Town Pond Restoration Project
Portsmouth, Rhode Island
Ecological Monitoring Report (2010 - 2012)

US ARMY CORPS
OF ENGINEERS
New England District

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1.0 INTRODUCTION

This report summarizes three years of monitoring activities and results associated with the restoration of estuarine habitats in Town Pond in Portsmouth, Rhode Island (Figure 1 inset). The US Army Corps of Engineers (Corps), in partnership with the Rhode Island Department of Environmental Management, constructed the Town Pond Restoration Project under the Project Modifications to Improve the Environment Program (Section 1135). The Corps filled the subtidal, intertidal, and marsh habitats in Town Pond in the early 1950s with dredged material from improvements to the Fall River Harbor Navigation Project, thereby eliminating flooding by tidal salt water. The filling of Town Pond created a brackish water marsh dominated by the invasive plant species *Phragmites australis* (hereafter referred to as phragmites). The elevations of the fill areas and limited tidal range did not allow the system to support the estuarine species that previously existed at the site. Therefore, a restoration plan was developed to return the area to its historic condition. The restoration plan for Town Pond involved re-establishing elevations and substrates at subtidal and intertidal elevations to allow salt marsh plants and associated fish and wildlife communities to re-colonize the site and reestablish the functions and values of the marsh system (USACE, 2002).

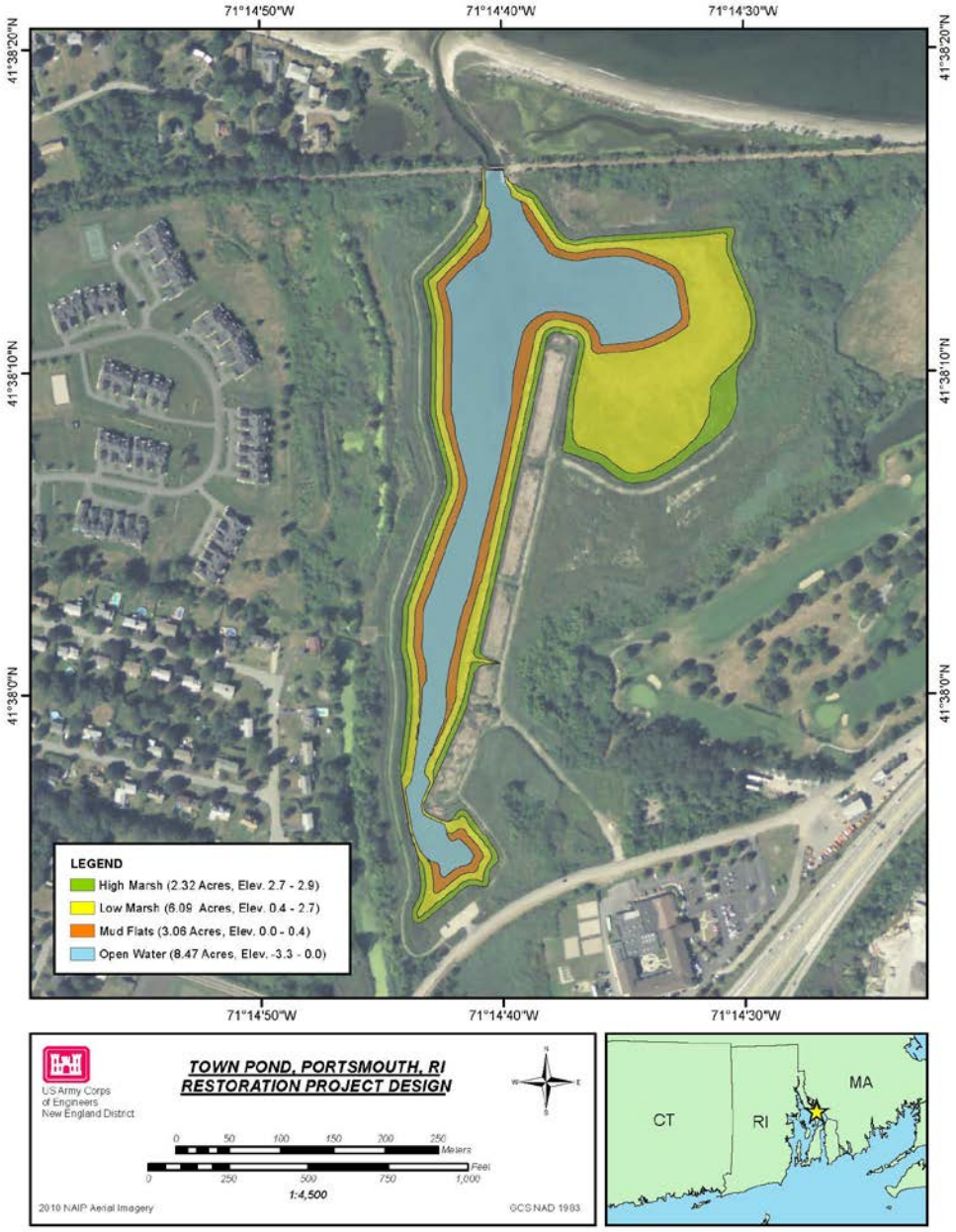
Specific objectives of the restoration project as stated in the monitoring plan (Appendix B) were: 1) to restore elevations and substrates at intertidal elevations to increase the abundance of salt marsh vegetation (e.g., salt marsh cordgrass (*Spartina alterniflora*), salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), etc.) and decrease the dominance of phragmites; 2) restore any salt marsh downstream of the railroad bride impacted by the project; 3) to restore elevations and substrates at lower intertidal elevations to allow invertebrates and their predators to re-colonize the site; 4) to restore permanent open water to allow populations of shallow subtidal invertebrates and submerged aquatic vegetation and the animals that feed on them to re-colonize the area; 5) to restore habitats in appropriate ratios to maximize use by fish and wildlife resources; 6) to maintain salinity levels of 0 ppt in an adjacent brook (Founder's Brook); and 7) to avoid changing flood levels in the project area.

To meet the restoration objectives 1, 3, 4, & 5, the dredged material that had been placed in the marsh was excavated and placed in a berm along the west side of the site and a disposal area on

the east side of the site (Figure 1). The marsh area was then graded to elevations that would support a combination of salt marsh, mudflat, and open water salt pond habitats. The recommended plan was to create 2.3 acres of *Spartina patens* dominated high marsh, 4.5 acres of *Spartina alterniflora* dominated low marsh, 2.9 acres of mudflats, and 5.3 acres of permanent open water. However, due to faster than anticipated consolidation rates is the disposal area, the design was modified during construction and apportioned and graded so that approximately 2.5 acres of high marsh, 8.9 acres of low marsh, 3.2 acres of mudflats, and 8.2 acres of permanent open water were created. Figure 1 details the distribution of these habitat types in the site. A weir with a top elevation of -0.2 ft NGVD was put in place to maintain permanent open water depths between 1.8 and 2.9 feet. The construction of the project was initiated in 2005 and completed in 2008. The tidal connection from Mount Hope Bay to Town Pond was reestablished on September 21, 2007. Formal monitoring of the site (as described in this report) was not initiated until 2010.

No salt marsh areas downstream of the railroad bridge were impacted so Objective 2 was removed from the monitoring effort. Efforts to assess objective 6, maintaining a salinity level of 0 ppt in Founder's Brook, were not performed during the course of monitoring. However, measurement of the salinity during a site inspection of the project in June of 2013 revealed that the salinity in Founder's Brook was 0 ppt (Randall, 2013). Efforts to assess objective 7, not changing flood levels of the project area, were also not performed during the course of monitoring.

Figure 1. Location of Town Pond and anticipated habitat types in the restoration project area.



2.0 METHODS

The methods used to monitor the Town Pond restoration site were objective specific and are described below.

2.1 Marsh Vegetation Monitoring in Restoration Area

Objective 1: The first objective of the Town Pond restoration project was to restore elevations and substrates at intertidal elevations that would allow salt marsh plants and associated animal communities to colonize the site. It was anticipated that an increase in the abundance of salt marsh vegetation (e.g., salt marsh cordgrass (*Spartina alterniflora*), salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), and black grass (*Juncus gerardii*), etc.) would be seen and a decrease in the dominance of common reed (*Phragmites australis*) would be observed.

To measure the success of this objective, the Corps conducted vegetation monitoring at ten (10) permanent sample stations established at locations within portions of the marsh between elevation 0.4 and 2.9 ft NGVD (Figure 2). The design elevations for the project were -3.3 – 0.0 ft for open water, 0.0 – 0.4 ft for mudflat, 0.4 – 2.7 ft for low marsh, and 2.7 – 2.9 ft for high marsh. The stations were established on April 8, 2010 by using a Trimble GeoXM Differential Global Positioning System (DGPS) with an accuracy of 3 meters or less to achieve positioning. The coordinates of the stations are presented in Table 1. The stations were also marked with numbered wooden stakes. Vegetation monitoring was performed on 10/05/2010, 08/20/2011, and 09/25/2012.

The permanent stations were intended to monitor vegetation plots in an area within a radius of approximately 10 feet at an angle of 0° from the stake (for high marsh vegetation monitoring) and monitoring vegetation in an area at a radius of approximately 10 feet from an angle of 180° from the stake (for low marsh monitoring). However, each monitoring event revealed that no distinctive high marsh communities were being established (See Section 3.1). As a result, the vegetation monitoring method was modified to sampling 5 plots around the station center-point with a $0.25m^2$ quadrat. The quadrat was placed randomly for each plot and all plant species within the quadrat were recorded. Each species was also assigned a percent cover value using the Daubenmire Cover Scale Values (Daubenmire, 1966). Table 2 displays the cover class values and their associated percent cover ranges.

For each station, average percent cover values for each species were determined by summing the midpoints of coverage classes for each plot and dividing the sum by the number of plots

observed at each sample station. For example, if salt marsh cordgrass occurred in three of the five plots randomly sampled at one of the stations and had coverage values of 2, 3, and 1 in those plots 15, 2.5, and 37.5 would be summed (=55) and divided by 5 to yield a mean coverage value of 11%. Results were rounded to whole percentage points except where values were very low. The coverage classes, range of coverage, and midpoint coverage values are presented in Table 2. The midpoint coverage values were used as conservative estimates of percent cover.

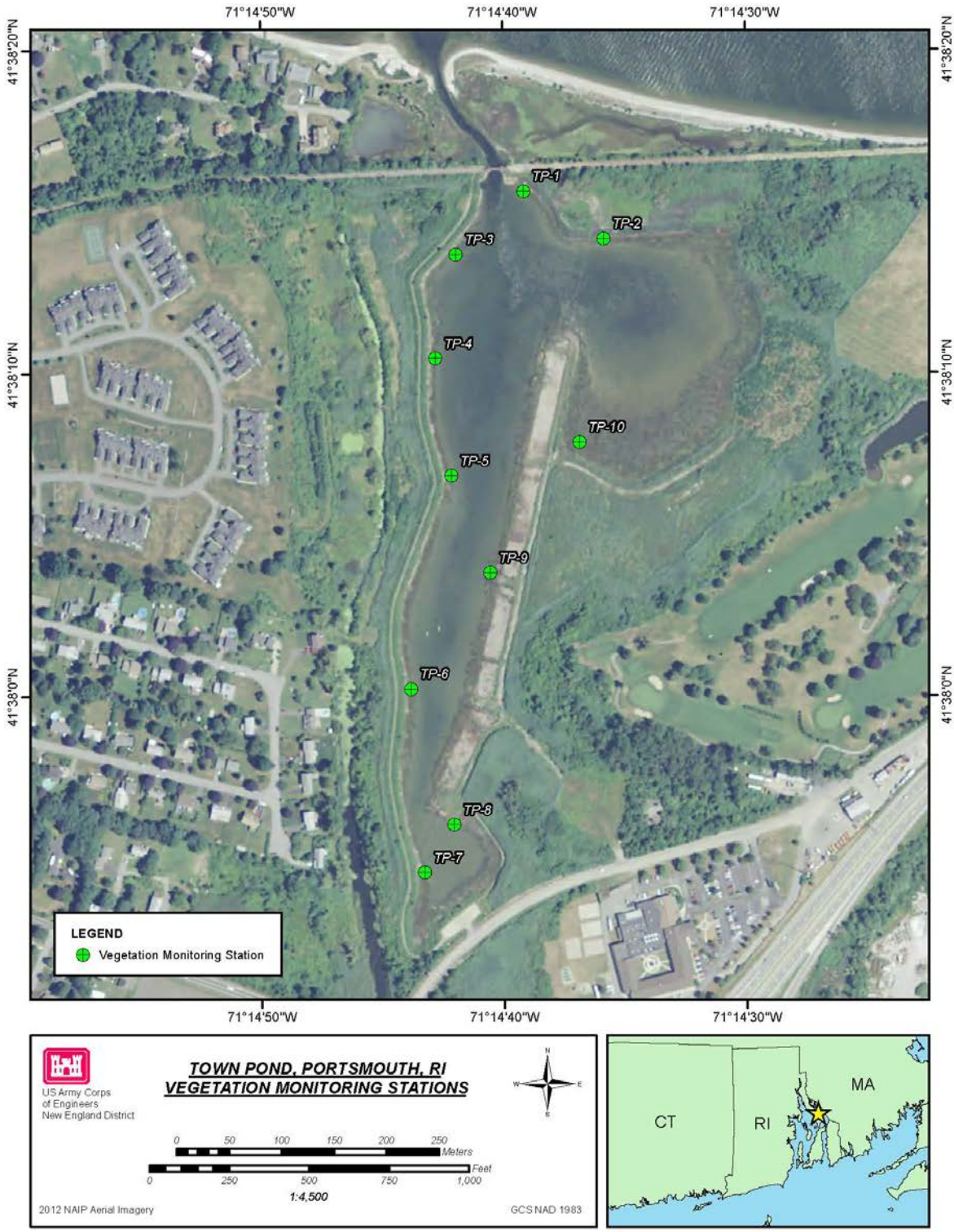
Table 1. Town Pond Vegetation Monitoring Station GPS Coordinates

Station ID	Latitude (NAD 83)	Longitude (NAD 83)
TP-1	-71.24421625560	41.63767615080
TP-2	-71.24329952090	41.63726829790
TP-3	-71.24499208840	41.63713224320
TP-4	-71.24522939470	41.63624055160
TP-5	-71.24505212750	41.63523281070
TP-6	-71.24551529690	41.63339960370
TP-7	-71.24536750930	41.63182035690
TP-8	-71.24502652250	41.63223201390
TP-9	-71.24460709440	41.63439687490
TP-10	-71.24358096700	41.63552024180

Table 2. Daubenmire Cover Classes

Cover Class	Range of Cover (%)	Class Midpoints (%)
0	0	0.0
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

Figure 2. Location of vegetation monitoring stations in Town Pond.



2.2 Intertidal/Subtidal Infaunal Monitoring & Qualitative Fauna Observations

Objectives 2 and 3: The remaining objectives of the restoration project were to restore elevations and substrates at low intertidal and subtidal elevations that would allow flora and fauna adapted to intertidal and subtidal habitats to colonize the site. To measure the success of these objectives, the Corps conducted benthic infaunal monitoring at permanent sample stations established at locations within intertidal and subtidal areas of the project area. Sampling was performed on June 2, 2011 and June 28, 2012.

Intertidal Monitoring

The intertidal sampling was performed using a 0.003 m^2 benthic core sampler (Figure 3) at three locations (Figure 4 & Table 3) within the mid-intertidal areas of the restoration project. Core samples were taken and the sediments passed through a 0.5 mm screen. Residues on the screen were jarred and preserved in Rose Bengal and a 10% formalin solution. Samples were sorted, identified, and enumerated in the Corps Environmental Resources Section laboratory (ERS lab).

Figure 3. Benthic Core Sampling in Town Pond

Figure 4. Location of intertidal and subtidal benthic monitoring stations in Town Pond.

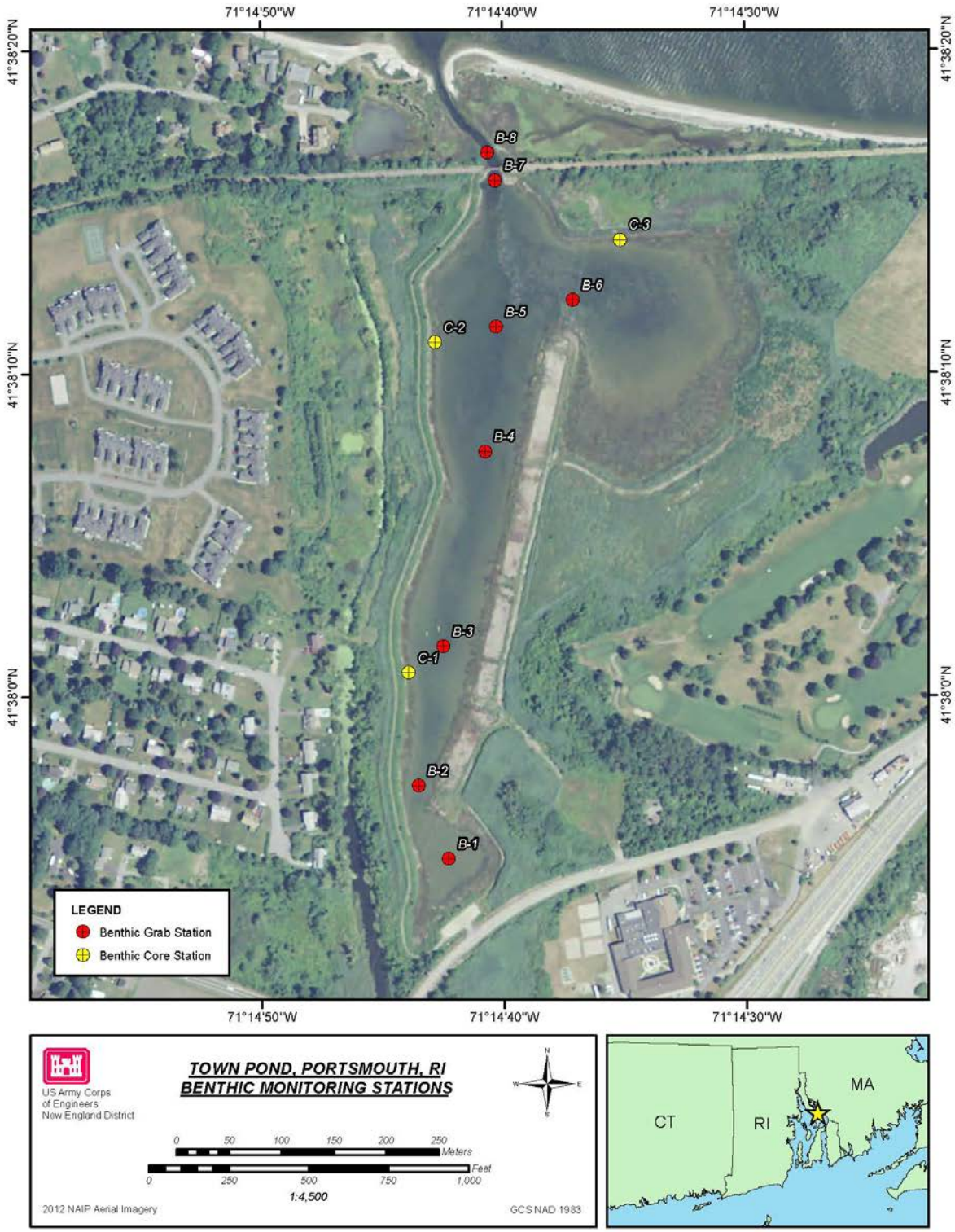


Table 3. Town Pond intertidal and subtidal benthic monitoring station GPS coordinates.

Station ID	Latitude (NAD 83)	Longitude (NAD 83)
B-1	-71.24508710570	41.63193804180
B-2	-71.24543275270	41.63256756740
B-3	-71.24514437140	41.63376640820
B-4	-71.24466069900	41.63543880220
B-5	-71.24452751840	41.63651223360
B-6	-71.24364978790	41.63674243680
B-7	-71.24453608190	41.63777146720
B-8	-71.24462876900	41.63800871280
C-1	-71.24554038660	41.63354147260
C-2	-71.24523187350	41.63637984150
C-3	-71.24310639760	41.63725724500

Subtidal Monitoring

The subtidal sampling was performed using a modified 0.04 m^2 VanVeen grab sampler (Figure 5) at eight locations (Figure 4 and Table 3) within the subtidal areas of the restoration project. Grab samples were taken and the sediments passed through a 0.5 mm screen. Residues on the screen were jarred and preserved in Rose Bengal and a 10% formalin solution. Benthic samples were sorted, identified, and enumerated in the ERS lab.

Metrics

Summary community metrics were calculated for both the intertidal core samples and the subtidal grab samples. Metrics included species richness (number of taxa per collection), total density, diversity (H'), and evenness (H'/H_{max}). Species richness (S) was defined as the number of taxa collected per sample (e.g., number of taxa per 0.04 m^2). Total density was defined as the total number of organisms collected per sample (e.g., number of individuals per 0.04 m^2). Diversity (H') was calculated on the $\log_e$ scale according to the Shannon-Wiener formula, $H' = -\sum p_i \log p_i$, where p_i is the proportion of the collection made up by taxon *i*. H_{max} is the minimum value H' could take, given an equitable distribution of the total abundance among all taxa in the collection.

Qualitative Fauna Observations

Qualitative observations of salt marsh fauna were also made and recorded during all monitoring events. Observations only include fauna that was observed and positively identified in the Town pond restoration area.

2.3 Habitat Estimation

The Town Pond Restoration Project was designed to provide approximately 2.5 acres of high marsh, 8.9 acres of low marsh, 3.2 acres of mudflats, and 8.2 acres of permanent open water (Figure 1). To approximate the amounts of restored habitats following the restoration effort, true color aerial photography was analyzed. Aerial photographs from 2010 and 2012 were compared to the predicted "as built" areas (as seen in Figure 1) in an attempt to quantify the habitat realized following construction. Figure 7 displays the site in preconstruction (2003), during construction (2007) and post construction (2010 & 2012) for comparative purposes.

Figure 5. Benthic grab sampling in Town Pond.

Figure 6. Benthic grab sampling in Town Pond.

Figure 7. Aerial imagery of Town Pond.

3.0 RESULTS & DISCUSSION

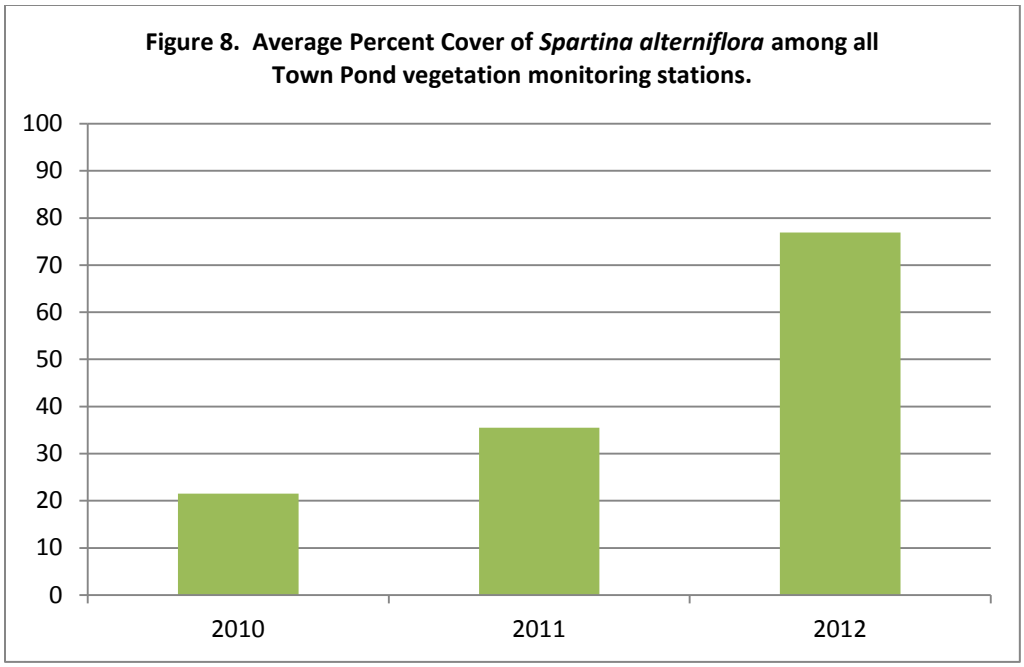
3.1 Marsh Vegetation

The restored marsh areas of Town Pond were dominated by *Spartina alterniflora*. *Salicornia virginica* and *Phragmites* were also observed regularly. A small patch of *Juncus gerardii* was noted at Station TP-6 in 2010, however in the subsequent years it was not observed. No evidence of *Spartina patens* or *Distichlis spicata*, typical high marsh plant species, was observed during the monitoring period.

In general, the average coverage of *S. alterniflora* in the restored marsh areas approximately doubled each year of monitoring. The combined average percent cover of *S. alterniflora* for all stations monitored was 21.5%, 35.5%, and 76.9% in 2010, 2011, and 2012, respectively (Figure 8). The average percent cover of *S.alterniflora* increased each year at all stations with the exceptions of Station TP-1 and TP-8 (Table 3). However, in the third year of monitoring both TP-1 and TP-8 had the highest average percent cover (85% and 80.5% respectively) among all stations. The largest increase in percent cover of *S. alterniflora* was observed at Station TP-3 which showed a 78.5% increase in cover between 2010 and 2012.

Table 4. Average Percent Cover of *Spartina alterniflora* at Town Pond Vegetation Monitoring Stations

Station ID	2010	2011	2012
TP-1	85.5	38	85
TP-2	26.5	33.5	66.5
TP-3	1	37.5	80.5
TP-4	11	33	71.5
TP-5	29	33	76
TP-6	4.5	38	80.5
TP-7	14.5	52.5	76
TP-8	29	13.5	80.5
TP-9	4	38	67
TP-10	10	37.5	85



Following the construction of the restoration project, which included Phragmites removal and a re-grading of the marsh/pond sediments, a primary concern for the system was the re-colonization of the site with Phragmites from adjacent stands of the plant. A Phragmites chemical control plan was developed and implemented. An initial treatment for Phragmites control in the vicinity of the power lines was performed in October 2008 and a follow-up treatment was performed in October 2009. Treatment of Phragmites along the fringes of the restoration area was performed in October 2010 and September 2011. The 3-year vegetation monitoring results show that while there was some initial colonization of the site, Phragmites has been effectively eliminated from the restoration areas. Table 4 summarizes the percent cover of Phragmites seen at each station each year throughout the monitoring effort. In 2012, no evidence of Phragmites was observed at any of the 10 monitoring stations. Phragmites is present within the Town Pond project area at elevations above high spring tides levels, however it appears to be eliminated from those areas that receive tidal inundation.

Table 5. Average Percent Cover of *Phragmites australis* at Town Pond Vegetation Monitoring Stations

Station ID	2010	2011	2012
TP-1	0.5	10.5	0
TP-2	0	6	0
TP-3	0	0	0
TP-4	0.5	0	0
TP-5	0	0	0
TP-6	0	0	0
TP-7	0	0	0
TP-8	0.5	13.5	0
TP-9	0	7.5	0
TP-10	0	0	0

3.2 Benthic Infauna

Intertidal Community

During the study period, 13 total taxa of invertebrates were collected from the intertidal benthic cores (Table 6). Nine (9) species were collected in 2011 and eleven (11) species were collected in 2012. The dominant species in 2011 were Oligochaetes, spionid polychaetes (*Polydora* & *Streblospio*), and capitellid polychaetes (*Capitella* sp.), while the dominant species in 2012 were capitellid polychaetes, spionid polychaetes, and the amphipod *Corophium* sp. Density values at each intertidal coring site rose between 2011 and 2012, while species richness values rose or remained the same. Fluctuations in diversity (H') values were seem among years, however no noticeable trends in increasing or decreasing diversity were observed.

In general, the intertidal benthic community of Town Pond during the monitoring period was dominated by typical opportunistic species existing in a stabilizing environment (i.e., an environment that is "recovering" from disturbance). Organisms such as the polychaetes *Capitella* and *Streblospio* are characteristic of these types of communities and are well represented in the Town Pond community. Over time, the community should trend toward more stable, non-opportunistic species such as deep burrowing long-lived polychaetes and bivalves. There were no obvious differences between the locations nearer to the inlet (C-2 and C-3) and the station farther from the inlet (C-1).

Subtidal Community

During the study period, 37 total taxa of invertebrates were collected from the subtidal benthic grabs in Town Pond (Tables 7 & 8). Thirty (30) species were collected in 2011 and thirty-one (31) species were collected in 2012.

The dominant species in the 2011 samples varied by station location. The dominant species in the inner (southern) portion of the pond (Stations B-1, B-2, & B-3) was the polychaete *Leitoscoloplos fragilis*, while the dominants in the outer (northern) portion of the pond (Stations B-4 through B-8) were the polychaetes *Capitella* sp., *Polydora cornuta*, *Streblospio benedicti,* and the amphipod *Ampithoe* sp. In 2012, there was a much more even distribution of dominant taxa throughout all stations. However, the spionid polychaetes (*Streblospio* & *Polydora)* were still dominant relative to other species.

Table 6. Benthic organisms collected (per 0.003 m^2) in intertidal areas of the Town Pond Restoration Project

YEAR STATION #	2011 C-1	2011 C-2	2011 C-3	2012 C-1	2012 C-2	2012 C-3
TAXON						
ANNELIDA						
POLYCHAETA						
Capitella sp.	5	2	31	117	3	16
Hyperetone heteropoda	0	0	0	0	0	1
Leitoscoloplos fragilis	0	0	0	2	0	5
Marenzellaria viridis	0	0	1	1	0	0
Nereis sp.	2	0	17	7	3	33
Polydora cornuta	0	12	8	10	1	7
Pygospio elegans	0	2	0	0	0	0
Streblospio benedicti	5	3	8	16	21	91
OLIGOCHAETA						
Unidentified Oligochaeta	25	11	52	17	5	49
ARTHROPODA						
INSECTA						
Unidentified Chironomid	0	2	0	0	0	0
AMPHIPODA						
Corophium sp.	17	2	2	25	22	3
Gammarus sp.	0	0	0	0	1	0
Ampithoe sp.	0	0	0	1	0	0
Total Numbers (Density)	54	34	119	196	56	205
Richness	5	7	7	9	7	8
Eveness	0.78	0.83	0.75	0.62	0.73	0.72
Shannon-Wiener Diversity	1.28	1.61	1.46	1.35	1.41	1.49

Table 7. Benthic organisms collected (per 0.04 m^2) in subtidal areas of Town Pond on June 2, 2011.

STATION #	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
ANNELIDA								
POLYCHAETA								
Capitella sp.	4	4	1	130	1061	162	4	41
Hypereteone heteropoda	1	0	0	0	15	0	26	10
Glycera sp.	0	3	2	0	9	2	0	5
Leitoscoloplos fragilis	100	183	142	0	2	34	4	1
Mediomastus sp.	0	0	1	0	4	0	0	20
Nephtys sp.	0	2	0	0	0	1	0	0
Nereis sp.	2	1	4	12	10	4	17	45
Pectinaria gouldii	0	0	0	0	1	1	0	0
Phyllodoce sp.	2	0	0	0	0	0	0	0
Polycirrus sp.	0	0	0	0	0	0	1	0
Polydora cornuta	0	0	2	4	0	18	212	121
Spiochaetopterus costarum	0	1	0	0	0	0	0	0
Spiophanes sp.	0	0	0	0	0	3	0	0
Sthenelais boa	0	0	0	0	1	0	12	25
Streblospio benedicti	0	1	3	1	29	3	41	80
Unidentified Terrebellidae	0	0	1	0	0	0	0	0
OLIGOCHAETA								
Unidentified Oligochaete	2	0	5	1	15	7	2	15
ARTHROPODA								
Ampelisca sp.	0	0	0	0	4	0	18	13
Ampithoe sp.	0	0	0	0	13	2	584	169
Caprella sp.	0	0	0	0	0	0	1	3
Carcinus maenus	0	0	0	0	0	0	1	0
Corophium sp.	0	0	0	0	0	0	21	0
Gammarus sp.	0	0	0	0	0	0	0	40
Jassa sp.	0	0	0	0	1	0	0	0
Leptocheirus pinguis	0	0	0	0	14	0	0	0
Oxyurostylis sp.	1	0	1	0	0	0	0	0
Pagurus longicarpus	0	0	0	0	0	0	2	0
Panopeus herbstii	0	0	0	0	0	0	3	1
MOLLUSCA								
BIVALVIA								
Gemma gemma	0	0	0	0	0	0	0	4
Macoma balthica	1	0	0	0	0	1	0	4
Total Numbers	113	195	162	148	1179	238	949	597
Richness	8	7	10	5	14	12	16	17
Eveness	0.27	0.17	0.27	0.29	0.20	0.47	0.45	0.76
Shannon-Wiener	0.57	0.33	0.62	0.48	0.54	1.17	1.27	2.16

Table 8. Benthic organisms collected (per 0.04 m^2) in subtidal areas of Town Pond on June 28, 2012.

STATION #	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
ANNELIDA								
POLYCHAETA								
Capitella sp.	15	19	37	31	0	13	1	22
Glycera sp.	3	4	3	0	0	0	0	1
Hypereteone heteropoda	7	5	1	1	0	0	5	17
Leitoscoloplos fragilis	6	24	12	6	2	0	2	0
Magelona sp.	0	0	1	3	0	0	0	0
Mediomastus sp.	1	0	1	0	0	0	0	0
Nephtys sp.	1	1	6	1	1	0	1	1
Nereis sp.	3	2	14	2	3	2	24	27
Pectinaria gouldii	0	0	2	2	1	0	0	0
Phyllodoce sp.	4	0	0	0	0	0	0	0
Polydora cornuta	15	12	44	10	4	0	51	91
Schistomeringous sp.	0	0	0	0	0	0	0	4
Spiochaetopterus costarum	0	0	1	0	0	0	0	0
Spiophanes sp.	0	0	1	4	0	0	0	0
Sthenelais boa	7	1	0	0	0	0	3	31
Streblospio benedicti	31	20	41	15	3	0	21	62
OLIGOCHAETA								
Unidentified Oligochaete	4	0	1	2	1	0	0	4
ARTHROPODA								
Corophium sp.	3	0	2	0	0	0	2	1
Oxyurostylis sp.	1	1	2	0	0	0	0	2
Ampithoe sp.	0	0	1	1	0	0	25	89
Leptocheirus pinguis	0	0	0	0	0	0	0	1
Ampelisca sp.	0	0	0	0	4	1	5	15
Pagurus longicarpus	0	0	0	0	0	0	0	1
Carcinus maenus	0	0	0	0	0	0	1	3
Panopeus herbstii	0	0	0	0	0	0	4	3
Crangon sp.	0	0	0	0	0	0	1	0
MOLLUSCA								
BIVALVIA								
Macoma balthica	6	0	0	0	0	0	0	0
Mya arenaria	0	0	4	0	1	0	0	0
Ensis directus	0	0	0	1	0	0	0	0
Mytilus edulis	0	0	0	0	0	0	15	6
GASTROPODA								
Ilyannassa trivittata	0	8	0	0	3	0	0	0
Total Numbers	107	97	174	79	23	16	161	381
Richness	15	11	18	13	10	3	15	19
Eveness	0.83	0.82	0.71	0.74	0.94	0.54	0.75	0.72
Shannon-Wiener	2.26	1.96	2.03	1.91	2.16	0.60	2.04	2.14

Similar to the dominant species, yearly density values varied between the inner and outer pond regions. Density values in the inner pond regions remained similar between 2011 and 2012 while density values in the outer portion of the pond dropped considerably. During 2011-2012, species richness values in the inner pond rose, while richness values in the outer pond tended to fluctuate. In general, large increases in diversity (H') values in the entire pond were observed between 2011 and 2012. Station B-6 was an exception showing a decrease in diversity, while diversity at Station B-8 remained similar among the years.

As was the case in the intertidal benthic community, the subtidal benthic community of Town Pond during the monitoring period was dominated by typical opportunistic species existing in a stabilizing environment. Organisms such as the polychaetes *Capitella* and *Streblospio* are characteristic of these types of communities and are well represented in the Town Pond subtidal community. The results presented within this report show that the subtidal benthos are trending toward a more stable, non-opportunistic species dominated community as evidenced by the presence of soft-shelled clams (*Mya arenaria*) and razor clams (*Ensis directus*) in the 2012 data.

Qualitative Fauna Observations

Qualitative observations of fauna in the project area during the monitoring effort revealed that the restored pond was being utilized by numerous types of wildlife. The following list of fauna was directly observed by monitoring crews and is not to be construed as a definitive list of organisms present within the project site:

> *Invertebrates*: Mud crabs, green crabs, blue crabs, blue mussels, fiddler crabs, mud snails, moon snails, oysters (introduced);
>
> *Birds*: great blue heron, black-crowned night heron, snowy egret, peregrine falcon, redwing black bird, mallard duck, herring gull, laughing gull, killdeer, cormorant, and semipalmated sandpiper;
>
> *Fish*: silversides, killifish, rock eel;
>
> *Mammals*: raccoons, white tail deer, red fox.

During the vegetation monitoring it was noted that fiddler crab burrows (Figure 9) are plentiful throughout all low marsh areas of the project area.

Figure 9. Fiddler crab burrows in Town Pond restoration area.

3.3 Habitat Estimations

As noted above, the recommended plan for Town Pond was to create 2.3 acres of *Spartina patens* dominated high marsh, 4.5 acres of *Spartina alterniflora* dominated low marsh, 2.9 acres of mudflats, and 5.3 acres of permanent open water. However, due to faster than anticipated consolidation rates is the disposal area, the design was modified during construction. The project was built to create approximately 2.5 acres of high marsh, 8.9 acres of low marsh, 3.2 acres of mudflats, and 8.2 acres of permanent open water (Figure 1). Table 9 contains the evolution of the size of the restoration areas from the Feasibility Study to the final design . Vegetation monitoring revealed that as of 2012, no high marsh vegetation (i.e., *Spartina patens*, *Distichlis spicata*, etc.) exists on site. Based upon aerial photographs from 2012 (Figure 7) it appears as if the 2.5 acres of area that was planned as high marsh is currently functioning as low marsh habitat. The mudflat areas and open water areas are functioning as planned. In May of 2013 a series of spot elevations were taken within the vegetated areas to assess their existing elevations relative to the as-built designs (design elevations for the project were -3.3 – 0.0 ft for open water, 0.0 – 0.4 ft for mudflat, 0.4 – 2.7 ft for low marsh, and 2.7 – 2.9 ft for high marsh.) From the

survey it was determined that the low marsh areas are currently existing at elevations between 1.2 - 3.4 ft NGVD, thus occurring at higher elevations than the predicted high marsh.

Table 9. Evolution of the Town Pond Restoration Size from Feasibility Report to Construction

HABITAT TYPE	DPR PLAN ACREAGE	ORIGINAL DESIGN ACREAGE	AS-BUILT ACREAGE
OPEN WATER	5.37	8.47	8.20
MUD FLAT	2.98	3.06	3.20
LOW MARSH	4.48	6.09	8.90
HIGH MARSH	2.33	2.32	2.50
TOTAL	15.16	19.94	22.80

4.0 Summary

The main goal of the Town Pond restoration project was to restore a salt marsh ecosystem by recreating the former habitat in the project area for associated flora and fauna. Based upon the monitoring results we have documented in this report, the restoration project functions physically as an intertidal salt marsh with areas of mudflats and permanent open water. The monitoring indicates that the project met the pre-construction restoration objectives.

In addition to the natural recruitment of flora and fauna to the site, researchers from Roger Williams University (Leavitt, 2011) have been introduction oyster cultch and juvenile oysters to the project area. The effort is summarized in Appendix C of this report.

5.0 References

Daubenmire, R. 1966. Vegetation: Identification of typal communities. Sci 151-291-298.

Nixon, S.W. 1982. The ecology of New England high salt marshes: a community profile. USFWS, Office of Biological Services. Washington, D.C. FWS/OBS-81/55. 70 pp.

USACE. 2002. Final Project Modification Report and Environmental Assessment for the Town Pond Restoration Project, Portsmouth, Rhode Island. US Army Corps of Engineers, 696 Virginia Road, Concord, MA 01742.

Appendix A

Low Level Aerial Photographs of the Town Pond Restoration Site

Town Pond July 2006

Town Pond August 2007

Town Pond April 2008

Town Pond July 2012

Appendix B

Ecological Resources Monitoring Plan

Town Pond Restoration Project
Ecological Resources Monitoring Plan
February 4, 2002

Introduction

This monitoring plan has been developed for the planned restoration of Town Pond in Portsmouth, Rhode Island. The purposes of this monitoring plan are 1) to guide implementation and generate information to formulate minor adjustments in the plan or mid-course corrections; and 2) to measure the success of the project. All of the procedures in this plan will be performed by or under the guidance of the New England District, Corps of Engineers. The plan is intended to measure and ensure achievement of the goals and objectives established during planning. It is intended to be flexible to allow readjustment as new information and conditions develop.

Goals and objectives formulated during the early planning of the project are the basis for the establishment of monitoring criteria. Goals are the target functional attributes to be restored, such as water quality, hydrology, or wetland flora and fauna. Objectives are more precise, such as the specific characteristics of water quality to be achieved or the species composition of the various communities of biota to be restored. Performance indicators are specific, measurable quantities such as pH, amount of chlorophyll in a water sample, or Secchi disk visibility (NRC, 1992). The goals, objectives and performance criteria for this project are specified in this document.

Project Goals

- Restore a combination of salt pond, salt marsh, and intertidal mudflat that maximizes fish and wildlife habitat value within project constraints.
- Maintain the value of existing estuarine habitats in the tidal inlet downstream of the railroad embankment as much as practicable.
- Increase the habitat value for estuarine dependent fish and wildlife, while maintaining some cover for the existing wildlife community.
- Avoid increasing salinity in Founder's Brook.
- Cause no increase in flooding potential to surrounding uplands.

Objectives

1. Restore elevations and substrates at intertidal elevations (spring high water to mean sea level) that allow salt marsh plants and associated animal communities to recolonize the site. Increase the abundance of salt marsh vegetation (e.g., salt marsh cordgrass (*Spartina alterniflora*), salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), etc.) and decrease the dominance of common reed (*Phragmites australis*).

2. Restore salt marsh vegetation to the edges of the existing tidal inlet downstream of the railroad embankment.

3. Restore elevations and substrates at lower intertidal elevations (about mean sea level to mean lower low water) that allow invertebrates adapted to intertidal areas and the animals that feed on them to recolonize the site.

4. Restore permanent open water to allow populations of shallow subtidal invertebrates and possibly submerged aquatic vegetation and the animals that feed on them to recolonize the site.

5. Restore habitats in appropriate ratios to maximize use by fish and wildlife.

6. Maintain salinity concentration in Founder's Brook of 0 parts per thousand.

7. Ensure existing flood heights on surrounding uplands remain unchanged.

Project Objectives, Success Criteria and Methods

Objective 1: Restore elevations and substrates at intertidal elevations (spring high water to mean sea level) that allow salt marsh plants and associated animal communities to recolonize the site. Increase the abundance of salt marsh vegetation (e.g., salt marsh cordgrass (*Spartina alterniflora*), salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), etc.) and decrease the dominance of common reed (*Phragmites australis*).

Success Criteria A: The area of the marsh flooded between once daily and two to eight times monthly is increased.

Method: Establish ten permanent sample stations at random locations within portions of the marsh between elevation 0.14 and 0.95 meters NGVD. (Apportion stations in high marsh and low marsh based on area and locate stations using GPS.) Install crest stage gauges at each station and determine the elevation of the station relative to a tidal datum. Determine the height of flooding of the marsh surface during neap and spring tides once each year for three years. Estimate the area flooded using surface water depth information and as built plans.

Success Criteria B: The soil water salinity is between 20 to 33 ppt in portions of the marsh between elevation 0.14 and 0.95 meters NGVD.

Method: At each of the ten marsh sample stations, measure the salinity of soil water during low tides during the spring and neap tide phases in pits once per year for three years. Salinity will be measured using a hand refractometer.

Success Criteria C: The percent cover of salt marsh vegetation is increased in areas flooded once daily to two to eight times monthly.

Method: Establish ten permanent sample stations at random locations within portions of the marsh between elevation 0.14 and 0.95 meters NGVD. Measure the percent cover of vegetation (in cover classes) and height, number of stems and number of flowering stems of common reed in 0.5 m^2 rectangular quadrats. Perform this sampling once each year in late August to September at two, three, and five years after construction.

Objective 2: Restore salt marsh vegetation to the edges of the existing tidal inlet downstream of the railroad embankment.

Success criteria: The area of salt marsh vegetation on the edge of the creek is similar to the area of vegetation removed to realign the inlet.

Method: Measure the area of salt marsh vegetation removed prior to construction and after construction for a period of at least five years after implementation (measurements at two, three, and five years after construction).

Objective 3: Restore elevations and substrates at lower intertidal elevations (about mean sea level to mean lower low water) that allow invertebrates adapted to intertidal areas and the animals that feed on them to recolonize the site.

Success criteria: The intertidal zone of the restored habitat supports a benthic community comparable to similar habitats at other locations.

Methods: Collect benthic cores at five stations randomly located in the intertidal zone each year for three years following the completion of construction. Screen samples through a 0.5-mm sieve and identify and count all organisms to the lowest practical classification.

Objective 4: Restore permanent open water to allow populations of shallow subtidal invertebrates and possibly submerged aquatic vegetation and the animals that feed on them to recolonize the site.

Success criteria: The subtidal zone of the restored habitat supports a benthic community comparable to similar habitats at other locations.

Methods: Collect benthic cores at five stations randomly located in the subtidal zone each year for three years following the completion of construction. Screen samples through a 0.5-mm sieve and identify and count all organisms to the lowest practical classification.

Objective 5: Restore habitats in appropriate ratios to maximize use by fish and wildlife.

Performance criteria: The ratio of open water to salt marsh is approximately one to one.

Methods: Collect true color aerial photography at a scale of 1 inch equal to 600 feet during December five years after implementation. Map cover types and compare to December 20, 1993 true color aerial photography.

Objective 6: Maintain salinity concentration in Founder's Brook of 0 parts per thousand.

Performance criteria: The salinity concentration in Founder's Brook is 0 parts per thousand.

Methods: Measure the salinity in Founder's Brook upstream and downstream of the road crossing prior to construction and once per year for three years following construction.

Objective 7: Ensure existing flood heights on surrounding uplands remain unchanged.

Performance criteria: Flood heights do not exceed those predicted by project modeling.

Methods: Measure flood height during normal tidal conditions and compare to predictions.