Horsley Witten Group

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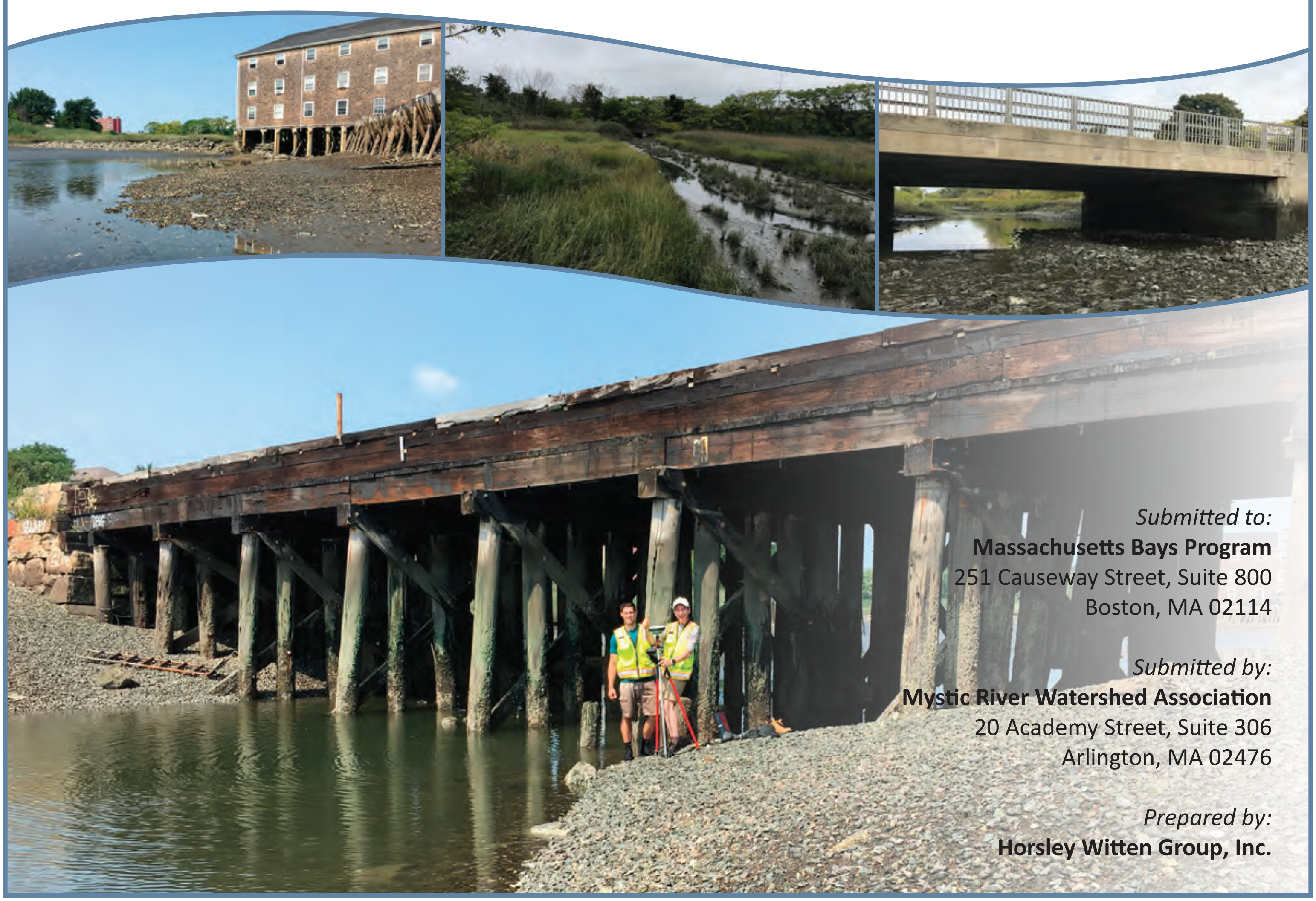
# Mystic River Restoration Project - Mill Creek Restoration Assessments

## FY18 MassBays Healthy Estuaries Grant Program

Chelsea and Revere, Massachusetts

July 15, 2019



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# Executive Summary

Mill Creek is a tidally influenced tributary to the Chelsea Creek and, ultimately, to the Mystic River that separates the cities of Chelsea and Revere. The subwatershed is highly developed and has been significantly impacted by cultural changes to the environment, including the filling in and modifications of the existing salt marsh and wetland areas in the mid and late 1900s. Roadways, bridges and dams have surrounded and segmented Mill Creek to create the distinct hydraulic cells and vegetation that are there to date. Some restoration efforts, most notably the removal of *Phragmites australis* (common reed), have taken place in recent years to address impacts without much success.

This current study was conducted between August 2018 and July 2019 by the Horsley Witten Group, Inc. (HW) and included the following projects tasks: review of historical and existing data and reports; development of basemaps using available GIS data; field assessments of tidal conditions, salt marsh conditions and stormwater drainage; identification of restoration opportunities; review of potential permitting requirements; and a preliminary prioritization of restoration opportunities for further consideration. Tidal data was collected between August 16, 2018 and October 1, 2018. Stormwater assessments were conducted on November 19, 2018.

There were six identified restrictions in the creek (listed from downstream to upstream): 1) MBTA railroad bridge, 2) Slade Spice Mill building and earthen dam, 3) Broadway Bridge, 4) Parkway Plaza Bridge, 5) Route 1 north off/on-ramp culvert, and 6) concrete revetment north of Home Depot. Each restriction creates an upper and/or lower bound for the distinct marsh cells discussed in this report. All restrictions contribute to the dampening of tidal influence in upper sections of the creek to varying degree. Notably, tidal logger data indicated that only the higher high tides reach the concrete revetment behind Home Depot. In addition, the artificial elevation controls created by the restrictions exacerbate conditions by slowing flow velocities and encouraging settling of sediment, rocks and debris which increase invert elevations and restrict the channel further.

During the qualitative vegetation assessment, HW found that the salt marsh vegetation community generally had a low diversity throughout the marsh cells, ranging from eight species in the lower cells of Mill Creek to only four species in the upper cells, nearest Route 1. In comparison, a healthy salt marsh community would have 20 or more species present. Further, many of the upstream cells were dominated by the invasive common reed, an occurrence typical of anthropogenically stressed salt marsh systems. Such cultural stresses include reduced salt water influence; increased freshwater, sediment, and nutrients from stormwater runoff; and/or other anthropogenic disturbances to the marsh. Vegetation density decreases in many of the downstream areas where rip rap and/or large granite blocks are providing hard armoring as well as where tidal flats are present.

Within the subwatershed, the high percent of imperious cover (60%), topography (slopes up to 25%), and poor soils all contribute large volumes of stormwater runoff with significant sediment and nutrient contributions into the existing drainage infrastructure. Sources of sediment and pollutants from stormwater runoff were observed to be from construction sites, exposed soils at residential properties, and erosion at the outfalls. Encroaching impervious areas (e.g., Parkway Plaza Shopping Area, Revere Beach Parkway, etc.) further contribute trash and debris to Mill Creek.

HW identified seven potential restoration projects in Mill Creek: removal of the Slade Spice Mill Dam; removal of riprap and stone; bank stabilization; removal of sediment in the channel, salt marsh replenishment, removal of the concrete revetment at Home Depot, and repair and cleaning of outfalls. There were 19 stormwater management retrofit opportunities identified, including removal of impervious cover, right-of-way bioswales, tree trenches, bioretention areas, and pervious pavement. Many of those same practices can likely be replicated in large numbers throughout the contributing subwatershed. The projects were prioritized using nine criteria that evaluated costs versus benefits, implementation feasibility, and the likelihood of long-term success.

The preliminary prioritization is intended to provide guidance for the Cities of Chelsea and Revere for moving forward with planning and design concepts but should be reevaluated as more data is collected and these projects are integrated with ongoing local and state planning efforts. Key data to be collected include: detailed topographic and bathymetric surveys; modeling (hydrologic/hydraulic/hydrodynamic); complete outfall assessments; and field assessments of contributing drainage areas upstream of the project area.

Recommended next steps in the short-term should focus on smaller, incremental maintenance activities such as cleaning catch basins and drainage pipes, street sweeping, and erosion and sedimentation controls. These near-term projects, conducted in quantity throughout the watershed, will be key to addressing significant sources of sediment, debris, trash and other pollutants that currently enter the drainage systems. In the long-term, future conditions considering climate impacts should be evaluated to ensure that potential projects do not adversely affect infrastructure or exacerbate flooding. Other considerations include: identifying potential public-private partnerships; conducting public outreach and education to address sources of pollutants; coordination with MassDOT, DCR and other key stakeholders; and progressing the priority projects into design development and permitting.

# 1. Project Background

Over the last 15 years, the Mystic River Watershed Association (MyRWA) along with Chelsea's GreenRoots staff has been working to make gradual improvements of the water quality and habitat of Mill Creek and Chelsea Creek. Evidence of improvements achieved include the return of anadromous fish to these systems and the increased presence of native vegetation. Activities completed to date have included the removal of invasive species, most notably common reed (*Phragmites australis*); the construction of stormwater best management practices (including tree trenches and bioswales); and increased public education on the Mill Creek and Chelsea Creek watersheds. Significant prior work that we are aware of include the following:

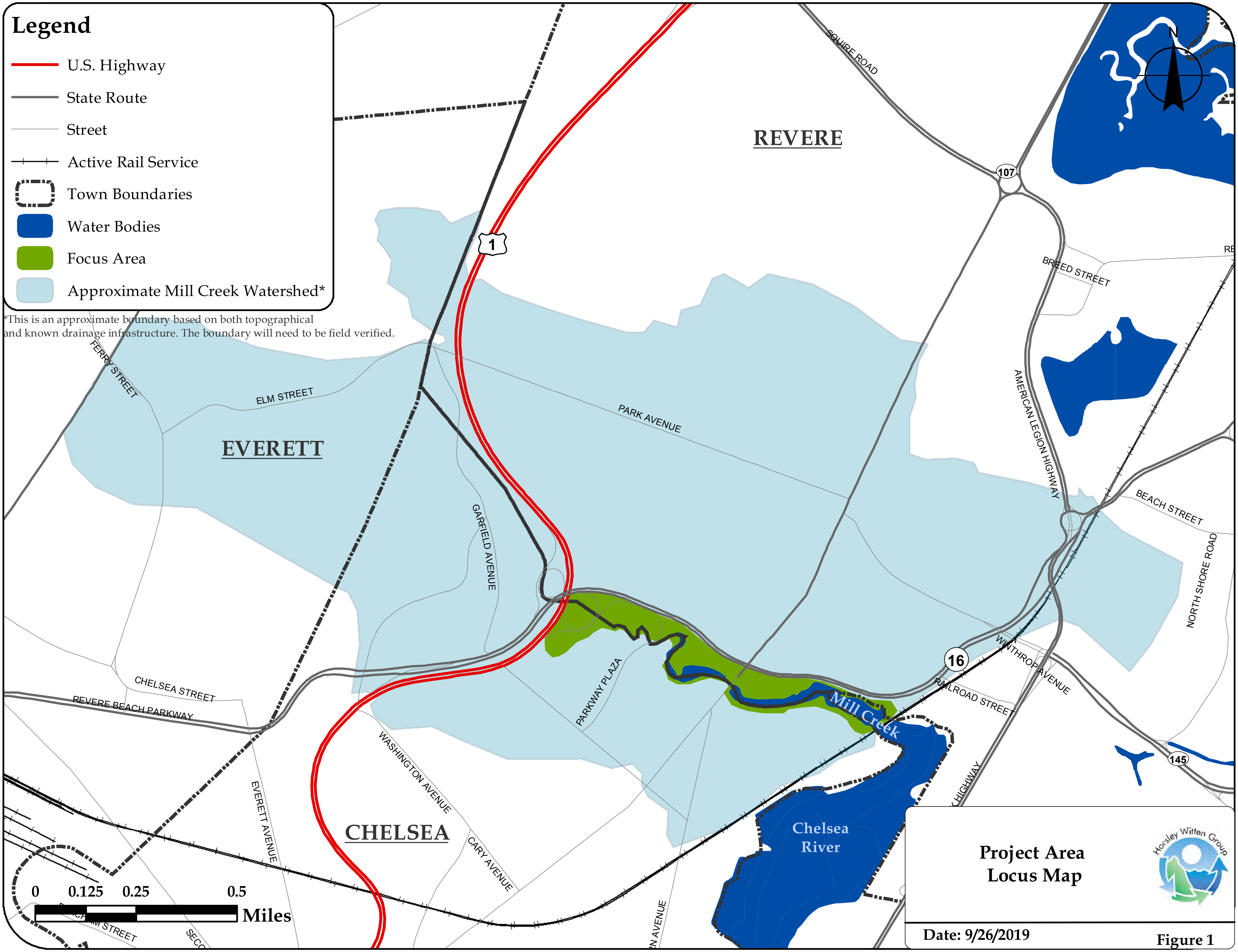
- Salt Marsh Restoration Site Identification on Mill Creek by ESS Group, Inc., July 18, 2005;
- Draft Restoration Plan for Mill Creek Wetland Areas by BSC Group, Inc., September 7, 2007;
- Evaluation of Mill Creek Salt Marsh Restoration Project - Chelsea, Massachusetts by the University of New Hampshire, April 28, 2008; and
- Notice of Intent for Mill Creek Ecological Improvements by Tetra Tech, Inc., March 24, 2009;

This current study of shoreline marsh and habitat restoration opportunities in Mill Creek was conducted through a MassBays Healthy Estuaries Grant (FY18). The project area includes Mill Creek and its tributaries between Route 1 to the northwest and the MBTA railroad bridge to the southeast (Figure 1).

The scope of work completed for this project included the following tasks:

- Reviewed existing reports, historical studies, mapping, plans and geospatial data for Mill Creek and its tributaries;
- Developed a base map using available GIS data and priority stormwater subcatchments identified through a desktop analysis;
- Conducted field assessments on existing tidal restrictions (including installing eight data loggers to collect tidal water level fluctuations and measuring key infrastructure dimensions), vegetation, and stormwater impacts and opportunities;
- Identified restoration opportunities for Mill Creek which address potential improvements to salt marsh communities, hydrology, and stormwater management;
- Reviewed potential permitting requirements; and
- Developed a preliminary prioritization of potential projects based on key criteria.

These tasks are summarized within this report. Additional relevant information is provided as appendices as noted herein.


Legend
U.S. Highway
State Route
Street
Active Rail Service
Town Boundaries
Water Bodies
Focus Area
Approximate Mill Creek Watershed*
*This is an approximate boundary based on both topographical and known drainage infrastructure. The boundary will need to be field verified.
REVERE
EVERETT
CHELSEA
SQUIRE ROAD
107
1
16
145
BREED STREET
AMERICAN LEGION HIGHWAY
BEACH STREET
NORTH SHORE ROAD
FERRY STREET
ELM STREET
PARK AVENUE
GARFIELD AVENUE
PARKWAY PLAZA
CHELSEA STREET
REVERE BEACH PARKWAY
WASHINGTON AVENUE
EVERETT AVENUE
CARY AVENUE
WINTHROP AVENUE
RAILROAD STREET
Mill Creek
Chelsea River
0
0.125
0.25
0.5
Miles
N
Horsley Witten Group
Project Area Locus Map
Date: 9/26/2019
Figure 1

## 2. Site Overview

Mill Creek is a tidal tributary to Chelsea Creek, which itself is tributary to the lower Mystic River. Mill Creek creates a natural border between the cities of Chelsea and Revere. Historical aerials suggest that the salt marsh remained a vibrant ecosystem through the early part of the 20th century (Figure 2). However, the salt marsh was slowly filled in and encroached upon as residential and commercial development and major transportation routes expanded through the 20th century (Figure 3). The creation of these transportation corridors has divided the salt marsh into discrete cells along the creek. Those roadway and railroad crossings constrict the hydraulic connectivity between cells and, thereby to varying degrees, restrict the ebb and flow of tides.

The Mill Creek marsh system is bordered by high density residential areas to the north and southeast, high density commercial development to the south, and major roads and highways on all sides with multiple roadways crossing the creek. The subwatershed includes lands that drain to Mill Creek naturally based on topography as well as land outside of the topographic drainage area that is conveyed via stormwater infrastructure (Figure 1). Available records show that there are 34 municipal and 7 MassDOT stormwater outfalls within the project area. Based on available GIS data, approximately 113 acres drains to 16 outfalls within the City of Chelsea, while 99 acres drains to 18 outfalls in the City of Revere. The subwatershed within the project area is approximately 60% impervious. The development within the subwatershed over time has increased impervious area, stormwater volume and pollutants to the creek, which in turn has increased impairments to the native salt marsh ecosystem. The most significant visible impacts have been the increased presence of *Phragmites australis* (Common Reed) and other non-native species and the increasing deposition of stormwater-derived sediments within the creek.

## 3. Existing Condition of Mill Creek

HW conducted three site visits in the summer and fall of 2018 to assess existing conditions. The first occurred on August 16th to install water level data loggers and to conduct a salt marsh vegetation and invasive plants assessment. The second site visit was conducted on October 1st to remove the data loggers, measure the dimensions of potential tidal restrictions (e.g., bridge spans and culvert dimensions); and visually observe sedimentation conditions at key outfalls. The final site visit was conducted on November 19th to assess the priority stormwater subcatchments and identify opportunities for stormwater management improvements.

### 3.1. Hydrology of Mill Creek and Potential Tidal Restrictions

The study of the existing hydrology of Mill Creek was primarily focused on the main channel within the project area, beginning downstream just below the MBTA railroad bridge and continuing upstream to US Route 1 (Figure 4). This section of Mill Creek is slightly greater than one mile in length. A small tributary that enters Mill Creek near Home Depot was included in the project area.


Figure 2. Aerial Photo from 1946 of Mill Creek and the Surrounding Area (EDR, 2015)

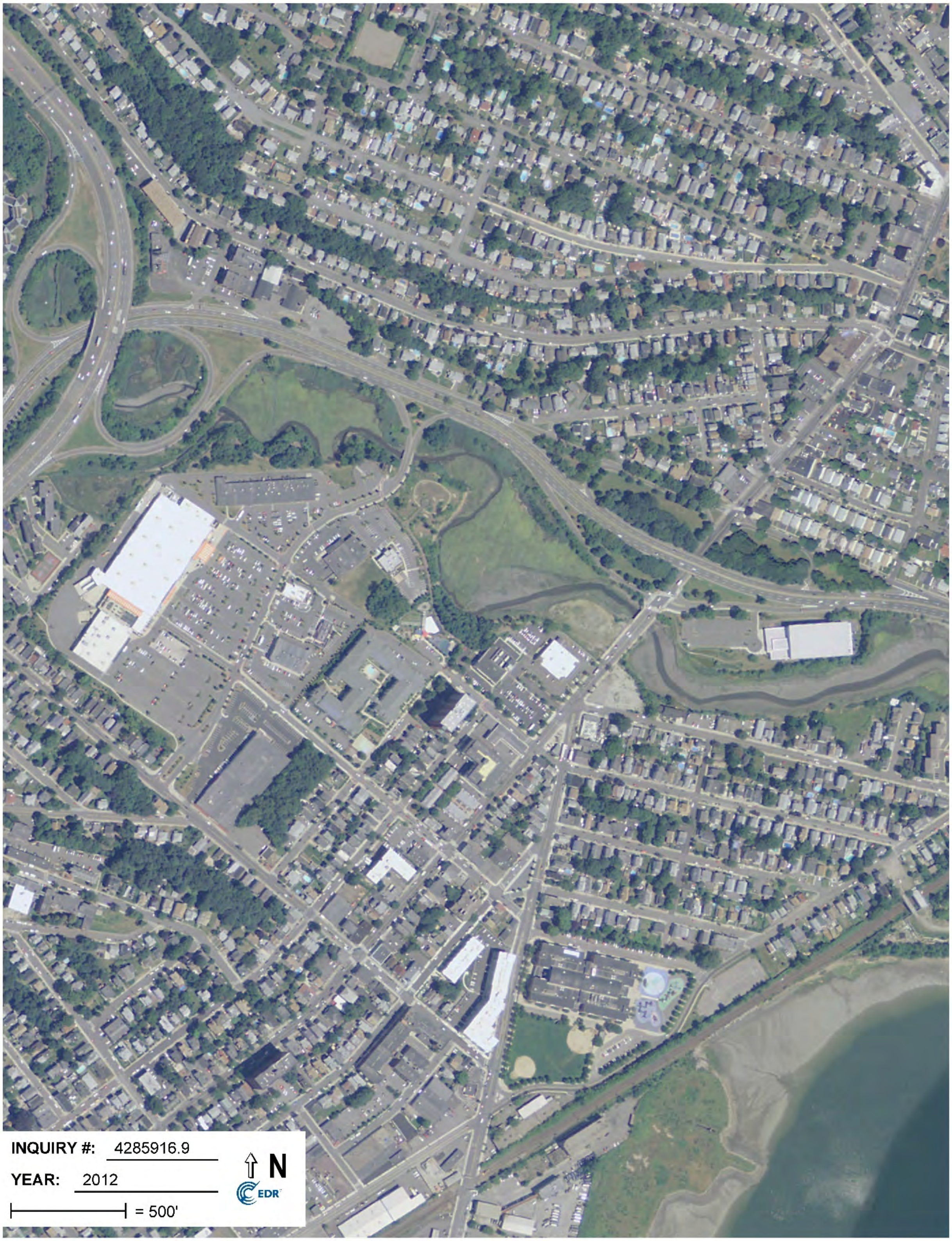



**Figure 3. Aerial photo from 2012 of Mill Creek and the Surrounding Area (EDR, 2015)**

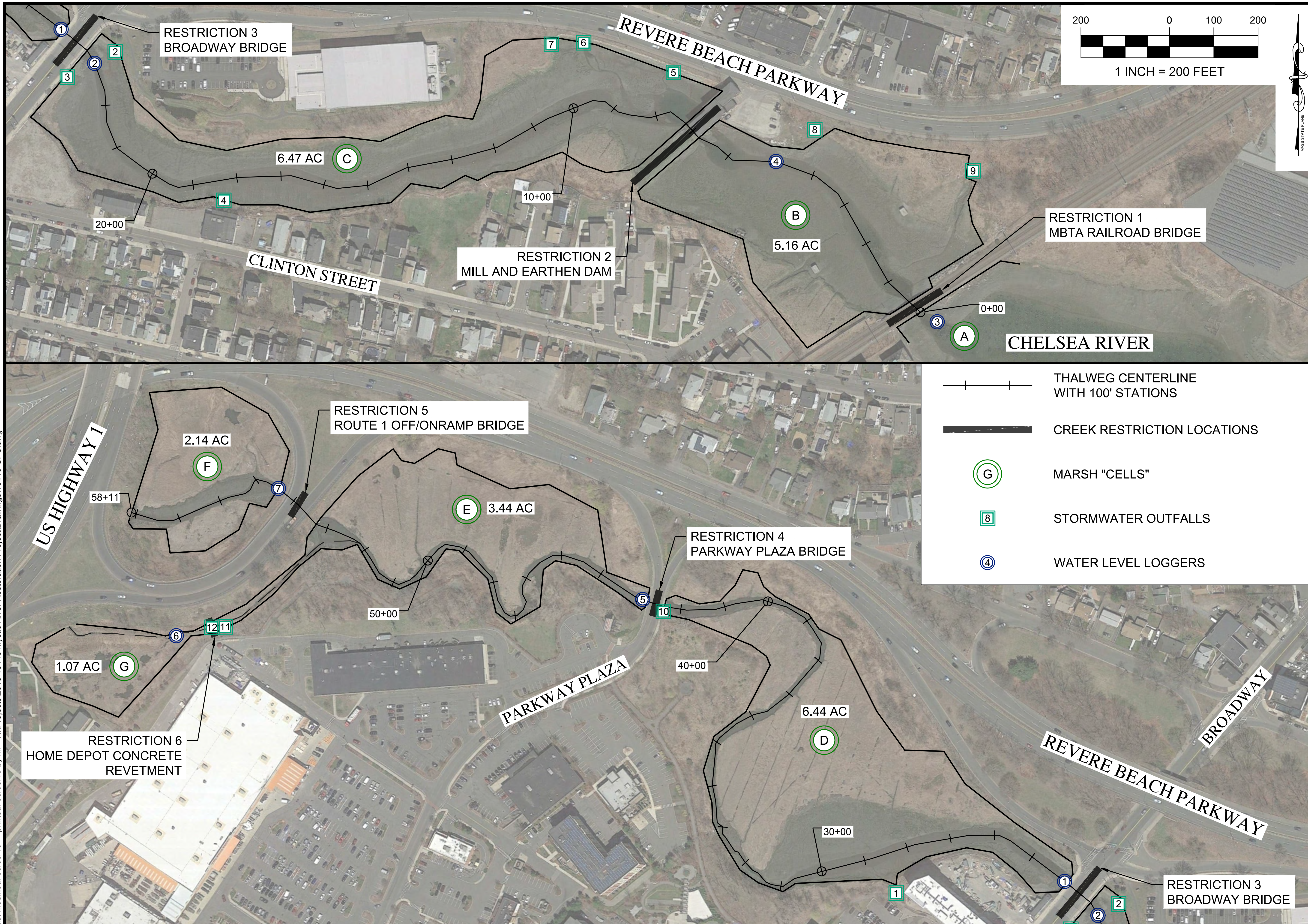



FIGURE 4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Date: August 17, 2018

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Plan Set: MILL CREEK SALT MARSH
CHELSEA & REVERE, MASSACHUSETTS

Plan Title: KEY FEATURES

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Project Number: 18113

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Six structures spanning the creek within the project area were identified as potential tidal restrictions: the MBTA railroad bridge; the Slade Spice Mill building and remnants of its' earthen-embankment dam; the Broadway Bridge; the Parkway Plaza Bridge; the culverts beneath the US Route 1 North off/on-ramp; and the concrete revetment immediately north of the Home Depot parcel along the Mill Creek tributary. These restrictions are numbered on Figure 4, starting downstream and moving upstream. Salt marsh areas between each of these potential tidal restrictions are identified herein as discrete marsh cells A through G, labeled on Figure 4 from downstream to upstream.

To assess the hydraulic impacts of the potential tidal restrictions, seven water level data loggers were installed in the creek on August 16, 2018 and removed on October 1, 2018. An additional barometric logger was installed on land nearby to correct the water level logger data for changes in atmospheric pressure. The underwater loggers were securely affixed to the inside of a concrete block, as near to the thalweg (centerline of the channel) as was practical. The horizontal and vertical locations of the deployed loggers were surveyed on August 16, 2018. Water level data and analyses are outlined and discussed in Section 3.2. Key dimensions of the potential tidal restriction structures were surveyed or measured on October 1, 2018. Those key dimensions are discussed below and provided in sketches in Appendix A.

### Restriction 1 (MBTA Railroad Bridge)

The most downstream of the potential tidal restrictions within the project area, the MBTA railroad bridge is a viaduct servicing two travel directions of the Newburyport/Rockport MBTA Commuter Rail line. The viaduct is a timber structure resting on cut granite block abutments and supported by a creosote-treated timber pile causeway (Photo 1).

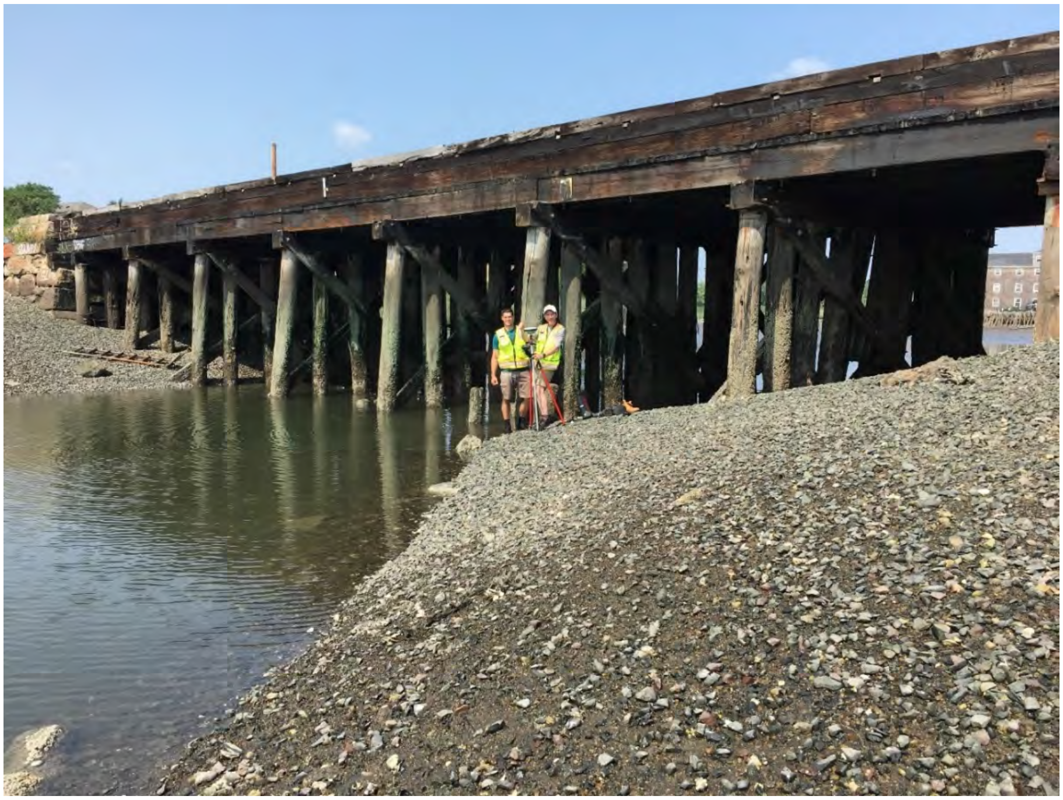


**Photo 1. MBTA Railroad Crossing (looking upstream)**

Crushed stone and rip rap are present below and surrounding the bridge to armor a roughly trapezoidal channel. The bottom of the lowest supporting beam (low chord) is a maximum of 14 feet above the thalweg bottom at the deepest point in the channel, 6.8 feet above the channel bottom near the north end of the bridge (to the right in Photo 1), and 4.1 feet above at the south end (to the left in Photo 1). A closer view of the north end of the bridge is shown in Photo 2.

The width between the abutments is 94 feet and there are seven rows of 15-inch-diameter timber piles supporting that span. The open, cross-sectional area between piles and abutments below the low chord of the bridge deck is approximately 945 square feet.

**Photo 2. North End of MBTA Bridge**

## Restriction 2 (Slade Spice Mill Building and Earthen Dam)

The historic Slade Spice Mill building, originally built in 1721, was a tidal-powered grist mill with an attached 30-foot-thick earthen dam to impound high tide for water power purposes. The mill building sits atop a foundation consisting of a combination of cut granite blocks, stone and masonry rubble, and old and new timber columns of various sizes (Photo 3).

**Photo 3. Foundation of Spice Mill**

There are many impediments to flow that can be found on the ground amongst the timber piles (e.g. boulders, large metal objects, piles of rubble, and rigid boards affixed to the channel bottom) (Photos 3 and 4). At its greatest height, near the center of the downstream building face, the bottom of the lowest supporting beam is 11 feet above the thalweg bottom (Photo 5). The opening beneath the mill building is 46 feet wide and has an open cross-sectional area of about 350 square feet.

At some point in the past a cut was made to the earthen dam to provide a route for flow through the creek in addition to the open area beneath the building. The cut is about 17 feet wide on the downstream side and about four feet wide on the upstream side (Photo 6). There is also a second, smaller cut in the earthen dam on its north end near where it meets the shoreline opposite the mill building (Photo 7). The invert elevation of this secondary cut is higher than the primary cut beside the mill building, and therefore only conveys flow at higher water levels.

Photo 4. Low Level Flow Obstructions Beneath Mill Building

Photo 5. Maximum Channel Clearance Beneath Mill

Photo 6. Primary Cut in Spice Mill Earthen Dam

Photo 7. Secondary Cut in Earthen Dam (red arrow)

## Restriction 3 (Broadway Bridge)

The Broadway Bridge is an approximately 48-foot wide open span bridge that carries two lanes of Broadway and its sidewalks across Mill Creek (Photo 8). The low chord bottom of the bridge deck is approximately eight feet above the thalweg bottom and the open area is approximately 385 square feet. The bottom of the channel and side slopes around the bridge abutments are armored with crushed stone and riprap with an average diameter of about nine inches. The stone material and fine sediments that have accumulated downstream of the bridge appear to create a flow restriction under low tide (Photo 9).

**Photo 8. Broadway Bridge Looking Upstream**

**Photo 9. Accumulated Material Downstream of Broadway Bridge**

### Restriction 4 (Parkway Plaza Bridge)

The Parkway Plaza bridge carries two lanes of automobile traffic atop a triple-barrel precast concrete box culvert system (Photo 10). The culverts roof height is a maximum of about seven feet above the channel thalweg (culverts are eight feet high with variable sediment depth in the bottoms) and each opening is ten feet across. The concrete walls between the culverts are approximately 1.9 feet wide and divide the creek into three channels with a combined open cross-sectional area of about 213 square feet. Flow through the northernmost culvert is heavily impeded by built-up fine sediment and muck to the point that it is completely blocked at lower water levels (left side of Photo 10 and Photo 11). The middle and southern channels are also filled with sediment, though to a lesser degree. A shopping cart and automobile tire were observed in the center channel (Photo 12).

**Photo 10. Parkway Plaza Bridge and Culvert**

**Photo 11. Northernmost Culvert of Parkway Plaza Bridge**

**Photo 12. Center Culvert of Parkway Plaza Bridge**

### Restriction 5 (Route 1 North Off/On-Ramp Culvert)

The Route 1 Off/On-ramp bridge carries two lanes of vehicle traffic over an asymmetric, quad-barrel precast concrete box culvert system comprising two pairs of openings (three of the four barrels visible in Photo 13). The bottom of the culvert roofs in the smaller (southern) pair of barrels are about 2.7 feet above the channel bottoms and these barrels are each five feet wide; the combined open area of these two culverts is 27 square feet. The bottom of the culvert roofs in the larger (northern) pair of barrels are 4.8 and 5.8 feet above the channel bottoms, and each barrel is 12 feet wide for a combined cross-sectional open area of 132 square feet. The four culvert channels together provide a total open area of 159 square feet.

The smaller pair of culverts were observed to be filled with sediment and no water was observed flowing through them at either of the two site visits. For the larger (northern) culvert pair, the northernmost barrel was observed conveying only limited flow (Photo 14). The bottom of the channel everywhere in this vicinity is covered with at least two feet of fine, mucky sediment.

**Photo 13. Route 1 Off/On-Ramp Culverts Looking South**

**Photo 14. Northernmost Route 1 Off/On-Ramp Culvert**

## Restriction 6 (Concrete Revetment north of Home Depot)

This restriction is located on an unnamed tributary to Mill Creek where the channel narrows between areas of fill that support the U.S. Route 1 off-ramp and the Home Depot shopping plaza. On the U.S. Route 1 off-ramp side the channel slope consists of a vegetated hillside on the north bank of the creek with an approximate slope of 2.75 to 1. On the Home Depot side, the channel slope has been covered with concrete at an approximate slope of 4.5 to 1. The intersection of these two slopes creates a narrow creek channel with a bottom width of approximately two feet (Photo 15). A reinforced concrete pipe outfall with a flared end is at this location protruding into the channel from beneath the slab on the south bank (red arrow in Photo 15). The purpose of this outfall is unknown. We were not able to attain record plans depicting this outfall or additional information from the City of Chelsea indicating its purpose. The combination of the narrow channel profile and the outfall pipe appear to create a significant restriction to flow. Due to the relatively low invert elevation and trapezoidal shape of the channel, the flow restriction is likely more significant at lower water levels than at higher ones.

**Photo 15. Narrow Tributary Channel with Concrete Slope**

## 3.2 Tidal Data Analysis

Water depths were measured every six minutes, continuously, for a period of 47 days by the seven water level loggers. When the loggers were retrieved, their data was compiled, the depths were converted to water surface elevations based upon the surveyed elevations of the loggers. A longitudinal profile of the creek was developed to convey the elevations of the loggers relative to minimum water levels (Figure 5). The water level data were plotted as hydrographs along with either daily rainfall data from Logan Airport or hourly rainfall data obtained from the Boston Water and Sewer Commission (BWSC) weather station in East Boston to visualize any correlations between rainfall and water levels throughout the system. A full set of hydrographs are available in Appendix B, while example datasets are shown in Figure 6 and 7. Longer duration time period hydrographs depict daily rainfall data and shorter duration hydrographs depict hourly rainfall data in order to better visualize the rainfall to water level response patterns over those shorter time periods.

Examination of the tidal data reveals several key observations for the Mill Creek system:

- **High Tide Influence**: The peak high tide elevation experienced is similar for all monitoring stations, but the duration and extent of tidal influence is significantly diminished at the most upstream stations. Most notably, Marsh G at the upstream end of the tributary creek behind the Home Depot only receives tidal input near the peak of the higher tides. As shown on Figure 6, tidal water only enters at the peak of the one highest tide shown on the figure. The other two tides shown do not reach a high enough elevation to flood into Marsh G. Looking at the full tidal record in Appendix B, with the exception of the highest Spring Tide periods, only the highest tide of any given day reaches into Marsh G for most days in the dataset. To some extent the diminished high tide influence experienced at upstream stations is a natural result of channel elevations increasing as one moves inland (Figure 5). However, invert elevation controls created by each of the identified stream crossings also create artificial elevation controls that restrict the exchange of tidal flow.
- **Tidal Range:** Also apparent on Figure 6 is that, due primarily to the elevation controls discussed above, the extent of the tidal range experienced and the duration of time higher water levels are present are both diminished for more upstream stations relative to the most downstream ones. Only approximately 10% of the full tidal range (water elevation difference between low and high tides) experienced at the MBTA bridge is experienced by Marsh G. The percent of the full tidal range experienced beyond each of the other restriction points is similarly diminished, though to a lesser degree, further downstream. For example, Marsh F (above the U.S. Route 1 off-ramp) experiences about 25% of the full tidal range, Marsh E (above Parkway Plaza) about 35%, Marsh D (above Broadway) approximately 55%, and Marsh C (above Spice Mill dam) approximately 65%. The MBTA Bridge, between Marshes A and B, presents only a minimal tidal restriction. As mentioned above, the diminished tidal range experienced at upstream stations is partly a natural result of channel elevations increasing as one moves inland. However, invert elevation controls created by each of the identified stream crossings also create artificial elevation controls that restrict the exchange of tidal flow.
- **Elevation controls**: The elevation to which water levels can drain during low tide is limited to some extent at all stations upstream from the MBTA bridge. Existing elevations of channel

thalwegs naturally limit the elevations to which the tide will influence upstream areas. However, invert elevation controls created by each of the identified stream crossings also create artificial elevation controls that maintain water levels behind them at a higher elevation than might otherwise have existed. The situation is exacerbated by the tendency for flow velocities to diminish upstream of these restriction points, allowing sediment to settle out and accumulate in and behind the stream crossings and further restricting the elevation to which water levels may drain during low tide and the time required for that drainage to occur (Figure 5). While field survey between road crossings was not comprehensive, it is evident that several of the crossings have impounded water behind them, allowing for sedimentation and infilling that have altered the profile of the stream and restricted the ebb and flood of tidal waters to varying degrees. Tidal data indicates that the extent of low tide drainage restriction is greatest at the more upstream locations and least at the more downstream (Figure 6).

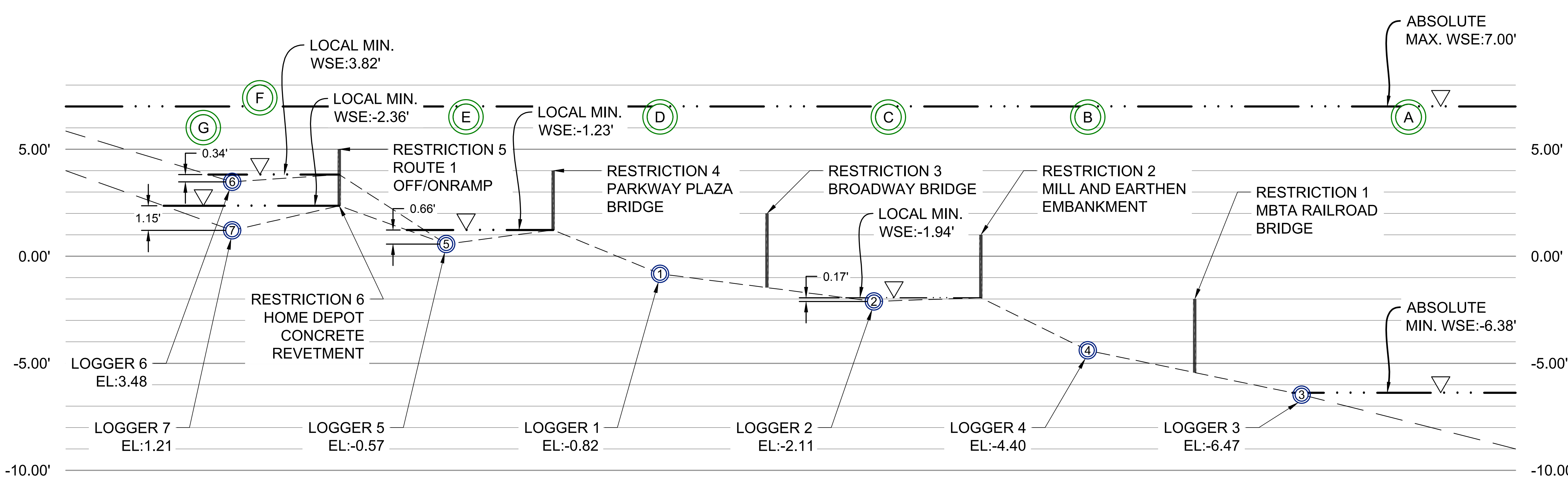
- **Time Lag During High Tide:** The time lag between when high tide is experienced in each marsh cell relative to the most downstream location is relatively short. The lag is variable with different tides but generally does not exceed a half hour between the arrival of high tide at MBTA bridge versus the two most upstream marsh cells (F&G) (Figure 6). Of course, since the lower magnitude high tides fail to even reach into Marsh G (as described above) the time lag between high tides for marsh cells F and G can exceed a full tidal cycle during those lower higher tides.

- **Time Lag During Ebb Tide**: The time lag for low tide drainage to occur for the most upstream locations relative the most downstream, is a little longer than is observed for the high tide flood, though still relatively minimal Ebb tide time lag is evident based on the flattened shape of the drainage curves for the more upstream locations relative to the downstream locations, particularly for Marshes E, F, and G (Figure 6). This indicates that, in addition to the controlling role played by the invert elevations of the various stream crossings, the open area size of the more upstream crossings restricts the rate to which tidal water can drain.

- **Rain Events for Lower Marshes:** Figure 7 shows an example hydrograph from September 18-19, 2018 during a rain event, with hourly precipitation included. The two most seaward stations, Marshes A and B on either side of the MBTA bridge show very minimal response to the precipitation as the tidal influence dominates on these two largely unrestricted stations.

- **Rain Events for Middle Marshes**: Beginning with Marsh C, above the Spice Mill dam, the influence of the rain event becomes more prominent moving upstream (Figure 7). Marshes C and D, on either side of the Broadway Bridge, show similar magnitudes of water level increase in response to an approximately half-inch burst of rain at around midday on September 18, even though the rain burst occurred during the outgoing tide. This indicates that sufficient rainfall and runoff were added to the system above the Slade Spice Mill dam to offset a background decline of water level during the outgoing tide. That fact that the two hydrographs above and below the Broadway Bridge display a generally similar shape with only the higher invert of the Broadway bridge elevating the upstream hydrograph above the downstream one suggests that the Slade Spice Mill dam may be more volumetrically restrictive to downstream drainage on the outgoing tide than the Broadway Bridge.

- **Rain Events for Upper Marshes**: Further upstream above Parkway Plaza there is a much more pronounced response to the rain event. Both the overall elevation of each of those upstream hydrographs (owing to the controlling invert elevation of each stream crossing), and the magnitude of the water level increase is greater for Marshes E, F, and G than they are for any of the more downstream stations (Figure 7). In fact, the precipitation-driven water levels in those upstream marsh cells during low tide are higher than the high tide elevations for those marsh cells for all but the astronomically high Spring Tides. The similar shape of the hydrographs above and below the U.S. Route 1 off-ramp indicate that the Parkway Plaza crossing may be more restrictive to low tide drainage of stormwater than is the U.S. Route 1 off-ramp crossing. The shape of the hydrograph for Marsh G on the tributary channel is a bit flatter than are the Marsh E and F hydrographs during the stormwater drainage period indicating that the narrow channel on the tributary creates a further drainage restriction beyond that which occurs along the main channel.


MILL CREEK LONGITUDINAL PROFILE
HORIZONTAL: NOT TO SCALE
VERTICAL: 1" = 5'

FIGURE 5

Horsley Witten Group, Inc.
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Checked By: NP
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Date: August 17, 2018

Plan Set: MILL CREEK SALT MARSH SURVEY
CHELSEA, MASSACHUSETTS

Plan Title: MILL CREEK SALT MARSH HYDROLOGY (2)

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Registration:

Project Number: 18113

Sheet Number: 1 of 1

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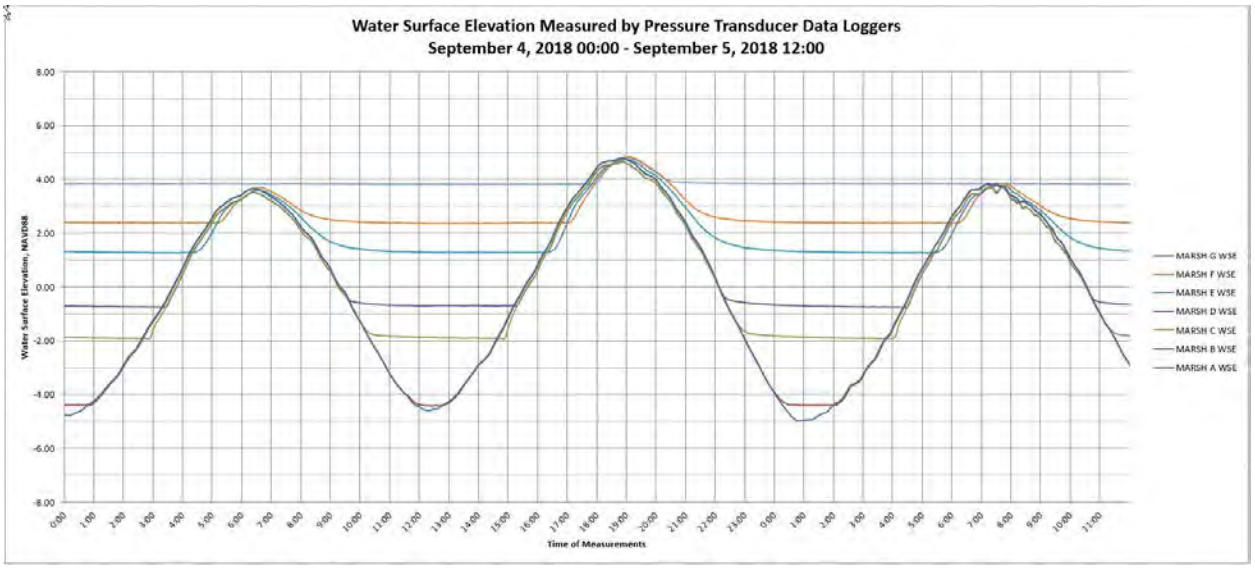



**Figure 6. Example 1.5-Day, Dry Weather Hydrograph**

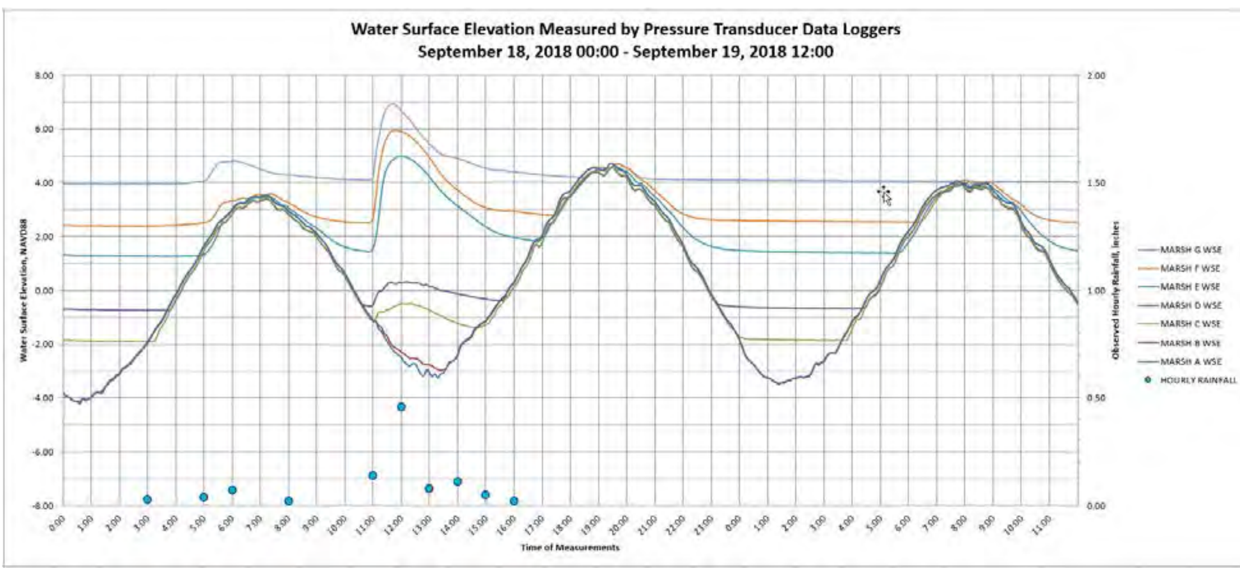



**Figure 7. Example 1.5-Day, Wet Weather Hydrograph**

## 3.3 Salt Marsh Vegetation Assessment

Screening-level salt marsh vegetation and habitat assessments were conducted along Mill Creek for an area within approximately 50 feet of the mean high water (MHW) elevation. From downstream to upstream, the assessment covered the area between the MBTA bridge and the U.S. Route 1 off-ramp, as well as the tributary channel between that off-ramp and the Home Depot parking lot (Figure 4). The assessments were not comprehensive or quantitative in nature.  Areas were visited as access allowed and generalized observations of vegetative conditions and habitat integrity were made within the areas visited.  Access points were at or near stream crossings and observations were made up and downstream from those access points to the extent that site conditions would allow.  Our focus was primarily on documenting observed impacts to salt marsh vegetation communities, but we also observed upland species in order to catalog the various native and invasive species that are present along the edges of the creek.  Data collection was conducted on August 16, 2018 using a tablet with Survey 123 for ArcGIS in a time window bracketing low tide (predicted low tide 9:47 AM).  Figure 8 shows an overview of significant observations from the vegetation assessment.

Overall, the salt marsh vegetation community predominantly consists of plants indicative of salt and brackish waters with the vegetation characteristics generally becoming more brackish in the upstream direction, as would be expected.  There do not appear to be significant or obvious differences in the salt marsh plant communities that are located upstream versus downstream of any specific tidal restriction.  Instead changes in the vegetative community are more gradual and cumulative moving upstream.

Typically, a healthy salt marsh will have 20 or more native salt marsh plant species; that level of diversity was not observed in Mill Creek.  However, there were several healthy salt marsh plants present; such as smooth cordgrass (*Spartina alterniflora*), saltmarsh hay (*Spartina patens*), saltmarsh hay (*Solidago sempervirens*), sea lavender (*Limonium carolinianum*), and spike grass (*Distichlis spicata*).  Conversely, there is also an abundance of the invasive common reed (*Phragmites australis*), especially along the marsh areas that abut upland areas.  Expansion of the coverage by the common reed at the expense of native salt marsh species is frequently bolstered by land disturbance, reduced tidal influence, and freshwater runoff into the marsh from adjacent impervious surfaces and/or stormwater outfalls.

There is a notable decrease of plant diversity as one moves upstream through the system (Marshes E, F and G) (Figure 8).  The most downstream marsh cells were observed to have the relatively highest diversity (eight species).  In contrast, at Marsh G, the furthest upstream marsh cell, above the concrete revetment, the salt marsh vegetation was observed to consist of only four species.  The overall diversity of the salt marsh cells within Mill Creek was assessed qualitatively by comparing the number of native salt marsh species present in each cell to the number of species typically found in a healthy salt marsh community (20).  The qualitative categories were defined as follows: low diversity (0-24%), low-medium diversity (25-39%), medium diversity (40-64%), medium-high diversity (65-79%), and high diversity (80-100%).  While common in many salt marshes, particularly those impaired by various human stressors, phragmites was not counted in this diversity qualification as it is an invasive species.  That qualitative assessment is summarized in Table 1 below.

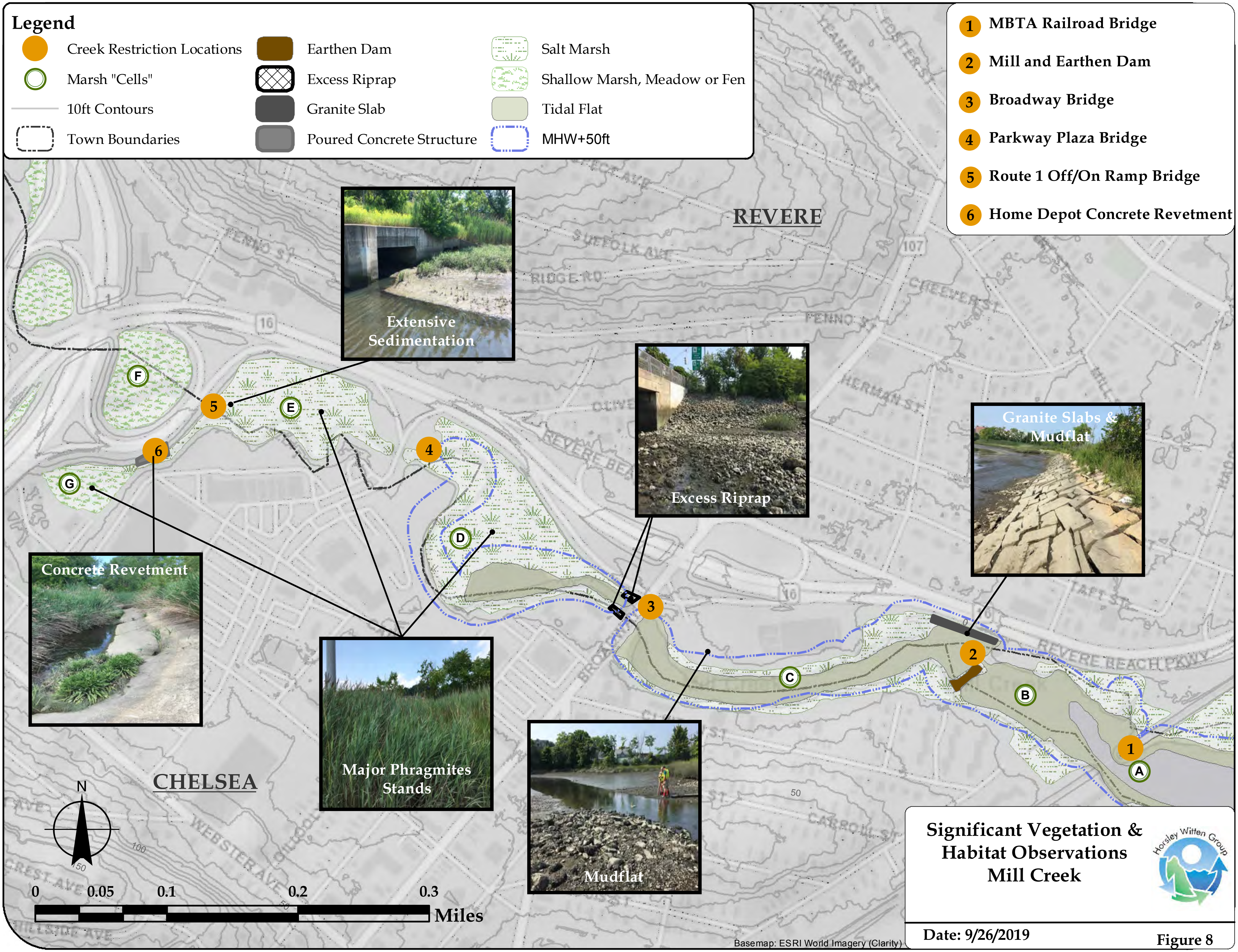
**Table 1. Qualitative Evaluation of Salt Marsh Cells in Mill Creek**

| Salt Marsh Cell | Description | Salt Marsh Plant Diversity | Assessment Notes |
|---|---|---|---|
| **A** | Downstream of MBTA Railroad Bridge | Medium | Only the area closest to the bridge was observed. |
| **B** | Between MBTA Railroad Bridge and Slade Spice Mill Building/ Earthen Dam | Low-medium | |
| **C** | Between the Slade Spice Mill Building/Earthen Dam and Broadway Bridge | Low | Observations influenced by limited access. |
| **D** | Between Broadway Bridge and Parkway Plaza Bridge | Low-medium | Notable increase in invasive species compared to downstream cells. |
| **E** | Between Parkway Plaza Bridge and the Route 1 N Off/On-Ramp | Low | *Phragmites* (common reed) is the dominant species. |
| **F** | Between the Route 1 N Off/On-Ramp and Route 1 | Low-medium | *Phragmites* (common reed) is the dominant species. |
| **G** | Between the Route 1 N Off/On-Ramp and the Chelsea Housing Authority | Low | Dominated by *Phragmites* and cattail. Both have a low salt tolerance. |

Large, unvegetated tidal flats are present in the lower elevation areas throughout the lower part of the system (notably marsh cells A-D). Tidal flats can be a natural tidal habitat for lower elevation areas that experience regular tidal fluctuations sufficient to regularly and alternatively inundate and expose the bottom. They can also occur when climate or anthropogenic induced stressors (e.g. sea level rise, stormwater inputs, or tidal restrictions that have created erosive water levels and flow velocities) have converted salt marsh to tidal flat. In the study area, the tidal flats in the lower marsh cells (A-C) may be either naturally occurring or in equilibrium with long term hydraulic conditions. The tidal flats in upper Marsh cells, such as Marsh D, may be enlarging at the expense of salt marsh in response to hydraulic conditions created by the Broadway Bridge and/or stormwater inputs. Longer-term, more extensive evaluations of the creek may help to understand the impacts over time.

Where banks have been reinforced by rip rap and large granite blocks, salt marsh vegetation is not able to establish (Figure 8). Salt marsh vegetation provides stabilization for the stream banks. In cases where it can't grow, the slopes are destabilized, promoting erosion and slumping.

Detailed observations are summarized below by individual marsh "cells" as labeled in Figure 4, from downstream to upstream. Those native and invasive species identified during the field assessment and discussed for each marsh cell are listed in Table 2.




**Significant Vegetation & Habitat Observations Mill Creek**

Horsley Witten Group

Date: 9/26/2019

Figure 8

**Table 2. Plant names, habitat and native status**

| Common Name | Latin Name | Salt Marsh Plant | Upland Plant | Native | Invasive |
|---|---|---|---|---|---|
| **Asian bittersweet** | ***Celastrus orbiculatus*** | | X | | X |
| **Black grass** | ***Juncus gerardii*** | X | | X | |
| **Black locust** | ***Robinia pseudoacaia*** | | X | | X |
| **Cattails** | ***Typha sp.*** | X | | X | X |
| **Common glasswort** | ***Salicornia depressa*** | X | | X | |
| **Common reed** | ***Phragmites australis*** | X | | | X |
| **Japanese knotweed** | ***Fallopia japonica*** | | X | | X |
| **Multiflora rose** | ***Rosa multiflora*** | | X | | X |
| **Saltmarsh hay** | ***Spartina patens*** | X | | X | |
| **Sea blite** | ***Suaeda linearis*** | X | | X | |
| **Sea lavender** | ***Limonium carolinianum*** | X | | X | |
| **Seaside goldenrod** | ***Solidago sempervirens*** | X | | X | |
| **Smooth cordgrass** | ***Spartina alterniflroa*** | X | | X | |
| **Spearscale orache** | ***Atriplex patula*** | X | | X | |
| **Spike grass** | ***Distichlis spicata*** | X | | X | |
| **Sycamore maple** | ***Acer pseudoplatanus*** | | X | | X |
| **Tick quack grass** | ***Thinopyrum pycnanthum*** | X | | | X |
| **Tree-of-heaven** | ***Ailanthus altissima*** | | X | | X |

## Marsh A

Marsh A is located downstream of the MBTA railroad bridge. The creek is approximately 300 feet wide at this location with salt marsh fringes along both banks. The banks are strewn with cobbles and shells with occasional large rocks. The salt marsh consists of a narrow strip of low marsh dominated by smooth cordgrass (*Spartina alterniflora)* with common reed (*Phragmites australis)* dominating the high marsh. Approximately 50 feet further downstream from the bridge, the high marsh widens and includes a variety of additional high marsh species, such as saltmarsh hay (*Spartina patens)*, spike grass (*Distichlis spicata)*, black grass (*Juncus gerardii)*, seaside goldenrod (*Solidago sempervirens)*, sea lavender (*Limonium carolinianum)*, sea blite (*Suaeada linearis*), common glasswort (*Salicornia depressa*), and spearscale orache (*Atriplex patula)*. The salt marsh at this location of the system is the healthiest section within the project limits, based on the observed diversity of salt marsh plants.

## Marsh B

Marsh B is located upstream from the MBTA railroad bridge and downstream from the Slade Spice Mill building and earthen dam. The creek along this stretch is approximately 270 feet wide with abundant cobbles and shells. Just downstream from the Spice Mill dam there are several piles of boulders and granite blocks of various sizes along the bank as well as in the salt marsh (Photo 16). The vegetation consists primarily of high marsh species including saltmarsh hay, black grass, spearscale orache, seaside goldenrod, annual sea-blite (*Suaeda linearis)*, sea lavender, and common glasswort (*Salicornia depressa)*. Along this high marsh area there are piles of dredged material on top of the marsh surface. Some of these areas have become colonized by common reed. The marsh transitions to low marsh near the creek and is dominated by smooth cordgrass. Tree-of-heaven (*Ailanthus altissima*) trees were noted along the northern bank upslope of the marsh. This stretch of salt marsh has a fairly healthy low marsh with impaired areas containing piles of granite debris and ditching spoils which have become colonized by *Phragmites*.

**Photo 16. Granite blocks downstream of the Spice Mill**

## Marsh C

Marsh C is located upstream of the Slade Spice Mill building and earthen dam and downstream of the Broadway Bridge. The creek along this stretch is approximately 120 feet wide. Large granite slabs line the northern bank of the stream (Photo 17). An occasional salt marsh plant grows through the cracks between the slabs including saltmarsh hay, sea lavender, and seaside goldenrod, but otherwise there is no room for significant vegetative growth. There are tree-of-heaven trees along the upland slope. The salt marsh on the south bank is more expansive because it has more room to grow.

Excessive rip rap is present along the banks of the creek close to the Broadway Bridge. The creek has muddy banks with very little vegetation in the low marsh area. There is a substantial peat base on the north side of the creek. Vegetation consists mostly of low marsh species with smooth cordgrass growing in the higher reaches of the low marsh, and unvegetated mud flats occupying the lower low marsh areas (Photo 18). There isn't much space for salt marsh to exist and grow in this location. The stretch of salt marsh upstream of Marsh C (beyond the area seen in Photo 17) but before the marsh downstream of the Broadway Bridge was not observed, so no assessment can be made of its health.

**Photo 17. Large Granite Slabs on the North Bank**

**Photo 18. Downstream of Broadway Bridge (Marsh C)**

### Marsh D

Marsh D is located between the Broadway bridge and the Parkway Plaza bridge. The creek bottom has riprap of various sizes covering sediment. Along both sides of the bank slope there is extensive riprap with occasional salt marsh plant species (*S. alterniflora, L. carolinianum*) growing between the rocks (Photo 19).

**Photo 19. Riprap Upstream of Broadway Bridge on Northeast Bank**

The marsh on the north side of the creek is a large expanse of mostly high marsh with a diverse range of salt marsh plants including smooth cordgrass, saltmarsh hay, spike grass, sea lavender, seaside goldenrod, spearscale orache (Photo 20). At the landward edges of the marsh, adjacent to Route 16, there is a fringe of common reed ranging from 20 to 100 feet deep. Upslope of the salt marsh, Japanese knotweed (*Fallopia japonica*), and tree-of-heaven were observed. The Japanese knotweed appeared unhealthy with a chemical-burn appearance to the leaves (Photo 21). Evidence of marsh "slumping" (Photo 22) was noted along the seaward edge of the marsh, as well as extensive areas of unvegetated mudflat where low marsh would typically be. On the south side of the creek there is a thin fringe of marsh between the creek and the paved parking areas. This marsh area is a thin ribbon, predominantly low marsh, and dominated by smooth cordgrass in the higher elevations of low marsh and by unvegetated mud in the lower portions of low marsh (Photo 23). Plant species present in the high marsh include spearscale orache, sea lavender, seaside goldenrod, tick quack grass (*Thinopyrum pycnanthum*). Plants upslope of the marsh included black locust (*Robinia pseudoacaia*), tree-of-heaven, Sycamore maple (*Acer pseudoplatanus*), Asian bittersweet (*Celastrus orbiculatus*), and multiflora rose (*Rosa multiflora*). Farther upstream the marsh area widens and the low marsh vegetation diversity increases. This area of salt marsh is a relatively healthy stretch until the marsh narrows near Route 16, just downstream of the Parkway Plaza bridge. At this point the vegetation becomes dominated by Phragmites. The area nearest Parkway Plaza bridge had previously undergone common reed removal by excavation and manual removal in 2010 (Tetra Tech, Inc., 2009), which now appears to have returned.

**Photo 20. High Marsh with a Diverse Range of Plants**

**Photo 21. Japanese Knotweed in the Creek**

**Photo 22. Low Marsh Slumping**

**Photo 23. Ribbon of Low Marsh with Mudflat on Left Bank**

## Marsh E

Marsh E is located between the Parkway Plaza bridge and the U.S. Route 1 off/on-ramp bridge. At the time of the vegetation assessment, there were debris (tires, cans, plastic) present in the water and along the banks. The stream bottom is composed of muck with occasional rocks (possibly riprap). The banks are covered in muck with little to no vegetation. Higher up on the bank, the low marsh is dominated by smooth cordgrass. The high marsh is dominated by common reed with occasional saltmarsh hay, sea lavender, and seaside goldenrod. The upland abutting the marsh has tree-of-heaven present. There are sections of marsh farther upstream from the Park Plaza Bridge that are healthier with slightly wider expanses of diverse high salt marsh vegetation. However, the high marsh quickly degrades and becomes dominated by common reed as it gets closer to the road.

## Marsh F

Marsh F is located between the U.S. Route 1 off/on-ramp and U.S. Route 1. The water at this stretch of the stream was observed to be stagnant and murky. Along the banks of the creek there is accumulation of muck which is unvegetated. The lower sections of the low marsh are tidal flats with no vegetation (Photo 24). At the higher elevations of low marsh robust smooth cordgrass is growing amid patches of muddy unvegetated areas. The vegetation in the high marsh is dominated by common reed with some spike grass, seaside goldenrod, sea lavender, saltmarsh hay, black grass present. Upslope of the marsh the invasive tree-of-heaven was observed. This stretch of salt marsh is degraded with some salt marsh vegetation surrounded by unvegetated muddy expanses and Phragmites.

**Photo 24. Marsh F Upstream of U.S. Route 1 Off/On-Ramp**

## Marsh G

Marsh G is located at the end of the Mill Creek tributary channel between the Chelsea Housing Authority (Scrivano Apartments), Home Depot and the U.S. Route 1 off/on-ramp. The tributary is bottle-necked by steep slopes on both sides, one of which (on the Home Depot side) is lined with concrete (Photo 25). The creek along this stretch was observed to be stagnant with a mucky bottom. At the time of the site visit the creek was still flowing out, four hours after predicted low tide. The vegetation along this narrow portion of the creek is dominated by common reed with a thin strip of smooth cordgrass mostly only present on the north side of the creek.

**Photo 25. Concrete Revetment on South Bank of Tributary Channel**

Farther upstream of the bottleneck, towards the Chelsea Housing Authority (Scrivano Apartments), the area of salt marsh widens and in addition to smooth cordgrass, the salt marsh also contains saltmarsh hay, sea lavender, seaside goldenrod, cattails (*Typha sp*.). However, the high marsh is dominated by common reed. Similar to Marsh D, this area was also attempted to be restored in 2005 (Burdick et al., 2008).

In the middle of this section of salt marsh there is a pool with deep water and no visible vegetation (Photo 26). The salt marsh in this location does not appear to be healthy with large areas that have no vegetation or are dominated by Phragmites.

**Photo 26. Open Water Pool in Marsh G**

## 3.4 Stormwater Outfall Conditions

During the field assessments HW staff observed the conditions of accessible outfalls, including dimensions and materials of the pipes, dimensions and materials of appurtenant structures, sediment and/or debris accumulations at the outfalls, and evidence of stormwater erosion to the streambanks, if applicable. HW observed 12 outfalls, most of which were located between Broadway bridge and the MBTA railroad bridge (Figure 4). HW was able to document material, dimensions, and visual observations of surrounding conditions. The results of the outfalls inspections are summarized in Table 3. Many of the other outfalls could not be found due to the density of common reed vegetation cover and the significant amount of muck.

**Table 3. Outfall Conditions at Mill Creek**

| Outfall ID | Outfall Type | Pipe Material | Pipe Size (inches) | Outfall Condition | Sediment Depth in Pipe | Comments |
|---|---|---|---|---|---|---|
| **1** | FES | CPP | 18 | GOOD | NONE | 4" iron pipe plugged with a single brick nearby, to the east |
| **2** | TIDE FLAP | RCP | 30 | GOOD | NONE | Square tide gate is made of thick rubber-like material |
| **3** | FES | RCP | 18 | GOOD | NONE | |
| **4** | PIPE | DI | 10 | GOOD | NONE | |
| **5** | PIPE | RCP | 12 | OK | 1/3 | |
| **6** | DUAL TIDE GATE | UNKNOWN | UNKNOWN | GOOD | NONE | Round tide gates are made of metal with hinge arms; pipes might be 12" |
| **7** | FES | RCP | 18 | POOR | NONE | |
| **8** | PIPE | RCP | 12 | POOR | NONE | |
| **9** | HEADWALL | RCP | 24 | DESTROYED | NONE | 6" perforated PVC pipe nearby, to the west |
| **10** | HEADWALL | RCP | 12 | GOOD | NONE | 4" PVC pipe (abutment weephole?) adjacent, appears to be carrying sediment |
| **11** | HEADWALL | RCP | 12 | GOOD | NONE | Flush cut to meet sloped concrete revetment |
| **12** | FES | RCP | 30 | OK | 1/3 | FES integrated into edge of sloped concrete revetment |

Two of the outfalls were covered with tide gates: Outfall 2 was equipped with a heavy-duty rectangular rubber flap valve, and Outfall 6 was covered with two circular metal discs attached with hinges. Overall, the stormwater outfalls observed by the survey team were in good condition with a few notable exceptions. Outfall 7 was slightly crushed and covered with large cut granite blocks that appeared to moderately impede flow. A cavity has eroded around the end of Outfall 8 causing its headwall to become detached. Outfall 9 was badly damaged with its pipe sections found strewn about the area and its headwall collapsed. Outfalls 5 and 12 were both about a third filled with sediment. Photos are provided in Appendix C.

## 3.5 Stormwater Assessments

HW utilized GIS data from the cities of Chelsea and Revere as well as from MassDOT to evaluate stormwater contributions to Mill Creek, including the topography, land uses, soils, drainage infrastructure and stormwater subcatchments. Based on those data sets, HW identified priority subcatchments for further investigation and created basemaps that were used for field assessments. Refer to Appendix D for the basemaps for the relevant data described below.

Topography

The subwatershed to Mill Creek is shown on Figure D.1 in Appendix D. The topography within Mill Creek varies significantly, from 50 to 58 ft at the highest elevations in Chelsea and Revere, respectively, to 0 ft at Mill Creek. Slopes vary from approximately 1 to 25%, depending on the location.

Land Use

The land uses within the project area are summarized in Table 4 and shown in Figure D.2 in Appendix D. The primary land uses are high density residential, multi-family residential, and commercial (approximately 74% of the total subwatershed in the project area). In Chelsea, the majority of the high density residential and multi-family units are located on Mill Hill, east of Eastern Avenue, and southwest of Webster Avenue up to Powder Horn Hill. The commercial area is primarily northeast of Webster Avenue and west of Broadway; which includes a strip mall, a Home Depot, and other restaurants and stores. The majority of the subwatershed's industrial area, albeit small, is located there as well. In Revere, the residential areas are widely distributed, but the commercial area is concentrated along Broadway.

**Table 4. Land Uses Draining to Mill Creek Project Area**

| Land Use | Percent of Subwatershed | Percent in Chelsea | Percent in Revere |
|---|---|---|---|
| **Residential** | 74.4 | 15.4 | 59.0 |
| **Commercial/Institutional/ Transitional** | 15.3 | 7.7 | 7.6 |
| **Nature/OpenSpace/Recreation** | 7.0 | 1.9 | 5.1 |
| **Transportation** | 2.8 | 0.7 | 2.1 |
| **Industrial** | 1.5 | 1.2 | 0.3 |

Soils and Hydrology

The soils in the subwatershed are mapped by the USDA Natural Resources Conservation Service (NRCS) as Newport-Urban land complex, Merrimac-Urban land complex, Scio-Urban land complex, Urban land, Udorthents, Newport silt loam, Pittstown silt loam and Ipswich mucky peat. The NRCS hydrologic soil groups (HSGs) of these soils are shown in Table 5. A significant percentage of the soils have no associated HSG because much of the area is in fill. Groundwater levels for most of these sites are not available within the NRCS dataset. However, given the topography, we assume that groundwater would be relatively close to the surface for areas at or near Mill Creek, but that groundwater would be relatively deep for areas at higher elevations in the subwatershed, such as at the top of Summit Avenue in Chelsea or Reservoir Avenue in Revere.

**Table 5. Soils Draining to the Mill Creek Project Area (source: NRCS)**

| Soil HSG | Percent in subwatershed |
|---|---|
| **A** | 15.9 |
| **B** | 11.8 |
| **C** | 3.0 |
| **D** | 36.0 |
| **N/A** | 33.3 |

Drainage Infrastructure

The existing stormwater drainage infrastructure consists of gutter and inlet collection systems that primarily discharge directly to outfalls in Mill Creek or its tributaries (Figures D.4 and D.5 in Appendix D). City of Chelsea and the City of Revere have a similar number of outfalls; 16 outfalls and 18 outfalls, respectively. MassDOT has seven outfalls within the project area. HW has worked with the City of Chelsea and other collaborators, including MyRWA and GreenRoots, to implement green infrastructure, including tree trenches on Gillooly Road and bioswales at the Mace Apartments of the Chelsea Housing Authority. HW was not able to obtain any information from the City of Revere about the presence of best management practices or green infrastructure within the subwatershed to the project area.

Water Quality

Mill Creek (MA71-08) is identified as an impaired waterbody on the 303(d) list as noted on the 2016 Integrated List of Waters. It is listed as impaired for fecal coliform and poly-chlorinated biphenyls (PCBs), as well as other (contaminants in fish tissue), and is listed as a Category 5 waterbody requiring a Total Maximum Daily Load (TMDL) to address its water quality concerns. MassDOT completed an evaluation of the waterbody in 2013, which looked at sources of pathogens relative to discharges from MassDOT's system (MassDOT, 2013). The report indicated that it is unlikely that MassDOT is the primary source of pathogens to Mill Creek and that the existing MassDOT stormwater management plan has been adequate to address potential MassDOT pollution sources.

The EPA released a report card for the Mystic River in 2018 which indicated that, while other parts of the Mystic River watershed achieved 'A's for meeting water quality standards for boating and swimming 85% of the time or better, Mill Creek was rated an 'F' because standards were met less than 40% of the time (USEPA, 2018). Mill Creek has been graded as an 'F' since the initiation of the current water quality assessment system began in 2014.

Stormwater Subcatchments

Stormwater subcatchment data for the City of Chelsea were provided through their GIS department. For the City of Revere, HW utilized the existing drainage infrastructure and topography along with the Watershed tool in ArcGIS to create the stormwater subcatchments. Quality control was performed on both the Chelsea and Revere's subcatchments to verify that the extents produced by the tool were reasonable based on the data available. However, field verification was not completed, so subcatchment boundaries should be considered as approximate only. Overall there are 16 total stormwater subcatchments draining to the Mill Creek focus area; seven of the subcatchments are primarily from Chelsea and nine are from Revere.

To prioritize those subcatchments that may be most impactful to stormwater runoff and water quality, HW overlaid the subcatchments and land uses and focused on larger contributing subcatchments with primarily commercial and high-density residential land uses. The larger subcatchments are more likely to create more significant runoff volumes and erosive velocities at outfalls. Higher percentages of impervious cover and high-density land use are more likely to generate higher pollutant loads (EPA, 2016). From this evaluation, HW identified six total stormwater subcatchments to assess in the field, including three subcatchments from Chelsea and three from Revere.

#### Field Assessment

HW conducted the field assessment of priority stormwater subcatchments on November 19, 2018, following a period of light rain (approximately 0.2 inches). HW used a tablet with a data collection survey, Survey 123 for ArcGIS, which captured details of the sites, photos and sketches. The data collection sheets are provided in Appendix E.

The field assessment methodology included the evaluation of the following site data:

- Site Description
- Ownership
- Primary Land Use
- Primary Pollutants
- Impervious Dimensions: Width of sidewalk or road (if applicable), parking spot and parking lot dimensions
- Proposed Best Management Practices and Feasibility includes evaluation of non-structural controls, potential site constraints and identification of the primary BMP benefit

Retrofit assessments were conducted at 19 sites within the six priority subcatchments. HW selected the sites within the priority subcatchments by walking and/or driving the subcatchments to identify potential retrofit opportunities. In most cases, HW identified the location of a ‘typical’ retrofit within a right-of-way (ROW) or a parking lot, which could be replicated along in adjacent areas, particularly those of similar land uses. Therefore, there are likely much more than 19 potential retrofits that could be implemented.

HW did not directly evaluate opportunities to manage stormwater within MassDOT ROW. However, HW did drive by these areas during the field assessment to understand existing conditions.

### Overall Observations and Recommendations

During the field visit, HW identified major observations for stormwater management within the cities of Chelsea and Revere:

1) Excess impervious cover: Many of the ROWs and parking lots appeared to have excess pavement for the type and amount of use. For example, there were several one-way roads within residential areas of both Chelsea and Revere that were 24 to 30 feet or greater in width. In comparison, typical road widths are 11 to 12 feet and parking lanes 7 to 9 feet. Photo 27 below shows Vinal Street in Revere, a one-way road which has a 24-ft width. Road network

configurations contributed to excess pavement as well; Suffolk Avenue in Revere (Photo 28) has a road width of 50 feet where the street splits into two one-way roads before joining at Tudor Street. Sidewalks, typically 5 to 7 feet in width, were present on both sides of the street in most areas.

**Photo 27: Vinal Street in Revere, MA**

**Photo 28: Suffolk Avenue in Revere, MA**

2) Slopes, tree canopy, and utilities are limiting factors for stormwater retrofits: The topography in both Chelsea and Revere creates significant slopes (>25% in some areas) that will make it difficult to manage stormwater runoff in the ROW. In addition, there were many mature trees identified along the ROWs, particularly in the subcatchments within Revere. Subsurface utilities (gas, water) and utility poles were on opposite sides with sanitary and stormwater infrastructure in the center of the road. Overall, these limiting factors will limit the siting and sizing of stormwater management retrofit practices.

3) Sediment and pollutants: Acknowledging that sediment is a large contributor to the impacts within Mill Creek, HW staff looked throughout the priority subcatchments for potential sediment sources. One of the potential sources is construction sites. HW noticed one site in the ROW on Webster Avenue in Chelsea that appeared to have no sediment or erosion control. HW also observed exposed soil at several residential properties where residents appeared to be parking their vehicles (Photo 29). Another likely upland source, though not observed at the time of the site visit, is the use of sand during winter seasons. Other pollutants observed included leaves, debris, trash and oil/grease which were present throughout the subcatchments.

**Photo 29: Photos of exposed soil at residential sites**

Large volumes and velocities of stormwater coming from outfalls at the creek may also be leading to scouring, undercutting of slopes and erosion that results in sedimentation in downstream areas. Further assessment of contributing drainage areas, hydraulic modeling and site observations can help to verify the impact of stormwater runoff into the creek.

4) Encroachment: The historical development of Chelsea and Revere, including the filling of existing waterways and wetlands, construction of Route 1 and Revere Beach Parkway, and development of commercial and residential uses has limited the amount of buffer and floodplain available between the impervious cover and the creek (see Figure 3). This means that much of the debris and trash noted within those areas can easily be wind-swept into the Creek. A reduced buffer also restricts the opportunities for end-of-pipe stormwater management.

# 4. Proposed Projects and Planning Level Cost Estimates

Based on this initial restoration assessment for Mill Creek, HW identified the major system stressors that dominate Mill Creek and its contributing subcatchments in order to inform the types of restoration projects that may offer the most benefit to address those stressors. The major stressors identified within the project limits include: channel restrictions, stormwater runoff, and encroachment. Encroachment is herein defined as the presence of structures, roads, parking lots and other development in the historically natural areas of the creek such as wetlands, floodplains, and buffers. These are inclusive of several subcategories, which have been described in Section 3.

All of the major stressors have collectively led to the major impacts in the creek over time including invasives, sediment buildup and channel/salt marsh alterations. This has led to significant degradation of the creek's water quality, habitat, hydrology, and geomorphology as noted in Section 3. A graphic showing the major stressors and subcategories is shown in Figure 9.

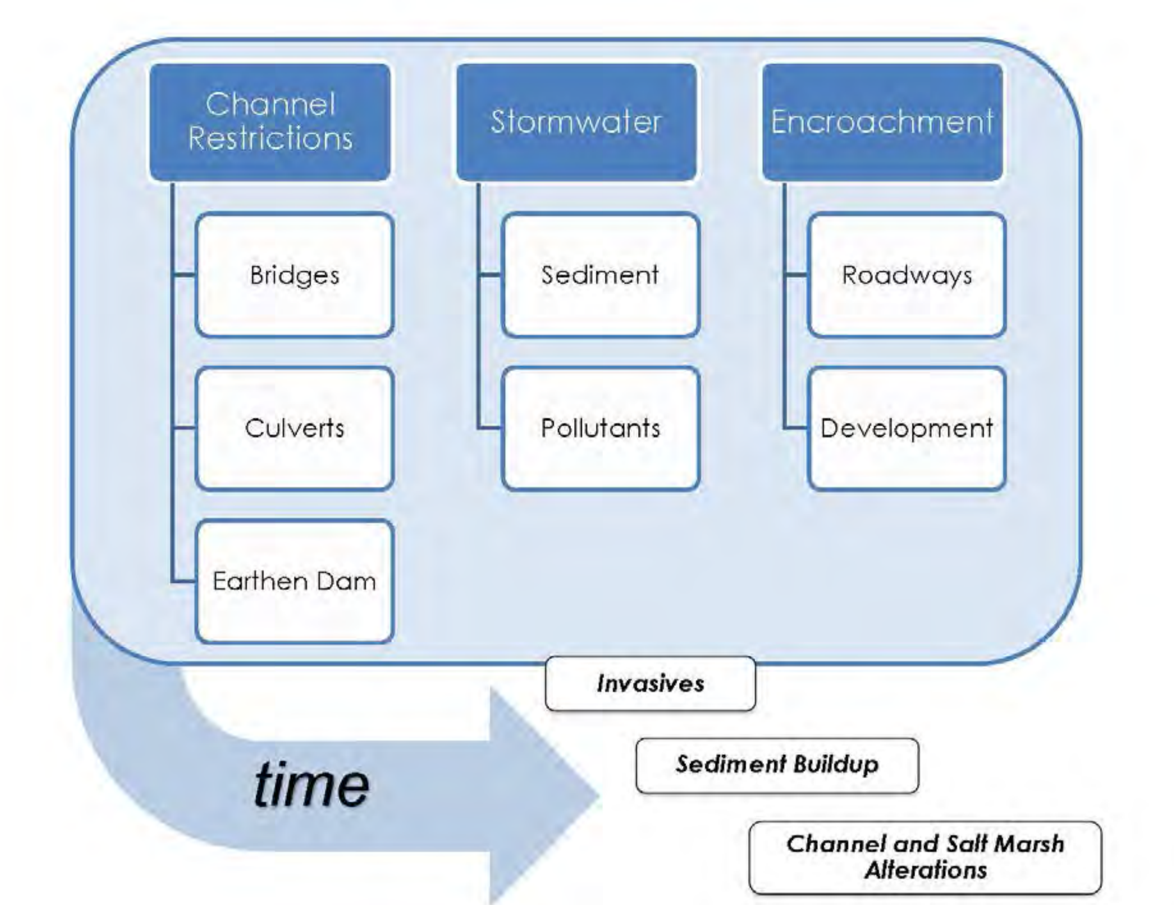



**Figure 9. Major Stressors Identified (blue) with relevant subcategories (blue outline)**

The first step in identifying restoration opportunities was to broadly consider solutions to the major stressors noted above in Figure 9. For example, to address channel restrictions, there may be partial or complete removal of a structure; replacement of an existing structure with a larger or alternate structure that reduces or removes the restriction; or otherwise altering an existing structure to reduce impacts, such as lowering invert elevations. Such opportunities are noted in Figure 10, all which collectively contribute to revitalizing the creek over time by removing sources of pollutants, reducing anthropogenic impacts and allowing the creek to slowly return to its natural state. The second step was to review sites in Mill Creek and in the contributing subcatchments to determine if there was an opportunity to apply those broader solutions. For example, reviewing all six of the channel restrictions for opportunities to either remove, replace or alter the existing structures. The final step is to identify the specific projects that may be implemented to address the stressors.

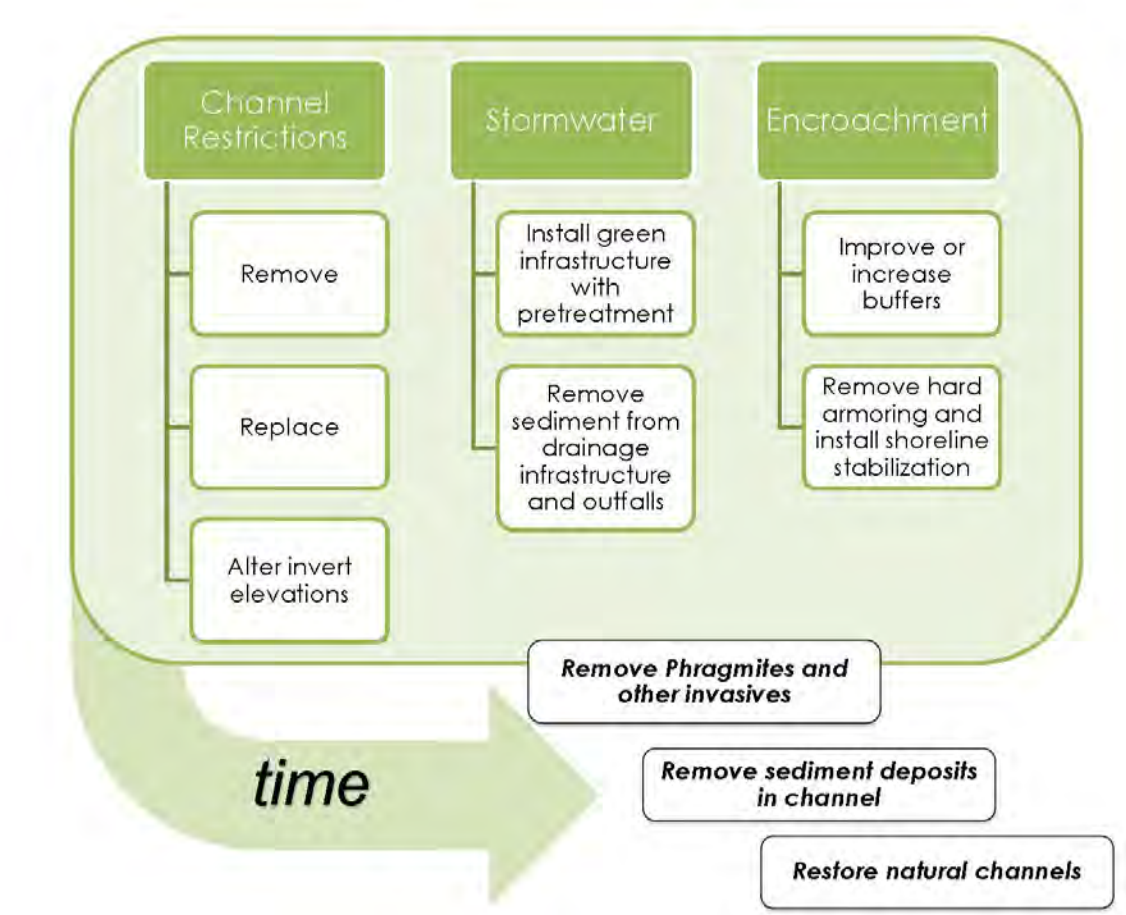
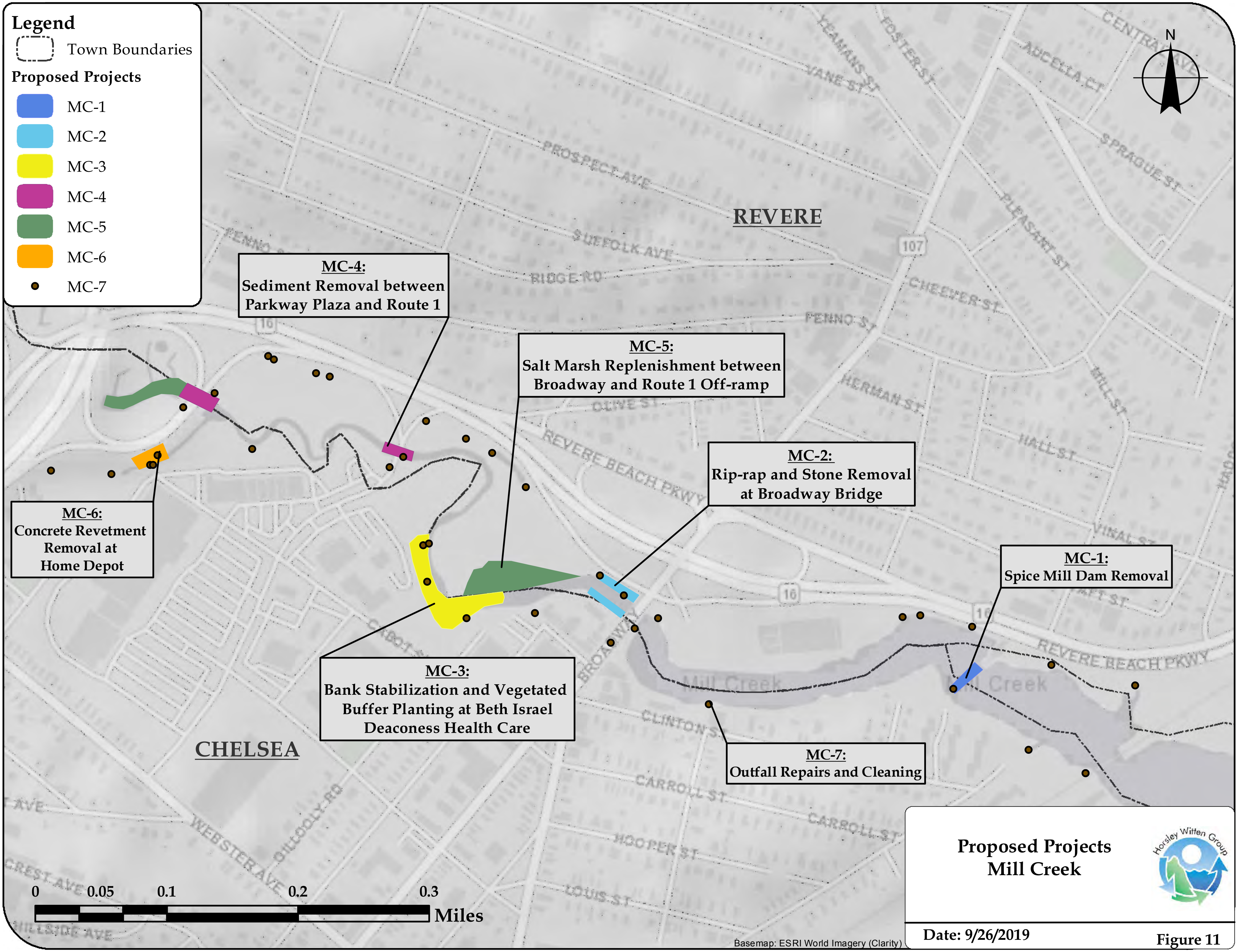



**Figure 10. Potential Opportunities (green outline) to address Major Stressors (green)**

## 4.1 Mill Creek Restoration Projects

The seven identified restoration projects within Mill Creek are summarized within this section. Figure 11 provides an overview of the location of the proposed projects.


Legend
Town Boundaries
Proposed Projects
MC-1
MC-2
MC-3
MC-4
MC-5
MC-6
MC-7
MC-4:
Sediment Removal between Parkway Plaza and Route 1
MC-5:
Salt Marsh Replenishment between Broadway and Route 1 Off-ramp
MC-2:
Rip-rap and Stone Removal at Broadway Bridge
MC-6:
Concrete Revetment Removal at Home Depot
MC-1:
Spice Mill Dam Removal
MC-3:
Bank Stabilization and Vegetated Buffer Planting at Beth Israel Deaconess Health Care
MC-7:
Outfall Repairs and Cleaning
REVERE
CHELSEA
Mill Creek
PROSPECT AVE
SUFFOLK AVE
RIDGE RD
FENNO ST
CHEEVER ST
HERMAN ST
OLIVE ST
REVERE BEACH PKWY
HALL ST
VINAL ST
PLEASANT ST
SPRAGUE ST
MILL ST
VANE ST
YEAMANS ST
FOSTER ST
AUCELLA CT
CENTRAL AVE
BROADWAY
CABOT ST
CLINTON ST
CARROLL ST
HOOPER ST
LOUIS ST
WEBSTER AVE
DILLOOLY RD
HILLSIDE AVE
16
107
N
0 0.05 0.1 0.2 0.3
Miles
Basemap: ESRI World Imagery (Clarity)
Proposed Projects
Mill Creek
Horsley Witten Group
Date: 9/26/2019
Figure 11

## MC-1: Spice Mill Dam Removal

The earthen berm dam to the southwest of the old Spice Mill building was constructed as part of that historic tidal grist mill complex but currently does not serve any functional purpose. The berm is approximately forty feet wide at its base, twenty feet wide at its top, and is about eight feet high. It is about 160 feet in length and spans the entire width of Mill Creek except for the area beneath the mill building itself and an approximately 4-foot wide gap between the mill building and the berm, and a second gap nearer to the southern bank of the creek. With a lower crest elevation, it allows water to move freely near the middle and higher tidal ranges but creates a restriction to both incoming and outgoing tidal flow at the lower end of the tidal range. As the most downstream of the observed tidal restrictions in the study area, its impacts affect the remaining upstream areas and, therefore exacerbate the individual impacts of each succeeding upstream restriction. The impacts of the Spice Mill Dam are particularly evident with regard to impeding drainage during storm events. The removal of the Spice Mill dam would offer tidal flushing benefits to the entire upstream area of the creek as well as allow free outflow of stormwater. The volume of the berm is estimated to be approximately 1,400 cubic yards of material if it were to be fully removed.

In terms of feasibility, it is the only tidal restriction identified on the main channel of Mill Creek that does not have a major roadway above it. This fact makes the potential removal of the Spice Mill dam a more feasible project than other restrictions, both economically and logistically. Moving forward with this project would require additional survey to obtain accurate cross sections and elevations for hydrologic, hydraulic and hydrodynamic modeling and design analyses which will provide a more complete evaluation of costs and benefits, including flooding risks.

## MC-2: Riprap and Stone Removal at Broadway Bridge

Excessive or unnecessary riprap, most notably observed in the vicinity of the Broadway bridge, could be removed to increase available habitat space for native salt marsh plants. Softer shoreline stabilization methods (for example using coir logs and vegetated slopes) could be used instead of hard armoring for seemingly low-velocity environments.

A similar approach could be taken at places where large granite blocks line the channel, most notably observed in the vicinity of the Spice Mill dam which could be replaced with vegetated shoreline stabilization methods.

## MC-3: Bank Stabilization and Vegetated Buffer Planting at Beth Israel Deaconess HealthCare

The bank and buffer of a section of 500 linear bank starting at the Beth Israel Deaconess and Walgreens Parking lot extending north could be restored and stabilized. This project could include the regrading of the shoreline to restore floodplain connection, soft shoreline stabilization methods, removal of approximately an acre of existing invasive species and revegetation of native buffer species. Pilot-scale salt marsh replenishment could also be considered as part of this project. In discussions with local community members and groups, including GreenRoots, this site also has a potential to become an active and/or passive recreation space due to the proximity of the existing Creekside Commons Park, the Mill Creek Riverwalk and the available water access. A photo of the existing site is shown in Photo 30.

**Photo 30. Exposed Bank Near Beth Israel Deaconess HealthCare**

## MC-4: Sediment Removal between Parkway Plaza and Route 1

A temporary improvement in flow conditions may be achieved by dredging one or more channels through the Parkway Plaza culvert and the Route 1 off/on-ramp culverts, removing some of the several feet of fine sediments that have accumulated in those narrow portions of the system (see Photos 11 and 24). However, hydraulic and/or sediment transport assessment and modeling would be necessary to determine what the sources and amounts of the current sediment deposits are to determine the overall impact of the removal and cost effectiveness. Further, modeling will help to determine whether there would be an increased flooding risk if those sediments were temporarily removed. Unless sediment sources from the subwatershed and in-stream erosion are addressed beforehand, sediment removal would offer only temporary improvement.

Based on observations in Mill Creek and in the upland areas, more effective stormwater management and reductions in stormwater runoff will be required in contributing subcatchments to achieve a more permanent solution to reducing erosion and sedimentation in the creek.

## MC-5: Salt Marsh Replenishment between Broadway and Route 1 Off-ramp

Extensive mudflat areas could be partially enhanced with salt marsh plantings to help the system adapt to climate change, particularly with seal level rise. Note that this would be a difficult and expensive project whose longer-term success would partially hinge on improving the hydraulic conditions that have historically contributed to salt marsh depletion (e.g. stormwater outfalls and tidal restrictions). It Is not recommended that significant salt marsh replenishment be attempted without first addressing the hydraulic and/or water quality stressors that likely contributed to past and/or ongoing salt marsh decline. Experimentation with smaller scale pilot projects of salt marsh restoration (e.g. by adding to the MC-3 bank stabilization discussed above) is recommended.

### MC-6: Concrete Revetment Removal at Home Depot

The tributary channel to Mill Creek encounters a bottleneck restriction between filled lands used to create the U.S. Route 1 off/on ramp and the Home Depot plaza. The steep slope on the Home Depot side of the channel is covered with concrete. The origin of the concrete is uncertain. It could potentially have been installed during the construction of the Home Depot plaza to prevent scour, erosion, slumping, and slope failure. It could also be potentially capping hazardous fill material underneath. The narrow nature of the bottleneck the concrete revetment, and the outfall pipe are all serving to restrict tidal flow to and from an upstream marsh area significantly impacted by invasive common reed growth. An alternative slope stabilization approach (potentially including retaining walls or living walls) could be designed at this location to lower the invert elevation of the channel and widen its cross-sectional area to allow improved tidal flow in and out the upstream salt marsh.

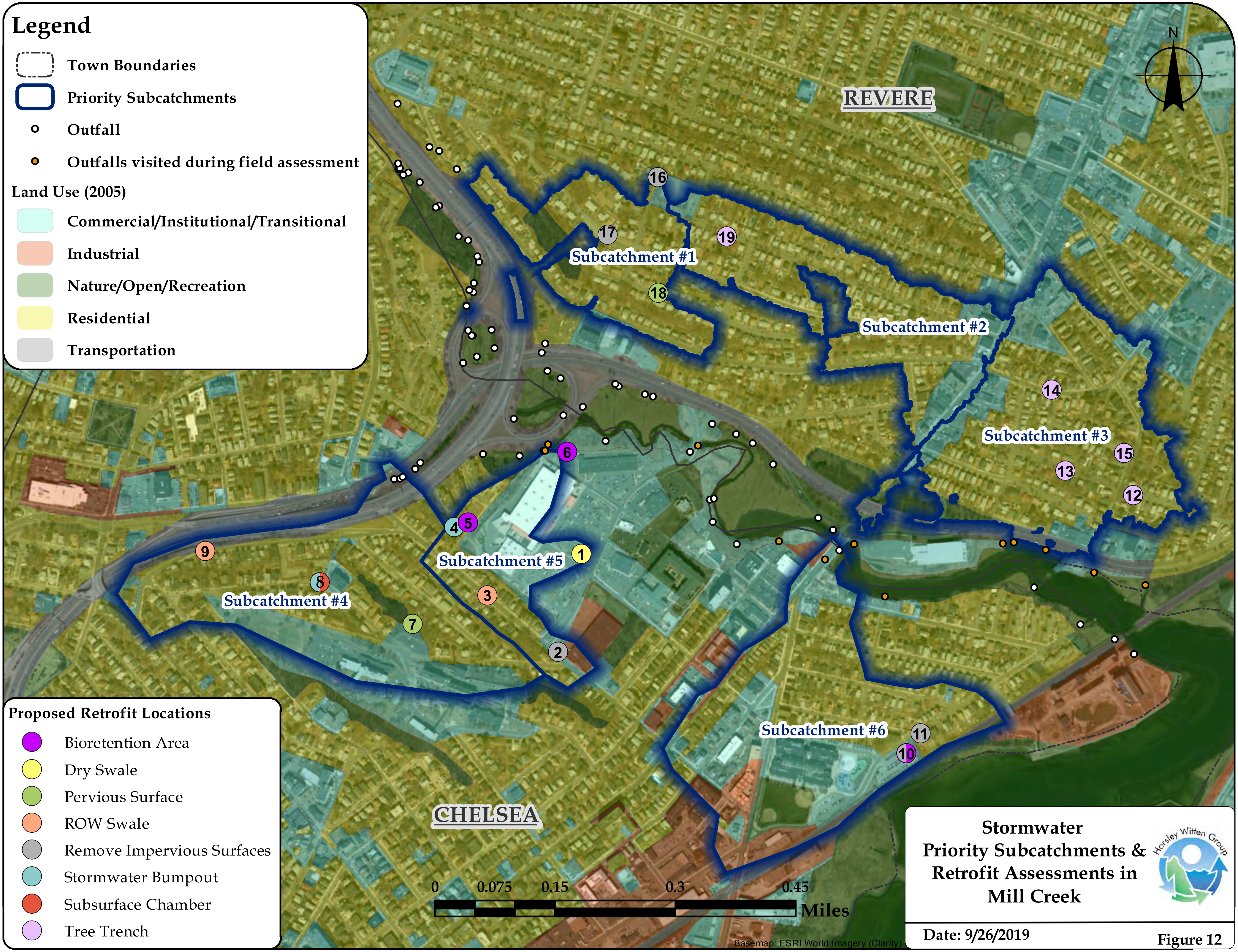
However, significant unknowns and concerns exist that would need to be evaluated before this concept is further pursued including the potential presence of hazardous materials, potential flooding impacts upstream or downstream, and overall impacts to vegetation in the area.

### MC-7: Outfall Repairs and Cleaning

Several outfalls observed during the field assessment had sediment buildup at and/or around at Mill Creek. In addition, three of the outfalls had structural deficiencies (e.g., broken/collapsed or in need of significant repair) with the headwall or pipe. Those deficiencies have also destabilized the bank in several places which has led to further erosion and sedimentation in the creek. HW recommends that all outfalls be cleaned and sediment removed to discourage sediment transport downstream. Repairs to deficient outfalls should also be completed, including the use of outfall and bank stabilization techniques to address potential high volumes and velocities of stormwater. As noted in Section 3.3, not all outfalls were assessed during this project; consequently, additional outfall assessments are required to understand the conditions at all outfalls and select the priority projects.

## 4.2 Stormwater Management Recommendations

The stormwater management retrofit opportunities are summarized in this section. Figure 12 provides the locations of the various retrofits recommended at the 19 sites visited during the field assessment.



Legend
Town Boundaries
Priority Subcatchments
Outfall
Outfalls visited during field assessment
Land Use (2005)
Commercial/Institutional/Transitional
Industrial
Nature/Open/Recreation
Residential
Transportation
REVERE
CHELSEA
N
Subcatchment #1
Subcatchment #2
Subcatchment #3
Subcatchment #4
Subcatchment #5
Subcatchment #6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Proposed Retrofit Locations
Bioretention Area
Dry Swale
Pervious Surface
ROW Swale
Remove Impervious Surfaces
Stormwater Bumpout
Subsurface Chamber
Tree Trench
0
0.075
0.15
0.3
0.45
Miles
Basemap: ESRI World Imagery (Clarity)
Stormwater
Priority Subcatchments &
Retrofit Assessments in
Mill Creek
Horsley Witten Group
Date: 9/26/2019
Figure 12

### Provide source control

Controlling the sources of pollution at the source is the most cost-effective way to reduce the amount of pollutants entering the stormwater drainage system.  These source controls are outlined under the MS4 and require written procedures and inspections as described under Section 2.3.7 Good Housekeeping and Pollution Prevention for Permittee Owned Operations (USEPA, 2016).

- Installing and monitoring sediment controls (e.g., catch basin inserts) near construction sites.
- Street sweeping of ROWs and parking lots to remove sand and other debris from the roadways.
- Regular pickup of trash and debris on roadways and parking lots, particularly around the Mill Creek area.  There was significant trash observed around the Mill Creek Riverwalk.
- Minimize/optimize the use of salt and sands during winter road maintenance activities to minimize the opportunities for pollutants to enter Mill Creek.

### Maintain drainage infrastructure

Outside of addressing source controls, inspection and maintenance of drainage infrastructure, particularly catch basins, is a cost-effective and critical defense in addressing pollutants to Mill Creek.  It is also important for addressing localized flooding impacts.  Maintenance includes the removal and proper disposal of sediment, trash, debris and other solids from catch basins, pipes and outfalls; repair of damaged catch basins, pipes and outfalls; and replacement of infrastructure if required by inspections.

Inspections, cleaning frequencies and maintenance procedures are required to be documented under the MS4 permit (USEPA, 2016).  In fiscal year 2018, the City of Chelsea estimated that one-third of their catch basins were cleaned (City of Chelsea, 2018), while the City of Revere noted that 6 structures and nearly 3,400 LF of pipe were cleaned (City of Revere, 2018).  For highly urban areas, catch basins likely need to be cleaned once or twice a year, depending on the land use and/or pollutant load intensity.  The MS4 Permit under Section 2.3.7.a.iii.2 currently requires cleaning when a catch basin sump is 50 percent full.

### Improve pollutant capture

Improving or enhancing pollutant capture is particularly important in high density urban areas, roadways and parking lots because they are more likely to contribute high concentrations of pollutants, including organics, metals, trash and sediments, from stormwater runoff into resource areas.  Enhanced drainage structures and devices can help to remove trash and coarse sediments from the stormwater drainage system.  Examples of typical structures and devices include deep sump catch basins, catch basin hoods, sediment chambers, oil/grease separators, and proprietary water quality units (hydrodynamic separators, flow-through devices, water quality inlets).  Installation of these structures, particularly in high pollutant load areas, are recommended for consideration when road drainage structures are being installed or replaced in the existing ROW as well as parking lot improvements.

### Reduce impervious cover

HW found that several ROWs, parking lots and other impervious areas could be replaced with pervious areas (and, in some cases, with green infrastructure) without impacting the existing function of those spaces.  Examples identified included: reducing road pavement width (particularly for one-way streets), adding stormwater bumpouts or green spaces along ROWs where street parking doesn't appear to be critical (primarily residential areas), and removing excess sidewalk or hardscaping (e.g., Crescent Avenue ROW in Chelsea or Home Depot parking lot).

## Install small-scaled, Distributed Green Infrastructure Practices

The contributing subcatchments to Mill Creek are significantly developed and do not provide sufficient open space to accommodate larger practices capable of server larger drainage areas, particularly at end-of-pipe locations. Further, within the developed areas there are many constraints (slope, tree canopy, utilities, etc.) that limit the opportunities for larger extensive stormwater management practices. Therefore, the use of small-scaled green infrastructure practices distributed throughout the subwatershed is recommended. During our site visits, HW noted that the use of ROW swales as well as tree trenches and/or subsurface infiltration trenches would provide the best opportunities and could be easily replicated in several locations. Renderings of ROW swales and tree trenches are provided in Figures 13 and 14, respectively.

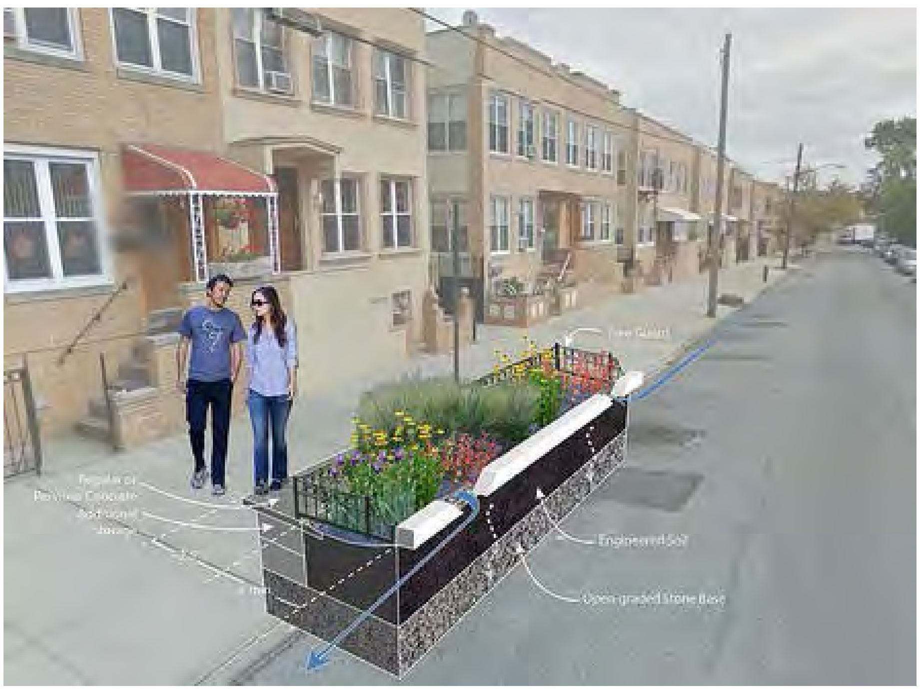



**Figure 13. Rendering of a ROW swale in New York City**

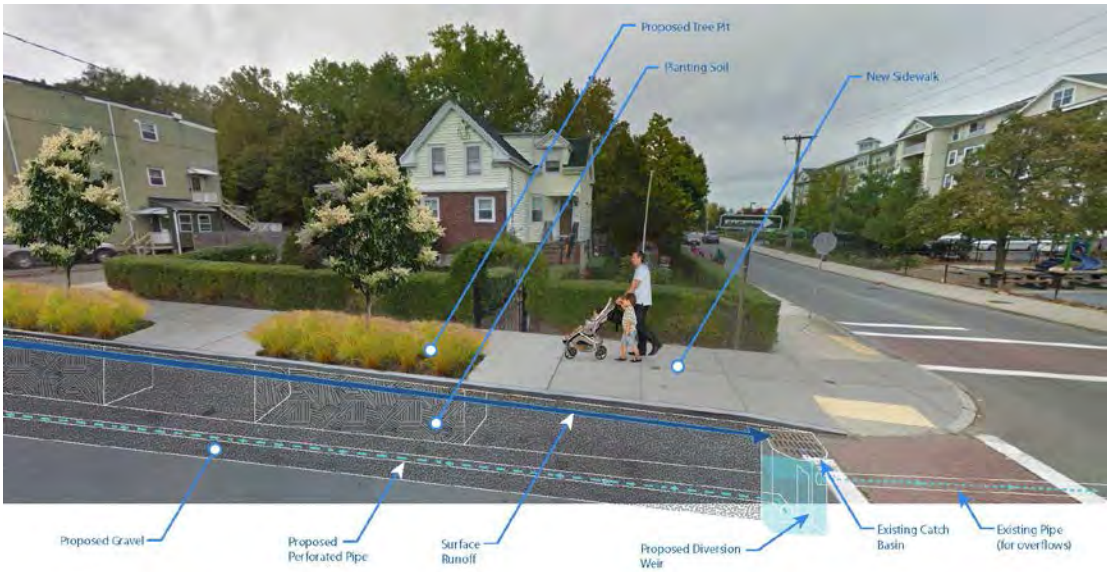



**Figure 14. Rendering of a Tree Trench at Gilloly Road in Chelsea, MA (installed in 2015)**

Other smaller stormwater practices recommended include: bioretention area, dry swale, stormwater bumpout, and pervious pavement. Overall, there were 15 specific sites where stormwater practices were cited as noted in Figure 12 and Appendix E.

### Manage State ROW Runoff

As noted in Section 3, HW did not directly identify the opportunities to manage MassDOT ROW during the site visit. However, from the desktop analysis, there are seven outfalls in the project area that appear to be capturing runoff from small contributing areas (typically two catch basins to one outfall) and discharging directly to Mill Creek. There is limited available ROW for stormwater management, with the exception of the open areas in the on-/off-ramps at Route 1/Revere Beach Parkway. However, based on topography and locations of the outfalls, it would not be possible to direct much drainage to these open areas. At this time, HW recommends that more frequent maintenance along the ROWs of Route 1 and Revere Beach Parkway with the addition of deep sump catch basins and/or enhanced treatment systems are the most recommended practical options to manage pollutants, particularly sediment contributions.

## 4.3 Planning Level Cost Opinions

The planning level cost opinions for the projects outlined above have been developed based on the review of construction costs for similar items from past HW projects as well as applicable reference cost data. The opinions were developed as a range that includes construction costs, design and permitting costs (20% of the construction costs) and construction administration costs (25% of the design and permitting costs). The planning level cost opinions for the Mill Creek restoration projects are summarized in Table 5, while those for stormwater management opportunities are outlined below.

- Street sweeping: $15- $100/curb mile annually (depends on type of equipment, purchased or rented)

- Cleaning of catch basins: $50-$75/structure
- Remove Impervious Surfaces: $2- $4/square foot of impervious area
- Stormwater BMPs: $50,000- $100,000/impervious acre

**Table 6. Planning Level Cost Opinions for Mill Creek Projects**

| Project ID | Project Description | Community | Ownership | Cost Opinion Range |
|---|---|---|---|---|
| **MC-1** | Spice Mill Dam Removal | Chelsea/ Revere | Public | $600 - $1M |
| **MC-2** | Broadway Bridge Riprap and Stone Removal | Chelsea/Revere | Public | $500 – $900k |
| **MC-3** | Beth Israel Deaconess Bank Stabilization and Buffer Planting | Chelsea | Public/ Private | $400 - $700k |
| **MC-4** | Parkway Plaza/Route 1 Sediment Removal | Chelsea/Revere | Public | $500 - $900k |
| **MC-5** | Salt Marsh Replenishment (Broadway/Route 1 Off-ramp) | Chelsea/Revere | Public | $6 - $10M |
| **MC-6** | Concrete Revetment at Home Depot | Chelsea | Public | $700k - $1M |
| **MC-7** | Outfall Cleaning and Repairs | Chelsea/Revere/ MassDOT | Public | $1 - $2M |

# 5. Permitting

## 5.1 Mill Creek Restoration Projects

The proposed restoration projects within Mill Creek (MC-1 through MC-7) will likely all require permitting through various regulatory agencies prior to implementation. For this report, HW has identified all potential permitting requirements that are applicable; each of the restoration projects may require one or more of the following permits:

- Wetland Protection Act, Order of Conditions (OOC) from the Chelsea Conservation Commission;
- Massachusetts Environmental Policy Act (MEPA), Environmental Notification Form (ENF) and possibly Environmental Impact Report (EIR) waiver request;
- U.S. Army Corps of Engineers 404 Programmatic General Permit for impacts to Waters of the United States;
- 401 Water Quality Certification (WQC) through the Massachusetts Department of Environmental Protection;
- Chapter 91 Waterways Permit;
- Jurisdictional Determination, Chapter 253 Permit with the Massachusetts Office of Dam Safety;
- National Pollutant Discharge Elimination System (NPDES) Construction General Permit – NOI;
- Massachusetts Coastal Zone Management Federal Consistency Review; and
- Massachusetts Historic Commission, Section 106.

Detailed permitting requirements include the following:

Order of Conditions under the Massachusetts Wetlands Protection Act – Alteration of any wetland resource area and/or its associated buffer zone will require the filing of a Notice of Intent (NOI) application with the local Conservation Commission and the Massachusetts Department of Environmental Protection (DEP). Depending upon the details of the final design, features will likely be required to address alterations to Salt Marsh and Coastal Bank within the limits of the restoration work. Depending upon the magnitude of the alterations, wildlife habitat assessments may be required by the issuing authority.

Environmental Notification Form through the Massachusetts Environmental Policy Act (M.G.L. c. 30 §§ 61 through 62H, inclusive or MEPA) – Alterations exceeding 1,000 square feet (SF) of salt marsh, 500 or more linear feet (LF) of Bank along a fish run, or alterations of 0.5 acres or more of any other resource area will require State agency review through an ENF. Based upon our understanding of the project, it does not appear that mandatory review through an Environmental Impact Report (EIR) would be required, although a request for a EIR Waiver may be necessary if the overall impacts to resource areas, even if beneficial, would exceed one or more acres of salt marsh or 10 or more acres of other wetlands. MEPA will consider waivers to these requirements if the applicant can demonstrate that the project meets the broad goals as defined in 301 CMR 11.11. Our project team successfully received such a waiver for the Eel River Restoration project (cranberry bog restoration to Atlantic White Cedar swamp that also included a dam removal).

Water Quality Certification (WQC) under Section 401 of the federal Clean Water Act (33 U.S.C. 1251, *et seq*.) – Alterations within BVW and/or land under water (LUW) that cumulatively exceed 5,000 SF will require WQC (issued by the Massachusetts DEP).

Programmatic General Permit (PGP) under Section 404 of the federal Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 – for activities that do not qualify for a self-verification (SV) a preconstruction notification (PCN) or an individual permit (IP) will be required. For example, dredged area exceeding ½ acre and bank stabilization projects occurring in tidal waters require filing of an PCN application with the U.S. Army Corps of Engineers.

Chapter 91 Waterways Permit. The Massachusetts DEP Bureau of Resource Protection, Waterways Regulation Program requires a license or permit for any project that will affect tidal waters or certain non-tidal rivers and streams where an activity may reduce the space available for navigation. The proposed project will occur below the mean high-water mark of the Mill Creek, the assumption is that the proposed project would require permitting under the Public Waterfront Act (M.G.L. Ch. 91) and its regulations at 310 CMR 9.00, if the project is supported by public funds.

Massachusetts Historic Commission. A Section 106 consultation is required under the National Historic Preservation Act (NHPA) to consider the effects of the project on potential historic properties. This may be done in conjunction with the Corps permitting process. The Massachusetts Historical Commission (MHC) will also be notified during the ENF and may provide comments toward the archaeological or historic significance of the Spice Mill building / dam removal.

Massachusetts Coastal Zone Management (CZM). The process is administered in conformity with the federal regulations entitled "*Federal Consistency with Approved Coastal Management Programs*" at 15 CFR 930 Subparts A through I. This process includes review for actions or activities that are have reasonably foreseeable effects on any land or water use or natural resource of a state coastal zone to ensure consistency with the enforceable policies of the federally approved coastal management program for the state. This review is done in conjunction with the Corps permitting process.

Massachusetts Chapter 253 Dam Safety Permit may be required for work that alters a jurisdictional dam structure beyond normal maintenance activity. If the Spice Mill building is determined to be jurisdictional it will be subject to a Dam Safety Order to be repaired or removed.

NPDES Construction Site Permit. If more than 1 acre will be disturbed by the construction activities for this project, an NPDES permit will require registration and preparation of a Storm Water Pollution Prevention Plan (SWPPP). The Mill Creek Restoration project may qualify as a 'large' construction activity depending on the number of acres of disturbance.

One of more of these projects may be eligible to serve as an Ecological Restoration Project, or a Limited Project. We recommend pursuing this avenue when possible. Types of Ecological Restoration Limited Projects include tidal restoration, shellfish habitat restoration, and other Ecological Restoration projects that may be permitted as an Ecological Restoration Limited Project include restoration of hydrologic and habitat connectivity, planting of vegetation to improve habitat value, fill removal and regrading, etc.

## 5.2 Stormwater Management Projects

Many of the projects proposed for stormwater improvements will not require a permit because they are located in the upland portion of the subwatershed, outside of the resource buffers. However, recommended projects located within the resource buffer will likely require an NOI submittal and ultimately an Order of Conditions from the local Conservation Commissions. These include sites SW-6 (in the Home Depot Parking Lot) and SW-10 (Edgar Hooks Elementary School Parking Lot).

# 6. Prioritizing Projects and Opportunities

The recommended projects identified in Section 4 were evaluated further for costs and benefits to provide a prioritized implementation plan moving forward. The criteria selected for evaluation include:

1) **Cost per Area Restored or Treated**: This criterion is based on the planning level cost opinions provided in Section 4, as well as a planning-level estimate of the area that may be restored or treated as a result of the project. The area estimate includes areas upstream of the project which may indirectly benefit from implementation. For example, upper marsh cells will benefit from tidal when a downstream restriction is reduced or removed.
2) **Potential Permitting Requirements**: This criterion is based on potential permits required as outlined in Section 5.
3) **Land Acquisition/Easement:** This criterion identifies whether a project may require additional land acquisitions or easements for implementation and/or maintenance. Land acquisition and/or easements may be required at sites where ownership may be mixed (public/private) or private.
4) **Maintenance Burden**: This criterion considers the level of maintenance that may be required for the long-term management of a project. Types of maintenance might include stormwater infrastructure cleaning; plant/tree management (e.g., watering, removal of dead plants, replacement of plants/trees); and invasive species management.
5) **Timeframe for Implementation**: This criterion estimates a range of the total number of years between a concept design and implementation (e.g., 3 to 5 years). Projects in Mill Creek with

highly complex designs and significant permitting requirements will likely require several years to complete, versus upland stormwater management improvements in the public right-of-way. This criterion does not directly take into account project financing or phasing, which may extend the implementation period.

6) **Climate Resiliency**: This criterion looks at whether the project is climate resilient and the extent to which they provide redundancy and adaptation, both in project scale and lifetime of impact.
7) **Public Benefit**: This criterion identifies the potential for public benefit including opportunities for recreation, education, habitat diversity, access to Mill Creek, improved water quality, improved aesthetics and other social and economic benefits.
8) **Potential Partnerships**: This criterion evaluates the potential for partnerships with local and state agencies, private entities, community groups and/or other stakeholders. Partnerships allow municipalities to leverage available staff, equipment and funds to efficiently design, implement and maintain projects.
9) **Timeframe for Results**: This criterion estimates a range total number of years between implementation and realization of benefits (e.g., 5 to 10 years).

Table 7 summarizes the criteria and associated point values. The projects were then scored on each of the criteria, incorporating all available data from desktop and field assessments. Given that the proposed projects in Mill Creek (IDs with MC-#) and the stormwater management retrofits (IDs with SW-#) are at vastly different scales, some criteria have slightly different ranges for scoring. The criteria cost per area treated or restored was given a slightly larger point value than others because the criteria generally reflects the overall cost-benefit of the project. The total score for each project is based out of 100 points.

### Table 7. Project Prioritization Criteria and Point Values

| Criteria | Sub-Criteria | Sub-Criteria Description | Point Value |
|---|---|---|---|
| Cost Per Area Restored or Treated (20 points) | | Low cost per area restored or treated (<$3 for MC projects, <$1 for SW projects) | 20 |
| | | Moderate cost per area restored or treated ($3-5 for MC projects, $1-3 for SW projects) | 10 |
| | | High cost per area restored or treated (>$5 for MC projects, >$3 for SW projects) | 0 |
| Ease of Implementation (40 points) | Potential Permitting Requirements | Minimal to no permitting required | 10 |
| | | Some permitting likely/ max be complex | 5 |
| | | Complicated permitting likely | 1 |
| | Land Acquisition/ Easement | City-owned property; acquisition/easement not required | 10 |
| | | Ownership is blended (another public entity or public/ private mix; easement agreements or acquisition possibly needed | 5 |
| | | Privately-owned property | 1 |
| | Maintenance Burden | Low relative maintenance burden (<1 maintenance day/year) | 10 |
| | | Moderate maintenance burden (1-2 maintenance days/year) | 5 |
| | | High maintenance burden (>2 maintenance days/year) | 1 |
| | Timeframe for Implementation | Short timeframe for implementation (<3 years for MC projects, <1 year for SW projects) | 10 |
| | | Moderate timeframe for implementation (3-5 years for MC projects, 1-3 years for SW projects) | 5 |
| | | Long timeframe for implementation (>5 years for MC projects, > 3 years for SW projects) | 1 |
| Long-term Success (30 points) | Climate Resiliency | Project is highly climate resilient; provides significant redundancy and adaptation as climate changes | 10 |
| | | Project is moderately climate resilient; provides some redundancy and adaptation on a smaller scale | 5 |
| | | Project has no or limited climate resiliency | 1 |
| | Public Benefit | Project provides a significant public benefit (multiple opportunities) | 10 |
| | | Project provides a few public benefits or benefits are not highly visible | 5 |
| | | Project provides little direct public benefit or benefits are not visible to the public | 1 |
| | Potential Partnerships | High potential for partnerships with local and state agencies, private entities, community groups and/or other stakeholders | 10 |
| | | Moderate potential for partnerships | 5 |
| | | Low potential for partnerships | 1 |
| | Timeframe for Results | Short timeframe for results (<5 years for MC projects, <1 year for SW projects) | 10 |
| | | Moderate timeframe for results (5-10 years for MC projects, 1-3 years for SW projects) | 5 |
| | | Long timeframe for results (>10 years for MC projects, >3 years for SW projects) | 1 |

The preliminary project scoring is presented in Tables 8 and 9 using the criteria above and the project rankings are provided in Table 10. These preliminary scores and rankings are intended to be general guidance for the selection of projects for implementation and should be revisited as the concept designs advance in greater detail and as opportunities become available within the communities. In particular, project prioritization adjustments are recommended for projects and sites that are within limits of proposed right-of-way improvements or capital improvement projects.

**Table 8. Preliminary Project Scoring for Mill Creek Projects**

| Project ID | Cost Per Area Treated | Potential Permitting | Land acquisition/ easement | Maintenance | Timeframe for Implementation | Climate Resiliency | Public Benefit | Partnership Opportunities | Timeframe for Results | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **MC-1** | 20 | 1 | 10 | 10 | 5 | 10 | 10 | 10 | 5 | 81 |
| **MC-2** | 10 | 5 | 10 | 10 | 10 | 5 | 5 | 10 | 5 | 70 |
| **MC-3** | 10 | 5 | 1 | 1 | 5 | 10 | 10 | 10 | 10 | 62 |
| **MC-4** | 20 | 5 | 10 | 10 | 5 | 1 | 1 | 1 | 5 | 58 |
| **MC-5** | 1 | 1 | 5 | 5 | 1 | 10 | 10 | 10 | 1 | 49 |
| **MC-6** | 1 | 1 | 10 | 10 | 5 | 10 | 1 | 10 | 10 | 53 |
| **MC-7** | 20 | 10 | 5 | 5 | 10 | 1 | 1 | 5 | 10 | 72 |

**Table 9. Preliminary Project Scoring for Stormwater Management Projects**

| Project ID | Cost Per Area Treated | Potential Permitting | Land acquisition/ easement | Maintenance | Timeframe for Implementation | Climate Resiliency | Public Benefit | Partnership Opportunities | Timeframe for Results | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **SW-1** | 10 | 10 | 5 | 10 | 1 | 10 | 5 | 5 | 1 | 57 |
| **SW-2** | 20 | 10 | 10 | 10 | 10 | 5 | 5 | 1 | 10 | 81 |
| **SW-3** | 10 | 10 | 10 | 5 | 5 | 10 | 10 | 1 | 5 | 66 |
| **SW-4** | 10 | 10 | 10 | 1 | 5 | 10 | 10 | 5 | 5 | 66 |
| **SW-5** | 1 | 10 | 10 | 1 | 5 | 10 | 10 | 5 | 1 | 53 |
| **SW-6** | 1 | 1 | 1 | 1 | 1 | 10 | 5 | 5 | 1 | 26 |
| **SW-7** | 1 | 10 | 5 | 1 | 1 | 10 | 1 | 5 | 10 | 44 |
| **SW-8** | 10 | 10 | 10 | 5 | 5 | 10 | 10 | 1 | 5 | 66 |
| **SW-9** | 10 | 10 | 10 | 5 | 5 | 10 | 10 | 1 | 5 | 66 |
| **SW-10** | 10 | 1 | 10 | 5 | 5 | 10 | 5 | 5 | 10 | 61 |
| **SW-11** | 20 | 10 | 10 | 10 | 10 | 5 | 10 | 1 | 10 | 86 |
| **SW-12** | 10 | 10 | 10 | 10 | 5 | 10 | 10 | 1 | 10 | 76 |
| **SW-13** | 10 | 10 | 10 | 10 | 5 | 10 | 10 | 1 | 10 | 76 |
| **SW-14** | 10 | 10 | 10 | 10 | 5 | 10 | 10 | 1 | 10 | 76 |
| **SW-15** | 10 | 10 | 10 | 10 | 5 | 10 | 10 | 1 | 10 | 76 |
| **SW-16** | 20 | 10 | 10 | 10 | 10 | 5 | 5 | 1 | 10 | 81 |
| **SW-17** | 20 | 10 | 10 | 10 | 10 | 5 | 5 | 1 | 10 | 81 |
| **SW-18** | 1 | 10 | 10 | 1 | 1 | 10 | 1 | 1 | 10 | 45 |
| **SW-19** | 10 | 10 | 10 | 10 | 5 | 10 | 10 | 1 | 10 | 76 |

**Table 10. Preliminary Project Ranking**

| Project ID | Description | Rank |
|---|---|---|
| **MC-1** | Spice Mill Dam Removal | 1 |
| **MC-7** | Outfall Cleaning and Repairs | 2 |
| **MC-2** | Broadway Bridge Rip-rap and Stone Removal | 3 |
| **MC-3** | Beth Israel Deaconess Bank Stabilization and Buffer Planting | 4 |
| **MC-4** | Parkway Plaza/Route 1 Sediment Removal | 5 |
| **MC-6** | Concrete Revetment at Home Depot | 6 |
| **MC-5** | Salt Marsh Replenishment (Broadway/Route 1 Off-ramp) | 7 |
| | | |
| **SW-11** | Remove Impervious Surfaces | 1 |
| **SW-16** | Remove Impervious Surfaces | 2 |
| **SW-17** | Remove Impervious Surfaces | 3 |
| **SW-2** | Remove Impervious Surfaces | 4 |
| **SW-12** | Tree Trench | 5 |
| **SW-13** | Tree Trench | 6 |
| **SW-14** | Tree Trench | 7 |
| **SW-15** | Tree Trench | 8 |
| **SW-19** | Tree Trench | 9 |
| **SW-3** | ROW Swale | 10 |
| **SW-4** | Stormwater Bumpout | 11 |
| **SW-8** | Stormwater Bumpout (Alt: Subsurface Chamber) | 12 |
| **SW-9** | ROW Swale | 13 |
| **SW-10** | Remove Impervious Surfaces (Alt: Bioretention Area) | 14 |
| **SW-1** | Dry Swale | 15 |
| **SW-5** | Bioretention Area | 16 |
| **SW-18** | Pervious Surface | 17 |
| **SW-7** | Pervious Surface | 18 |
| **SW-6** | Bioretention Area | 19 |

# 7. Conclusions and Next Steps

The previous sections of this report provide a summary of the desktop analyses and field assessments that were undertaken during the summer and fall of 2018 in the project focus area as well as the processes for evaluating opportunities for creek restoration and stormwater management retrofit projects. This assessment is intended to be a broad, qualitative review of existing conditions and potential opportunities based on the data available to date, including previous evaluations conducted prior to 2018, GIS data, and tidal and vegetation data collected in the summer and fall of 2018. The identified projects and prioritization thereof are subject to revisions depending on the acquiring of additional data; additional input from the communities, community stakeholders, and/or project partners (e.g., CZM, MassBays, MBTA, MassDOT); and ongoing project planning efforts.

In the short-term, immediate opportunities such as maintenance of stormwater drainage infrastructure and overall management of stormwater runoff to Mill Creek, should be integrated into planning and capital improvement projects to the extent practicable. In addition, addressing regulatory updates required under the MS4 Permit will help to further encourage the design, implementation and maintenance of stormwater best management practices during and after construction to address sources of sediment and nutrients.

In the long-term, the implications of climate change will need to be evaluated. Climate change impacts including increased frequency and volume of rain events, raised sea levels, and increased storm surges and associated flooding risks will create vulnerabilities to Mill Creek and contributing drainage infrastructure. A recent report completed for the City of Chelsea in 2017 identified that the MBTA and Broadway bridges were both priority critical infrastructure that will be vulnerable to climate change (Stantec and Woods Hole Group, 2017). Further, much of the low-lying areas adjacent to the creek, including residential areas and Revere Beach Parkway, have increased probability of flooding in the next 10 years. Therefore, all recommended projects, particularly those within Mill Creek, will require further evaluation in the context of potential climate change impacts to ensure that future changes would not negatively impact communities or infrastructure.

Therefore, HW recommends that the following activities be conducted to help support the conceptual design of the projects and prioritization:

- Conduct a field assessment of areas and outfalls in the Mill Creek subwatershed that are upstream of the project area and upstream of Route 1 off-ramp, including the drainage swales contributing to the Creek that parallel Route 1.
- Conduct detailed topographic and bathymetric surveys of the creek, including obtaining detailed cross sections at consistent intervals and additional details at all restriction points. This additional detail is necessary for future modeling efforts.
- Conduct hydrologic/hydraulic/hydrodynamic modeling of the system, which may require additional tidal and/or flow monitoring data. Modeling is needed to assess the impacts of the climate change and restoration projects under future conditions.
- Verify stormwater subcatchments and drainage areas contributing to the outfalls at Mill Creek.
- Locate and assess all remaining outfalls in Mill Creek, obtaining information about existing conditions, dimensions, materials and impacts at the creek.
- Conduct a pre-restoration program of wet and dry weather water quality sampling to evaluate whether water quality conditions are suitable to support restored salt marshes. This should include sampling for salinity, temperature, dissolved oxygen, pathogens, nutrients, sediments, and hazardous substances, as well as pore water salinity analysis in salt marsh cell slated for restoration.
- Study salt marsh health at outfall locations. There is a clear pattern of erosion and muddy unvegetated banks at some of these. Study the specific effects of stormwater flow at key outfalls.
- Conduct a detailed habitat assessment in salt marsh cells to be restored to provide a baseline of salt marsh system health to be used in future studies.

Beyond collecting additional data, the next steps for this project include:

- Meeting with MassBays staff to review findings from this report and opportunities for future planning and/or implementation projects
- Meeting with City of Revere and City of Chelsea staff to review findings and obtain information on upcoming City projects, if available, to help project prioritization
- Collecting additional data and/or perform additional analyses as outlined above
- Identify potential public-private partnerships and key stakeholders
- Conducting public outreach and education to address non-point source pollutants
- Progressing priority projects into design development and permitting
- Implementing projects as funding is available
- Monitoring project benefits

## 7.1 Recommendations Beyond the Scope of this Project

A more complete evaluation of MassDOT stormwater runoff from Route 1 to Mill Creek from is recommended to understand potential contributions and identify potential solutions, whether stormwater retrofits or improved maintenance. Additional coordination with MassDOT will be required including obtaining available construction or as-built plans of the stormwater infrastructure and outfalls.

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