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Muddy Creek Restoration Bridge Project Vegetation and Photographic Monitoring

Chatham, Massachusetts

January 2019

Prepared for:
The Town of Chatham
549 Main Street
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Prepared by:
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Muddy Creek Restoration Bridge Project
Chatham, Massachusetts

VEGETATION AND PHOTOGRAPHIC MONITORING

January 2019

Table of Contents

VEGETATION AND PHOTOGRAPHIC MONITORING REPORT

January 2019

1.0 INTRODUCTION

Muddy Creek, located along the town boundary between Chatham and Harwich, was tidally restored in 2016. Two box culverts, approximately 2.5-feet wide, 3.75-feet in height, and 100-feet in length, were replaced with a single span bridge with a 22-foot wide opening. The tidal restoration benefits 55 acres of wetland upstream of the Route 28 Bridge.

In 2018, the Town of Chatham hired Horsley Witten Group, Inc. (HW) to conduct post-tidal monitoring at the pre-existing vegetation and photographic monitoring stations established in 2015. This report summarizes the vegetation and photographic monitoring performed by Horsley Witten Group, Inc., in accordance with permit requirements.

2.0 METHODOLOGY

HW simultaneously conducted vegetation and photographic monitoring on October 25, 26 and November 1, 2018, at established vegetation transects and photo monitoring stations. This survey was conducted at the end of the growing season at peak biomass but before senescence. HW followed the methodology guidelines described in the *Town of Chatham Request for Quotation: Vegetation Transects and Photo Monitoring, Muddy Creek Restoration Bridge Project* (Town of Chatham, 2018) (RFQ), and described below. HW also relied heavily upon the Massachusetts Division of Ecological Restoration's (MassDER) Environmental Monitoring Plan: Muddy Creek Restoration Project (Plan). The purpose of this work was to assess changes in vegetation following increased tidal inundation in Muddy Creek and to track the trajectory of ecological restoration.

2.1 Vegetation

Vegetation species composition was determined using the line-intercept method (Barbour et al., 1987), along transects established in 2015 by MassDER. Transects of variable length were located and monitored in the upper, middle, and lower basins, including a single reference site located downstream of Route 28 Bridge (Table 1). A total of 8 transects were re-established and marked at both ends with non-biodegradable stakes and blue flagging tape. Transect locations, end points, and labels are provided in Attachment A – Monitoring Location Figures from DER's Plan. GPS coordinates of the transect ends are provided in Attachment D.

Table 1. Transect labels and associated transect end points as labeled on Figure 1 (See Appendix A).

	Vegetation Transect ID	Transect End Pt.	Transect End Pt.
1	MC-DS-T1	VEG T1 DS SOUTH	VEG T1 DS NORTH
2	MC-US-T1	VEG T1 UPST SOU	VEG T1 UPST NORT
3	MC-US-T2	VEG T2 UPST SOU	VEG T2 UPST NOR
4	MC-US-T4	VEG T4 UPS SOU	VEG T4 UPST NOR
5	MC-MID-T3	MC MID VEG T3	MC MID VEG T3
6	MC-UP-T3	MC UP VEG T3	MC UP VEG T3
7	MC-UP-T2	MC UP VEG T2	MC UP VEG T2
8	MC-UP-T1	MC UP VEG T1	MC UP VEG T1

All plants that projected through the transect line (i.e., tape measure) were identified at one meter intervals. Percent frequency for each plant species was determined by dividing the absolute frequency of a species by the total number of intervals along the transect, serving as an indicator of overall vegetation cover.

Additionally, to determine if *Phragmites australis* (Phragmites) has expanded, retreated, or remained the same, the height of the two tallest Phragmites plants were measured for each five-meter interval along established transects where Phragmites was present. Mann-Whitney U tests were applied on the Phragmites heights per transects to determine pre- versus post-tidal restoration. The extent of distinct Phragmites stands along the transect were also recorded to document the distance, in meters, of Phragmites presence.

2.2 Photographic Documentation

According to the RFQ Task 2, 18 photo documentation stations were established by MassDER and U. S. Fish and Wildlife Service (USFWS) during the fall of 2015 (pre-restoration). However, a total of 19 photo stations were included in the Plan, eight in Figure 4 (of the Plan), and 11 in Figure 5 (of the Plan). Six additional photo stations were listed on the MassDER shared Google Drive (e.g. Sugar Hill and Old Dike). Additionally, not all 18 of the photo monitoring stations had GIS coordinates, and lastly there was discrepancy between photo station names.

Nineteen photographic monitoring stations were documented by HW on October 25, 26 and November 1 of 2018. HW used the photo monitoring stations referenced in the Plan and those in the Google Drive as the sources for which sites were photographed. GIS coordinates for seven of the photo stations were not provided prior to HW's scheduled field visits, however, HW was able to locate these stations (and take photographs at the required compass bearings) by visually comparing and lining up the area with the photographs taken in 2015.

Table 2. Photographic monitoring stations documented in fall 2018 (gray rows indicate points for which we did not have GPS coordinates prior to our field day).

Count	Plan name	DER/Google Drive Name	HW Name
1	PHOTO DS 1	DS1	DS-1
2	MC PHOTO TIDE POLL	TIDE-POLL	TIDE_POLL
3	PHOTO RT28 DS	RT28-DS	RT28-DS
4	PHOTO RT28 US	RT28-US	RT28-US
5	MC PHOTO VEG T2 US	VEG-T2	VEG-T2
6	PHOTO VEG T1 US	VEG-T1	VEG-T1
7	PHOTO BATH TR7	TR7	TR7
8	PHOTO VEG TR4	Veg T4	VEG-T4
9	MC PHOTO POWERLINES	Powerline	Powerline
10	MC PHOTO VEG TR3	VEG-T3	VEG-T3
11	MC PHOTO MID DOCK	MID-DOCK	MID-DOCK
12	MC PHOTO 177 CD DR	177-CSDR	177-CSDR
13	MC Photo MID 1	MID 1	MID-1
14	MC PHOTO MID 2	MID2	MID-2
15	MC PHOTO MID 3	MID3	MID-3
16	MC PHOTO UP DOCK	UP-DOCK	UpDock
17	MC UP PHOTO 1	UP1	UP1
18	MC Photo UP VEG T3	UP-VEG-T3	UP-VEG-T3
19	MC UP PHOTO 2	UP2	UP2

Established photo stations were photographed to provide a means to qualitatively assess change over time. An 11.5 inch by 11.5 inch dry-erase board was placed in the camera field of view to provide a permanent record within each image of the photo location (station ID), camera orientation (compass bearing), and date.

2.3 Survey

GIS data were provided by the Town of Chatham on October 19, 2018 and uploaded to the RTK GPS. The vegetation survey information for the vegetation transects was complete.

However, there was a fair amount of discrepancy with the GIS coordinates for photographic monitoring stations. Several photographic documentation stations were not included in the GIS coordinates. There were also issues with the nomenclature code matching the photos and the stations, what was mapped, the photos taken, and the actual photo monitoring stations as described in the *Environmental Monitoring Report: Muddy Creek Restoration Bridge Project* (Report). Please see Table 3 for a list of coordinates and the code or "name" associated with those points.

Table 3. GIS data summary.

Point Type	Point No.	Northing	Easting	Code	Survey located by HW
Veg Transect Pt	201	2723731.551	1067325.463	VEG T1 DS SOUTH	Y
Veg Transect Pt	202	2723819.963	1067118.122	VEG T1 DS NORTH	Y
Veg Transect Pt	207	2723582.458	1066951.921	VEG T1 UPST SOU	Y
Veg Transect Pt	208	2723738.281	1066998.29	VEG T1 UPST NORT	Y
Veg Transect Pt	209	2723761.437	1066853.282	VEG T2 UPST SOU	Y
Veg Transect Pt	210	2723892.192	1066841.826	VEG T2 UPST NOR	Y
Veg Transect Pt	211	2723387.665	1066861.948	VEG T4 UPST NOR	Y
Veg Transect Pt	213	2723337.211	1066943.903	VEG T4 UPS SOU	Y
Veg Transect Pt	214	2720432.25	1063356.715	MC MID VEG T3	Y
Veg Transect Pt	216	2720539.408	1063283.174	MC MID VEG T3	Y
Veg Transect Pt	220	2718906.819	1063163.107	MC UP VEG T3	Y
Veg Transect Pt	221	2719019.683	1063226.499	MC UP VEG T3	Y
Veg Transect Pt	222	2718821.735	1063144.707	MC UP VEG T2	Y
Veg Transect Pt	223	2718776.064	1063131.398	MC UP VEG T2	Y
Veg Transect Pt	225	2718797.385	1063405.177	MC UP VEG T1	Y
Veg Transect Pt	226	2718717.214	1063395.631	MC UP VEG T1	Y
Photo	200	2723757.848	1067531.228	PHOTO DS 1	Y
Photo	203	2723696.456	1067240.438	PHOTO RT28 DS	Y
Photo	204	2723705.292	1067164.398	PHOTO RT28 US	Y
Photo	205	2723530.203	1067067.577	PHOTO BATH TR7	Y
Photo	206	2723581.526	1066951.606	PHOTO VEG T1 US	Y
Photo	212	2723386.437	1066863.705	PHOTO VEG TR4	Y
Photo	215	2720440.954	1063351.394	T3 STK3.2METERS	Y
Photo	217	2720001.568	1062819.534	MC PHOTO MID 1	Y
Photo	218	2720112.164	1062613.863	MC PHOTO MID 2	Y
Photo	219	2719027.643	1062927.917	MC UP PHOTO 1	Y
Photo	224	2718814.708	1063171.461	MC UP PHOTO 2	Y
Photo	10000	2723812.827	1067453.313	MC-PHOTO-TIDE-POLL	N
Photo	10001	2721402.618	1064854.427	MC-PHOTO-OLD-DIKE	N
Photo	10002	2720639.347	1064068.695	MC-PHOTO-POWERLINES	N
Photo	10003	2720162.897	1063412.55	MC-PHOTO-MID-DOCK	N
Photo	10004	2720049.292	1063212.553	MC-PHOTO-177-CS-DR	N
Photo	10005	2719974.881	1063096.993	MC Photo MID 1	N
Photo	10006	2719180.432	1062937.819	MC-PHOTO-UP-DOCK	N

In Table 3, the column for Point Number was maintained to show that the Photo monitoring stations came from different sources. HW had not received the coordinates for the stations at the bottom half of Table 3 (point no. 10000 – 10006) prior to field work and so we were unable to survey locate them.

3.0 RESULTS

3.1 Vegetation

Three sites were selected to draw specific comparisons for change in tidal flow: MC-DS-1 (no change), MC-US-T4 (moderate change), and MC-UP-T1 (definitive change).

Transect MC-DS-1

The reference transect located downstream of the Route 28 Bridge, MC-DS-1, was selected as a transect with little indication of change from pre-restoration conditions. All of the transects upstream of the Route 28 Bridge experienced moderate to definitive change in vegetation community, likely as a direct response to the increase in tidal inundation.

Minimal changes in the vegetation community were observed at transect MC-DS-1. In September 2015 and in October 2018, Saltwater Cordgrass (*Spartina alterniflora*) was observed throughout the transect at a frequency of 100%. Common Glasswort (*Salicornia depressa*) (76% in 2015, 78% in 2018) and Salt Meadow Grass (*Spartina patens*) (12% both years) were both observed at similar frequencies in both years. The only change in vegetation frequency was with Sea Blight (*Suaeda maritima*) which was far more abundant in 2015 (68%) than in 2018 (28%).

Table 4. Frequency of vegetation at Transect MC-DS-T1 pre (2015) and post (2018) tidal restoration.

Transect MC-DS-T1	Frequency (%)	
Species	2015	2018
Spartina alterniflora Saltwater Cordgrass	100	100
Spartina patens Salt Meadow Grass	12	12
*Salicornia depressa** Common Glasswort	76	78
Suaeda maritima Sea Blight	68	28

*Note that *Salicornia europea* and *Salicornia virginica* have been reclassified and are both referred to as *Salicornia depressa*.

Transect MC-US-T4

Transect US-T4 was selected as a transect that showed indication of moderate change in the vegetation community from pre-restoration conditions. Between September 2015 and October 2018 there is minimal change in the frequency of Saltwater Cordgrass along US-T4, from 70 % to 77% respectively indicating minimal change in the low marsh. It is worth noting that the

extent of Saltwater Cordgrass expanded a few meters past where it was present in 2015 (21 meter in 2015, 23 meters in 2018), indicating low marsh expansion.

There is evidence of reduced high marsh with dramatic reduction in Salt Meadow Grass and Black Grass (*Juncus gerardii*). Phragmites also dramatically declined at this transect from 43% to 0% from 2015 to 2018.

Table 5. Frequency of vegetation at Transect MC-US-T4 pre (2015) and post (2018) tidal restoration.

Transect MC-US-T4	Frequency (%)	
Species	2015	2018
Spartina alterniflora Saltwater Cordgrass	70	77
Spartina patens Salt Meadow Grass	57	3
Phragmites australis Common Reed	43	0
Juncus gerardii Black Grass	30	0
Salicornia depressa Common Glasswort	17	27
Distichlis spicata Spike Grass	0	3
Atriplex patula Marsh Orach	3	0
Pluchea purpurescens Common Fleabane	3	0
Solidago sempervirens Seaside Goldenrod	37	0

Just upstream of this transect, there are also notable differences in the vegetation community at transect MC-MID-T3 with increased frequency of Saltwater Cordgrass (from 18% to 50%), Common Glasswort (0% to 15%), Sea Blight (0% to 7%), and Marsh Orach (*Atriplex patula*) (0% to12%), and shift away from fresh and brackish water plants.

Transect MC-UP-T1

The transects in the upper reaches of Muddy Creek show definitive signs of increased tidal inundation. Transect MC-UP-T1 is indicative of this change as the type of vegetation and the diversity of vegetation were both impacted. The vegetation community shifted from a freshwater system to brackish with a loss of all freshwater wetland plans including Winterberry (*Ilex verticillata*), Sweet Pepperbush (*Clethra alnifolia*), Swamp Azalea (*Phododendron viscosum*), Northern Bayberry (*Myrica pensylvanica*), Red Maple (*Acer rubrum*), Cinnamon Fern (*Osmunda cinnamomea*), and Marsh Fern (*Thelypteris palustris*).

Between September 2015 and October 2018, Little-headed Spikesedge (*Eleocharis parvula*) increased in frequency from 0% to 32%, while Annual Salt Marsh Fleabane (*Pluchea purpurascens*) and Narrow-leaved Cattail (*Typha angustifolia*) declined in frequency.

Table 6. Frequency of vegetation at Transect MC-UP-T1 pre (2015) and post (2018) tidal restoration.

Transect MC-UP-T1	Frequency	
Species	2015	2018
Eleocharis parvula Little-headed Spikesedge	0	32
Pluchea purpurescens Marsh Fleabane	28	4
Typha angustifolia Narrow-leaved Cat-tail	68	20
Toxicodendron radicans Poison Ivy	24	0
Scirpus validus Soft-stemmed Bulrush	20	0
Solanum dulcamara Climbing Nightshade	4	0
Ilex verticillata Winterberry	16	0
Clethra alnifolia Coastal Sweet-pepperbush	24	0
Rhododendron viscosum Swamp Azalea	4	0
Myrica pensylvanica Northern Bayberry	4	0
Acer rubrum Red Maple	24	0
Osmunda cinnamomea Cinnamon Fern	8	0
Thelypteris palustris Marsh Fern	8	0

As this tidal restoration trajectory continues it is important to monitor these transects in the upper reaches as Phragmites has been documented at transects MC-UP-T2 and MC-UP-T3, which according to the pre-tidal restoration data did not have Phragmites.

3.2 Phragmites

Less robust and smaller patches of Phragmites were noted in 2018 as compared to 2015. Transects US-T2 and MID-T3 have less tall and fewer Phragmites plants in 2018. While transect US-T4 had no Phragmites present anywhere on the transect in 2018 as compared to 43% in 2015.

To determine if Phragmites has expanded, retreated, or remained the same the measurement along the transect of the Phragmites boundary was documented (Table 7). This measurement

was used to compare to pre-tidal restoration information. At one location, MC-US-T2, retreat of Phragmites was noted.

Table 7. Phragmites presence at each transect.

Transect	Location on Transect 2015 (meters)	Location on Transect 2018 (meters)
MC-DS-T1	Not present	Not present
MC-US-T1	Not present	Not present
MC-US-T2	12	14
MC-T4-US	18	Not present
MC-MID-T3	20 – 25*	22
MC-UP-T1	Not present	Not present
MC-UP-T2	Not present	13
MC-UP-T3	Not present	25

*Presence of Phragmites along transect MID-T3 was not noted on the 2015 datasheets.

Retreat or spread of Phragmites on transect MID-T3 can't be evaluated because the presence of Phragmites along the transect was not noted on the 2015 datasheets. However, based on the heights and frequency of measured plants, the extent and robustness of Phragmites at this transect seems to have not changed.

The spread of Phragmites was noted in the upper reaches of Muddy Creek at transects where it was not observed in 2015 (MC-UP-T2 and MC-UP-T3). Particular attention to the upper reaches of the creek should be made over the next few years of monitoring.

Mann-Whitney U test was applied to the Phragmites heights for 2015 and 2018 to determine pre- versus post-tidal restoration. The results indicate that there is no statistical difference between the pre and post Phragmites heights.

3.3 Photo Documentation

Photographic documentation monitoring is an excellent way to easily and visually indicate change in a landscape. The photo monitoring at Muddy Creek showed very notable post tidal changes in 2018. Three photo stations were selected to compare pre- and post-tidal restoration conditions.

Table 8. Photo station selections for comparison between pre- and post-tidal conditions.

Indication of change from pre-restoration conditions	Photo Station	Bearings
No change	DS-1 (reference)	50°, 260°, 326°*
Moderate change	VEG-T4	0°, 70°, 140°, 240°, 320°
Definitive change	UP2	20°, 70°, 110°, 140°, 210°, 260°, 310°, 340°

*The bearing is in fact 360°, not 326° as written on the dry-erase board in the photo.

Photo Monitoring Station DS-1

The photo station DS-1 is located downstream of the Route 28 Bridge, the farthest station on the east shoreline, and serves as a reference site. Three bearings were photographed at this station (50°, 260°, and 360°). At all bearings, a robust population of Saltwater Cordgrass is visible along the edge of the water. Outside of a slight browning, likely due to a 2018 sampling date later in the fall than the 2015 photo monitoring date, there does not appear to be change in vegetative cover.

Photo Monitoring Station VEG-T4

The photo station VEG-T4 is located just upstream of the Route 28 bridge, on the east shoreline. Five bearings were photographed at this station (0°, 70°, 140°, 240°, and 320°). Saltwater Cordgrass dominates the adjacent shoreline. At bearings 0°, 70° and 320° there is evidence of increased saltwater inundation. Salt intolerant vegetation bordering the creek has receded, opening the shoreline to increased light and snags for wildlife habitat. A reduction in Phragmites is visible at 140° just beyond the Cordgrass in the foreground. In addition, there appears to be new robust Saltwater Cordgrass growth in the foreground of 240°.

Photo Monitoring Station UP2

The photo station UP2 is located in the upper basin of muddy creek, on the south shoreline. Eight bearings were photographed at this station, including 20°, 70°, 110°, 140°, 210°, 260°, 310°, and 340°. At each bearing there is evidence of a dramatic increase in saltwater inundation. Mudflats have replaced vegetative cover, for example, in the foreground at 140°, 210°, 260°, and 310°. Salt intolerant vegetation bordering the creek has significantly receded, leaving unvegetated mudflats (20°, 70°, 110°, and 340°).

Phragmites

Additional differences noted include the decline in Phragmites stand in Mid-1, 310° photo. The Phragmites stand on the right side of the 2018 photo is dramatically less robust than it was in 2015.

There is a similar reduction in robustness of the Phragmites across the river in Mid-2, 10° 2018 photo as compared to the same photo taken in 2015. And what appears to be an increase in robustness of Saltwater Cordgrass in the 2018 photo as compared to the conditions in the 2015 photo.

4.0 SUMMARY

In 2015, prior to the tidal restoration in 2016, the Muddy Creek system spanned from being brackish near the Route 28 Bridge to freshwater in the upstream reaches of the creek. Two years after the tidal restriction was removed, there is clearly a shift in the vegetation community within the Muddy Creek system, as evidenced by both the vegetation and photo monitoring. Both show changes in vegetation transitioning away from brackish and fresh water plants

towards salt and brackish water tolerant vegetation. In some locations the vegetation has died off completely leaving unvegetated mud flats. Reintroducing salt water tidal flow into a system that has been dominated by freshwater will cause die-off of the predominantly freshwater plants. Before the salt water tolerant plants can re-establish, many of the areas will remain unvegetated.

As is typical of ecosystems where tidal restrictions are removed, conditions at Muddy Creek will look worse before they improve. As the system is inundated with more water from Pleasant Bay the salinity in the water will increase changing the system from brackish and fresh water to salt and brackish water. Freshwater plants die off as the salinity of the water increases. Currently there are areas that are bare mud and peat banks without any vegetation.

Transects immediately upstream of Route 28 Bridge have increased Saltwater Cordgrass populations because salinity and daily inundation of water has increased. Saltwater Cordgrass is a salt tolerant plant that grows well in salt marshes. The Phragmites population, which is less tolerant of salt and daily tidal inundation, has decreased.

In the upper reaches of Muddy Creek where the system has been predominantly freshwater (MC-UP-T1, MC-UP-T2, and MC-UP-T3), the majority of the plants identified along these transects in 2015 are no longer present. These transects have a dramatic decline in plant species diversity. Much of the area is now dominated by unvegetated muddy flats; some have persistent dead vegetation present (dead shrubs and vines, especially poison ivy). Many of the muddy areas have begun to see new growth of more salt tolerant plants such as Little-headed Spiksedge, Seaside Goldenrod and Saltwater Cordgrass. This shift in vegetation is due to the increase in salinity associated with the reduced tidal restriction at the Route 28 Bridge.

Although there were obvious visual indicators of a decline in Phragmites robustness and expanse, according to the Mann-Whitney U-test, the difference was not statistically significant. It should be noted that there may be a shift in the Phragmites population as the reaches of water with higher salt content “push” the Phragmites to the upstream, fresher water areas of the system.

5.0 REFERENCES

Applied Coastal Research and Engineering, 2016. “Muddy Creek Post Construction Tidal Monitoring, Chatham and Harwich, MA.”

Barbour, M. G., J. H. Burk, and W. D. Pitts. 1987. Terrestrial Plant Ecology. Benjamin Cummings Publishing Company, Menlo Park, CA, USA.

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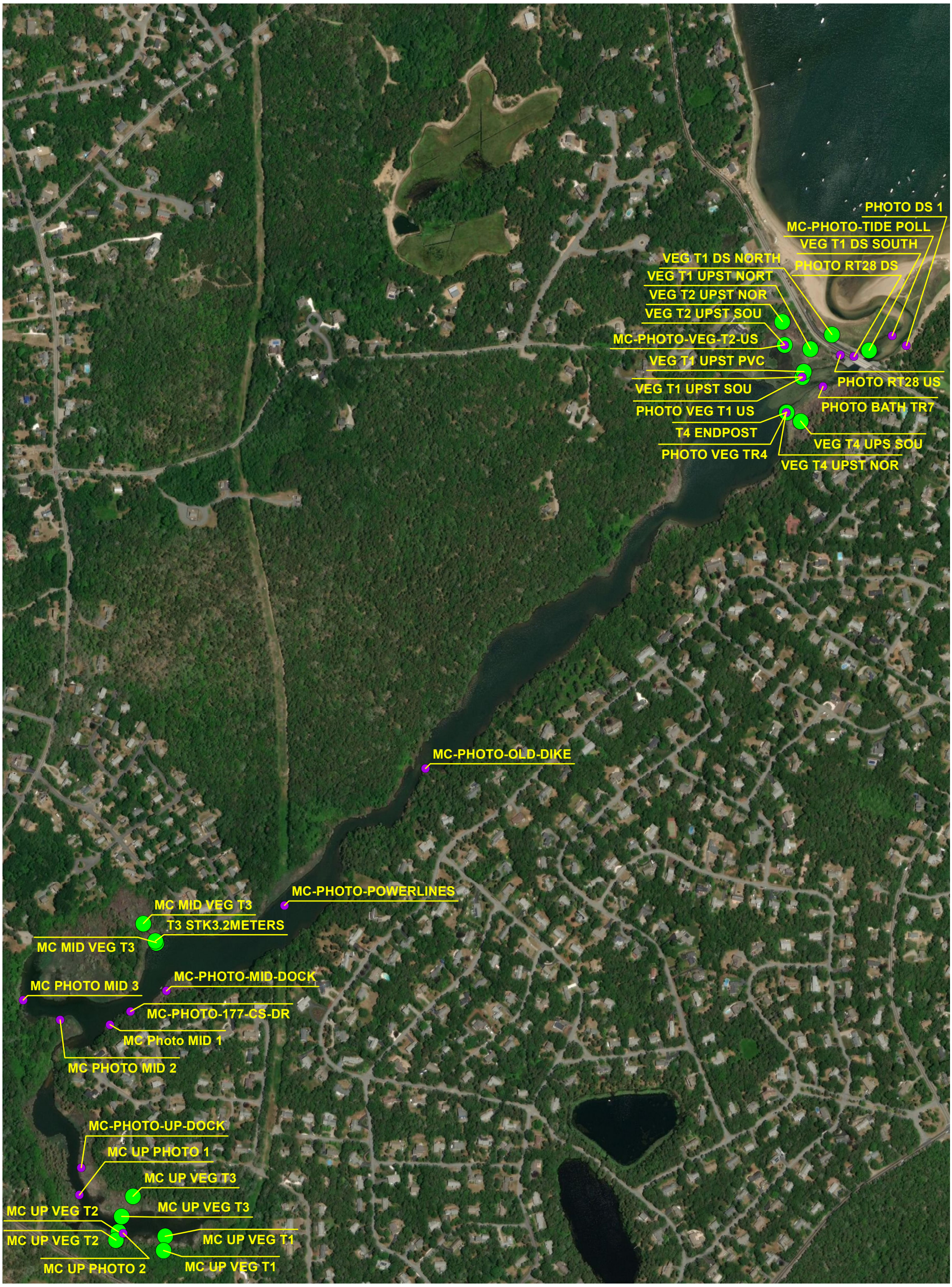
Town of Chatham. 2018. “Request for Quotation: Vegetation Transects and Photo Monitoring, Muddy Creek Restoration Bridge Project.” Town of Chatham, MA.

ATTACHMENT A

Locus Maps



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Legend

RTK Monitoring Points

- Vegetation Transect Endpoint
- Photo Station

Basemap: ESRI Aerial

N

Feet

0 250 500

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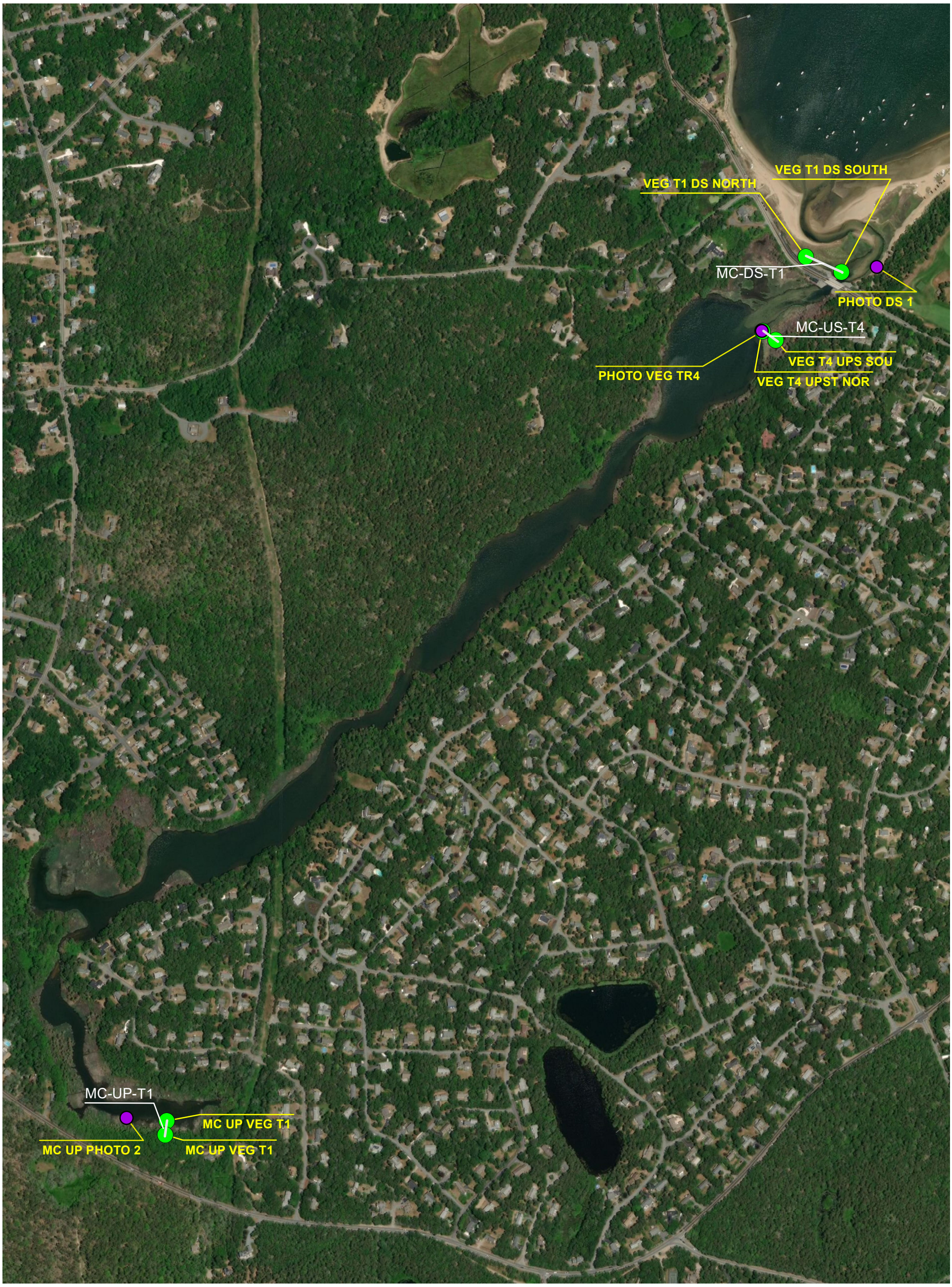
Muddy Creek, Chatham, MA
Monitoring Transects &
Photo Stations

Date: 1/3/2019

Figure 1



Path: H:\Projects\2018\18147 Muddy Creek Restoration, Chatham, MA\GIS\Maps\190103_ResultsComparisonStations.mxd

Legend

- Vegetation Transect
- Vegetation Transect Endpoint
- Photo Station

Basemap: ESRI Aerial

N

Feet

0 275 550

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Muddy Creek, Chatham, MA
Result Comparison Transects & Photo Stations

Date: 1/3/2019

Figure 2

Monitoring Station Locations from DER Environmental Monitoring Plan

Transect Identification Labels Added by HW

Figure 1. Vegetation monitoring transect endpoints and transect IDs in the lower (downstream) Muddy Creek system.

Monitoring locations from DER Environmental Monitoring Plan with Transect ID info added by HW

Figure 2. Vegetation monitoring transect endpoints and transect IDs in the middle of the Muddy Creek system.

Monitoring locations from DER Environmental Monitoring Plan with Transect ID info added by HW

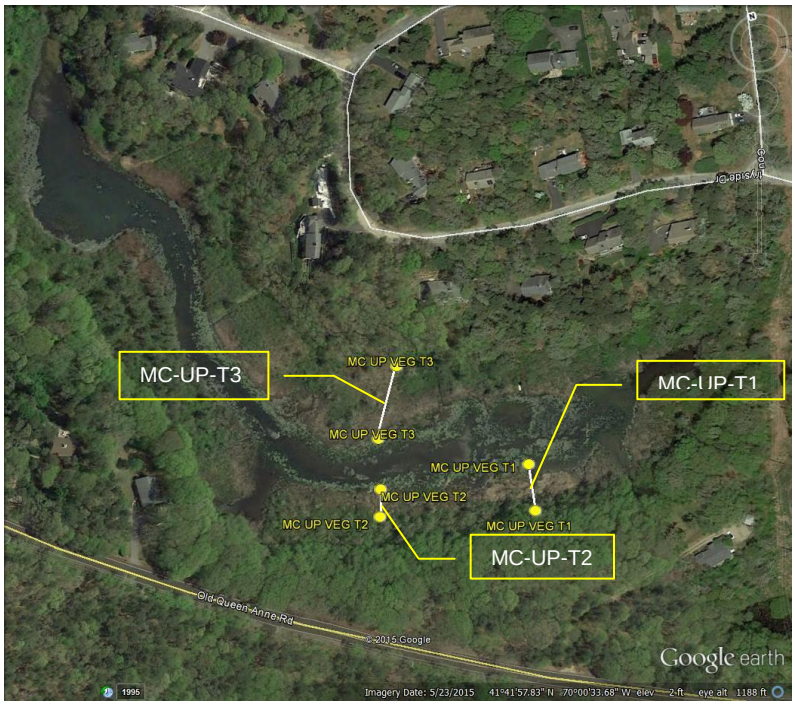


Figure 3. Vegetation monitoring transect endpoints and transect IDs in the upper (upstream) Muddy Creek system.

Monitoring locations from DER Environmental Monitoring Plan with Transect ID info added by HW

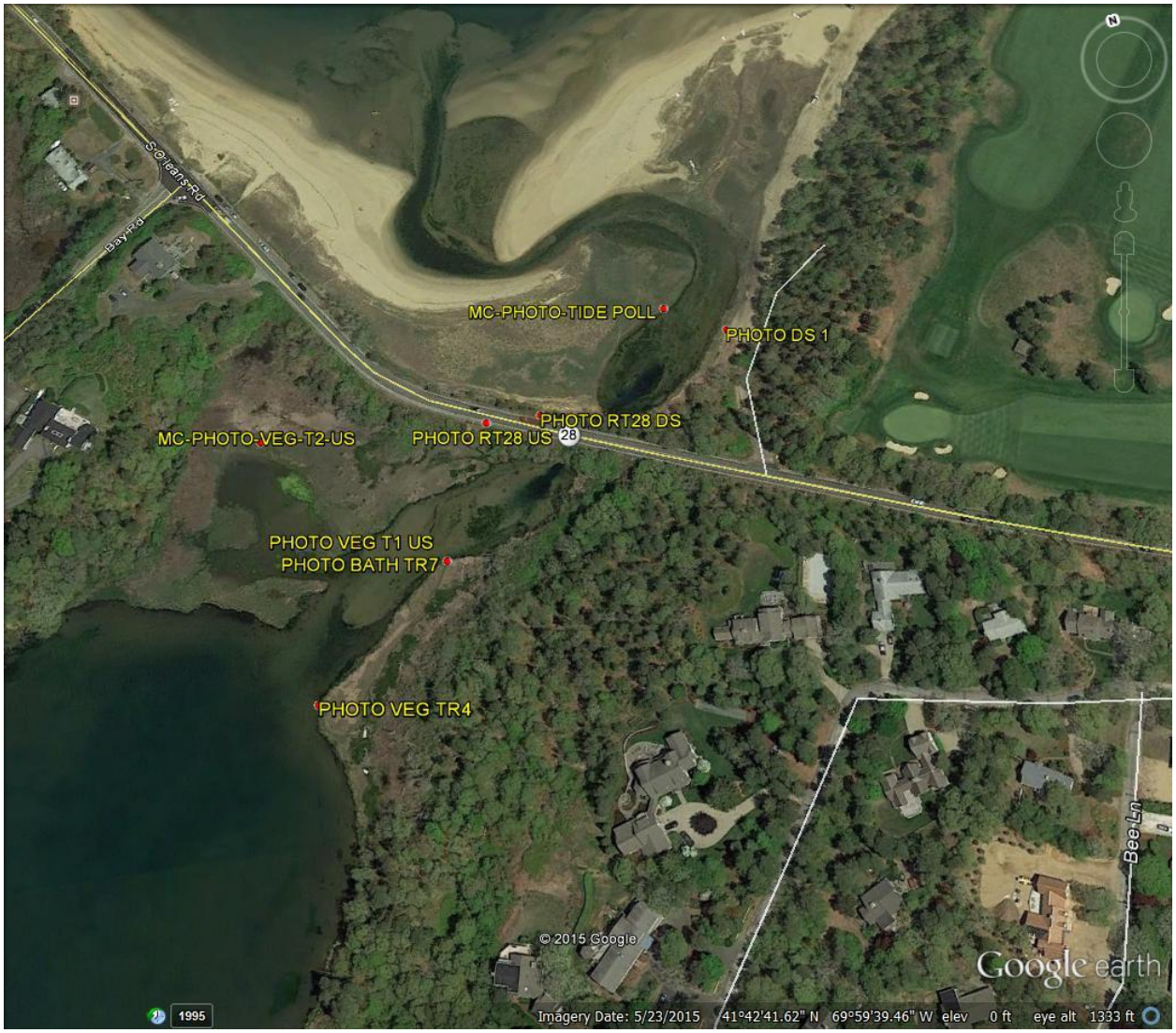


Figure 4. Photo monitoring within the lower Muddy Creek system.

Monitoring locations from DER Environmental Monitoring Plan with Transect ID info added by HW

Figure 5. Photo monitoring stations within the upper Muddy Creek system.

Monitoring locations from DER Environmental Monitoring Plan with Transect ID info added by HW

ATTACHMENT B

Photographs: Pre and Post Comparisons

DS-1 50°, Top 2015, Bottom 2018

DS-1 260°, Top 2015, Bottom 2018

DS-1 360°, Top 2015, Bottom 2018

VEG-T4 0°, Top 2015, Bottom 2018

VEG-T4 70°, Top 2015, Bottom 2018

VEG-T4 140°, Top 2015, Bottom 2018

VEG-T4 240°, Top 2015, Bottom 2018

VEG-T4 320°, Top 2015, Bottom 2018

UP2 20°, Top 2015, Bottom 2018

UP2 70°, Top 2015, Bottom 2018

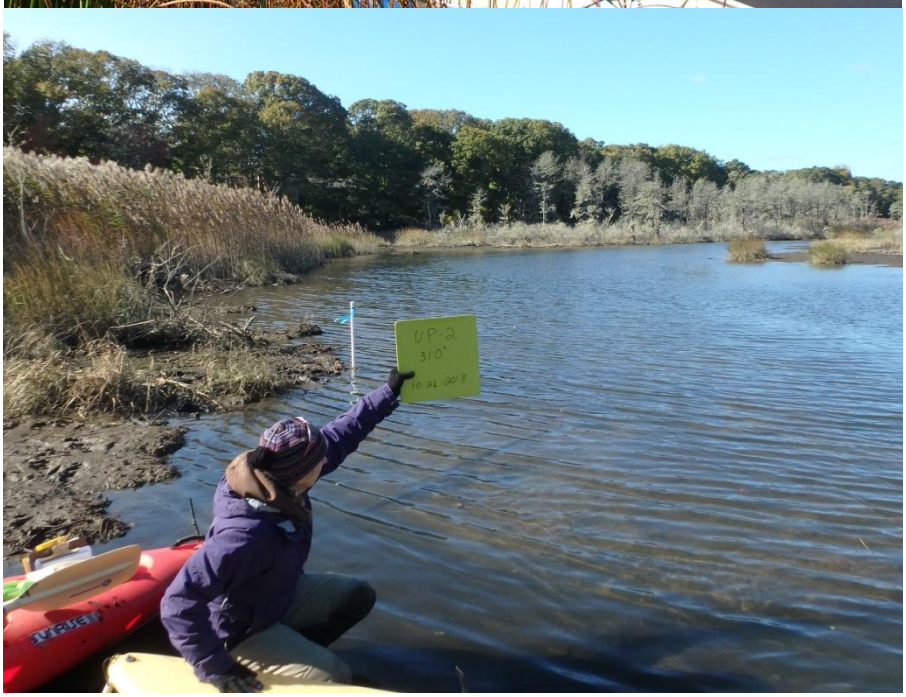
UP2 110°, Top 2015, Bottom 2018

UP2 140°, Top 2015, Bottom 2018

UP2 210°, Top 2015, Bottom 2018

UP2 260°, Top 2015, Bottom 2018

UP2 310°, Top 2015, Bottom 2018



UP2 340°, Top 2015, Bottom 2018

ATTACHMENT C

Field Data Sheets

Site Name	Muddy Creek	Date:	10/24/2018
Tansect / Plot Number	MC-DS-T1	Observer:	Tara Nye
Transect Length (m)	50		
Transect Bearing (magnetic)	320		
Notes			

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Phrag ht. 1 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. 2 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Water's Edge																																						Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora Saltwater Cordgrass	50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Spartina patens Salt Meadow Grass	6																																												1	1	1	1	1	0.12
Phragmites australis Common Reed	0																																																	0
Toxicodendron radicans Poison Ivy	0																																																	0
Distichlis spicata Spike Grass	0																																																	0
Juncus gerardii Black Grass	0																																																	0
Salicornia depressa Common Glasswort	39	1	1		1								1	1		1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.78
Eleocharis parvula Little-headed Spikesedge	0																																																	0
Suaeda maritima Sea Blite	14															1	1			1							1							1									1	1	1	1	1		1	1	1	1	0.28

Site Name	Muddy Creek	Date:	10/25/2018
Tansect / Plot Number	MC-US-T1	Observer:	Tara Nye
Transect Length (m)	50		
Transect Bearing (magnetic)	212		
Notes			

5 Meter Interval	0-5 m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Phrag ht. 1 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. 2 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Water's Edge — Upland

Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora Saltwater Cordgrass	43	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1					1	1	1	1	1	1	0.86
Spartina patens Salt Meadow Grass	22																								1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1				0.44
Phragmites australis Common Reed	0																																																			0
Toxicodendron radicans Poison Ivy	0																																																			0
Distichlis spicata Spike Grass	0																																																			0
Juncus gerardii Black Grass	0																																																			0
Salicornia depressa Common Glasswort	41				1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1				0.82

Site Name	Muddy Creek	Date:	10/25/2018
Tansect / Plot Number	MC-US-T2	Observer:	Tara Nye
Transect Length (m)	40		
Transect Bearing (magnetic)	12		
Notes			

5 Meter Interval	0-5 m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	
Phrag ht. 1 (cm)	0	0	91	76	82	103	65	160	0	0	
Phrag ht. 2 (cm)	0	0	61	70	107	70	96	140	0	0	
Phrag ht. Ave. (cm)	0.00	0.00	76.00	73.00	94.50	86.50	80.50	150.00	0.00	0.00	93.41667

		Water's Edge																																						Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora																																																		
Saltwater Cordgrass	9	1	1	1	1	1	1	1	1	1																																								0.225
Spartina patens																																																	
Salt Meadow Grass	0																																																0
Phragmites australis																																																	
Common Reed	15														1	1		1	1	1		1		1	1			1	1							1	1		1	1	1										0.375
Toxicodendron radicans																																																	
Poison Ivy	0																																																0
Distichlis spicata																																																	
Spike Grass	0																																																0
Juncus gerardii																																																	
Black Grass	0																																																0
Salicornia europaea																																																	
Common Glasswort	0																																																0

Site Name	Muddy Creek	Date:	10/25/2018
Tansect / Plot Number	MC-US-T4	Observer:	Tara Nye
Transect Length (m)	30		
Transect Bearing (magnetic)	142		
Notes			

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Phrag ht. 1 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. 2 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Water's Edge																																				Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora																																																		
Saltwater Cordgrass	23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																												0.766667
Spartina patens																																																		
Salt Meadow Grass	1												1																																						0.033333
Phragmites australis																																																		
Common Reed	0																																																	0
Toxicodendron radicans																																																		
Poison Ivy	0																																																	0
Distichlis spicata																																																		
Spike Grass	1																							1																											0.033333
Juncus gerardii																																																		
Black Grass	0																																																	0
Salicornia depressa																																																		
Common Glasswort	8			1	1													1				1	1										1	1	1															0.266667

Site Name	Muddy Creek
Tansect / Plot Number	MC-MID-T3
Transect Length (m)	40
Transect Bearing (magnetic)	345
Notes	

Date:	10/25/2018
Observer:	Tara Nye

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	
Phrag ht. 1 (cm)	0	0	0	0	260	270	340	290	0	0	
Phrag ht. 2 (cm)	0	0	0	0	240	250	290	290	0	0	
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	250.00	260.00	315.00	290.00	0.00	0.00	278.75

		Water's Edge																																		Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora																																																	
Saltwater Cordgrass	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1																													0.5
Spartina patens																																																	
Salt Meadow Grass	0																																																0
Phragmites australis																																																	
Common Reed	13																						1						1		1	1	1	1	1	1	1	1	1	1	1									0.325
Toxicodendron radicans																																																	
Poison Ivy	0																																																0
Distichlis spicata																																																	
Spike Grass	0																																																0
Juncus gerardii																																																	
Black Grass	0																																																0
Salicornia depressa																																																	
Common Glasswort	6					1							1	1		1	1					1																												0.15
Eleocharis parvula Little-headed Spikesedge	0																																																0
Suaeda maritima																																																	
Sea Blite	3					1																	1	1																											0.075
Atriplex patula																																																	
Marsh Orach	5		1	1	1	1																		1																										0.125
Pluchea purpurascens																																																	
Annual Salt Marsh Fleabane	0																																																0
Solidago sempervirens																																																	
Seaside Goldenrod	3																					1			1	1																									0.075
Baccharis halimifolia																																																	
Groundsel Tree	0																																																0
Typha angustifolia																																																	
Narrow-leaved Cattail	0																																																0
Scirpus pungens																																																	
Common Three-square	0																																																0
Bolboschoenus robustus Salt Marsh Bulrush	2																																						1		1									0.05

Site Name	Muddy Creek	Date:	10/26/2018
Tansect / Plot Number	MC-UP-T1	Observer:	Tara Nye & Lara Kappler
Transect Length (m)	25		
Transect Bearing (magnetic)	204		
Notes	Very muddy, very little vegetation		

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Phrag ht. 1 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. 2 (cm)	0	0	0	0	0	0	0	0	0	0
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Water's Edge																																				Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora																																																		
Saltwater Cordgrass	0																																																	
Spartina patens																																																	
Salt Meadow Grass	0																																																	
Phragmites australis																																																	
Common Reed	0																																																	
Toxicodendron radicans																																																	
Poison Ivy	0																																																	
Distichlis spicata																																																	
Spike Grass	0																																																	
Juncus gerardii																																																	
Black Grass	0																																																	
Salicornia europaea																																																	
Common Glasswort	0																																																	
Eleocharis parvula Little-headed spikesedge	8					1		1		1	1	1	1	1	1																																			
Suaeda maritima																																																		
Sea Blite	0																																																	
Atriplex patula																																																		
Marsh Orach	0																																																	
Pluchea purpurascens																																																	
Annual Salt Marsh Fleabane	1																					1																												
Solidago sempervirens																																																	
Seaside Goldenrod	0																																																	
Baccharis halimifolia																																																	
Groundsel Tree	0																																																	
Typha angustifolia																																																	
Narrow-leaved Cattail	5								1		1					1				1				1																											

Frequency
0
0
0
0
0
0
0
0
0
0.32
0
0
0
0.04
0
0
0
0.2

Site Name	Muddy Creek	Date:	10/26/2018
Tansect / Plot Number	MC-UP-T2	Observer:	TNye & LAKappler
Transect Length (m)	15		
Transect Bearing (magnetic)	210		
Notes	Very little phrag along transect by a fair amount just upstream and downstram of transect		

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	
Phrag ht. 1 (cm)	0	0	41	151	0	0	0	0	0	0	
Phrag ht. 2 (cm)	0	0	32	0	0	0	0	0	0	0	
Phrag ht. Ave. (cm)	0.00	0.00	36.50	75.50	0.00	0.00	0.00	0.00	0.00	0.00	74.66667

		Water's Edge																																		Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora Saltwater Cordgrass	3				1	1		1																																									0.2
Spartina patens Salt Meadow Grass	0																																																0
Phragmites australis Common Reed	2													1		1																																		0.133333
Toxicodendron radicans Poison Ivy	0																																															0
Distichlis spicata Spike Grass	0																																															0
Juncus gerardii Black Grass	0																																															0
Salicornia europaea Common Glasswort	0																																															0
Eleocharis parvula Little-headed spikesedge	8	1	1	1	1	1	1	1	1																																								0.533333

Site Name	Muddy Creek
Tansect / Plot Number	MC-UP-T3
Transect Length (m)	40
Transect Bearing (magnetic)	40
Notes	

Date: 10/26/2018
Observer: TNye & LAKappler

5 Meter Interval	0-5 m	5-10 m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	
Phrag ht. 1 (cm)	0	0	0	0	0	93	195	0	0	0	
Phrag ht. 2 (cm)	0	0	0	0	0	0	189	0	0	0	
Phrag ht. Ave. (cm)	0.00	0.00	0.00	0.00	0.00	46.50	192.00	0.00	0.00	0.00	159

		Water's Edge																																				Upland	
Species	Tally	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Frequency
Spartina alterniflora																																																		
Saltwater Cordgrass	2																	1			1																															0.05
Spartina patens																																																	
Salt Meadow Grass	0																																																	0
Phragmites australis																																																	
Common Reed	5																									1	1	1			1	1																		0.125
Toxicodendron radicans																																																	
Poison Ivy	0																																																0
Distichlis spicata																																																	
Spike Grass	0																																																0
Juncus gerardii																																																	
Black Grass	0																																																0
Salicornia depressa																																																	
Common Glasswort	7																														1		1		1			1	1	1	1							0.175
Eleocharis parvula Little-																																																	
headed spikesedge	25	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1		1			1								1			1								0.625
Suaeda maritima																																																	
Sea Blite	0																																																0
Atriplex patula																																																	
Marsh Orach	0																																																0
Pluchea purpurascens																																																	
Annual Salt Marsh Fleabane	0																																																0
Solidago sempervirens																																																	
Seaside Goldenrod	4			1			1																	1							1																		0.1
Baccharis halimifolia																																																	
Groundsel Tree	0																																																0
Typha angustifolia																																																	
Narrow-leaved Cattail	5																													1	1	1	1	1															0.125
Scirpus pungens																																																	
Common Three-square	0																																																0
Scirpus validus																																																	
Soft-stemmed Bullrush	4																										1	1	1		1																		0.1

ATTACHMENT D

GPS Coordinates

GIS Coordinates of Vegetation and Photographic Monitoring Stations

Point Type	Point No.	Northing	Easting	Code	Survey located by HW
Veg Transect Pt	201	2723731.551	1067325.463	VEG T1 DS SOUTH	Y
Veg Transect Pt	202	2723819.963	1067118.122	VEG T1 DS NORTH	Y
Veg Transect Pt	207	2723582.458	1066951.921	VEG T1 UPST SOU	Y
Veg Transect Pt	208	2723738.281	1066998.29	VEG T1 UPST NORT	Y
Veg Transect Pt	209	2723761.437	1066853.282	VEG T2 UPST SOU	Y
Veg Transect Pt	210	2723892.192	1066841.826	VEG T2 UPST NOR	Y
Veg Transect Pt	211	2723387.665	1066861.948	VEG T4 UPST NOR	Y
Veg Transect Pt	213	2723337.211	1066943.903	VEG T4 UPS SOU	Y
Veg Transect Pt	214	2720432.25	1063356.715	MC MID VEG T3	Y
Veg Transect Pt	216	2720539.408	1063283.174	MC MID VEG T3	Y
Veg Transect Pt	220	2718906.819	1063163.107	MC UP VEG T3	Y
Veg Transect Pt	221	2719019.683	1063226.499	MC UP VEG T3	Y
Veg Transect Pt	222	2718821.735	1063144.707	MC UP VEG T2	Y
Veg Transect Pt	223	2718776.064	1063131.398	MC UP VEG T2	Y
Veg Transect Pt	225	2718797.385	1063405.177	MC UP VEG T1	Y
Veg Transect Pt	226	2718717.214	1063395.631	MC UP VEG T1	Y
Photo	200	2723757.848	1067531.228	PHOTO DS 1	Y
Photo	203	2723696.456	1067240.438	PHOTO RT28 DS	Y
Photo	204	2723705.292	1067164.398	PHOTO RT28 US	Y
Photo	205	2723530.203	1067067.577	PHOTO BATH TR7	Y
Photo	206	2723581.526	1066951.606	PHOTO VEG T1 US	Y
Photo	212	2723386.437	1066863.705	PHOTO VEG TR4	Y
Photo	215	2720440.954	1063351.394	T3 STK3.2METERS	Y
Photo	217	2720001.568	1062819.534	MC PHOTO MID 1	Y
Photo	218	2720112.164	1062613.863	MC PHOTO MID 2	Y
Photo	219	2719027.643	1062927.917	MC UP PHOTO 1	Y
Photo	224	2718814.708	1063171.461	MC UP PHOTO 2	Y
Photo	10000	2723812.827	1067453.313	MC-PHOTO-TIDE-POLL	N
Photo	10001	2721402.618	1064854.427	MC-PHOTO-OLD-DIKE	N
Photo	10002	2720639.347	1064068.695	MC-PHOTO-POWERLINES	N
Photo	10003	2720162.897	1063412.55	MC-PHOTO-MID-DOCK	N
Photo	10004	2720049.292	1063212.553	MC-PHOTO-177-CS-DR	N
Photo	10005	2719974.881	1063096.993	MC Photo MID 1	N
Photo	10006	2719180.432	1062937.819	MC-PHOTO-UP-DOCK	N

ATTACHMENT E

Town of Chatham Request for Quotation: Vegetation Transects and Photo Monitoring,
Muddy Creek Restoration Bridge Project
2018

Request for Quotation

Vegetation Transects and Photo Monitoring
Muddy Creek Restoration Bridge Project

Town of Chatham, MA

Responses Due: September 17, 2018 by 2:00 PM
Late Responses Will Be Rejected

The Town of Chatham reserves the right to reject any or all proposals.

REQUEST FOR QUOTATION

VEGETATION TRANSECTS AND PHOTO MONITORING
MUDDY CREEK RESTORATION BRIDGE PROJECT

The Town of Chatham invites responses from qualified Consultants for Professional Services related to **Vegetation Transects and Photo Monitoring** to assess changes resulting from increased tidal flow in Muddy Creek, located in Chatham and Harwich, MA.

The August 2017 Environmental Monitoring Report, Muddy Creek Restoration Bridge Project, is included (Attachment D) for reference.

Questions may be directed, be email, subject line "Muddy Creek Vegetation", to Robert Duncanson, Ph.D., Director of Health & Natural Resources at rduncanson@chatham-ma.gov, to be received no later than 2 PM September 13, 2018.

Letter responses must be received by **2PM on September 17, 2018**. Responses may be emailed, in PDF format, to rduncanson@chatham-ma.gov.

Responses should include:

1. Sufficient detail to document the responder is capable of performing the Tasks requested using the methodologies outlined.

2. A qualifications statement addressing the needs identified in the request, including resumes of those proposed to undertake the work. The statement should reference examples of comparable work successfully completed.

3. A proposed schedule.

The attached Forms must be completed and submitted as part of the proposal:

Attachment A – State Taxes Certification Clause

Attachment B – Certificate of Non-Collusion

Attachment C – Price Proposal

Attachment D - 2017 Environmental Monitoring Report

Vegetation Transects and Photo Monitoring

The Town of Chatham is seeking proposals for consulting services to conduct vegetation transect and photo monitoring to assess changes resulting from increased tidal flow in Muddy Creek, located in Chatham and Harwich, Massachusetts.

I. Background

The Muddy Creek Restoration Bridge Project, a cooperative effort of the Towns of Chatham and Harwich, Massachusetts in partnership with Massachusetts Division of Ecological Restoration (MADER), US Fish & Wildlife, and NOAA Restoration Center, was completed in 2016. The restoration encompassed the removal of two restrictive box culverts and construction of a new single span bridge with an open channel. The pre-existing stone box culverts were each approximately 2.5-feet wide, 3.75-feet in height, and 100-feet in length. The post restoration hydraulic opening is a trapezoidal channel with a 22-foot wide base and 1.7:1 side slopes. Partial tidal flow was restored through the east (Chatham) side of the channel on February 11, 2016 and the channel was fully open to tidal flow on April 1, 2016. The restoration of tidal flow benefits 55 acres of wetlands upstream of the new bridge and channel, and improves passage for diadromous fisheries.

Data from previous vegetation and photo monitoring will be available to the selected Consultant.

II. Scope of Work for Vegetation Monitoring for Muddy Creek

Task 1. Transect Monitoring:

Pre-restoration species composition was determined by the line-intercept method (Barbour et al. 1987[1]). Vegetation transects were established and surveyed by MADER during the fall of 2015 and end-points permanently marked with 3.5 ft lengths of ½" PVC pipe set into the marsh. There is a high likelihood that endpoints of the vegetation transect (especially the marsh endpoints) in the lower, mid- and upper basins will have to be located and reestablished. These endpoints were formerly located at the end of vegetation, but now may be located in open water or mudflats. This effort may necessitate use of GPS and previously completed photo points. A total of eight transects were established: three transects in the upper basin, one in the middle basin, three in the lower basin, and a single reference transect located downstream of Route 28 Bridge (Figures 1, 2 and 3), Transect lengths varied but were generally 50m and were oriented perpendicular to Muddy Creek from the edge of the marsh creek toward the adjacent upland.

Post-restoration, vegetation line transects will be resurveyed at one, three, and five years post-construction. The first full post-construction transect measurements will take place in 2018. Species composition will be characterized by dividing each transect into one-meter intervals and recording the species of plants present under the line at each meter interval. The number of one meter intervals in which a plant species was present (absolute frequency) will then be divided by the total number of intervals in the transect to derive the percent frequency for that species along

[1] Barbour, M. G., J. H. Burk, and W. D. Pitts. 1987. Terrestrial Plant Ecology. Benjamin Cummings Publishing Company, Menlo Park, CA, USA.

each transect. Percent frequency along transects will serve as an indicator of overall vegetation cover.

The heights of *Phragmites australis* will be used as an indicator of its aboveground biomass and overall vigor. The two tallest *P. australis* plants for each five-meter interval where this species occurs along a transect will be measured. Mann-Whitney U tests (Sokal and Rohlf 1995[2]) will be completed on mean *P. australis* heights per transect to determine if there was a difference between heights pre- vs. post-restoration.

The spread or retreat of distinct patches of *P. australis* will be evaluated by recording the distance in meters that the boundary of the *P. australis* patch expanded or declined along the transect relative to the adjacent salt marsh each year.

Vegetation and photo monitoring should take place at the end of the growing season at peak biomass but before senescence.

Consultant shall re-establish both ends of the transects and mark said ends with non-biodegradable stakes. Consultant shall provide GPS coordinates of the transect ends.

Deliverable: Transect monitoring data record.

Figure 1: Vegetation transects within the upper basin of Muddy Creek

[2] Sokal, R. R. and F. J. Rohlf. 1995. Biometry, 3rd ed. W.H. Freeman and Company, New York, NY, USA.

Figure 2: Vegetation monitoring transects in the middle basin of Muddy Creek

Figure 3: Vegetation monitoring transects within the lower basin of Muddy Creek

Task 2. Photo Monitoring:

Photo-station monitoring of vegetation conditions is scheduled at the same frequency as the vegetation line transect monitoring.

Pre-restoration, eighteen photo stations were established and monitored by MassDER and USFWS during the fall of 2015 to provide a means to qualitatively assess marsh vegetation change overtime (Figures 5 and 6). Photo stations were marked with PVC pipe or wooden stakes, the location recorded with RTK GPS, and attending photos labeled accordingly: Station ID-(Orientation)-Date. A Site Identification Card (8.5" x 11"), placed in the camera field of view was used to provide a permanent record within each image of the photo location, camera orientation, and date. There is a high likelihood that endpoints of the vegetation transect (especially the marsh endpoints) in the lower, mid- and upper basins will have to be located and reestablished. These endpoints were formerly located at the end of vegetation, but now may be located in open water or mudflats. This effort may necessitate use of GPS and previously completed photo points.

Post Construction: Photo monitoring locations are scheduled to be revisited 1, 3, and 5 years post-construction to coincide with vegetation line transect monitoring. However, since the first year of transect monitoring is planned for 2018, an additional set photo stations monitoring data were collected in the fall of 2016, to capture any early changes in vegetation following the first post-construction growing season. Photo monitoring was conducted on October 24 and 25, 2016 at the eighteen photo monitoring stations with 2-4 photos taken at each point. These photo points will be repeated over time.

Figure 4: Photo monitoring stations within the lower basin of Muddy Creek

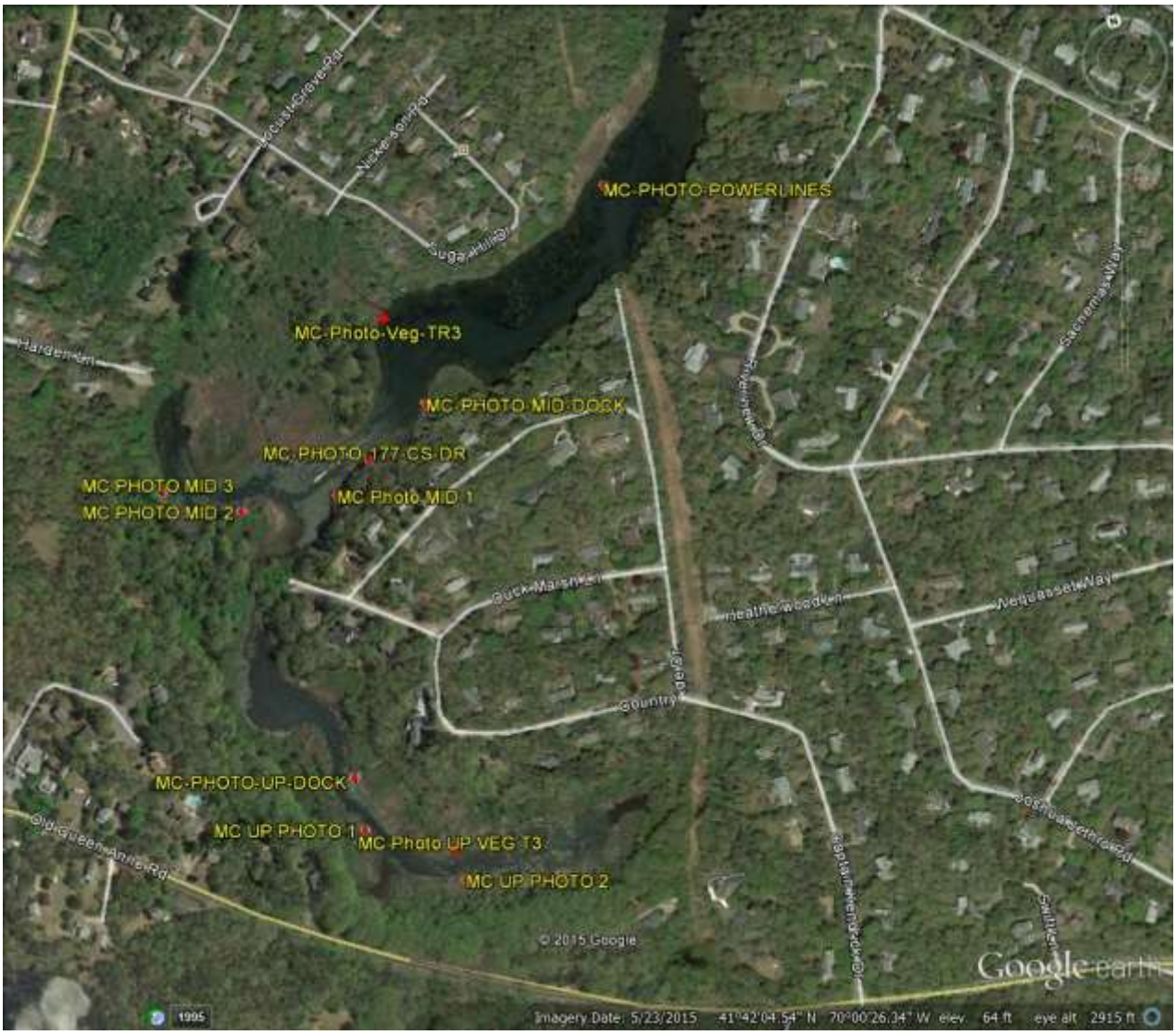


Figure 5: Photo monitoring stations within the upper reaches of Muddy Creek. Not illustrated is the point location on the relic cranberry berm located mid-basin.

Deliverable: Photo monitoring data record.

Task 3. Draft and Final Report

Compile the analysis and findings contained in the deliverables for Task 1, including a comparison with pre-restoration conditions, and Task 2, including a comparison of 3 selected sites {no change; moderated changes; definitive change}in a written report with appropriate figures and charts, photos, introduction, executive summary, methods and sources. A draft report will be provided to the Pleasant Bay Alliance for review and comment, with one set of comments submitted to the contractor to incorporate into a final report. All transect and photo data will be archived and provided in electronic format.

Deliverable: Draft and final reports with appropriate figures, charts methods and sources. Six bound hard copies of the draft report shall be provided along with a Word editable electronic file and a complete electronic file of the Final Report in pdf format.

Task 4. Meetings
Participate in up to two meetings to discuss project scope, methods, initial findings task memoranda, and the draft and final reports. Incorporate one round of comments between draft and final reports.

The Consultant shall present an overall project schedule. The final report must be delivered no later than December 31, 2018.

Deliverable: Project Schedule
Meeting participation.