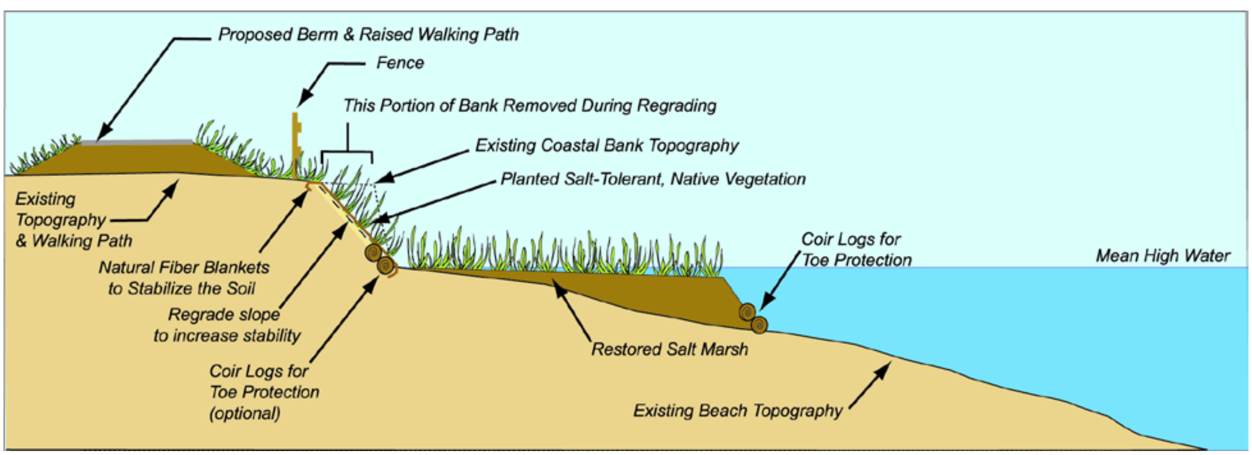
Watson Park Shoreline Erosion Mitigation and Coastal Resiliency Improvement in Braintree, MA



June 17, 2019

PREPARED FOR:
Town of Braintree
Planning Department
1 John F. Kennedy Memorial Drive
Braintree, MA 02184

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A CLS Company
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The Massachusetts Office of Coastal Zone Management

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1.0 INTRODUCTION

Watson Park is an urban park located on the Weymouth Fore River in Braintree, MA (Figure 1-1). Braintree has a population of approximately 36,000 people and is a suburb of Boston. The Town is densely populated with few areas that provide access to and views of the Fore River, making Watson Park a valuable public asset.

The park is located on the northern shore of the Fore River and is currently fronted by mix of natural shoreline and a seawall. The riverfront areas adjacent to the park are heavily developed with two marinas and the Quincy Avenue bridge. The popular park has several baseball fields, a basketball court, a tennis court, a children's splash pad and a walking path. Residents frequently walk in the park to observe boating activities in the Fore River, riverine wildlife and the seasonal changes that occur in the fronting salt marsh.

The park has been experiencing significant erosion along its eastern shoreline, which threatens use of the park. There was also a concern that sea level rise would exacerbate erosion as wind generated waves, boat wakes, and coastal storms impact the shoreline more frequently. As such, the Town of Braintree applied for a CZM Coastal Resiliency Grant to address this erosion while also increasing the long-term coastal resiliency of the Watson Park shoreline. As secondary goals, the Town hoped to find a solution that would also increase the diversity of the nearshore habitat and potentially allow for salt marsh migration in coming decades.

Figure 1-1. Project site locator map.

2.0 EXISTING CONDITIONS

To develop a full understanding of the existing conditions at the site on which to base coastal resiliency recommendations, existing information related to the current FEMA flood zones, wetland resources, topography and bathymetry, and grain size was compiled as part of this project. In addition, due to the recreational importance of Watson Park, data on the recreational use and features were also gathered. The existing conditions data gathered as part of this project is summarized in the sub-sections below.

2.1 FEMA FLOOD ZONES

The Effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the Watson Park Area is dated June 9, 2014. The Special Flood Hazard Areas (SFHAs) for Watson Park are shown in Figure 2-1. The entire shoreline of Watson Park and the majority of the playing fields and recreational spaces are located with an AE zone with a base flood elevation (BFE) of 10 feet (NAVD88). The main parking area and portions of two of the playing fields are located within the 0.2% annual change flood hazard area (i.e., the 500 year flood plain).

Figure 2-1. FEMA SFHAs for the Watson Park area (Effective Date: June 9, 2014).

2.2 EXISTING WETLAND RESOURCE AREAS

The Massachusetts Department of Environmental Protection (MassDEP) Wetlands Resources shapefile was obtained from the MassGIS datalayers website. This layer is based on photo-interpretation that was conducted using 2005 aerial photos. The 2005 MassDEP Wetlands Resources shapefile provides a medium-scale representation of the wetland areas of the state and is intended for planning purposes only. The MassDEP layer indicates that there is salt marsh abutting most of the Watson Park site, with a small area of coastal beach near the area of current erosion in the center of the Park (Figure 2-2). There is also a fairly significant area of tidal flat due to the 10+ foot tides in the Fore River, and then an area of open water in the subtidal portions of the River channel itself (Figure 2-2).

Figure 2-2. MassDEP Wetland Resource Areas (based on a 2005 photointerpretation).

Although the MassDEP dataset provides some indication about what types of wetland resources are likely to be present at the site, additional wetland delineation and survey work was necessary to develop an accurate accounting of the current wetland resources present. This more detailed delineation was used to guide future design alternatives intended to increase the resiliency of the park. The field-based wetland delineation was conducted on November 15, 2018. Although Watson Park is much larger in extent, because the area of interest is the area of erosion in the immediate vicinity of the culvert, wetland resource area delineations were constrained to an area approximately 250 feet to either side of the culvert (Figure 2-3).

Figure 2-3. Proposed wetland resource area delineation extent.

As anticipated from the MassDEP wetland data, salt marsh, coastal beach, tidal flat and open water resources areas were observed at the site. However, a number of significant differences were documented. First, the salt marsh area was significantly reduced and fragmented from what was indicated in the 2005 MassDEP dataset. Second, there is a low coastal bank present at the site that was not identified in the MassDEP wetland layer. Finally, three small areas of rocky intertidal shore were delineated within the area of interest (Figure 2-4). These areas of rocky intertidal shore habitat collectively encompass 2,388 square feet (individually they are 957, 920 and 511 square feet in area). Note that the lower boundary of the tidal flat resource area was not delineated; the mud was too soft to safely traverse any farther riverward. The dashed line at the lower boundary of the tidal flat area in Figure 2-4 is meant to indicate that this resource area continues some distance past the edge of the surveyed points. Although not delineated during the field survey, there is an area of open water in the main river channel; its location is similar to that show in the 2005 MassDEP dataset.

Figure 2-4. Results of the Woods Hole Group wetland resource area delineation (11/15/18).

In addition to delineating wetland resource areas present at the site, Woods Hole Group also evaluated these wetland resource areas for stability, ecological health and signs of stress. The sub-sections below will describe the salt marsh, rocky intertidal shore, coastal beach and tidal flat, and coastal bank resource areas within the surveyed area in more detail. Existing information concerning shellfish and eelgrass habitat is also presented below.

2.2.1 Salt marsh

There were various disconnected segments of salt marsh within the surveyed area. This fragmentation is likely the result of ongoing erosion of the marsh platform (a detailed shoreline change analysis is described in Section 3.3 that addresses this issue in more detail). The two small western patches of salt marsh vary in width from 3 to 12 feet. The vegetation along the front (i.e., river side) of these salt marsh areas is very sparse, consisting largely of sea lavender (*Limonium carolinianum),* with denser vegetation as you move landward, largely consisting of *Spartina patens* and *Distichlis spicata* (Figure 2-5). There was also a very small patch of *Spartina alterniflora* at the far western end of the western-most salt marsh area. In the few places where these two salt marsh areas are not directly adjacent to the seawall, they are backed by small, slightly higher elevation areas, dominated by marsh elder *(Iva frutescens)* and seaside goldenrod *(Solidago sempervirens)* (Figure 2-5).

The presence of the seawall does not bode well for the long-term future of the salt marsh habitat fronting it. Continued erosion and retreat of the front face of the salt marsh coupled with an inability for the landward side of the salt marsh to retreat due to the presence of a solid vertical structure means that in the future there will likely be no salt marsh at all front this portion of the seawall.

Figure 2-5. Thin western salt marsh segments fronting the seawall, characterized by sparse sea lavender (*L. carolinianum*) as well as *S. patens* and *D. spicata*, fronting *I. frutescens*.

The area of salt marsh immediately west of the culvert is characterized by extremely sparse sea lavender (*L. carolinianum*) fronting a slightly denser patch of *D. spicata* and *S. patens*. This salt marsh area was also bordered on its landward side by predominantly *I. frutescens* and *S. sempervirens*, but unlike the two salt marsh segments to the west, this area was not backed by a stone seawall (Figure 2-6). Instead, there is a naturally vegetated coastal bank between the salt marsh and the maintained field area above.

Figure 2-6. Thin central salt marsh segment fronting a low coastal bank.

The eastern segment of salt marsh within the surveyed area is significantly larger than the others. The majority of the marsh platform was characterized by dense, healthy *D. spicata* and

S. patens, with a narrow outer fringe of the salt marsh dominated by *S. alterniflora* along the riverfront edge (Figure 2-7); this riverfront edge is slightly lower in elevation than the majority of the marsh platform, leading to the difference in observed vegetation. Although the existing vegetation appears to be healthy and thriving, the front face of the salt marsh is essentially a 4- to 5-foot high vertical scarp. This scarp is evidence of ongoing erosion, undercutting and slumping. Large chunks of recently eroded peat and newly exposed rocks were also observed at the base of the peat platform (Figure 2-7).

Although erosion is still a concern for this salt marsh area, as it is for the other three salt marsh areas, the relatively dense, healthy vegetation and a low grade natural slope landward of the existing salt marsh mean that this area of salt marsh has the ability to migrate landward overtime in response to sea-level rise. However, there is an invasive species concern for this area of salt marsh. Although this section is currently dominated by native species, the far eastern edge of the surveyed area is dominated by *Phragmites australis*. With only a single wetland survey it is impossible to say whether the *Phragmites* extent is stable or expanding. It would be prudent to monitor this native-*Phragmites* boundary in the future, and take actions to address any continued spread of the *Phragmites* stand if necessary.

Figure 2-7. Larger eastern salt marsh segment, which was characterized by a relatively healthy high marsh platform, but is experiencing ongoing erosion and scarping on its seaward face.

2.2.2 Rock intertidal shore

As shown in Figure 2-4, there were three small areas of rocky intertidal shore delineated within the survey area. These areas consisted of somewhat angular boulders (i.e., rocks greater than 10 inches in diameter) below the observed high water line (i.e., in the intertidal zone). In many cases, these boulders had attached biota, such as the oysters, barnacles, and rockweed pictured in Figure 2-8, and the periwinkles pictured in Figure 2-9. Although these small sections of rocky intertidal shore are not complex enough to create tide pool habitat, they do appear to be stable and persistent enough to be supporting attached biota. Based on the cobbles and boulders observed in the front face of the eroding marsh peat platform and the coastal bank, it seems likely that these rocks have been deposited here overtime as the smaller grain sized material in the marsh peat and bank are eroded away.

Figure 2-8. Example section of the rocky intertidal shore, with oysters, barnacles and attached microalgae.

Figure 2-9. Example section of the rocky intertidal shore, with periwinkles.

2.2.3 Coastal beach and tidal flat

The upper portions of the coastal beach were interspersed between unconsolidated sandy, gravelly substrate, and degrading peat remnants (Figure 2-10). In many places, these upper portions of the coastal beach were covered in a thin, dry, and cracking film of algae. The intertidal portions of the coastal beach, classified as tidal flat by MassDEP and in the November 15, 2018 wetland delineation (Figure 2-4), also vary significantly in terms of substrate. Some portions of the tidal flat area, particularly those immediately fronting the area of concern, are dominated by gravel and cobble, and have a fairly firm consistency that can support walking (Figure 2-10). Other areas, particularly fronting the eastern marsh segment, are dominated by very fine, mucky material (Figure 2-11). As with the appearance of the rocky intertidal shore areas, it is likely that the rockiness of the coastal beach and tidal flat immediately fronting the area of concern is the result of all the finer grained material being eroded away through river currents and boat wakes, as well as through surface runoff flowing from the culvert.

Figure 2-10. Coastal beach and tidal flat immediately fronting the area of significant erosion and the culvert.

Figure 2-11. Tidal flat fronting the eastern segment of salt marsh.

2.2.4 Coastal bank

The western section of the coastal bank is relatively well vegetated, predominately with marsh elder (*I. frutescens*) and other shrubs. One medium size eastern red cedar (*Juniperus virginiana*) was also present within the coastal bank (Figure 2-12). This vegetation is interspersed with relatively large cobbles and some small boulders (Figure 2-12). Along the eastern section of the coastal bank, beginning at approximately the concrete block headwall for the culvert, there is evidence of recent and ongoing erosion of the coastal bank. The scarped face of the coastal bank in this area is approximately 2 feet high (Figure 2-13). This erosion is threatening the structural integrity of the culvert headwall, as well as the split rail fence and walking path.

Figure 2-12. The well vegetated western portion of the coastal bank.

Figure 2-13. The eroded eastern portion of the coastal bank.

2.2.5 Shellfish habitat

Although a field-based shellfish survey was outside of the scope of this project, some preliminary information can be obtained from the Shellfish Suitability Areas layer maintained by the Massachusetts Department of Marine Fisheries (MarineFisheries). This dataset is comprised of polygons representing habitats suitable for ten commercially important species of shellfish along the coast of Massachusetts. The ten species are:

- American Oyster
- Bay Scallop
- Blue Mussel
- European Oyster
- Ocean Quahog
- Quahog
- Razor Clam
- Sea Scallop
- Soft-shelled Clam
- Surf Clam

The polygons within the MarineFisheries Shellfish Suitability Areas layer delineate areas that are believed to be suitable for particular species of shellfish based on the expertise of MarineFisheries, local Shellfish Constables, input from commercial fishermen, and information contained in maps and studies of shellfish in Massachusetts. The MarineFisheries Shellfish Suitability Areas layer for the Watson Park area identifies the intertidal and shallow subtidal areas as suitable habitats for soft-shell clams (*Mya arenaria*) (Figure 2-14). This does not necessarily mean that soft-shell clams are present, or if they are that they are present in significant numbers, but it does mean that any work proposed in the intertidal zone could require additional information to be gathered on the shellfish present in this area.

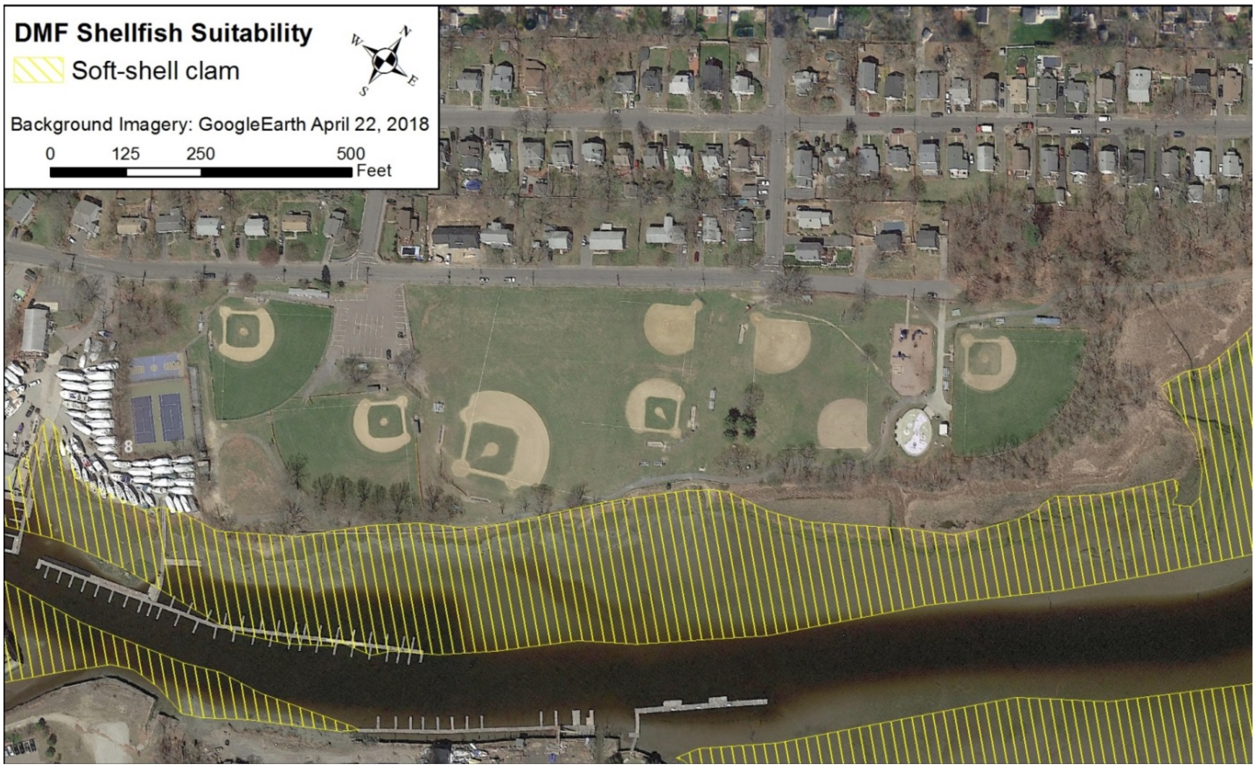

Figure 2-14. MarineFisheries Shellfish Suitability Areas.

2.2.6 Eelgrass habitat

The Massachusetts Department of Environmental Protection (MassDEP) began a program to map the state's submerged aquatic vegetation (SAV) resources in the early 1990s and since 1995 the MassDEP Eelgrass Mapping Project has produced multiple surveys of SAV along the Massachusetts coastline. In Massachusetts, the dominant SAV is eelgrass (*Zostera marina*). This database was queried to determine if it was likely that eelgrass was present in the Fore River near Watson Park. Surveys for this area were conducted in 1995, 2001, 2006, 2012 and 2016. In five years of assessment, there has been no indication that there is eelgrass in the Fore River. Therefore, it was deemed unnecessary to collect additional data concerning eelgrass in this area.

2.3 TOPOGRAPHY AND BATHYMETRY

Woods Hole Group initially compiled and evaluated three existing sources of topographic and bathymetric data at and around Watson Park. The first source was the most up-to-date LiDAR available for this area: 2013-2014 USGS Coastal and Marine Geology Program (CMGP) Lidar: Post Sandy data for MA, NH and RI. This dataset was downloaded from the NOAA Data Access Viewer in a horizontal coordinate system of NAD83 Massachusetts State Plane feet, and a vertical datum of NAVD88 feet for the project area (Figure 2-15). These data indicate that the majority of Watson Park falls within elevations 8 and 10 feet (NAVD88). There are two areas of lower elevation, between 6 and 8 feet (NAVD88): the first area is an area of the western end of the park just landward of the seawall, and the second is a low spot in approximately the middle of the park, just south of the road. There is also one area, the far eastern field that is much higher than the rest of the park, ranging in elevation from 10 to above 12 feet (NAVD88).

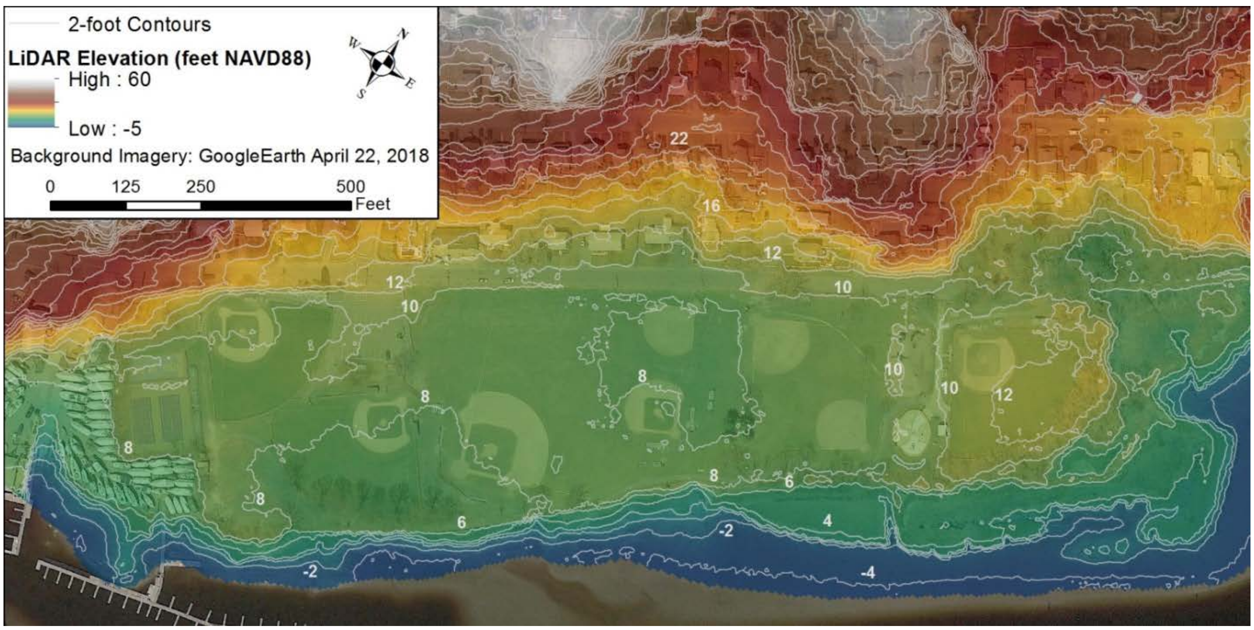

Figure 2-15. 2013-2014 USGS CMGP LiDAR: Post Sandy for the Watson Park Area (all elevations are in NAVD88, ft).

The second source of topographic data reviewed was an engineering survey of the Park performed by the Town, developed by planimetric methods from 1993 aerial photography. Woods Hole Group received AutoCAD files of spot elevations and contour lines from the Town of Braintree Department of Public Works. Elevations were collected in a vertical datum of NGVD29 feet. Note that NAVD88 is 0.79 feet above NGVD29 in Braintree. In order to compare the datasets, 0.79 feet should be subtracted from any NGVD29 spot or contour elevation to calculate the NAVD88 elevation in feet. This survey elevation data developed by the Town, in NGVD29 feet, is shown in Figure 2-16.

Figure 2-16. Town of Braintree topographic survey (all elevations are in NGVD29, ft).

The third source of topographic data was the post-dredge bathymetric survey conducted in December 2010 by Steele Associates in the vicinity of the Braintree Yacht Club. These data were added to the post-dredge plan produced by Peda, Inc. on December 30, 2010 (Figure 2-17). Elevations on this post-dredge plan are presented in a vertical datum of mean low water (MLW). Note that NAVD88 is 5.29 feet above MLW in Braintree (based on NOAA's online vertical datum transformation tool: VDatum). Therefore, in order to compare the datasets, 5.29 feet should be subtracted from each spot elevation on the plan to calculate the NAVD88 elevation in feet. This post-dredge plan was also georeferenced and the bathymetric survey points were digitized and converted to NAVD88 so these data could be directly compared, and potentially combined, with the adjacent topographic information from other sources to get a full bathymetric and topographic picture of the project site area (Figure 2-18). Unfortunately, as seen in Figure 2-18, the extent of these data does not extend to our area of interest; they stop approximately 200 feet southwest of the area of eroding shoreline.

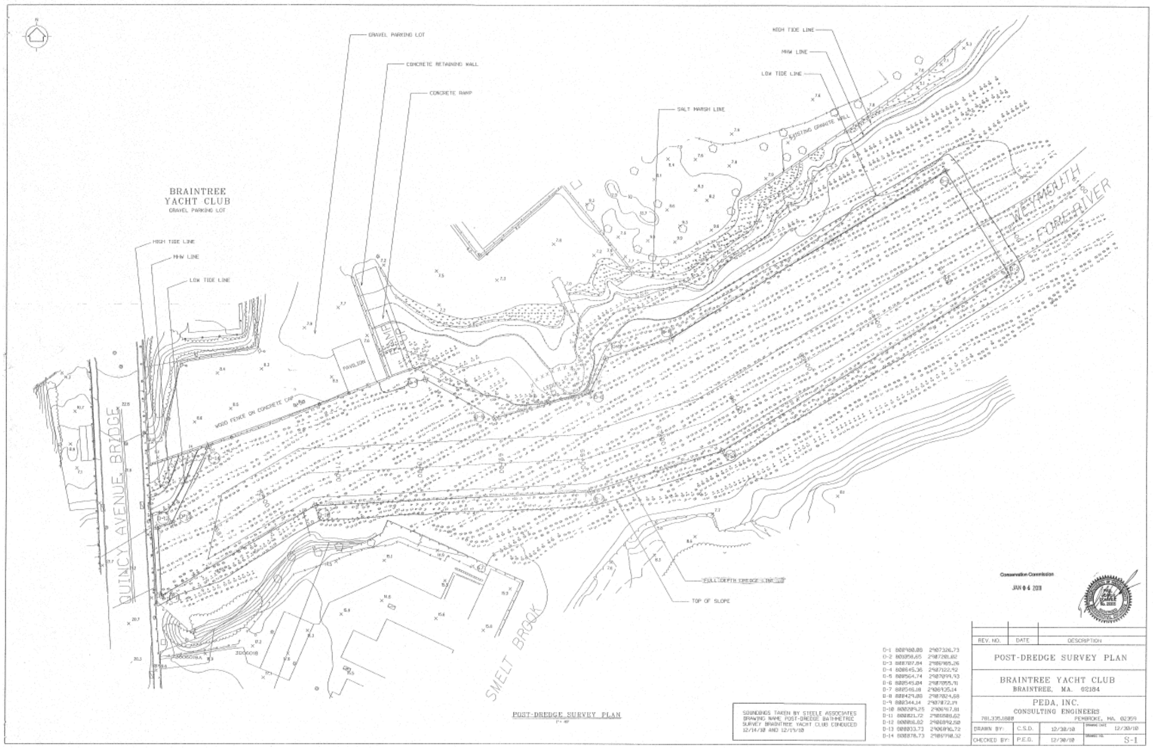

Figure 2-17. Fore River Post-Dredge Survey produced by Peda, Inc. on December 30, 2010.

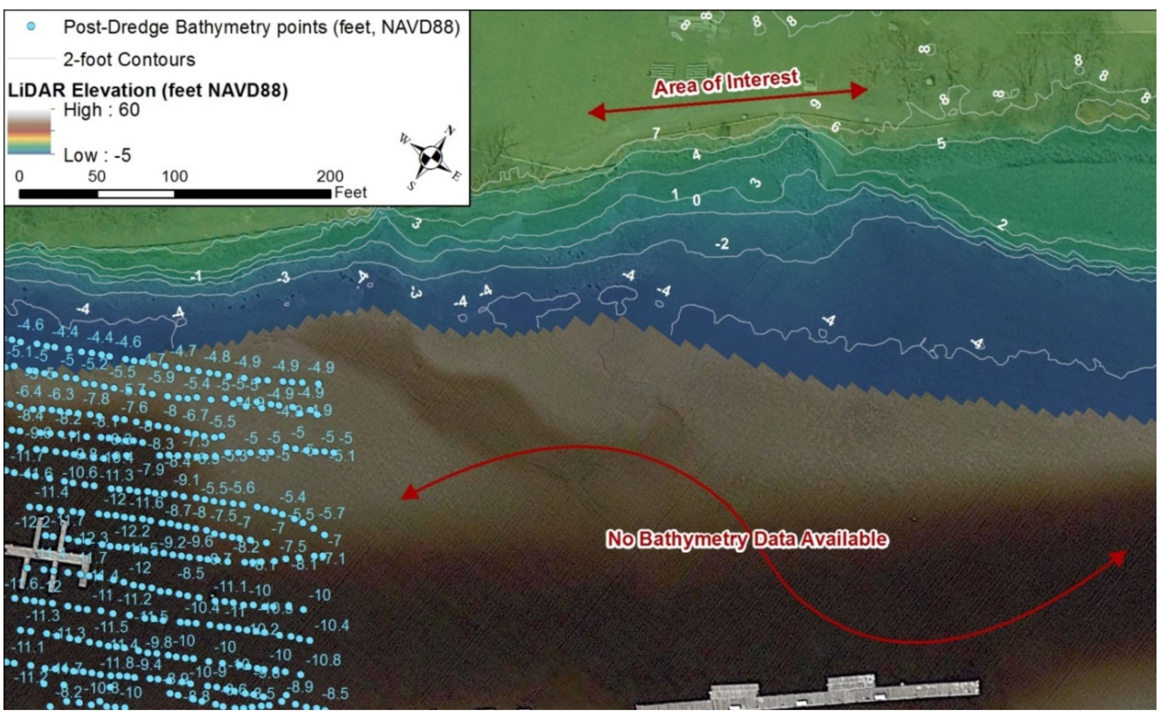

Figure 2-18. Fore River Post-Dredge Survey bathymetry points combined with topographic elevations from LiDAR data.

Finally, due to the ongoing erosion at the site, it was important to collect current topographic survey data to accurately capture the existing conditions. The field topographic survey was conducted on November 15, 2018 (Figure 2-19. The focus of the data collection was in the area of current erosion, where elevations were most likely to be different from previously collected elevation information. Data collection efforts also focused on confirming the following elevations:

- Elevations throughout the fields at Watson Park, as these will impact long-term planning of the site with regards to flood risk and sea level rise;
- Elevations of the eastern salt marsh platform where vegetation appears to be healthy and thriving, as these will be useful as a reference area for any salt marsh restoration within the area of interest;
- Elevations of the existing culvert inverts and headwall; and
- Elevations of Gordon Road.

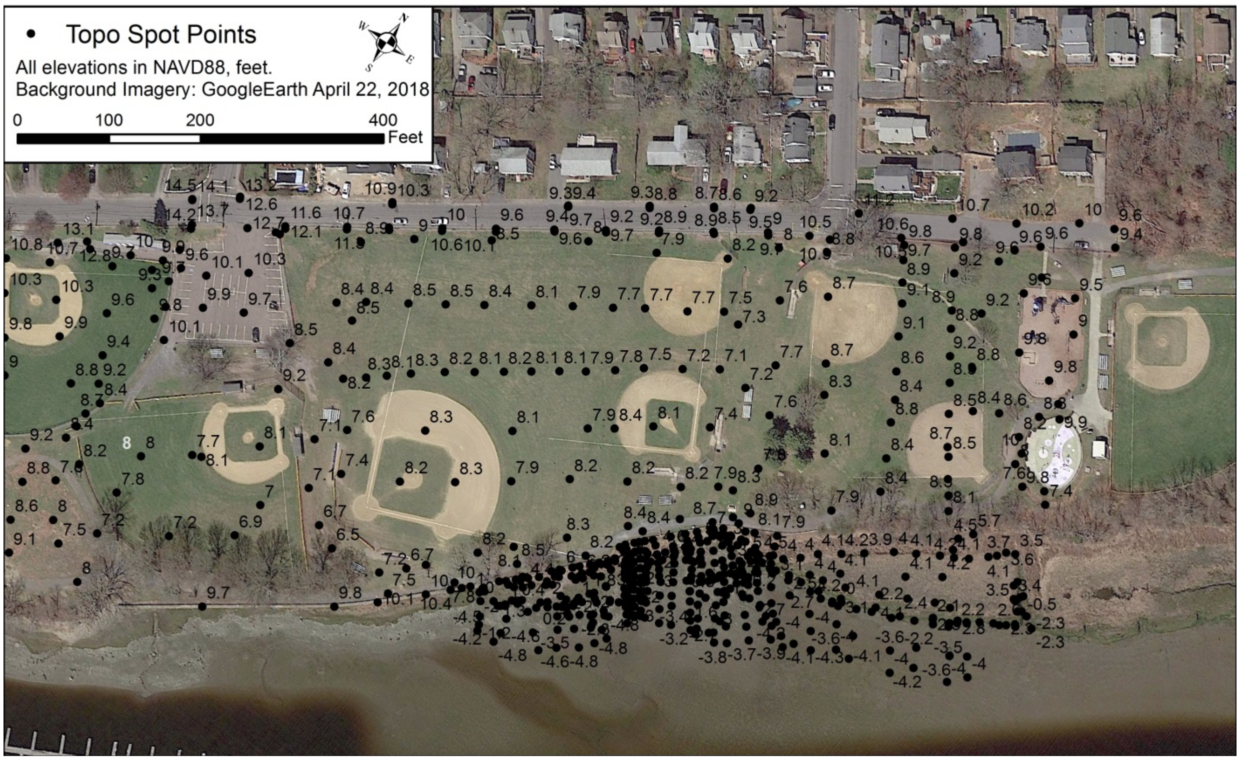

Figure 2-19. Woods Hole Group topographic survey (all elevations are in NAVD88, ft).

It is worth noting that although both the 2013-2014 LiDAR dataset (Figure 2-15) and the recent Woods Hole Group topographic survey (Figure 2-19) contain some information from the intertidal areas around Watson Park, neither dataset contains bathymetry information within the River. Although there are bathymetric data from the Fore River post-dredge survey in 2010 (Figure 2-17), these data do not extend far enough to cover the sub-tidal area immediately in front of the area of interest (Figure 2-18). While this is unfortunate, it will not constrain the alternatives analysis and/or the conceptual design that is ultimately selected, as none of the alternatives described in Section 4 extend past the existing topographic information.

2.4 GRAIN SIZE ANALYSIS

Five sediment and soil samples were collected from the site for grain size analyses. Two soil samples were collected from locations within the coastal bank, one from either side of the culvert headwall. Three sediment samples were collected from locations within the coastal beach/tidal flat. These sample locations are shown in Figure 2-20.

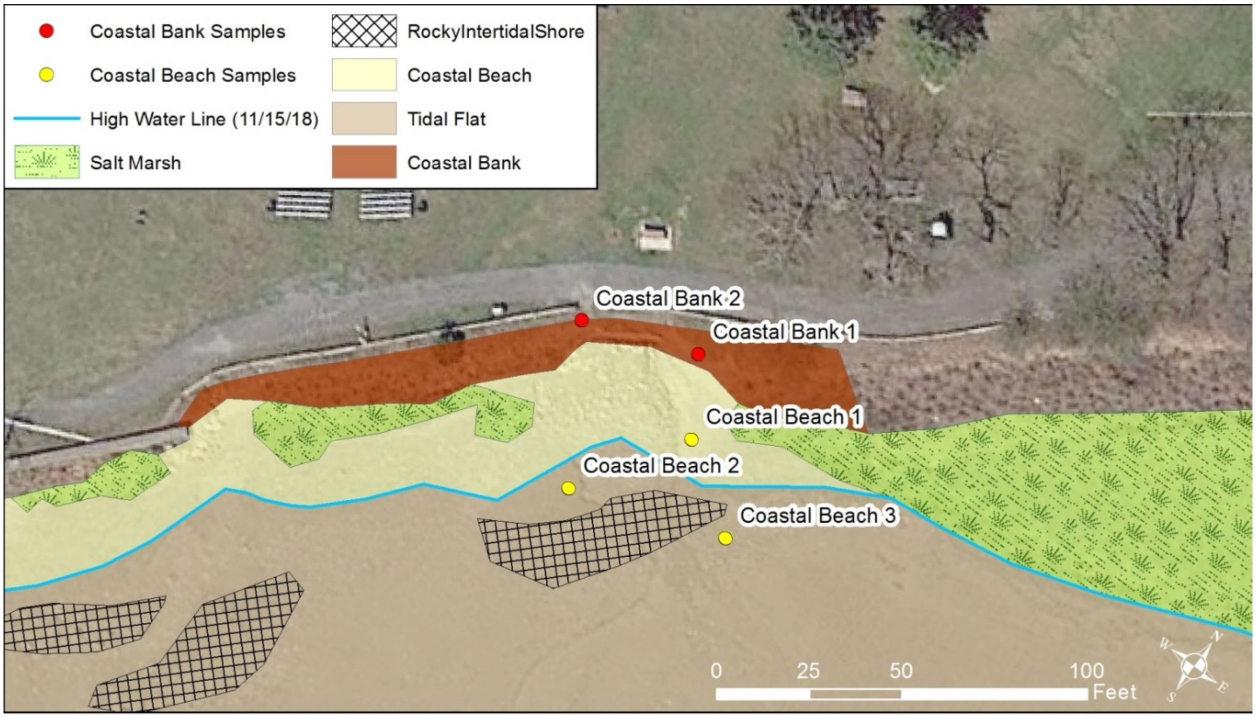

Figure 2-20. Locations of the five (5) grain size samples.

The results of the grain size analyses indicate that all five samples contained relatively heterogeneous material. The two coastal bank samples returned relatively similar results with gravel content ranging from 22% to 28%, sand content between 36% and 48%, and silt and clay content between 25% and 42% (Table 1); essentially, these coastal bank samples are a fairly evenly distributed mix of gravel, sand and silt/clay. The coastal beach samples, however, produced more variable results. Coastal beach 1 and coastal beach 3 were more similar to each other than to coastal beach 2, with gravel content ranging from 38% to 51%, sand content between 41% and 52%, and silt and clay content between 8% and 10% (Table 2-1). Coastal beach 2, on the other hand, was composed of much finer material: 14% gravel, 36% sand, and the highest percent of silt/clay among any of the samples: 50% (Table 2-1). This result is not unexpected given that the coastal beach 2 sample was taken from an area of degrading peat.

The detailed grain size results and curves, as well as photos of each of the samples and sample locations are included in Appendix A.

Table 1-1. Grain size results.

Sample	% Gravel	% Sand	% Silt & Clay	D_{50}
Coastal bank 1	21.8	36.3	41.9	0.1706 mm
Coastal bank 2	27.5	47.9	24.6	0.5646 mm
Coastal beach 1	51.2	40.5	8.3	4.9550 mm
Coastal beach 2	13.7	36.2	50.1	N/A
Coastal beach 3	38.0	51.8	10.2	1.9913 mm

2.5 RECREATIONAL USE

The Braintree Director of Recreation provided a site layout for Watson Park identifying each of the baseball fields play (Figure 2-21). The Town maintains the Babe Ruth Field and mows the entire Watson Park complex with the exception of three Little League fields (Delory Field, DaRosa Field and Sheridan Field) that the East Braintree Little League prefers to mow because they are fenced in. The Babe Ruth Field is heavily used; it is used for games almost every day from the beginning of April through the middle of July, including evening events on weekdays and full day events on most weekend days. The East Braintree Little League also runs from early April through early August, utilizing the three Little League fields (Delory Field, DaRosa Field and Sheridan Field) that the League maintains. In addition, a Fall Ball League uses two of the Little League fields and the Babe Ruth Field on Sundays in September and October. The rest of the fields are used predominantly for T-Ball games and for practice fields.

In addition to the eight baseball fields, Watson Park also contains two tennis courts, a basketball court, a playground, and a splash pad. The splash pad was constructed in 2012, and was designed with a drainage swale and raingarden around most of its perimeter. Finally, there is an approximately 1/3-mile long pedestrian walking path around the perimeter of the Park.

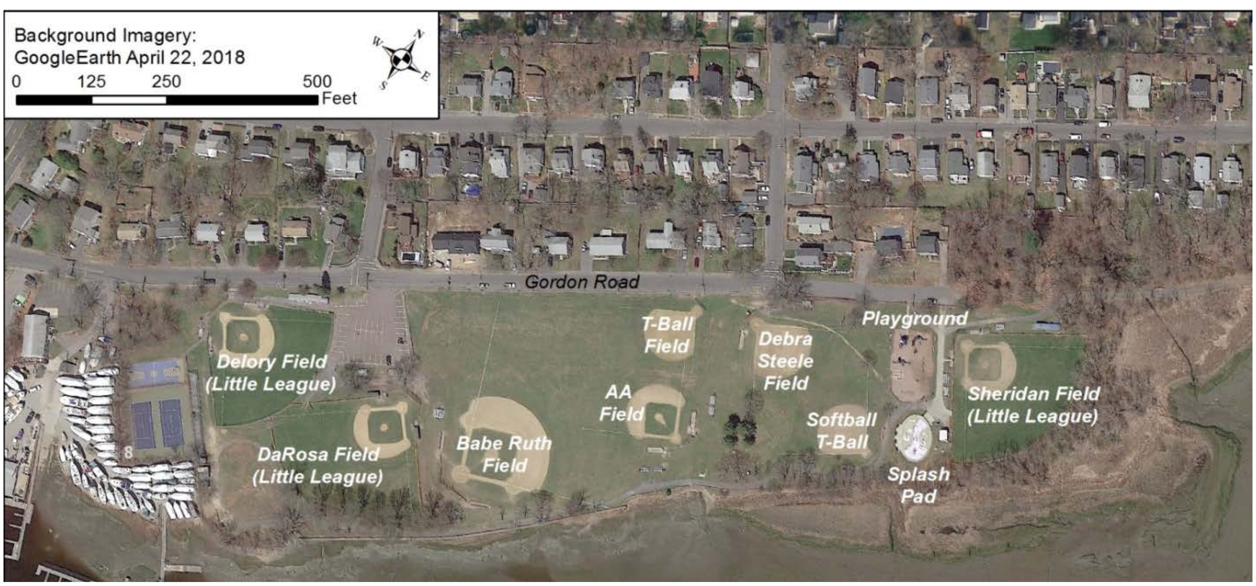

Figure 2-21. Baseball fields and other existing recreational features at Watson Park.

3.0 ANALYSIS OF COASTAL PROCESSES

This Section provides a summary of the analyses of coastal processes conducted as part of this project, which involved extracting water level information from the Boston Harbor Flood Risk Model (BH-FRM) for existing and future 5-, 10-, 20- and 50-year return period storms, summarizing potential wave impacts generated by wind and boat wakes, an analysis of historical erosion rates at the site, and reviewing the projected wetland change data produced by Woods Hole Group for the Massachusetts Office of Coastal Zone Management (CZM) using the Sea Level Affecting Marshes Model (SLAMM). These coastal processes analyses provide a more in depth understanding of the potential historic processes contributing to the ongoing erosion of the coastal bank, as well as insight into future conditions that may influence the ultimate shoreline project design and the long term management of Watson Park. The results of these analyses are summarized below.

3.1 PRESENT AND FUTURE WATER LEVELS

As with any coastal erosion mitigation project, an accurate understanding of water level elevations is crucial for developing a successful design. Accurate present day water levels can be derived from a detailed analysis of long term historical records and detailed site specific topography. Historical water level data from the National Oceanic and Atmospheric Agency (NOAA) tide gage in Boston, MA (station ID: 8443970) (NOAA, 2014a) were collected as hourly observations between May 3, 1921 and July 31, 2014: a 92-year period of record that was used as an input dataset for the BH-FRM. Water levels for this station have been rising continuously for each epoch since the beginning of data collection in 1921. To calculate accurate present day water levels, historic values were adjusted based on the observed annual sea-level rise rate for the station (NOAA, 2014b). In addition to an accurate calculation of present day water levels, BH-FRM also provides data on water levels during storms of various intensities. Impacts from both tropical (i.e., hurricanes) and extra-tropical (i.e., nor'easters) storm conditions were evaluated by the model. The BH-FRM results provide high resolution water level elevations for locations throughout the greater Boston area. The present day MHW and MLW are presented in Table 3-1 and are 4.82 and -4.89 ft NAVD88, respectively (Table 3-1). In addition, Table 3-1 also presents the water level elevations expected today under 5-, 10-, 20-, and 50-year storm conditions.

In addition to the present day water level elevations, corresponding data from two future years, 2030 and 2070, are also presented in Table 3-1, assuming a high sea-level rise scenario (i.e., assuming a high emissions trajectory). Sea-level rise (SLR) by itself and SLR combined with storm events have most commonly been evaluated by simply increasing the water surface elevation by the projected SLR and comparing the new water elevation with the topographic elevations of the land. While this simplified "bathtub" approach can provide a first order assessment of potentially vulnerable areas, it does not accurately represent the dynamic nature of coastal storm events. To develop more refined flood vulnerability projections, the BH-FRM utilized high-resolution hydrodynamic modeling, which included multiple key processes that affect coastal water levels, such as riverine flows, tides, waves, winds, storm surge, sea level rise, and wave set-up. SLR scenarios were modeled for four distinct time periods (2013 [i.e., Present Day], 2030, 2070, and 2100) to bracket the potential future sea level rise outcomes for the Boston Harbor area. SLR estimates were taken from Figure ES1 of Global Sea Level Rise Scenarios for the United States National Climate Assessment (NOAA 2012). Final sea level heights were adjusted for local subsidence rates.

Table 3-1. Water level elevations at Watson Park, Braintree from the BH-FRM.

Water Level (ft, NAVD88)	Present Day	2030	2070
Mean Low Water	-4.89	-3.91	-1.35
Mean High Water	4.82	5.80	8.36
5-year	7.7	9.1	11.0
10-year	8.1	9.3	11.6
20-year	8.6	9.8	12.2
50-year	9.0	10.1	12.5

Ground elevations throughout much of Watson Park range between 7.5 and 9.0 feet (NAVD88). The results in Table 3-1 indicate that even today, high return frequency storms (i.e., 5- and 10-yr events) will impact portions of the park, with larger less frequent storm events (i.e., 20- and 50-yr events) will flood almost the entire park area. Although everyday water levels will not crest the banks of the Fore River until approximately 2070, by as early at 2030 even a 5-yr return period event could produce water level elevations of 9.1 feet (NAVD88) capable of flooding almost all of Watson Park. By 2070, the projected MHW elevation is 8.36 feet (NAVD88), which would flood large portions of the park on a twice daily basis.

3.2 WAVE IMPACTS

In additional to the water levels, Woods Hole Group also considered potential wave impacts to the shoreline, as these impacts could be contributing to the observed erosion and depending on the intensity of potential wave impacts, could dictate future erosion mitigation remedies for the site. Wave impacts were considered from two separate sources: locally generated wind waves and boat wakes produced from the vessels using the Fore River. Impacts from both of these sources are described in more detail in the sub-sections below.

3.2.1 Locally generated wind waves

When considering wind waves, it is necessary to evaluate accurate long-term wind data. Woods Hole Group acquired data on the sustained wind speeds and wind directions from Boston Logan International Airport from January 1, 1945 through January 6, 2019 (Iowa State University, 2019). Figure 3-1 shows the wind rose produced from this 74 year record of observations at Logan. Presented in a circular format, the wind rose shows the frequency of winds blowing from particular directions for a given time period. The length of each "spoke" or “pie piece” around the circle is related to the frequency that the wind blows from that particular direction. Each spoke is further broken down into color-coded bands that show wind speed ranges, so it is possible to determine not only which directions wind come from most frequently overall, but also which direction is more likely to produce very calm or very strong wind speeds. The predominant wind direction at Logan is from the West (270°) and West-Northwest (292.5°), as evidenced by the longest spokes emanating from those directions (Figure 3-1). Although the overall frequencies of wind observations from the offshore direction, between North-Northeast (22.5°) and South-Southeast (157.5°) are lower, when wind does originate offshore, it is less likely to be calm, as evidenced by the very small <10 mph observations (depicted in light blue) in Figure 3-1.

Initial review of this 74-year dataset identified several significant outliers from the long term record, which were removed. Annual maxima for each of the 74 years were then extracted from the total record and used to model wind speeds during various storm conditions. An extremal analysis was conducted to develop low-frequency return period wind speeds for the 5-, 10-, 25- and 50-year return frequency sustained wind events using the EXTRM2 extremal analysis program (Resio, 1989). This program computes results using a Gumbel extreme value distribution. The results from the EXTRM2 extremal analysis are presented in the wind speed columns of Table 3-2.

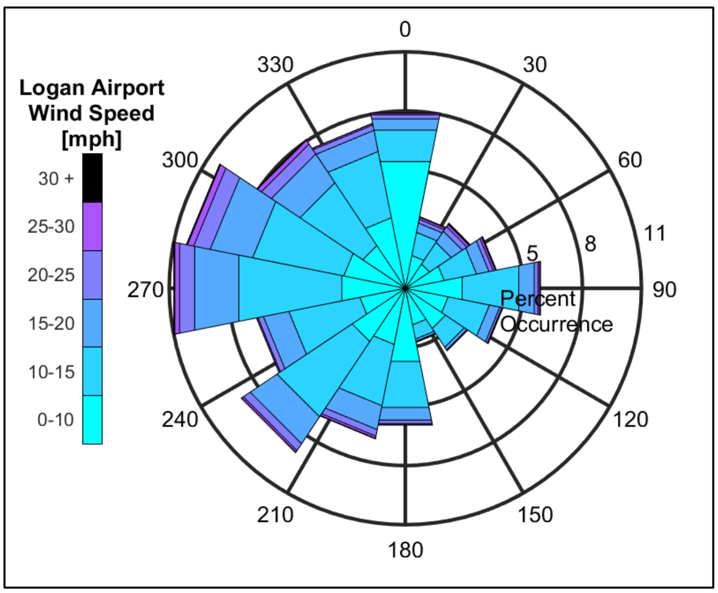

Figure 2-1. Wind rose showing the directions and sustained wind speeds at Boston Logan International Airport from January 1945 through January 2019.

The Fore River near Watson Park is not subject to waves generated in the relatively open waters of Hingham Bay due to the sinuosity of the river. Instead, any wave action in the study area is likely to be generated within the local embayment. In enclosed basins such as this, both the wave height and the wave period are limited by the distance of open water over which the wind can blow, referred to as the fetch. Fetch limited waves in enclosed basins have the potential to attain the largest sizes along the longest fetch length. Figure 3-2 shows potential fetch lengths measured within the study area. Fetch length was calculated radially in 22.5° increments. The longest fetch (1,578 feet) in the study area was for winds generated from the west-southwest (247.5°), followed by the fetch from east-northeast (67.5°), which was only slightly shorter at a length of 1,275 feet.

Based on the fetch measurements described above, a wind direction of 247.5° was used to generate the largest possible waves. An average basin depth of 6.76 feet[1] was used for the Automated Coastal Engineering System (ACES) (Leenknecht, Szuwalski, & Sherlock, 1992) wind-wave prediction module to calculate the wave periods and wave heights associated with each of the extreme value distributions for the 5-, 10-, 25-, and 50-year wind events, calculated previously using the Gumbel extreme value distribution. These wave height and wave period results are listed in Table 3-2. Due to the limited fetch length, the largest potential waves at the 50-year recurrence level are not expected to exceed 1.3 feet, with an associated peak wave period of less than 2 seconds. It is also worth noting that the modeled wave heights do not change in the future given projected sea level rise.

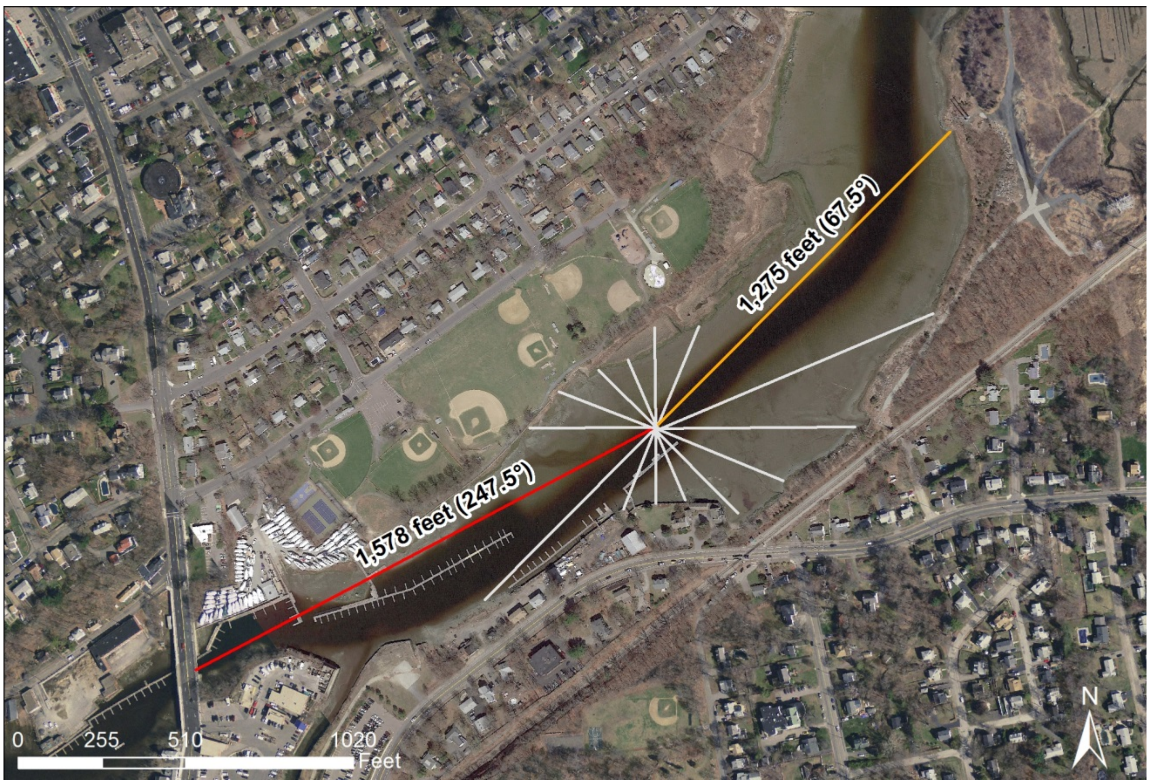

Figure 3-2. Fetch lengths for wind generated waves in the Fore River at Watson Park.

[1] Depth information for was extracted from topo-bathymetric grid used as an input for BH-FRM.

Table 3-2. Return period wind and wave conditions in the Fore River.

Return Frequency (yr)	Wind Speed (mph)	Mean Wave Height (ft)	Peak Wave Period (s)
5	50.2	0.92	1.66
10	54.9	1.04	1.74
25	60.9	1.18	1.85
50	65.4	1.3	1.93

3.2.2 Vessel Wakes

In addition to wind generated waves, Woods Hole Group also evaluated the potential impacts from boat wakes at the site. There are several marinas in the immediate vicinity of Watson Park with approximately 188 boat slips capable of mooring boats. Additionally, there is at least one publically accessible boat ramp, within the Braintree Yacht Club west of the park, although public parking is limited. Boat wakes generated by vessels are related to both the geometry of the vessels and the speed at which the boats operate. Using the range of measured dimensions (length and beam) for the boats shown in Figure 3-3, an estimated range of vessel drafts, along with two speeds (an idle speed of 5 mph, and a secondary speed of 10 mph), Woods Hole Group calculated the potential wake heights and wake periods that could be generated in this area. The lower vessel speed (i.e., 5 mph) was chosen as the entire area is posted as a “No Wake” zone; vessels operating by the posted rules would not likely produce wakes exceeding these predictions. The higher speed (i.e., 10 mph) was chosen as there was anecdotal evidence of boaters occasionally ignoring the ”No Wake” signage.

Figure 3-3. Aerial view of the Fore River near Watson Park during June 2016, showing the approximate size of vessels likely to use this reach of river.

Wave heights associated with the vessel wakes for all vessel geometries and speeds were calculated using Equation 1 (Sorenson, 1997):

$$H_m = 0.0448 * V_s{}^2 * \sqrt{\frac{D_v}{L_v} * \left(\frac{S_c - 1}{S_c}\right)^{2.5}} \qquad \textit{Equation 1}$$

where V_s is the vessel speed in feet per second, D_v is the vessel draft in feet, L_v is the vessel length in feet, and S_c is the channel cross-section coefficient represented as the channel area in square feet divided by the wetted perimeter in feet.

The wave periods were calculated using Equation 2 (PIANC, 1987):

$$T_p = 0.82 * V_s * \frac{2\pi}{g} \qquad \textit{Equation 2}$$

where T_p is the peak wave period, and g is the acceleration due to gravity (32.2 ft/s^2). Results of the wave characteristics at the lower idle vessel speed (5 mph) are listed in Table 3-3, while the wave characteristics associated with the faster vessel speed (10 mph) are listed in Table 3-4. Shaded cells in Tables 3-3 and 3-4 represent unrealistic combinations of vessel lengths and drafts; boat wakes were therefore not calculated for these vessel sizes.

Regardless of size, vessels traveling at 5 mph or lower (i.e., following the “No Wake” rules) would not produce wakes greater than 0.5 feet (Table 3-3). Vessels of any length ignoring the “No Wake” signs and traveling at speeds of 10 mph could produce wakes up to 2 feet high (Table 3-4).

Table 3-3. Vessel wakes (height in feet) produced as 5 mph by a variety of small craft sizes that are likely to be navigating the Fore River. The associated wave period with the 5 mph velocity was calculated as 1.2 seconds.

	Vessel Draft					
Vessel Length	**1.5 ft**	**2 ft**	**2.5 ft**	**3 ft**	**3.5 ft**	**4 ft**
20 ft	0.43	0.50				
25 ft	0.38	0.44	0.50			
30 ft	0.35	0.40	0.45	0.50		
35 ft			0.42	0.46	0.50	
40 ft				0.43	0.46	0.50

Table 3-4. Vessel wakes (height in feet) produced as 10 mph by a variety of small craft sizes that are likely to be navigating the Fore River. The associated wave period with the 10 mph velocity was calculated as 2.3 seconds.

	Vessel Draft					
Vessel Length	**1.5 ft**	**2 ft**	**2.5 ft**	**3 ft**	**3.5 ft**	**4 ft**
20 ft	1.72	1.98				
25 ft	1.54	1.77	1.98			
30 ft	1.40	1.62	1.81	1.98		
35 ft			1.68	1.84	1.98	
40 ft				1.72	1.85	1.98

3.2.3 Summary of Wave Impacts

Wind generated waves are likely to be a contributor to the erosion of the coastal bank at Watson Park. However, due to the relatively small size of wind generated waves (only 1.45-foot wave heights at the 50-year return level) combined with a low expected return rate of sizable storm generated wind waves, storm waves are not expected to be the sole mechanism for erosion. It is possible that wakes produced by vessel traffic are also contributing to the erosion observed along the coastal bank. A preliminary analysis of the vessel sizes moored at the nearby marinas identified vessel lengths ranging from 20 to 40 feet in length. This was used as a proxy for the likely vessel sizes to operate in this section of the Fore River, including boats launched from the public boat ramp. Regardless of size, however, when vessels are operated inappropriately (i.e., not following the "No Wake Zone" rules) at speeds of 10 mph or more, they are capable of generating wakes almost 2 feet high. Given the large volume of vessels likely to operate in the vicinity of Watson Park on a regular basis during the summer, even if only a fraction of boat operators disregard the "No Wake Zone" rules, the combined effect of frequent (in comparison to the 50-yr return event) vessel wakes may also be contributing to the observed erosion.

3.3 SHORELINE CHANGE ANALYSIS

Detailed shoreline change data exists for much of the Massachusetts coastline through the Massachusetts Office of Coastal Zone Management (CZM) Shoreline Change Project, which illustrates how the shoreline of Massachusetts has shifted between the mid-1800s and 2009. Unfortunately, due to the relatively upstream/inland location of Watson Park along the Fore River, the CZM Shoreline Change Project does not contain any data for this location. Therefore, in order to have a better understanding of how this shoreline has changed overtime, a detailed site-specific shoreline change analysis was conducted for this site.

A computer-based shoreline mapping methodology within a Geographic Information System (GIS) framework was used to compile and analyze changes in the historical high water line along Watson Park. The purpose of this task was to quantify the spatial and temporal changes in shoreline position using the most accurate data sources and compilation procedures available, and to evaluate the long-term rates of change. Assuming that the trends continue at the same rate into the future, the information from the shoreline change analysis can also be used to predict patterns of shoreline erosion over the next several decades.

Woods Hole Group compiled and analyzed aerial photographs from MassGIS, GoogleEarth, and USGS. Data covering nine (9) time periods were evaluated spanning the 49-year period from 1969 to 2018 (Table 3-5).

Table 3-5. Data Sources for Shoreline Change Analysis.

Year	Source
2018	GoogleEarth
2016	GoogleEarth
2013	MassGIS
2008	MassGIS
2005	MassGIS
2001	MassGIS
1995	MassGIS
1975	USGS EarthExplorer
1969	USGS EarthExplorer

Woods Hole Group acquired the photos from MassGIS as georeferenced orthoimagery. However, the aerial photos acquired from GoogleEarth and USGS EarthExplorer were not tied to a geographic coordinate system and could not be directly compared with historical map data or with each other without geo-referencing them to a common horizontal coordinate system and scale. All photos from these sources were obtained as high-resolution digital images. Georeferencing was accomplished by identifying a series of evenly spaced control points on the images for which real world x, y coordinates were known. The 2013 MassGIS orthoimagery was utilized as the base image from which the ground control was obtained for all georeferencing.

Once the aerial photographs were geo-referenced and all data sources were brought to a common coordinate system, the locations of the high water line (HWL) were identified and digitized from each of the nine (9) data sources. Once these data were compiled, spatial and temporal changes in the data were computed. This was accomplished by identifying a series of shore normal transects along the coastline where discrete measurements of change could be made through time, and where rates of change could be determined. A total of 35 shore normal transects were established at 50 foot evenly-spaced intervals along the coastline. At each transect, distances of shoreline movement were calculated, and annual rates of change were determined using the various time intervals between the data sources. Rates of change were calculated using the linear regression method. In this method, an average rate of change is based on a best-fit line to a series of points representing the shoreline/bank position over time. The linear regression method is most accurate when looking at long-term averages and is most often used for planning purposes and management decisions.

The digitized positions of the HWLs from each year, as well as the transect locations, are shown in Figure 3-4. Shoreline change rates were analyzed for the entire time period (1969 to 2018) to provide long-term trends, as well as two sub-periods (1969 to 1995 and 1995 to 2018) to determine if these periods of time had significantly different trends. The linear regression rates of shoreline change from these time periods are presented in the inset graph in Figure 3-4.

In general, the rate of change results from 1938 to 2016 show two areas of significant change along the Watson Park shoreline. The first, between transects 14 and 18, aligns with the area of significant coastal bank erosion observed around the stormwater outfall pipes, with erosion rates as high as -2.2 ft/yr. The second, between transects 28 and 35, represents an area of significant salt marsh loss over the last 49 years, although this portion of the shoreline is much less visible from the park itself. The rates of change in this area between 1969 and 2018 were as high as -2.7 ft/yr. The average rate of erosion across the entire study area is -0.9 ft/yr, and the 1969 to 2018 rates indicate no accretion (i.e., the blue line in the graph in Figure 3-4 is always below 0). Similar trends were observed during both additional sub-periods (1969 to 1995 and 1995 to 2018). However, the rates of erosion calculated between 1995 and 2018 were greater than those between 1969 and 1995 (i.e., the green line in the graph in Figure 9 (1995 to 2018) is consistently below the red line (1969 to 1995)), indicating that overall the rates of erosion have increased over time.

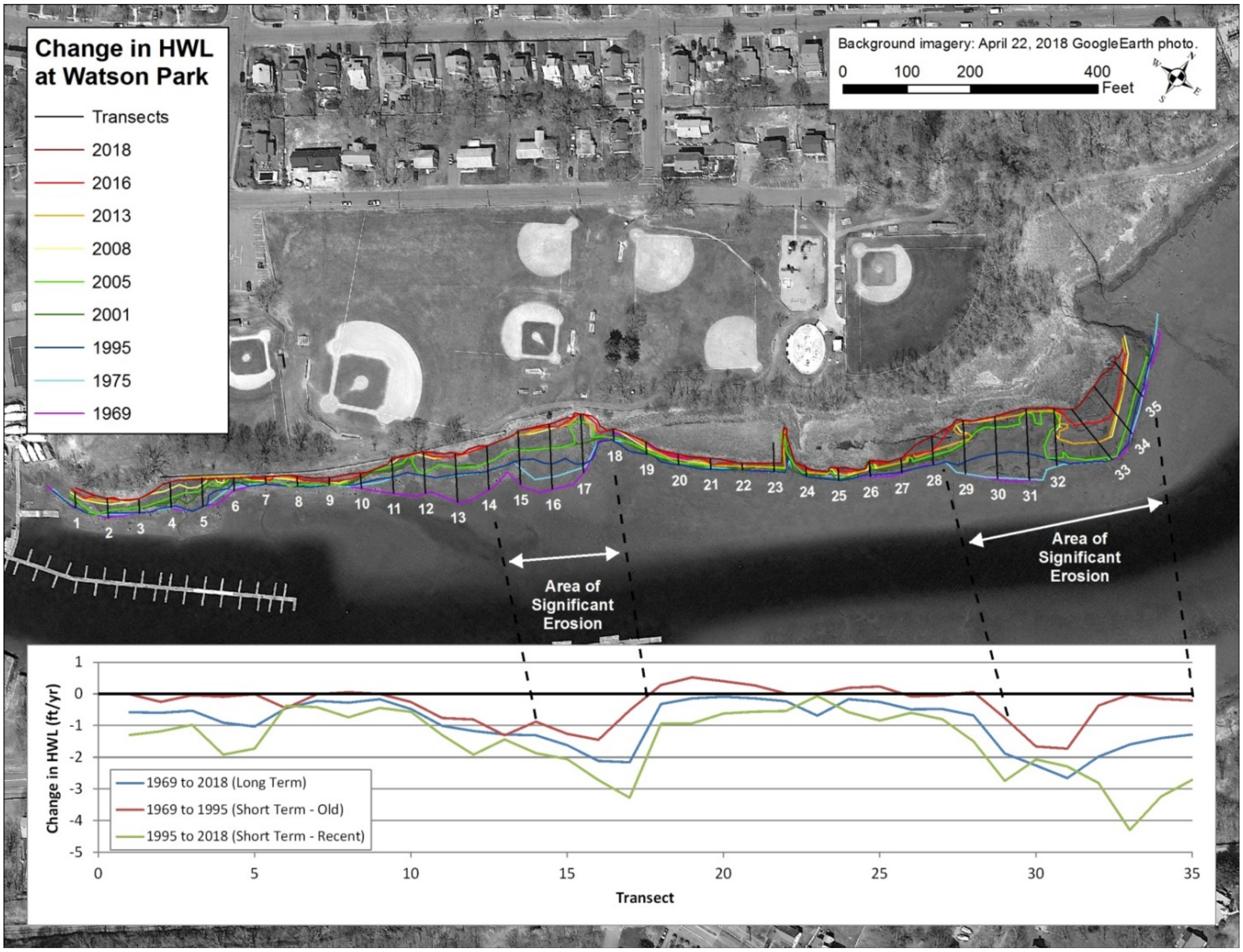

Figure 3-4. Historical shoreline positions and locations of transects.

3.4 SLAMM RESULTS

In addition to present and future water levels, wave impacts and erosion rates, with a site such as this, it is also useful to consider the potential long-term habitat changes likely to occur as a result of sea level rise. Woods Hole Group recently completed a study for CZM to model the effects of sea level rise on coastal wetlands and natural resources statewide (Woods Hole Group 2016). The software Sea Level Rise Affecting Marshes Model (SLAMM) was used to assess the sea-level rise impacts to natural resources.

High resolution elevation data are one of the most important SLAMM inputs, since the elevation data will determine the extent and frequency of salt water inundation when combined with tide range data, as well as helping to define the lower elevation boundary for beaches, wetlands and tidal flats, dictating when these resource areas should be converted to a different land-cover type or open water due to an increased frequency of inundation. For this study, 2011 USGS LiDAR data was utilized as the initial elevation input for this area of the state (at the time it was the most recent LiDAR dataset available). In addition to detailed elevation information, SLAMM also requires an initial classification of the existing wetland conditions. For this, the 2011 wetland layer developed by the National Wetlands Inventory (NWI) was used as the baseline wetland classification for the wetland modeling. Simulations were performed for a range of SLR scenarios. To be consistent with the BH-FRM results presented in Section 3.1, the SLAMM results from the high SLR scenario simulations are presented here.

Figures 3-5 through 3-8 show the wetland classification area results for 2011, 2030, 2050, 2070, and 2100. Figure 3-5 presents the current (i.e., 2011) conditions, as defined by the NWI data. Figures 3-6, 3-7, 3-8 and 3-9 show the change in wetland classifications and extents projected in 2030, 2050, 2070, and 2100 respectively, as a result of sea-level rise under a high emissions scenario.

Implications of these results include:

- Little to no landward migration of the upland edge of the salt marsh is projected between now and 2050, although the area of coastal beach/tidal flat fronting Watson Park is projected to significantly decrease in width during that time. Because the top of the coastal bank in the vicinity of the salt marsh is at an elevation of approximately 8 feet (NAVD88), salt marsh is unlikely to expand considerable landward until sea-level rise results in daily high tides that exceed that elevation. A mean high water (MHW) elevation of 8.36 is not expected until 2070 (Table 3-1).
- Between 2050 and 2070 the salt marsh is projected to transition from predominantly irregularly flooded marsh (i.e., high marsh) to predominantly regularly flooded marsh (i.e., low marsh).
- By 2070 (Figure 3-8), a large portion of Watson Park is projected to be wetland, comprised largely of Tidal Swamp and Transitional Marsh/Scrub Shrub; these habitat types are often found along the upper edges of salt marshes and other estuarine wetlands, and may be only seasonally wet. With this increased wetland extent, however, it is likely that the majority of Watson Park will no longer be a suitable location for recreational fields. Under this scenario, the fields at either end of the park (Sheridan and Delory Fields) will still be useable given their slightly higher elevations.
- By 2100 (Figure 3-9), under a high sea-level rise scenario, the wetlands within the park area are projected to transition primarily to Regularly Flooded Marsh (i.e., low marsh). In addition, the spatial extent of the wetlands is projected to expand, resulting in a conversion of significant parts of both Sheridan and Delory Fields to wetland as well.

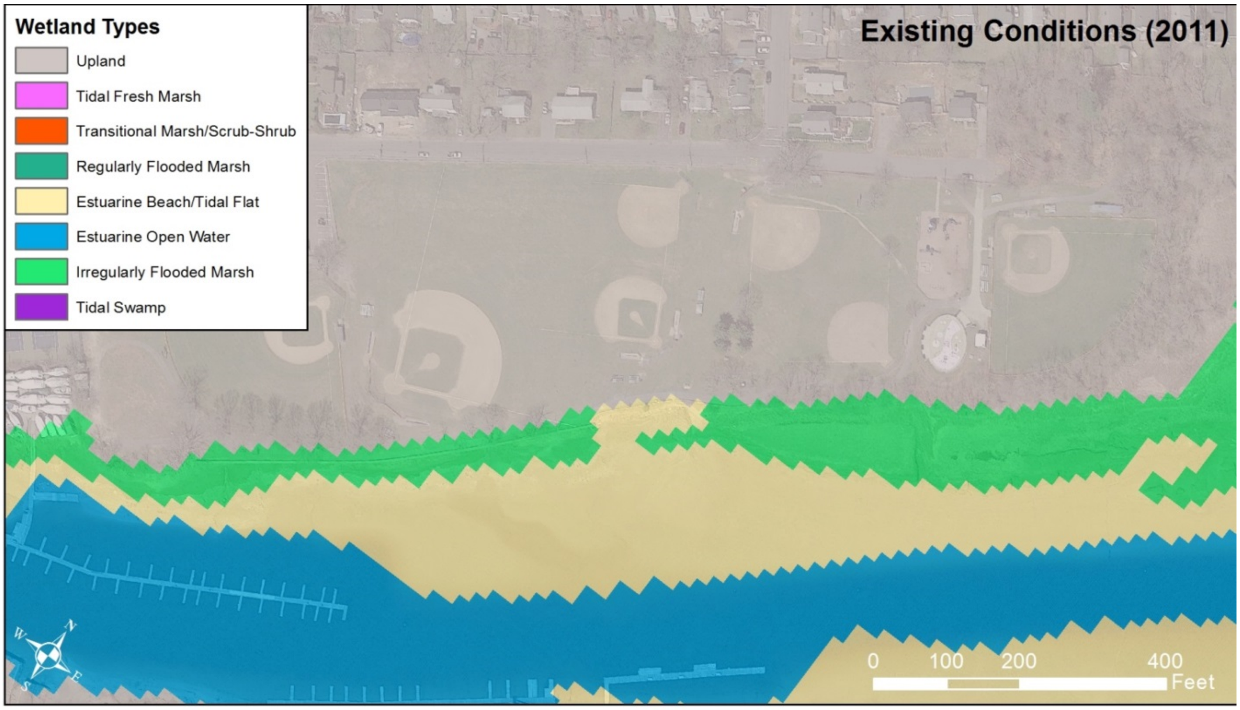

Figure 3-5. Wetland classifications under existing conditions (i.e., 2011) used as input data for the SLAMM modeling.

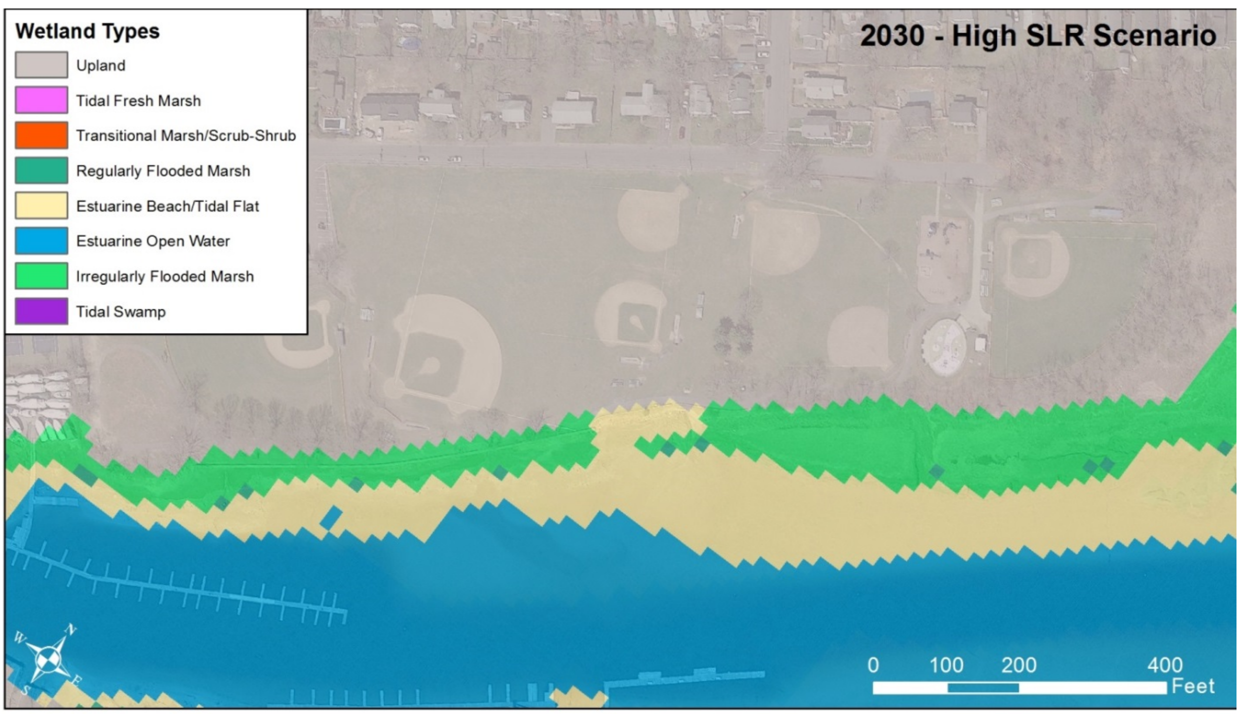

Figure 3-6. SLAMM results for projected wetland conditions in 2030 under "high" sea-level rise conditions.

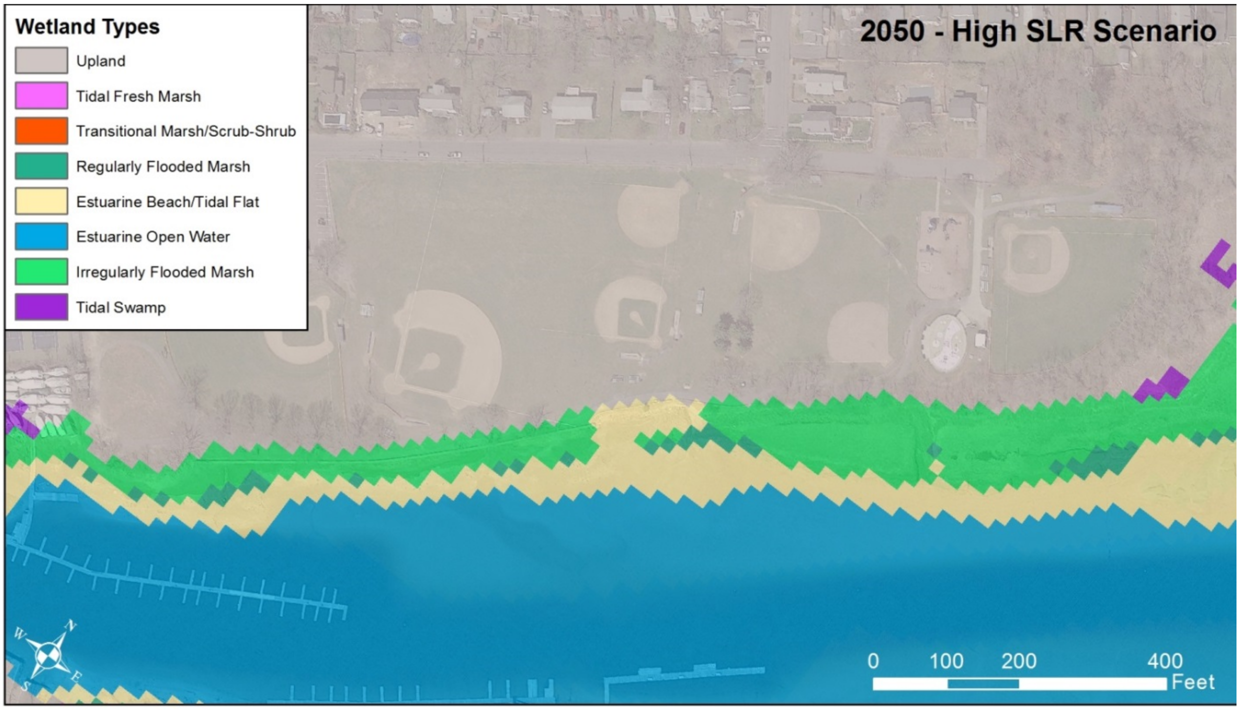

Figure 3-7. SLAMM results for projected wetland conditions in 2050 under "high" sea-level rise conditions.

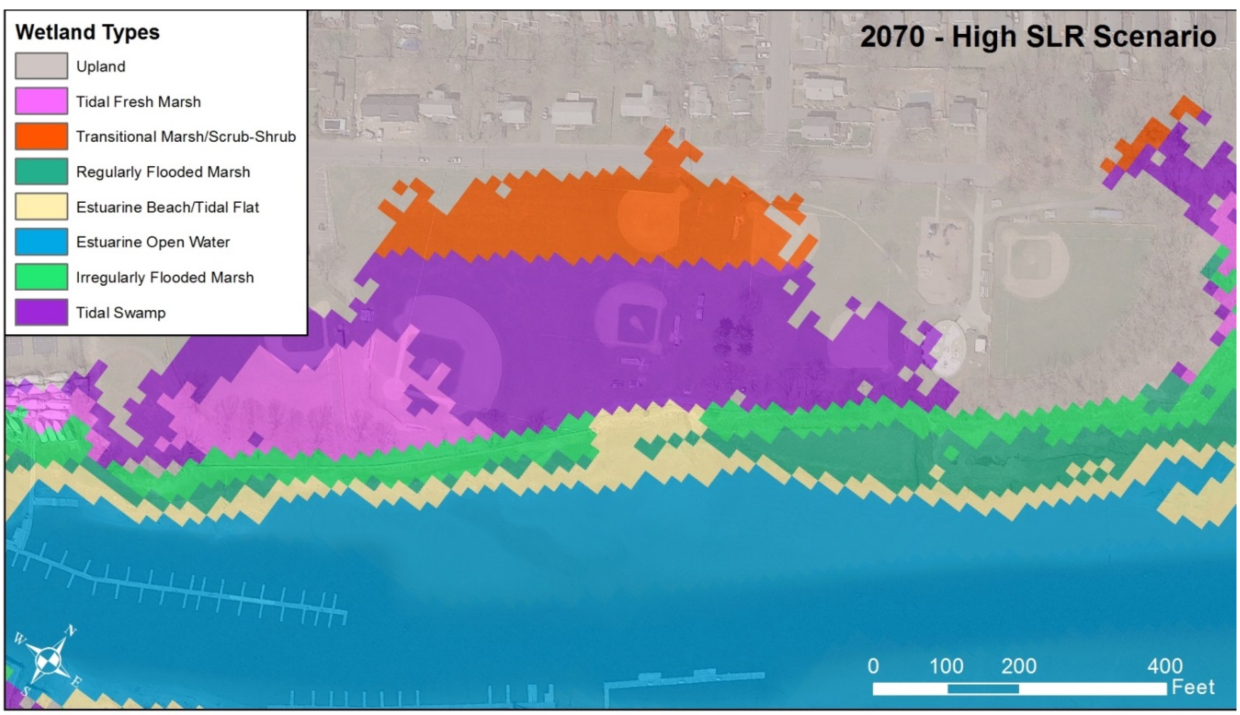

Figure 3-8. SLAMM results for projected wetland conditions in 2070 under "high" sea-level rise conditions.

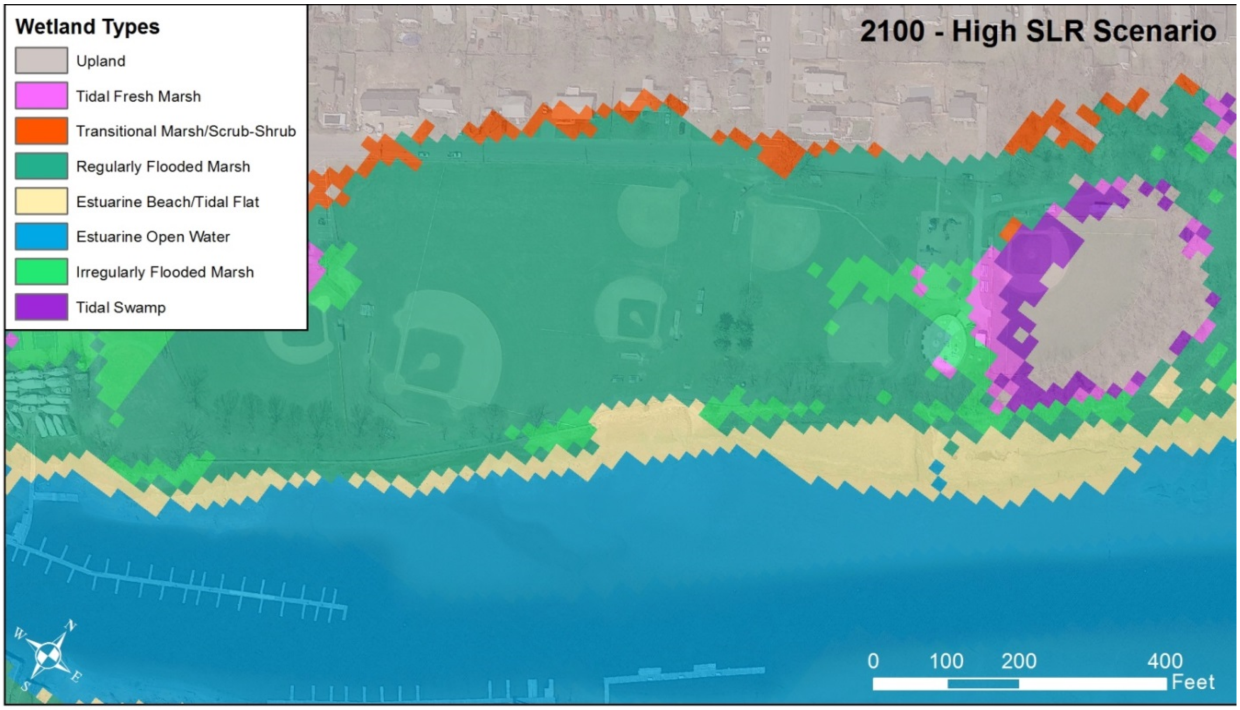

Figure 3-9. SLAMM results for projected wetland conditions in 2100 under "high" sea-level rise conditions.

4.0 ALTERNATIVES ANALYSIS

This section details the development and evaluation of multiple alternatives to address the erosion occurring along the shoreline of Watson Park, as well as development of recommendations to address the possibility of the Town retreating from active recreational use of the ball fields to allow for migration of the salt marsh. These alternatives and future management recommendations draw from the results of the coastal processes analyses presented in Section 3. The results of the alternatives analysis and proposed long-term plan for salt marsh migration are summarized below.

4.1 GREEN INFRASTRUCTURE ALTERNATIVES

Based on the existing and expected future conditions at Watson Park, Woods Hole Group developed a suite of green infrastructure shoreline stabilization and flood prevention alternatives. Due to the unique nature of the site, Woods Hole Group developed a separate set of alternatives for three different components of the project:

1. Pipe outlet and salt marsh restoration;
2. Bank stabilization; and
3. Flood protection (optional).

Prior to the start of the project, it was obvious to Town staff that there were ongoing erosion and deterioration of the existing salt marsh and coastal bank in the vicinity of the storm water outfall. This project was implemented primarily to address those concerns. However, after completing the coastal processes analyses, it became evident that additional measures may be warranted to address flood risk to the fields in the short term. Although the elevation of the main field area will not be subject to daily tides until approximately 2070, and therefore won't be suitable for salt marsh migration and establishment, the fields will become increasingly vulnerable to flooding during storm events. As a result, a suite of flood protection alternatives were also evaluated. In many cases, a successful green infrastructure project is one that incorporates multiple components, each uniquely designed for different elevations within a single site. If one alternative is selected for each of the above project components, then their combined effect will be more beneficial than any one component by itself.

This section provides a description of each of the alternatives, while Section 4.2 presents the alternatives analyses, which account for the relative feasibility, effectiveness, benefits and potentially adverse impacts of each. This evaluation was designed to help the Town select the most appropriate alternative(s) for the site. Alternatives for each project component are described below separately, and were meant to be considered a "menu" of green infrastructure alternatives. Any alternative for repair of the storm water outfall and restoration of the salt marsh can be combined with any alternative for coastal bank stabilization. Finally, depending on the Town's risk tolerance for flooding within Watson Park, an optional flood protection component could be added to any combination of pipe/salt marsh options and coastal bank stabilization alternatives.

4.1.1 Pipe outlet and salt marsh restoration alternatives:

This set of alternatives is focused on the intertidal portion of the site, and predominantly focuses on restoring the salt marsh habitat and redesigning the storm water outfall to reduce scour. Salt marsh was chosen as a consistent element in all four alternatives due to the historical presence of salt marsh at this site, and the continued existence of salt marsh immediately adjacent to the area of concern. By implementing a living shoreline project with salt marsh as its main component, we are essentially restoring the site to a previous condition. Additionally, the project alternatives assumed that it would be necessary to incorporate the stormwater pipe outlets into the design, as the stormwater captured by the catchment basins along Gordon Road and the surrounding neighborhood will continue to need a pathway to the river. However, to improve upon the existing conditions, all of the alternatives presented here would incorporate a check valve or tide gate at the seaward end of the pipes to ensure that flow through the pipe is unidirectional, and flood water will not transfer back up the system during high tides or flood conditions.

Pipe/Marsh Alternative 1: Habitat Enhancements with Pipes in Place

This alternative (Figure 4-1) involves repairing the headwall and the seaward portion of the storm water pipes within their existing footprint. As mentioned above, a check valve or tide gate will be added to the seaward end of the pipes to ensure that flow through the pipe is unidirectional. Alternative 1 also involves restoration of the salt marsh habitat on either side of the existing outfall location, as well as enhancement of the rocky intertidal shore habitat seaward of the pipe outfall. The alternative involves approximately 3,750 square feet of salt marsh habitat restoration, across approximately 210 linear feet of shoreline. At a minimum, coir logs would be placed at the toe of the restored salt marsh to stabilize the fill brought in to establish appropriate elevations for salt marsh restoration. It may also be prudent to incorporate some stone as added toe protection, depending on how much fill is required and whether additional stabilization is needed. Utilization of natural fiber erosion control blankets (ECBs) immediately following construction could also help to hold the fill material in place until the newly planted marsh vegetation fully establishes. Given the presence of rockweed (F*ucus sp*.) along the existing beach, it is possible that the seaweed could attach to the ECBs and adversely affect the establishment and health of the salt marsh vegetation. As such, monitoring for and removal of any attached macroalgae would be required on a regular basis. Alternative 1 also involves approximately 900 square feet of rocky intertidal shore habitat enhancement. Not only will this provide additional hard substrate on which invertebrates and macroalgae can establish, but it will also minimize scour and erosion of the beach caused by high velocity flows that emanate from the outfall pipe during and following a heavy rain event. Much of the stone required for this portion of the project could be acquired on site and relocated from within the footprint of the salt marsh restoration.

Figure 4-1. Conceptual design for Pipe/Marsh Alternative 1: Habitat Enhancements with Pipes in Place.

Pipe/Marsh Alternative 2: Stone Forebay Landward of Existing Outlets

This alternative (Figure 4-2) involves relocating the headwall and the seaward portion of the storm water pipes approximately 50 feet landward. As mentioned above, a check valve or tide gate will be added to the seaward end of the pipes to ensure that flow through the pipes is unidirectional. This alternative involves the creation of a stone sediment forebay between the relocated headwall and the existing walking path. This forebay would reduce the velocity of the storm water as it leaves the pipes, reducing the scouring on the beach and tidal flat. A sediment forebay such as this could be designed in such a way that it could be an attractive landscape feature, ornamental fencing could be added to ensure safety around the basin, and the walking path could incorporate a bridge, bringing visual interest to the site. Note that because detailed flow data from the existing stormwater outlets was not available, the forebay may need to be somewhat larger than what is pictured below to adequately handle the flow.

Like Alternative 1, this alternative also involves the restoration of salt marsh habitat on either side of the existing outfall location, as well as enhancement of the rocky intertidal shore habitat. This alternative involves approximately 3,750 square feet of salt marsh habitat restoration, across approximately 210 linear feet of shoreline. At a minimum, coir logs would be placed at the toe of the restored salt marsh to stabilize the fill brought in to establish appropriate elevations for salt marsh restoration. It may also be prudent to incorporate some stone as added toe protection, depending on how much fill is required and whether additional stabilization is needed. Utilization of natural fiber erosion control blankets (ECBs) immediately following construction could also help to hold the fill material in place until the newly planted marsh vegetation fully establishes. Given the presence of rockweed (F*ucus sp*.) along the existing beach, it is possible that the seaweed could attach to the ECBs and adversely affect the establishment and health of the salt marsh vegetation. As such, monitoring for and removal of any attached macroalgae would be required on a regular basis. In addition, Alternative 2 also involves approximately 900 square feet of rocky intertidal shore habitat enhancement, although it is likely that less stone will be required in the intertidal zone to protect from scour, since flow velocities will be significantly reduced in the landward forebay. Much of the stone required for this portion of the project could be acquired on site and relocated from within the footprint of the salt marsh restoration.

Figure 4-2. Conceptual design for Pipe/Marsh Alternative 2: Stone Forebay Landward of Existing Outlets.

Pipe/Marsh Alternative 3: Pipe Extension and Marsh Restoration

This alternative (Figure 4-3) involves dismantling the existing headwall and extending the pipe outlets approximately 75 to 100 feet seaward. As mentioned above, a check valve or tide gate will be added to the seaward end of the pipes to ensure that flow through the pipes is unidirectional. By extending the pipe seaward, the salt marsh habitat can be restored cohesively over the pipes, resulting in approximately 4,200 square feet of salt marsh restoration, across approximately 230 linear feet of shoreline. At a minimum, coir logs would be placed at the toe of the restored salt marsh to stabilize the fill brought in to establish appropriate elevations for salt marsh restoration. It may also be prudent to incorporate some stone as added toe protection, depending on how much fill is required and whether additional stabilization is needed. Utilization of natural fiber erosion control blankets (ECBs) immediately following construction could also help to hold the fill material in place until the newly planted marsh vegetation fully establishes. Given the presence of rockweed (F*ucus sp*.) along the existing beach, it is possible that the seaweed could attach to the ECBs and adversely affect the establishment and health of the salt marsh vegetation. As such, monitoring for and removal of any attached macroalgae would be required on a regular basis. One drawback of extending the pipe so far seaward, however, is that stormwater effluent sampling would not be feasible during higher tides.

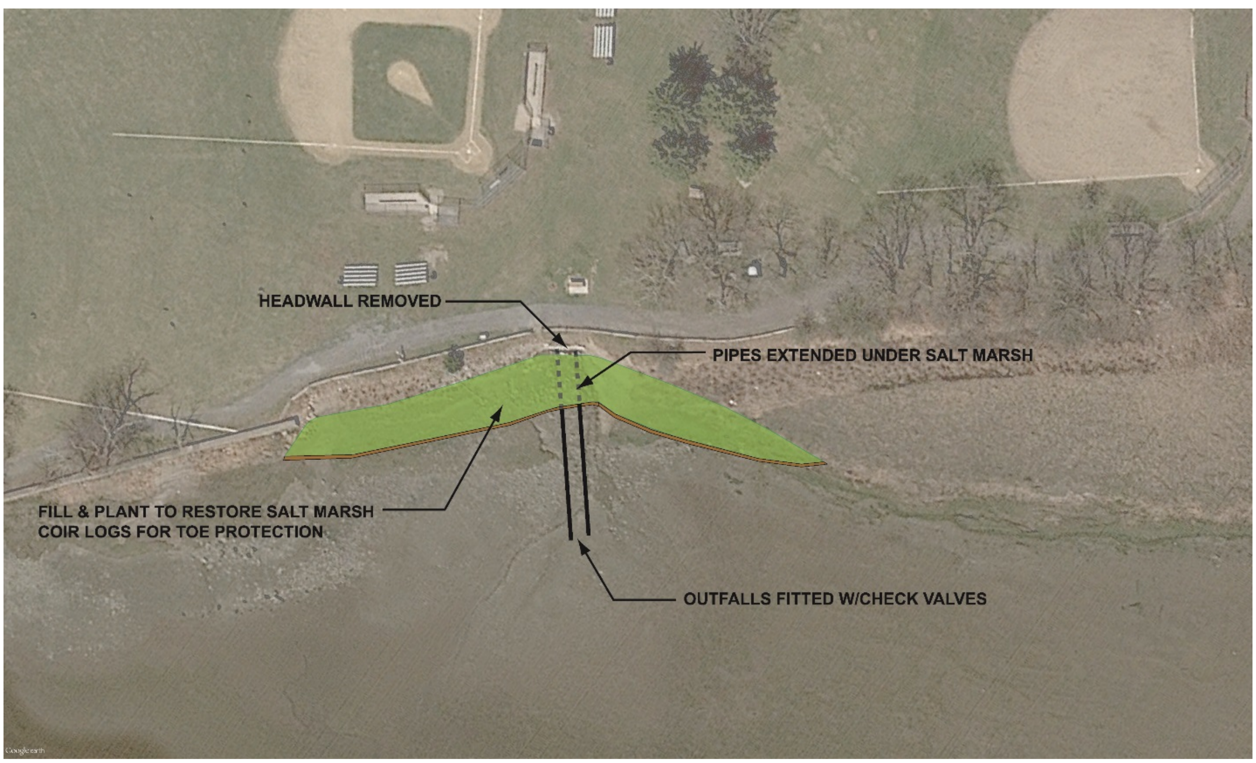

Figure 4-3. Conceptual design for Pipe/Marsh Alternative 3: Pipe Extension and Marsh Restoration.

Pipe/Marsh Alternative 4: Reroute Outlets to a New Location

This alternative (Figure 4-4) involves dismantling the existing headwall and relocating the pipe outlets to a location along the existing concrete wall, approximately 250 feet to the southwest. This location is outside the existing salt marsh resource areas, and would remove the scour problem from this vulnerable section of shoreline to an area already armored by a concrete wall. Alternative 4 would also involve some rocky intertidal shore habitat enhancement. Much of the stone required for this portion of the project could be acquired on site and relocated from within the footprint of the salt marsh restoration. Furthermore, by relocating the pipe to the southwest, the salt marsh habitat can be restored cohesively at the area of interest, resulting in approximately 4,200 square feet of salt marsh restoration, across approximately 230 linear feet of shoreline. At a minimum, coir logs would be placed at the toe of the restored salt marsh to stabilize the fill brought in to establish appropriate elevations for salt marsh restoration. It may also be prudent to incorporate some stone as added toe protection, depending on how much fill is required and whether additional stabilization is needed. Utilization of natural fiber erosion control blankets (ECBs) immediately following construction could also help to hold the fill material in place until the newly planted marsh vegetation fully establishes. Given the presence of rockweed (F*ucus sp*.) along the existing beach, it is possible that the seaweed could attach to the ECBs and adversely affect the establishment and health of the salt marsh vegetation. As such, monitoring for and removal of any attached macroalgae would be required on a regular basis.

Figure 4-4. Conceptual design for Pipe/Marsh Alternative 4: Reroute Outlets to a New Location.

Pipe/Marsh Alternative 5: Do Nothing

This alternative would maintain the status quo. No habitat restoration would occur, no erosion control measures would be taken, and no repairs would be made to the existing storm water pipe infrastructure, which is currently damaged and in need of repair.

4.1.2 Coastal bank stabilization alternatives:

This set of alternatives is focused on the eroding coastal bank portion of the site, and predominantly focuses on establishing a stable slope, protecting the toe of that slope, and vegetating the coastal bank. All of these alternatives would incorporate native salt-tolerant vegetation.

Bank Alternative 1: Natural Coastal Bank Stabilization

This alternative (Figure 4-5) involves stabilizing the eroding coastal bank using natural materials. In some areas, the top of the coastal bank may need to be cut back to restore a stable slope. Once an appropriate slope has been obtained, the coastal bank will be stabilized with a natural fiber erosion control blanket and planted with native, salt-tolerant vegetation. Although native vegetation will be incorporated into the design, it is unlikely that this alternative will facilitate salt marsh habitat migration in the future due to the relatively steep slopes. Coir logs can be utilized at the toe of the restored coastal bank to help stabilize the site from future erosion.

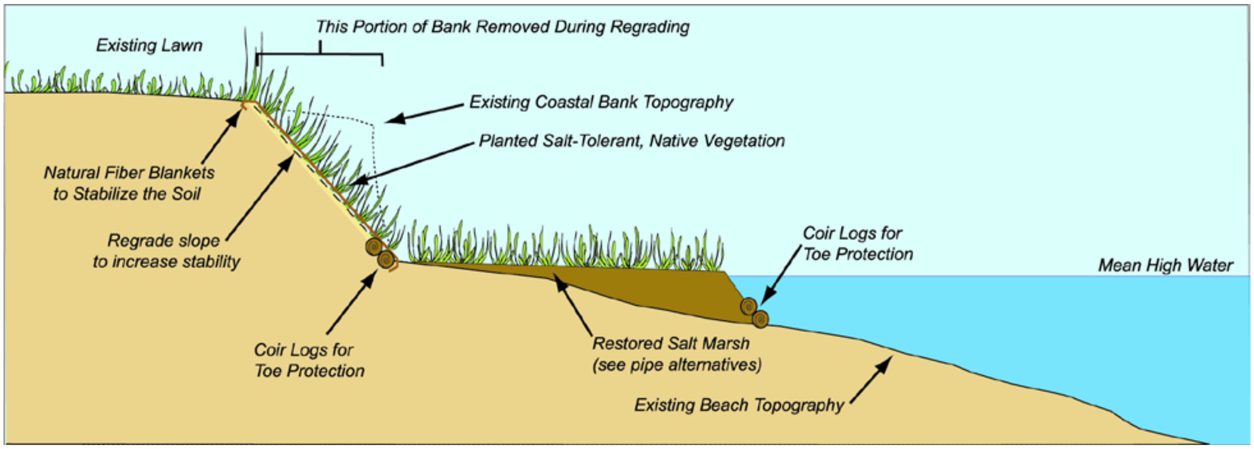

Figure 4-5. Conceptual design for Bank Alternative 1: Natural Coastal Bank Stabilization.

<u>Bank Alternative 2: Engineering Core</u>

This alternative (Figure 4-6) is similar to Bank Alternative 1, but also includes an engineered core for added stability and erosion control protection within the coastal bank. This core will be comprised of sand filled tubes or envelopes, which will be buried under native material. This alternative may also require cutting back the top of the bank in some areas to restore a stable slope. Once an appropriate slope has been obtained, the face of the coastal bank will be stabilized with a natural fiber erosion control blanket and planted with native, salt-tolerant vegetation. Although native vegetation will be incorporated into the design, it is unlikely that this alternative will facilitate salt marsh habitat migration in the future due to the relatively steep slopes. Additionally, although the inner sand filled core will provide added erosion protection for the coastal bank, it can reduce the success of plant establishment since the density of the material can interfere with root growth.

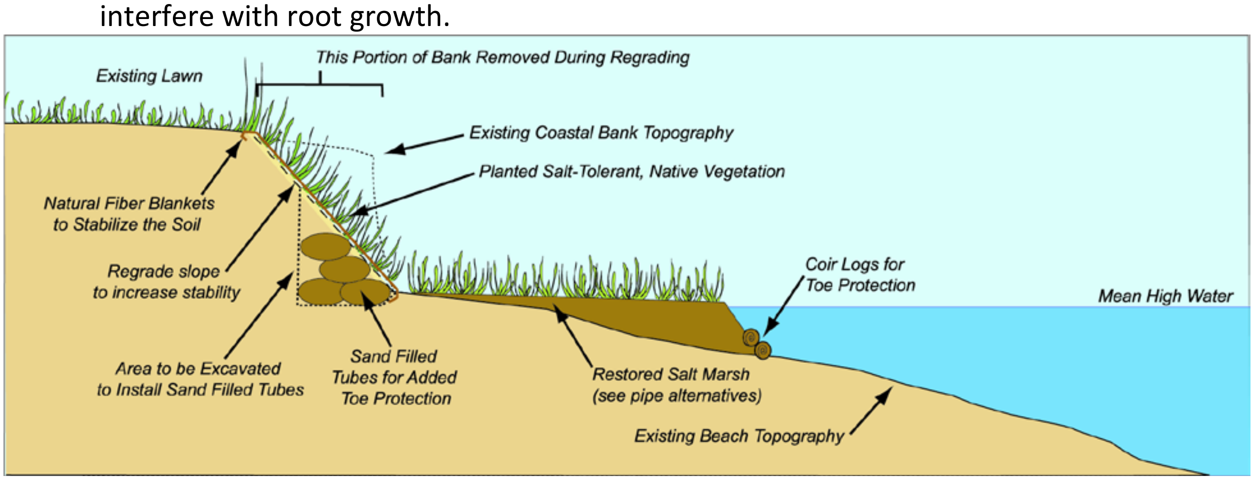

Figure 4-6. Conceptual design for Bank Alternative 2: Engineering Core.

<u>Bank Alternative 3: Vegetated Terraces</u>

While Alternatives 1 and 2 may require minor cutting back of the top of the coastal bank to restore a stable slope, this alternative (Figure 4-7) would require the largest loss of upland area due to the additional space required by the terraces. Each terrace would be supported by stone gabions and would be planted with native, salt-tolerant vegetation. Although this alternative does incorporate more hard materials, it does result in a series of terraces at successively higher elevations that could actually facilitate salt marsh habitat migration in the future as sea-level rises. Additional viewing platforms could also be easily incorporated into this design to enhance public access and recreational value of the shoreline.

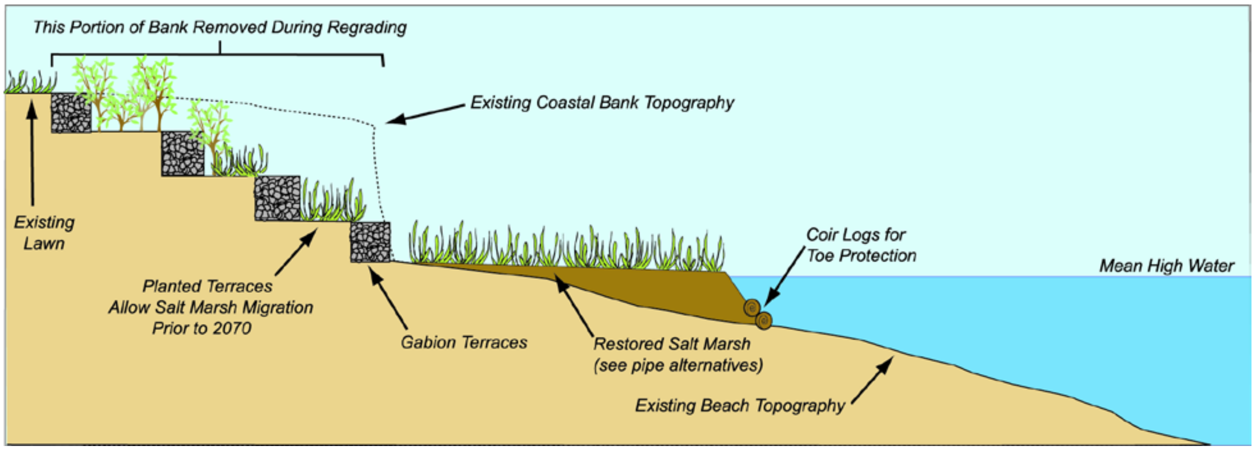

Figure 4-7. Conceptual design for Bank Alternative 3: Vegetated Terraces.

Bank Alternative 4: Do Nothing

This alternative would maintain the status quo. No habitat restoration would occur and no erosion control measures would be taken. The coastal bank would remain undercut and unvegetated.

4.1.3 Flood protection alternatives:

This set of alternatives is focused on minimizing the near-term flood risk at the baseball fields at Watson Park. Although the long-term goals for the property may include allowing or facilitating salt marsh migration, based on the SLAMM results showing the likely future wetland extents, it is unlikely that salt marsh would be able to establish in the field area prior to 2070. Because the top of the coastal bank in the vicinity of the salt marsh is at an elevation of approximately 8 feet (NAVD88), salt marsh is unlikely to expand considerable landward until sea-level rise results in daily high tides that exceed that elevation. A mean high water (MHW) elevation of 8.36 is not expected until 2070.

In the interim, although daily high tides will not likely impact the fields prior to 2070, the combination of sea-level rise and coastal storm surge will flood the field with increasing regularity during storm events. The alternatives presented below would reduce the risk of flooding in the near-term, extending the useable lifetime of the baseball fields as long as possible, but could be removed prior to 2070 to allow salt marsh habitat migration.

Flood Protection Alternative 1: Extend Wall

This alternative (Figure 4-8) involves extending the existing stone and concrete wall to the north. Although this alternative does not meet the definition of green infrastructure, given the presence of the existing wall to the southwest of the area of interest, to ensure that we considered the full suite of alternatives, we included this alternative in the evaluation. This alternative would be more permanent than alternatives 2 and 3, and may be more difficult to remove in 2070 to allow for salt marsh migration.

Figure 4-8. Conceptual design for Flood Protection Alternative 1: Extend Wall.

Flood Protection Alternative 2: Earthen Berm

This alternative (Figure 4-9) involves bringing in fill to create a natural earthen berm landward of the top of the coastal bank, along the approximate location of the existing footpath. This berm would tie into the existing concrete seawall and would extend northeast of the area of interest to join higher elevations near the splash pad to provide a cohesive flood barrier. To ensure scenic views are not obstructed, and to minimize the amount of space needed for both the earthen berm and the path, the walking path could be relocated along the crest of the berm. Finally, the fill placed to create this berm could be removed prior to 2070 to return the site to its original topography and to allow for salt marsh habitat migration.

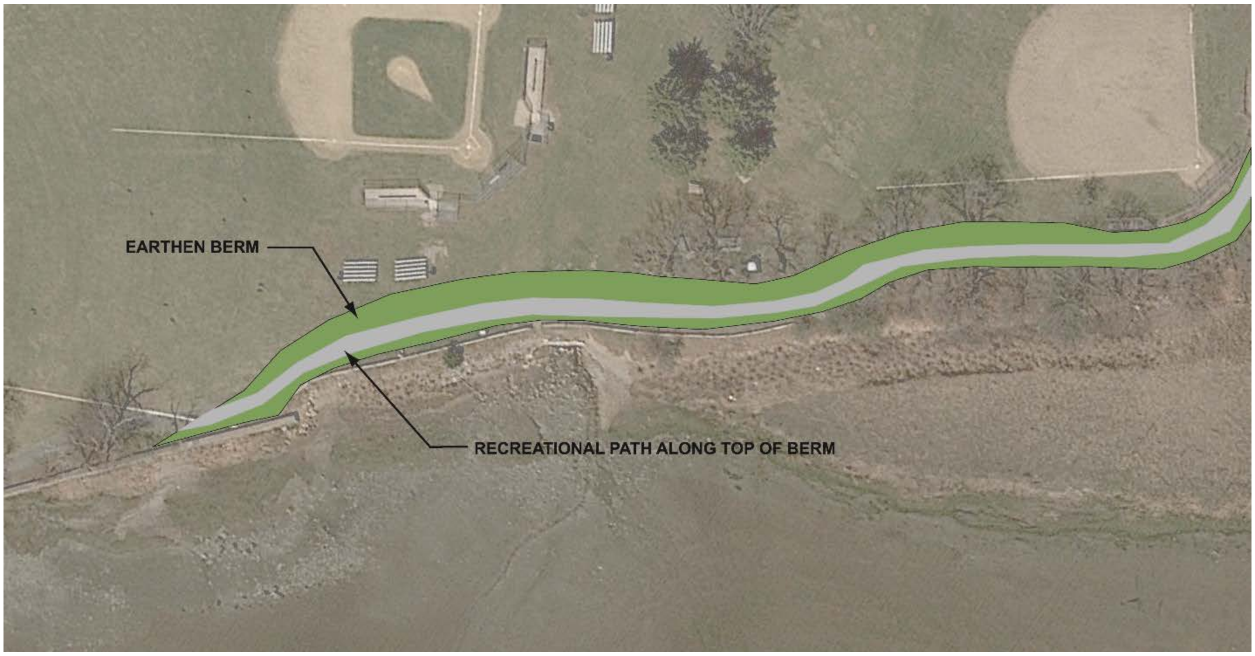

Figure 4-9. Conceptual design for Flood Protection Alternative 2: Earthen Berm.

Flood Protection Alternative 3: Raised Vegetated Terraces

This alternative (Figure 4-10) is similar to the earthen berm in Alternative 2, in that it involves bringing in fill to raise the elevation landward of the top of the coastal bank, along the approximate location of the existing footpath. It would also tie into the existing concrete seawall and would extend northeast of the eroding area of interest to join higher elevations near the splash pad to provide a cohesive flood barrier. With this alternative, however, the elevation gain would be achieved through a series of vegetated terraces along the seaward side, similar to those proposed in Bank Alternative 3. The landward side of the raised area could either incorporate vegetated terraces, or could be adjusted to end with a landward facing vertical wall; a vertical wall would not only minimize the total footprint of this design, minimizing the impact to the adjacent ball fields, but could also incorporate benches or seating that could be used by spectators during baseball games. As with the earthen berm in Alternative 2, to ensure scenic views are not obstructed, and to minimize the amount of space needed for both the berm and the path, the walking path could be relocated along upper tier of the terraces. Finally, the fill and materials placed to create this feature could be removed prior to 2070 to return the site to its original topography and to allow for salt marsh habitat migration.

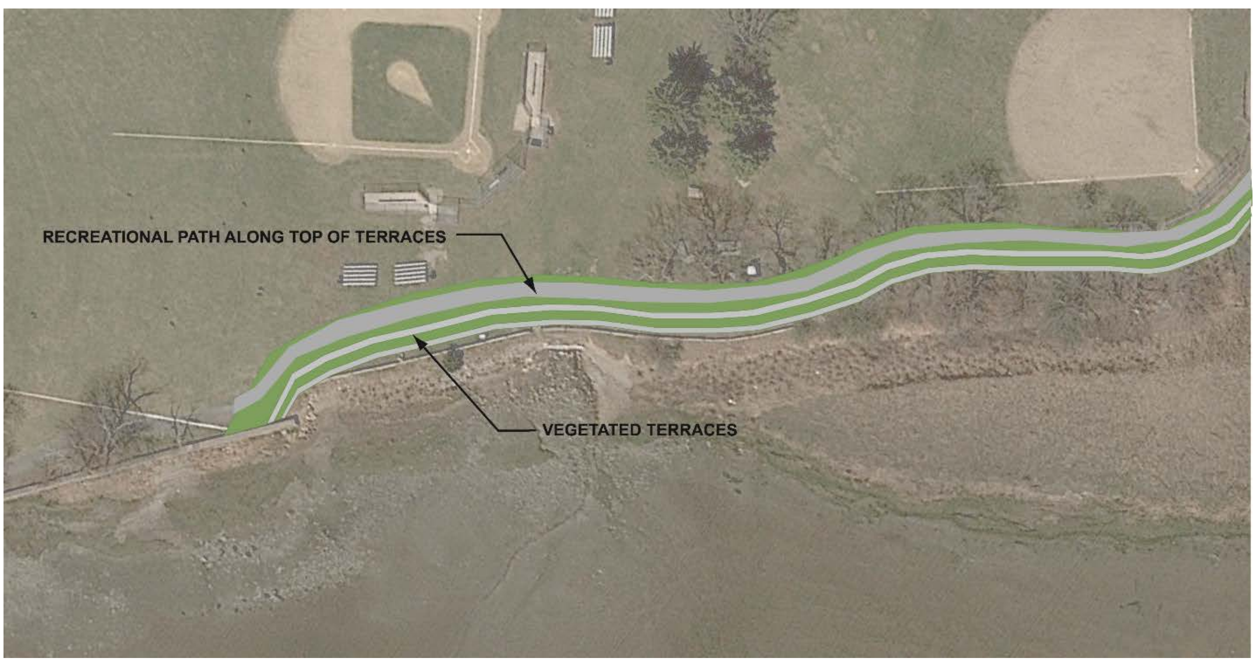

Figure 4-10. Conceptual design for Flood Protection Alternative 3: Raised Vegetated Terraces.

Flood Protection Alternative 4: Do Nothing

This alternative would maintain the status quo. No additional flood protection measures would be taken, and the walking path would stay in place. No additional work would be required in 2070 to prepare the site for salt marsh migration, as the topography landward of the coastal bank would not have been changed.

4.2 ALTERNATIVES ANALYSIS

4.2.1 Pipe outlets and salt marsh restoration alternative analysis

This section compares and evaluates the alternatives described in Section 4.1.1 above for addressing the issue of the degraded storm water outlets and the ongoing salt marsh deterioration. This evaluation is based on a number of criteria that address the relative feasibility, effectiveness, benefits, and avoidance of adverse impacts, detailed in the table below (Table 4-1). Responses for each criterion qualitatively describe each alternative's merits relative to the others. However, in order to rank the alternatives, some quantification was necessary in the form of scoring. To this end, all responses were scored 1 to 3. Responses that are considered the most desirable (e.g., least cost, easiest to permit, most effective, etc.) were scored 3 (and color-coded green), while the least desirable responses (e.g., highest cost, difficult to permit, least effective, etc.) were scored a 1 (and color-coded red). The summations of these scores, based on an equal weighting of all criteria, are displayed at the bottom of each column, and the alternative with the highest score was selected as the preferred alternative.

With these assumptions, *Alternative 1: Habitat Enhancement with the Pipe in Place* and *Alternative 2: Forebay (Landward of Outlets)* are the best options for this site. *Alternative 3: Pipe Extension and Marsh Restoration* and *Alternative 4: Reroute Outlets to New Location and Restore Marsh* rank lower based on increased complexity, cost, and permitting difficulty, despite having increased effectiveness and salt marsh habitat enhancement. The do nothing alternative (Alternative 5) scores the lowest of these five options; although there is no immediate cost, this alternative does not address the ongoing problem of erosion identified by the Town and does not provide any benefits.

Table 4-1. Alternatives analysis for pipe outlets and salt marsh restoration.

		1		2		3		4		5	
		Habitat Enhancement w/Pipes in Place		Stone Forebay Landward of Existing Outlets		Pipe Extension and Marsh Restoration		Reroute Outlets to New Location and Restore Marsh		Do Nothing	
Feasbility	Engineering Complexity	Simple	3	More Complex	1	Increased Complexity	2	More Complex	1	Nothing to Engineer	3
	Construction Costs	Low	3	High	1	Moderate	2	Very High	1	Zero Construction Cost	3
	Maintenance Costs *(in addition to the salt marsh/coir logs which are present in all alternatives)*	Low	3	Moderate	2	Low	3	Low	3	Moderate	2
	Permittability	Relatively Straightforward	3	Increased Complexity	2	Potential Permitting Hurdles	1	Potential Permitting Hurdles	1	No Permits Needed	3
	Constructability	Relatively Simple	3	Moderately Complex	2	Moderately Complex	2	Increased Complexity	1	No Construction Needed	3
	Maintenance Frequency	Moderate for marsh toe; infrequent for pipe	3	Moderate for marsh toe; moderate for cleaning forebay	2	Moderate for marsh toe; moderate for seaward end of pipe	2	Moderate for marsh toe; infrequent for pipe	3	Nothing to Maintain	3
	Outfall Sampling	Feasible	3	Feasible	3	Difficult	1	Feasible	3	Feasible	3
Effectiveness	Design Life	Low to Moderate	2	Low to Moderate	2	Moderate	3	Moderate	3	Low	1
Benefits	Erosion Control	Low to Moderate	2	Moderate	2	Higher	3	Higher	3	Low	1
	Salt Marsh Habitat Enhancement	Partial Marsh Restoration	2	Partial Marsh Restoration	2	Contiguous Marsh Restoration	3	Contiguous Marsh Restoration	3	None	1
	Rocky Intertidal Shore Habitat Enhancement	Some RIS Enhancement	3	Some RIS Enhancement	3	None	1	Some RIS Enhancement	3	None	1
	Water Quality Improvements	None	1	Reduction of sedimentation	3	None	1	None	1	None	1
	Public Outreach/Education	Moderate Potential	2	More Visible - Higher Potential	3	Moderate Potential	2	Moderate Potential	2	None	1
	Recreational Enhancement	No Recreational Enhancement	1	Potential New Exploration Area; Bridge	3	No Recreational Enhancement	1	No Recreational Enhancement	1	No Recreational Enhancement	1
Avoidance of Adverse Impacts	Shellfish Impacts	Potential Shellfish Impacts In Project Footprint	3	Potential Shellfish Impacts In Project Footprint	3	Potential Shellfish Impacts In Larger Project Footprint	2	Potential Shellfish Impacts In Larger Project Footprint	2	Shellfish Impacts Unlikely	3
	Loss of Recreation Area	Low	3	Low	3	Low	3	Low	3	Potential Loss of Fields Over Time; Potential loss of Public Access	1
	Final Score:	40		37		32		34		31	

4.2.2 Coastal bank stabilization alternative analysis

This section compares and evaluates the alternatives described above in Section 4.1.2 for addressing the issue of coastal bank stabilization. As in Section 4.2.1, this evaluation is based on a number of criteria that address the relative feasibility, effectiveness, benefits, and avoidance of adverse impacts, detailed in the table below. Responses for each criterion qualitatively describe each alternative's merits relative to the others (Table 4-2). However, in order to rank the alternatives, some quantification was necessary in the form of scoring. To this end, all responses were scored 1 to 3. Responses that are considered the most desirable (e.g., least cost, easiest to permit, most effective, etc.) were scored 3 (and color-coded green), while the least desirable responses (e.g., highest cost, difficult to permit, least effective, etc.) were scored a 1 (and color-coded red). The summations of these scores, based on an equal weighting of all criteria, are displayed at the bottom of each column, and the alternative with the highest score was selected as the preferred alternative.

With these assumptions, *Alternative 1: Natural Coastal Bank Stabilization* is the best option for this site. All other alternatives rank just slightly lower based on the criteria evaluated. Interestingly, the do nothing alternative (Alternative 4) score is equal to that of *Alternative 2: Bank Stabilization with an Engineered Core* and *Alternative 3: Vegetated Terraces*.

Table 4-2. Alternatives analysis for coastal bank stabilization.

		1		2		3		4	
		Natural Coastal Bank Stabilization (regrade, ECB, plants, coir toe)		Engineered Core (same as #1, but w/buried sand-filled tubes)		Vegetated Terraces (to assist marsh migration)		Do Nothing	
Feasibility	Engineering Feasibility	Simple	3	Increased Complexity	2	More Complex	1	Nothing to Engineer	3
	Construction Costs	Low	3	Moderate	2	High	1	Zero Construction Cost	3
	Maintenance Costs	Potentially High	1	Moderate	2	Low	3	Moderate	2
	Permittability	Straightforward / Routine	3	Increased Complexity	2	Not Permittable	0	No Permits Needed	3
	Constructability	Simple	3	Increased Complexity	2	More Complex	1	No Construction Needed	3
	Maintenance Frequency	Moderate	2	Moderate	2	Low	3	Nothing to Maintain	3
Effectiveness	Design Life	Low	1	Moderate	2	High	3	Low	1
Benefits	Erosion Control	Low	1	Moderate	2	Moderate	2	Low	1
	Habitat Enhancement	Natual Vegetation; Too Steep for Marsh Migration	2	Natual Vegetation, but Won't Establish as Well Due to Core; Too Steep for Marsh Migration	1	Natual Vegetation, but Contains "Hard" Elements; Allows Stepped Marsh Migration	2	None	1
	Public Outreach/Education	Moderate Potential	2	Moderate Potential	2	More Visible - Higher Potential	3	None	1
	Recreational Enhancement	No Recreational Enhancement	1	No Recreational Enhancement	1	Potential View Platform Options	3	No Recreational Enhancement	1
Avoidance of Adverse Impacts	End Effect Erosion	Low	3	Low	3	Potentially Moderate	2	Low	3
	Loss of Recreation Area	Low	3	Low	3	Moderate	2	Potential Loss of Fields Over Time; Potential loss of Public Access	1
	Final Score:	28		26		26		26	

4.2.3 Flood protection alternative analysis

This section compares and evaluates the alternatives described above in Section 4.1.3 for addressing the issue of flood protection. Similar to the alternatives analyses for pipe/salt marsh and coastal bank solutions described above, this evaluation is based on a number of criteria that addresses the relative feasibility, effectiveness, benefits and avoidance of adverse impacts, detailed in the table below (Table 4-3). Responses for each criterion qualitatively describe each alternative's merits relative to the others. However, in order to rank the alternatives, some quantification was necessary in the form of scoring. To this end, all responses were scored 1 to 3. Responses that are considered the most desirable (e.g., least cost, easiest to permit, most effective, etc.) were scored 3 (and color-coded green), while the least desirable responses (e.g., highest cost, difficult to permit, least effective, etc.) were scored a 1 (and color-coded red). The summations of these scores, based on an equal weighting of all criteria, are displayed at the bottom of each column, and the alternative with the highest score was selected as the preferred alternative.

With these assumptions, *Alternative 2: Earthen Berm* is the best option for this site. *Alternative 3: Raised Vegetated Terraces* and *Alternative 1: Extend Wall* rank lower based on increased complexity, cost, and/or permitting difficulty. The do nothing alternative (Alternative 4) scores the lowest of these four options; although there is no immediate cost, this alternative does not provide any flood protection benefits.

Table 4-3. Alternatives analysis for flood protection.

		1		2		3		4	
		Extend wall		Earthen berm		Raised vegetated terraces		Do Nothing	
Feasibility	Construction Costs	Moderate	2	Low to Moderate	2	High	1	Zero Construction Cost	3
	Maintenance Costs	Relatively Low	3	Low to Moderate	2	Low to Moderate	2	Nothing to Maintain	3
	Permittability	Likely Unpermittable	1	Relatively Straightforward	3	Increased Complexity	2	No Permits Needed	3
	Constructability	Simple	3	Simple	3	Increased Complexity	2	No Construction Needed	3
	Maintenance Frequency	Low	3	Potentially Moderate	2	Potentially Moderate	2	Nothing to Maintain	3
Effectiveness	Design Life	High	3	Moderate	2	Moderate	2	NA	1
Benefits	Flexibility of Use of Property	Low	1	High	3	Moderate	2	Low	1
	Flood Control	Better Flood Protection	3	Increased Flood Protection	2	Increased Flood Protection	2	No Added Flood Protection	1
	Habitat Enhancement	None	1	Creates a Natural Vegetated Buffer	3	Creates a Vegetated Buffer	2	None	1
	Public Outreach/Education	None	1	Visible Project - Higher Potential	3	Visible Project - Higher Potential	3	None	1
	Recreational Enhancement	No Recreational Enhancement	1	Improved / Interesting Path Options	3	Improved / Interesting Path Options	3	No Recreational Enhancement	1
Avoidance of Adverse Impacts	Loss of Recreation Area	No Loss of Lawn; Loss of Public Access	2	Minor Loss of Lawn; No loss of Public Access	3	Minor Loss of Lawn; No loss of Public Access	3	Potential Loss of Fields Over Time; Potential loss of Public Access	1
	Final Score:	24		31		26		22	

4.2.4 Alternatives analysis summary

Based on the alternatives analysis evaluation matrices presented in Section 4.2, the recommended approach for the area of interest at Watson Park includes the following combination of features:

- Salt marsh and rocky intertidal shore habitat enhancement with the storm water pipes repaired and retrofitted with check valves or tide gates in place;
- Natural coastal bank stabilization provides a permittable solution to stabilize the eroding bank and provide natural habitat; and
- An earthen berm that can provide flood protection for the baseball fields in the short-term, with a long-term plan to remove it when sea-level rise has resulted in daily tidal ranges that would allow salt marsh migration into the fields.

These three components have been incorporated into a preliminary engineering design plan, included in Appendix B to this report.

4.3 PLAN FOR LONG-TERM SALT MARSH MIGRATION

Given the high recreational value of Watson Park, it makes sense to utilize and protect the playing fields as long as possible, while still planning for salt marsh habitat migration in the long-term. Based on the SLAMM results presented in Section 3.4, even under a high emissions scenario, water levels will not be high enough to promote salt marsh establishment on the recreational fields at Watson Park until approximately 2070. Because the top of the coastal bank in the vicinity of the salt marsh is at an elevation of approximately 8 feet (NAVD88), salt marsh is unlikely to expand considerably landward until sea-level rise results in daily high tides that exceed that elevation. For reference, current mean high water is at elevation 4.82 feet (NAVD88). A mean high water (MHW) elevation of 8.36 is not expected until 2070. In other words, although flooding is expected on the fields during storms today, with an increased likelihood and depths moving forward, daily tides are not expected to impact the playing fields until approximately 2070.

Keeping in mind that the salt marsh cannot expand into the playing field area until approximately 2070, steps can be taken to reduce the risk of storm flooding on the fields over the next 50 years (Figure 4-11A). Although it is unlikely that anyone would be utilizing the fields during a storm event that results in flooding of the fields, flood events can still result in damages and required maintenance. Flooding with salt water can kill the grass, flood waters can deposit sediment and debris on the fields, and smaller objects, such as benches and trash barrels, can be dislodged and washed away. Municipal funding and staff time will be required at an increasing frequency in the future to repair these damages and to continue to maintain the fields in playable condition. Incorporating a flood protection alternative, as described in Section 4.1.3 and evaluated in Section 4.2.3, such as an earthen berm, can minimize the flood impacts to the playing fields. Since the salt marsh will not be able to expand into the playing field area until approximately 2070, installation of an earthen berm (or other alternative) would provide added flood protection to an important recreational resource over the next 50 years, at no expense to the salt marsh.

Any flood protection alternative that is implemented should, however, be considered temporary. In the interim (approximately the next 50 years), the Town should develop a long-term plan for developing recreational space in another part of Town, at a higher elevation. Concerns have been expressed that Braintree is densely developed and that there are no other useable areas of a suitable size. However, given the long-term timeline associated with this relocation, areas of Town that are identified as potential candidates for future recreational space could be targeted for land acquisition and "un-development". Alternatively, perhaps cooperative inter-municipal agreements could be explored with neighboring Towns for shared use of fields. By 2070, the flood protection barrier should be removed, providing suitable elevations for the salt marsh to begin establishing in the central portions of the existing recreational area. Consideration may also want to be given to shortening or removing the existing concrete seawall around the same time; with daily high tides above 8 feet (NAVD88), water will flow around the wall and salt marsh will begin establishing behind it. Eliminating that vertical barrier would facilitate salt marsh establishment and prevent pooling of water behind the wall.

It is also important to consider that the individual recreational components of Watson Park do not all need to be abandoned at the same time. Although the park is relatively flat, the elevations on the far eastern and western edges of the park are slightly higher than the elevations in the center of the fields. For example, Delory Field (closest to the tennis courts) and Sheridan Field (on the northeast side of the splash pad), as well as the parking lot, playground and splash pad, are all a couple feet higher than the majority of the park area. These areas are approximately 9 to 11 feet (NAVD88) in elevation, compared to an elevation of approximately 8 feet (NAVD88) for the majority of the center of the park. This slight increase in elevation will allow continued use of these higher fields for some time after 2070, at the same time that the central field areas are left to naturalize and convert to salt marsh habitat (Figure 4-11B). There is also the possibility of reorienting the Debra Steele Field so that it is situated the remaining high ground beside the playground. As shown in Figure 4-11B below, there is some overlap between the footprint of the reoriented field and the predicted area of wetland habitat expansion, but if minor regrading is done, the Debra Steele Field could be retained as a third usable field during this time. If additional fill material is needed to bring the full extent of this field to an appropriate elevation, material from the earthen berm that will be removed could be repurposed for this use. Any dugouts, fences and other infrastructure in locations identified as salt marsh transition areas should be removed.

It is also important to remember that although the majority of Watson Park may not be suitable for baseball fields by the end of the century, it could still have high recreational and open space value. Walking paths along the edge of a future salt marsh, and boardwalks and lookout platforms within the salt marsh could be developed to allow residents continued use and enjoyment of the parcel and access to the water front.

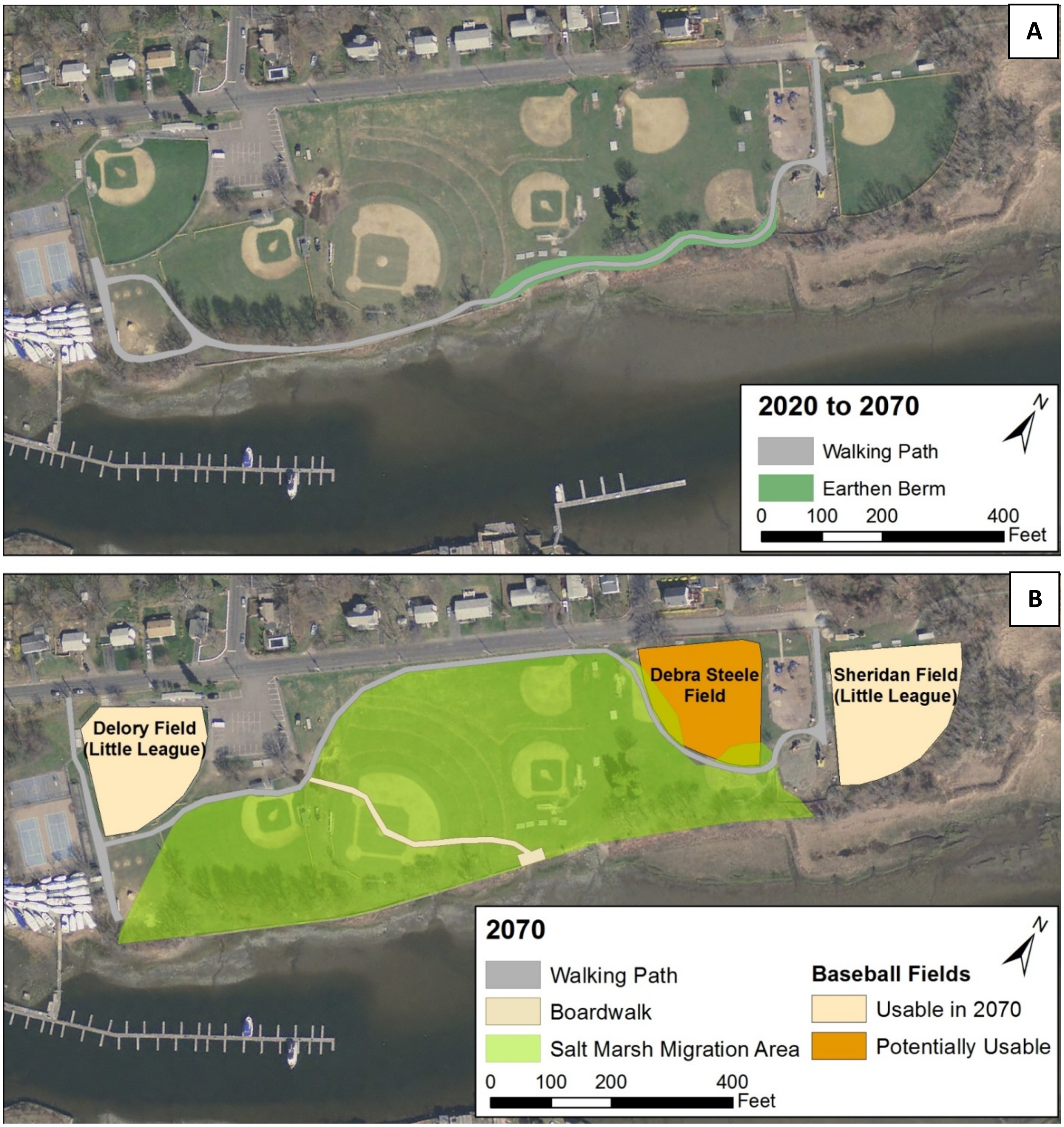

Figure 4-11. Long-term conceptual plan for recreational use and salt marsh migration.

5.0 SUMMARY AND RECOMMENDATIONS

Based on the alternatives analysis presented in Section 4, and feedback received from the Town, the recommended approach for the area of interest at Watson Park includes the following combination of features:

- Salt marsh and rocky intertidal shore habitat enhancement with the storm water pipes repaired and retrofitted with check valves or tide gates in place;
- Natural coastal bank stabilization provides a permittable solution to stabilize the eroding bank and provide natural habitat; and
- An earthen berm that can provide flood protection for the baseball fields in the short-term, with a long-term plan to remove it when sea-level rise has resulted in daily tidal ranges that would allow salt marsh migration into the fields.

Figure 5-1 presents a summary graphic depicting the combination of these project components. The preliminary engineering design plan, which also incorporates all three of these key components, is included in Appendix B.

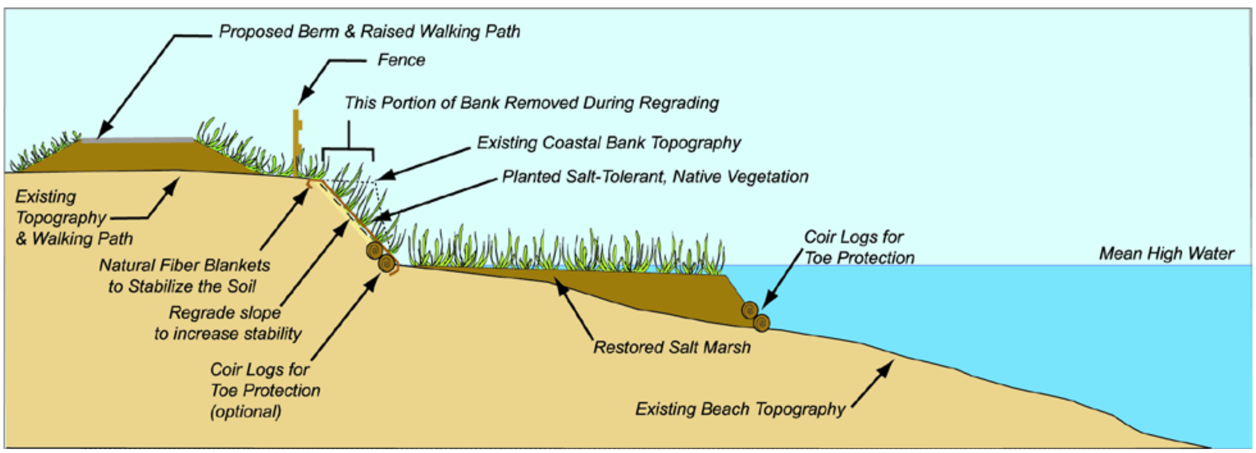

Figure 5-1. Preferred alternative conceptual design.

While this proposed conceptual design presents the main components, there are still some details that will need to be finalized prior to or during the permitting phase of this project. Most importantly, a monitoring and maintenance plan will need to be developed. Living shoreline projects, such as the coastal bank stabilization and the proposed marsh enhancement, require ongoing monitoring and maintenance to ensure their success. It is also worth noting that while some of the future monitoring and maintenance could likely be performed by Town of Braintree staff, other work will likely need to be done by a restoration professional. For example, monitoring for and removing any attached seaweed from the erosion control blankets on the restored marsh platform could be performed by the Town, or by trained volunteers. Maintenance and repair of the coir rolls or their anchors, on the other hand, should be performed by a restoration professional experienced with the installation and maintenance of these features.

Additionally, when permitting and planning for this project, special attention will need to be given to how the earthen berm is permitted and how its purpose and expected time frame is communicated to the public. While the earthen berm is proposed as a near-term solution to reduce flooding from storm impacts, there is the danger that it will be difficult to remove the fill in the future, whether due to lack of public and/or Town support for removing it or due to other limiting logistics (e.g., lack of financial resources). Furthermore, given the likely turnover in Town staff that is likely between now and the targeted removal date (i.e., 2070), long term goals for the park and willingness to retreat from rising sea levels may have changed. To ensure proper execution of the long-term management and eventual removal of the earthen berm, we recommend that special ongoing conditions be added to any eventual permit approval.

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APPENDIX A: GRAIN SIZE SAMPLES AND RESULTS

Figure A-1. Grain size sample from Coastal Bank 1.

Figure A-2. Grain size sample from Coastal Bank 2.

Figure A-3. Grain size sample from Coastal Beach 1.

Figure A-4. Grain size sample from Coastal Beach 2.

Figure A-5. Grain size sample from Coastal Beach 3.

APPENDIX B: PRELIMINARY ENGINEERING DESIGN PLAN