.e., multiplying factor established by the decision makers) was set at one (1).

- ***Alternative A* –** The FCIs were lower for four (4) of the five (5) assessed functions than for the baseline condition. The area used to calculate the FCUs for Alternative A was 2.70 acres. The target FCUs were lower than the baseline FCUs for four (4) of the five (5) functions. Results of the assessment demonstrate that the predicted FCUs for Alternative A cannot be achieved with the available acreage in the WAA.
- ***Alternative B* –** The FCIs were higher for all five (5) assessed functions than the baseline condition. The area used to calculate the FCUs for Alternative B was 5.55 acres. The target FCUs exceeded the baseline FCUs for all five (5) functions. Results of the assessment demonstrate that the predicted FCUs for Alternative B can be achieved with the available acreage in the WAA.
- ***Alternative C* -** The FCIs were higher for all five (5) assessed functions than for the baseline condition. The area used to calculate the FCUs for Alternative C was 5.95 acres. The target FCUs exceeded the baseline FCUs for all five (5) functions. Results of the assessment demonstrate that the predicted FCUs for Alternative C can be achieved with the available acreage in the WAA.

Table 8-2: Year 2 EPW Scores for Flushing Creek

Function	Existing Conditions WAA			Alt A			Alt B			Alt C		
	FCI	AREA	FCUs*	FCI	AREA	FCUs	FCI	AREA	FCUs	FCI	AREA	FCUs
SB	0.27	6.13	1.655	0.89	2.70	2.38	0.89	5.55	3.36	0.89	5.95	3.49
SS	0.55	6.13	3.372	1.00	2.70	3.29	1.00	5.55	4.50	1.00	5.95	4.67
WQ	0.75	6.13	4.598	0.98	2.70	3.75	0.98	5.55	5.04	0.98	5.95	5.22
WL	0.36	6.13	2.207	0.45	2.70	1.76	0.43	5.55	2.30	0.46	5.95	2.47
FS	0.28	6.13	1.716	0.36	2.70	1.39	0.36	5.55	1.86	0.36	5.95	1.93
TOTAL			13.55			12.58			17.07			17.80

8.2.2 Average Annual Functional Capacity Units (AAFCUs)

AAFCUs for each alternative were calculated for Years 2, 20, and 50 (presented in Appendix A). AAFCUs calculated for Year 50 are presented in Table 8-3.

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 8-3: 50 Year AAFCU Calculation Results

Wetland Function	AAFCUs		
	A	B	C
SB	2.336	3.290	3.424
SS	3.227	4.414	4.581
WQ	3.678	4.940	5.117
WL	1.802	2.342	2.602
FS	1.437	1.940	2.011
AAFCU Total	12.481	16.926	**17.734**

Note: The shaded alternative is the TSP.

Results of the EPW indicate that alternatives B and C will provide increased wetlands benefits to upper Flushing Creek. The annualized wetland functional benefits predicted to be derived from the environmental restoration of upper Flushing Creek were based on the results of the EPW assessment and the above AAFCU formula. In estimating the AAFCUs it was assumed that the benefits for all three (3) restoration alternatives associated with the water quality, fish and sediment stabilization functions would be fully realized in Year One at the conclusion environmental restoration efforts. It was also assumed that for the two remaining functions, wildlife and shoreline bank erosion control, the benefits would be fully realized by the end of Year Three. This is based on the proposed creation of a predominantly herbaceous intertidal wetland and an anticipated increase in wildlife (bird) usage as the marsh establishes itself and the regraded banks would be further stabilized by the root mat created by the saltmarsh cordgrass plantings. As demonstrated in the EPW assessment (Attachment A, Tables A-1) the restoration alternatives B and C will provide a net benefit to all assessed functions over the baseline conditions.

Attachment A
EPW Summary Sheets

Table A.1.
Comparison of WAA and planned wetland: calculations of FCIs and FCUs

Project Title: Flushing Creek EPW

Comparison between WAA# Baseline and wetland # Alternative A

Function	WAA			Goals for Planned Wetland**					Planned Wetland			Check if goals met
	FCI	AREA	FCUs*	Target FCI	R	Target FCUs	Predicted FCI	Minimum Area	FCI	Area	FCUs*	
SB	0.27	11.30	3.05	0.89	1	3.05	0.89	3.43 ac	0.89	10.8	9.61	X
SS	0.55	11.30	6.22	1.00	1	6.22	1	6.22 ac	1.00	10.8	10.8	X
WQ	0.75	11.30	8.48	0.98	1	8.48	0.98	8.65 ac	0.98	10.8	10.58	X
WL	0.36	11.30	4.07	0.44	1	4.07	0.44	9.25 ac	0.44	10.8	4.75	X
FS	0.22	11.30	2.49	0.29	1	2.49	0.29	8.58 ac	0.29	10.8	3.13	X
UH	#N/A								#N/A			

*FCUs = FCU x AREA

**Target FCI = *goal* established by decision makers

R = multiplying factor established by decision makers

Target FCUs = FCUWAA x R (i.e., planned wetland *goal*)

Predicted FCI = FCIs which designers presume planned wetland may achieve at a particular site (Note this may be greater than Target FCI)

Minimum Area = Target FCUs/Predicted FCI

Flushing Creek EPW

Calculation of Shoreline Bank Erosion Control

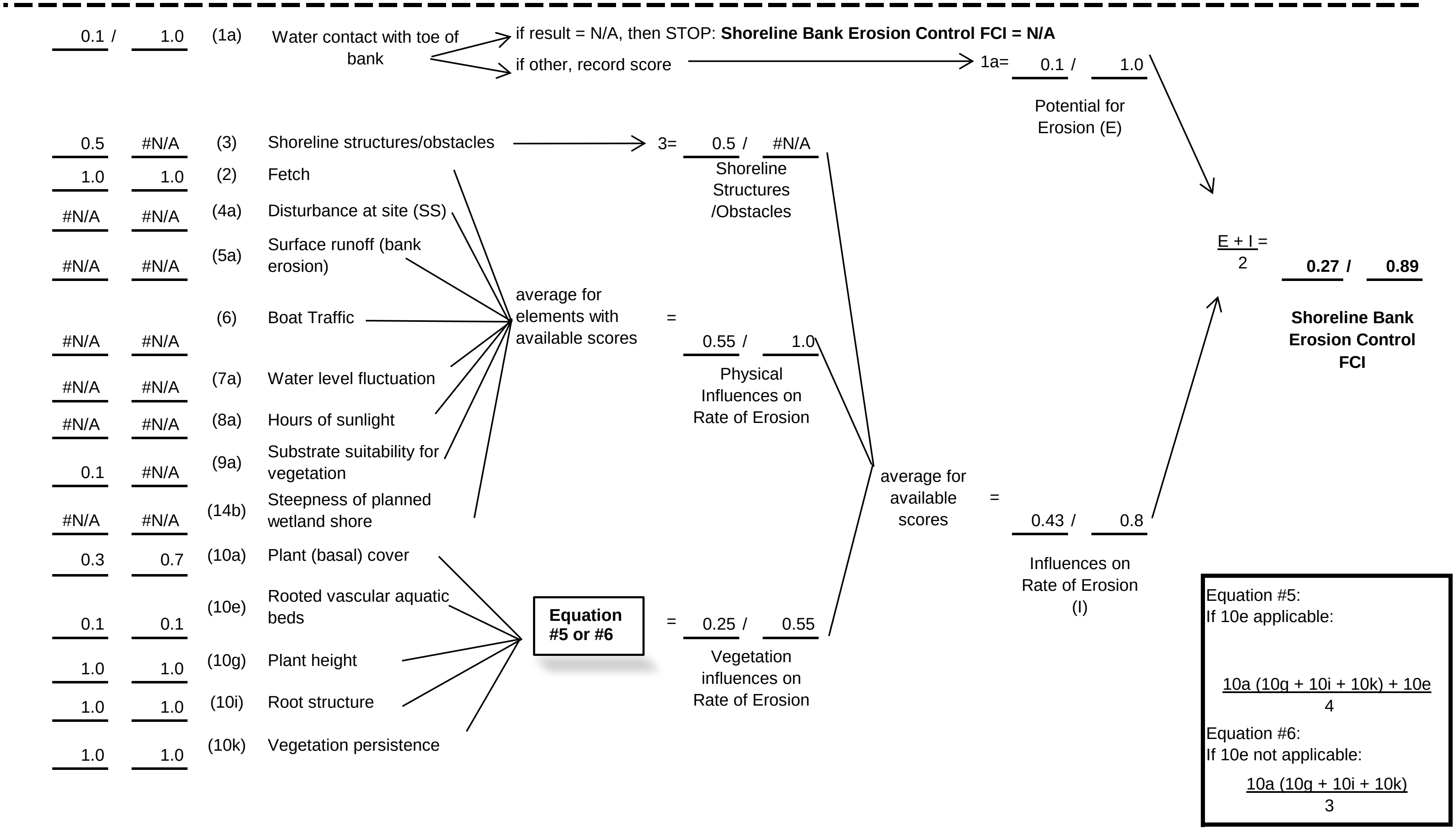
Baseline v. Alternative A

Site Suitability For Planned Wetland:

Selected Scores		(#)	Element
1.0	1.0	(2)	Fetch
#N/A	1.0	(14a)	Steepness of existing shore

if result = 0.1 for either element, then the planned wetland site is UNSUITABLE

if result ≠ 0.1 for both elements, then continue with model



Selected Scores		(#)	Element
0.1 /	1.0	(1a)	Water contact with toe of bank
0.5	#N/A	(3)	Shoreline structures/obstacles
1.0	1.0	(2)	Fetch
#N/A	#N/A	(4a)	Disturbance at site (SS)
#N/A	#N/A	(5a)	Surface runoff (bank erosion)
#N/A	#N/A	(6)	Boat Traffic
#N/A	#N/A	(7a)	Water level fluctuation
#N/A	#N/A	(8a)	Hours of sunlight
0.1	#N/A	(9a)	Substrate suitability for vegetation
#N/A	#N/A	(14b)	Steepness of planned wetland shore
0.3	0.7	(10a)	Plant (basal) cover
0.1	0.1	(10e)	Rooted vascular aquatic beds
1.0	1.0	(10g)	Plant height
1.0	1.0	(10i)	Root structure
1.0	1.0	(10k)	Vegetation persistence

if result = N/A, then STOP: **Shoreline Bank Erosion Control FCI = N/A**

if other, record score

1a= 0.1 / 1.0

Potential for Erosion (E)

3= 0.5 / #N/A

Shoreline Structures /Obstacles

average for elements with available scores = 0.55 / 1.0

Physical Influences on Rate of Erosion

Equation #5 or #6 = 0.25 / 0.55

Vegetation influences on Rate of Erosion

average for available scores = 0.43 / 0.8

Influences on Rate of Erosion (I)

$\frac{E + I}{2}$ = **0.27 / 0.89**

Shoreline Bank Erosion Control FCI

Equation #5:
If 10e applicable:

$$\frac{10a\ (10g + 10i + 10k) + 10e}{4}$$

Equation #6:
If 10e not applicable:

$$\frac{10a\ (10g + 10i + 10k)}{3}$$

Calculation of Sediment Stabilization

Baseline V. Alternative A

Selected Scores		(#)	Element
#N/A /	#N/A	(4a)	Disturbance at site
#N/A /	#N/A	(7a)	Water level fluctuation
1.0 /	1.0	(10b)	Plant (basal) cover
0.3 /	0.7	(10c)	Leaf litter and debris cover
1.0 /	1.0	(10j)	Root structure
1.0 /	1.0	(10l)	Vegetation Persistence
0.1 /	1.0	(14c)	Wetland slope

(4a), (7a): if both 4a and 7a = N/A, record N/A
if not, then record lowest
score from 4a or 7a
= #N/A / #N/A
Disturbance Factors (DF)

(10b), (10c), (10j), (10l): **Equation** = 1.0 / 1.0
Vegetation Characteristics (V)

(14c): = 0.1 / 1.0
Slope Stability (S)

$\frac{V+S}{2}$ = 0.55 / 1.0
Wetland Characteristics (W)

If DF= N/A

$\frac{DF + W}{2}$ = **0.55 / 1.00**

If DF= N/A

Sediment Stabilization FCI

Equation #7:

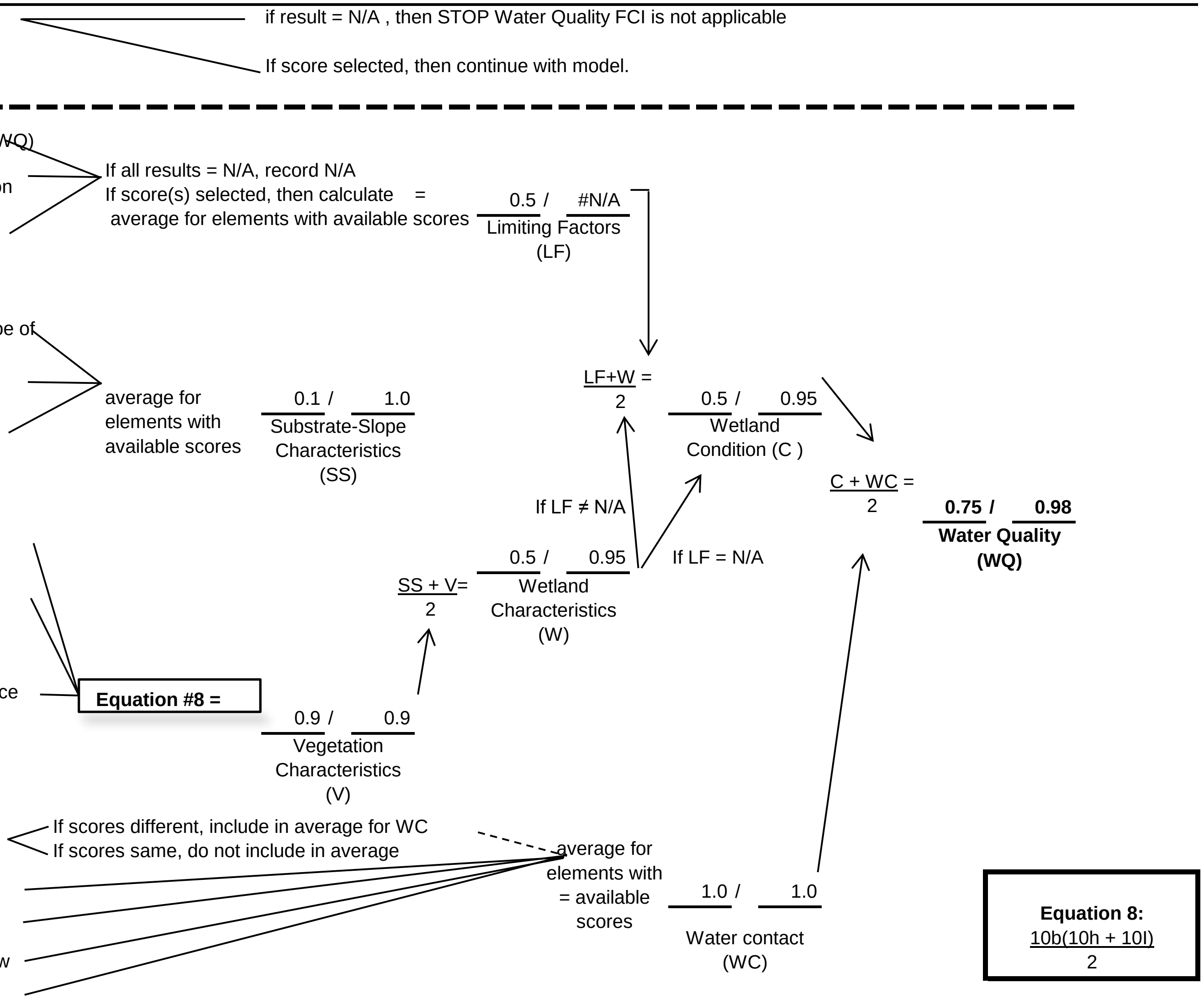
$$\frac{10b\ (10j + 10l) + 10c\ (1-10b)}{2}$$

Flushing Creek EPW

Calculation of Water Quality

Baseline v. Alternative A

Selected Scores	(#)	Element
1 / 1	(15)	Hydrologic condition
0.5 / #N/A	(4b)	Disturbance at site (WQ)
#N/A / #N/A	(7a)	Water level fluctuation
#N/A / #N/A	(16a)	Wetland width
0.1 / 1.0	(1a)	Water contact with toe of bank
#N/A / #N/A	(5b)	Surface runoff (wetland erosion)
0.1 / 1.0	(14c)	Wetland Slope
1.0 / 1.0	(10b)	Plant (basal) cover
0.8 / 0.8	(10h)	Plant height
1.0 / 1.0	(10l)	Vegetation persistence
1.0 / 1.0	(9b)	Dominant substrate
1.0 / 1.0	(15)	Hydrologic condition
#N/A / #N/A	(17)	Detention time
#N/A / #N/A	(18)	Sheet vs channel flow
#N/A / #N/A	(19)	Average water depth



Calculation of Wildlife

Baseline V. Alternative A

Selected Scores			(#)	Element
#N/A	/	#N/A	(4c)	Disturbance of wildlife habitat
#N/A	/	#N/A	(20a)	Gross contamination
#N/A	/	#N/A	(16b)	Wetland size
0.1	/	0.1	(11a)	Layers
0.1	/	0.7	(11b)	Condition of Layers
1.0	/	1.0	(11c)	Spatial pattern of shrubs/trees
0.07	/	0.07	(12a)	Cover types
0.5	/	0.5	(12b)	Ratio of cover types
0.1	/	0.5	(12c)	Cover type interspersion
0.1	/	0.1	(12d)	Undesirable species
1.0	/	1.0	(13a)	% open water
0.5	/	0.5	(13b)	Vegetation/water interspersion
0.1	/	0.1	(21a)	Shape of upland/wetland edge
#N/A	/	#N/A	(22a)	Wildlife attractors
0.1	/	0.1	(23)	Islands

(4c), (20a), (16b): If 4c, 16b and 20a = N/A, record N/A
If any score = 0.1, record 0.1 = #N/A / #N/A Features Which Reduce Habitat Value (F)

(11a), (11b), (11c): average for elements with available scores = 0.4 / 0.6 Vegetation Strata

(12a), (12b), (12c), (12d): average for elements with available scores = 0.19 / 0.29 Vegetation Cover Types

(13a), (13b): average for elements with available scores = 0.75 / 0.75 Vegetation/ Water Proportions

(21a), (22a), (23): average for elements with available scores = 0.10 / 0.10 Physical Features

Vegetation Strata, Vegetation Cover Types, Vegetation/ Water Proportions, Physical Features: average for available scores = 0.36 / 0.44 Habitat Complexity (HC)

If F ≠ NA: $\frac{F + HC}{2}$ =

If F = NA:

0.36 / 0.44
Wildlife FCI

`

Flushing Creek EPW

Calculation of Fish (tidal Stream/River)

Comparison: Baseline / Alternative A

Site Suitability For Planned Wetland:

Selected Scores		(#)	Element
0.5	0.5	(24)	Obstruction to fish passage

if result = 0.1, STOP. There is no potential for providing tidal fish habitat

if result ≠ 0.1 or N/A, then continue with model

Selected Scores		(#)	Element
0.1	#N/A	(1b)	Shoreline bank stability
#N/A	#N/A	(4a)	Disturbance at site (SS)
0.5	0.5	(4d)	Disturbance in channel/open water
#N/A	#N/A	(7b)	Most Permanent Fish passage
0.5	0.5	(24)	Obstruction to fish passage

average for elements with available scores = 0.37 / 0.5 Limiting Factors

Selected Scores		(#)	Element
0.5	0.5	(7c)	Specially dominant hydroperiod
1.0	1.0	(9C)	Substrate suitability fish
0.1	0.3	10d	Plant basal cover
0.1	0.1	10f	Rooted Vascular aquatic beds
0.5	0.5	21b	shape of wetlands
0.1	0.1	22b	Available cover

average for elements with available scores = 0.2 / 0.2 Food/Cover

Selected Scores		(#)	Element
0.1	0.1	(20b)	Water quality rating

If score available, record score for WQ

If information not available, continue

Selected Scores		(#)	Element
0.1	0.1	(20c)	Nutrient/sediment/contaminant sources
0.1	0.1	(20d)	Dissolved Oxygen
1.0	1.0	(20f)	Maximum water temperature

average for elements with available scores = 0.1 / 0.1 Water Quality (WQ)

average for available scores = **0.22 / 0.29**

Fish (Tidal Stream/River) FCI

Project Title: Flushing Creek EPW

Calculation of Uniqueness/Heritage

Comparison: Baseline / Alternative A (e.g., WAA/planned

Site Suitability For Planned Wetland:

Selected Scores		(#)	Element
#N/A	/ #N/A	(29)	Endangered species
#N/A	/ #N/A	(30)	Rarity
#N/A	/ #N/A	(31)	Unique features
#N/A	/ #N/A	(32)	Historical or archaeological significance
#N/A	/ #N/A	(33)	Natural landmark
#N/A	/ #N/A	(34)	Connected to Wild and Scenic River
#N/A	/ #N/A	(35)	Park, sanctuary, etc.
#N/A	/ #N/A	(36)	Scientific research site

average for elements with available scores = #N/A / #N/A

Uniqueness/ Heritage FCI

Table A.1.
Comparison of WAA and planned wetland: calculations of FCIs and FCUs

Project Title: Flushing Creek EPW

Comparison between WAA# Baseline and wetland # Alternative B

Function	WAA			Goals for Planned Wetland**					Planned Wetland			Check if goals met
	FCI	AREA	FCUs*	Target FCI	R	Target FCUs	Predicted FCI	Minimum Area	FCI	Area	FCUs*	
SB	0.27	11.30	3.05	0.89	1	3.05	0.89	3.43 ac	0.89	10.59	9.43	X
SS	0.55	11.30	6.22	1.00	1	6.22	1	6.22 ac	1.00	10.59	10.59	X
WQ	0.75	11.30	8.48	0.98	1	8.48	0.98	8.65 ac	0.98	10.59	10.38	X
WL	0.36	11.30	4.07	0.43	1	4.07	0.43	9.47 ac	0.43	10.59	4.55	X
FS	0.22	11.30	2.49	0.29	1	2.49	0.29	8.59 ac	0.32	10.15	3.25	X
UH	#N/A								#N/A			

*FCUs = FCU x AREA

**Target FCI = *goal* established by decision makers

R = multiplying factor established by decision makers

Target FCUs = FCUWAA x R (i.e., planned wetland *goal*)

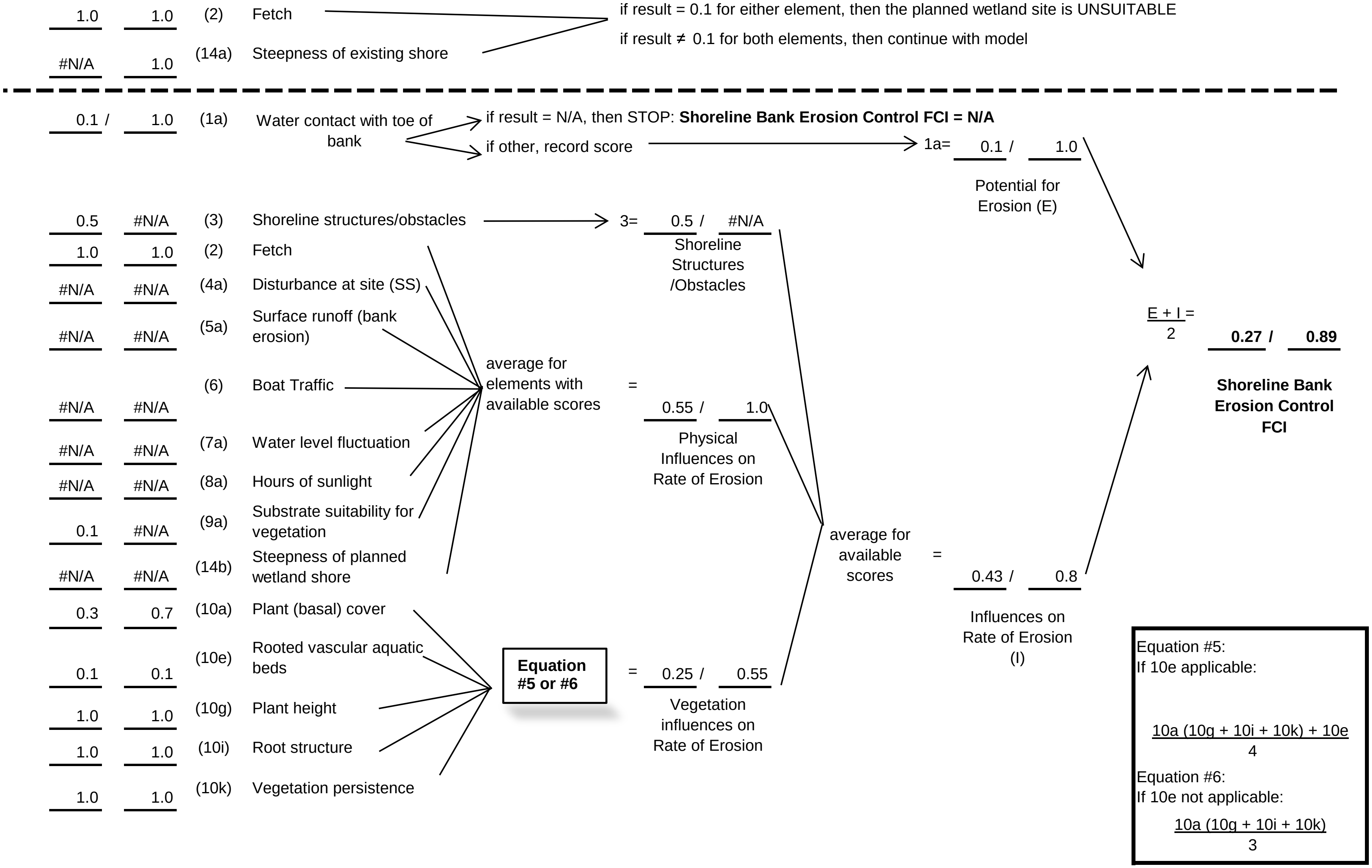
Predicted FCI = FCIs which designers presume planned wetland may achieve at a particular site (Note this may be greater than Target FCI)

Minimum Area = Target FCUs/Predicted FCI

Flushing Creek EPW

Calculation of Shoreline Bank Erosion Control

Baseline v. Alternative B



Site Suitability For Planned Wetland:

Selected Scores		(#)	Element
1.0	1.0	(2)	Fetch
#N/A	1.0	(14a)	Steepness of existing shore

if result = 0.1 for either element, then the planned wetland site is UNSUITABLE

if result ≠ 0.1 for both elements, then continue with model

Selected Scores		(#)	Element
0.1 /	1.0	(1a)	Water contact with toe of bank

if result = N/A, then STOP: **Shoreline Bank Erosion Control FCI = N/A**

if other, record score → 1a= 0.1 / 1.0

Potential for Erosion (E)

Selected Scores		(#)	Element
0.5	#N/A	(3)	Shoreline structures/obstacles
1.0	1.0	(2)	Fetch
#N/A	#N/A	(4a)	Disturbance at site (SS)
#N/A	#N/A	(5a)	Surface runoff (bank erosion)
#N/A	#N/A	(6)	Boat Traffic
#N/A	#N/A	(7a)	Water level fluctuation
#N/A	#N/A	(8a)	Hours of sunlight
0.1	#N/A	(9a)	Substrate suitability for vegetation
#N/A	#N/A	(14b)	Steepness of planned wetland shore
0.3	0.7	(10a)	Plant (basal) cover
0.1	0.1	(10e)	Rooted vascular aquatic beds
1.0	1.0	(10g)	Plant height
1.0	1.0	(10i)	Root structure
1.0	1.0	(10k)	Vegetation persistence

3= 0.5 / #N/A

Shoreline Structures /Obstacles

average for elements with available scores = 0.55 / 1.0

Physical Influences on Rate of Erosion

Equation #5 or #6 = 0.25 / 0.55

Vegetation influences on Rate of Erosion

average for available scores = 0.43 / 0.8

Influences on Rate of Erosion (I)

$\frac{E + I}{2}$ = **0.27 / 0.89**

Shoreline Bank Erosion Control FCI

Equation #5:
If 10e applicable:

$$\frac{10a\ (10g + 10i + 10k) + 10e}{4}$$

Equation #6:
If 10e not applicable:

$$\frac{10a\ (10g + 10i + 10k)}{3}$$

Calculation of Sediment Stabilization

Baseline V. Alternative B

Selected Scores		(#)	Element
#N/A /	#N/A	(4a)	Disturbance at site
#N/A /	#N/A	(7a)	Water level fluctuation
1.0 /	1.0	(10b)	Plant (basal) cover
0.3 /	0.7	(10c)	Leaf litter and debris cover
1.0 /	1.0	(10j)	Root structure
1.0 /	1.0	(10l)	Vegetation Persistence
0.1 /	1.0	(14c)	Wetland slope

if both 4a and 7a = N/A, record N/A
if not, then record lowest
score from 4a or 7a

= #N/A / #N/A
Disturbance Factors (DF)

Equation = 1.0 / 1.0
Vegetation Characteristics (V)

= 0.1 / 1.0
Slope Stability (S)

$\frac{V+S}{2}$ = 0.55 / 1.0
Wetland Characteristics (W)

If DF= N/A

If DF= N/A

$\frac{DF + W}{2}$ = **0.55 / 1.00**

Sediment Stabilization FCI

Equation #7:

$$\frac{10b\ (10j + 10l) + 10c\ (1\text{-}10b)}{2}$$

Calculation of Water Quality

Baseline v. Alternative B

Selected Scores		(#)	Element
1	1	(15)	Hydrologic condition

if result = N/A , then STOP Water Quality FCI is not applicable

If score selected, then continue with model.

Selected Scores		(#)	Element
0.5	#N/A	(4b)	Disturbance at site (WQ)
#N/A	#N/A	(7a)	Water level fluctuation
#N/A	#N/A	(16a)	Wetland width

If all results = N/A, record N/A
If score(s) selected, then calculate average for elements with available scores = 0.5 / #N/A Limiting Factors (LF)

Selected Scores		(#)	Element
0.1	1.0	(1a)	Water contact with toe of bank
#N/A	#N/A	(5b)	Surface runoff (wetland erosion)
0.1	1.0	(14c)	Wetland Slope

average for elements with available scores: 0.1 / 1.0 Substrate-Slope Characteristics (SS)

Selected Scores		(#)	Element
1.0	1.0	(10b)	Plant (basal) cover
0.8	0.8	(10h)	Plant height
1.0	1.0	(10l)	Vegetation persistence

Equation #8 = 0.9 / 0.9 Vegetation Characteristics (V)

$\frac{SS + V}{2}$ = 0.5 / 0.95 Wetland Characteristics (W)

If LF ≠ N/A: $\frac{LF+W}{2}$ =

If LF = N/A: 0.5 / 0.95 Wetland Condition (C)

Selected Scores		(#)	Element
1.0	1.0	(9b)	Dominant substrate
1.0	1.0	(15)	Hydrologic condition
#N/A	#N/A	(17)	Detention time
#N/A	#N/A	(18)	Sheet vs channel flow
#N/A	#N/A	(19)	Average water depth

If scores different, include in average for WC
If scores same, do not include in average

average for elements with = available scores: 1.0 / 1.0 Water contact (WC)

$\frac{C + WC}{2}$ = **0.75 / 0.98 Water Quality (WQ)**

Equation 8:
$\frac{10b(10h + 10l)}{2}$

Calculation of Wildlife

Baseline V. Alternative B

Selected Scores	(#)	Element
#N/A / #N/A	(4c)	Disturbance of wildlife habitat
#N/A / #N/A	(20a)	Gross contamination
#N/A / #N/A	(16b)	Wetland size
0.1 / 0.1	(11a)	Layers
0.1 / 0.7	(11b)	Condition of Layers
1.0 / 1.0	(11c)	Spatial pattern of shrubs/trees
0.07 / 0.07	(12a)	Cover types
0.5 / 1.0	(12b)	Ratio of cover types
0.1 / 0.5	(12c)	Cover type interspersion
0.1 / NA	(12d)	Undesirable species
1.0 / 0.5	(13a)	% open water
0.5 / 0.5	(13b)	Vegetation/water interspersion
0.1 / 0.1	(21a)	Shape of upland/wetland edge
#N/A / #N/A	(22a)	Wildlife attractors
0.1 / 0.1	(23)	Islands

(4c), (20a), (16b): If 4c, 16b and 20a = N/A, record N/A
If any score = 0.1, record 0.1 = #N/A / #N/A Features Which Reduce Habitat Value (F)

(11a), (11b), (11c): average for elements with available scores = 0.4 / 0.6 Vegetation Strata

(12a), (12b), (12c), (12d): average for elements with available scores = 0.19 / 0.52 Vegetation Cover Types

(13a), (13b): average for elements with available scores = 0.75 / 0.50 Vegetation/ Water Proportions

(21a), (22a), (23): average for elements with available scores = 0.10 / 0.10 Physical Features

average for available scores = 0.36 / 0.43 Habitat Complexity (HC)

If F ≠ NA: $\frac{F + HC}{2}$ = **0.36 / 0.43 Wildlife FCI**

If F = NA: **0.36 / 0.43 Wildlife FCI**

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Flushing Creek EPW

Calculation of Fish (tidal Stream/River)

Selected Scores

Comparison: Baseline / Alternative B

Site Suitability For Planned Wetland:

Baseline	Alternative B	(#)	Element
0.5	0.5	(24)	Obstruction to fish passage

if result = 0.1, STOP. There is no potential for providing tidal fish habitat

if result ≠ 0.1 or N/A, then continue with model

Baseline	Alternative B	(#)	Element
0.1	#N/A	(1b)	Shoreline bank stability
#N/A	#N/A	(4a)	Disturbance at site (SS)
0.5	0.5	(4d)	Disturbance in channel/open water
#N/A	#N/A	(7b)	Most Permanent Fish passage
0.5	0.5	(24)	Obstruction to fish passage

average for elements with available scores = 0.37 / 0.5 Limiting Factors

Baseline	Alternative B	(#)	Element
0.5	0.5	(7c)	Specially dominant hydroperiod
1.0	1.0	(9C)	Substrate suitability fish
0.1	0.3	10d	Plant basal cover
0.1	0.1	10f	Rooted Vascular aquatic beds
0.5	0.5	21b	shape of wetlands
0.1	0.1	22b	Available cover

average for elements with available scores = 0.21 / 0.23 Food/Cover

Baseline	Alternative B	(#)	Element
0.1	0.1	(20b)	Water quality rating

If score available, record score for WQ

If information not available, continue

Baseline	Alternative B	(#)	Element
0.1	0.1	(20c)	Nutrient/sediment/contaminant sources
0.1	0.1	(20d)	Dissolved Oxygen
1.0	1.0	(20f)	Maximum water temperature

average for elements with available scores = 0.1 / 0.1 Water Quality (WQ)

average for available scores = **0.22 / 0.29**

Fish (Tidal Stream/River) FCI

Project Title: Flushing Creek EPW

Calculation of Uniqueness/Heritage

Comparison: Baseline / Alternative B (e.g., WAA/planned

Site Suitability For Planned Wetland:

Selected Scores	(#)	Element
#N/A / #N/A	(29)	Endangered species
#N/A / #N/A	(30)	Rarity
#N/A / #N/A	(31)	Unique features
#N/A / #N/A	(32)	Historical or archaeological significance
#N/A / #N/A	(33)	Natural landmark
#N/A / #N/A	(34)	Connected to Wild and Scenic River
#N/A / #N/A	(35)	Park, sanctuary, etc.
#N/A / #N/A	(36)	Scientific research site

average for elements with available scores = #N/A / #N/A

Uniqueness/ Heritage FCI

Table A.1.
Comparison of WAA and planned wetland: calculations of FCIs and FCUs

Project Title: Flushing Creek EPW

Comparison between WAA# Baseline and wetland # Alternative C

Function	WAA			Goals for Planned Wetland**					Planned Wetland			Check if goals met
	FCI	AREA	FCUs*	Target FCI	R	Target FCUs	Predicted FCI	Minimum Area	FCI	Area	FCUs*	
SB	0.27	11.30	3.05	0.89	1	3.05	0.89	3.43 ac	0.89	10.51	9.35	X
SS	0.55	11.30	6.22	1.00	1	6.22	1.00	6.22 ac	1.00	10.51	10.51	X
WQ	0.75	11.30	8.48	0.98	1	8.48	0.98	8.65 ac	0.98	10.51	10.30	X
WL	0.36	11.30	4.07	0.49	1	4.07	0.49	8.31 ac	0.49	10.51	5.15	X
FS	0.22	11.30	2.49	0.29	1	2.49	0.29	8.59 ac	0.29	10.10	2.93	X
UH	#N/A								#N/A			

*FCUs = FCU x AREA
**Target FCI = *goal* established by decision makers
R = multiplying factor established by decision makers
Target FCUs = FCUWAA x R (i.e., planned wetland *goal*)
Predicted FCI = FCIs which designers presume planned wetland may achieve at a particular site (Note this may be greater than Target FCI)
Minimum Area = Target FCUs/Predicted FCI

Flushing Creek EPW

Calculation of Shoreline Bank Erosion Control

Baseline v. Alternative C

Site Suitability For Planned Wetland:

Selected Scores		(#)	Element
1.0	1.0	(2)	Fetch
#N/A	1.0	(14a)	Steepness of existing shore

if result = 0.1 for either element, then the planned wetland site is UNSUITABLE

if result ≠ 0.1 for both elements, then continue with model

Selected Scores		(#)	Element
0.1 /	1.0	(1a)	Water contact with toe of bank

if result = N/A, then STOP: **Shoreline Bank Erosion Control FCI = N/A**

if other, record score → 1a= 0.1 / 1.0

Potential for Erosion (E)

Selected Scores		(#)	Element
0.5	#N/A	(3)	Shoreline structures/obstacles
1.0	1.0	(2)	Fetch
#N/A	#N/A	(4a)	Disturbance at site (SS)
#N/A	#N/A	(5a)	Surface runoff (bank erosion)
#N/A	#N/A	(6)	Boat Traffic
#N/A	#N/A	(7a)	Water level fluctuation
#N/A	#N/A	(8a)	Hours of sunlight
0.1	#N/A	(9a)	Substrate suitability for vegetation
#N/A	#N/A	(14b)	Steepness of planned wetland shore
0.3	0.7	(10a)	Plant (basal) cover
0.1	0.1	(10e)	Rooted vascular aquatic beds
1.0	1.0	(10g)	Plant height
1.0	1.0	(10i)	Root structure
1.0	1.0	(10k)	Vegetation persistence

(3) → 3= 0.5 / #N/A

Shoreline Structures /Obstacles

(2), (4a), (5a), (6), (7a), (8a), (9a), (14b): average for elements with available scores = 0.55 / 1.0

Physical Influences on Rate of Erosion

(10a), (10e), (10g), (10i), (10k): **Equation #5 or #6** = 0.25 / 0.55

Vegetation influences on Rate of Erosion

average for available scores = 0.43 / 0.8

Influences on Rate of Erosion (I)

$\frac{E + I}{2}$ = **0.27 / 0.89**

Shoreline Bank Erosion Control FCI

Equation #5:
If 10e applicable:

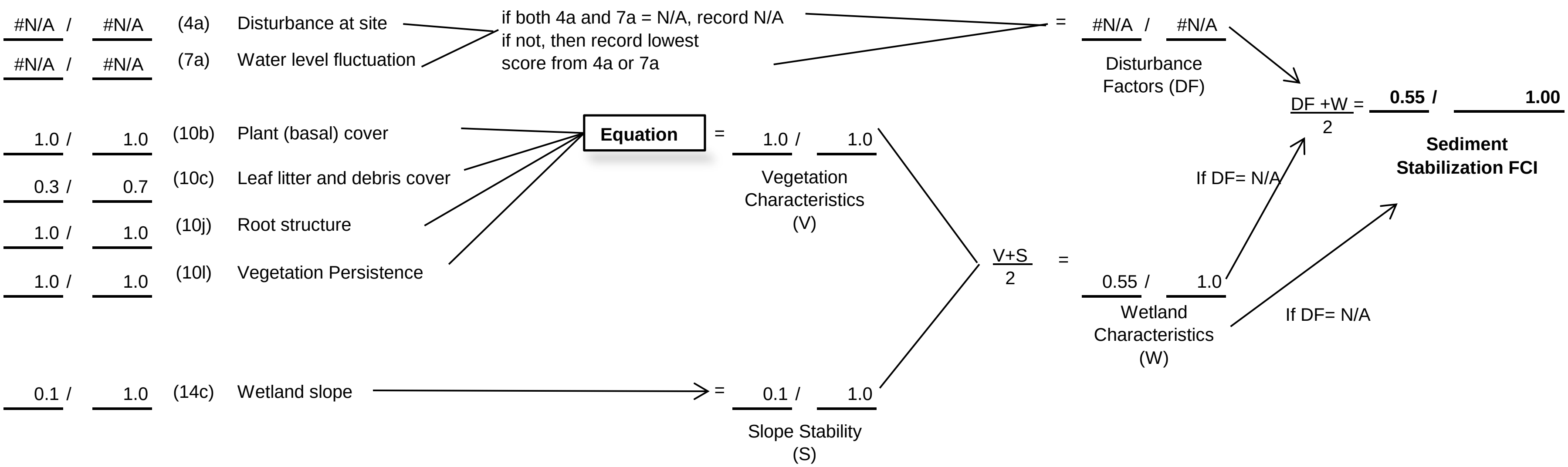
$$\frac{10a\ (10g + 10i + 10k) + 10e}{4}$$

Equation #6:
If 10e not applicable:

$$\frac{10a\ (10g + 10i + 10k)}{3}$$

Calculation of Sediment Stabilization

Selected Scores		(#)	Element
Baseline V. Alternative C			
#N/A /	#N/A	(4a)	Disturbance at site
#N/A /	#N/A	(7a)	Water level fluctuation
1.0 /	1.0	(10b)	Plant (basal) cover
0.3 /	0.7	(10c)	Leaf litter and debris cover
1.0 /	1.0	(10j)	Root structure
1.0 /	1.0	(10l)	Vegetation Persistence
0.1 /	1.0	(14c)	Wetland slope



if both 4a and 7a = N/A, record N/A
if not, then record lowest
score from 4a or 7a

= #N/A / #N/A
Disturbance Factors (DF)

Equation = 1.0 / 1.0
Vegetation Characteristics (V)

= 0.1 / 1.0
Slope Stability (S)

$\frac{V+S}{2}$ = 0.55 / 1.0
Wetland Characteristics (W)

If DF= N/A

If DF= N/A

$\frac{DF+W}{2}$ = **0.55 / 1.00**

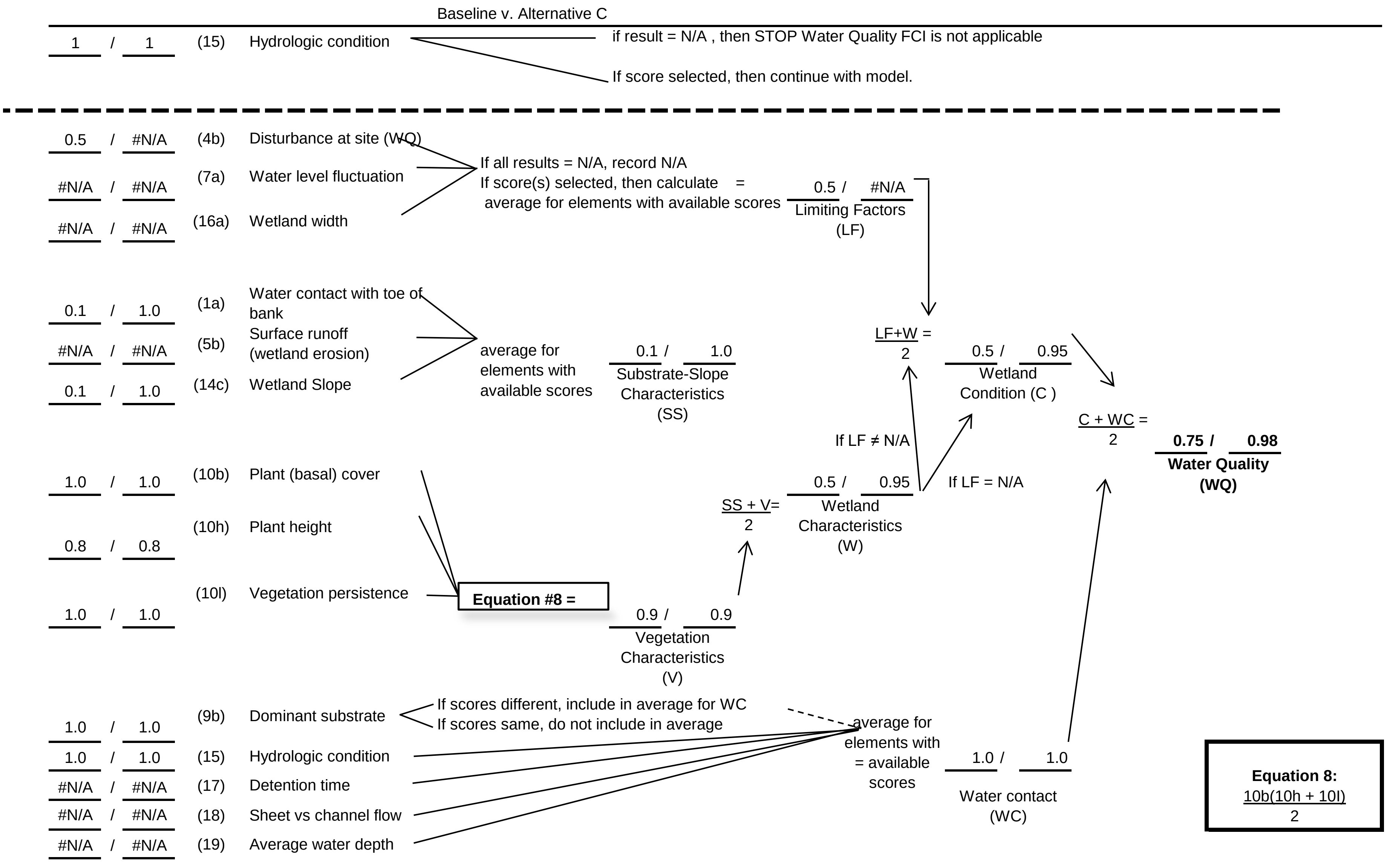
Sediment Stabilization FCI

Equation #7:

$$\frac{10b\ (10j + 10l) + 10c\ (1-10b)}{2}$$

Flushing Creek EPW

Calculation of Water Quality



Selected Scores		(#)	Element
			Baseline v. Alternative C
1	1	(15)	Hydrologic condition
0.5	#N/A	(4b)	Disturbance at site (WQ)
#N/A	#N/A	(7a)	Water level fluctuation
#N/A	#N/A	(16a)	Wetland width
0.1	1.0	(1a)	Water contact with toe of bank
#N/A	#N/A	(5b)	Surface runoff (wetland erosion)
0.1	1.0	(14c)	Wetland Slope
1.0	1.0	(10b)	Plant (basal) cover
0.8	0.8	(10h)	Plant height
1.0	1.0	(10l)	Vegetation persistence
1.0	1.0	(9b)	Dominant substrate
1.0	1.0	(15)	Hydrologic condition
#N/A	#N/A	(17)	Detention time
#N/A	#N/A	(18)	Sheet vs channel flow
#N/A	#N/A	(19)	Average water depth

if result = N/A , then STOP Water Quality FCI is not applicable

If score selected, then continue with model.

If all results = N/A, record N/A

If score(s) selected, then calculate = average for elements with available scores

0.5 / #N/A Limiting Factors (LF)

average for elements with available scores

0.1 / 1.0 Substrate-Slope Characteristics (SS)

Equation #8 =

0.9 / 0.9 Vegetation Characteristics (V)

$\frac{SS + V}{2}$ =

0.5 / 0.95 Wetland Characteristics (W)

If LF ≠ N/A

$\frac{LF+W}{2}$ =

If LF = N/A

0.5 / 0.95 Wetland Condition (C)

If scores different, include in average for WC

If scores same, do not include in average

average for elements with = available scores

1.0 / 1.0 Water contact (WC)

$\frac{C + WC}{2}$ =

0.75 / 0.98

Water Quality (WQ)

Equation 8:

$\frac{10b(10h + 10l)}{2}$

Flushing Creek EPW

Calculation of Wildlife

Baseline V. Alternative C

Selected Scores	(#)	Element
#N/A / #N/A	(4c)	Disturbance of wildlife habitat
#N/A / #N/A	(20a)	Gross contamination
#N/A / #N/A	(16b)	Wetland size
0.1 / 0.1	(11a)	Layers
0.1 / 0.7	(11b)	Condition of Layers
1.0 / 1.0	(11c)	Spatial pattern of shrubs/trees
0.07 / 0.07	(12a)	Cover types
0.5 / 1.0	(12b)	Ratio of cover types
0.1 / 0.5	(12c)	Cover type interspersion
0.1 / NA	(12d)	Undesirable species
1.0 / 1.0	(13a)	% open water
0.5 / 0.5	(13b)	Vegetation/water interspersion
0.1 / 0.1	(21a)	Shape of upland/wetland edge
#N/A / #N/A	(22a)	Wildlife attractors
0.1 / 0.1	(23)	Islands

(4c), (20a), (16b): If 4c, 16b and 20a = N/A, record N/A
If any score = 0.1, record 0.1 = #N/A / #N/A Features Which Reduce Habitat Value (F)

(11a)–(11c): average for elements with available scores = 0.4 / 0.6 Vegetation Strata

(12a)–(12d): average for elements with available scores = 0.19 / 0.52 Vegetation Cover Types

(13a)–(13b): average for elements with available scores = 0.75 / 0.75 Vegetation/ Water Proportions

(21a), (22a), (23): average for elements with available scores = 0.10 / 0.10 Physical Features

Vegetation Strata, Vegetation Cover Types, Vegetation/ Water Proportions, Physical Features: average for available scores = 0.36 / 0.49 Habitat Complexity (HC)

If F ≠ NA: $\frac{F + HC}{2}$ =

If F = NA:

0.36 / 0.49
Wildlife FCI

Flushing Creek EPW

Calculation of Fish (tidal Stream/River)

Comparison: Baseline / Alternative C

Site Suitability For Planned Wetland:

Selected Scores			(#)	Element
0.5	/	0.5	(24)	Obstruction to fish passage

if result = 0.1, STOP. There is no potential for providing tidal fish habitat

if result ≠ 0.1 or N/A, then continue with model

0.1	/	#N/A	(1b)	Shoreline bank stability
#N/A	/	#N/A	(4a)	Disturbance at site (SS)
0.5	/	0.5	(4d)	Disturbance in channel/open water
#N/A	/	#N/A	(7b)	Most Permanent Fish passage
0.5	/	0.5	(24)	Obstruction to fish passage

average for elements with available scores = 0.37 / 0.5 Limiting Factors

0.5	/	0.5	(7c)	Specially dominant hydroperiod
1.0	/	1.0	(9C)	Substrate suitability fish
0.1	/	0.3	10d	Plant basal cover
0.1	/	0.1	10f	Rooted Vascular aquatic beds
0.5	/	0.5	21b	shape of wetlands
0.1	/	0.1	22b	Available cover

average for elements with available scores = 0.2 / 0.2 Food/Cover

0.1	/	0.1	(20b)	Water quality rating

If score available, record score for WQ

If information not available, continue

0.1	/	0.1	(20c)	Nutrient/sediment/contaminant sources
0.1	/	0.1	(20d)	Dissolved Oxygen
1.0	/	1.0	(20f)	Maximum water temperature

average for elements with available scores = 0.1 / 0.1 Water Quality (WQ)

average for available scores = **0.22 / 0.29**

Fish (Tidal Stream/River) FCI

Project Title: Flushing Creek EPW

Calculation of Uniqueness/Heritage

Comparison: Baseline / Alternative C (e.g., WAA/plannec

Site Suitability For Planned Wetland:

Selected Scores	(#)	Element
#N/A / #N/A	(29)	Endangered species
#N/A / #N/A	(30)	Rarity
#N/A / #N/A	(31)	Unique features
#N/A / #N/A	(32)	Historical or archaeological significance
#N/A / #N/A	(33)	Natural landmark
#N/A / #N/A	(34)	Connected to Wild and Scenic River
#N/A / #N/A	(35)	Park, sanctuary, etc.
#N/A / #N/A	(36)	Scientific research site

average for elements with available scores = #N/A / #N/A

Uniqueness/ Heritage FCI