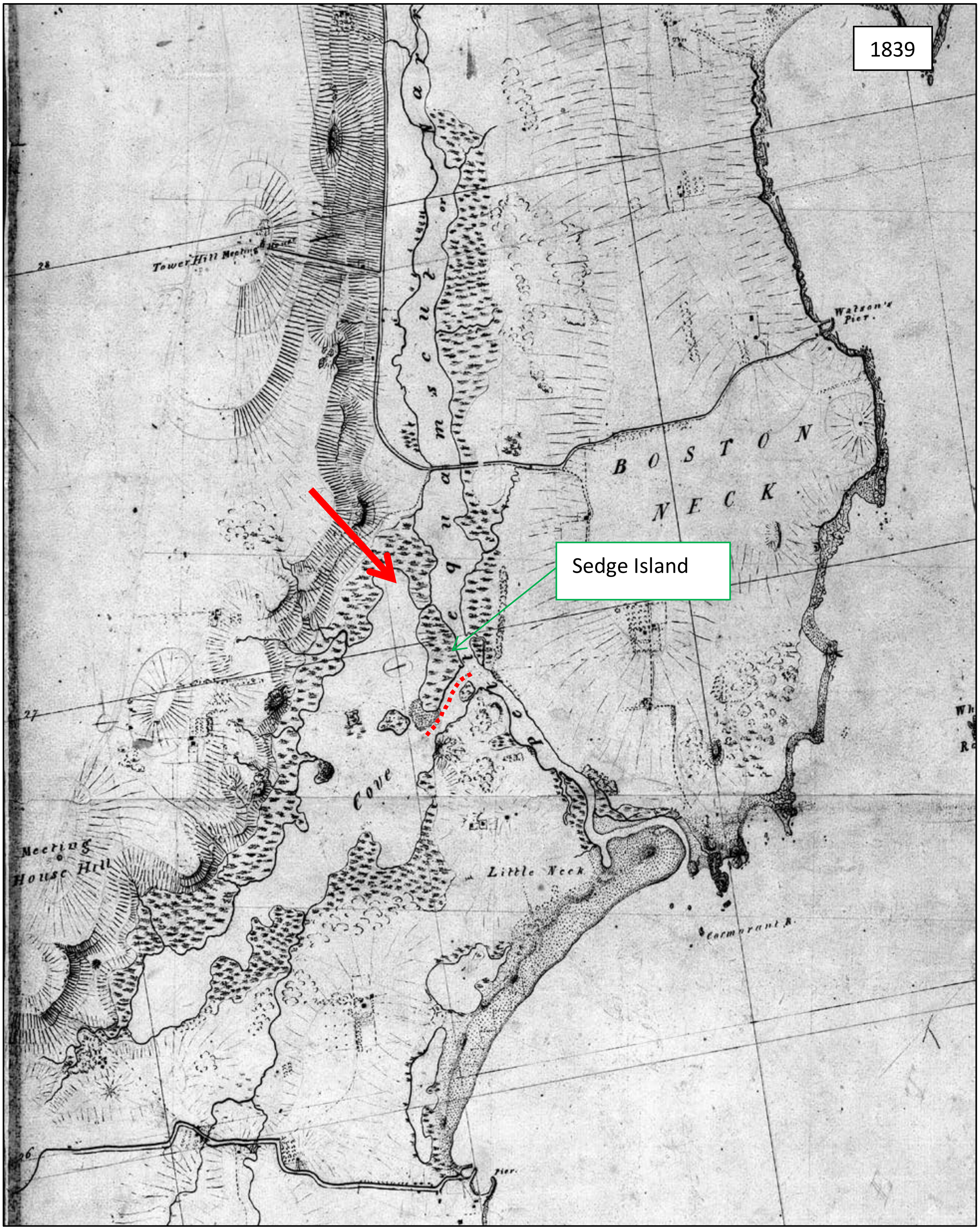
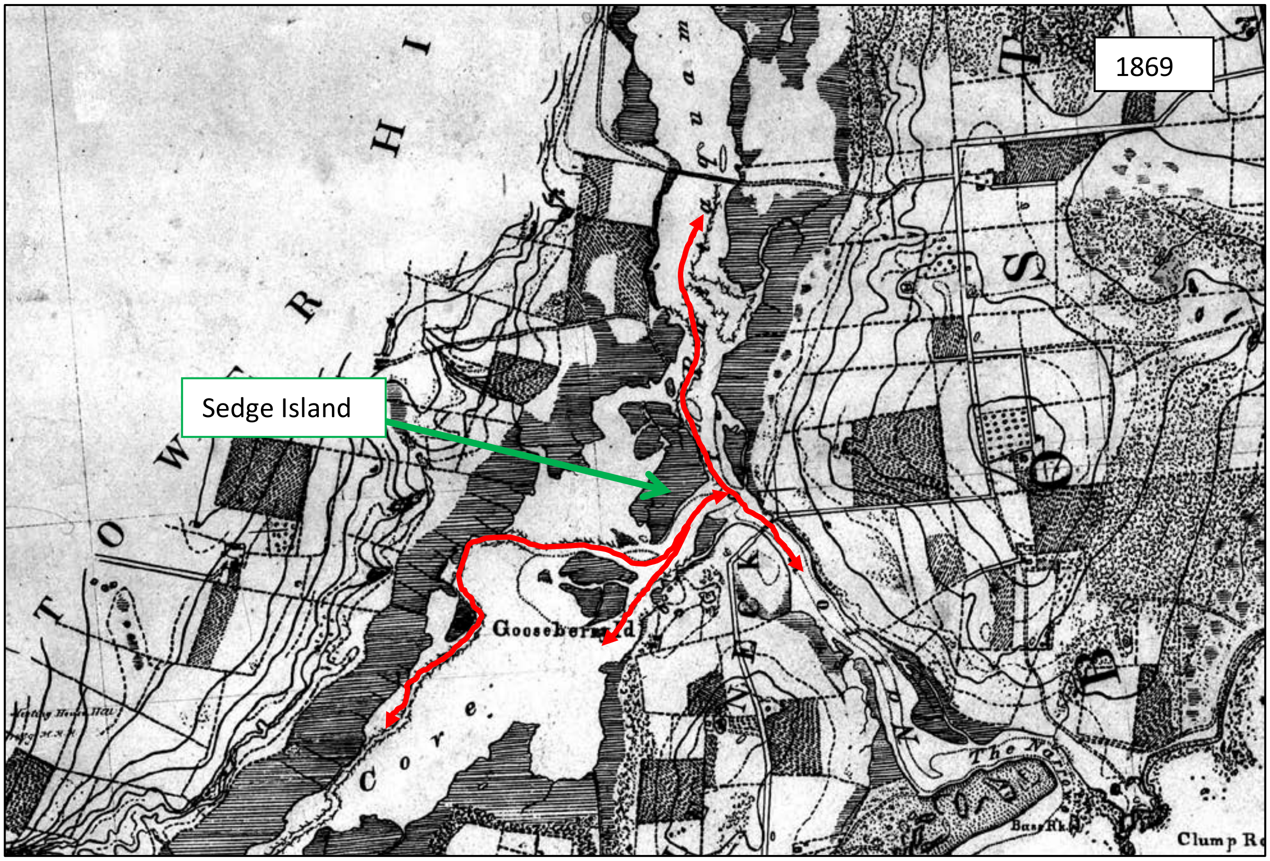
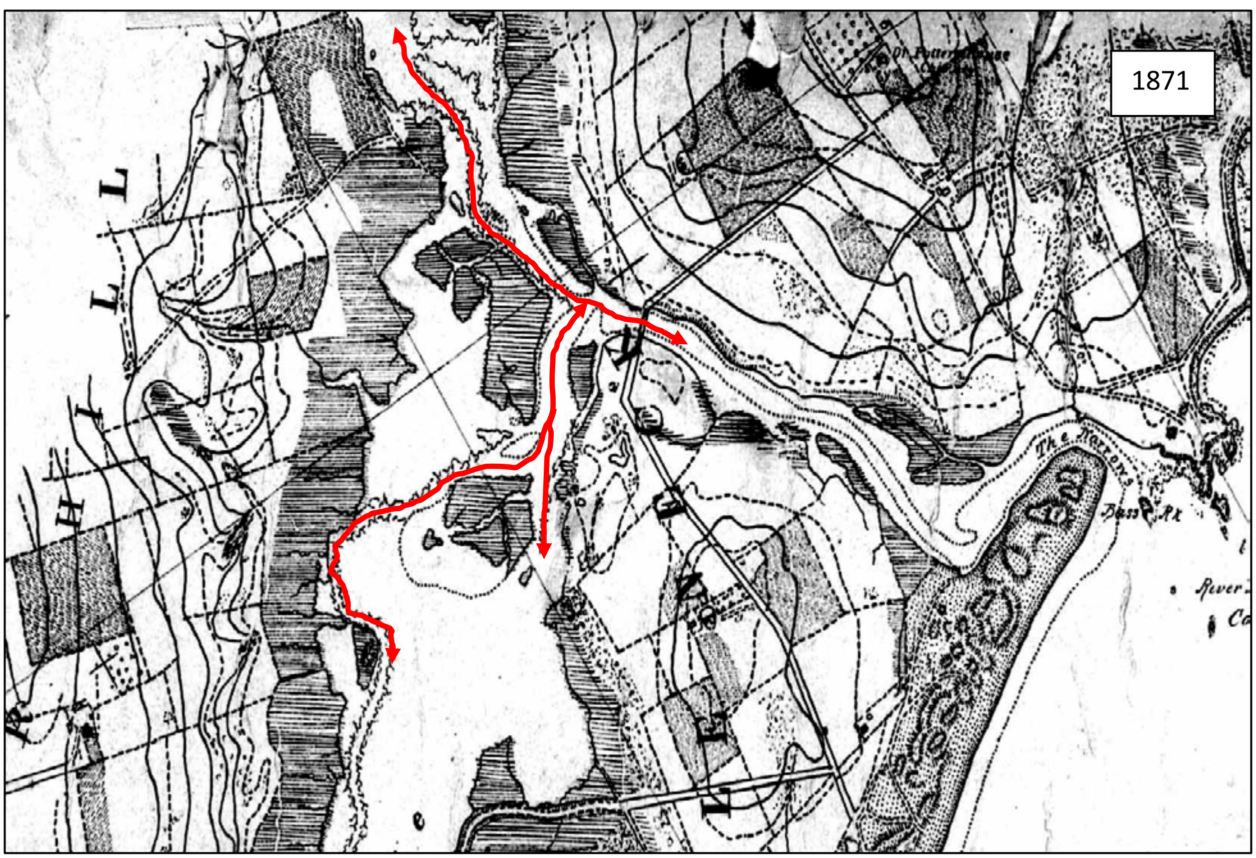
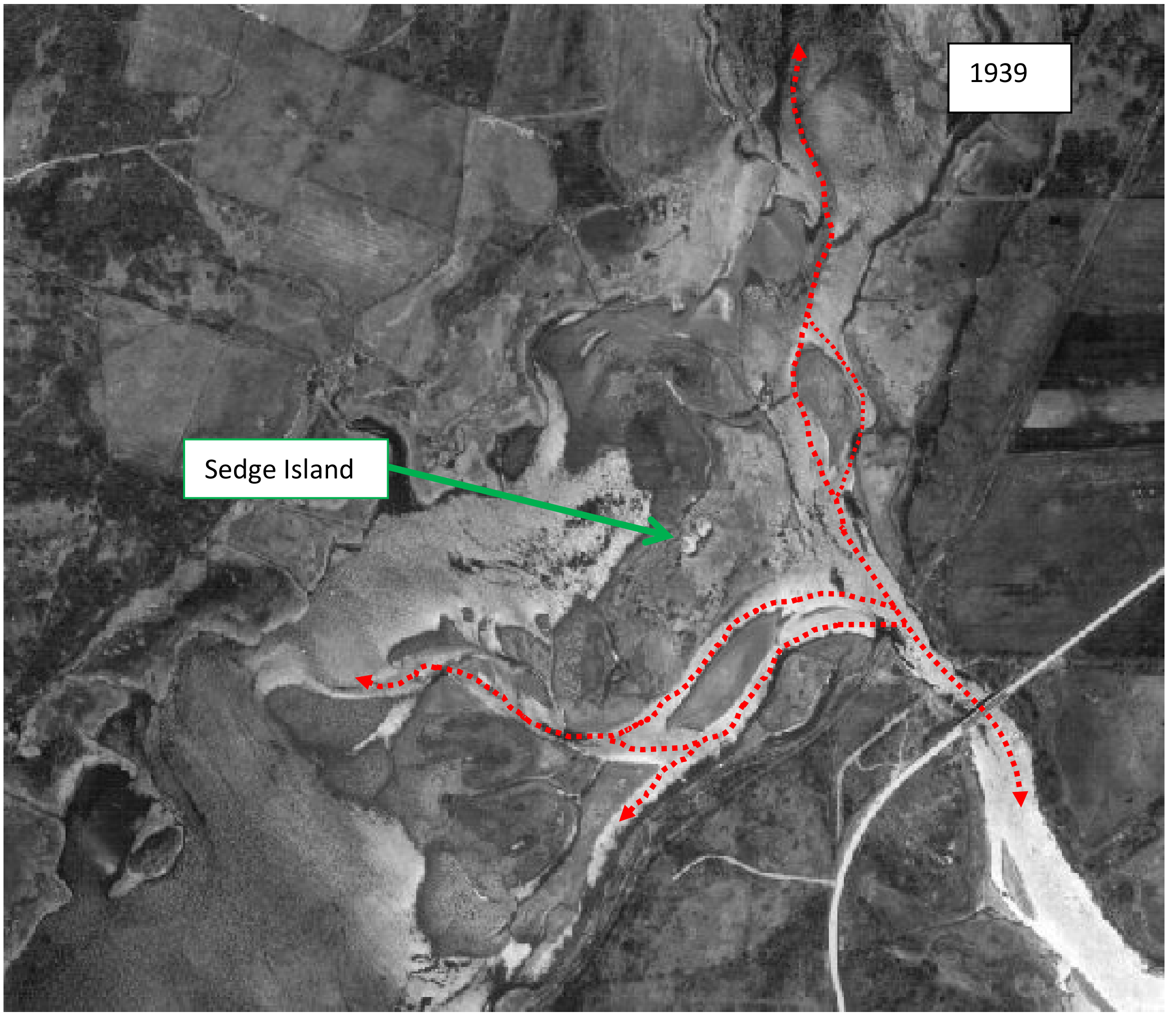
APPENDIX A

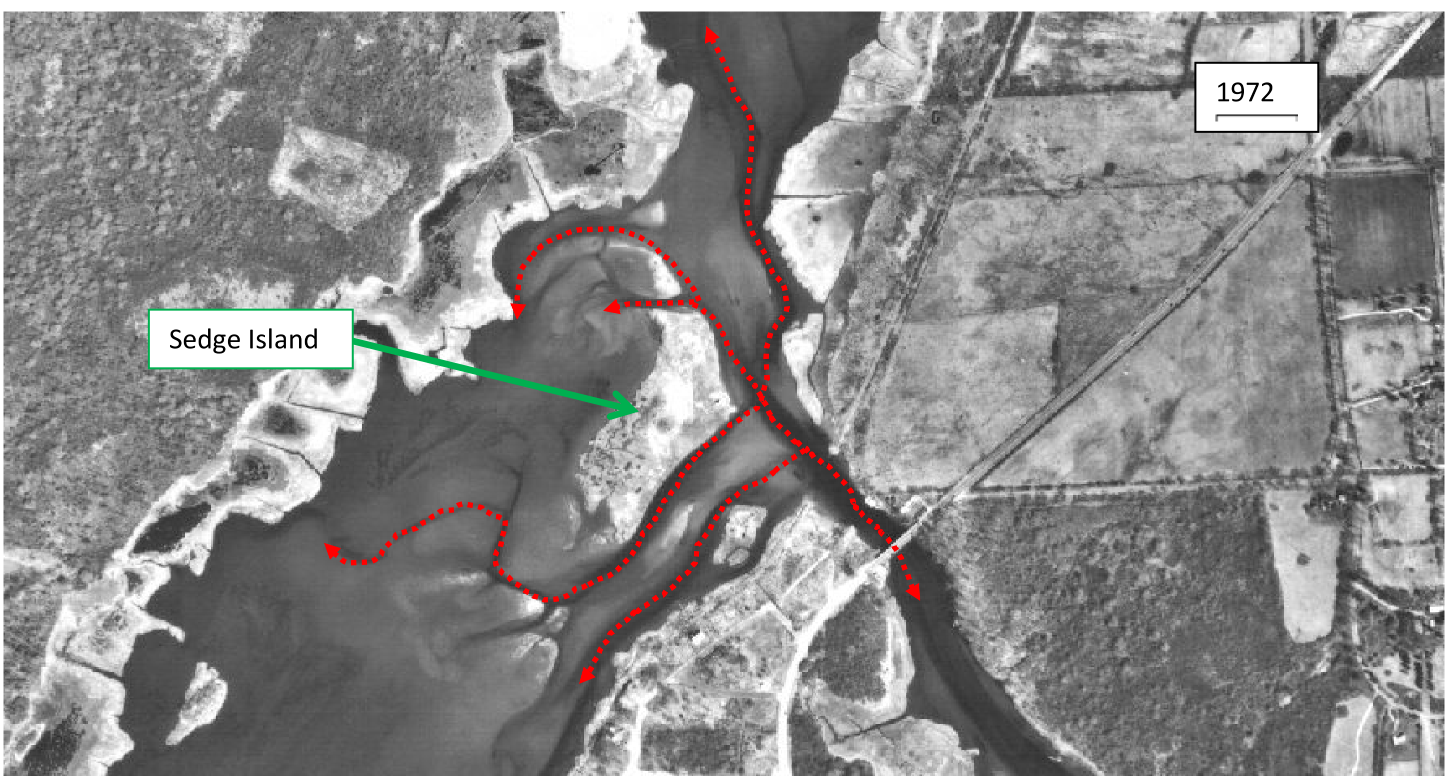
Changes in the Narrow River Estuary Channels Over Time.



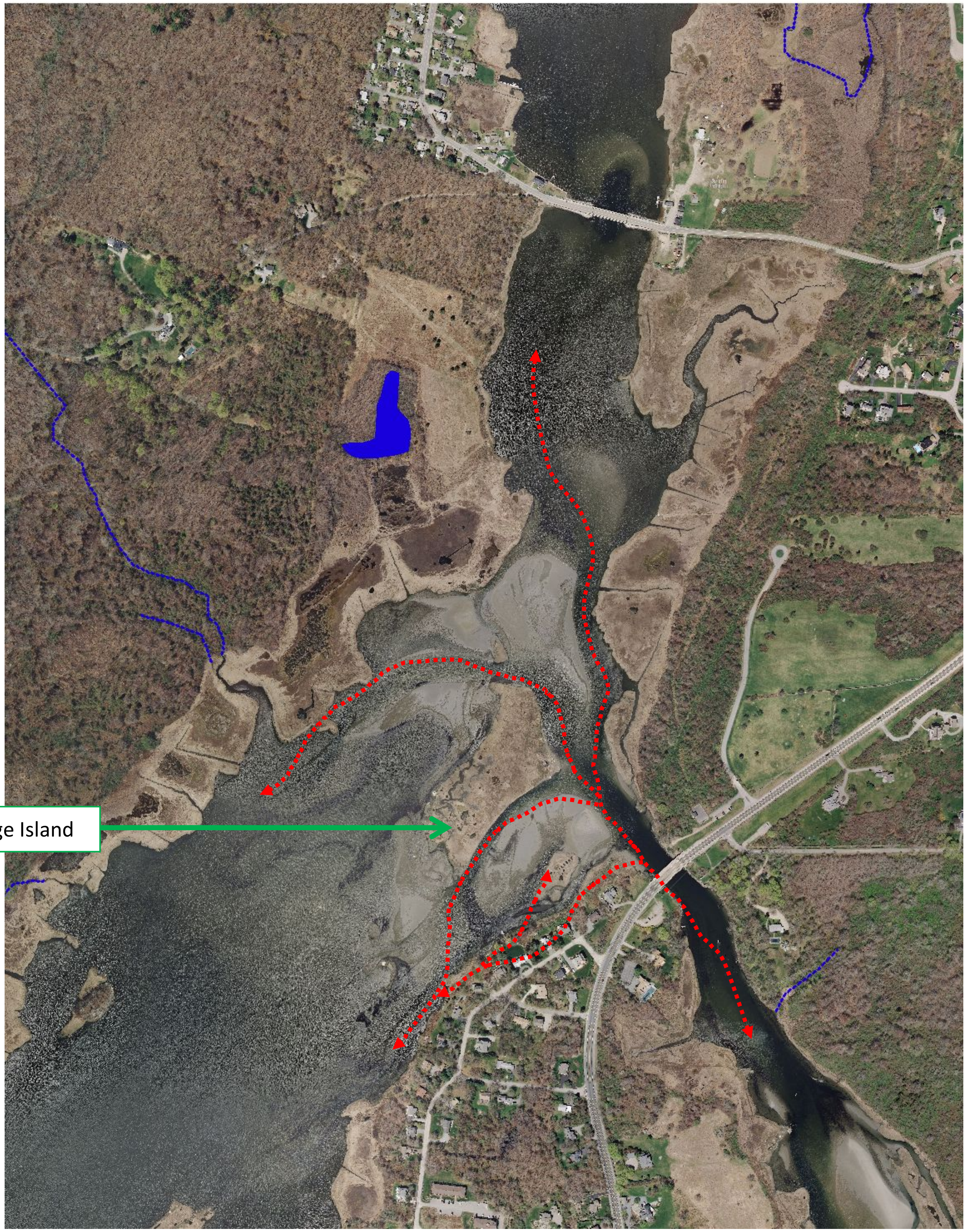

1869
Sedge Island
Gooseberry Id
Cove
The Narrows
Bass Rk
Clump R


1871
The Narrows
Bass Rk


1939
Sedge Island


1972
Sedge Island

2011



APPENDIX B

Saltmarsh Habitat Information in the Narrow River Drainage

John H. Chafee National Wildlife Refuge

Towns of South Kingstown and Narragansett

Washington County, Rhode Island

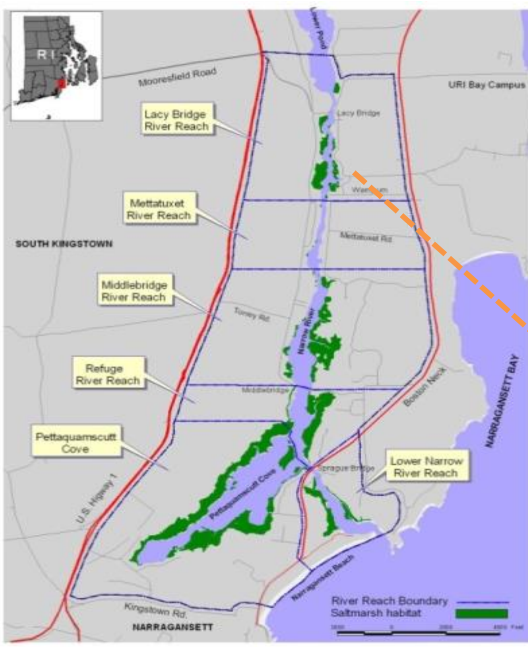
Overview:

This appendix provides broad level information regarding saltmarsh habitats in the Narrow River estuary.

Organization of Information

The project area has been stratified into river reaches to facilitate analysis and restoration needs. Within each river reach, each saltmarsh was placed into saltmarsh management units. The salt marsh management units contain current saltmarsh, associated tidal (brackish) wetlands, shrub wetlands, and pools and pans. Generally, the two foot LIDAR elevation encompasses all current saltmarsh habitat. Possible areas where saltmarsh habitat may "migrate" into higher elevations are included within each unit, and include all between the two foot and four foot LIDAR elevation contours.

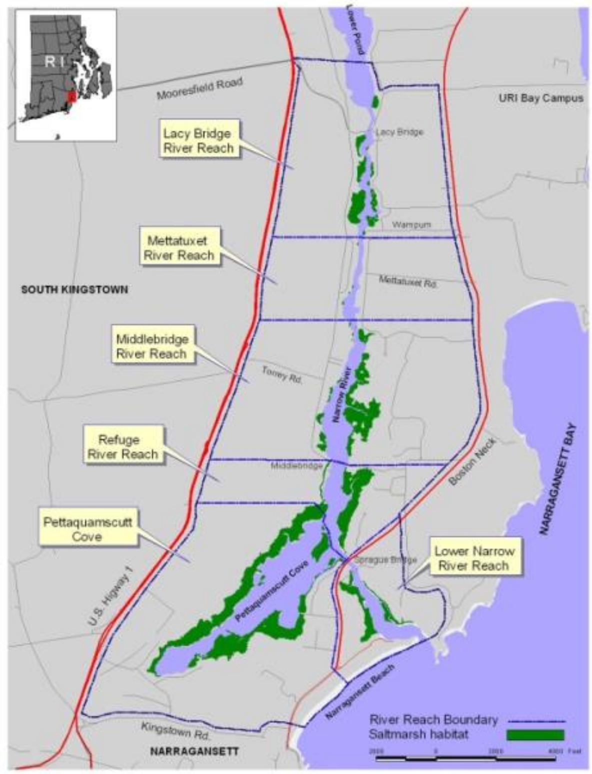
River Reaches in the Project Area Boundary



Saltmarsh Units, Lacy Bridge River Reach

Summary

The Narrow River estuary contains about 175 acres of saltmarsh primarily concentrated in the lower portions of the River below Middlebridge. Pools and pans comprise a substantial portion of the area, with well drained salt marsh comprising less than half (48%) of the salrtmarshes. Based on aerial imagry from 1939 - 2011, it appears that up to 40% of the pools and pans have developed since 1939. As a consequence most saltmarsh surfaces appear to be dominated by S. Alternaflora, with S. Patens occuring in upper elevations and in well drained areas near drainages.

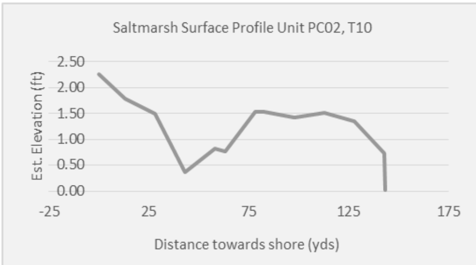


RIVER REACH	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTUARINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
Lacy Bridge	31.7	15.2	4.4	0.9	5.2	34.3	5.3	0.2	25.9	5.8	38.1
Mettatuxet	2.0	1.6	0.0	0.0	0.0		0.1	0.0	1.8	0.2	14.7
Middlebridge	83.3	31.6	3.3	4.9	8.2	26.0	9.2	2.1	51.1	32.2	102.2
Refuge	36.9	24.8	1.0	0.5	1.5	5.9	1.6	1.3	29.1	7.8	31.3
Pettaquamscut Cove	169.0	86.8	5.7	14.2	20.0	23.0	12.6	0.6	119.9	49.1	56.5
Lower Narrow River	21.4	14.0	0.0	0.5	0.5	3.7	0.0	0.0	14.5	6.8	48.8
All River Reaches	344.2	174.0	14.3	21.0	35.4	20.3	28.8	4.2	242.3	101.9	58.6

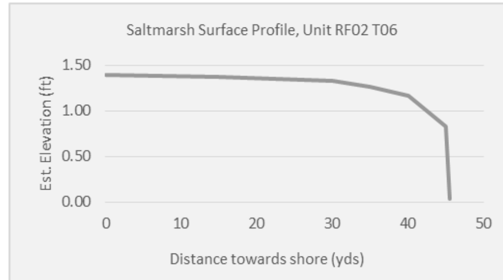
Saltmarsh Surface Profiles

Saltmarsh profiles vary markedly throughout the estuary, from relatively flat in the vicinity of Sedge Island to very

Irregular saltmarsh surface profile in Pettaquamscutt Cove.

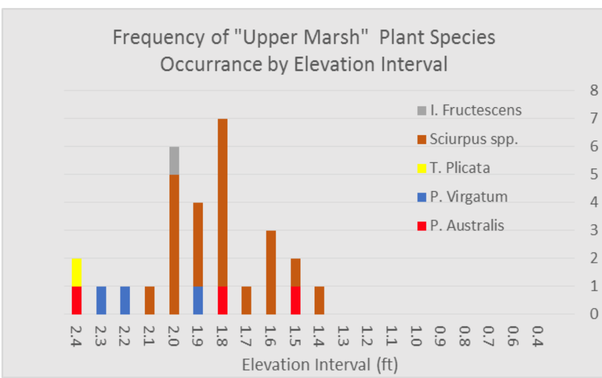


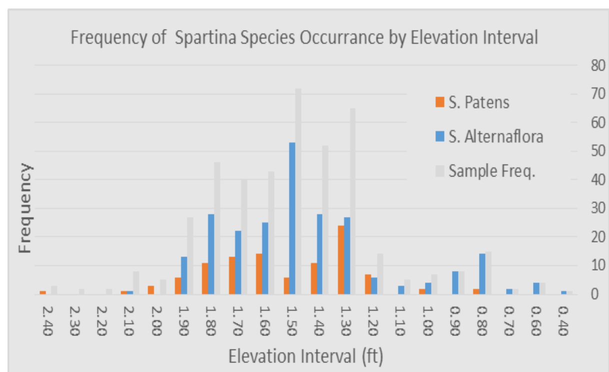
Well drained, consistent surface profile.



Plant Species Occurance by Elevation

During collection of surface profiles, the crew was asked to identify the dominant plant species witin a square meter of an elevation sample. While the results appear to characterize the distribution of "upper marsh" species, it dows not aide in identifyinf where S. patens is most domiant on the landscape. This species appears to be influenced both by elevation and proximity to drainage dicthes (well drained areas). The data in the graph below may be more influenced by sampling by elevation interval than dominance on the landscape.





ABOUT THE INFORMATION

Habitat Components:

Aerial imagry from2011 was used along with field knowledge to idenfity broad habitat categories:

Saltmarsh: Areas primarily dominated by S. Patens and S. Alternaflora

Tidal Marsh: Areas primarily dominated by cattail, sciurpus, and phragmites. Brackish to freshwater marsh.

Estuarine Shrub wetland: Areas dominated by Iva fructescens.

Pools and Pans: Areas on the marsh surface generally devoid of vegetation and either intermittantly of permantly flooded. Those found on 1939 aerial imagry deemed old pools and pans. These are generally freshwater in nature, and some depths exceed .75 meters.

Possible saltmarsh migration area: Areas below the fout foot LIDAR elevation, but not occupied by tidal marsh or shrub wetlands.

Saltmarsh drainage:

Aerial imagry from 1939, 1986, 2003 and 2011 were used to locate drainage ditches in the marsh, and to categorize them as to functioning or non-functioning. Some field verification was completed. Well drained areas were identified based on field observations and aerial image interpretation. Well drained areas generally occur within 50 feet of a functioning drainage. Increases in well drained areas based on ditch repair based on 50 foot buffer, except in areas where drainage did not discet a pool or pan, which reduced the buffer size.

Saltmarsh Surface Profiles:

Surface profiles were idenitifed collecting elevationas along transects within saltmarsh units using a laser level. In the Refuge and Pettaquamscutt Cove areas, the elevations were tied to a standard UFWS survey marker with known elevation (1.54 feet NGVD 1988). In other areas, profiles were taken but without a known field elevation. These data are relative to eachother but not a field elevation. The sample interval ranges between every 3 meters to every 15 meters dependng on the location. These data are not suitable for detailed task specific planning. At each elevation sample, the field crew examined the area a meter square to determine the dominant plant species.

Boat wake impacts

Information relative to possible impacts from boat wakes on saltmarsh shorelines was collected in 2008-2010. The river is heavily used in summertime to access Narragansett beach. Vessel counts on Sprague bridge found an average of 16 vessels per hour passing underneath the bridge in summer. The size of boat wakes was determined to be related to boat speed, vessel size, loading, and a Froude index which measures wave dissipation based on distance and depth. Boat wakes were found to be related to near shore turbidity and the amount of vegetation on the bank. An assessment of boat wake wave dissipation suggests areas farther than 300ft from a vessel will have wave dissipation to levels equivalent to a no wake speed.

Shoreline stability

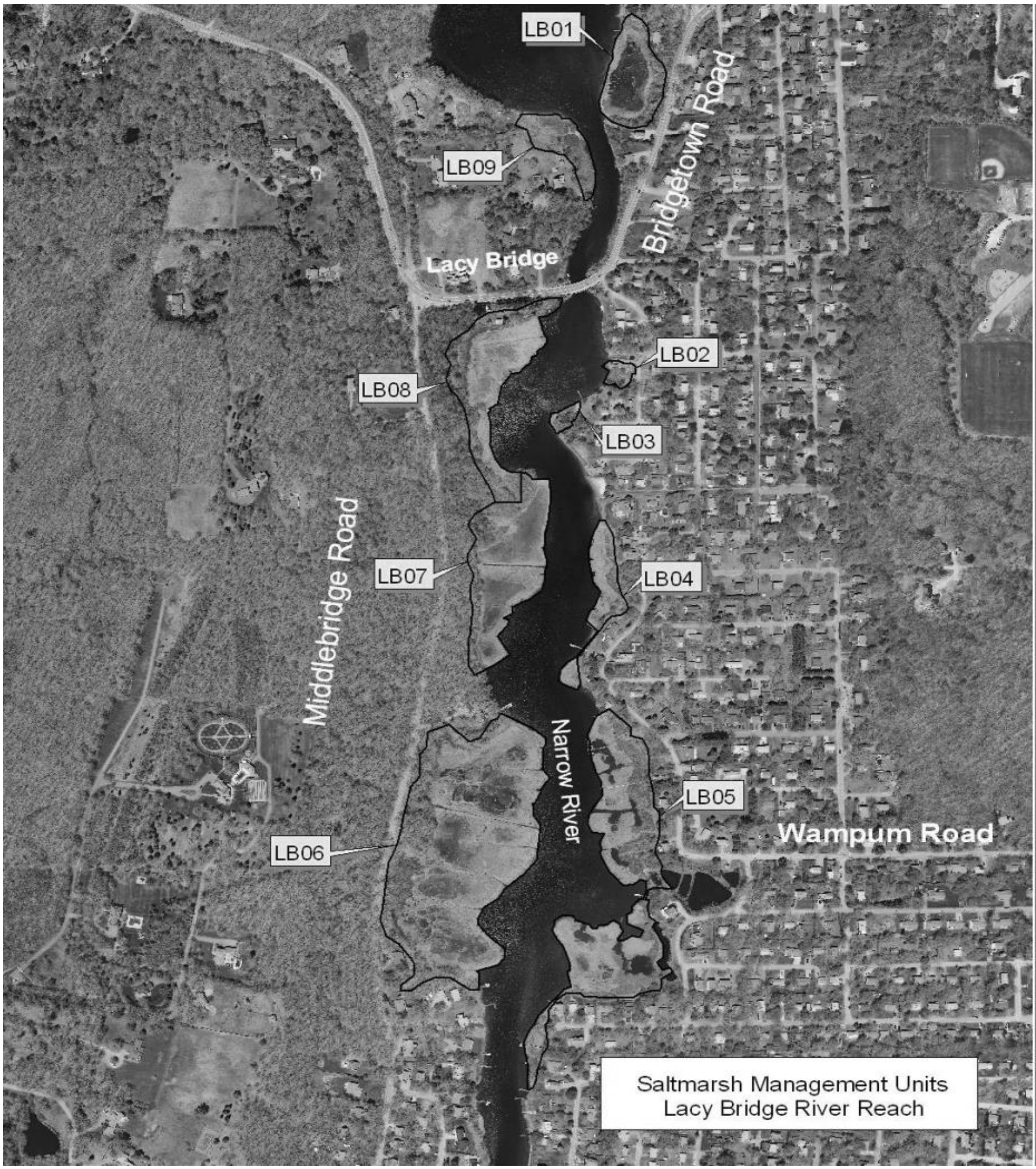
Shoreline stabi;ity surveys were undertaken in 2011 on refuge saltmarsh shorelines. Most shorelines are undercut on the River and in many sloughs. Bank height was highest in the lower narrow river, and most stable in the Middlebridge reach.

Lacy Bridge River Reach

I. Overview

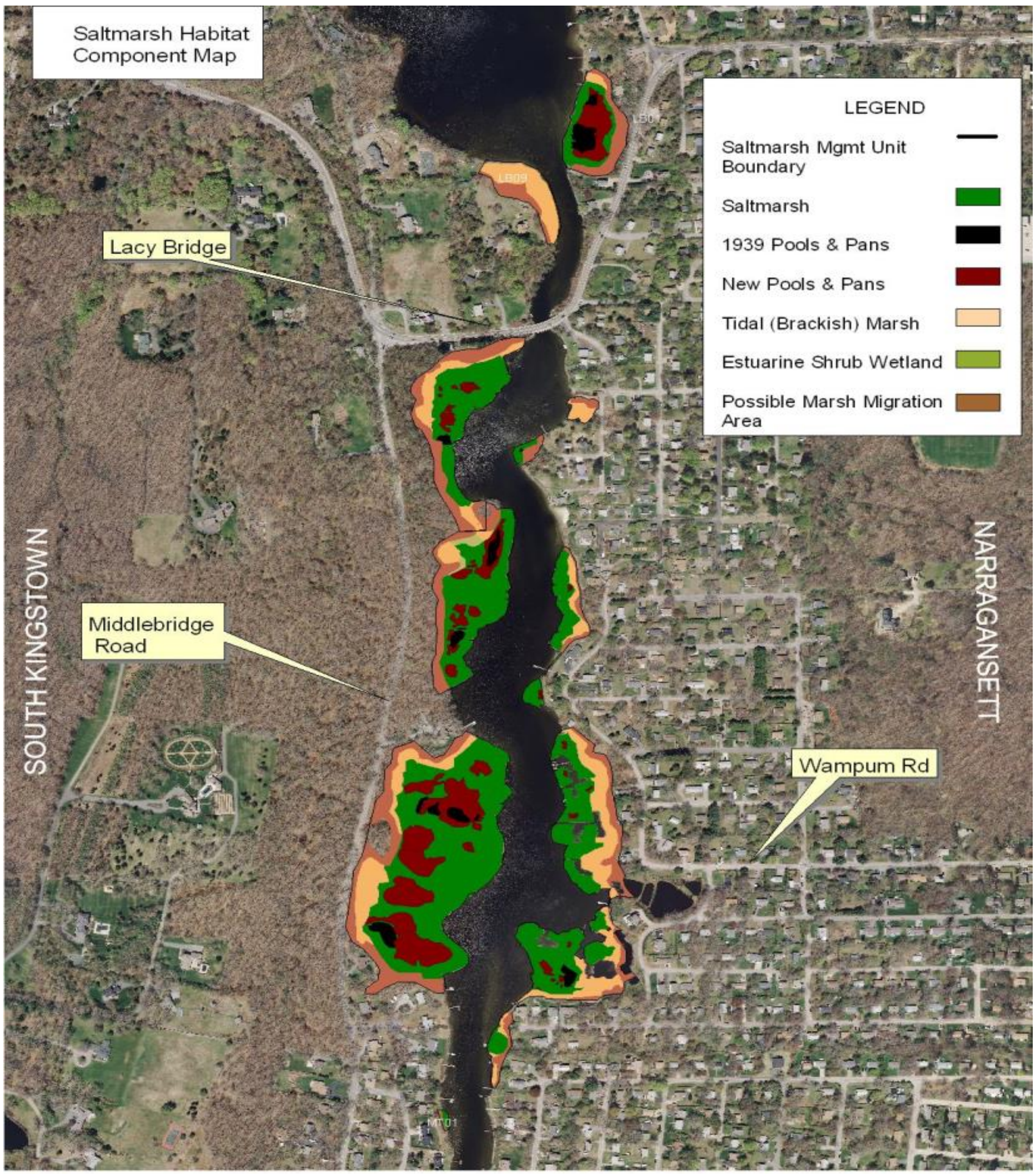
This reach contains the northern most extent of saltmarsh in the Narrow River. These 15 acres of saltmarsh may be isolated from downriver marshes except for small habitat patches in the Mettatuxett River reach. Larger marshes in South Kingstown are owned by Narrow River Land Trust. Most tidal (brackish) marsh dominated by phragmites; estuarine shrub wetlands dominated by I. Fructescens. Possible marsh migration areas questionable due to private ownership and developments.

II. Saltmarsh Management Units:



III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
ALL	31.7	15.2	4.4	0.9	5.2	34.3	5.3	0.2	25.9	5.8	38.1
LB01	2.1	0.8	0.5	0.2	0.7	93.9	0.1		1.6	0.6	73.9
LB02	0.3	0.0		0.0	0.0		0.2		0.2	0.1	
LB03	0.2	0.1			0.0				0.1	0.1	109.1
LB04	1.2	0.8	0.0		0.0	2.6	0.3		1.1	0.1	18.2
LB05	6.4	3.3	0.1	0.1	0.2	6.3	1.9		5.4	0.9	28.0
LB06	12.2	6.1	3.0	0.4	3.3	55.2	1.1		10.5	1.7	27.6
LB07	4.2	2.3	0.5	0.2	0.7	30.5	0.2	0.2	3.4	0.8	34.3
LB08	3.9	1.9	0.2	0.0	0.2	12.2	0.6		2.8	1.2	61.9
LB09	1.2	0.0					0.9		0.9	0.3	



IV. Marsh Surface Conditions and Drainage (NOTE IMAGES FOUND IN APPENDIX G)

UNIT	MARSH SURFACE DRAINS						CONDITION OF MARSH SURFACE				
	FUNCTIONAL DRAINAGE (FT)				NONFUNCTIONAL (FT)		CURRENT WELL DRAINED MARSH SURFACE		WELL DRAINED MARSH W/ DITCH REPAIR		
	DITCH / SLOUGH	SHORELINE	TOTAL	DENSITY	TOTAL	DENSITY	ACRES	PERCENT	NEW AC	TOTAL	PERCENT
ALL LB	6003.0	8628.0	14631.0	715.5	2281.0	111.5	11.4	55.9	4.0	15.5	75.7
LB01		481.0	481.0	327.2		0.0	0.4	23.8		0.4	23.8
LB02		134.0	134.0							0.0	
LB03		223.0	223.0	2027.3		0.0	0.1	90.9		0.1	90.9
LB04		882.0	882.0	1116.5	455.0	575.9	0.7	88.6	0.0	0.7	93.8
LB05	3474.0	2322.0	5796.0	1641.9	483.0	136.8	3.1	86.7	0.2	3.3	93.2
LB06	1855.0	1628.0	3483.0	370.9	1103.0	117.5	4.3	46.1	3.3	7.6	81.0
LB07	363.0	1345.0	1708.0	561.8	59.0	19.4	1.5	48.7	0.3	1.7	57.3
LB08	311.0	1027.0	1338.0	631.1	181.0	85.4	1.4	67.0	0.2	1.6	77.6
LB09		586.0	586.0								

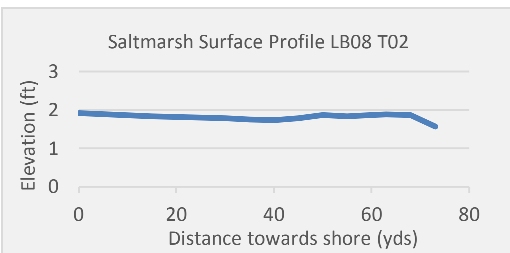
V. Shoreline Conditions

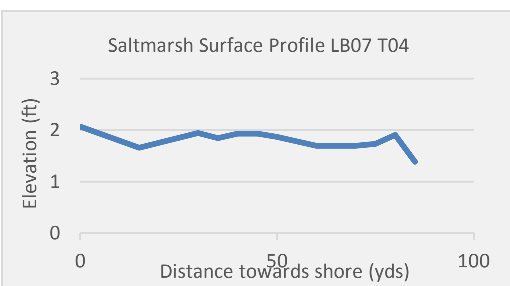
Not available

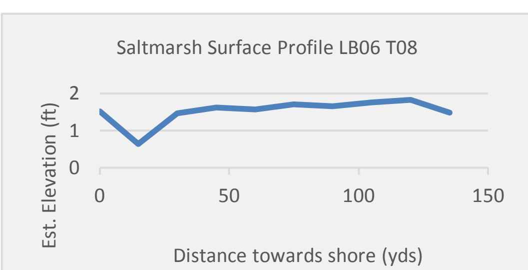
Susceptibilty to boat wake impacts: Low

VI. Representative Saltmarsh Surface Profiles:

NOTE: Data not tied to known elevation. Reported elevations relative to each other, not to a set elevation in the field. See Appendix A for specific profile data.





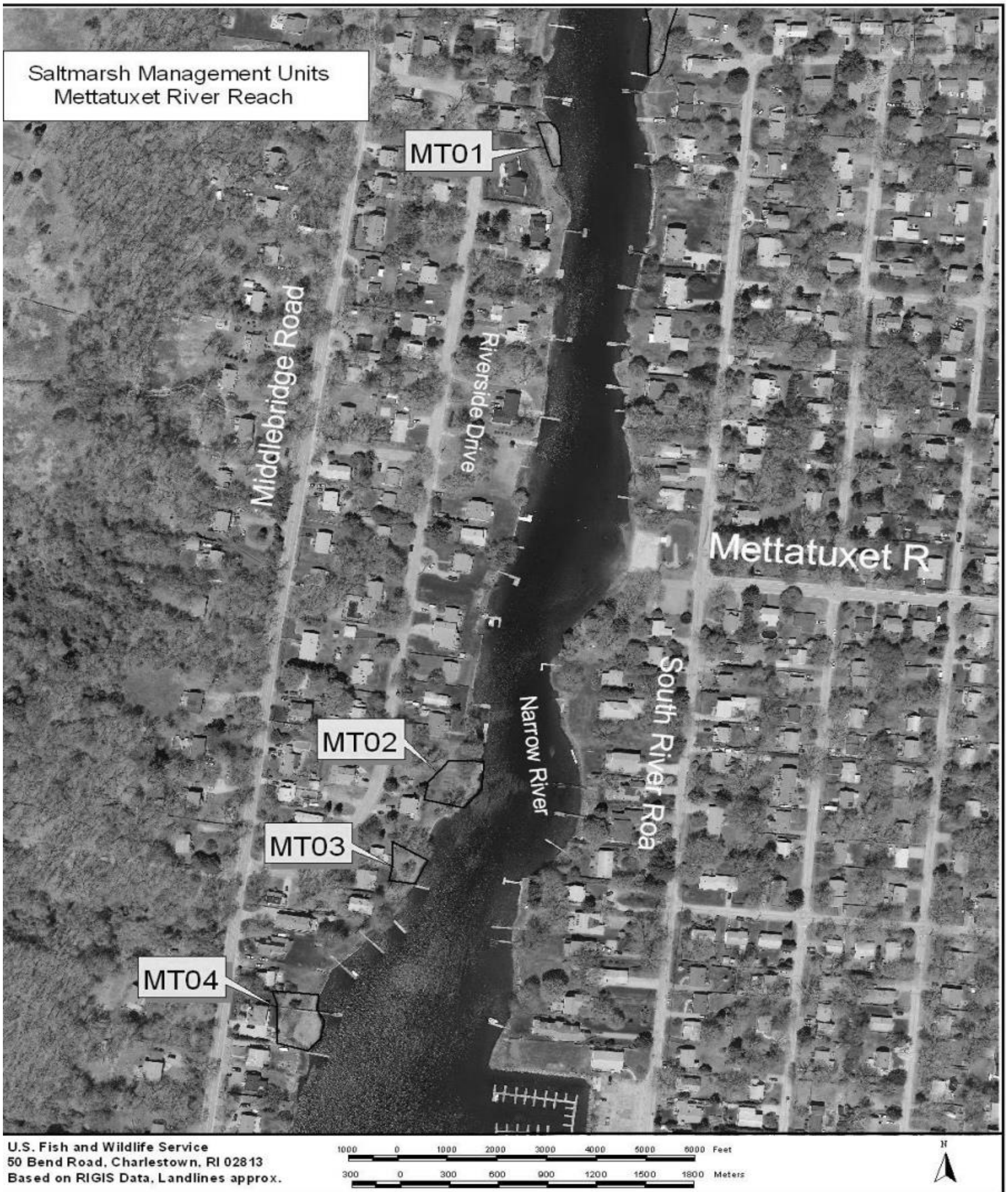


Mettatuxet River Reach

I. Overview

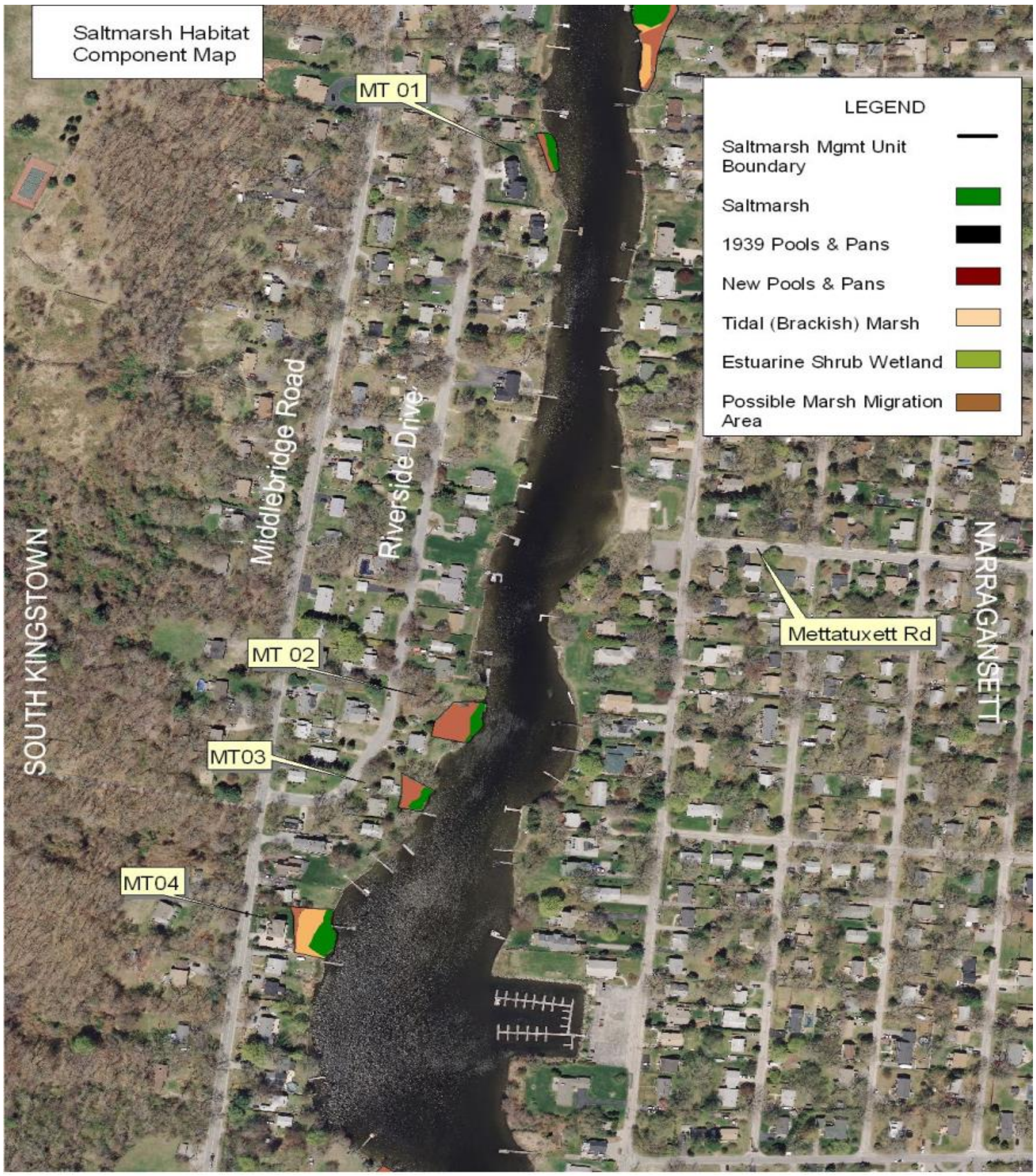
This reach contains small, privately owned fringe marsh patches. Their value in "connecting" the Lacy Bridge River reach marshes to those downriver is unknown. Small size, high public use and disturbance may limit nesting values. Most tidal (brackish) marsh dominated by phragmites. Possible migration areas questionable due to private ownership and developments.

II. Saltmarsh Management Units:



III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)									POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS		MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS						
ALL	2.0	1.6	0.0	0.0	0.0		0.1	0.0	1.8		0.2	14.7
MT01	0.4	0.4							0.4		0.0	6.6
MT02	0.5	0.4							0.4		0.1	35.9
MT03	0.1	0.0							0.0		0.1	183.9
MT04	1.0	0.9					0.1		1.0		0.0	2.3

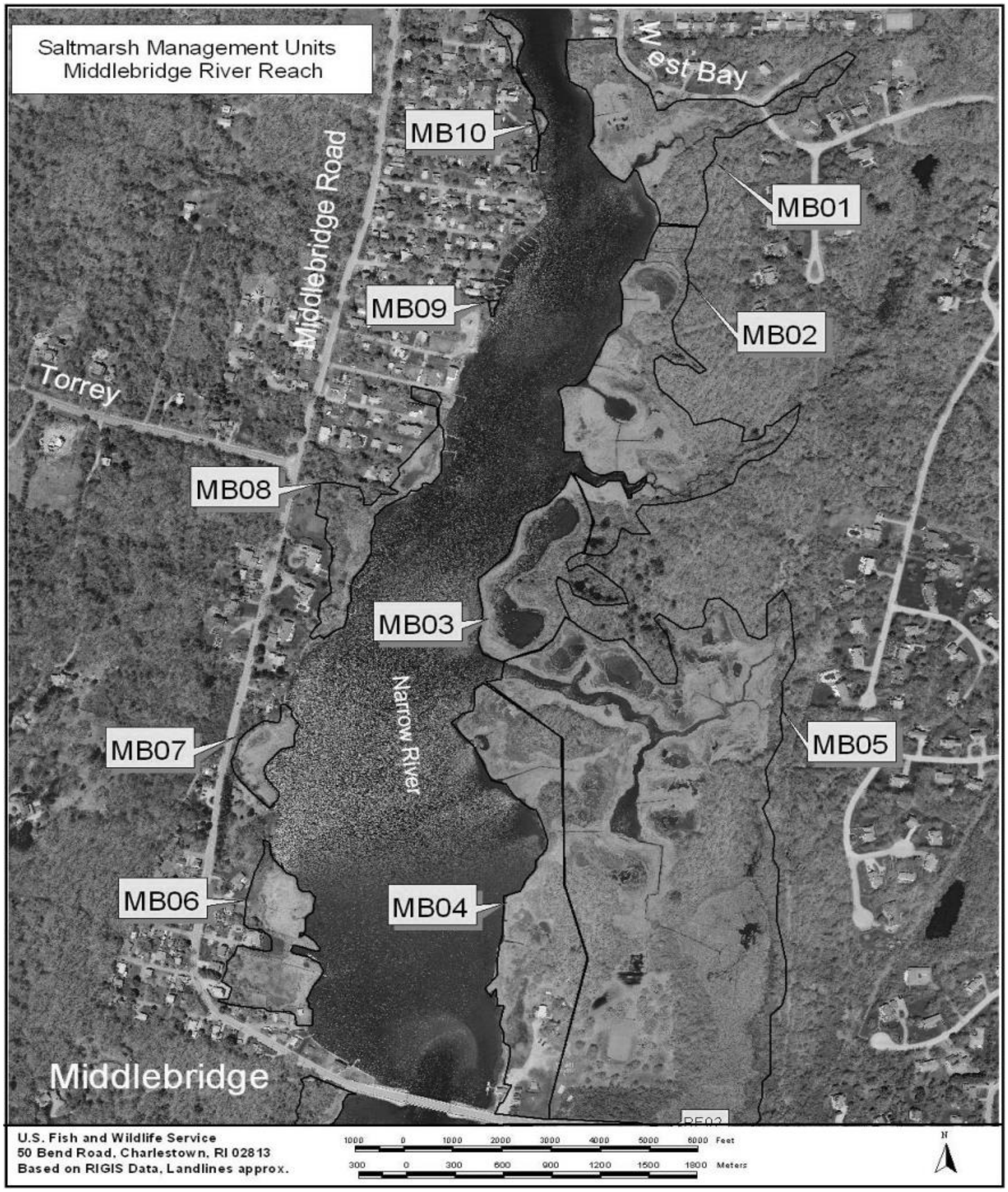


Middlebridge River Reach

I. Overview

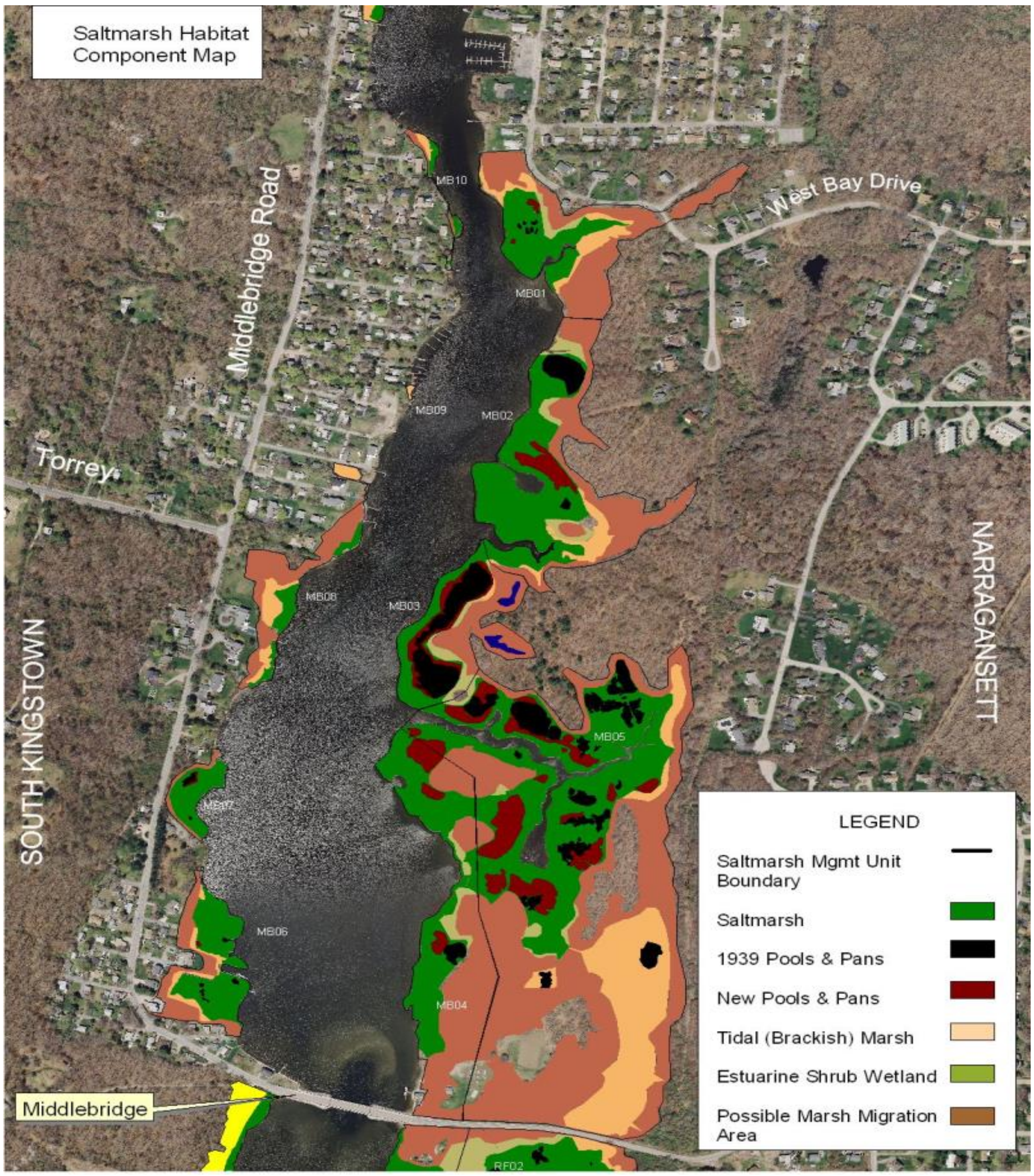
This reach contains 32 acres of saltmarsh - fringe marshes on the West side of the river and a sizable acreage within the slough on the Eastern side. Tidal wetlands a mix between phragmites and sciurpus. Reach has most estuarine shrub wetland, and the largest possible saltmarsh migration area. Bulk of migration area is a mix of tidal marsh (cattail) on the refuge and upland owned by the Town of Narragansett at Middlebridge. Boat wake impacts are rated low on East side of River and moderate on West side. Banks appear stable.

II. Saltmarsh Management Units:



III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
ALL	83.3	31.6	3.3	4.9	8.2	26.0	9.2	2.1	51.1	32.2	102.2
MB01	6.8	2.4	0.0	0.0	0.1	3.2	0.8	0.2	3.5	3.3	137.8
MB02	13.6	8.5	0.0	0.5	0.5	6.5	0.7	0.7	10.4	3.2	38.1
MB03	5.6	1.6	0.0	1.5	1.5	96.2	0.1	0.4	3.6	2.0	129.0
MB04	10.3	4.8	0.5	0.2	0.7	13.9		0.4	5.8	4.4	93.2
MB05	39.1	10.5	2.6	2.7	5.3	50.4	6.9	0.4	23.0	16.0	153.4
MB06	3.3	2.2	0.0	0.0	0.0	2.0			2.2	1.1	50.2
MB07	1.2	0.9	0.0	0.0	0.1	6.7			1.0	0.2	22.4
MB08	3.1	0.6					0.7		1.3	1.8	297.8
MB09	0.0	0.0					0.0		0.0		
MB10	0.3	0.1					0.1		0.2	0.1	78.6

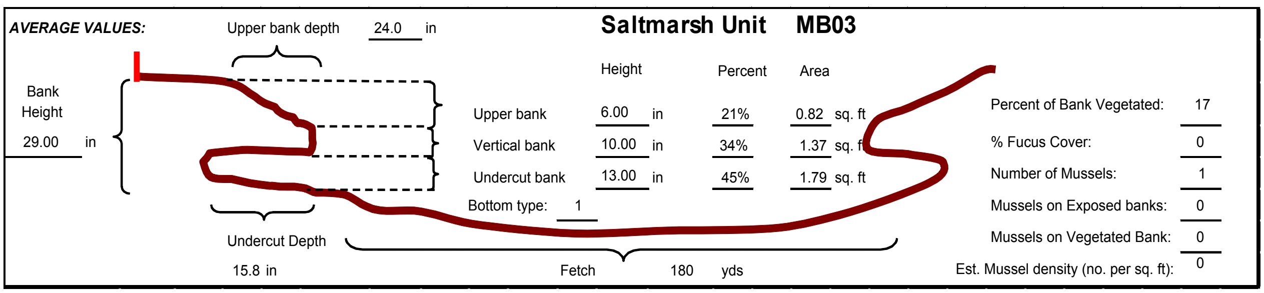


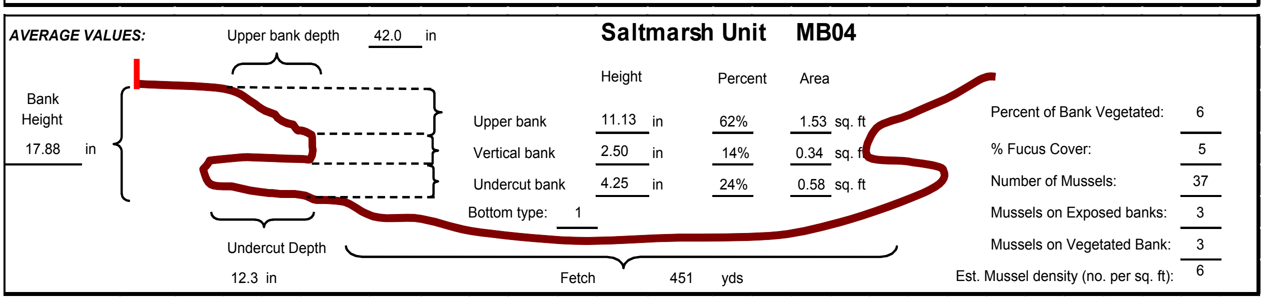
IV. Marsh Surface Conditions and Drainage (NOTE MAPS SHOWN IN APPENDIX G):

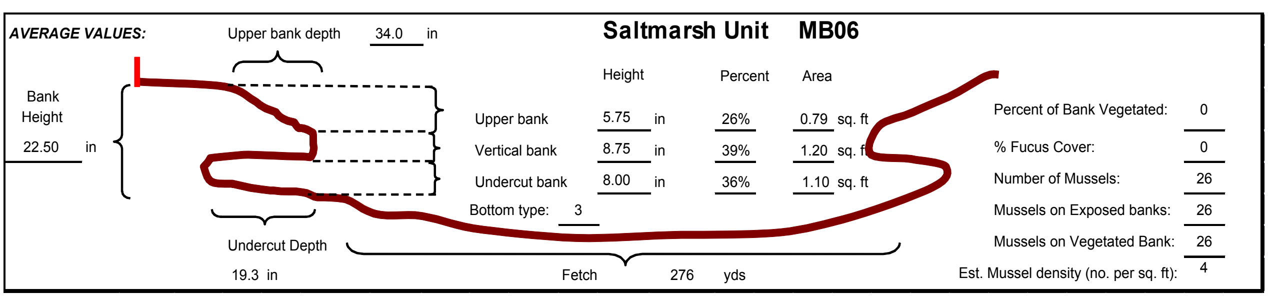
UNIT	MARSH SURFACE DRAINS						CONDITION OF MARSH SURFACE				
	FUNCTIONAL DRAINAGE (FT)				NONFUNCTIONAL (FT)		CURRENT WELL DRAINED MARSH SURFACE		WELL DRAINED MARSH W/ DITCH REPAIR		
	DITCH / SLOUGH	SHORELINE	TOTAL	DENSITY	TOTAL	DENSITY	ACRES	PERCENT	NEW AC	TOTAL	PERCENT
ALL	12366.0	8542.0	20908.0	526.1	1887.0	47.5	17.5	44.1	3.4	20.9	52.5
MB01	1567.0	936.0	2503.0	1009.3	660.0	266.1	1.7	69.8	0.3	2.0	82.5
MB02	2173.0	1183.0	3356.0	370.8	483.0	53.4	4.0	44.0	0.5	4.4	49.1
MB03	923.0	1020.0	1943.0	626.0		0.0	0.9	28.7		0.9	28.7
MB04	473.0	2230.0	2703.0	498.7	387.0	71.4	2.8	52.2	1.1	3.9	71.7
MB05	7230.0		7230.0	459.8	238.0	15.1	6.1	38.9	1.4	7.5	47.9
MB06		1229.0	1229.0	548.4	119.0	53.1	0.9	37.9		0.9	37.9
MB07		556.0	556.0	562.2		0.0	0.5	47.5	0.1	0.6	58.1
MB08		796.0	796.0	1351.4		0.0	0.5	86.6		0.5	86.6
MB09		69.0	69.0							0.0	
MB10		523.0	523.0	3735.7		0.0	0.1	100.0		0.1	100.0

V. Saltmarsh Shoreline Conditions

Data summarized by saltmarsh management unit from shoreline stability surveys completed in 2012.
Susceptibilty to boat wake impacts: Moderate on western shore; low on eastern shore.





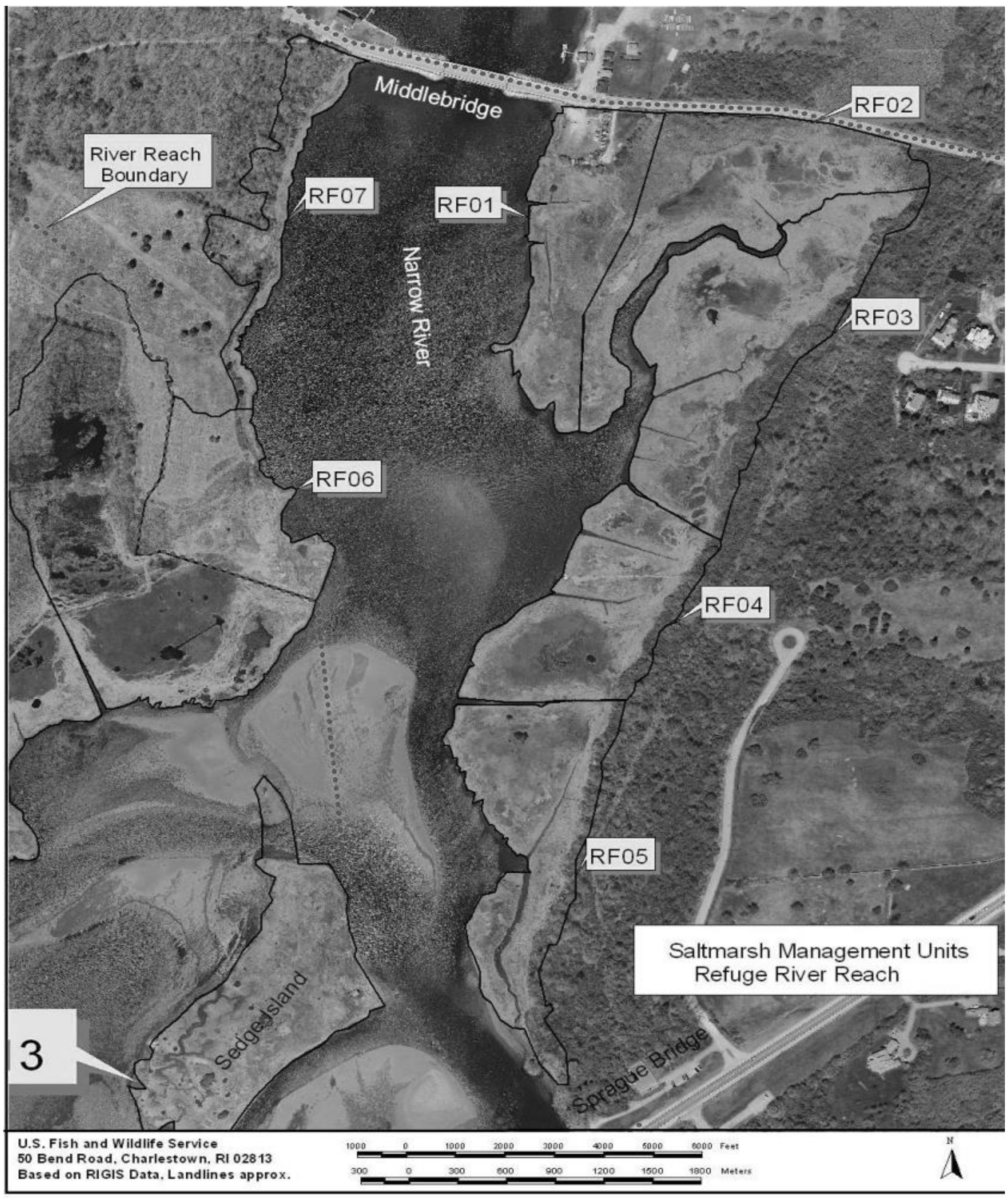


Refuge River Reach

I. Overview

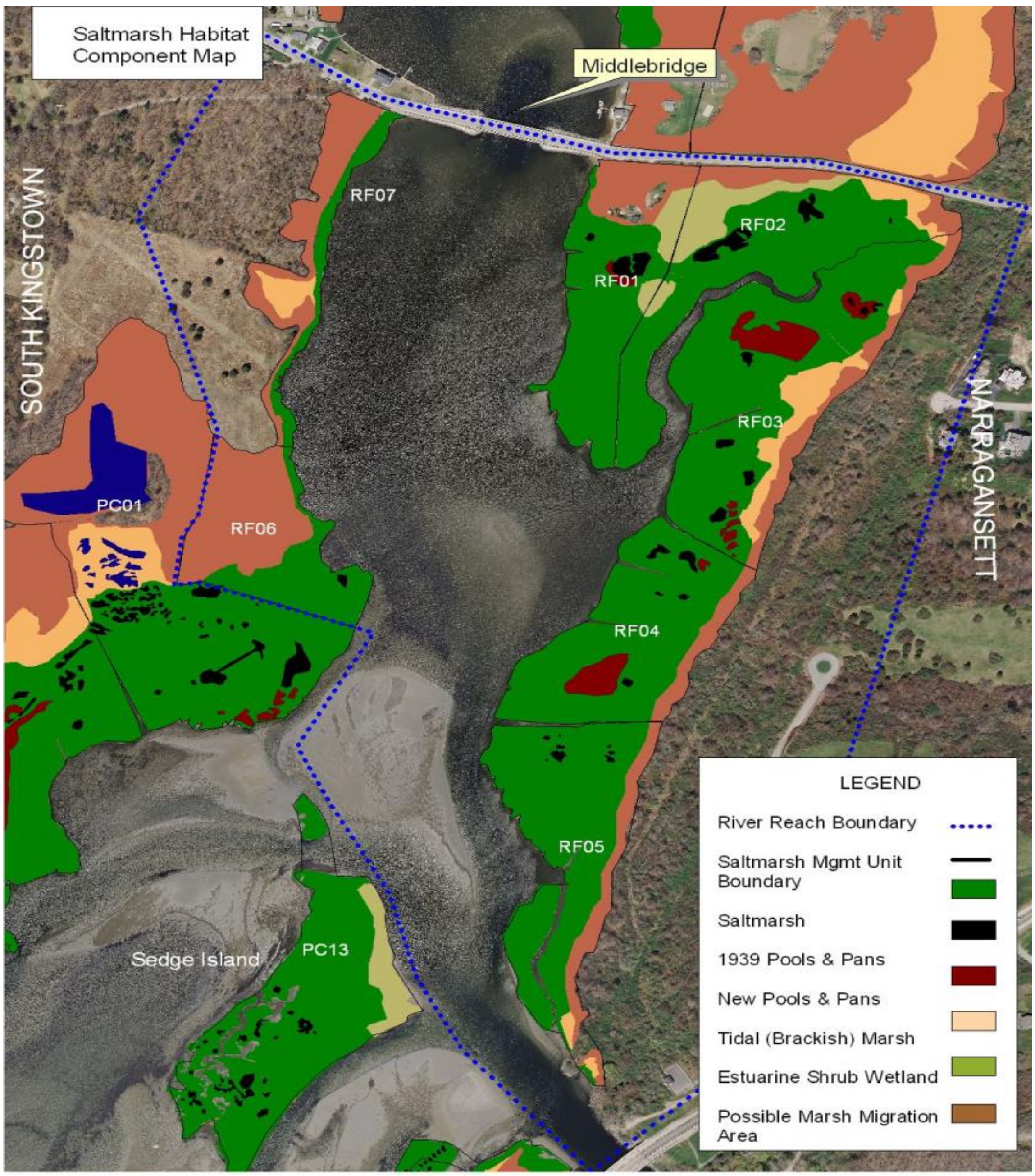
A high energy river reach with substantial shoreline erosion and moderate to high boat wake impacts and wind driven waves (accelerated/aggravated rates of erosion). Much of the RF01, RF04, and RF05 shoreline is actively peeling and eroding. The peninsula at RF01 will be lost in near future without intervention. RF05 island has large blocks of marsh eroding, propeller scars have increased susceptibility to erosion. High use by saltmarsh sparrows in RF01-RF03. Fringe marshes on West side have public trails on marsh surface. Several distinct layers of peat deposition apparent. Profile data suggest the marsh surface in the Eastern slough (RF02, RF03) are two to three inches lower than in other portions of estuary.

II. Saltmarsh Management Units:



III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
ALL	36.9	24.8	1.0	0.5	1.5	5.9	1.6	1.3	29.1	7.8	31.3
RF01	4.6	3.2	0.0	0.2	0.2	6.6		0.4	3.8	0.9	26.8
RF02	6.0	4.1		0.1	0.1	1.5	0.3	0.9	5.4	0.6	15.2
RF03	8.4	5.8	0.6	0.1	0.7	12.7	0.9		7.4	1.0	17.0
RF04	5.5	4.6	0.3	0.1	0.4	8.6			5.0	0.5	11.0
RF05	5.8	4.9		0.0	0.0	0.8	0.1		5.0	0.9	17.5
RF06	3.9	1.5		0.0	0.0	1.9			1.5	2.4	156.0
RF07	2.6	0.8				0.0	0.3		1.0	1.6	210.9



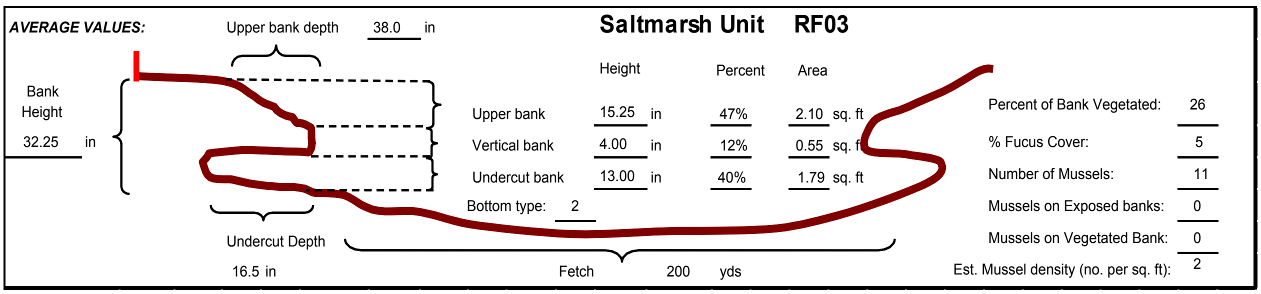
IV. Marsh Surface Conditions and Drainage (NOTE MAPS SHOWN IN APPENDIX G)

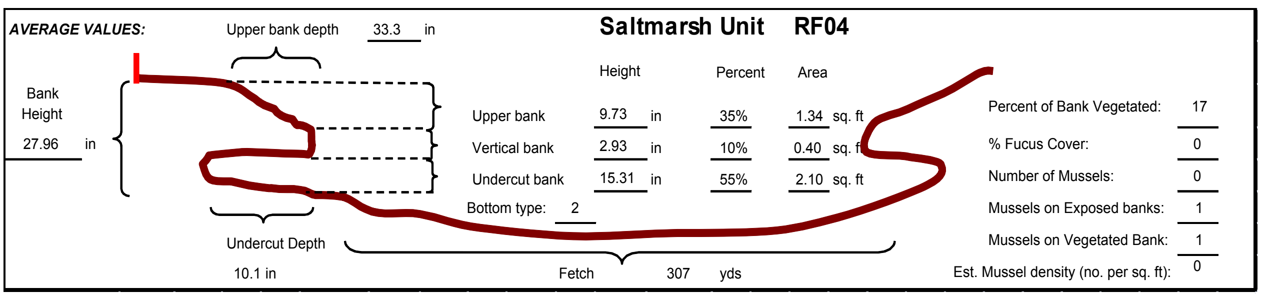
UNIT	MARSH SURFACE DRAINS						CONDITION OF MARSH SURFACE				
	FUNCTIONAL DRAINAGE (FT)				NONFUNCTIONAL (FT)		CURRENT WELL DRAINED MARSH SURFACE		WELL DRAINED MARSH W/ DITCH REPAIR		
	DITCH / SLOUGH	SHORELINE	TOTAL	DENSITY	TOTAL	DENSITY	ACRES	PERCENT	NEW AC	TOTAL	PERCENT
ALL	7035.0	5640.0	12675.0	482.1	1810.0	68.8	12.1	46.1	1.8	13.9	52.9
RF01	583.0	1306.0	1889.0	558.9	174.0	51.5	0.4	11.5	0.4	0.8	23.1
RF02	1656.0		1656.0	393.3	1094.0	259.9	2.3	54.2	1.0	3.2	77.0
RF03	3039.0	109.0	3148.0	481.8	245.0	37.5	3.4	51.7	0.3	3.7	56.8
RF04	943.0	840.0	1783.0	357.7	297.0	59.6	1.7	33.1	0.1	1.8	35.4
RF05	814.0	1491.0	2305.0	471.1		0.0	3.0	61.9		3.0	61.9
RF06		759.0	759.0	493.8		0.0	0.7	42.9		0.7	42.9
RF07		1135.0	1135.0	1509.3		0.0	0.7	95.7		0.7	95.7

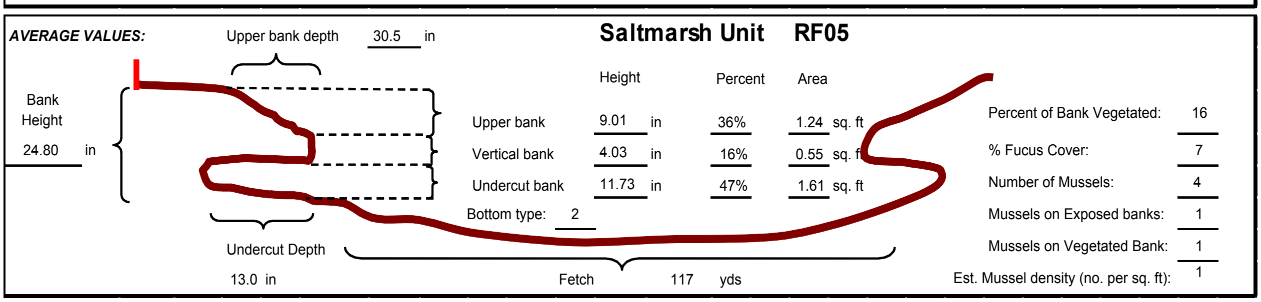
V. Saltmarsh Shoreline Conditions

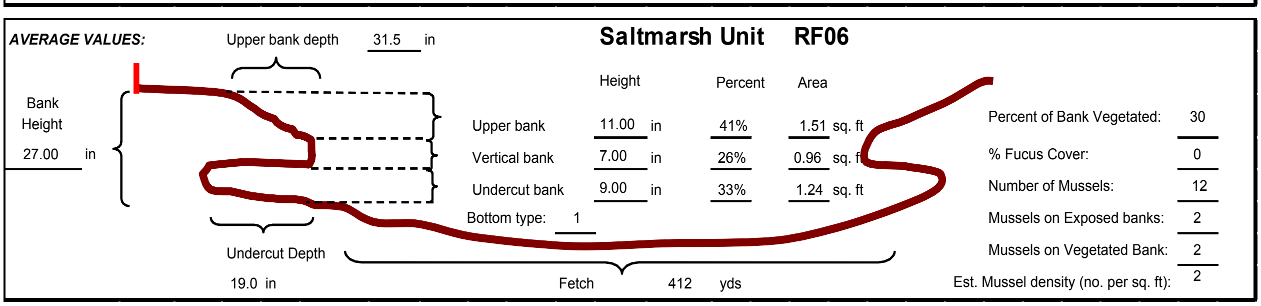
Data summarized by saltmarsh management unit from shoreline stability surveys completed in 2012.

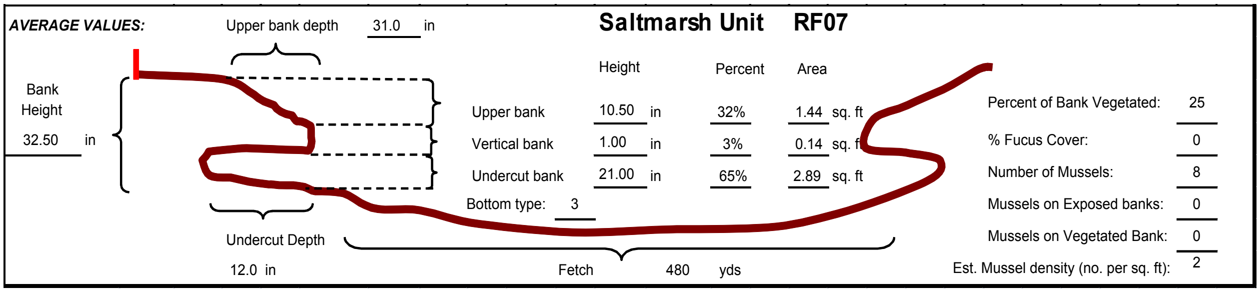
Susceptibilty to boat wake impacts: High at RF04 and RF05. Moderate RF01, RF06, RF07. Boats pass wihin 50 feet of RF05 shoreline. Overall stability of saltmarsh shporelines is very low in RF02,RF04, RF05.





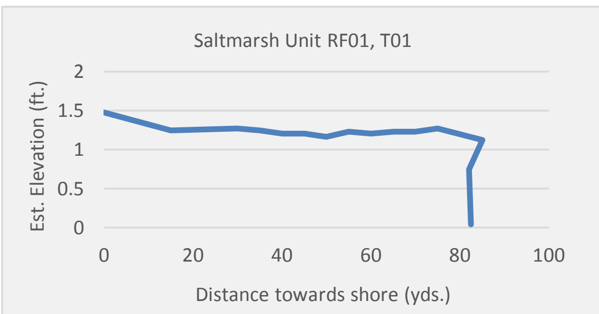


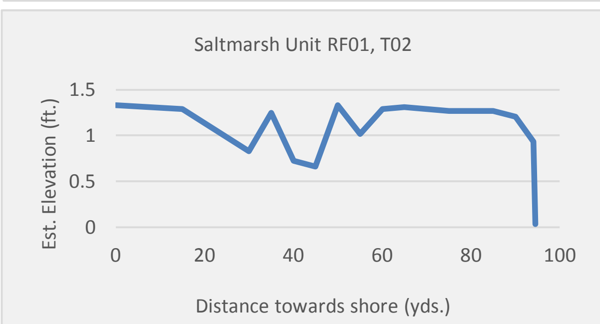


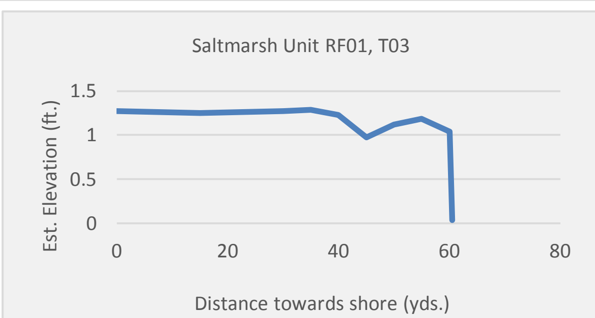


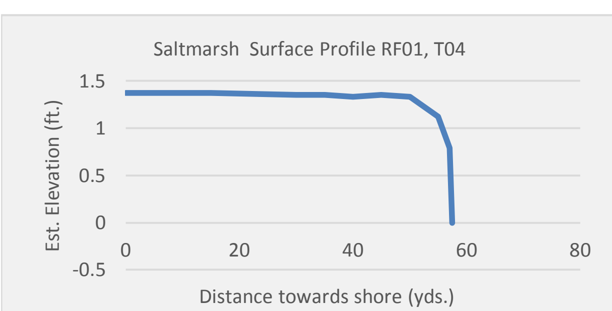
VI. Saltmarsh Profiles

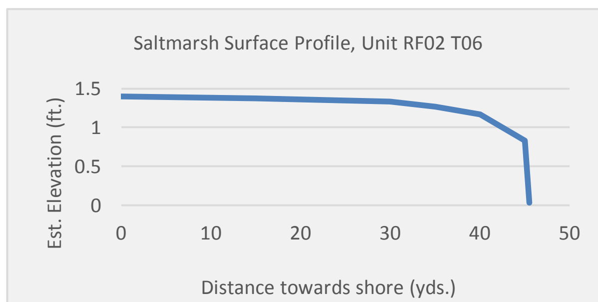
NOTE: Data tied to known elevation of survey marker located in SMU RF02. Expand graph to view details.

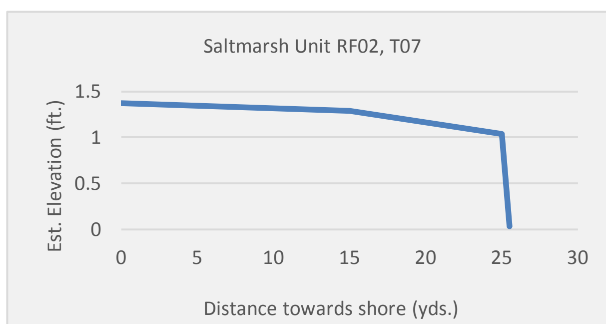


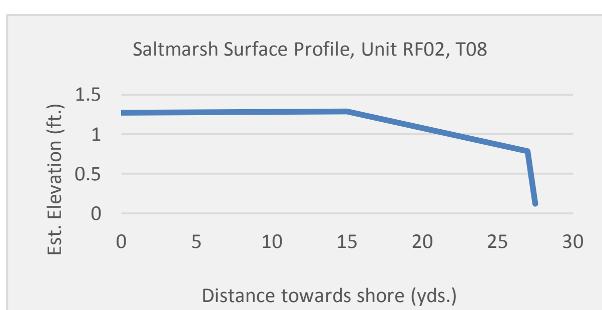


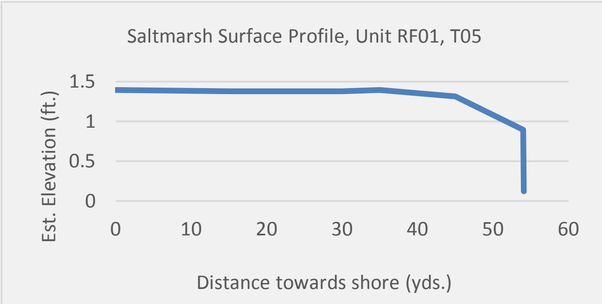


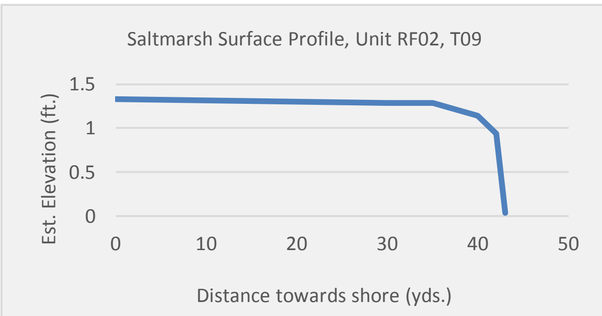


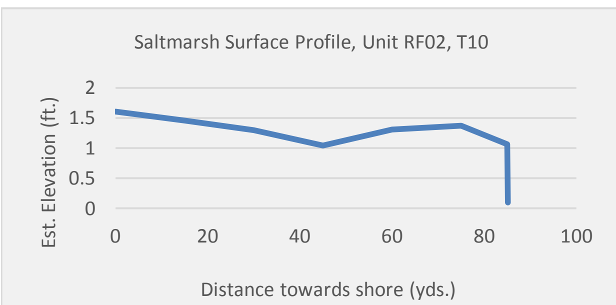


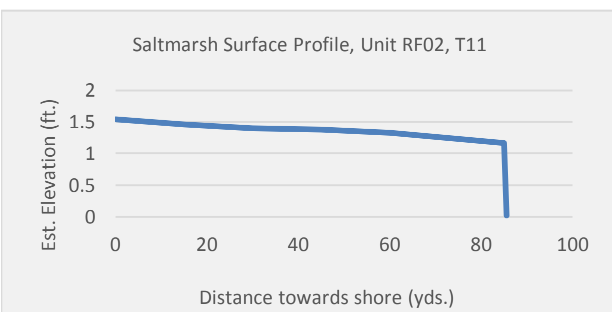


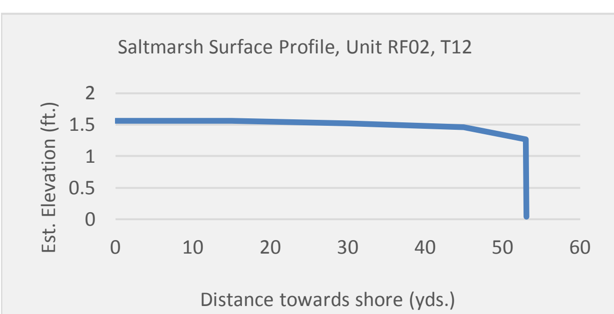



Saltmarsh Surface Profile, Unit RF01, T05
Est. Elevation (ft.)
1.5
1
0.5
0
0
10
20
30
40
50
60
Distance towards shore (yds.)

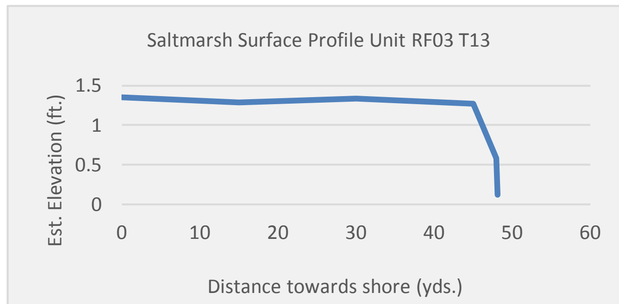

Saltmarsh Surface Profile, Unit RF02, T09
Est. Elevation (ft.)
1.5
1
0.5
0
0
10
20
30
40
50
Distance towards shore (yds.)

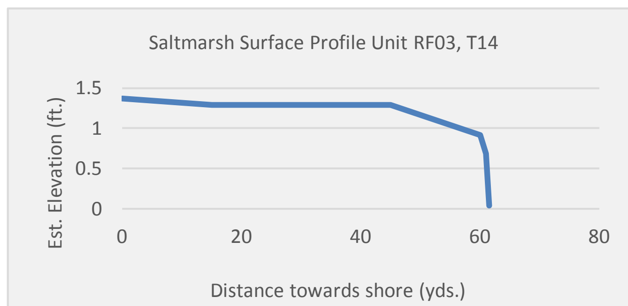

Saltmarsh Surface Profile, Unit RF02, T10
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
20
40
60
80
100
Distance towards shore (yds.)

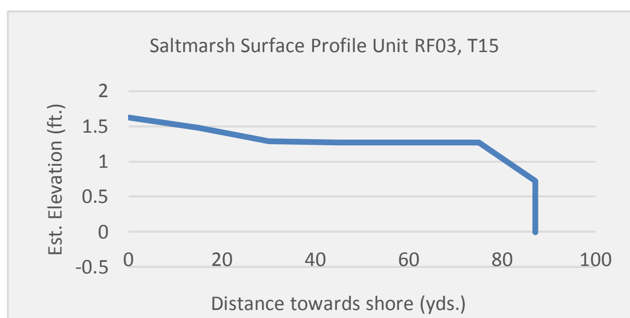

Saltmarsh Surface Profile, Unit RF02, T11
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
20
40
60
80
100
Distance towards shore (yds.)

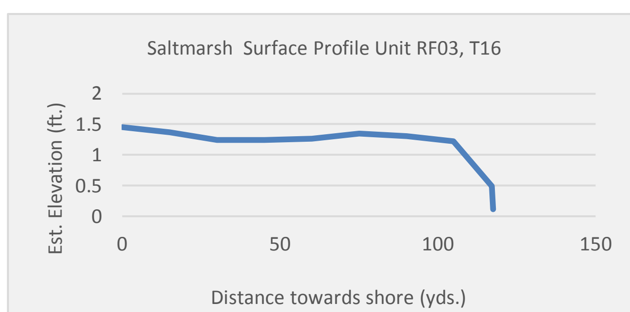

Saltmarsh Surface Profile, Unit RF02, T12
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
10
20
30
40
50
60
Distance towards shore (yds.)

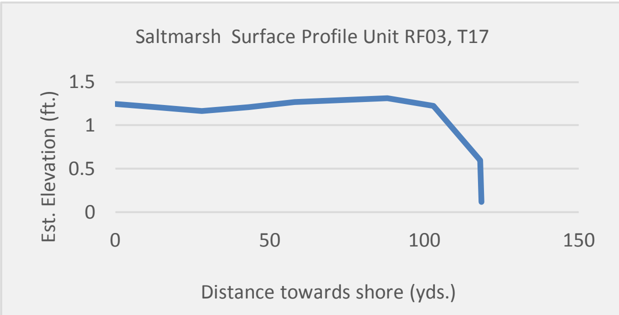

SPRF01
SPRF02
SPRF09
SPRF10
SPRF03
SPRF08
SPRF04
SPRF17
SPRF05


Saltmarsh Surface Profile Unit RF03 T13
Est. Elevation (ft.)
1.5
1
0.5
0
0
10
20
30
40
50
60
Distance towards shore (yds.)

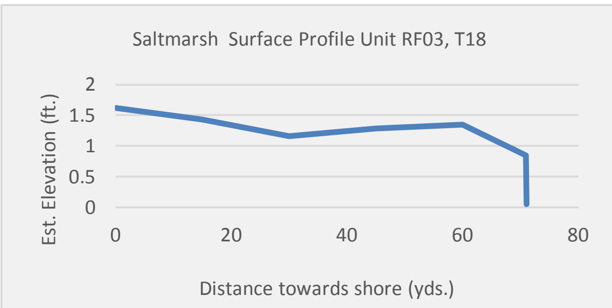

Saltmarsh Surface Profile Unit RF03, T14
Est. Elevation (ft.)
1.5
1
0.5
0
0
20
40
60
80
Distance towards shore (yds.)

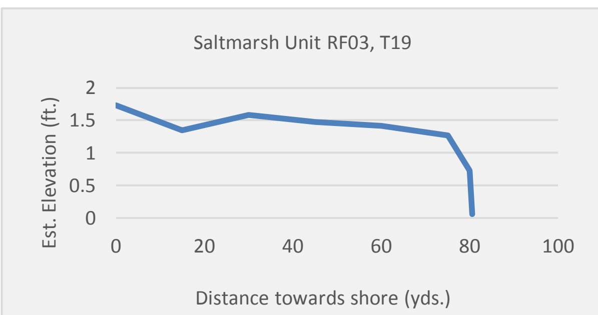

Saltmarsh Surface Profile Unit RF03, T15
Est. Elevation (ft.)
2
1.5
1
0.5
0
-0.5
0
20
40
60
80
100
Distance towards shore (yds.)

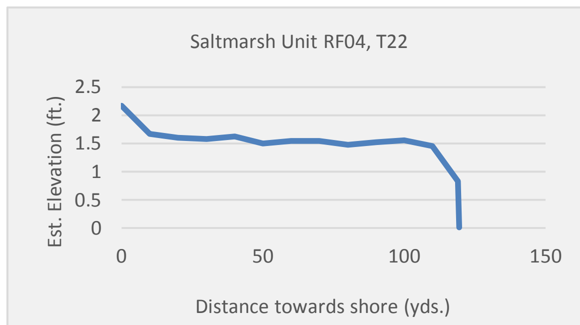

Saltmarsh Surface Profile Unit RF03, T16
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
50
100
150
Distance towards shore (yds.)

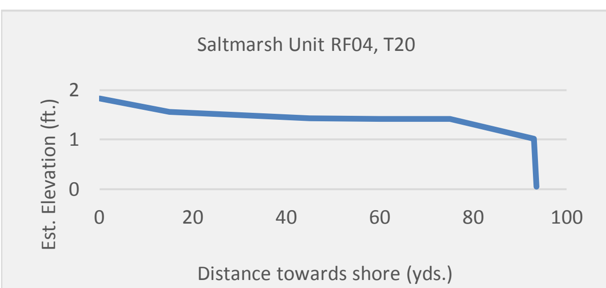

Saltmarsh Surface Profile Unit RF03, T17
Est. Elevation (ft.)
0
0.5
1
1.5
0
50
100
150
Distance towards shore (yds.)

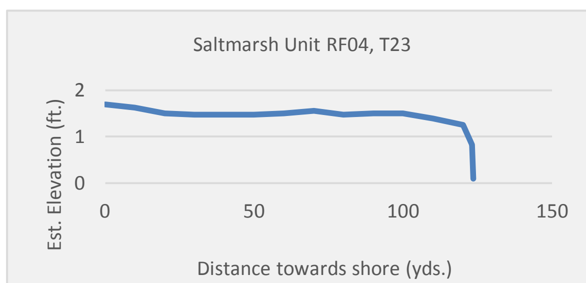

SPRF01
SPRF02
SPRF09
SPRF10
SPRF11
SPRF14
SPRF03
SPRF08
SPRF16
SPRF17
SPRF04
SPRF05
SPRF18
SPRF19
SPRF20
SPRF21

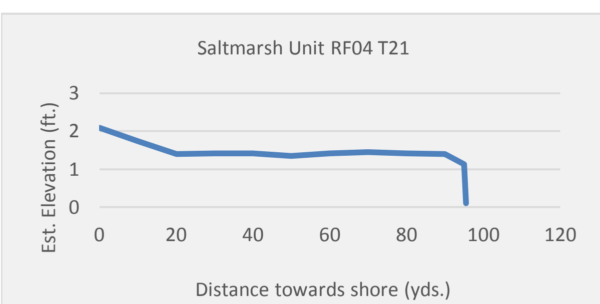

Saltmarsh Surface Profile Unit RF03, T18
Est. Elevation (ft.)
0
0.5
1
1.5
2
0
20
40
60
80
Distance towards shore (yds.)

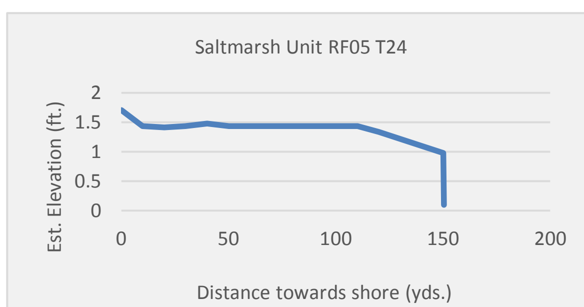

Saltmarsh Unit RF03, T19
Est. Elevation (ft.)
0
0.5
1
1.5
2
0
20
40
60
80
100
Distance towards shore (yds.)

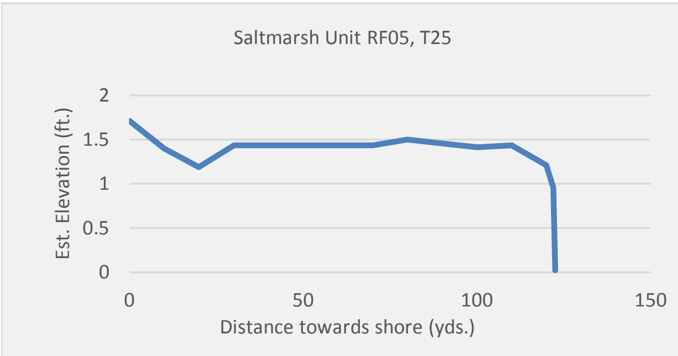

Saltmarsh Unit RF04, T22
Est. Elevation (ft.)
0
0.5
1
1.5
2
2.5
0
50
100
150
Distance towards shore (yds.)


Saltmarsh Unit RF04, T20
Est. Elevation (ft.)
0
1
2
0
20
40
60
80
100
Distance towards shore (yds.)

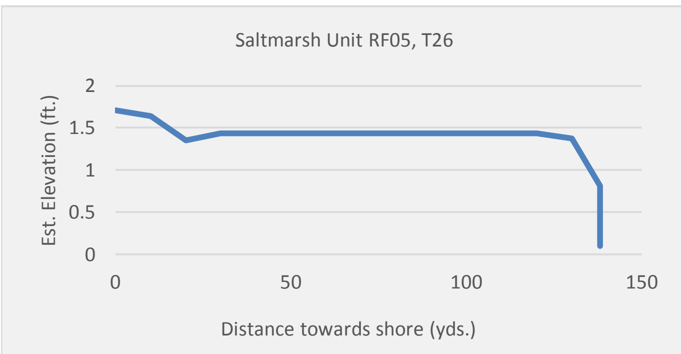

Saltmarsh Unit RF04, T23
Est. Elevation (ft.)
0
1
2
0
50
100
150
Distance towards shore (yds.)

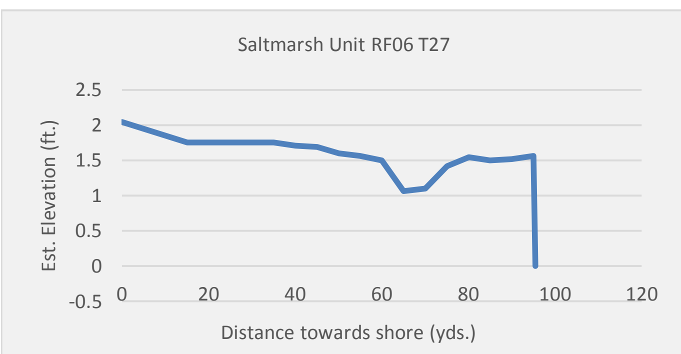

Saltmarsh Unit RF04 T21
Est. Elevation (ft.)
0
1
2
3
0
20
40
60
80
100
120
Distance towards shore (yds.)


Saltmarsh Unit RF05 T24
Est. Elevation (ft.)
0
0.5
1
1.5
2
0
50
100
150
200
Distance towards shore (yds.)


Saltmarsh Unit RF05, T25
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
50
100
150
Distance towards shore (yds.)


SPRF01
SPRF02
SPRF09
SPRF03
SPRF08
SPRF04
SPRF17
SPRF05
SPRF18
SPRF19
SPRF20
SPRF21
SPRF22
SPRF23
SPRF24
SPRF25
SPRF26


Saltmarsh Unit RF05, T26
Est. Elevation (ft.)
2
1.5
1
0.5
0
0
50
100
150
Distance towards shore (yds.)


Saltmarsh Unit RF06 T27
Est. Elevation (ft.)
2.5
2
1.5
1
0.5
0
-0.5
0
20
40
60
80
100
120
Distance towards shore (yds.)

Pettaquamscutt Cove

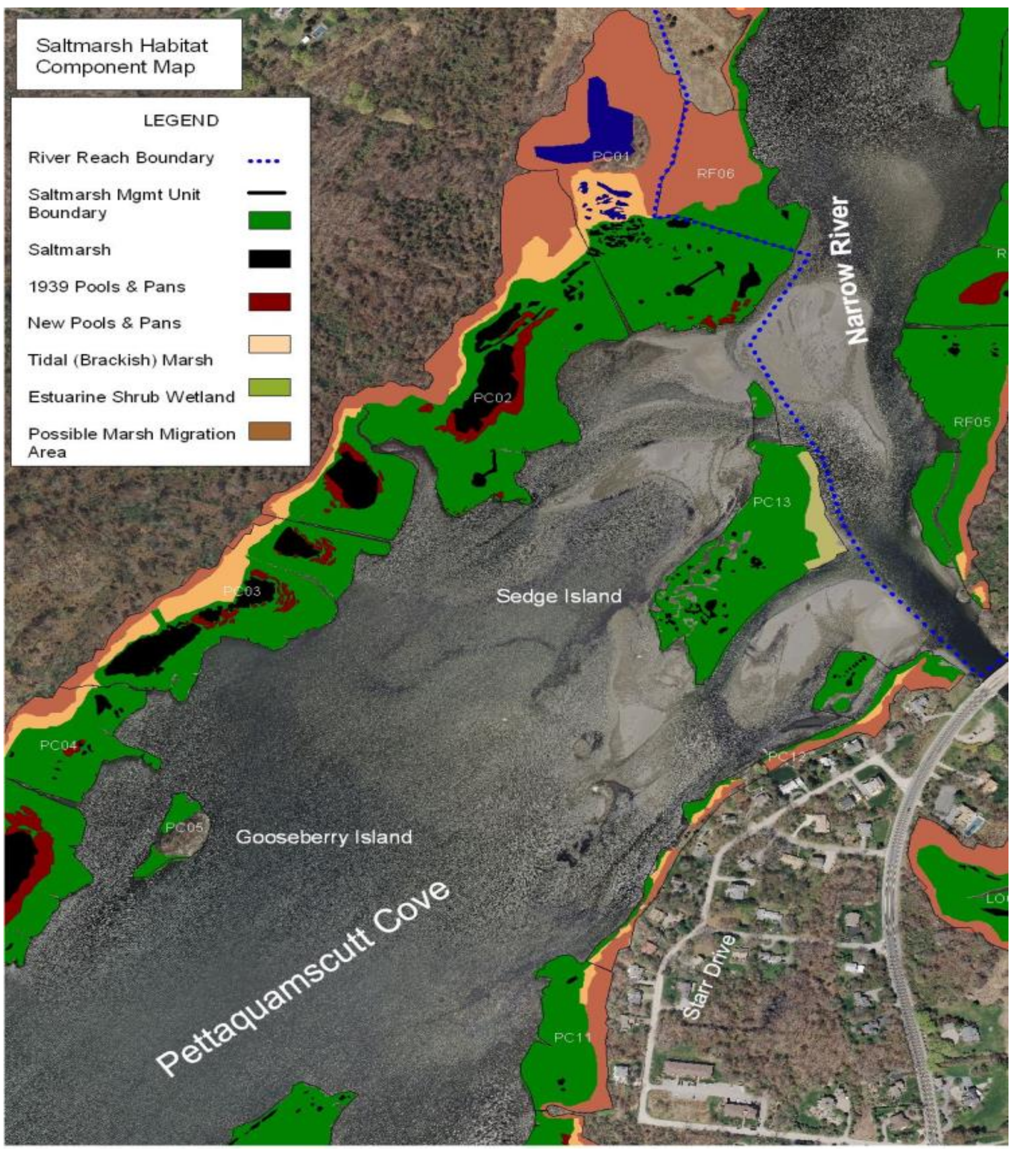
I. Overview

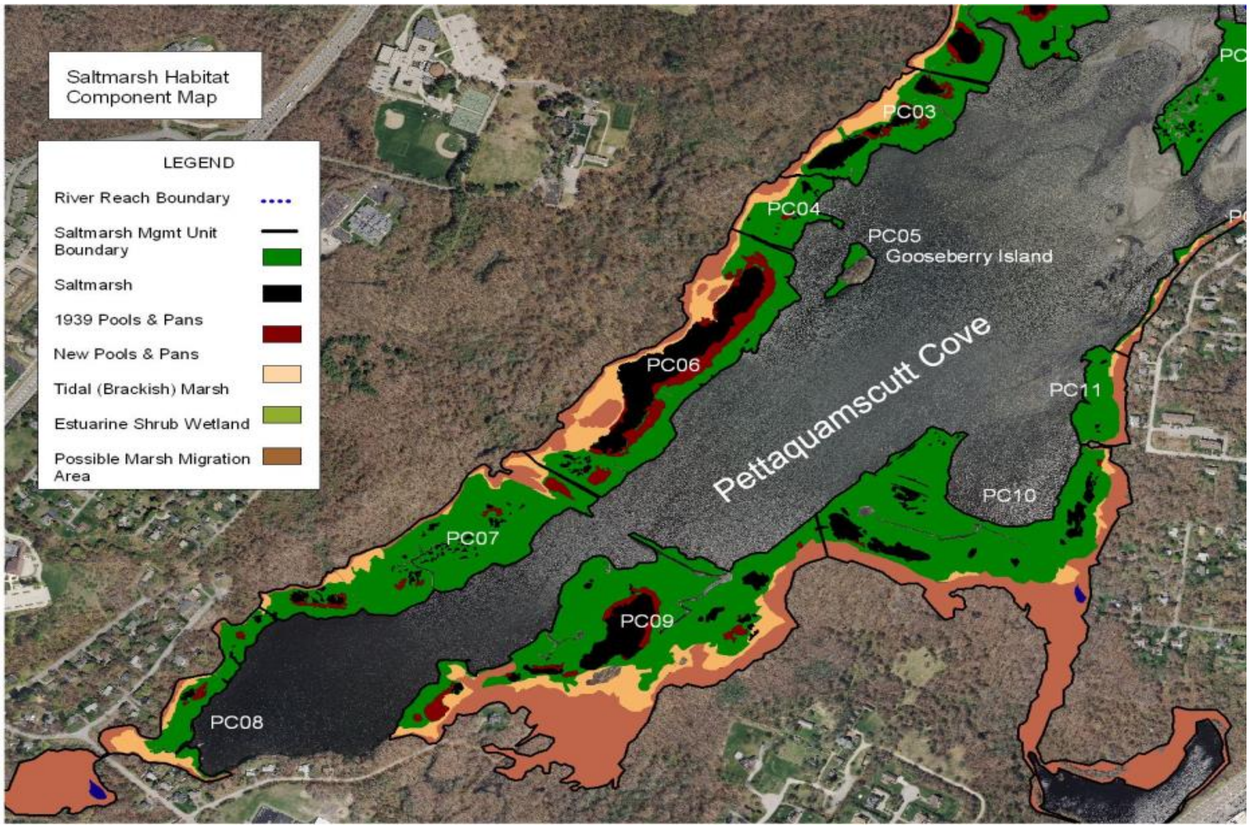
This reach contains the bulk of current saltmarsh habitat in the estuary. Brackish marsh dominated variably by phragmites, cattail, sciurpus. Stone walls along the side of the marshes either focus freshwater into channels, or disperse the water into tidal wetlands directly onto saltmarshes. Most pre-1939 ditches nonfunctional. Possible migration areas on NRLT and Audubon Society lands, Town of Narragansett lands at Canonchet farms, and the Mumford drainage on the Refuge. Boat wake impacts low in the cove, but wind driven waves of concern. Bank stability rated moderate in most areas, but low in vicinity of Gooseberry Island and the Starr Drive Cove.

II. Saltmarsh Management Units:

III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
ALL	169.0	86.8	5.7	14.2	20.0	23.0	12.6	0.6	119.9	49.1	56.5
PC01	13.2	4.9	0.1	0.4	0.5	10.7	1.1		6.5	6.7	137.5
PC02	16.4	9.2	0.9	1.9	2.8	30.5	1.2		13.1	3.2	34.9
PC03	9.0	5.3	0.3	1.3	1.6	30.8	1.3		8.2	0.8	15.6
PC04	3.8	2.8	0.0	0.1	0.1	4.8	0.4		3.3	0.4	15.5
PC05	0.4	0.4				0.0			0.4		0.0
PC06	18.2	6.8	2.6	4.9	7.5	110.4	1.0		15.3	2.9	41.8
PC07	16.5	13.0	0.5	0.5	1.0	7.6	1.2		15.2	1.3	10.3
PC08	10.0	3.1	0.1	0.1	0.2	7.4	1.1		4.5	5.6	179.5
PC09	36.8	15.8	1.2	2.9	4.1	25.6	4.2		24.1	12.7	80.4
PC10	31.8	16.0	0.0	1.8	1.9	11.6	0.7		18.5	13.2	82.8
PC11	3.7	2.6		0.0	0.0	0.8	0.1		2.7	0.9	36.2
PC12	2.9	1.4		0.0	0.0	1.9	0.3		1.7	1.2	86.6
PC13	6.3	5.5		0.2	0.2	2.9		0.6	6.3		0.0





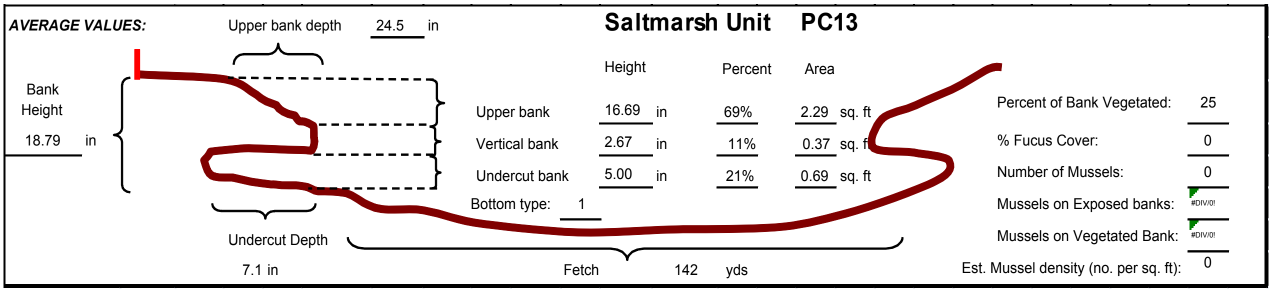
IV. Marsh Surface Conditions and Drainage (NOTE MAPS SHOWN IN APPENDIX G)

UNIT	MARSH SURFACE DRAINS						CONDITION OF MARSH SURFACE				
	FUNCTIONAL DRAINAGE (FT)				NONFUNCTIONAL (FT)		CURRENT WELL DRAINED MARSH SURFACE		WELL DRAINED MARSH W/ DITCH REPAIR		
	DITCH / SLOUGH	SHORELINE	TOTAL	DENSITY	TOTAL	DENSITY	ACRES	PERCENT	NEW AC	TOTAL	PERCENT
ALL	18427.0	27497.0	45924.0	430.3	3984.0	37.3	54.6	51.2	7.9	62.5	58.6
PC01		860.0	860.0	158.7		0.0	0.9	16.4	0.1	0.9	17.5
PC02	1431.0	2568.0	3999.0	333.5	38.0	3.2	3.7	31.1	0.1	3.8	31.6
PC03	1540.0	1454.0	2994.0	433.7	117.0	16.9	2.7	39.0	0.9	3.6	52.1
PC04	973.0	969.0	1942.0	668.3		0.0	1.6	53.7		1.6	53.7
PC05		590.0	590.0	1362.6		0.0	0.4	87.8		0.4	87.8
PC06	1575.0	2279.0	3854.0	268.9	210.0	14.7	8.0	56.0	1.5	9.6	66.6
PC07	4202.0	2602.0	6804.0	485.4		0.0	7.4	52.6		7.4	52.6
PC08	933.0	1480.0	2413.0	724.6		0.0	1.9	57.4		1.9	57.4
PC09	3649.0	5028.0	8677.0	436.3	2753.0	138.4	16.4	82.2	3.6	20.0	100.4
PC10	2780.0	2757.0	5537.0	310.0	866.0	48.5	6.7	37.3	1.8	8.4	47.2
PC11	150.0	887.0	1037.0	395.2		0.0	1.1	41.5		1.1	41.5
PC12		2700.0	2700.0	1920.3		0.0	1.4	100.3		1.4	100.3
PC13	1194.0	3323.0	4517.0	803.3		0.0	2.5	45.0		2.5	45.0

V. Saltmarsh Shoreline Conditions

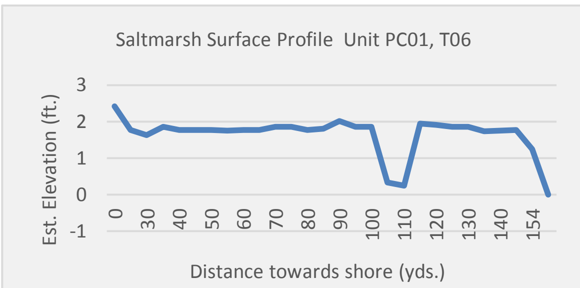
Data summarized by saltmarsh management unit from shoreline stability surveys completed in 2012. Data only available for Sedge Island North shore.

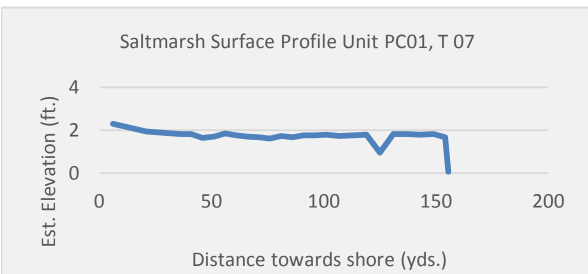
Susceptibilty to boat wake impacts: High on North Shore; low in remaining areas. High susceptibility to wind driven waves west and south; high erosion east side from river channel.

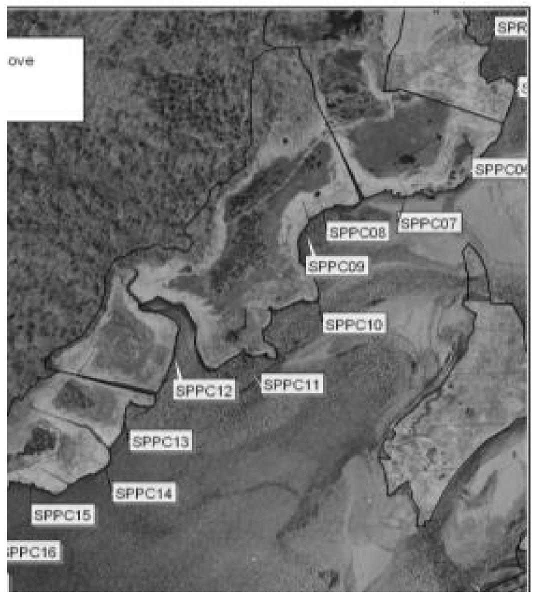


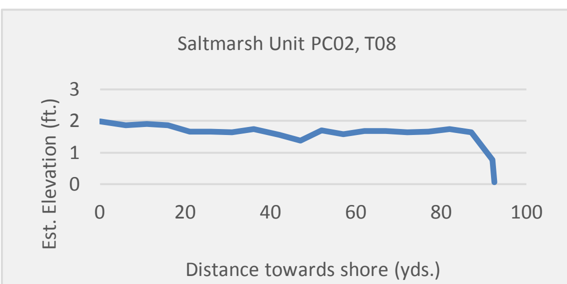
VI. Saltmarsh Surface Profiles

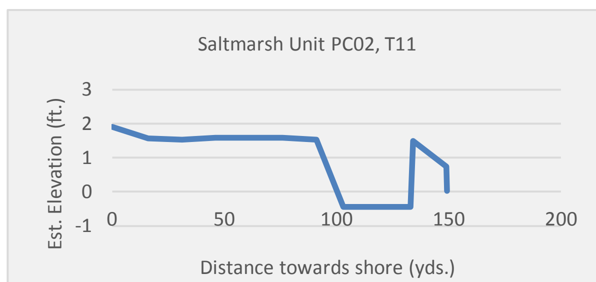
NOTE: All elevations tied to field elevation at Refuge Survey marker established in 2008. Reference elevation is 1.54' NGVD88.











Lower Narrow River Reach

I. Overview

Saltmarsh in this reach is typified by very high (1 meter +) banks with deep undercuts which appear relatively stable. The marsh surface is typically coated with algae. Shallow tidal flats limit wave action on saltmarsh shorelines, although the shore at LO02 is failing. Heavily used fishing trail on LO04. Fringe marsh on Northern shore moves up and down with wave action.

II. Saltmarsh Management Units

III. Habitat Components:

UNIT	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								POSSIBLE FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				TIDAL (BRACKISH) MARSH	ESTURINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOLS & PANS	OLD POOLS & PANS	ALL POOLS & PANS	PERCENT POOLS & PANS					
ALL	21.4	14.0	0.0	0.5	0.5	3.7	0.0	0.0	14.5	6.8	48.8
LO01	5.6	3.6		0.1	0.1	1.5			3.6	2.0	55.4
LO02	6.9	4.2		0.2	0.2	5.2			4.4	2.5	59.8
LO03	2.4	1.8		0.0	0.0	1.8			1.9	0.5	26.8
LO04	6.5	4.4		0.2	0.2	4.9			4.6	1.9	42.3

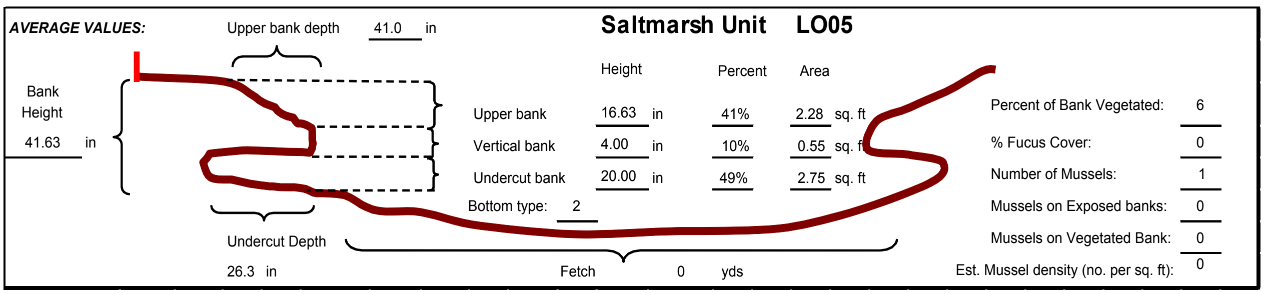
IV. Marsh Surface Conditions and Drainage (NOTE MAP SHOWN IN APPENDIX G)

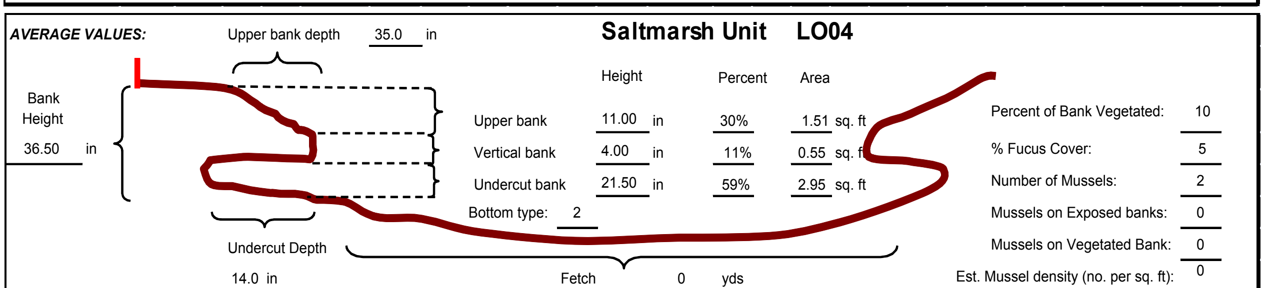
UNIT	MARSH SURFACE DRAINS						CONDITION OF MARSH SURFACE				
	FUNCTIONAL DRAINAGE (FT)				NONFUNCTIONAL (FT)		CURRENT WELL DRAINED MARSH SURFACE		WELL DRAINED MARSH W/ DITCH REPAIR		
	DITCH / SLOUGH	SHORELINE	TOTAL	DENSITY	TOTAL	DENSITY	ACRES	PERCENT	NEW AC	TOTAL	PERCENT
ALL	7972.0	6414.0	14386.0	989.5	58.0	4.0	11.7	80.5	0.1	11.8	81.1
LO01	2240.0	3750.0	5990.0	1652.4		0.0	3.2	88.8		3.2	88.8
LO02	2423.0	630.0	3053.0	695.6		0.0	4.4	100.0		4.4	100.0
LO03	2356.0	752.0	3108.0	1650.6	58.0	30.8	1.8	95.6	0.1	1.9	99.9
LO04	953.0	1282.0	2235.0	481.6		0.0	2.3	49.6		2.3	49.6

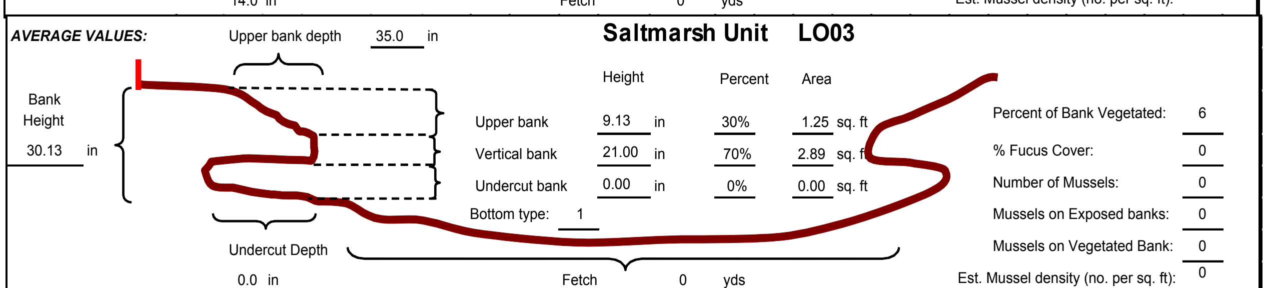
V. Saltmarsh Shoreline Conditions.

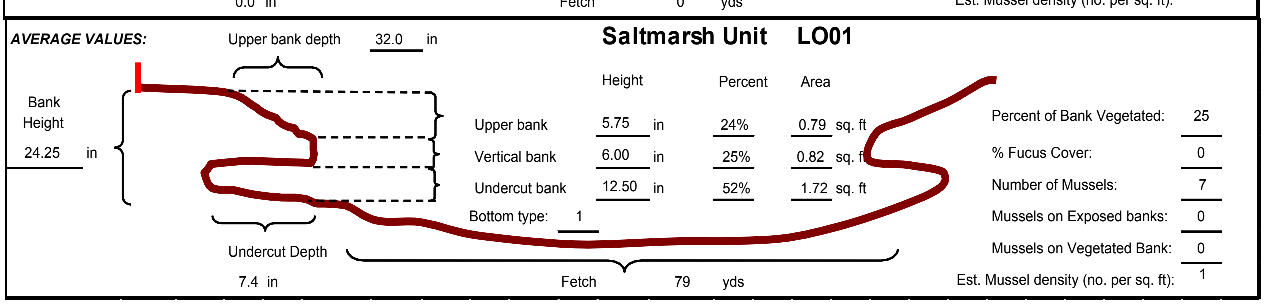
Data summarized by saltmarsh management unit from shoreline stability surveys completed in 2012.

Susceptibility to boat wake impacts: Moderate to high all areas except for lower half of LO01. Overall stability of saltmarsh shorelines is moderate except RF02 which is actively eroding, large blocks coming off of shoreline. Shoals along RF04 and 05 provide wave abatement.









APPENDIX C

Change in Saltmarsh Abundance in the Narrow River Estuary

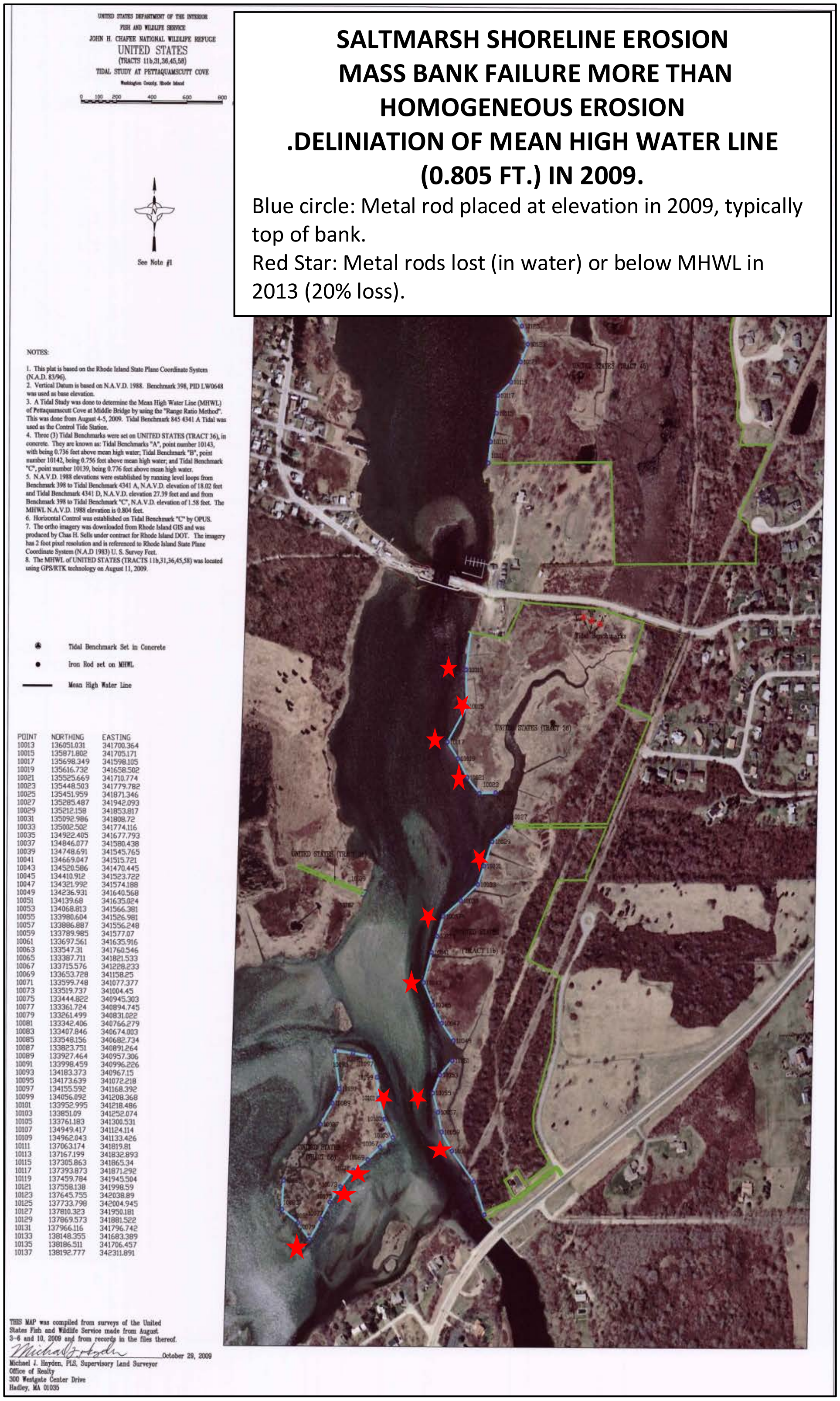
SALTMARSH HABITAT - LOSS OVER TIME

PRIMARILY RESULT OF CHANGES IN CHANNELS/DRAINAGE AND POOR TO NO RECRUITMENT

ESTIMATED LOSS FROM HISTORICAL LEVEL: 12 ACRES

APPENDIX D

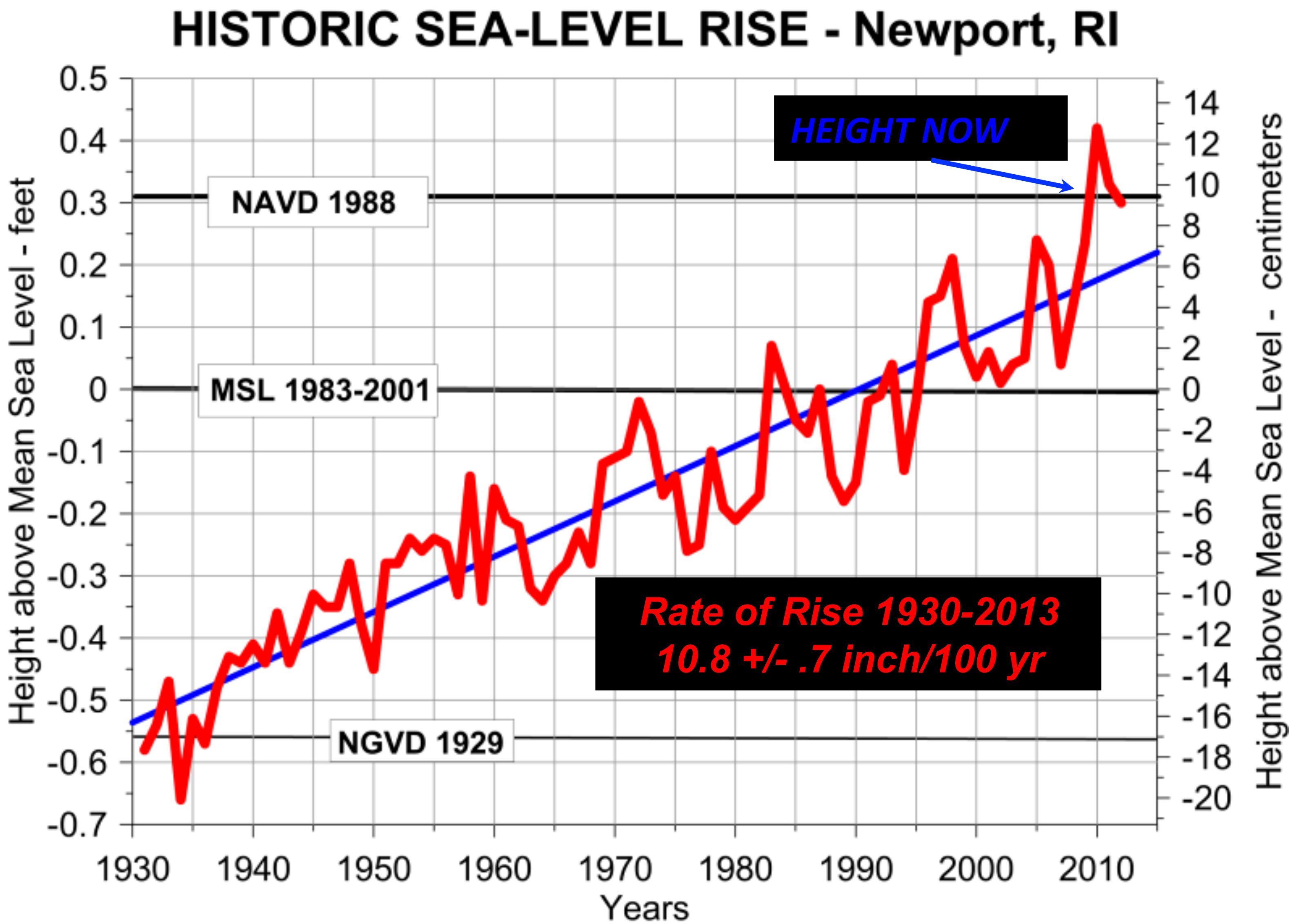
Mean High Tide Line Survey in 2009



APPENDIX E

Sea Level Rise Projection in the Narrow River Estuary

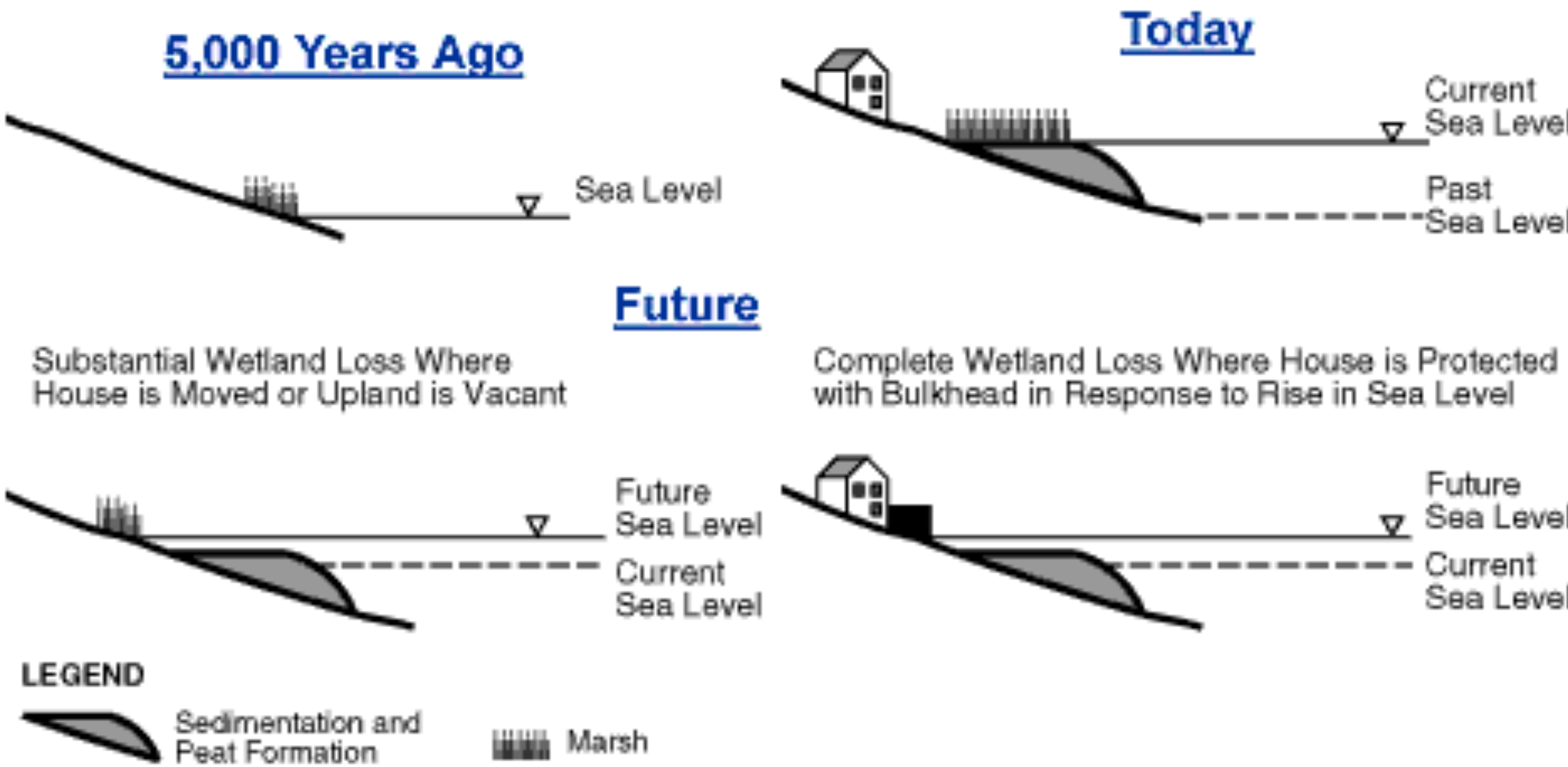
This Appendix presents the sea level rise at the Newport Gauge, and SLAMM modelling data showing changes in the Narrow River Estuary (RICRMC 2014)

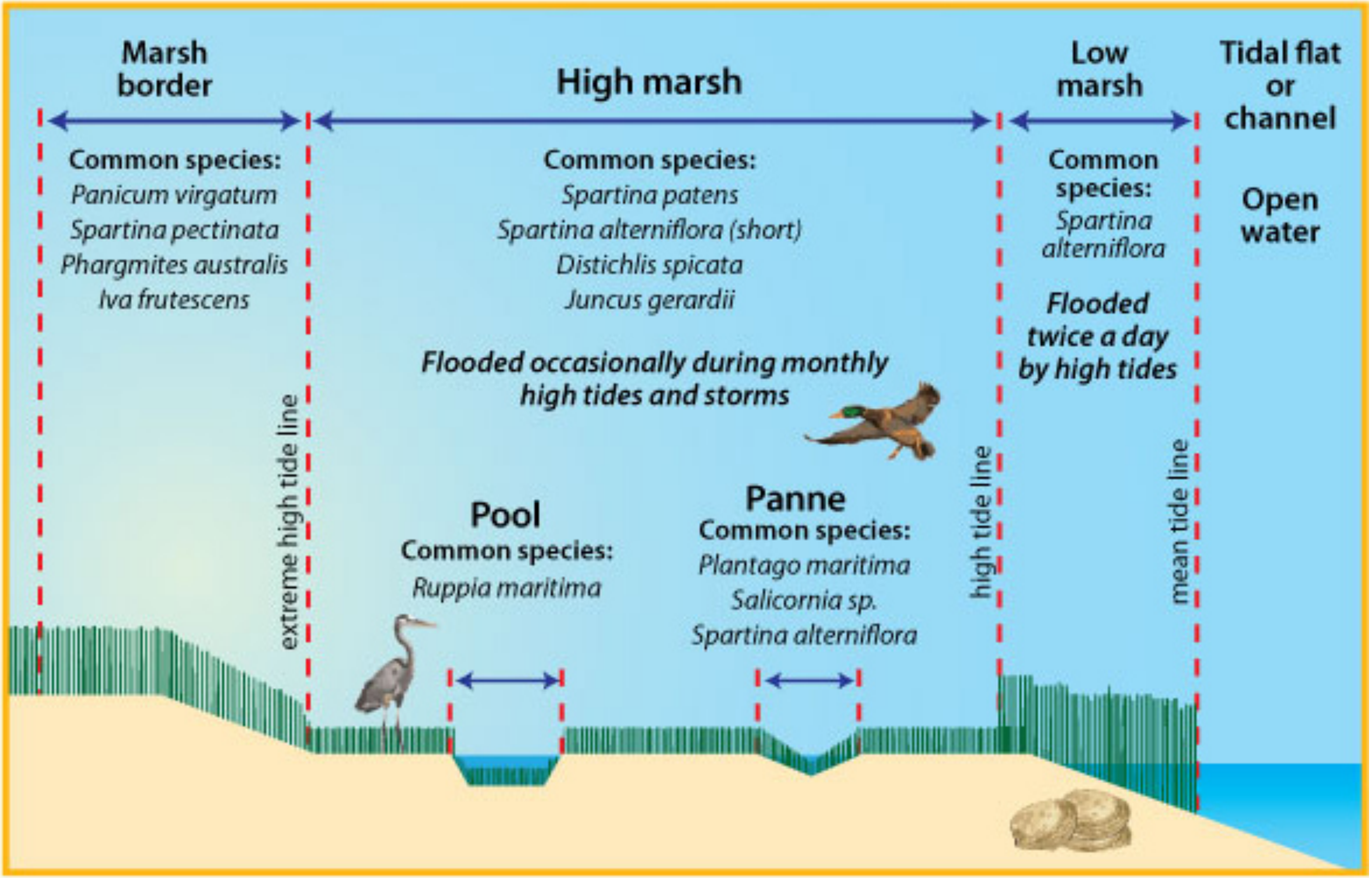


Adapted from:
http://tidesandcurrents.noaa.gov/sltrends/
sltrends_station.shtml?stnid=8452660%20Newport,%20RI

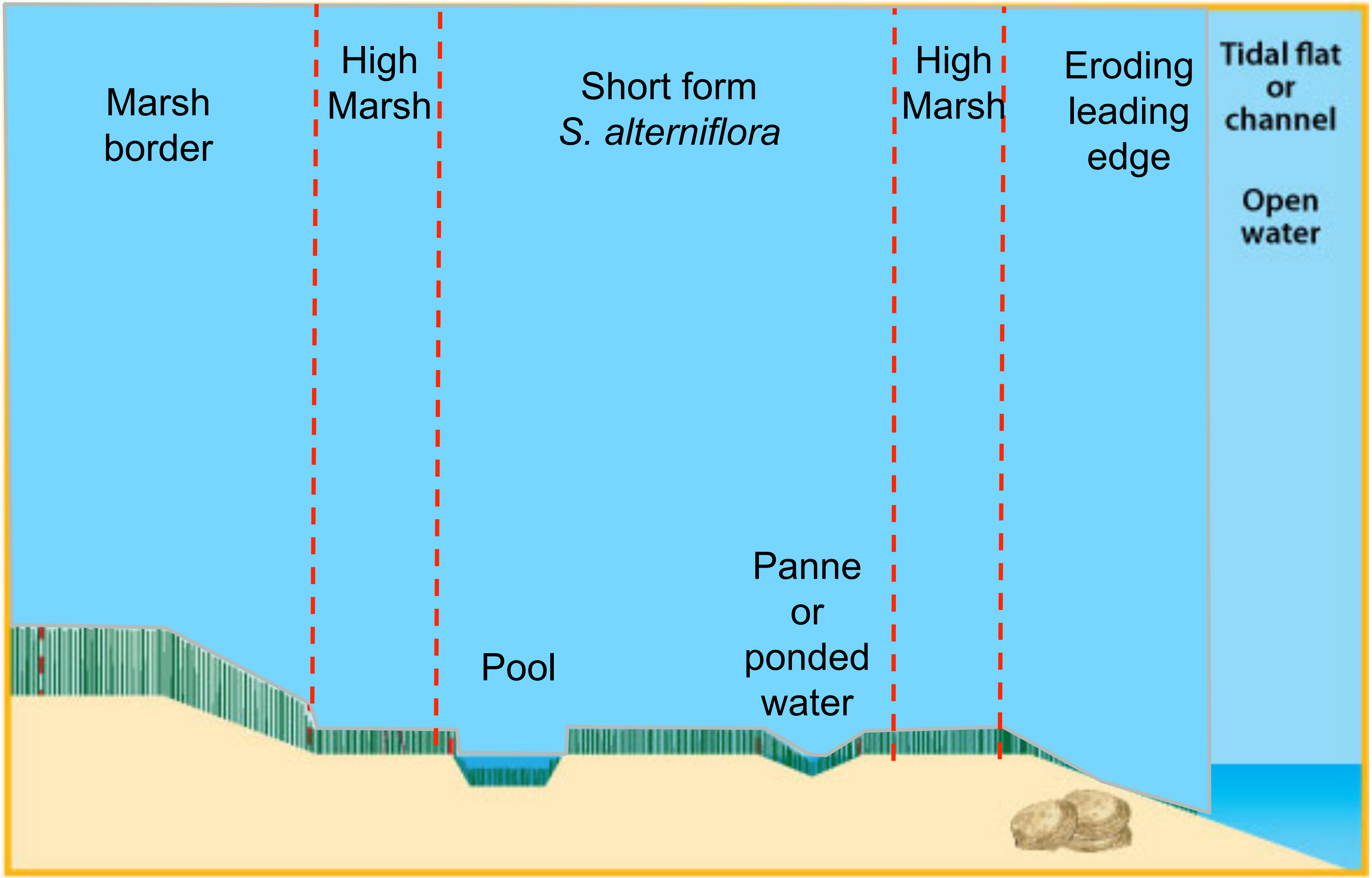
Boothroyd 2013

Evolution of a Marsh as Sea Level Rises

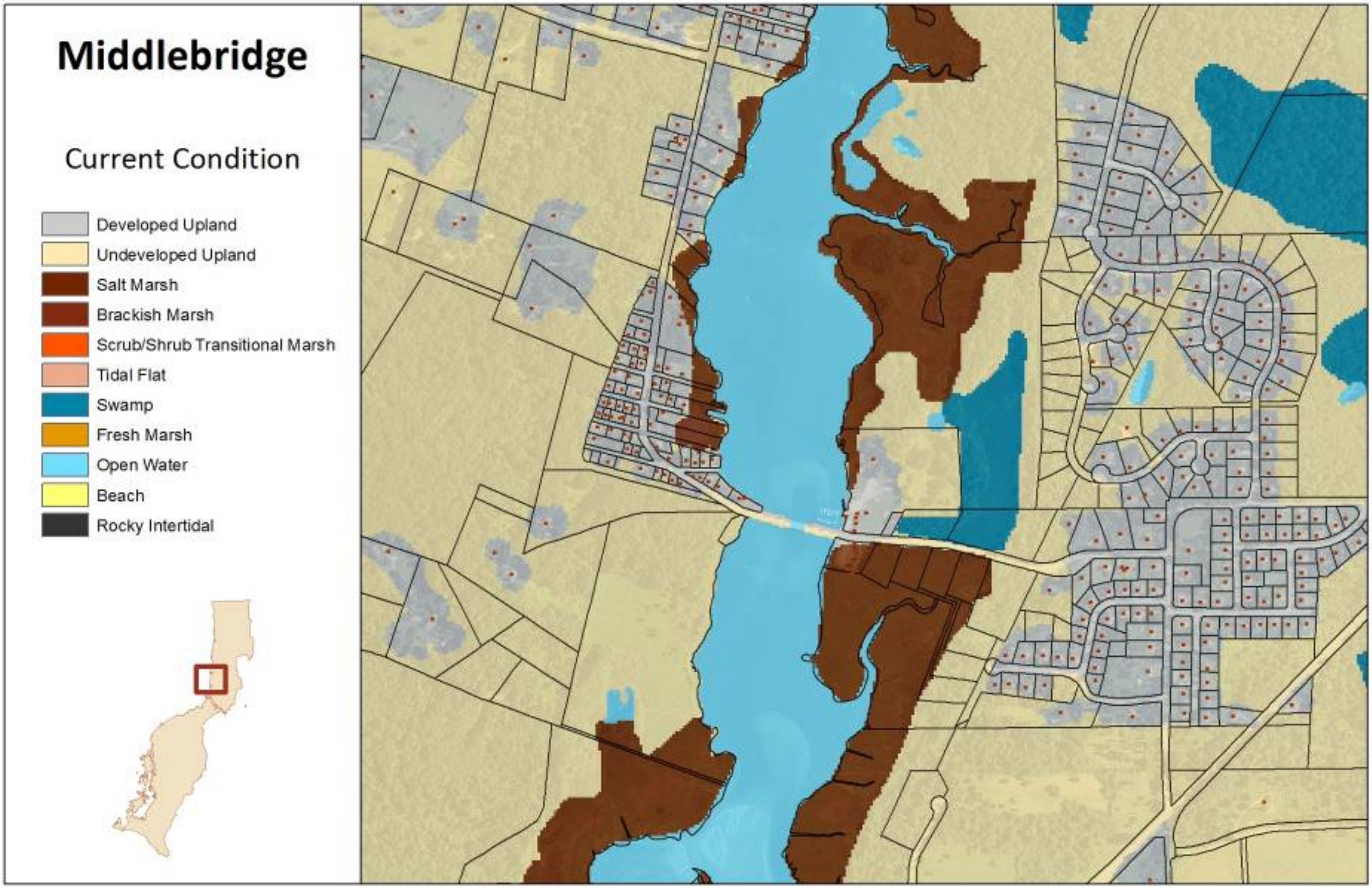


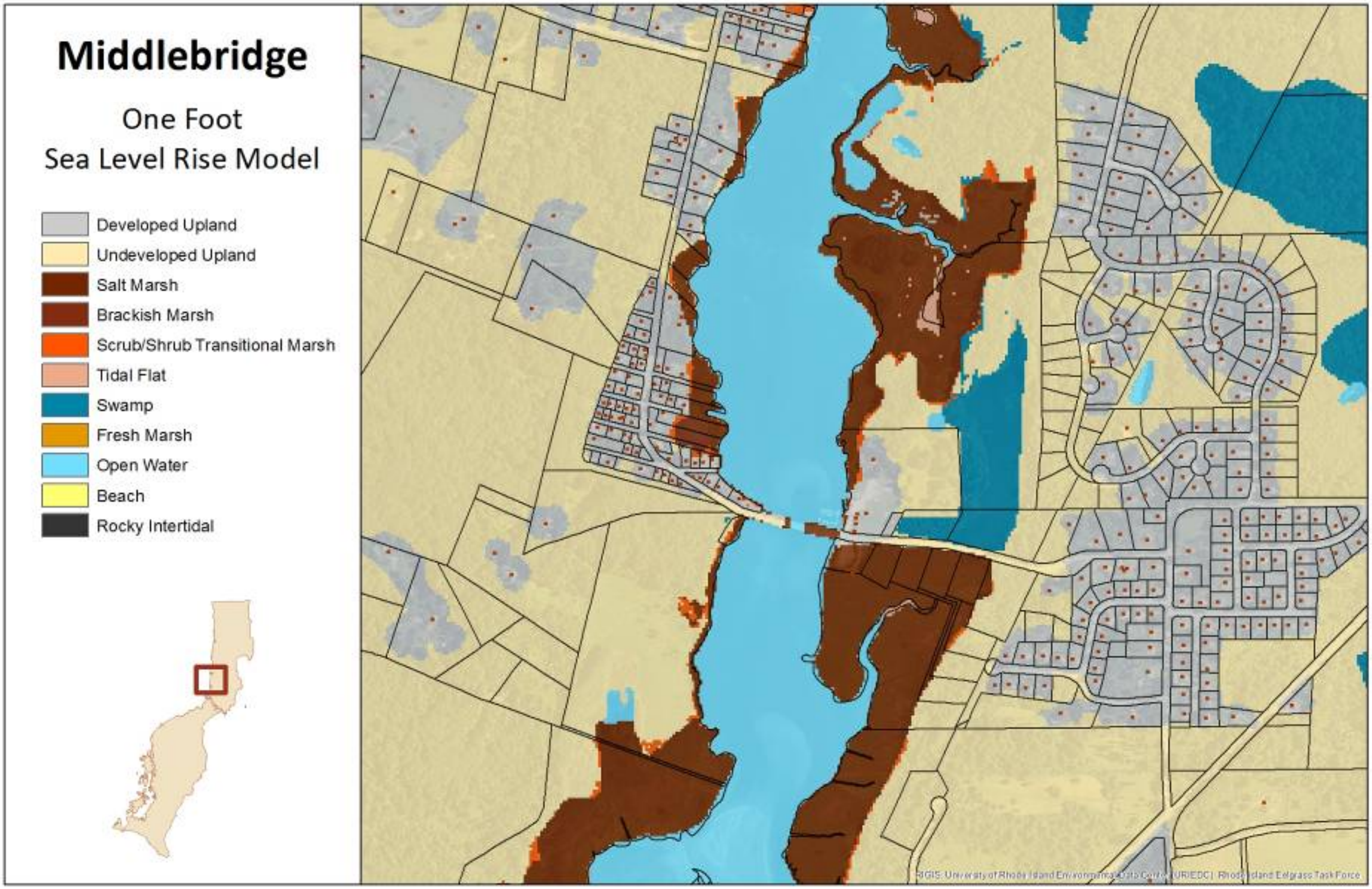


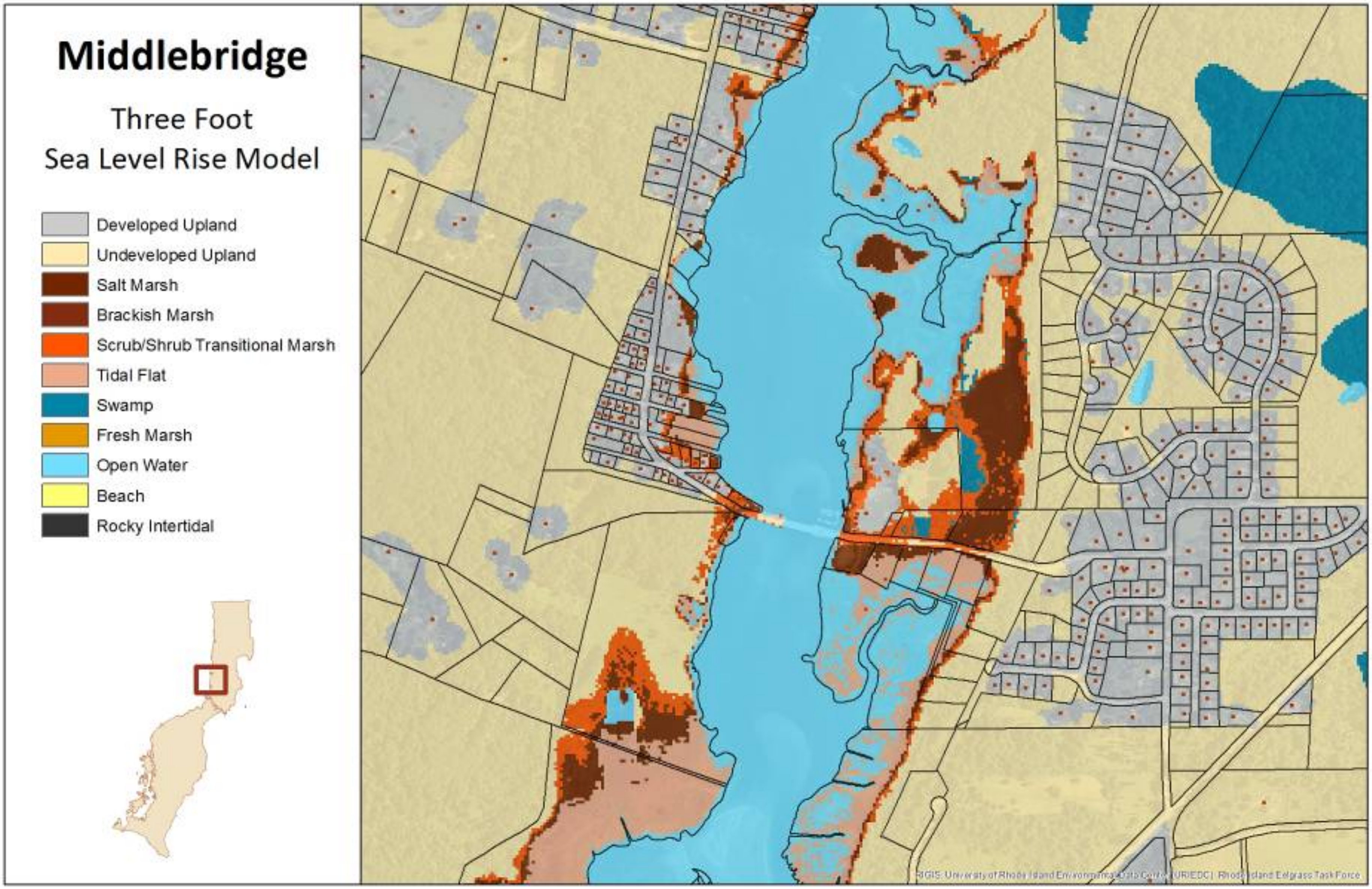
Source: Maine SeaGrant

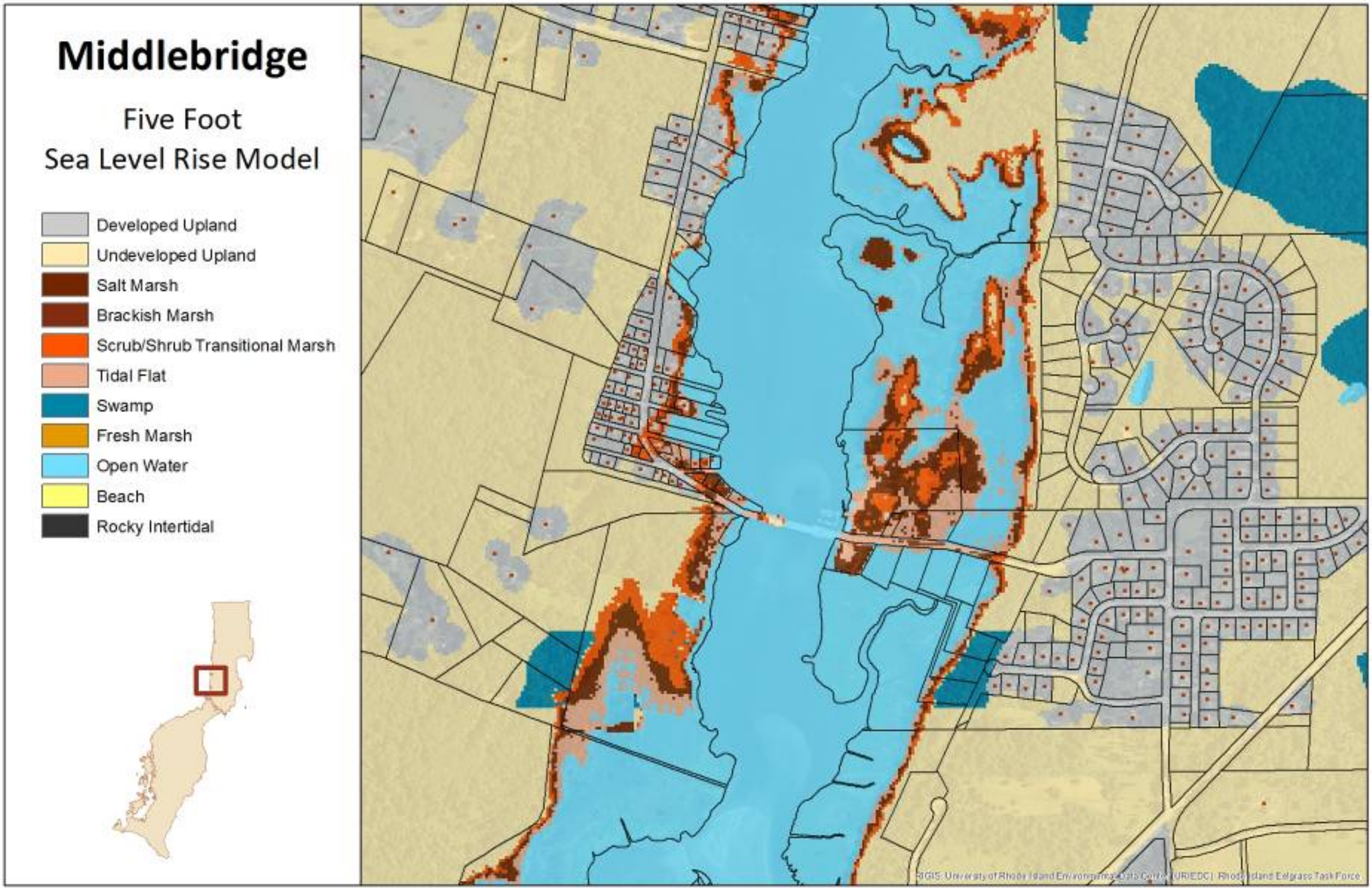


Source: Save The Bay


Middlebridge
Current Condition
Developed Upland
Undeveloped Upland
Salt Marsh
Brackish Marsh
Scrub/Shrub Transitional Marsh
Tidal Flat
Swamp
Fresh Marsh
Open Water
Beach
Rocky Intertidal


Middlebridge
One Foot
Sea Level Rise Model
Developed Upland
Undeveloped Upland
Salt Marsh
Brackish Marsh
Scrub/Shrub Transitional Marsh
Tidal Flat
Swamp
Fresh Marsh
Open Water
Beach
Rocky Intertidal


Middlebridge
Three Foot
Sea Level Rise Model
Developed Upland
Undeveloped Upland
Salt Marsh
Brackish Marsh
Scrub/Shrub Transitional Marsh
Tidal Flat
Swamp
Fresh Marsh
Open Water
Beach
Rocky Intertidal
RIGIS: University of Rhode Island Environmental Data Center (URIEDC) | Rhode Island Eelgrass Task Force


Middlebridge
Five Foot
Sea Level Rise Model
Developed Upland
Undeveloped Upland
Salt Marsh
Brackish Marsh
Scrub/Shrub Transitional Marsh
Tidal Flat
Swamp
Fresh Marsh
Open Water
Beach
Rocky Intertidal

APPENDIX F

ESSENTIAL FISH HABITAT ASSESSMENT

APPENDIX F

ESSENTIAL FISH HABITAT ASSESSMENT

NARROW RIVER ESTUARY RESILIENCY RESTORATION PROGRAM

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- F.5.2 LITERATURE REVIEW
- F.5.3 ALTERNATIVES ANALYSIS

Lead Federal Agency:
U.S. Fish and Wildlife Service
Rhode Island National Wildlife Refuge Complex
50 Bend Road, Charlestown, RI 02813

This Appendix to the Environmental Assessment (EA) evaluates potential effects of implementation of the proposed action on Essential Fish Habitat (EFH) and managed species, in compliance with the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1908, PL 94-265 as amended). The format of this Appendix is based on the Code of Federal Regulations guidance for EFH Assessments (50 C.F.R. 600.920).

F.1 DESCRIPTION OF ACTION: RESTORE ESTUARINE HABITAT TO PROMOTE RESILIENCY IN THE NARROW RIVER ESTUARY

The proposed Narrow River Estuary Resiliency Restoration is an integrated set of actions designed to restore, enhance and preserve estuarine habitat functions, values, and resiliency, including actions to enhance eelgrass *(Zostera marina)* beds, salt marshes, tide flat habitat, water quality, EFH and other shallow-water habitats. The project is intended to improve the health and productivity of the range of fish and wildlife species that utilize the estuary, including managed species and other marine and estuarine fish and shellfish. The EA and its appendices provide a detailed description of the proposed action and its consequences. This Appendix focuses on the evaluation of effects on marine fish and essential fish habitat.

F.1.1 PURPOSE AND NEED FOR ACTION – NARROW RIVER ESTUARY RESILIENCY RESTORATION

The purpose of this resiliency restoration program is to abate degradation of fish and wildlife habitat and to increase the ecological health of the Narrow River Estuary (estuary). Enhancing the health of system components now will allow the estuary to become more resilient to changes brought about by sea level rise, climate change, and future storm events. Enhancement of estuarine conditions will also help achieve the mission of the National Wildlife Refuge System, and the purposes for which the John H. Chafee National Wildlife Refuge was established.

Estuaries and estuarine habitats are among the productive ecosystems known, serving as critical transitional areas between land and sea, and provide a wealth of values to society, including fish and wildlife production, pollution attenuation, and socio-economic values such as flood control and recreation (NHDES 2004; RAE 2007; Tiner 1989). Estuarine habitats are important to numerous life stages of many fish species (Stevenson *et al.* 2014); indeed, 75% of commercial fish species depend on estuaries for their feeding habitat, spawning grounds, and nurseries (RAE 2007).

Salt marshes are recognized as some of the most ecologically important wetland habitats in Narragansett Bay (Schwartz 2009). These wetlands support the coastal estuarine ecosystem because of their role in providing food, space, and refugia for a wide variety of terrestrial and aquatic species (Teal *et al.* 1999). Salt marshes buffer and protect estuarine waters and habitats from land-based pollutants (USEPA 1993). The location of salt marshes between river and upland sites provides a buffer during storm events, and aide in reducing nitrogen inputs from uplands into estuaries (Wigand *et al.* 2004). Salt marshes provide habitat to wildlife species of highly restricted range, such as the salt marsh sparrow (*Ammodramus caudacutus*), a salt marsh obligate species of high conservation concern (USFWS 2008). Salt marshes are also valued as open space and provide scenic vistas.

The Narrow River drains a watershed approximately 14 square miles in size, and provides estuarine habitat along roughly half its length. The estuary supports a variety of diverse habitats, including eelgrass beds, estuarine channels and basins, shallow water habitats, intertidal shoals (tide flats), and extensive salt marshes.

Despite the important biological, economic, and social values this area provides, these estuarine habitats are threatened from a variety of natural and anthropogenic influences; and several characteristics of this estuary suggest key components are in decline. There is a need to act.

The estuary is susceptible to increased rates of sea level rise. The RI Coastal Resource Management Council (RICRMC) predicts a one foot sea level rise over 1990 levels by 2050 (URI 2013). Salt marsh habitats occur at elevations less than two feet above mean sea level: therefore only modest increases in sea level rise can have a marked change in the amount, type, distribution, and quality of salt marsh habitats.

Locations where salt marsh vegetation can migrate inland in response to sea level rise is limited and will accommodate less than half of the current marsh acreage, with remaining marsh having a much patchier fragmented distribution (USFWS 2014). Relatively flat elevations on some marsh surfaces suggest that with only slight increases in sea level, large expanses of salt marsh will be lost at one time.

Changes in climate will also influence the estuary. If current predictions hold true, increased precipitation can increase freshwater input onto salt marsh surfaces, further degrading marsh conditions. Shifts in wind directions can make now stable shorelines more susceptible to wind driven waves. Increased frequency of storm events could limit recovery times and make some habitats less resilient to future storm events.

Despite ongoing efforts of the State, local municipalities, and the Narrow River Preservation Association (NRPA) to improve water quality, the estuary suffers from low water quality in the form of excess nitrogen influx and the presence of coliform bacteria, particularly after rainfall events (NRPA 2012). Excessive nitrogen loading can limit production of roots and rhizomes which help bind and stabilize salt marsh banks (Johnson *et al*. 2012), and make above ground vegetation more susceptible to grazing (Ramnarine *et al.* 2008). Poor water quality can reduce the diversity of aquatic insects, and protracted flushing rates such as in Pettaquamscutt Cove limit the system's ability to abate water quality issues (RICRMC 1999).

Salt marsh habitats have declined over time in both abundance and health. We estimate that over 12 acres have been lost to development of bare pans and mud flats on the salt marsh surface from waterlogging and entrapment of water on the salt marsh surface. Shoreline erosion continues at a rapid pace in some portions of the estuary. In combination with the natural undercutting of banks and accelerated erosion from boat wakes in some areas, large lengths of shoreline are failing, with little, if any recruitment of salt marsh areas apparent in the watershed (USFWS 2009; 2012). In 2014, most of Sedge Island's Eastern shore has failed with two feet or more of the marsh bank lost due to channel erosion.

Over 39% of current salt marsh habitat is dominated by a mixture of stressed vegetation and bare pans, typical of degraded marsh conditions. Vegetated high marsh surfaces and permanent marsh pools provide important habitat for marine fish during higher tidal periods (MacKenzie and Dionne, 2008), yet access to these marshes has declined over time. Clogging of channels in the estuary limits access to 17 acres of otherwise suitable habitat except during lunar or higher tides than average.

Historic changes in channels draining the estuary are likely due both to natural and anthropogenic factors, with once clear secondary river channels transformed into growing flood and ebb tidal deltas. Increasing sediment deposition has resulted in a loss of deeper habitat areas that provide feeding areas and thermal refuge for estuarine fish. Channel braiding as a result of sediment loads in excess of the river's ability to carry them has caused channels to migrate against salt marsh shorelines, causing deteriorating salt marsh and shallow-water habitats.

Important marine habitats such as eelgrass beds appear to have recently expanded in the estuary South of Middlebridge, although this increase has been located in shallow areas, making the bed susceptible to elevated summer temperatures and prop scarring from motorized vessels. High summertime water temperatures, reduced biomass on marsh surfaces, limited access to the salt marsh surface by fish species, and the limited availability of cold water refugia all likely limit fish production.

In short, estuarine habitats in the Narrow River are threatened and declining due to a number of anthropogenic and natural factors. These include climate-change-driven factors such as sea level rise, as well as use-driven factors such as shoreline erosion as aggravated by motorboat wakes, and lingering effects of historic alterations (ditching, berm construction, etc.). As a result, the estuary is losing the mosaic of healthy habitats that supports its diverse ecosystem. Salt marsh vegetation is dying, transforming formerly healthy marsh areas into hypersaline pans of low habitat value. Salt marsh edges are eroding, causing net loss of marsh habitat. Marsh erosion transports sediments into sub-tidal areas of the estuary, aggravating shoaling. This anthropogenic shoaling combines with natural shoaling trends caused by the expansion of flood-tide deltas in the estuary, increasing the area of tidal flats, and eliminating deeper areas that formerly provided important essential fish habitat and shallow-water habitats.

The cumulative impact of these changes is a loss of habitat diversity in the estuary and a "leveling" trend towards more uniform habitats. Where the estuary once supported high marsh, some low marsh, tidal flats, and deeper estuarine areas including eelgrass beds, it is losing habitats at both the higher and lower ends of the elevational range. As deeper areas of the estuary are lost, areas of passage, feeding and thermal refuge are lost for a variety of marine fish species. Benthic and estuarine habitat diversity is declining in the estuary.

This trend is expected to negatively impact estuarine fish and wildlife resources. Larger fish species such as striped bass *(Morone saxatilis)* and bluefish *(Pomatomus saltatrix)* that require deeper areas to feed, and species such as winter flounder *(Pseudopleuronectes americanus)* that utilize deeper areas for spawning and thermal refuge will likely see further declines in habitat quality. Wildlife species such as salt marsh sparrows, which require high marsh habitat for nesting, are expected to decline. Lacking restorative actions, the salt marsh sparrow is likely to require protection under the Endangered Species Act within a few years, and faces the possibility of extinction by 2050 (Paton 2014, pers. comm.).

Reversing these trends and restoring key estuarine components, preventing the loss of habitat diversity, and increasing the resiliency of fish and wildlife habitats will allow us to achieve the goals and objectives of the John H. Chafee National Wildlife Refuge, and the National Wildlife Refuge System.

F.1.2 DESCRIPTION OF THE PROPOSED ACTION

In developing this proposed restoration plan, the Service surveyed and evaluated potential EFH and shallow-water habitat resources, including salt marshes; eelgrass beds; tidal flats; mud, sand, and gravel bottoms; and benthic fauna, including shellfish beds. Using the results of these inventories and in consultation with fisheries biologists, initial restoration plans were modified to insure that implementation of the plan would benefit all of the key components of the estuary, while avoiding any significant adverse impacts to existing EFH and shallow-water habitats. The modifications included removal of areas where nekton production for fish was high; elimination of a boat channel originally intended to bring motorized vessels away from salt marsh banks (due to the presence of eelgrass), inclusion of measures to enhance eelgrass habitat, provision of cool water refugia for fish, enhance access to upper salt marsh surfaces and production of prey species in those areas, and to protect and expand the amount of low marsh habitats in the estuary. By restoring salt marshes, shallow-water habitats, and estuarine areas, the proposed action will restore ecological resilience to the Narrow River Estuary as intended by Congress and the President under the Sandy Recovery and Improvement Act of 2013 (PL 113-2), and will benefit EFH and managed species.

The Environmental Assessment and Appendix G provide a more detailed description of the proposed action than presented here. All actions are conceptual in nature and subject to further refinement as more information becomes available; however the Service has endeavored to assess the maximum potential impact for the purposes of this EA and environmental permitting. The Service proposes to implement, over the next 3 years, an integrated set of actions to help restore key estuarine resources in the Narrow River Estuary:

ACTION A. WATERSHED AND WATER QUALITY RESTORATION

The objective of this action is to improve knowledge of non-point source pollution, improve water quality, and improve flushing in Pettaquamscutt Cove.

(1) In collaboration with NRPA, intensify ongoing, long term water quality monitoring to enhance knowledge of non-point source pollution in an attempt to locate priority sites for water quality abatement actions. Further investigate the source of pollution in the Mumford Brook using such techniques as trained canines.
(2) In collaboration with the RI Department of Environmental Management (RIDEM), survey, design, and install (funding dependent) best management practice BMP sites in the Mettatuxet drainage in Narragansett and at Kimberly Drive in South Kingstown. The BMP's will remove excess nutrients and pathogens from storm water runoff in order to reduce anthropogenic sources of fecal coliform as well as nutrients and sediments which impair habitat quality of the waters of the estuary. All BMP work will be conducted in upland areas. Final design of BMPs will be subject to approval by RIDEM.
(3) Improve flushing and water circulation in Upper Pettaquamscutt Cove by removing remnants of an old road crossing. The current arrangement of materials suggests that these remnants are inhibiting natural flow and flushing. Material will be excavated to the depth of typical bottom elevations northeast and southwest of the crossing. Material (typically coarse gravel, small rock to 12" diameter) will be removed for upland disposal.

Appendix G provides maps, management controls, and background materials of the action as summarized here.

ACTION B. EELGRASS MANAGEMENT, ESTUARINE CHANNEL AND BASIN RESTORATION

This action takes advantage of the opportunity to enhance marine fisheries habitat by creating habitat conducive to eelgrass establishment and creation of thermal refugia. Basins and channels will be deepened by removing existing sediments to a depth of approximately -5 feet NAVD88. Areas where excavation will occur are channels which were present historically (Appendix A). All treatment areas are where deposition of flood and ebb tidal deltas have formed over time, shifting channel flow to less favorable locations for preservation of other EFH values.

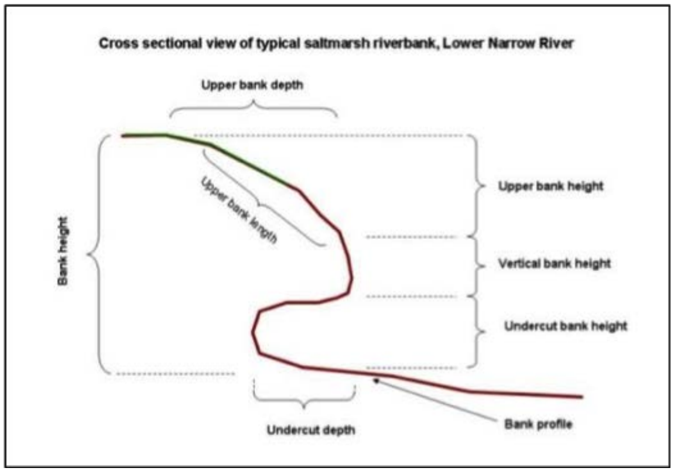
This action will establish 7 acres of deeper estuarine areas, suitable for eelgrass habitat and serving as thermal refugia and passage for important estuarine fish species. The depth is anticipated to provide ideal habitat for existing eelgrass beds to expand, will ensure they are at a depth not susceptible to prop scarring, and will provide for cooler temperatures for growth and production.

To ensure no significant loss of *upper* tidal flat habitat for important shore and wading birds and shellfish, over three acres of tidal flat will be created or enhanced in areas less prone to disturbance compared to current locations. Sand bottom habitat will be maintained on side slopes, remaining tidal flats, and at the bottom of excavated areas.

As shown in Appendix G, 35,629 cubic yards of material will be excavated. As existing eelgrass beds provide a ready seed source, no planting or seeding of eelgrass is proposed. Sediments removed from restoration areas will be repurposed for beneficial re-use in restoring degraded and lost salt marshes (Actions D and E, below). Sediments in proposed restoration areas are generally sandy, with fines ranging from 2-60%, but less than 25% in 78% of the units analyzed. All strata were tested for potential chemical contaminants, including TPH, PCBs, SVOCs and metals. All parameters are within EPA and state criteria for beneficial use of dredged material.

Maps of sediment types, bottom habitats and bathymetry are included in Section F.2.2 below. Appendix G provides maps, management controls, and background materials of the action as summarized here.

Figure 1. Typical Salt Marsh Shoreline Bank



ACTION C: RESTORE SALT MARSH SHORELINES

This action builds upon the existing installation of living shoreline techniques in the River and the associated monitoring. The Service will apply living shoreline treatments to shorelines with serious bank stability issues, where such application is expected to be effective and possible.

Collapse of undercut banks appears to be the primary causal factor of salt marsh shoreline loss, and frequently occurs as a mass, or catastrophic loss along several feet of shoreline. In 2013/2014, this pattern of bank loss has occurred along the eastern shore of Sedge Island and near Starr Drive. Surveys completed in 2012 of salt marsh shorelines found that 96% of the banks along the main river channel are undercut (Figure 1).

Living shoreline applications are generally not suited in areas of deeper water or in very high energy locations. This action is intended to reduce marsh erosion using a variety of designs using a combination of biodegradable erosion control materials (bank stabilizer) and shell reefs (wave attenuator) that have been proven successful in protecting eroding shorelines and enhancing important estuarine processes and services elsewhere (O'Brien 2014, pers. comm.). Fiber (coir) logs and bagged oyster shell will be placed in a variety of formations along eroding marsh edges. In 2014, RICRMC and The Nature Conservancy completed a pilot-scale test of this approach that is demonstrating its effectiveness to enhance marsh edge habitat through re-vegetation and colonization. Shell bags were stacked to a set height to attenuate waves and wakes. A sill which approximates a rectangle (20 x 5 x 2.5 ft.) with a set gap (approximately 10 ft.) was placed between units.

Other, simpler arrangements will be used to retard undercut erosion and failure by placing coir logs within the undercut area of the banks. Providing further protection of undercuts is anticipated to (a) retard bank failure; and (b) maximize lateral growth from the salt marsh, rather than having this horizontal extension of salt marsh lost due to bank failure from undercuts.

Appendix G summarizes treatments by salt marsh management units, and conceptual maps showing general locations (subject to field verification, actual locations may vary) where living shoreline protection strategies will be applied. Approximately 7% of all marsh shoreline in the estuary will be treated using living shoreline techniques.

ACTION D: RESTORE SALT MARSH SURFACE HYDROLOGY THROUGH DRAINAGE RESTORATION/RUNNELS.

This action is intended to help restore growing conditions for marsh vegetation while improving habitat and productivity of small estuarine fish such as mummichog (*Fundulus heteroclitus*), striped killifish *(F. majalas)*, and other fish and invertebrates that utilize high marsh surfaces and permanent marsh pools.

The combination of fresh water flow and seepage onto salt marsh shorelines, and entrapment of tidal flows due to a lack of adequate drainage has resulted in degraded salt marsh conditions on 39% of salt marshes in the estuary. As shown in Appendix B, pools and pans have expanded significantly on salt marsh surfaces over the past 75 years. Most historical pools have high value for fish production, wildlife habitat, and biological diversity and will not receive treatment, however newer pools and pans are shallow, devoid of vegetation, dry up in the summertime, and have little biological value.

In areas where excess water is entrapped on the salt marsh surfaces, vegetation shows evidence of stress. Degraded marsh is typified by the presence of bare areas, and where glasswort (S*alicornia spp*.) and short forms of smooth cordgrass (*Spartina alterniflora*) are dominant with fringes of saltgrass (*Distichlis spicata*). In many cases, *S. alterniflora* is less than 4" high and frequently shorter with a low density (Figure 2a).

Comparatively areas which are well drained (in general, within 50 feet of a drainage or shoreline) are dominated by robust stands of salt marsh hay (*Spartina patens*) or mixed vegetation including tall forms of *S. alterniflora*, *D. spicata*, and much lower densities of *Salicornia spp*. Vegetation is robust, important in maintaining the salt marshes ability to keep pace with sea level rise (Figure 2b).

Degraded salt marshes will be restored by improving surface drainage using the "runnel" method—excavating shallow channels (generally 8" to 12" or less in depth and two feet wide) on the surface of the marsh to provide surface drainage. The minimum number and lengths of runnels will be created, with the density based on site specific analysis. In some cases, existing pans and pools will be connected to tidal waters, but only newly developed pans will be drained.

In addition, some clogged existing ditches which have filled with sediments will be cleared, but only to the extent surface drainage can be achieved (6" to a foot in depth or less). In all cases, both the minimum number and minimum depths and width will be used to enhance drainage. The purpose is to allow drainage while minimizing any increased volume or flow onto the surface. This approach has been used successfully to restore salt marshes on Narragansett Bay and in the South Shore salt ponds of Rhode Island by Save The Bay (Ferguson 2014, pers. comm.).

Figure 2a and 2b. Degraded Salt Marsh Conditions; Healthy Salt Marsh Conditions.

This action will be implemented on 46.9 acres, and will be undertaken through an adaptive approach—beginning small scale in the first year, and then evaluating the need and opportunity for continued hydrologic restoration. In most areas, creation of runnels will be completed by hand, although in some areas of excavation will be accomplished using low-ground-pressure excavation equipment.

Appendix G provides maps, management controls, and background materials of the action as summarized here.

ACTION E: RESTORE LOST LOW MARSH, RESTORE DEGRADED MARSH, AND ENHANCE RESILIENCY TO SEA LEVEL RISE THROUGH RESTORATION OF INTERTIDAL ELEVATIONS

The objectives for this action are to increase the availability of low marsh habitat, to restore degraded salt marsh, and to increase salt marsh elevations to enhance resiliency in the face of sea level rise. This will be accomplished by repurposing sediments dredged under Action B (Eelgrass Restoration), for beneficial use through thin layer deposition (TLD) of dredged sediments.

The material excavated for eelgrass and channel enhancements (Action B) will be moved and temporarily be stored at the staging area at Sprague Bridge, then moved to salt marsh creation or thin layer deposition areas by barge. Material within the containers will be re-slurried and pumped onto salt marsh surfaces, or the excavator will place material directly into areas designated for low marsh creation. Material placed on the marsh surface will be retained using a series of small coir logs or similar retaining methods until it settles. Once target elevations are met, material will be pumped into the next compartment. A series of straw bale fences will be installed within the drainage channels in order to keep sediments on site. Following placement of material, elevations will be retaken to determine whether additional placement of material will be needed.

TDL work will occur after dredging but prior to summer work restrictions, thereby avoiding impacts to fish and the busy summer boating season. During the winter, navigation through the river will be difficult with all of the equipment and barges, but it is likely boat traffic will be able to pass through the area. Appendix G provides a more detailed description of the action, including management controls and mitigation.

Low Marsh Restoration:
The availability of low marsh in the estuary is inherently limited by the relatively high elevations of the salt marsh surface. Survey of the mean high tide line in 2009 found that the high tide line lies within 1 foot of the salt marsh bank

with the river (Appendix D). Subsequent surveys of salt marshes between Middlebridge and Sprague Bridge have also shown that most areas of the salt marsh lie above MHW (NAVD 88; Appendix G).

Low marsh is important for marine fish because it is frequently inundated in most if not all tide cycles, and provides habitat for a variety of prey species. Currently, low marsh (areas dominated by tall form *S. alterniflora* or as a mixture of vegetation including *S. alterniflora* with *S. patens, D. spicata,* and *Salicornia spp.*) occurs only in narrow bands along drainages and tidal creeks. Given the changes in salt marshes in the estuary over time, particularly in areas to the southeast of Sedge Island (Appendix A), it seems reasonable that low marsh was more abundant than at present.

A total of 1.2 acres in areas of historical marsh occurrence will be designated for low marsh creation. Target elevations will be 0.850 feet NAVD88, with gentle (20:1 or greater) slopes to provide drainage. Coir logs, 12 inches in diameter or less, will be installed along the periphery of the salt marsh units to contain the repurposed dredge material. Material will be transported to the site by barge (as described under Action B) and offloaded using the excavator to establish required elevations.

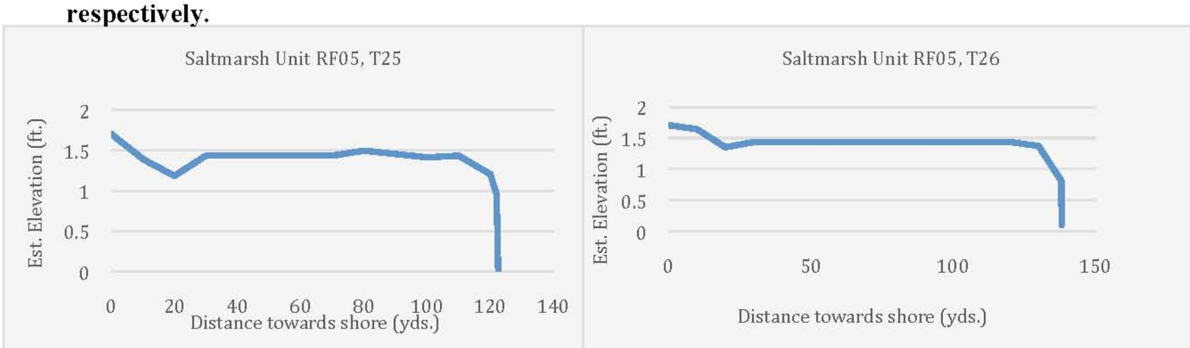
All sites will be planted with salt marsh plugs (*S. alterniflora* and *D. spicata*) on a 30” x 30” spacing or less once the material has settled and growing conditions are suitable. This approach to marsh restoration has been used successfully in Jamaica Bay, NY, Chesapeake Bay, MD, and elsewhere (ACOE 2014; Frame *et al.* 2006; Frame 2007; Wilson 2014).

This action applies a thin layer of locally sourced sediment to the surface of the marsh, raising intertidal elevations in order to mimic and augment natural accretion processes. This method has been successfully used on Delaware Bay, DE, Chesapeake Bay, MD, and Jamaica Bay, NY, to restore marshes adversely affected by accelerated sea level rise (ACOE 2014; Frame *et al.* 2006; Frame 2007; Wilson 2014).

Elevation Capital and Restoration of Degraded Marsh:
The intent of this action is to restore degraded marsh where tidal water entrapment on the salt marsh surface has resulted in reduced productivity and expanding bare pans on the marsh surface (see description under Action B, above); and to provide elevation capital so that treated areas are more resilient to sea level rise.

As shown in figures 3a and 3b, the surface profiles of the eastern bank of the River (Unit 8 from Appendix G), elevations across the marsh surface are relatively uniform.

Figure 3a and 3b. Salt Marsh Elevation Relative to Distance from Shore at transects T25 and 26 respectively.



In the case of T25 (Figure 3a) lower elevations in the back of the marsh and the presence of higher areas in the middle show that water flowing onto the marsh has a high likelihood of entrapment, resulting in degraded salt marsh conditions. Application of materials can aide in development of better drainage.

Examination of the profile at T26 (Figure 3b) shows that the surface profile is essentially flat. As sea level rise progresses to the point it reaches the upper bank, the entire marsh surface will be inundated at once, potentially causing an expansive loss of salt marsh habitat in a short period of time. Applying material to the salt marsh surface on an incremental basis (higher to the back of the marsh, lower closest to the riverbank) will allow a more gradual loss of salt marsh over a longer period of time. Based on RICRMC's estimated average rate of 0.2 inches per year for sea level rise, this catastrophic loss of salt marsh at Unit 8 would be expected to occur within decades without treatment.

TLD will be used to restore approximately 14 acres of degraded marsh by applying sediments to recently degraded marsh areas. Marsh elevational restoration will target degraded and ponded areas, particularly areas of new or increasing pans and stressed/low density vegetation, and will seek to restore high marsh habitat and vegetation such as *S. patens* and salt marsh rush *(Juncus gerardii).* Areas adjacent to the existing banks containing tall form *S. alterniflora*, or stands of *S. patens* will not receive treatment.

Appendix G provides maps of application areas, purposes, management controls, estimated materials, and vegetation and elevation information for this action. It also provides information on development of elevation targets for TLD.

ACTION F: TEST TREATMENTS TO ENHANCE CONDITIONS FOR MARSH MIGRATION

Within a two-acre site currently comprised of an oak forest overstory near salt marsh transition zones, trees will be girdled to stimulate shrub production in the understory. Adjacent control sites in untreated oak forest neat the salt marsh transition zone will be evaluated and compared to determine whether this treatment has the potential to enhance conditions for salt marsh migration. This action will occur in upland sites and will have no impact on EFH or managed species.

F.1.3. MONITORING

Monitoring is a key component of adaptive management strategies. Information collected as part of monitoring can be used to adjust treatment as necessary to insure objectives are met.

Fisheries:
R.I. Dept. of Environmental Management (RIDEM), Div. of Fish and Wildlife, monitors finfish at three sites in the Narrow River Estuary on an ongoing basis**.** Fish samples are collected using a seine 130 ft. long (39.62m) and 5.5 ft. deep (1.67m) with ¼" mesh (6.4mm). The seine has a bag at its midpoint, a weighted footrope and floats on the head rope. The area swept by the seine net is estimated to be between 2000 and 2400 square feet. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard-powered 16' Lund aluminum boat. The net is then hauled toward the beach by hand and the bag is emptied into a large water-filled tote. All fish collected are identified by species, measured, enumerated, and sub-samples are taken when appropriate. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station. Seining at each station is conducted once a month for 6 months of the year between May and October.

The coordinates of the RIDEM fishery monitoring stations in Narrow River are:

Station	Latitude (Degrees)	Longitude (Degrees)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
NR1:	41 29' 09.6"	71 26' 53.3"	41.486	-71.448139
NR2:	41 27' 28.6"	71 27' 06.9"	41.457944	-71.451917
NR3:	41 27' 17.1"	71 27' 10.0"	41.45475	-71.452778

Results of this monitoring are described in Section F.2, below.

Nekton:
*As part of the Regional Salt marsh Integrity Monitoring Program (SMI), t*he Service monitors salt marsh nekton at 20 randomly chosen stations within the estuary. Additional sample locations will be established within TLD treatment units. Nekton are sampled from pools, pans, ditches and creeks in the salt marsh using either a ditch net or throw trap depending on the type of water body. Salinity data are also collected at each sampling location. The results of this survey were used to monitor nekton use over time.

Both the fisheries and nekton monitoring programs will be used to track ongoing status and trends of fish and invertebrate communities in the estuary, including any changes resulting from the proposed action.

Water quality:
The Narrow River Preservation Association will monitor nutrients and bacteria using methodologies approved by RIDEM and the U.S. Environmental Protection Agency (USEPA) for water quality monitoring in compliance with Clean Water Act reporting requirements throughout Rhode Island.

Tidal flow and volumes:
Water level data loggers, and water volume loggers, have been installed at five sites within the estuary: from just north of Middlebridge, just south of Sprague Bridge, two at Sedge Island, and one at Gooseberry Island. These data loggers have been operating continuously since July of 2014, and will be run over the next two years. This data will be used to determine how treatments applied in the estuary have influenced flows. Additional loggers will be installed at the crossing in Upper Pettaquamscutt Cove should the crossing remnant be removed there.

Living shorelines:
Salt marsh shoreline condition surveys (USFWS 2012) will be re-run in 2015 and in 2016 to determine trends in salt marsh shoreline conditions within and outside of treatment areas.

The Nature Conservancy has developed monitoring protocol to evaluate response to installation of shoreline treatments in those installments completed in 2014. This same protocol will be continued over the next two years.

Shoreline condition surveys (USFWS 2012) will be completed before and immediately after installation of additional shoreline treatments. Inspections will be completed in all shoreline treatment areas three times per year and after any significant storm event to monitor structure integrity.

Boat wakes:
Shorelines including those with and without living shoreline treatments will be monitored for erosion. Protocol for evaluating boat wakes and accelerated erosion will be redone and compared to data collected in 2009 (USFWS 2009).

Salt marsh elevations:
A total of 16 Surface Elevation Tables (SETs) have been installed within the estuary on salt marsh surfaces to monitor salt marsh elevations and compare them to rates of sea level rise. SETs have been installed both within and outside of treatment units.

Within TLD units, elevations before and after applications will be measured in order to determine salt marsh elevations both within and adjacent to treated sites. Surveys will be re-run at 6 month intervals for a period of two years. Monitoring protocols developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Save the Bay has developed protocols for intensive monitoring of two sites where runnels treatments will be applied (Cole Ekberg 2014). In other areas, elevation profiles will be completed along with establishment of photo plots at each site. Monitoring will occur at 6-month intervals following treatment. General inspections of all runnel treatment areas will be made three times per year to determine whether the treatments are trending towards achievement of goals, and to identify any modifications necessary to abate any unintended results (unanticipated levels of erosion, etc.).

Low marsh creation:
Elevation surveys will be undertaken before and immediately after creation. Standard planting success surveys will be implemented to determine whether salt marsh plug planting is successful. Sites will be inspected three times per year over two years to determine whether objectives are being met, whether erosion or drainage issues appear in order to rectify any potential problems.

Degraded salt marsh restoration with elevation capital (TLD treatments):
Elevation surveys will be completed prior to application, and immediately afterward. Target elevations will be staked throughout the units to guide application. Pre- and post-restoration vegetation surveys will be undertaken and repeated at yearly intervals for three years. The combination of standard vegetation monitoring (USFWS 2013), and unit-wide vegetation surveys will help determine vegetation response. Both within and outside units, bulk density and estimates of above and below ground biomass will be completed. Monitoring protocols developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Marsh migration treatments:
Surveys for vegetation composition will be completed on a yearly basis for three years.

F.2 POTENTIAL EFFECTS ON EFH AND MANAGED SPECIES

In order to evaluate potential impacts on EFH and managed species, this section provides information on fish and shellfish in Narragansett Bay and the Narrow River Estuary (Section F.2.1); describes existing EFH and fish habitat, including an analysis of the value of shallow-water habitats (Section F.2.2); and evaluates potential adverse effects of the actions on EFH and managed species (Section F.2.3).

In addition, literature was reviewed regarding utilization of salt marsh surfaces by estuarine fish in order to fully understand the value of salt marsh to estuarine species, and better assess potential impacts of the project on EFH and managed species (Section F.5.2). Based on this information and these assessments, conclusions regarding potential effects of the project on EFH and managed species are summarized in Section F.3.

F.2.1 FISH AND SHELLFISH IN NARRAGANSETT BAY AND THE NARROW RIVER ESTUARY

In order to develop a list of potential EFH and managed species in the Narrow River, the combined results of NOAA's 10 Minute Square EFH Tables (see http://www.greateratlantic.fisheries.noaa.gov/hcd/webintro.html) and results of a query to the NOAA Essential Fish Habitat Mapper V. 3.0 (as advised by NMFS staff on Sept. 18, 2014) was used. The combined list is provided in Table 1. Species that have been documented in the Narrow River by RIDEM are indicated by the shaded rows. The query to the EFH mapper and discussions with NMFS staff indicate there are no Habitat Areas of Particular Concern (HAPC) within the project area.

Table 1. Potential EFH Species in the Narrow River Area (NOAA 2014a and b)

Species (from NOAA 10 x 10 tables)	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Haddock (*Melanogrammus aeglefinus*)		X			
Red hake (*Urophycis chuss*)		X	X	X	X
Redfish (*Sebastes fasciatus*)	n/a				
Winter flounder (*Pleuronectes americanus*)	X	X	X	X	X
Windowpane flounder (*Scopthalmus aquosus*)	X	X	X	X	X
American plaice (*Hippoglossoides platessoides*)		X	X	X	
Atlantic sea herring (*Clupea harengus*)		X	X	X	
Bluefish (*Pomatomus saltatrix*)			X	X	
Long finned squid (*Loligo pealei*)	n/a	n/a			
Short finned squid (*Illex illecebrosus*)	n/a	n/a			
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X	
Summer flounder (*Paralicthys dentatus*)		X	X	X	
Scup (*Stenotomus chrysops*)	X	X	X	X	
Black sea bass (*Centropristus striata*)			X	X	
Surf clam (*Spisula solidissima*)	n/a	n/a			
Ocean quahog (*Artica islandica*)	n/a	n/a			
Spiny dogfish (*Squalus acanthias*)	n/a	n/a			
King mackerel (*Scomberomorus cavalla*)	X	X	X	X	
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X	
Cobia (*Rachycentron canadum*)	X	X	X	X	
Additional Species from EFH Mapper	**Life Stages from EFH Mapper**				
Ocean pout (*Zoarces americanus*)	Juvenile, Adult, Eggs, Larvae, All				
Sand tiger shark (*Carcharias taurus*),	Neonate, All				
Winter skate (*Leucoraja ocellata*)	Adult, Juvenile, All				
Little skate (*Leucoraja erinacea*)	Adult, Juvenile, All				
Atlantic cod (*Gadus morhua*)	Adult				
Silver hake (*Merluccius bilinearis*)	Larvae, Eggs, Juvenile, All				
Bluefin tuna (*Thunnus thynnus*)	Juvenile, Adult				
Monkfish (*Lophius americanus*)	Eggs, Larvae, All				
White shark (*Carcharodon carcharias*)	All				
Smooth dogfish (*Mustelus canis*)	All				
Common thresher shark (*Alopias vulpinus*)	All				
Sandbar shark (*Carcharhinus plumbeus*)	Adult, All				
Atlantic butterfish (*Peprilus triacanthus*)	Adult, All, Juvenile				

The notation "n/a" in Table 1 indicates either that no data are available on the designated life stages, or that those life stages are not present in the species' reproductive cycle (NOAA 2014a).

The RIDEM finfish survey has documented more than 70 species of fish and shellfish in the Narrow River Estuary (Table 2). Shaded rows indicate those for which NMFS has designated Narragansett Bay as potential EFH. The Service's nekton monitoring has documented more than 20 species of fish and invertebrates utilizing salt marsh pools, pans and ditches. These species are listed in Table 3.

Table 2. RIDEM Narrow River Fisheries Survey Results

Common name	Scientific name	Common name	Scientific name
Alewife	*Alosa pseudoharengus*	Menhaden Atlantic	*Brevoortia tyrannus*
Anchovy bay	*Anchoa mitchilli*	Minnow sheepshead	*Cyprinodon variegatus*
Anchovy striped	*Anchoa hepsetus*	Mojarra spotfin	*Eucinostomus argenteus*
Barbfish	*Scorpaena brasiliensis*	Mullet striped	*Mugil cephalus*
Bass largemouth	*Micropterus salmoides*	Mullet white	*Mugil curema*
Bass striped	*Morone saxatilis*	Mummichog	*Fundulus heteroclitus*
Bigeye	*Priacanthus arenatus*	Needlefish atlantic	*Strongylura marina*
Blue crab	*Calinectes sapidius*	Perch silver	*Bairdiella chrysoura*
Bluefish	*Pomatomus saltatrix*	Perch white	*Morone americana*
Butterfish	*Peprilus triacanthus*	Permit	*Trachinotus falcatus*
Cod Atlantic	*Gadus morhua*	Pipefish northern	*Syngnathus fuscus*
Conger eel	*Conger oceanicus*	Pollock	*Pollachius virens*
Cunner	*Tautogolabrus adspersus*	Pompano african	*Alectis ciliaris*
Eel American	*Anguilla rostrata*	Puffer bandtail	*Sphoeroides spengleri*
Flounder gulfstream	*Citharichthys arctifrons*	Puffer northern	*Sphoeroides maculatus*
Flounder smallmouth	*Etropus microstomus*	Rainwater killifish	*Lucania parva*
Flounder summer	*Paralichthys dentatus*	Sand lance American	*Ammodytes americanus*
Flounder winter	*Pseudopleuronectes americanus*	Scad bigeye	*Selar crumenophthalmus*
		Scup	*Stenotomus chrysops*
Flying gurnard	*Dactylopterus volitans*	Sea bass black	*Centropristis striata*
Goby naked	*Gobiosoma bosc*	Seahorse lined	*Hippocampus erectus*
Goby naked	*Gobiosoma bosc*	Searobin northern	*Prionotus carolinus*
Goby seaboard	*Gobiosoma ginsburgi*	Searobin striped	*Prionotus evolans*
Grubby	*Myoxocephalus aenaeus*	Sennet northern	*Sphyraena borealis*
Gunnel rock	*Pholis gunnellus*	Silverside Atlantic	*Menidia menidia*
Haddock	*Melanogrammus aeglefinus*	Silversides	*Atherinidae*
Hake red	*Urophycis chuss*	Smelt rainbow	*Osmerus mordax*
Hake spotted	*Urophycis regia*	Snapper gray	*Lutjanus griseus*
Hake white	*Urophycis tenuis*	Spot	*Leiostomus xanthurus*
Herring atlantic	*Clupea harengus*	Stickleback fourspine	*Apeltes quadracus*
Herring blueback	*Alosa aestivalis*	Stickleback ninespine	*Pungitius pungitius*
Hogchoker	*Trinectes maculatus*	Stickleback threespine	*Gasterosteus aculeatus*
Horseshoe crab	*Limulus polyphemus*	Tautog	*Tautoga onitis*
Jack crevalle	*Caranx hippos*	Toadfish oyster	*Opsanus tau*
Jenny silver	*Eucinostomus gula*	Tomcod Atlantic	*Microgadus tomcod*
Killifish striped	*Fundulus majalis*	Windowpane	*Scophthalmus aquosus*
Kingfish northern	*Menticirrhus saxatilis*		
Lizardfish inshore	*Synodus foetens*		

Table 3. Nekton species sampled at the John H. Chafee and Sachuest NWR from 2012-2014	
Common Name	**Scientific Name**
Mummichog	*Fundulus heteroclitus*
Striped killifish	*Fundulus majalis*
Banded killifish	*Fundulus diaphanous*
Sheepshead minnow	*Cyprinodon variegatus*
Atlantic silverside	*Menidia menidia*
Ninespine stickleback	*Pungitius pungitius*
Fourspine stickleback	*Apeltes quadracas*
Rainwater killifish	*Lucania parva*
Bluefish	*Pomatomus saltatrix*
White perch	*Morone Americana*
Alewife	*Alosa pseudoharengus*
Northern pipefish	*Syngnathus fuscus*
American eel	*Anguilla rostrata*
Winter flounder	*Psuedopleuronectes americanus*
Blue crab	*Callinectes sapidus*
Sand fiddler crab	*Uca pugilator*
European green crab	*Carcinus maenas*
Asian shore crab	*Hemigrapsus sanguineus*
Common spider crab	*Libinia emarginata*
Daggerblade grass shrimp	*Palaemonetes pugio*
American prawn	*Palaemonetes vulgaris*
Sand shrimp	*Crangon septemspinosa*

RIDEM survey results indicate the most abundant species in the estuary are Atlantic silverside, mummichog, winter flounder, sheepshead minnow, striped killifish, four-spine stickleback, Northern pipefish and Atlantic menhaden. Of these, potential EFH is designated in the area only for winter flounder; however all of these species are of great ecological importance, providing forage for larger fish species as well as predatory birds and marine mammals. Fish species of greatest commercial and recreational importance found by RIDEM are bluefish, tautog, black sea bass and striped bass (RIDEM 2014). NOAA has designated the estuary as potential EFH for all of these species except striped bass.

Diadromous species present in estuary include alewife, blueback herring and American eel. The Gilbert Stuart Brook system in North Kingstown supports one of Narragansett Bay's most important river herring runs; all of these fish pass through the Narrow River Estuary while migrating between salt and fresh water habitats (RICRMC 2001).

Winter flounder were an abundant recreational and commercial fishery species on Narragansett Bay as late as the 1970's. The species declined significantly over the past several decades due to ecological and anthropogenic factors (Gibson 2013), leading to increased recreational and commercial fishery restrictions. Juvenile winter flounder are abundant in the Narrow River Estuary, indicating the high value of the estuary as spawning habitat for this species and its ecological importance in maintaining Narragansett Bay's fish populations.

According to RIDEM, alewife, blueback herring, winter flounder and American eel are regionally declining or vulnerable to decline. Fishing bans are in effect on alewives and blueback herring due to regional population declines; however local populations of these fish are stable, due in part to the abundant Narrow River runs (Lake 2014, pers. comm.).

Table 4. Historical Presence of Shellfish in the Estuary (Adapted from Berounsky and Nixon 2007)			
Author	**Study Dates**	**Shellfish Description**	**Locations**
Wright et al.	**1948**	**Little commercial shellfishing**	
		"Fairly large crop of quahogs" for rec. shellfishing	Throughout river
Campbell in Wright 1958	**Summer 1957**		**Maps of shellfish beds are included in the report**
		Quahogs (hard clams) = now *Mercenaria mercenaria*:	Found between Sprague Bridge and Middlebridge, mostly on low marsh islands.
		Soft shell clams = *Mya arenaria:*	Found only in one bed, in channel north of Bridgetown Bridge.
		Oysters = *Ostrea virginica,* now *Crassotrea virginica:*	Continually line both shores from Upper Pond to Bridgetown Bridge.
		Oysters = *C. virginica:*	Patches south of Bridgetown Bridge until Middlebridge.
		Mussels = *Mytilus edulis:*	Found only between Middlebridge and Sprague Bridge.
		Blue crabs = *Callinectes sapidus*	Found along entire river, numbers fluctuate, 1957 season very productive.
Nixon and Oviatt	**July 1970**		
		Quahogs, Biomass = 292.2 g/m2	Middlebridge area
		Soft shell clams, Biomass = 0.2 g/m2	Middlebridge area
Baczenski and Ganz	**1980**		
		Density = 2/m2 oysters	Upper Pond
		Density = 6/m2 oysters	Lower Pond
		Density = 0.5/m2 razor clams	Middlebridge
		Density = 0.5/m2 razor clams	Pettaquamscutt Cove
		Density= 4/m2 soft shell clams	Pettaquamscutt Cove
		Density = 2/m2 quahogs	Pettaquamscutt Cove
		Density = 0.5/m2 mussels	Breachway
		Density=0.5/m2 soft shell clams	Breachway
		Density = 0.5/m2 quahogs	Breachway
Kelz	**1990-1991**		**Water column turnover occurred in Oct.1990**
		Nothing noted	Upper Pond
		Abundant oysters	Lower Pond (off beach at Pettaquamscutt Lake Shores)
		Patches of oysters	Pettaquamscutt Terrace Beach
		Small mussel beds	100 m south of Middlebridge
		Mussel bed covers most of channel	200m west of Sprague Bridge
Kelz	**1996**		
		Oysters	Population "wide-spread" on gravel edges of both Ponds.
		Oysters	No oysters found in mud areas of Ponds.

During the 1950's the estuary supported a commercial fishery for striped bass (RICRMC 2001); it also formerly supported a beach seine fishery for white perch (O'Brien 2014, pers. comm.). Today the estuary remains an important feeding area for striped bass, and the Narrow River Inlet, as well as open-water areas within the estuary, are popular recreational fishing spots for this species. Striped bass is among the most important fishery species on the U.S.

Atlantic Coast. The species experienced a period of rebuilding following fishery restrictions during the 1980's, but has declined somewhat in abundance over the past decade (ASMFC 2014).

Shellfish presence is varied; most species occur in relatively low densities (Table 4). Shoreline surveys conducted in 2009 found the density of ribbed mussel (*Geukensia demissa*) increases with increased distance from the mouth of the river, likely due to a salinity gradient (USFWS 2009). Oysters occur throughout the estuary, but are generally limited because of unfavorable substrates. Razor clam (*Siliqua patula*), quahog, and soft shell clams all occur, but the density of quahog and soft shell clams, at least in the tidal flats near Sedge Island, occur in very low density (less than one per square meter; RICRMC data 2014).

F.2.2 SHALLOW WATER HABITAT ANALYSIS

Shallow water habitats important as essential fish habitat include mud, sand, and gravel/cobble substrates, eelgrass beds, and salt marsh (tidal creeks and channels) habitat. No Habitat Areas of Particular Concern (HAPC) are listed by NOAA within the project area.

To fully assess fish habitat values in the Narrow River Estuary, an analysis of the value of shallow-water habitats was completed using information from, and employing the analytical approach used by, Stevenson and others (2014) in the report "Shallow Water Benthic Habitats in the Gulf of Maine." This analysis was applied to species in the report that are present in the Narrow River estuary, based on RIDEM surveys, or for which EFH habitat is expected to be present, based on NOAA EFH tables and mapper results.

Results of the shallow-water habitat analysis are presented in Table 5 for each shallow-water habitat type present in the estuary (mud, sand, eelgrass, salt marsh, and gravel/cobble) below, followed by an analysis of relative values for all species (Figure 4).

Table 5. Shallow water habitat analysis for the Narrow River Estuary

Species	Scientific Name	RIDEM Priority	EFH Priority	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
Mud									
American eel	*Anguilla rostrata*	Yes	No	NA	NA	1	1	1	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	0	NA	1	NA	1	0
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	0	0	0	0
Little skate	*Leucoraja erinacea*	No	Yes	0	NA	1	1	1	0
Pollock	*Pollachius virens*	Yes	No	NA	NA	1	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	1	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	0	0	0	0
White hake	*Urophycis tenuis*	Yes	No	NA	NA	1	-	-	-
Windowpane Flounder	*Scophthalmus aquosus*	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	1	NA	2	2	1	1

Species	Scientific Name	RIDEM Priority	EFH Priority	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
Sand									
American eel	*Anguilla rostrata*	Yes	No	NA	NA	1	1	1	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	1	NA	1	NA	1	1
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	0	0	0	0
Little skate	*Leucoraja erinacea*	No	Yes	2	2	2	2	2	2
Pollock	*Pollachius virens*	Yes	No	NA	NA	1	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	1	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	1	0	0	0
White hake	*Urophycis tenuis*	Yes	No	NA	NA	1	-	-	-
Windowpane	*Scophthalmus aquosus*	Yes	Yes	NA	NA	2	2	2	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	2	NA	2	2	1	2

Table 5, continued

Eelgrass									
Species	**Scientific Name**	**RIDEM Priority**	**EFH Priority**	**Life History Stage**					
				Eggs	**Larvae**	**YOY Juveniles**	**Older Juveniles**	**Adults**	**Spawning Adults**
American eel	*Anguilla rostrata*	Yes	No	NA	NA	1	0	0	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	2	0	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	1	NA	2	NA	1	1
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	1	1	1	1
Little skate	*Leucoraja erinacea*	No	Yes	0	0	0	0	0	0
Pollock	*Pollachius virens*	Yes	No	NA	NA	2	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	2	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	2	2	2	2
White hake	*Urophycis tenuis*	Yes	No	NA	NA	2	-	-	-
Windowpane	*Scophthalmus aquosus*	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	2	NA	2	2	1	2
Salt Marsh									
Species	**Scientific Name**	**RIDEM Priority**	**EFH Priority**	**Life History Stage**					
				Eggs	**Larvae**	**YOY Juveniles**	**Older Juveniles**	**Adults**	**Spawning Adults**
American eel	*Anguilla rostrata*	Yes	No	NA	NA	-	1	1	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	1	NA	1	NA	1	1
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	0	1	1	1
Little skate	*Leucoraja erinacea*	No	Yes	0	0	0	0	0	0
Pollock	*Pollachius virens*	Yes	No	NA	NA	1	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	1	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	0	0	0	0
White hake	*Urophycis tenuis*	Yes	No	NA	NA	2	-	-	-
Windowpane	*Scophthalmus aquosus*	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	0	NA	1	2	1	0

Table 5, continued

Gravel/Cobble									
Species	**Scientific Name**	**RIDEM Priority**	**EFH Priority**	**Life History Stage**					
				Eggs	**Larvae**	**YOY Juveniles**	**Older Juveniles**	**Adults**	**Spawning Adults**
American eel	*Anguilla rostrata*	Yes	No	NA	NA	-	1	1	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	2	1	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	1	NA	1	NA	1	1
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	1	1	1	1
Little skate	*Leucoraja erinacea*	No	Yes	0	NA	2	2	2	0
Pollock	*Pollachius virens*	Yes	No	NA	NA	1	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	1	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	1	1	1	1
White hake	*Urophycis tenuis*	Yes	No	NA	NA	2	-	-	-
Windowpane	*Scophthalmus aquosus*	Yes	Yes	NA	NA	0	0	0	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	1	NA	-	0	1	1

Figure 4. Relative Value of All Narrow River Shallow Water Habitats for Estuarine Fish

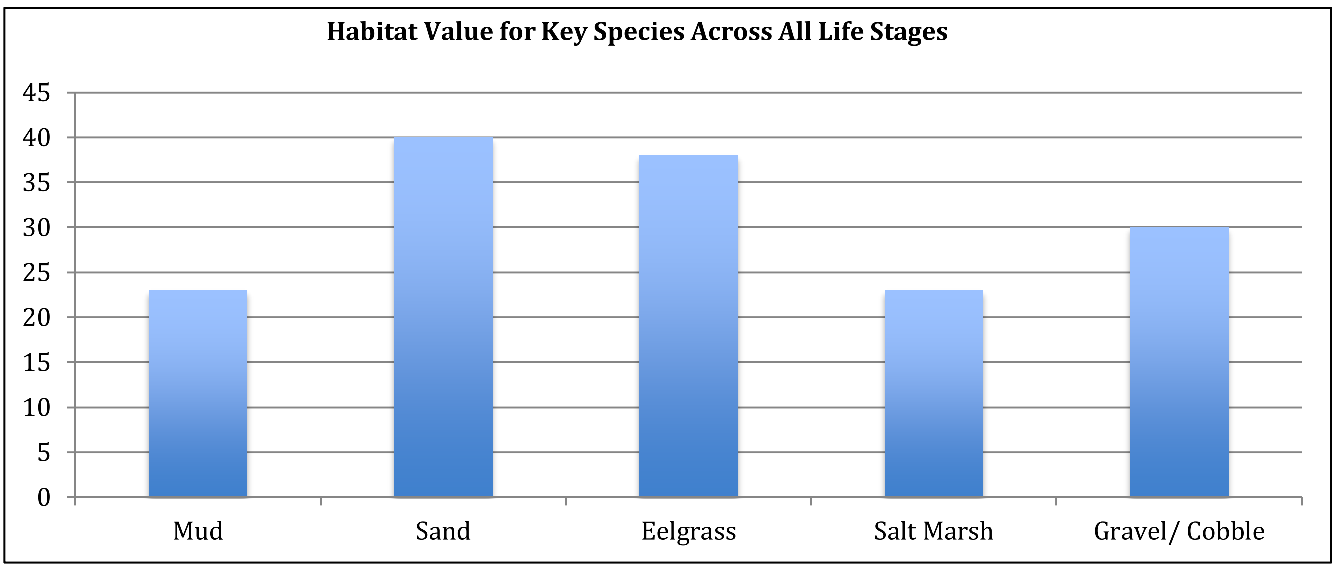
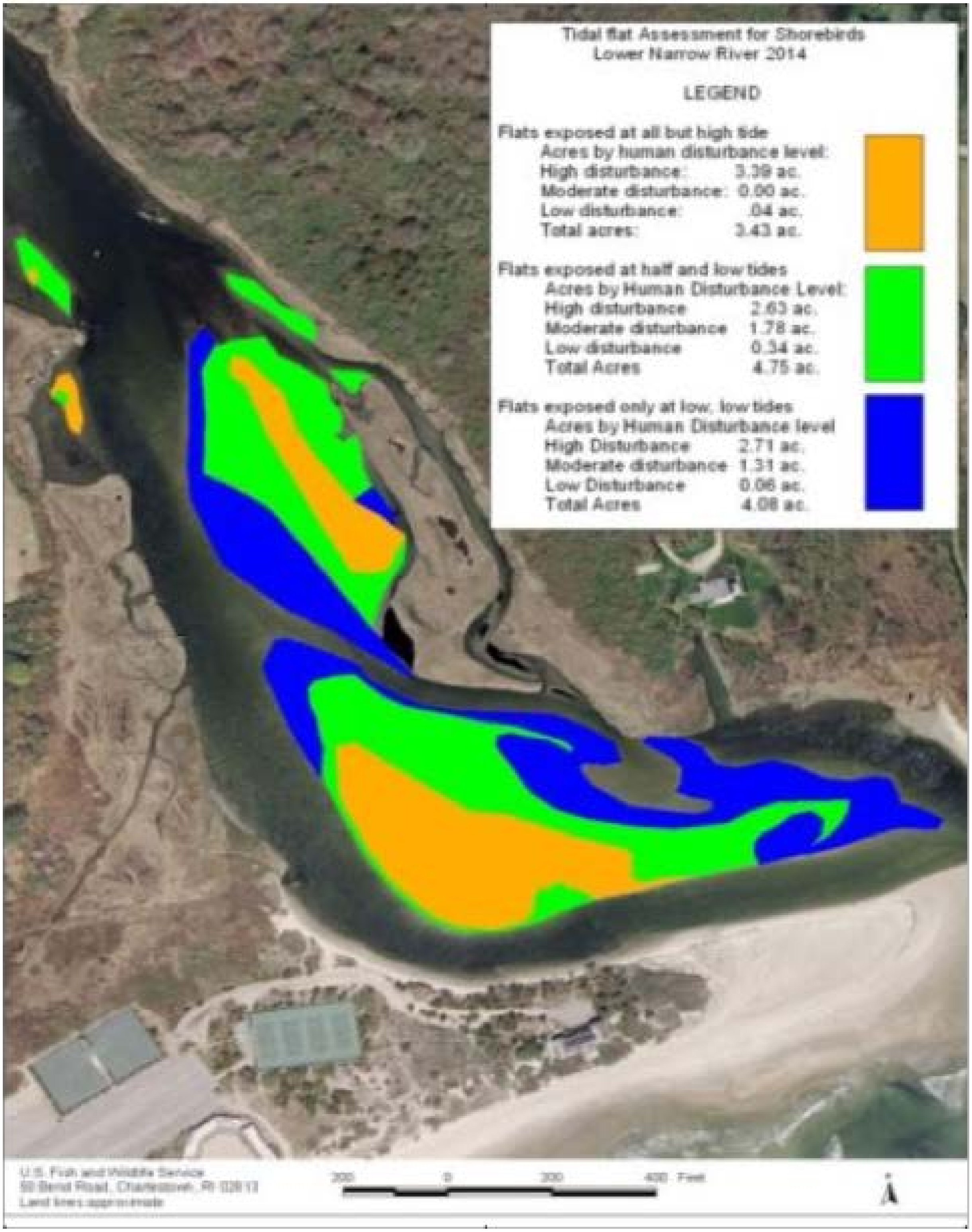
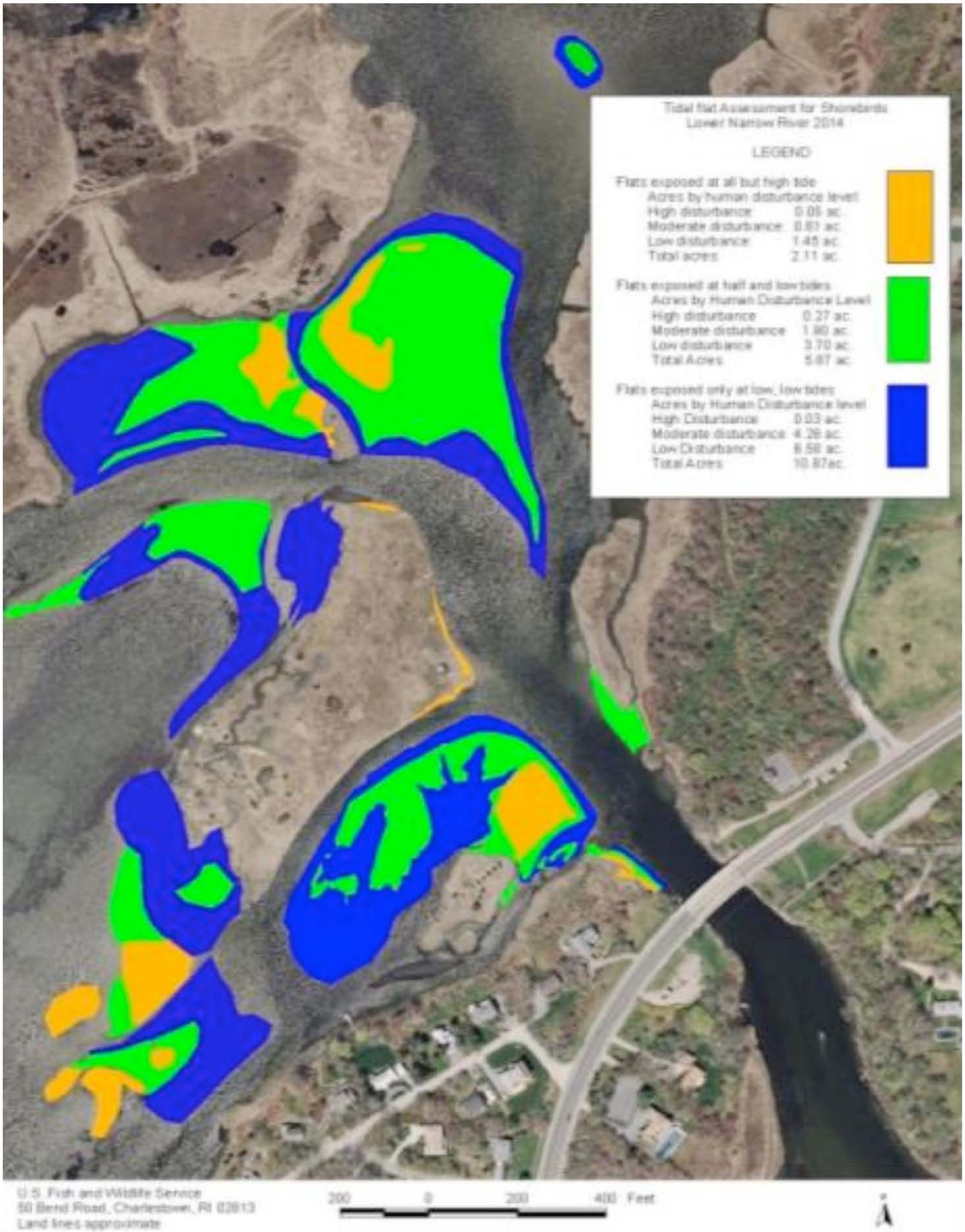


Figure 5a and 5b. Occurrence of Tidal Flats in the Lower Estuary (based on aerial photo interpretation)



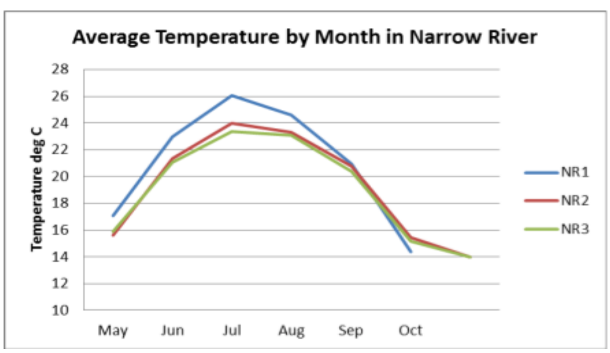

Total flat Assessment for Shorebirds
Lower Narrow River 2014
LEGEND
Flats exposed at all but high tide
Acres by human disturbance level
High disturbance 0.05 ac.
Moderate disturbance 0.61 ac.
Low disturbance 1.45 ac.
Total acres 2.11 ac.
Flats exposed at half and low tides
Acres by Human Disturbance Level
High disturbance 0.27 ac.
Moderate disturbance 1.90 ac.
Low disturbance 3.70 ac.
Total Acres 5.87 ac.
Flats exposed only at low, low tides
Acres by Human Disturbance level
High Disturbance 0.03 ac.
Moderate disturbance 4.26 ac.
Low Disturbance 6.58 ac.
Total Acres 10.87ac.
U.S. Fish and Wildlife Service
50 Bend Road, Charlestown, RI 02813
Land lines approximate
200 0 200 400 Feet

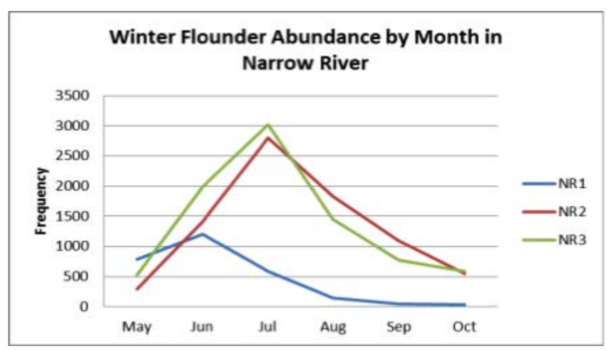
The analysis demonstrates that all shallow-water habitats present are valuable to estuarine fish. Sand-bottom and eelgrass appear to be the most valuable, although this result is qualified by the fact that much of the fine sand habitat is intertidal or very shallow (less than 2 feet MLW), and therefore cannot provide sufficient depth or temperature to support estuarine species during lower tides or warmer weather. As shown in Figure 6, most fine sand habitat is concentrated within tidal flats. Course sands and cobbles occur in deeper portions of the channel and provide better habitat conditions than the shallow fine sand deposits.

Examination of fish survey data collected by RIDEM (Lake 2014, pers. comm.), demonstrates that the waters of the estuary have little fish habitat value once water temperature reaches 26-28 degrees C, which commonly occurs in the shallowest areas during the summer (Table 6).

Table 6. Narrow River Water Parameters, 1994 – 2013 (May – Oct.) (Lake 2014, pers. comm.)	
Near Lacy (Bridgetown) Bridge	
Average Temperature:	21.2 +/- 4.6 °C
Average Salinity:	17.2 +/- 5.3 ppt
Average Dissolved Oxygen:	7.7 +/- 1.7 mg/l
At Middlebridge	
Average Temperature:	20.3 +/- 4.2 °C
Average Salinity:	26.9 +/- 5.3 ppt
Average Dissolved Oxygen:	7.6 +/- 1.3 mg/l
At Refuge Reach (South of Middlebridge)	
Average Temperature:	19.9 +/- 4.0 °C
Average Salinity:	27.4 +/- 4.7 ppt
Average Dissolved Oxygen:	7.6 +/- 1.3 mg/l

Figures 6a and 6b. Comparison Between Average Temperature and Abundance of Winter Flounder in the Estuary





It is therefore likely that eelgrass is in fact the most valuable fish habitat in the Narrow River Estuary. Although salt marsh creeks and channels did not score as highly as sand and eelgrass, they provide value to at least nine species of fish across multiple life stages. Most important, the analysis demonstrates that the Narrow River's historic mosaic of shallow-water and estuarine habitats provides EFH value across multiple species and life stages.

While an inventory of habitats has not been completed estuary wide, it has been completed for the area between Middlebridge and Sprague Bridge, where most proposed intensive actions will take place. Figures 7 and 8 display elevations (bathymetry) and benthic habitat types respectively.

Eelgrass distribution in the Estuary has varied markedly over time. Since at least 1948, the main bed for eelgrass has been near Middlebridge while eelgrass apparently occurred near the breachway in the 1940's (Berounsky and Nixon

Figure 7. Bathymetry of the Middle Portion of the Narrow River Estuary (Boothroyd and Oakley 1987)

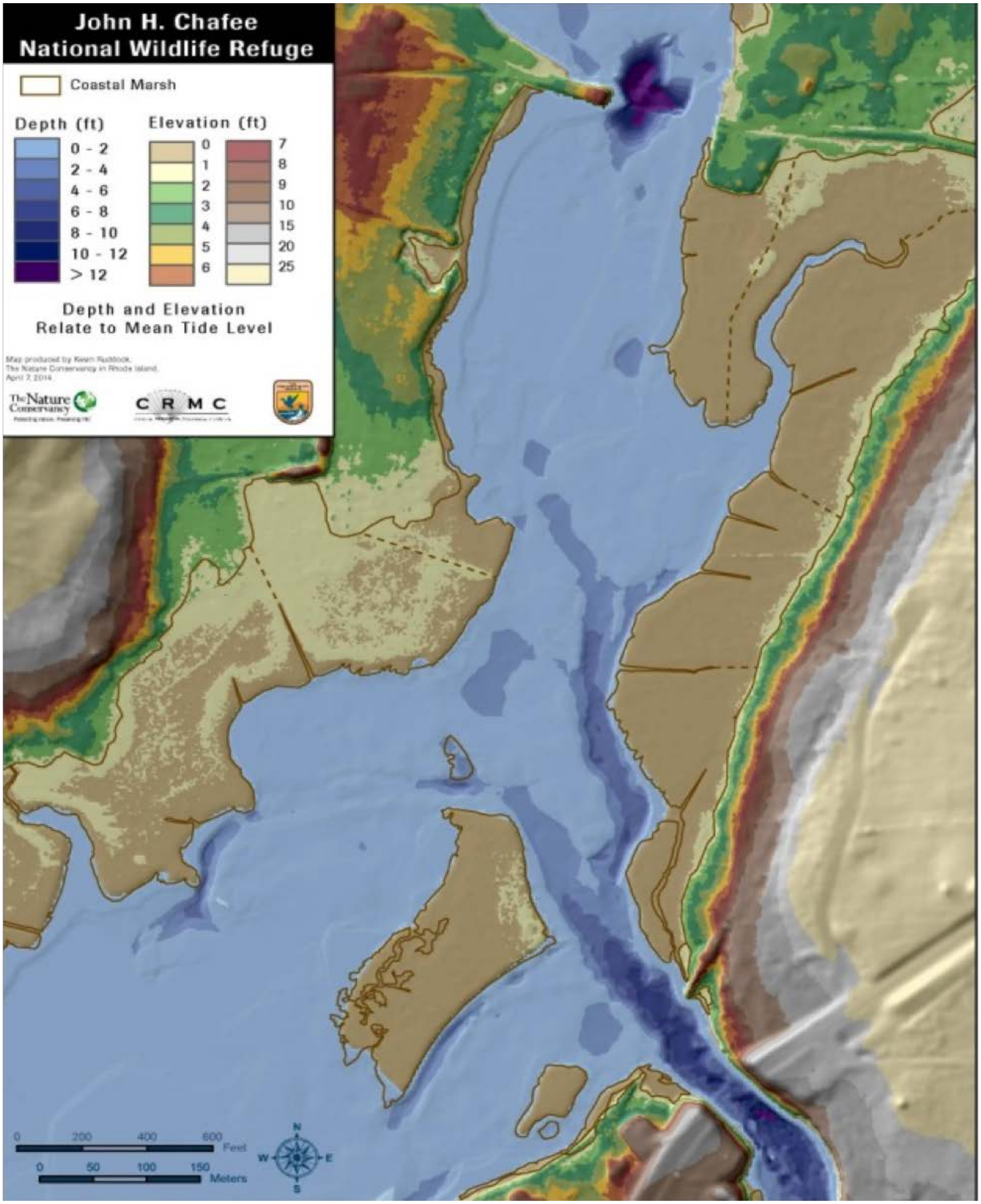
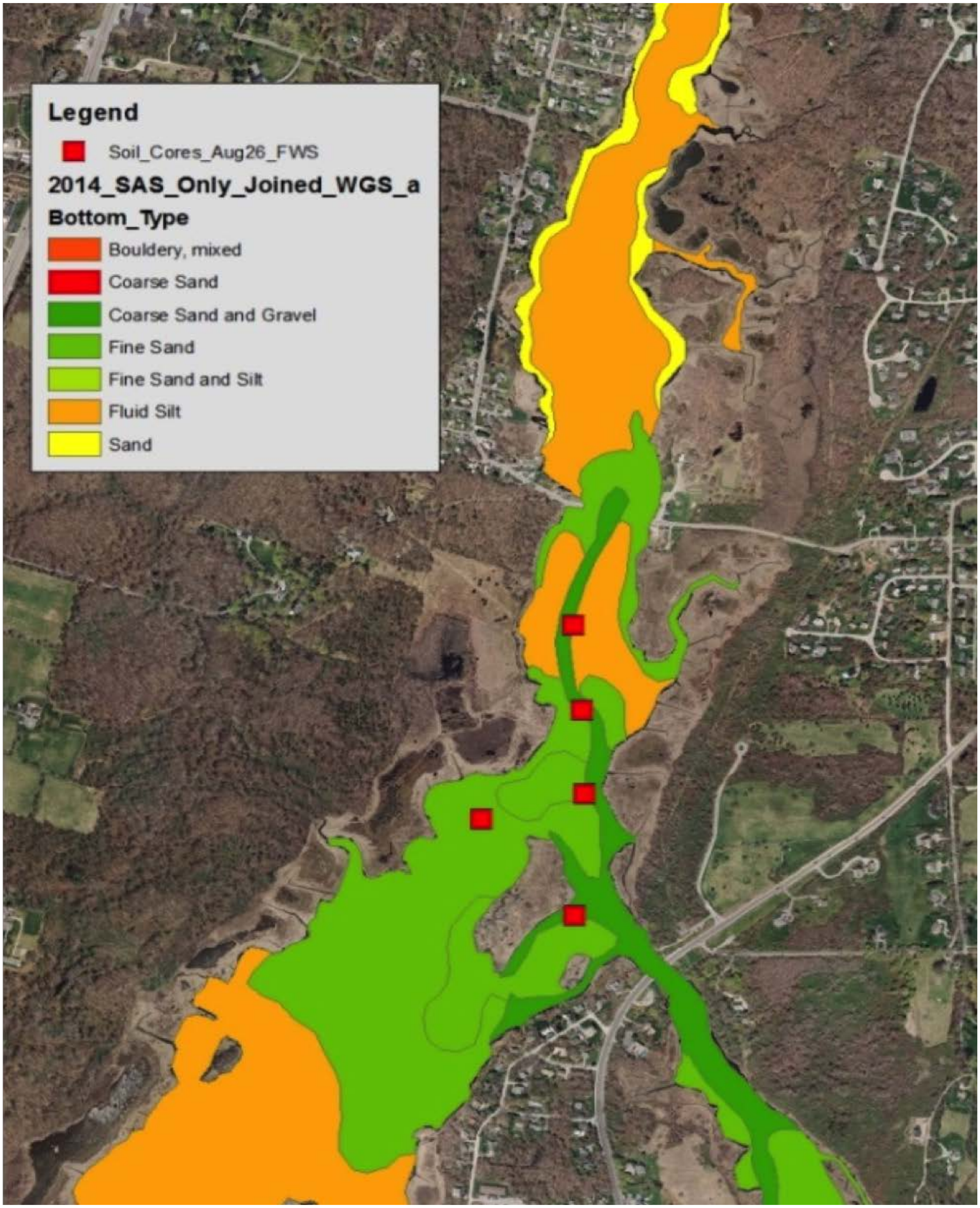


Figure 8. Benthic Habitats in the Narrow River Estuary (NRCS 2007).



2007; see Table 7). Bradley and others (2013) surveyed south of Middlebridge in 2012 and only found three small locations where eelgrass was present. In contrast, surveys in 2014 (USFWS 2014) found eelgrass in many areas, albeit at low densities. The 2014 surveys did not detect any eelgrass downstream of Sprague Bridge (Figure 9).

Table 7. Presence of Eelgrass in the Estuary (Adapted from Berounsky and Nixon 2007)

Author	Study Dates	Locations	Eelgrass description
Wright et al.	**1948**	**South of Middlebridge to breachway**	**"Excellent"**
		North of Middlebridge	Extends a few hundred yards
		Pettaquamscutt Cove to Rock Island	"Good" stand
		South of Rock Island	Absent
		East by old railroad piling	Some
		Unidentified areas	"Great expanses" with no eelgrass
Nixon and Oviatt	**Jul 1970**	**Middlebridge area, south**	**Eelgrass present, used for experiment**
Nagle	**1971**	**Gilbert Stuart Stream**	**No vegetation**
		Mouth of Gilbert Stuart Stream	No vegetation
		Upper Pond beach, west shore	No vegetation
		Walmsley Lane end, west shore	No vegetation
		Bridgetown Bridge, upstream, east shore	No vegetation
		Middlebridge, near bridge, west shore	None near shore, but extensive beds in River
		Middlebridge, downstream, west shore	Extensive eelgrass beds
		Sprague Bridge, upstream, south shore`	No vegetation
		Sprague Bridge, downstream, north shore	Extensive eelgrass beds
Sieburth and Thomas	**October 1971**	Mid-Narrow River	Mature, 1st year plants
	March-April 1972	Mid-Narrow River	Young plants collected by SCUBA divers
Kesler	**March-April 1973**		
		Bridgetown Bridge, downstream, west shore	Eelgrass present
		Middlebridge, downstream, west shore	Eelgrass abundant
		Sprague Bridge, downstream, west shore	No eelgrass mentioned
Short	**1974-1975**	Middlebridge, south	Abundant large eelgrass beds
	1989	Middlebridge, south	No eelgrass, much macroalage
Kelz	**October 1990-August 1991**		***Turnover in Oct.1990**
		Upper Pond	No eelgrass noted
		Lower Pond (off beach at Pettaquamscutt Lake Shores)	No eelgrass noted
		Pettaquamscutt Terrace Beach	No eelgrass noted
		100 m south of Middlebridge	Small eelgrass stand
		200m west of Sprague Bridge	No eelgrass noted
Tuxbury	**2006**	Whole river via aerial photos	No eelgrass identified
Bradley	**2012**	South of Middlebridge	Three small patches found
USFWS	**2014**	Middlebridge to Mouth excluding Pettaquamscutt Cove.	Light density from Middlebridge downstream to North of Sedge Island in deeper channels.

Figure 9. Current Distribution of Eelgrass below Middlebridge (USFWS 2014). Areas above Middlebridge contain a high density of eelgrass.

The Environmental Assessment provides a more detailed discussion of salt marsh habitat availability, conditions, and trends. Appendix B provides detailed information regarding current salt marsh habitats in the estuary, as summarized in Table 8.

Table 8. Availability of Salt marsh Habitats in the Narrow River Estuary

RIVER REACH	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				Non-TIDAL (BRACKISH) MARSH	ESTUARINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOL and PANS	OLD POOL and PANS	ALL POOL and PANS	% POOLS and PANS					
Lacy Bridge	31.7	15.2	4.4	0.9	5.2	34.3	5.3	0.2	25.9	5.8	38.1
Mettatuxet	2	1.6	0	0	0		0.1	0	1.8	0.2	14.7
Middle-bridge	83.3	31.6	3.3	4.9	8.2	26	9.2	2.1	51.1	32.2	102.2
Refuge	36.9	24.8	1	0.5	1.5	5.9	1.6	1.3	29.1	7.8	31.3
Pett. Cove	169	86.8	5.7	14.2	20	23	12.6	0.6	119.9	49.1	56.5
Lower Narrow River	21.4	14	0	0.5	0.5	3.7	0	0	14.5	6.8	48.8
All River Reaches	344.2	174	14.3	21	35.4	20.3	28.8	4.2	242.3	101.9	58.6

Low marsh, typified by the presence of tall form variant of *S. alterniflora*, is inherently limited in availability because of the relatively high elevations of salt marsh in the estuary. Most salt marsh lies above the mean high water line, calculated to be 0.85 feet NAGVD88 in 2009. A survey of the marsh in 2009 found the high tide line typically occurs within two feet of the salt marsh bank interior from the river.

The tall form variant of *S. alterniflora* primarily occurs at elevations of .90 feet NAVD88 or lower primarily along drainage ways and shorelines within 10 to 20 feet of the bank, and is typically associated with *salicornia spp. and Distichlis spicata.* There is an estimated 24 acres of healthy, low marsh in the estuary. Salt marsh at higher elevations and in well-drained areas is dominated by *S. patens,* and *Juncus spp.*

In waterlogged, poorly drained sites, a mix of sparse short form variant of *S. alterniflora* and *Salicornia* occur interspersed with open bare flats, many of which contain residual root masses of S. patens. These areas are considered as degraded salt marsh. Many of these sites are believed to have been dominated by a mixture of *S. patens, Juncus*, and tall form *S. alterniflora*. But because of trapped water on the salt marsh surface, only sparse short form S. *alterniflora*, large areas dominated by *Salicornia*, and open pans dominate these sites. Ongoing vegetation monitoring indicates these sites are expanding (Figures 10a-c).

At the upper edge of salt marsh habitats, high tide bush *(Iva fructecsens)* occurs as well as non-tidal, brackish marsh plant communities dominated in varying degrees with cattail *(Typha spp.)* phragmites *(Phragmites australus),* and bulrush *(Scirpus spp,)* (USFWS data 2009-2014), where salt marsh is typically dominated by *S. patens* high marsh communities, and are typically located on higher elevations above mean high water not regularly flooded by tides (Montague and Wiegert 1990).

Salt marsh habitat has likely declined over time in the Narrow River. Comparison of coastal survey maps completed in the 1800's and early aerial photography reveals that over 12 acres of salt marsh have been lost over time, and salt marsh shoreline surveys conducted by the Service (USFWS 2009; 2012) show a continuing loss of salt marsh along the shoreline (Appendix D). This survey revealed that over 96% of salt marsh shorelines along the river are undercut on average by two feet or more, and that this causes catastrophic loss of salt marsh banks as the undercut areas fail.

Salt marsh habitat has also declined due to expansion of newer pools and pans on the salt marsh surface by an estimated 14.3 acres. Increased tide heights, drainage of fresh water sources directly onto the salt marsh surface, pooling of tidal water on the marsh due to poor drainage of the surface, all seem to be adversely affecting the amount of salt marsh vegetation, species composition within salt marsh habitats the health or robustness of vegetation, and biomass production needed to allow the marsh to keep up with sea level rise. The presence and possible overabundance of green crabs (*Carcinus spp*.) may also play a role in reduced bank vegetation from herbivory.

Field surveys indicate that pools, which were present on the marsh in 1939 (based on aerial photo interpretation) and are still present today provide high quality habitat for fish, in particular mummichog, killifish and stickleback. These "historic" pools (Table 8) are deeper, with more established banks, than those which have developed since 1939. Fish production in established pools attracts a wide variety of wading birds and waterfowl, and also aids in mosquito abatement. Newer pools and pans are much shallower, dry up in the summertime, and have little biological value.

Tidal channels and ditches provide ready access onto the surface of the marsh and into some pools for managed species (Table 9; note each side of a slough was counted separately). There are approximately 17 acres of tidal marsh where clogging of channels and ditches with sediment has limited access to these areas (see Appendix B for locations). The length of channels providing access is expected to decline over time as they fill with sediment and vegetation.

Table 9. Slough and Channels Providing Access to Salt marsh Habitats

River Reach	Functional drainage (ft)*	Non-functional Drainage (ft)	Accessible Marsh (ac.)**	Limited Accessible Marsh (ac.)***
Lacy Bridge	6,003	2,281	11.4	4
Middlebridge	12,366	1,887	17.5	3.4
Pettaquamscutt Cove	18,427	3,984	54.6	7.9
Refuge	7,035	1,810	12.1	1.8
Lower	7,972	58	11.7	0.1
Total	51,803	10,020	107.3	17.2

*Length of slough and channel shorelines.
**Areas within 50 ft of a functional drainage.
*** Areas farther than 50' from functional drainage.

F.2.3 POTENTIAL EFFECTS ON ESSENTIAL FISH HABITAT AND MANAGED SPECIES

The Narrow River Estuary supports and depends on a mosaic of diverse estuarine habitats, ranging from eelgrass beds in deeper waters to high marsh habitat. However, habitat degradation and loss are occurring in the estuary due to accelerating sea level rise, motorboat wakes and other anthropogenic factors. The proposed restoration is intended to address these ongoing impacts, to preserve and restore existing habitats while preventing and reducing habitat loss. The proposed project will restore the mosaic of healthy estuarine habitats, including EFH, by deepening estuarine areas, providing conditions suitable for eelgrass expansion, restoring salt marsh surfaces and vegetation, restoring salt marsh shorelines, and reducing the rate of salt marsh loss.

ACTION A: WATERSHED AND WATER QUALITY RESTORATION

Increased knowledge of non-point source pollution from intensified monitoring will allow informed decisions regarding effective abatement of pollution sources in the estuary. Further investigation of pollution sources within the Mumford Brook drainage, which has the poorest water quality of all tributaries to the estuary, will further efforts for the detection of specific pollution source locations.

Design and construction of BMPs in two of the highest priority sites will directly reduce pollution into the estuary by treating stormwater runoff. If funds are unavailable for construction, designs created and approved by RIDEM will provide "shovel ready" projects should other funding sources become available. All BMP work will be conducted in upland areas and therefore this construction will not impact EFH.

Reductions in nitrogen entering the aquatic system can beneficially influence both salt marsh shoreline stability and biomass production on the marsh. In estuaries with excessive nitrogen inputs, above ground biomass increased, however Johnson and others (2012) found that taller salt marsh grasses also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Over time, wide cracks began forming in the grassy banks of the tidal creeks, which eventually slumped down and collapsed into the muddy creek. Taller grass also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Excessive nitrogen loading can adversely impact below ground biomass production in salt marshes, in addition to making above ground production more susceptible to grazing from species such as green crab (Ramnarine *et al.* 2008). Maximizing above and below ground biomass production on salt marsh surfaces will help rates of elevation gain on the salt marsh as a whole.

Removal of portions of the former road crossing will enhance flushing in Upper Pettaquamscutt Cove, alleviating, to a degree, water quality impairments in this portion of the Cove. Crossing remnant removal may cause short-term disruption of benthic habitats, but habitat values will be improved over time.

Reductions in nitrogen loading and placement of living shorelines adjacent to salt marsh shorelines are anticipated to enhance salt marsh bank stability along 3,000 feet of shoreline.

ACTION B: EELGRASS, ESTUARINE CHANNEL AND BASIN RESTORATION

Estuarine basins and channels will be deepened by removing existing sediments to a depth of approximately -5 feet NAVD88.

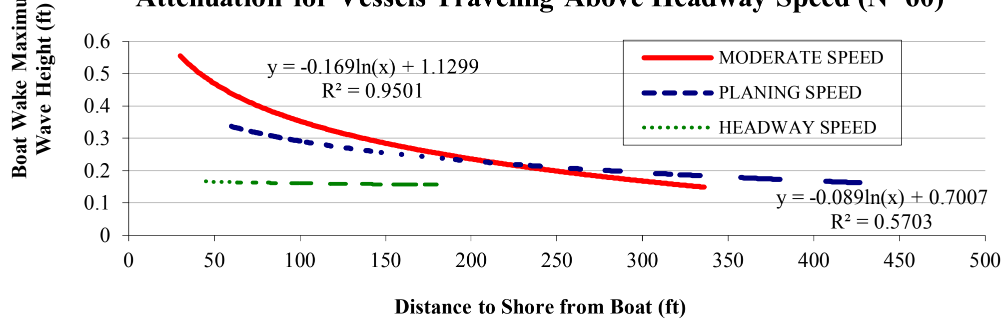
The action is expected to have the following results:

- Establish depths suitable for eelgrass colonization and the expansion of existing eelgrass beds on 7 acres;
- Improve estuarine fish habitat by increasing estuarine and benthic habitat diversity and by restoring deeper areas of passage, feeding and thermal refuge for species such as winter flounder and striped bass on 7 acres;
- Improve flushing of nutrients and pathogens from Pettaquamscutt Cove, thereby enhancing water quality to improve fish and wildlife habitat, ecosystem functions and human health;
- Protect and restore salt marsh shorelines by reducing current speeds along marsh shorelines and moving boat traffic and wakes further from eroding marsh banks, reducing mechanical weakening of the banks from wave action, and reducing prop scarring of salt marshes;
- Provide material for beneficial re-use, including living shoreline restoration and marsh restoration (Actions C and E, below); and
- Testing of different excavation techniques will evaluate the use of local materials and equipment to apply similar treatments in other restoration areas along coastal Rhode Island and New England.

As noted above, eelgrass occurs at depths greater than 2 feet NAVGD88. By increasing areas at or below this depth, the proposed action is expected to result in an expansion of up to 7 acres of eelgrass habitat and deeper estuarine areas, with substantial benefits to managed species and EFH within the estuary. Re-alignment of the channel easterly of Sedge Island will improve eelgrass habitat availability by creating a channel shallower than current depths of 8 feet, which may be too deep for eelgrass at present. In Ninigret Pond, Charlestown, RI, a similar project to deepen flood-tide shoals within a coastal pond resulted in significant colonization by eelgrass (ACOE 2011). As shown by the shallow-water habitat analysis above, eelgrass is one of the most valuable—likely the most valuable—types of estuarine habitat present.

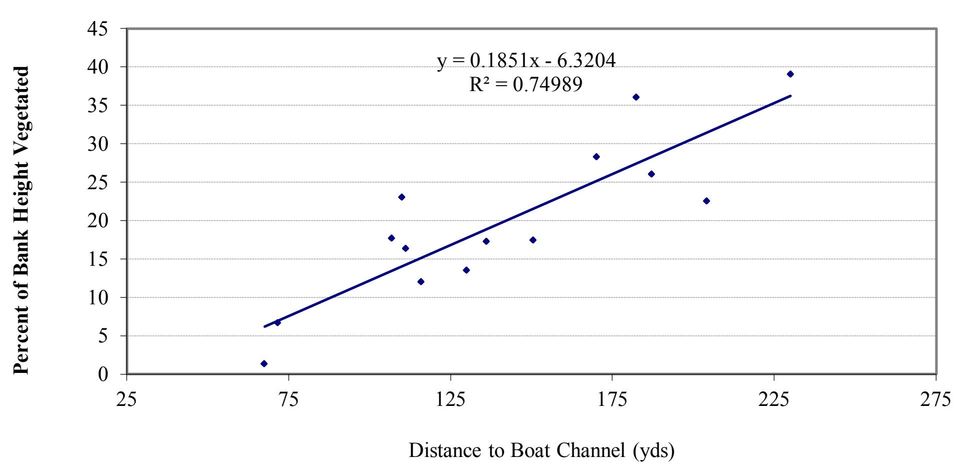
Providing deeper water away from salt marsh shorelines will allow motorized vessels to pass further from salt marsh shorelines. Currently, motorized vessels must, due to shallow water, than to pass within 65 feet of salt marsh shorelines in the vicinity of Sedge Island. Boat wake wave attenuation modeling (USFWS 2009) indicates that the closer vessels travel to a shoreline, the greater the wave energy (synonymous with maximum wave height) and hence erosive potential these boat wakes will have (Figure 10). Applying this model, this action could result in reducing boat wake wave energy on salt marsh shorelines by 65%.

FIGURE 10. Predicted Boat Wake Maximum Wave Height Attenuation for Vessels Traveling Above Headway Speed (N=60)



Allowing motorized vessels to pass farther from salt marsh shorelines may also enhance vegetative growth on some banks. As shown in Figure 11, there appears to be a relationship between percent bank vegetative cover and distance from boat channel (USFWS 2012). Applying this relationship suggests that vegetative growth on affected salt marsh shorelines may increase by 25%.

Figure 11. Percent Bank Vegetated Vs. Distance to Boat Channel



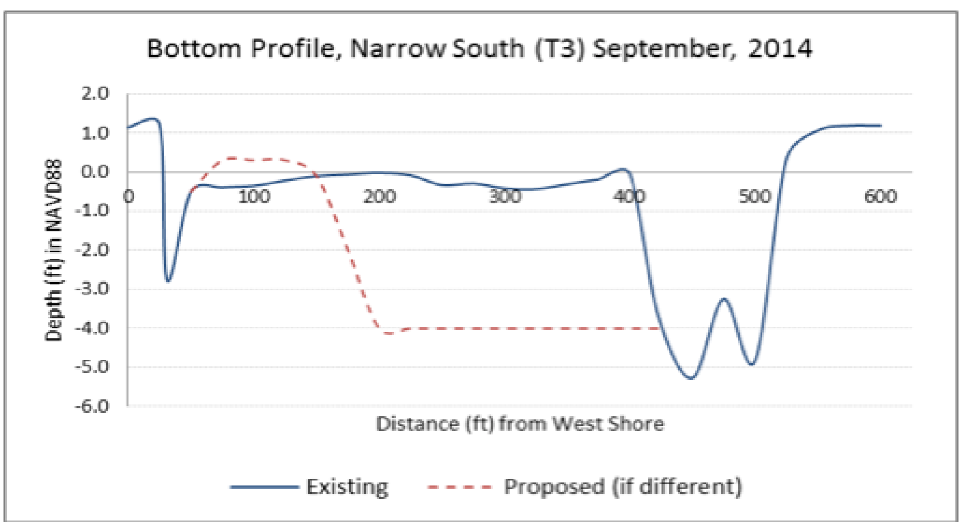
In areas of eelgrass restoration, 7 acres of existing shallow-water coarse sand and tide flat habitat will be affected; however the amount of surface area, or wetted area of this habitat available to fish will not be significantly reduced. As shown in the sample excavation profile below, the primary change in surface area available to fish is in the distribution of habitat by depth. Currently within areas proposed for deepening, 90% of the wetted surface area lies above -2NAVD88. Implementing the proposed action would essentially reverse this distribution, providing more coarse sand at greater depth, where cooler and deeper water favors fish habitat use. Excavated areas will remain as sand bottom until eelgrass colonizes the area, further improving habitat heightened value. Areas targeted for creation of sand bottom habitats by excavation are in areas of low biological value, based on the results of eelgrass and shellfish/infauna surveys (RICRMC data 2014; USFWS 2014). The larger tidal flats in the lower river will remain available, and likely expand over time. Under the proposed action, minor loss of low-value tide flat habitat will be more than compensated by the restoration of valuable, declining habitats such as low marsh, high marsh, fringing marsh, and deeper estuarine areas suitable for the expansion of eelgrass beds and thermal refugia. The wetted surface of coarse sand benthic habitats will change little over existing conditions. This change in tidal flat habitat will be offset by 3.3 acres of tide flat enhancement.

Tide flats can provide important habitat for benthic infauna; feeding habitat for estuarine fish and invertebrates during higher portions of the tidal cycle; and valuable feeding and resting habitat for several shorebird species of conservation concern (as described in detail in the EA). Tide flats are an important component of the estuary's mosaic of estuarine habitats.

The RIDEM finfish surveys have demonstrated that in summer, the deeper, cooler waters support greater fish abundance and diversity than shallower, warmer areas. Winter flounder are absent from areas of the estuary once water temperature reaches 26-28 degrees C (Lake 2014, pers. comm.). This action will improve habitat for managed species by increasing areas of thermal refuge for species such as winter flounder and improving feeding access for larger fish such as bluefish and striped bass.

As shown in Appendix A, filling of river channels in this area with shoals and flats has taken a number of years. Therefore, while tidal flats can be expected to return in these areas, the effectiveness of this beneficial treatment can be expected to persist for a long period of time.

Figure 12. Bottom Profile of Narrow River South, Transect T3.



Creation of eelgrass beds is not anticipated to significantly change tidal flow in the River. The presence of a large flood tidal delta at the mouth of the river, and channel restriction caused by the abutments of Sprague Bridge combine to inherently limit the volume of water passing into and out of the upper reaches (ACOE 2009). Because of these restrictions, tidal flows are delayed approximately one hour after the tides measured at Narragansett Pier.

By restoring estuarine habitat complexity and diversity; by promoting the expansion of eelgrass beds; by restoring valuable shallow-water habitat; and by providing areas of thermal refuge for species such as winter flounder, restoration of estuarine depths is expected to have a positive effect on EFH and managed species in the Narrow River Estuary.

In summary, anticipated effects include:

- Improve estuarine fish habitat and EFH by increasing estuarine and benthic habitat diversity and by restoring deeper areas of passage, feeding and thermal refuge for species such as winter flounder and striped bass;
- Improve flushing of nutrients and pathogens from Pettaquamscutt Cove, thereby enhancing water quality to improve fish and wildlife habitat, ecosystem functions and human health;
- Better protect salt marsh shorelines by reducing current speeds along marsh shorelines. This will benefit resources in the vicinity of Sedge Island, where river flows were originally disaggregated into two channels, and are now concentrated into one, deep channel flowing against the eastern shore of Sedge Island. This will also aid the conservation of salt marsh on the eastern shore of the River northeast of Sedge Island.
- Better protect salt marsh shorelines from boat wake accelerated erosion along salt marsh shorelines. In some portions of the estuary, motorized vessels must past by salt marsh shorelines within 65 feet due to shallow waters and restricted channels. Boat wakes generated by boats this close to the salt marsh shoreline is likely causing accelerated erosion rates on the bank, and prop scarring on the edge of the marsh has caused direct loss of habitat. Based on boat wake wave modeling and wave energy assessments (USFWS 2009), boat wake wave energy reaching salt marsh shorelines may decline by as much as 65% in some areas.
- Provide material for beneficial re-use, including living shoreline restoration and marsh restoration (Actions C and E, below).

ACTION C: RESTORE SALT MARSH SHORELINES

The stability and health of salt marsh shorelines will benefit from implementation of Actions A (Water Quality Management) and B (Eelgrass Management). Reducing pollutants, in particular excess nitrogen loading, may help in promoting both aboveground and below ground biomass (Johnson *et al.* 2012). Enhancing eelgrass and providing cool water refugia for larger fish and ensuring no net loss in shorebird and wading bird habitats may, to an unknown degree, increase predation on green crab (*Carcinus spp*.) and thereby reducing herbivory on salt marsh banks. Without direct restoration of shoreline however, these actions will not adequately address bank erosion of salt marsh shorelines.

This action will reduce ongoing erosion and loss of salt marshes caused in part by motorboat wakes, mechanical weakening of the bank, and direct loss through prop scarring. Living shoreline treatments such as coir logs and bagged oyster shell will be applied along approximately 7% of all marsh shorelines, targeting the most vulnerable banks, based on shoreline stability assessments by USFWS (2012).

At present, eroding marsh banks are deeply undercut. Pilot-scale living shoreline treatments placed by RICRMC and the Nature Conservancy in 2014 were rapidly colonized by *S. alterniflora*, stabilizing the marsh edge and establishing fringing low marsh habitat.

Salt marsh edge erosion is a major source of salt marsh loss in the Narrow River Estuary, and motorboat wakes are a significant factor in accelerating marsh edge erosion. At mid and low tides, boat wakes enter undercut areas of banks, and in addition to enhancing erosive conditions, boat wake generated waves have been observed to move the cut bank up and down mechanically. Excessive nitrogen loading may reduce below ground biomass, and natural events such as ambient, wind driven waves, ice carving, and natural erosion all combine to influence salt marsh shoreline stability.

Collapse of undercut banks appears to be the primary causal factor of salt marsh shoreline loss, and frequently occurs as a mass, or catastrophic loss along several feet of shoreline. In 2013/2014, this pattern of bank loss occurred along the eastern shore of Sedge Island and near Starr Drive

It is believed that the natural rate of collapse and erosion of undercut shorelines may be exacerbated by boat wakes in those portions of the estuary from Mettatuxett downstream to the mouth (USFWS 2010). Approximately 70% of the wave energy reaching some salt marsh shorelines during the summer months was estimated to originate from boat wakes. Ambient wave action, channels which have shifted over time toward salt marsh shorelines, and accelerated erosion caused by boat wakes and loss from prop scarring are contributing to active erosion of salt marsh shorelines.

This action will improve marsh shoreline complexity, stability and habitat value by interspersing the undercut areas with fringing marsh. The fringing marsh created by the living shoreline treatment will provide similar habitat value as the low marsh created under Action E, including colonization and feeding areas for invertebrates, feeding and refuge for small fish and nekton, and food web support to larger estuarine and marine fish.

Salt marsh grows both vertically and horizontally. Gains in horizontal salt marsh growth are typically lost due to collapse of undercut shoreline banks. Reducing the rate of undercutting could reasonably be expected to allow the marsh to expand, rather than being continually lost from undercut bank failure.

More stable marsh shorelines will support higher trophic level epifauna than the current eroding banks, improving biodiversity throughout the estuary. Like other marsh restoration actions proposed, marsh shoreline restoration will help protect estuarine water quality by reducing or reversing the rate of marsh loss. By reducing erosion, marsh shoreline restoration will reduce sediment re-suspension and transport into deeper areas, thereby improving water clarity and helping to protect eelgrass and other benthic and shallow-water habitats.

By improving estuarine habitat complexity and stability, reducing marsh erosion, improving biodiversity, and reducing sedimentation, marsh shoreline restoration will have positive affects on EFH and managed species in the Narrow River Estuary.

ACTION D: RESTORE SALT MARSH SURFACE HYDROLOGY AND DRAINAGE (RUNNELS)

Degraded salt marshes will be improved by enhancing surface drainage using the “runnel” methods—excavating shallow tidal channels on the surface of the marsh. This approach has been used successfully elsewhere on Narragansett Bay to restore degraded marsh surfaces, spur re-vegetation by *S. alterniflora* and other marsh plants, and improve habitat connectivity (Ferguson 2014, pers. comm.). This action will affect 47 acres, and will be undertaken through an adaptive approach—beginning small scale in the first year, and then evaluating the need and opportunity for continued hydrologic restoration. A robust and detailed monitoring plan is being implemented for the first treatments under this action, using Before/After/Control/Impact (BACI) study design at two sites, while long-term vegetative monitoring will be used at other sites.

The proposed action D will have marked improvement in salt marsh conditions (see previous section on salt marsh impacts). Action D will restore marsh creeks and channels and create access through runnels which, as shown by the shallow-water habitat analysis (Appendix F), provide significant value to estuarine fish, including winter flounder. Habitat connectivity will be increased, allowing fish and invertebrates access and egress to and from pans and pools on the marsh surface. This is expected to improve production of small fish and other nekton adapted to the harsh conditions of these shallow water features, such as mummichog, striped killifish, ninespine stickleback, fourspine stickleback, and daggerblade grass shrimp. By enhancing conditions for these important prey species, this action will improve EFH for larger, managed species such as winter flounder that feed on these and other marsh surface users. Enhanced access from clearing clogged channels and creation of small runnels on the marsh surface is expected to occur over 47 acres.

This action will improve fish habitat on the surface of the marsh by improving habitat structure and condition. High marsh surfaces, marsh creeks, and permanent marsh pools provide highly productive habitat for many small estuarine fish and other nekton (MacKenzie and Dionne 2008; see Table 3). By restoring vegetative complexity to the surface of the marsh, this action will improve habitat for many small fish and invertebrates, particularly during spring high tides when the surface of the marsh is flooded. Historical pools and pans, which provide important habitat for marine fish, will be protected.

As discussed previously, areas where excess water is entrapped on the salt marsh surfaces, vegetation shows evidence of stress, and bare pans eventually become prevalent. Degraded marsh is typified by the presence of bare areas, areas where *Salicornia spp.* dominate in association with short forms of *S. alterniflora*. Biomass production is reduced in these areas, inhibiting the ability of the marsh to keep pace with sea level rise.

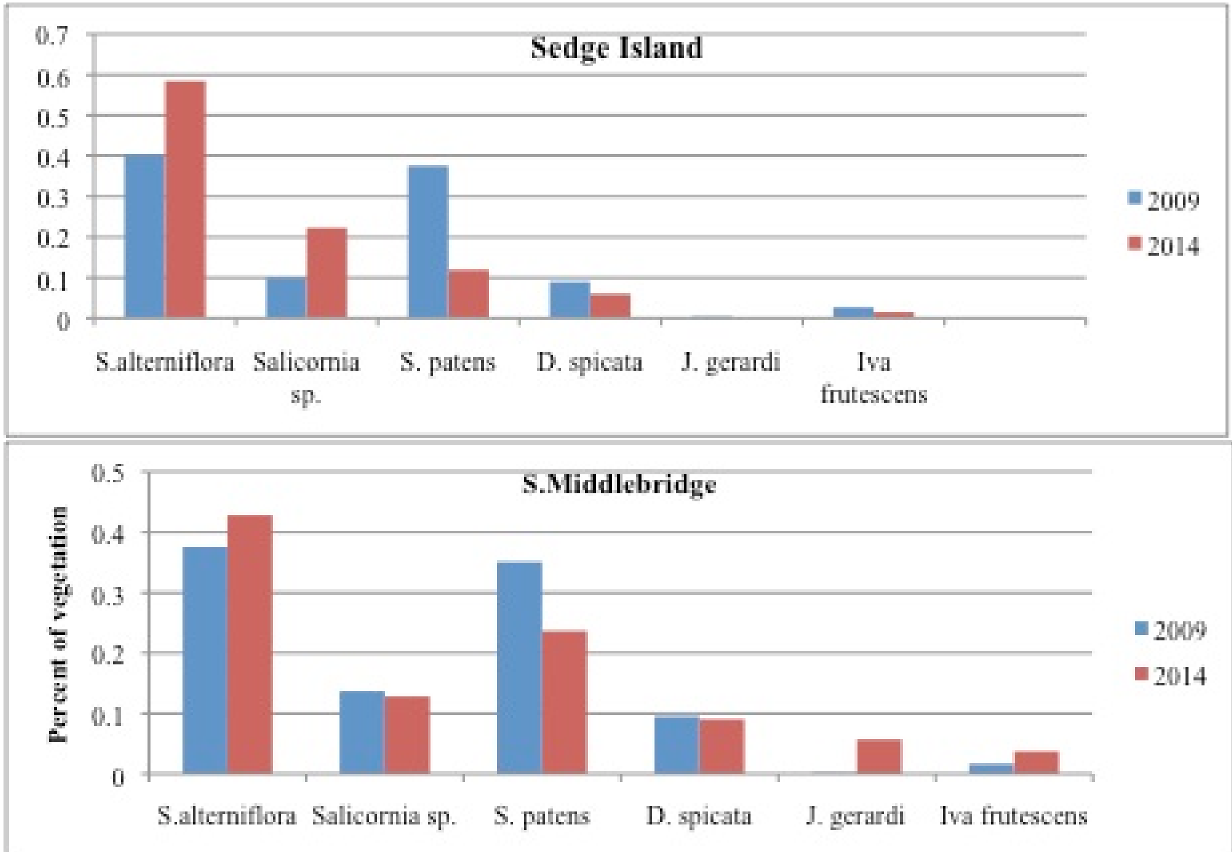
Without restorative actions, the amount of degraded salt marsh can be expected to increase in the estuary. As shown in the graphs below, the amount of short form *S. alterniflora* and *Salicornia* has increased in the estuary, while the amount of *S. patens* has declined (Figures 13a and 13b; USFWS data 2014).

Restoring 14.3 acres of salt marsh habitat lost to development of newer, shallow pools and pans which dry up in the summertime will improve salt marsh conditions. Of these acres, we estimate 4 acres of newly created, low marsh dominated by the tall form variant of *S. alterniflora* will occur. This would be an important contribution to managed species, given the small amount of low marsh currently available in the estuary. Protection of historical pools and pans within treated areas will retain habitat diversity and the important values.

Hydrologic restoration of marsh surfaces can benefit open water estuarine habitats such as eelgrass beds by maintaining salt marshes that, in turn, help maintain water quality in the Narrow River Estuary. Salt marshes buffer and protect estuarine waters and habitats from land-based pollutants from the largely developed watershed (Dionne *et al.* 2011).

By restoring estuarine habitat complexity, diversity and connectivity on marsh surfaces; by providing vegetated habitat for marsh epifauna; by restoring valuable shallow-water habitat; and by helping to maintain and improve estuarine water quality, hydrologic restoration of marshes will have a positive effect on EFH and managed species in the Narrow River Estuary.

Figures 13a and 13b. Changes in Vegetation Composition of Salt marsh Vegetation from 2009-2014



ACTION E: RESTORE LOW MARSH, DEGRADED MARSH, AND INTERTIDAL ELEVATIONS

Thin layer deposition (TLD) of dredged sediments will be applied to narrowly targeted areas of degraded marshes, in order to prevent and reduce estuarine habitat loss, improve habitat resiliency and aid in preventing catastrophic loss of salt marsh with incremental sea level rise. TLD applications are expected to establish conditions to restore and maintain vegetated marsh in areas of vegetation die-back, waterlogging, and rapidly expanding pools and pans.

The TLD approach will use a thin layer of sediment produced during the eelgrass restoration work, applying it to the surface of the marsh and raising intertidal elevations in order to mimic and augment natural accretion processes. This measure is intended to help salt marshes keep pace with accelerating sea level rise, and to restore low marsh habitat to lost areas of historic marsh. USFWS will also use this method to restore limited tide flat areas.

This action is closely integrated with Action B, Eelgrass, Estuarine Channel and Basin Restoration, which will provide source material for this action. A map of proposed restoration areas, and a table of proposed areas and volumes, for this measure are included in Appendix G.

Under this action, TLD will be applied to narrowly targeted areas of degraded marshes, in order to prevent and reduce estuarine habitat loss, improve habitat resiliency and aide in preventing catastrophic loss of salt marsh with incremental sea level rise. TLD applications are expected to establish conditions to restore and maintain vegetated marsh in areas of vegetation die-back, waterlogging, and rapidly expanding new pools and pans. This action will restore approximately 15.3 acres of degraded high marsh, 4 acres of low marsh, 1.2 acres of lost low marsh areas and 3.3 acres of tide flat habitat. Providing increased resiliency to sea level rise, these habitats will continue to be present for a longer period of time than without treatment, and will help prevent the large-scale loss of salt marsh by enhancing relief. TLD will not be applied next to salt marsh creeks, thereby retaining existing low marsh values, or areas where tall form variant of *S. alterniflora* occurs in a mix with other species.

Like Action D, this measure will improve fish habitat on the surface of marshes by improving habitat structure and condition, particularly during spring high tides when the surface of the marsh is flooded. Also like Action D, it will restore vegetative complexity to the surface of the marsh, improving habitat for many small fish and invertebrates. MacKenzie and Dionne (2008) demonstrate that even high marsh surfaces are important estuarine fish habitat. The literature review in section F.5.2, below, provides further studies of the importance of high marsh habitat to estuarine fish.

Restoration of lost low marsh habitat (Actions C, D, and E) will greatly increase habitat complexity and value for estuarine fish, invertebrates and epifauna. Low marshes provide valuable colonization and feeding areas for invertebrates such as ribbed mussel, fiddler crab, and snails such as *Littorina littorea* and *Melampus bidentatus*. During mid-high tides when covered with water, *S. alterniflora* low marshes provide valuable feeding and refuge for fish and nekton such as mummichogs, killifish, sticklebacks and shrimp which, in turn, provide food web support to fish species of commercial and recreational values, including winter flounder, bluefish and striped bass.

This restoration action will help restore the historic balance of estuarine habitats, restoring valuable marsh habitat for estuarine fish and nekton, including areas of feeding and refuge. By restoring and improving estuarine habitat complexity, diversity and value for fish and invertebrates, restoration of marsh and tide flat habitat is expected to provide significant benefit to EFH and managed species. Further, this action will help improve and protect estuarine water quality, with benefits to EFH, shallow-water habitats, and managed species in the Narrow River Estuary.

Management controls, including restriction of dredging operations to periods of minimal impact to manage species (November 15-January 31), application of best management practices to control erosion, protecting key habitats such as pools and pans, and minimizing channel clearing and runnels development will help ensure short term impacts are minimized (Appendix G).

This restoration action will help restore the historic balance of estuarine habitats, restoring valuable marsh habitat for estuarine fish and nekton, including areas of feeding and refuge. By restoring and improving estuarine habitat complexity, diversity and value for fish and invertebrates, restoration of marsh and tide flat habitat is expected to provide significant benefit to EFH and managed species. Further, this action will help improve and protect estuarine water quality, with benefits to EFH, shallow-water habitats, and managed species in the Narrow River Estuary.

ACTION F: TEST TREATMENTS TO ENHANCE CONDITIONS FOR MARSH MIGRATION

This action will occur in upland sites and will not affect managed species or EFH.

7.2.4 POTENTIAL SHORT-TERM CONSTRUCTION IMPACTS AND AVOIDANCE MEASURES

Potential short-term impacts from construction include:

- Displacement of estuarine habitats: Estuarine deepening actions, if poorly sited, could displace valuable existing habitats. To avoid this impact, detailed surveys and analysis of benthic, shallow-water and intertidal habitats were undertaken, including mud and sand habitats, eelgrass beds, gravel/cobble bottoms, shellfish and other benthic infauna. The results of these surveys and analyses were used to site dredging activities in areas of low biological value, removed from eelgrass beds or other valuable estuarine habitats or resources.

- In-water sedimentation impacts: The Service has considered the potential impact of re-suspension of sediments and sediment deposition on estuarine habitats (e.g. eelgrass beds), causing loss of habitat or disruption to fish spawning, feeding or passage. Areas to be dredged are primarily fine sandy areas, where sediment re-suspension is short-lived and sediment transport distances are short. Mechanical, rather than hydraulic dredging equipment are being tested in order to better control dredging areas and impacts. Much of the excavation will be performed at lower tides, “in the dry,” in areas which are exposed at low tide; in these cases there will be little opportunity for re-suspension of sediments. In addition, seasonal restrictions for in-water dredging activities will limit dredging activities to the period of least biological activity (November 1 - January 31). This window was developed in consultation with RIDEM fishery biologists to protect the fall outmigration of juvenile river herring as well as winter flounder spawning.
- Marsh surface sedimentation impacts: The Service has considered the potential that marsh restoration actions could disrupt marsh surface biota through uncontrolled sediment deposition. Sediment controls such coir logs to compartmentalize treatment areas will help ensure that sediment application is limited to targeted restoration areas. The coir logs will also be positioned to mimic natural shallow marsh creeks on the surface of the marsh, in order to maintain habitat connectivity and provide valuable shallow-water habitat in restoration areas. Hay bale fences will be installed in channels, which drain the areas to further contain sediments on site. Hay bales will not completely restrict flows, and will be installed in series to enhance effectiveness.
- Construction equipment impacts: Construction equipment has the potential to impact the salt marshes through compaction of marsh peat, leading to a loss of marsh elevation, or damage to marsh turf, causing accelerated erosion. Much of the drainage restoration will be performed by hand digging, which has been shown elsewhere to have negligible impacts on marsh surfaces. Where construction equipment operation on marsh surfaces is unavoidable, specialized low-ground-pressure equipment designed for wetland restoration, ground protection mats, and/or other best practices for construction on marsh surfaces will be used, and will target cold-weather periods for sensitive construction activities in order to take advantage of partially frozen marsh surfaces. For in-water work, equipment will be floated on barges rather than driven over the marsh in order to avoid damage to marsh surfaces. As noted above, lower-impact mechanical dredging equipment will be used rather than hydraulic dredging equipment. Contractual requirements and inspections will ensure adherence to all applicable RIDEM stormwater management requirements at the staging area.
- Fishing access impacts: The Sprague Bridge access site on the Northeast side of the bridge (off Route 1A by Sprague Bridge in Narragansett) will be used for construction staging. This will disrupt fishing access and parking at this location during the winter construction period. The Service will work to minimize impacts on recreational use during the summer season; however some disruption of fishing access will be unavoidable. Temporary closure of this area will result in the temporary loss of 12 parking spaces; however, most fishers park on the south side of Sprague Bridge and on the east side of Boston Neck Road. Moreover, an alternate boat launch location is available at Pollock Avenue, South Kingstown, approximately one mile north. Excavation and relocation of the channel near Sedge Island may make access to the east side of Sedge Island difficult. However, enhanced habitat for fish (deeper waters with coarse sand bottom habitat and eelgrass) will be created closer to parking areas, and walk-in fishing access to the eastern shore of the River will be maintained.

7.2.5 SUMMARY

Applying the series of interconnected restoration/resiliency actions is expected to result in the following:

- Action A, Watershed Management / Water Quality Restoration: Improve estuarine water quality and flushing; reduce pollutant concentrations, particularly in Pettaquamscutt Cove. Potential long-term improvement in ecosystem function, fishery closures and human health. Increased bank stability on 3,300 ft of salt marsh shoreline.

- Action B, Eelgrass Management and Restoration, Estuarine Basins and Channels: Provide conditions for establishment of up to 7 acres of new eelgrass beds. Improve flushing and provide areas of thermal refuge, feeding and passage for important estuarine fish such as striped bass and winter flounder. Reduce boat wake impacts on salt marsh shorelines; limit shoreline loss along the eastern side of Sedge Island.
- Action C, Restore Salt Marsh Shorelines: Restore 7% of salt marsh shorelines which are eroding; preserve salt marsh habitat; enhance low marsh habitat and stable marsh banks; reduce sedimentation and infilling of estuarine habitats. Increase shoreline habitat diversity and productivity for prey; create fringe habitat with low marsh characteristics.
- Action D, Restore Salt Marsh Surface Hydrology: Restore hydrology to 47 acres while simultaneously clearing clogged channels and creation of linkage to habitats with runnels; restore 14.3 acres which are currently occupied by new, shallow pools and pans which dry up in the summertime. Of these acres, roughly 4 acres are expected to be occupied by productive low marsh, dominated by tall form *S. alterniflora*. Spur revegetation of recently degraded/denuded marsh areas; restore habitat structure and function, particularly during higher tides.
- Action E, Marsh and Tide Flat Restoration: Restore 15.3 acres of degraded existing marsh, up to 1.2 acres of lost low marsh, and up to 3 acres of tide flat habitat. Protect existing, productive low marsh and mixed low marsh habitats within treatment areas. Restore estuarine habitat complexity, diversity and value to a total of 19.5 acres.
- Action F, Test Enhancement of Marsh Migration: Girdle trees to release shrub understory; will determine whether this techniques can be successfully applied elsewhere to promote marsh migration.

7.2.6 POTENTIAL CUMULATIVE IMPACTS

Water quality in the Narrow River will remain in a degraded condition or slightly improve. While the project will help improve conditions in some portions of the watershed, storm runoff and persistent non-point sources will continue to inhibit water quality in the watershed as a whole. The action is not expected to have a significant effect outside of the watershed.

While the project is expected to improve salt marsh habitat conditions in the estuary, areas remaining untreated will continue to decline. While treatments to enhance elevation capital will help prevent catastrophic loss of salt marsh in the near term, sea level rise will continue to add stress on salt marsh and estuarine habitats, not only in the Narrow River, but in Narragansett Bay and along the entire Eastern Seaboard. While projects located on the South Coast of Rhode Island in Ninigret, Quonochontaug, and Winnapaug Ponds will aid in "buying time" against the full consequences of sea level rise and climate change, current trends and projections suggest that the health and availability of salt marsh habitats will decline markedly in the region, whether or not this project is implemented. Only in areas where salt marsh has the opportunity to migrate inland, or where treatments are applied for elevation capital, will salt marsh communities be maintained in the long-term.

The health of managed species will likely improve in the estuary. Based on previous distribution of eelgrass demonstrating it's likely occupation of suitable habitat, and providing cold water refugia will have a marked benefit on habitat conditions for managed species. However long-term trends in habitat as influenced by sea level rise and climate change, as well as broader trends in fisheries, will ultimately determine the stability of managed species.

F.3 CONCLUSIONS REGARDING EFH IMPACTS

The Service concludes that the proposed Narrow River Estuary Resiliency/ Restoration project will provide significant overall and long-term benefits to EFH, managed species, and shallow-water habitats by:

- Restoring and preserving the historic mosaic of estuarine habitats within the Narrow River Estuary;
- Improving estuarine water quality and clarity; improving flushing, and reducing concentrations of nutrients and pathogens;
- Increasing areas of sufficient depth to support eelgrass habitats, with expected expansion of eelgrass beds;
- Improving and increasing habitat complexity, including shoreline complexity and stability;
- Increasing the area and lineal extent of low marsh and fringing low marsh, providing new areas of settlement for estuarine infauna and epifauna; areas for feeding and refuge for small estuarine fish and nekton; and food web support and production for larger fish species;
- Reducing rates of marsh erosion and loss, thereby reducing sedimentation and helping to maintain estuarine water quality;
- Increasing vegetated marsh area, with benefits for estuarine fish and other wildlife;
- Increasing areas of thermal refuge for species such as winter flounder;
- Providing increased feeding and passage areas for larger fish species such as striped bass and bluefish.

The proposed action will have minor short-term negative consequences such as the disruption of fishing access due to construction staging; and all practicable measures to avoid and reduce short-term impacts on EFH and managed species will be implemented. This impact is not anticipated to be significant.

The proposed action will impact current tide flat and very shallow water areas by 7 acres in areas, but the wetted surface available to fish will not be altered significantly. The coarse sand habitat, instead of concentrated in less than two feet of water, will be concentrated in deeper water, which will provide better foraging for striped bass and bluefish, and provide cool water refugia for winter flounder. Approximately 3.3 acres of tidal flat will be enhanced. Tide flat habitat is currently expanding due to natural and anthropogenic processes.

The proposed action will have substantial positive impacts for EFH, shallow-water habitats and managed species, and no significant adverse effects on EFH, shallow-water habitats or managed species.

USFWS expects the cumulative impact of this project to be beneficial to EFH, shallow-water habitats and managed species by providing greater habitat diversity and complexity, including improved estuarine productivity, improved water quality, areas for fish feeding, refuge from predators, settlement areas for a greater diversity of infauna and epifauna, areas of thermal refuge for species such as winter flounder, and a restoration of the Narrow River Estuary's historic mosaic of estuarine habitats. No adverse cumulative impacts are anticipated.

F.4 PROPOSED MITIGATION

All appropriate permits from the U.S. Army Corp of Engineers, RI Coastal Resource Management Council, RI Dept. of Environmental Management, and other regulatory agencies will be obtained prior to undertaking any restoration actions. Cultural resource clearance under the Historic Preservation Act will be obtained prior to conducting ground-disturbing activities. In areas proposed for restoration on non-federal lands, written permission from the landowner will be secured prior to taking any action. All mitigation measures and conditions identified in the permits will be adhered to.

Actions B and E of the restoration will be coordinated in order to minimize construction impacts, minimize sediment storage, maximize equipment utilization, and minimize adverse impacts from restoration operations. Excavators on floats or operating on sand will be used to restore estuarine habitat depths; these sediments will then be applied in very limited areas to achieve target elevations, in order to implement Action E. Coir logs and other controls, as specified above, will limit sediment application to target areas, and will be used to maintain habitat connectivity following the restoration.

The Service will perform in-water work from November 15 to January 31 in order to protect out-migrating alewives and spawning winter flounder. For work on the surface of the marsh, summer seasonal restrictions in appropriate areas will be implemented to protect nesting birds such as salt marsh sparrows.

Implementation of monitoring will provide a feedback loop, which will be used to assess, evaluate, and as necessary change management activities to insure they are effective, are not resulting in deleterious effects, and are appropriate to site conditions.

To minimize impacts to recreational uses of the river—including recreational fishing—actions which could significantly hamper recreational use of the river will be timed to occur outside of the heavily used summer season.

Appendix G details the specific control measures by action to avoid or reduce potential impacts from implementation of the proposed action.

F.5 ADDITIONAL INFORMATION

F.5.1 SITE-SPECIFIC INFORMATION

The EA as well as the Appendices provide site-specific information regarding the estuary, alternatives considered, and anticipated effects of the action.

F.5.2 LITERATURE REVIEW

In order to ensure that the proposed restoration of low and high marsh habitats is beneficial to managed species and EFH, and to ensure the avoidance of impacts to valuable fish habitat, USFWS has been conducting nekton monitoring on the surface of the estuary salt marshes. In addition, we conducted a literature review of estuarine fish use of salt marsh habitats.

Most of the available research pertains to *Fundulus heteroclitus*, the common mummichog, and is summarized here. This species is an important indicator of EFH functions and values of the estuary salt marshes, since *Fundulus* spp. are among the most abundant fish utilizing salt marsh habitats in the estuary, and because of their value to the estuarine food web and larger managed species. *F. heteroclitus* is an important energy link between the marsh surface and subtidal food webs (Weisberg and Lotrich, 1982).

In addition to the mummichog, the Service's nekton monitoring, described above, indicates that at least 20 other species of fish and invertebrates are using these habitats as well. Certainly many of the marsh habitat values and uses indicated for *Fundulus* would apply to other species documented on the surface of the marsh.

Research by DiMichele and Taylor (1980) and Petersen and others (2010) indicates that most *Fundulus* spawning occurs during spring high tides. *Fundulus* lay eggs on mud under *S. patens*, at juncture of leaves and stems of *S.*

alterniflora, and unvegetated gravel. Eggs incubate in the open air, not in water, over 7-9 days or longer. Hatching occurs when the eggs are stimulated by immersion in tidal waters. This research demonstrates that vegetated high marsh is needed for mummichog spawning, and suggests that vegetated marsh restoration, as proposed for the estuary marshes, will benefit estuarine food web productivity and EFH.

Research by Kneib and Stiven (1978), Taylor and others (1979), and Able and others (2006) has shown that young of year *F. heteroclitus* and *F. luciae* are found almost exclusively in the intertidal marsh surface microhabitats of shallow depressions and pools. The proposed restoration will preserve this habitat type by preventing marsh loss (conversion of intertidal marsh surfaces to subtidal habitats, which offer no predator protection and therefore reduced production for small fish such as *Fundulus spp.*). Moreover the proposed restoration will preserve historic marsh pools, pannes and creeks shown by this and other studies to be valuable habitat for *Fundulus* and other estuarine nekton at various life stages (e.g., Allen *et al.* 1994, Able *et al.* 2012).

Research indicates the value of intertidal and high marsh habitat to feeding, growth and production of *Fundulus*. Studies by Weisberg and Lotrich (1982) and Weisberg (1986) show that "growth rates were significantly higher for mummichogs allowed access to the marsh surface." MacKenzie and Dionne (2008) showed that high marsh habitat, in particular, stimulates mummichog growth and productivity. Studies by Butner and Brattstrom (1960), Meyer and Posey (2009), and Banikas and Thompson (2012) indicate that this is likely a function both of food availability and predator protection provided by high marsh, and that interior marsh surfaces are preferred when accessible, with tidal creeks serving as access pathways when high marsh surfaces are not flooded. The proposed restoration will restore tide creeks and runnels, in order to maintain habitat connectivity. It will restore marsh surfaces through TLD and elevational enhancement, and restore marsh habitat structure by improving conditions for vegetation growth and by planting restored marsh surfaces.

All of literature reviewed supports the Service's determination that the proposed action will benefit EFH functions and values by restoring both low marsh and high marsh habitat structure to the estuary, enhancing the productivity of *Fundulus spp.* and other estuarine nekton, and by restoring and enhancing the estuarine food web and trophic network of the Narrow River Estuary.

F.5.3 ALTERNATIVES ANALYSIS

The EA provides a full alternatives analysis of the proposed action. This section evaluates alternatives as they may potentially affect EFH and managed species only. Two alternatives were evaluated: the no-action alternative, and the proposed restoration action described above.

The no-action alternative would have no immediate impacts on EFH; however, the habitats of the Narrow River Estuary, including EFH such as deeper estuarine areas and low salt marsh, will continue to decline, as demonstrated by current trends in the estuary. The no-action alternative is expected to lead to a reduction in eelgrass beds; a reduction in vegetated marsh areas; and a reduction in salt marsh habitat health and abundance. As marshes continue to erode and decline, the no-action alternative is expected to lead to increased sedimentation and reduced water quality. The no-action alternative would therefore have a long-term adverse effect on EFH and managed fish species in the Narrow River Estuary.

Flood and ebb tidal deltas are likely to continue their expansion, resulting in some loss of deeper areas which provide cool water refugia for winter flounder and foraging habitat for larger species such as striped bass. Similarly, habitat available for eelgrass will decline commensurate with loss of deeper channels.

Salt marsh habitat will continue to decline in extent by an estimated 6.2 acres per decade, eventually succumbing to sea level rise, and turning into mudflats with eventual loss. Continued entrapment of water on the salt marsh surface will further degrade vegetation, which will become less dense with open bare pans becoming prevalent. This will hamper the marshes' ability to keep pace with sea level rise, hastening the time period before loss. Marsh channels and creeks will continue to fill with sediments, limiting fish access to the upper marsh surfaces for foraging.

Under the no-action alternative, as deeper estuarine habitats and eelgrass beds are reduced in the estuary, small fish and diadromous species will become more vulnerable to predators, with potential local and regional impacts. These species are important components of the diet of striped bass, the most important and valuable recreational fishing species on Narragansett Bay, which also tend to utilize deeper areas of the estuary. The no-action alternative is expected to allow further declines in diadromous fish and striped bass in the estuary and Narragansett Bay; this, in turn, will affect the fishing and recreational values of the estuary and Rhode Island.

The overall loss of estuarine habitat diversity caused by the no-action alternative will lead to reduced fish diversity in the estuary, with consequences for many other kinds of fish and wildlife, both within and beyond the Narrow River Estuary.

The proposed restoration action will provide significant improvement of EFH and shallow-water habitats—specifically, restoration of the historic estuarine habitat mosaic; restoration and improvement of estuarine habitat diversity; restoration and improvement of estuarine habitat complexity; and improvement of areas for fish passage, feeding, predator protection and thermal refuge. By restoring deeper areas suitable for eelgrass bed establishment, the proposed action is likely to result in an increase in habitat considered most important to managed species in the estuary. By reducing the process of marsh erosion and loss, the proposed action will reduce sedimentation and restore and maintain estuarine water quality. The proposed restoration action will therefore provide significant short- and long-term benefits to EFH and managed fish species.

The proposed action has the potential for minor negative impacts on EFH, including minor short-term construction impacts, and minor loss of low-value tide flat habitat. In implementing the Narrow River Estuary Resiliency Restoration Project, the Service will adhere to all practicable measures to avoid and minimize such potential impacts to EFH, including the observance of seasonal restrictions, sediment controls where warranted, minimization of operations on marsh surfaces, and use of best construction practices such as stormwater management at staging areas.

The alternatives analysis demonstrates that the proposed action is preferred in order to preserve and restore EFH and managed species.

APPENDIX G

DETAILS OF IMPLEMENTATION FOR ALTERNATIVE 2

THE PREFFERED ALTERNATIVE AND PROPOSED ACTION

ACTION A
WATERSHED MANAGEMENT/WATER QUALITY RESTORATION

The following actions will be undertaken to address water quality management (Figure A1):

- Intensify water quality monitoring to locate priority sites for water quality abatement actions.
- Survey, design, and install (funding dependent) best management practice (BMP) sites in the Mettatuxet drainage in Narragansett, and at Kimberly Drive in South Kingstown. All BMP work will be conducted in upland areas. Final design of BMPS will be subject to approval by the RIDEM. Generally this entails creation of basins where runoff is captured and treated naturally prior to flowing into surface or groundwater. Construction would entail the use of excavators, dump trucks, and backhoes. Construction traffic (trucks, light trucks, cars, tractor trailers) would occur intermittently along Kimberly Drive and Mettatuxet Ave. Temporary one lane detours may be needed on Mettauxett Ave. during construction. Construction scheduling would attempt to avoid the summer season, and would only occur during daylight hours. Construction may last 30 to 60 days. Once constructed, periodic inspections would occur, and period maintenance, once every five years, may be needed to place fresh gravel or other materials in the basins.
- Improve flushing and water circulation in Upper Pettaquamscutt Cove by removing remnants of an old road crossing (Figure. A2). Material will be excavated to the depth of typical bottom elevations northeast and southwest of the crossing. The crossing would not be widened, only deepened, to prevent loss of salt marsh. Profiles of the 150' x 75' x 2' deep (approximately -3 feet NAVD) area which would be excavated are shown below. Both pre-project and post-project profiles will be taken should removal of the crossing remnants be found necessary.

  Excavation of materials would be accomplished with the use of an excavator on a barge. Material would be removed from the bottom, placed on the barge or in containers on adjacent barges, and then removed off-site. Activities would only occur during the winter dredging window of November 15 through January 31. A staging area would be temporarily constructed at the northwest corner of Sprague Bridge on National Wildlife Refuge lands. Traffic associated with both construction of the staging area, transportation of personnel, supplies, equipment (barges, excavators, etc.) and materials for the dredging operation will increase traffic and fuel emissions near the bridge. This impact will occur outside of the busy summer season.

This action is subject to the following management controls:

- Completion of water level and water flow (volume) monitoring to determine the extent this remnant crossing adversely influences flushing and circulation of flow. If flow and circulation is not significantly altered, the crossing remnants will not be removed.
- Excavation will be allowed only within the approved dredging period, typically November 15 through January 31.
- Securing necessary permits and providing supporting information including sediment core contaminant analysis. If contaminants are found, no action will be taken. Completion of consultation with the RI Historical Preservation and Heritage Commission and the Narragansett Indian Tribe consistent with Section 106 of the National Historic Preservation Act (NHPA; Public Law 89-665; 16 U.S.C. 470 et seq.);
- No activities will occur above the mean high tide line; 3:1 slopes will be retained along each bank. Excavated material will be transported and disposed off-site.

Figure A1. Vicinity Map for Proposed Water Quality Improvement Actions

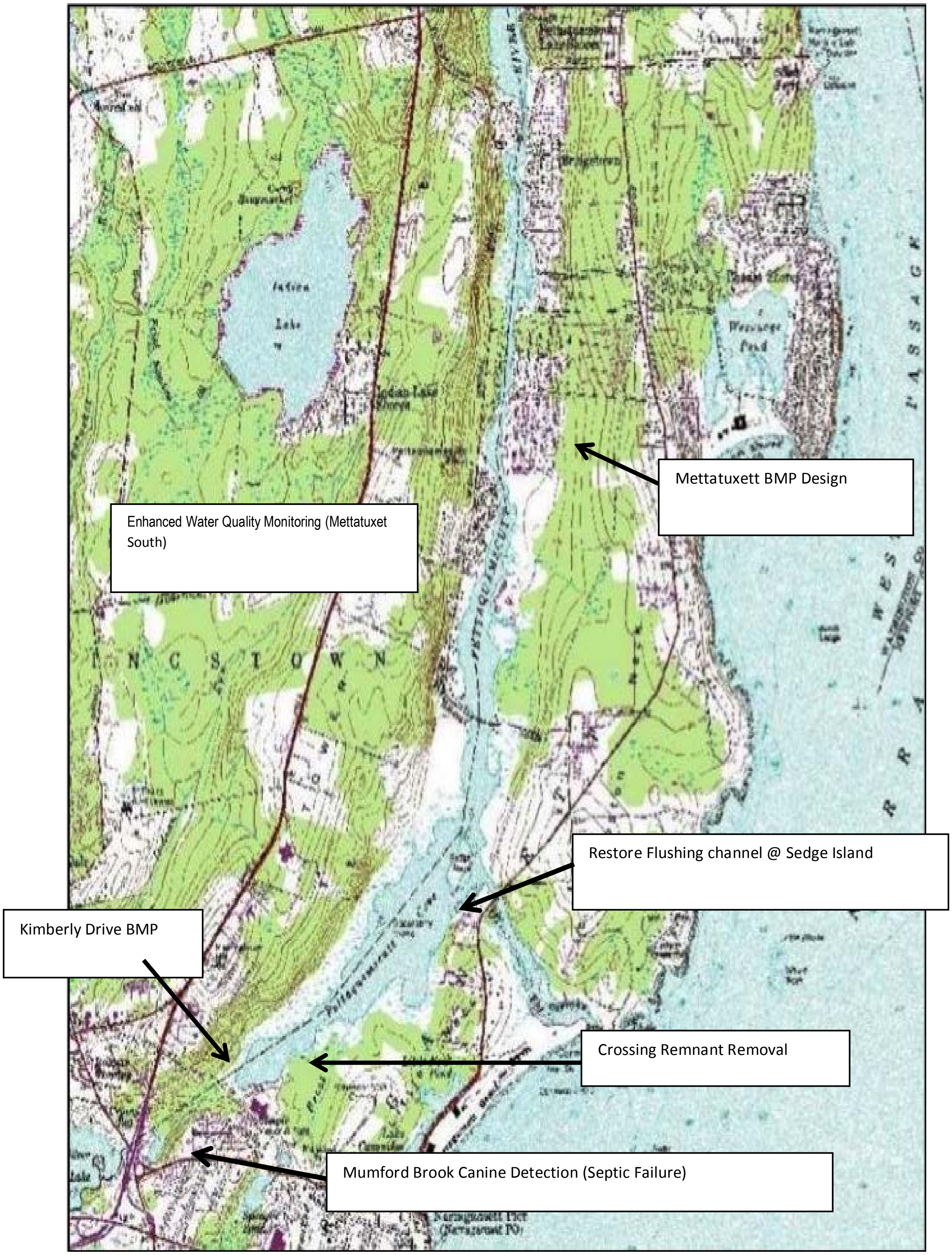
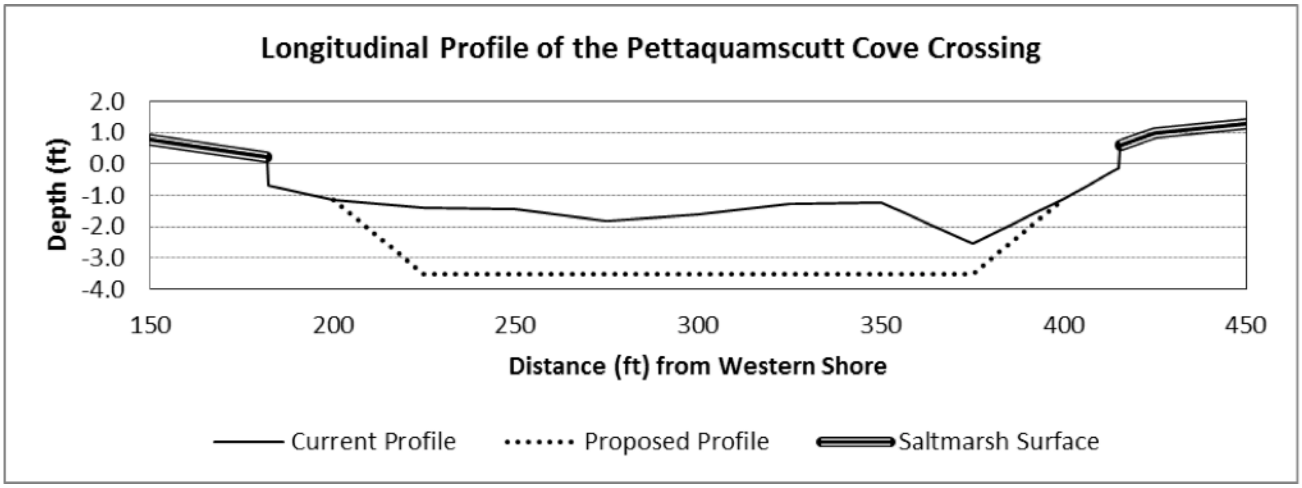


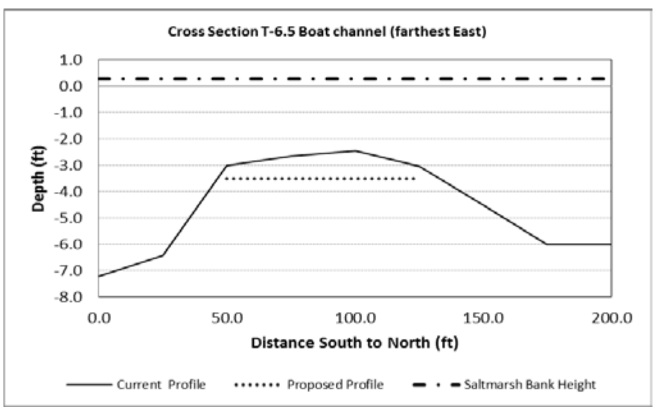
Figure A2. Vicinity Map for Crossing Remnant Removal

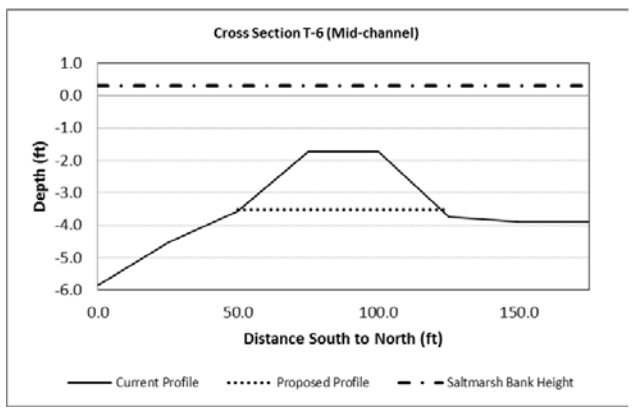

Proposed Removal of Remnant Crossing Fill for Enhanced Flushing.
National Wildlife Refuge
Pettaquamscutt Cove
T 1
T 4
T 5
T 6
T 6A
T 7
T 8
T 9
T 10
LEGEND
Excavation Area
Profile Transect
100
0
100
200
300
Feet

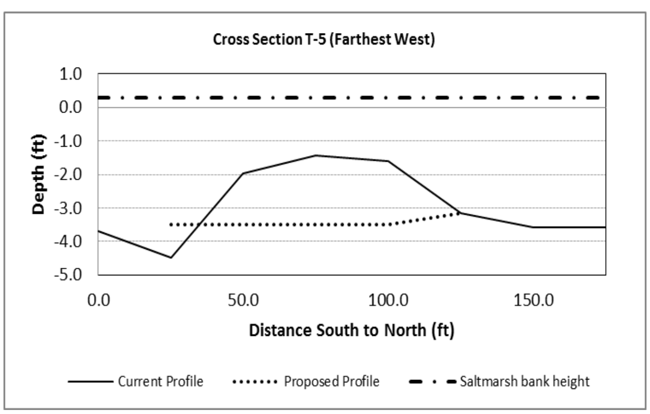
Table A1. Excavation Volumes											
TREAT-MENT	CURRENT CONDITIONS					PROPOSED CONDITIONS					
	AREA (SQ. FT.)	WETTED AREA ABOVE -2FT	WET. AREA BELOW -2FT	TOTAL WET. AREA (AC.)	AVE. DEPTH (FT)	TARGET DEPTH (FT)	CUT VOLUME (CYD)	FILL VOLUME (CYD)	WET. AREA ABOVE -2FT	WET. AREA BELOW -2FT	CHANGE IN WET. AREA (ACRES)
Exc.	12,612	1,016	0	0.02	-0.50	-3.00	1,120.6	0			0.02

Figures A3 –A6. Profiles of Excavation to Remove Crossing Remnant (note transect numbers in Figure A2, above).

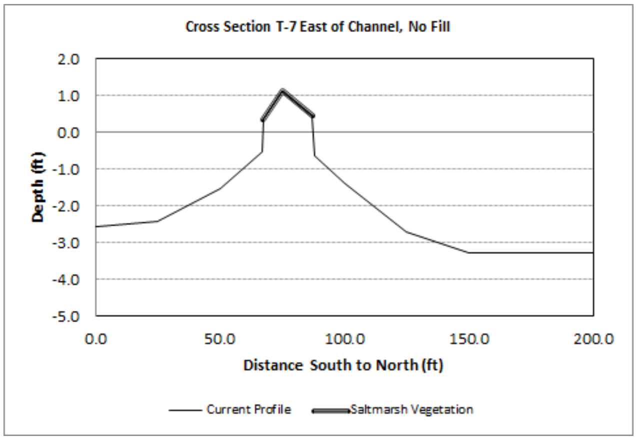


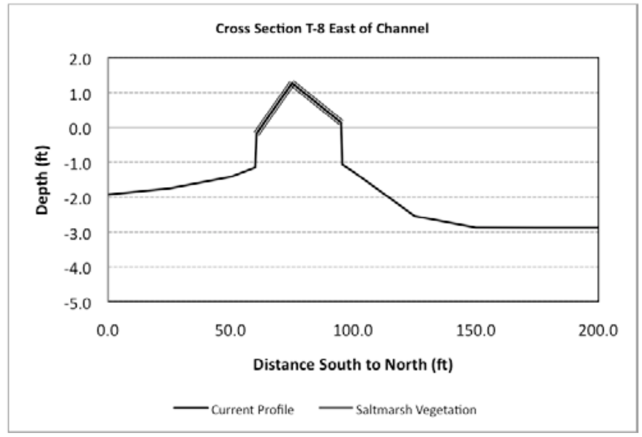


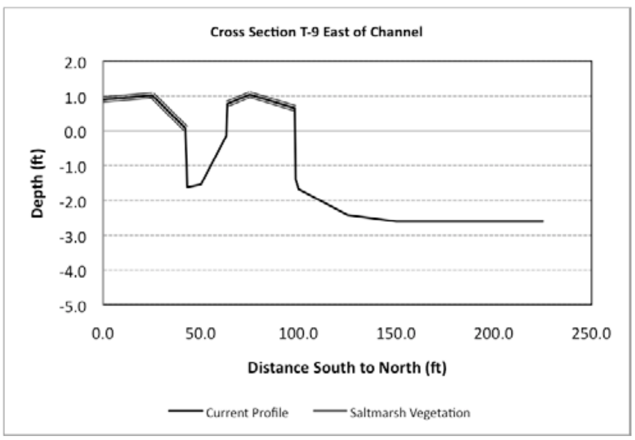


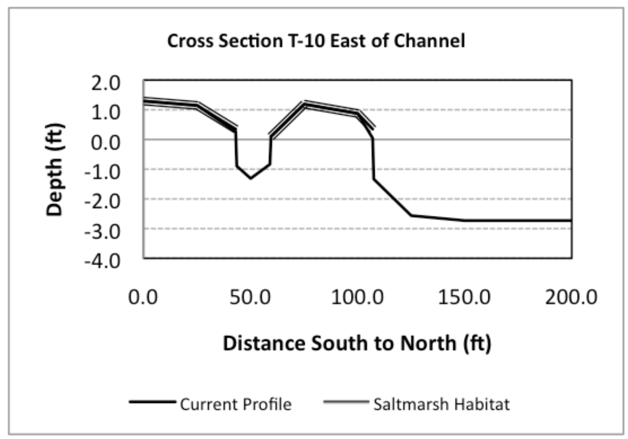


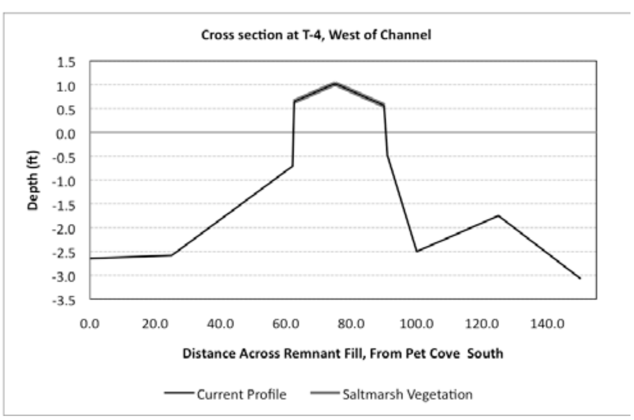
Figures A7 –A11. Profiles of Crossing Remnant, Continued (note transect numbers in Figure A2, above).











ACTION B
EELGRASS, ESTUARINE CHANNEL AND BASIN RESTORATION

Basins and channels will be deepened by removing existing sediments to a depth of approximately -4 feet NAVD88 in areas where channels were present historically. Flood and ebb tidal deltas have increased over time, shifting channels to less favorable locations for preservation of estuarine values.

Approximately 7 acres of deeper areas will be dredged, suitable for eelgrass habitat, thermal refugia, and foraging areas for fish species (Units 1, 10, 11, & 15 in Fig. B1 and Table B1). Resulting depths will provide habitat for existing eelgrass beds to expand, ensure depths that will make beds less susceptible to prop scarring, and will provide for cooler temperatures for fish growth and production. Figures B2a – B2f provide sample profiles for these sites.

This action will be accomplished using small conventional construction equipment and multiple management controls in order to avoid negative impacts to estuarine and marsh habitats within the estuary. A temporary staging area will be installed with a gravel surface at the river access point on the northwest side of Sprague Bridge on National Wildlife Refuge lands. A small, temporary floating dock will be installed at this location with temporary pilings and a simple access ramp. In order to avoid impacts to estuarine fish and wildlife and recreational uses, this dock will be placed no earlier than October 15, and removed by March 15 each year.

In order to minimize construction impacts from this work, the Service intends to deploy small-scale mechanical, rather than hydraulic, equipment to accomplish dredge and fill operations. Equipment will be placed on small work floats to access construction areas, and will be operated from the floats, thereby avoiding equipment impacts to marsh or tide flat surfaces.

In instances where a fill operation is adjacent to a dredge area, for example in deepening and moving the channel southeast of Sedge Island, the work will be accomplished through a simple sidecast operation, using an excavator on a float to dig the new channel, and to place the material in the old channel to be filled. Sediment re-suspension is expected to be minimal, due to the sandy nature of the material in these areas. Where needed, oyster shell bags or similar “living shoreline” materials will be used to contain the material that is being placed.

Where sediments must be moved any distance from a dredge to a fill area, they will be placed in sealed containers on floats, and barged into position adjacent to application areas. In some instances dredged material may be stored in the staging area, in non-wetland areas, for a period of several months. If stored, all construction storm water regulations and erosion control best practices will be adhered to. The process of applying sediments to marshes for restoration is described under Action E, below.

This action is subject to the following management controls:

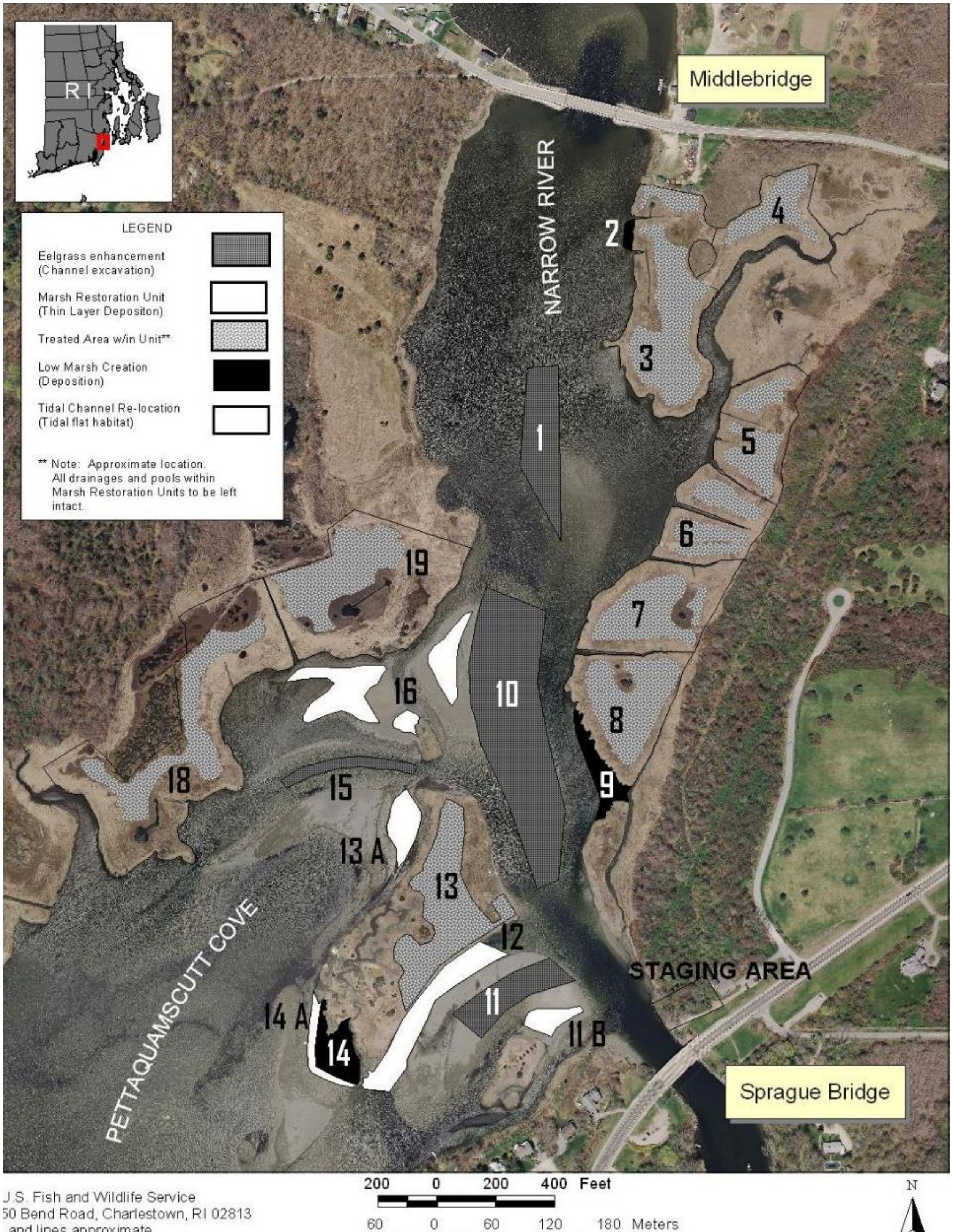
- Engineering designs approved by CRMC will be finalized and followed to ensure widths, depths, and slopes are not exceeded. Excavated areas will be re-surveyed following treatments to determine whether treatments were followed and to generate “as built” drawings. Excavated areas will be re-surveyed one year following excavation to determine whether any further actions are necessary.
- Excavation will occur only during the approved dredging seasons, typically November 15 - January 31;
- Receipt of all required permit requirements (see EA Sec. 6.3);
- As directed by RIDEM, shellfish species will be removed from areas prior to excavation.
- Monitor eelgrass distribution for three years from Middlebridge downstream including Pettaquamscutt Cove;
- Monitor tidal levels for three years.

- Excavated material will be first used for tidal flat enhancements to insure no significant loss in key shorebird, wading bird, and shellfish habitats. Materials will be contained with the use of temporary coir log or similar containment devices.
- Tree clearing at the staging area will be kept to the minimum necessary; all trees will be provided protection (wooden slats) during the construction period.
- The staging area will be regularly inspected for environmental compliance for erosion control, hazardous material containment, public safety, and other items.
- Gravel placed to develop the staging area will be removed, topsoil will be used to resurface the area, with native vegetation re-established on the site, including grasses, shrubs, and trees.

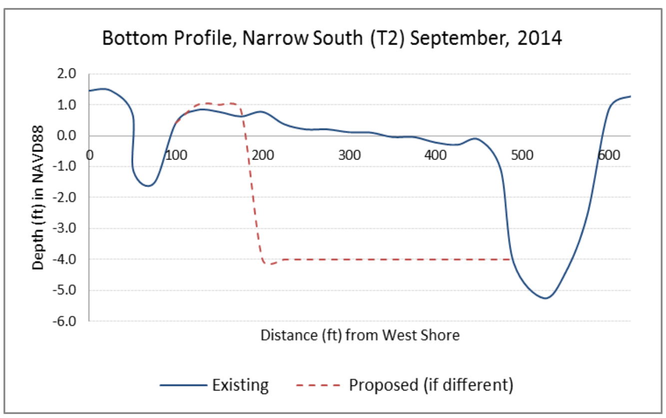
TABLE B1. HABITAT TREATMENTS RELATED TO EXCAVATION FOR EELGRASS RESTORATION

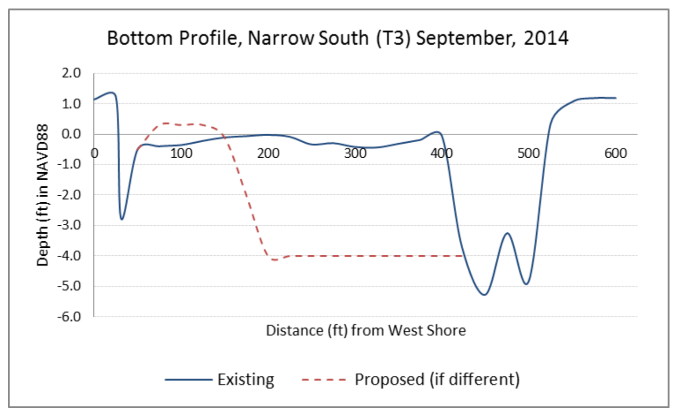
UNIT	CURRENT CONDITIONS						PROPOSED CONDITIONS					NOTES
	AREA (SQ. FT.)	AREA (ACRES)	WETTED AREA ABOVE -2FT (1) (SQ. FT.)	WETTED AREA BELOW -2FT (2) (SQ. FT.)	TOTAL WETTED AREA (ACRES)	AVERAGE ELEV / DEPTH (FT)	TARGET ELEV / DEPTH (FT)	EXCAVATE VOLUME (CYD)	WETTED AREA ABOVE -2FT (SQ. FT.)	WETTED AREA BELOW -2FT (SQ. FT.)	CHANGE IN WETTED AREA (ACRES)	
1	56,618	1.3	58,469	0	1.34	-1.25	-3.00	3,669.7	0	56,618	-0.04	
10	194,235	4.5	197,179	2,944	4.59	-0.50	-4.00	25,510.4	2112	179,520	-0.42	Sideslope of 5:1 on western side.
11	39,462	0.9	39,842	200	0.92	0.00	-4.00	5,156.4	1552	40,352	0.04	Sideslope of 3:1
15	16,687	0.4	16,687	0	0.38	-1.00	-3.00	880.5	1724	1640	-0.31	Sideslope of 3:1 on western side.
TOTAL:	7.05	7.05	7.17	0.07	7.24	-2.75	-14.00	35,217.1	0.12	6.38	-0.73	

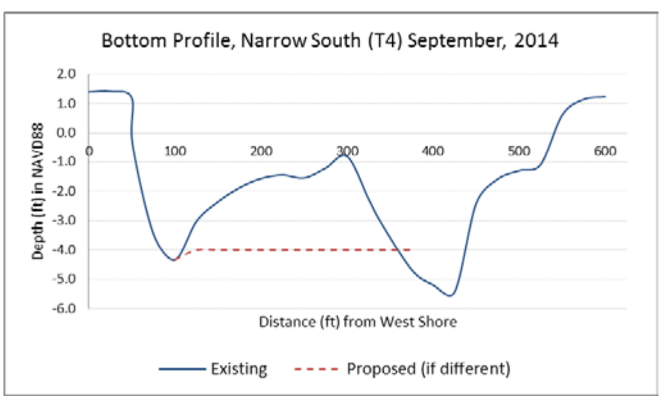
Figure B1. Excavation, fill, and Thin Layer Deposition Units under the Proposed Action.
Figures B2a-B2f. Sample Profiles in Areas Excavated for Eelgrass Improvement (note: T1 not in proposed excavation area). Final designs may differ from shown here.



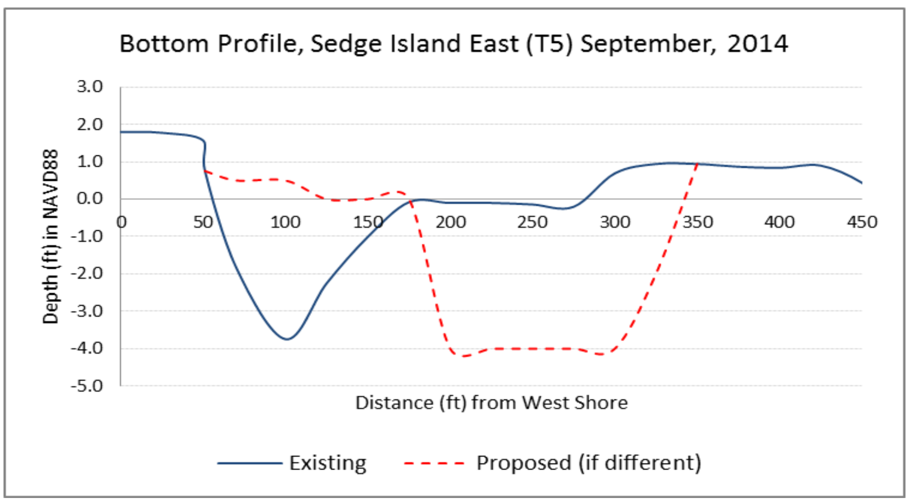

t1
t2
t3
t4
t5
t6


Bottom Profile, Narrow South (T2) September, 2014
Depth (ft) in NAVD88
Distance (ft) from West Shore
Existing
Proposed (if different)

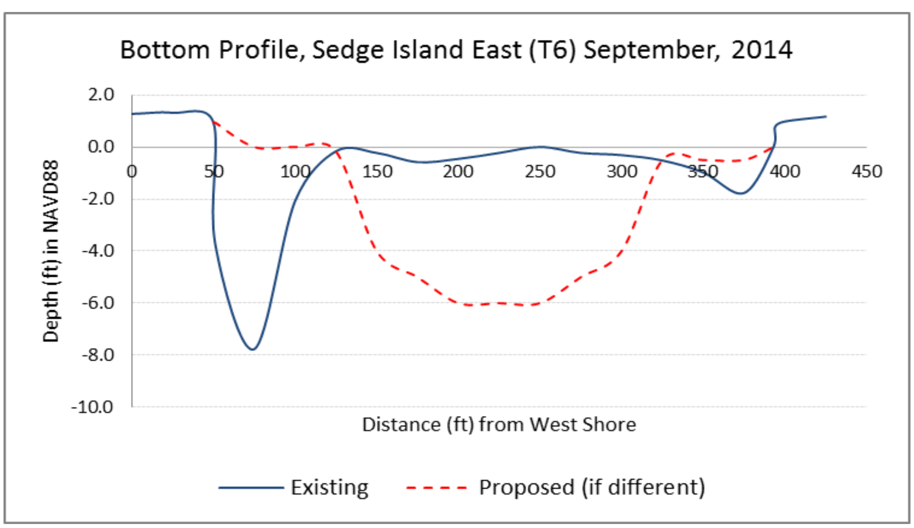

Bottom Profile, Narrow South (T3) September, 2014
Depth (ft) in NAVD88
Distance (ft) from West Shore
Existing
Proposed (if different)


Bottom Profile, Narrow South (T4) September, 2014
Depth (ft) in NAVD88
Distance (ft) from West Shore
Existing
Proposed (if different)

t4
t5
t6



Bottom Profile, Sedge Island East (T5) September, 2014
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0
50
100
150
200
250
300
350
400
450
Depth (ft) in NAVD88
Distance (ft) from West Shore
Existing
Proposed (if different)



Bottom Profile, Sedge Island East (T6) September, 2014
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
0
50
100
150
200
250
300
350
400
450
Depth (ft) in NAVD88
Distance (ft) from West Shore
Existing
Proposed (if different)

ACTION C
RESTORE SALT MARSH SHORELINES

Fiber (coir) logs and bagged oyster shell will be placed in a variety of formations along eroding marsh edges. Based on salt marsh shoreline assessments (USFWS 2009; TNC 2014), the lengths of shoreline per salt marsh unit in need of treatment were identified where shoreline stability is particularly poor, and bank loss could result in significant salt marsh habitat loss. Application of living shoreline treatments is based on site specific analysis of a particular bank, with designs created based on those evaluations. Site specific locations therefore cannot be identified at this time. The lengths of shoreline to be treated does not mean that living shoreline treatments will be placed along each foot of bank; there will be gaps in the areas where shoreline treatments are installed. Table C1 identifies the lengths of shoreline to be treated by salt marsh management unit, and figure C1—C4 show the locations of Salt Marsh Management Units where treatments will be applied. Overall, no more than 7% of the total salt marsh shoreline in the estuary will be treated.

Installation requires transportation of materials, typically on a pontoon boat to the site from river access points. A crew or workers place the materials by hand along the bank, with rope and stakes placed to secure the materials in the arrangements needed. Installation could take place anytime during the warmer seasons, however we will attempt to avoid the busiest summer months. Use of the Pollock Avenue Boat Ramp would be required for loading and offloading small vessels.

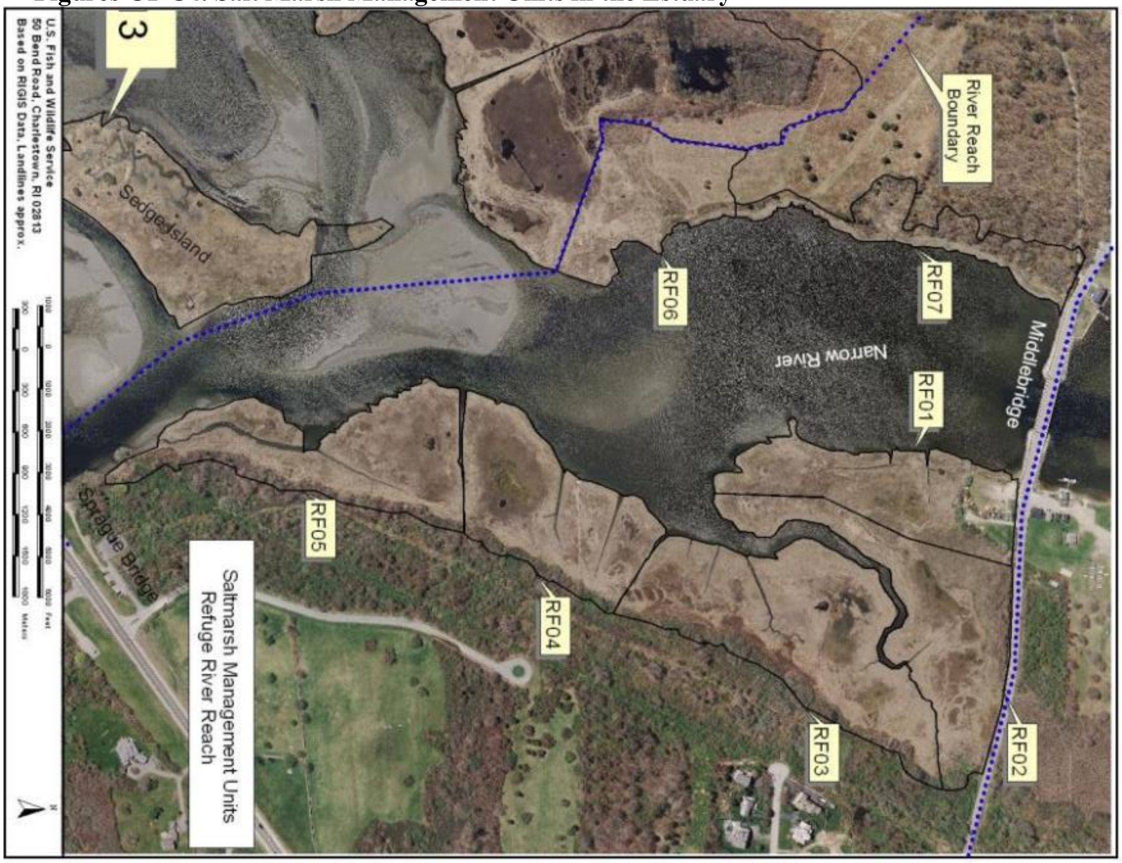
In all cases, living shoreline applications will be subject to the following management controls:

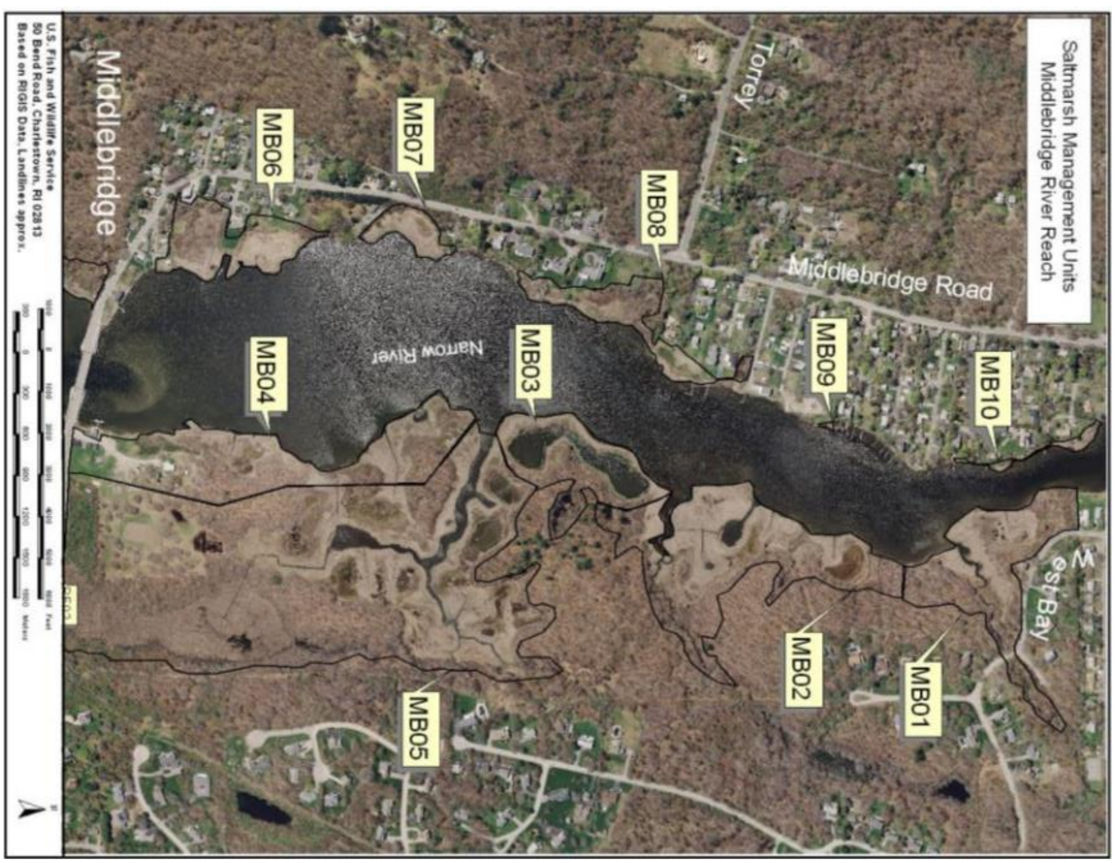
- The current installations will continue to be monitored in detail;
- All applications will be inspected three times per year (spring, summer, fall) to determine whether structures are in good operational condition. Repairs to structures will be made promptly. As soon after major storm or flooding events, all structures will be re-inspected. Structures with recurring maintenance issues, or which are clearly not meeting intended results, will be removed.
- Structures will be located so as to ensure provision of natural banks on both the upstream and downstream sides of the installation that are at least as long as the living shoreline installation. This will ensure the availability of control sites for monitoring effectiveness, as well as preserving existing bank habitats.
- Written landowner permission will be secured prior to implementation on shorelines where adjacent lands are in non-federal or State ownership.

Table C1. Salt Marsh Shoreline Restoration Summary

RIVER REACH AND SALT MARSH UNIT	Application of Living Shoreline Treatments by River Reach and Salt Marsh Unit								
	TOTAL SURFACE ACRES	SHORE-LINE (FT)	BANK TREATMENT (FT)	% OF SHORE-LINE	RIVER REACH AND SALT MARSH UNIT	TOTAL SURFACE ACRES	SHORE-LINE (FT)	BANK TREATMENT ACTION (FT)	% OF SHORE-LINE
LACY BRIDGE	25.9	8,628	0	0	PET. COVE	119.9	27,497	1,140	4
LOWER RIVER	14.5	6,414	1,391	22	PC01	6.5	860	43	5
LO01	3.6	3,750	750	20	PC02	13.1	2,568	385	15
LO04	4.6	1,282	641	50	PC03	8.2	1,454	145	10
MIDDLEBRIDGE	51.1	8,542	951	11	PC04	3.3	969	97	10
MB01	3.5	936	234	25	PC10	18.5	2,757	138	5
MB03	3.6	1,020	410	40	PC13	6.2	3,323	332	10
MB06	2.2	1,229	307	25	REFUGE	29.1	5,640	343	6
					RF01	3.8	1,306	131	10
METATUXET	2.3	401	0	0	RF04	5.0	840	42	5
					RF07	1.0	1,135	170	15

Figures C1-C4. Salt Marsh Management Units in the Estuary






Saltmarsh Management Units
Pettaquamscutt Cove
PC01
PC02
PC03
PC04
PC05
PC06
PC07
PC08
PC09
PC10
PC11
PC12
PC13
U.S. Fish and Wildlife Service
50 Bend Road, Charlestown, RI 02813
Based on RIGIS Data. Landlines approx.


Saltmarsh Management Units
Lower River Reach
LO01
LO02
LO03
LO04
Boston Neck Road
The Narrows
Sprague Bridge
The Dunes Club
U.S. Fish and Wildlife Service
50 Bend Road, Charlestown, RI 02813
Based on RIGIS Data. Landlines approx.

ACTION D
RESTORE SALT MARSH SURFACE HYDROLOGY AND DRAINAGE

This action is designed to drain excess water trapped on the salt marsh surface, which is causing loss of vegetation. Degraded salt marshes will be restored by improving surface drainage using the “runnel” method—excavating shallow (generally 8” to 12” or less in depth, and less than two feet wide) channels on the surface of the marsh to provide surface drainage. The minimum number and lengths of runnels will be created, with the density based on site-specific analysis. In some cases, existing pans and pools will be connected to tidal waters, but only recently developed pans will be drained (i.e. historic or long-term pools and pans will be preserved). In addition, some clogged existing ditches which have filled with sediments will be cleared, but only to the extent surface drainage can be achieved (generally a foot in depth or less). In all cases, both the minimum number and minimum depths and width will be used to enhance drainage. The purpose is to allow drainage while minimizing any increased volume of flow onto the surface. Runnels will be constructed using hand tools such as pulaskis and shovels. Materials removed will be spread on the marsh surface where they will not impede drainage. In some areas, a small low-ground-pressure excavator, typically used for mosquito control, will be used to create runnels and clear drainages. This excavator will only be used in the Middlebridge and Pettaquamscutt Cove management reaches. Poorly drained salt marsh surfaces which will be targeted for treatment are shown in the following images by river reach (Figures D1-D5) and summarized in Table D1.

Management Constraints/Controls

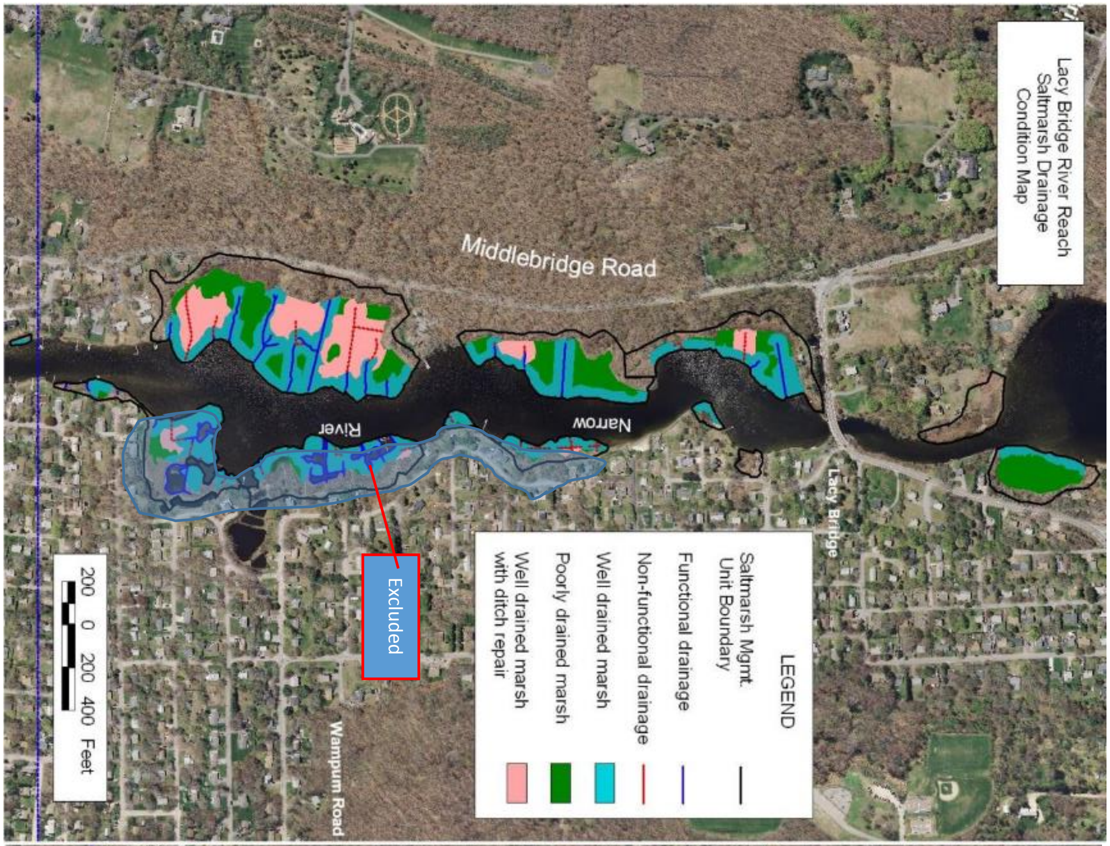
- Restoration on non-federal lands requires written landowner permission prior to any action.
- No long-term (historic) pools or pans, or brackish marsh, will be drained; these habitats will be protected.
- Excavator use is limited to stable salt marsh surfaces only.
- In locations where motorized, low-ground-pressure equipment is used, seasonal restrictions will limit activities during the period May 15 to August 31 in order to limit disturbance to nesting birds.
- In locations where manual runnel development occurs, and where such use is concentrated in one area over a period of more than one day, seasonal restrictions will limit activities during the May 15 to August 31 period to limit disturbance to nesting birds.
- Runnel development north of Middlebridge and near Canonchet will receive intensive monitoring. All sites will be inspected three times per year for a period of two years to evaluate whether the treatment meets intended objectives, whether maintenance is necessary, and to monitor response to storm events.

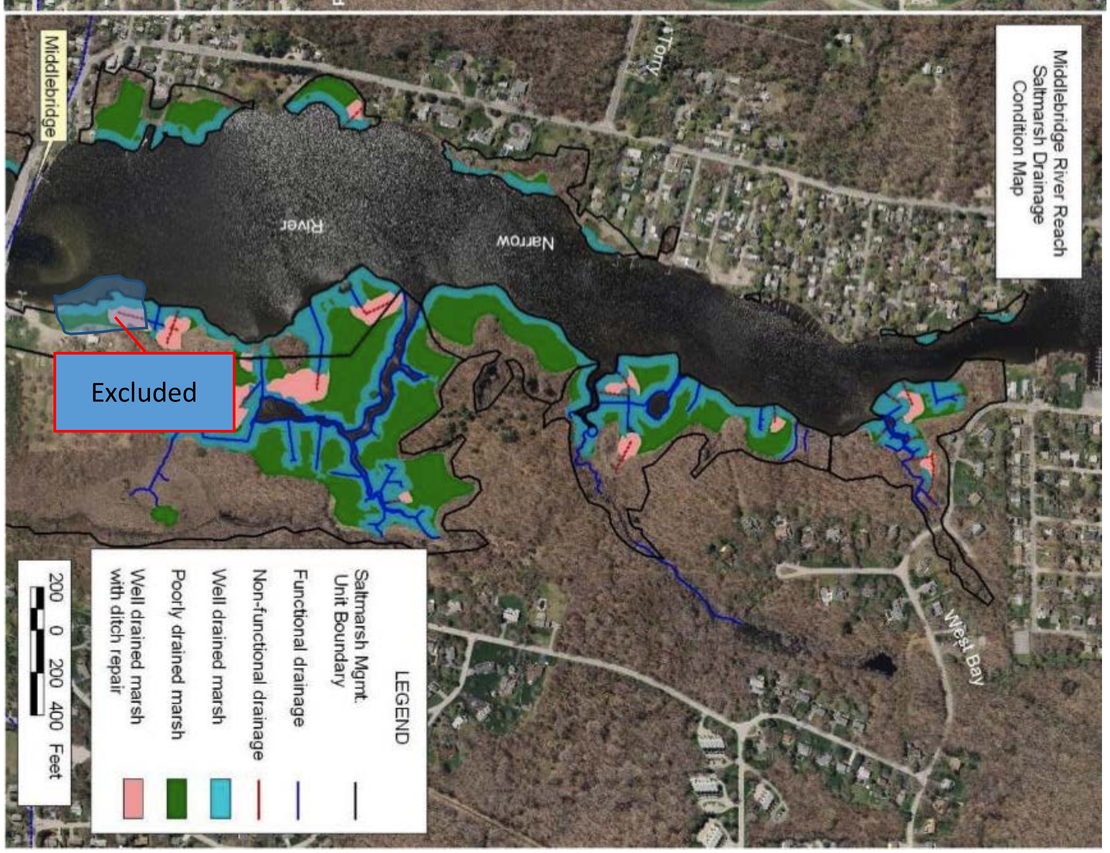
Table D1. Areas for Salt Marsh Drainage Improvement (poorly drained and areas with clogged drainage)

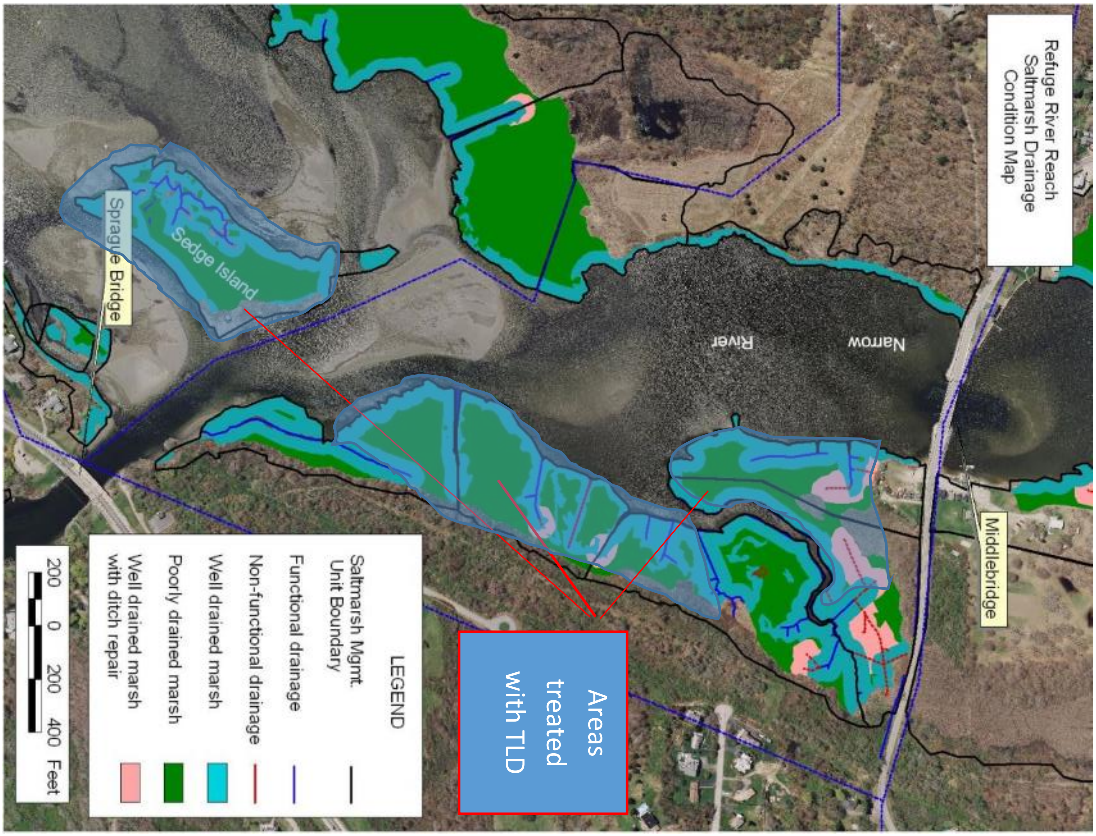
RIVER REACH	TOTAL ACRES	MARSH DRAINAGE (FT)			CONDITION OF MARSH SURFACE				SALT MARSH
		RIVER / MARSH SHORE LINE	DITCHES & SLOUGHS		WELL DRAINED SALT MARSH HABITAT		POORLY DRAINED SALT MARSH HABITAT		IMPACTED - CLOGGED DRAINAGE
			FUNCTIONAL	NON-	ACRES	%	ACRES	%	ACRES
LACY BRIDGE	15.2	8,628	6,003	2,281	11.4	75	3 (3.8)*	20	4(4.1)*
LOWER RIVER	14.0	6,414	7,972	58	11.3	81	2.7	19	0.1
MIDDLE-BRIDGE	31.6	8,542	12,366	1,887	17.5	56	12 (14)*	38	3(3.4)*
METTATUXET	1.6	401	0	0	0.2	12	1.4	88	0.0
PET COVE	86.8	27,497	18,427	3,984	52.8	61	27.8(34)*	32	3(8.0)*
REFUGE	24.8	5,640	7,035	1,810	12.1	49	0 (12.7)*	0	.5(1.8)*
TOTAL TREATED	174.0	57,122	51,803	10,020	105.4	61	46.9(68.6)	27	10.5(6.8)

*/ Acres in Parenthesis are total poorly drained area, some areas excluded from treatment. Total of 46.9 treated (27%).

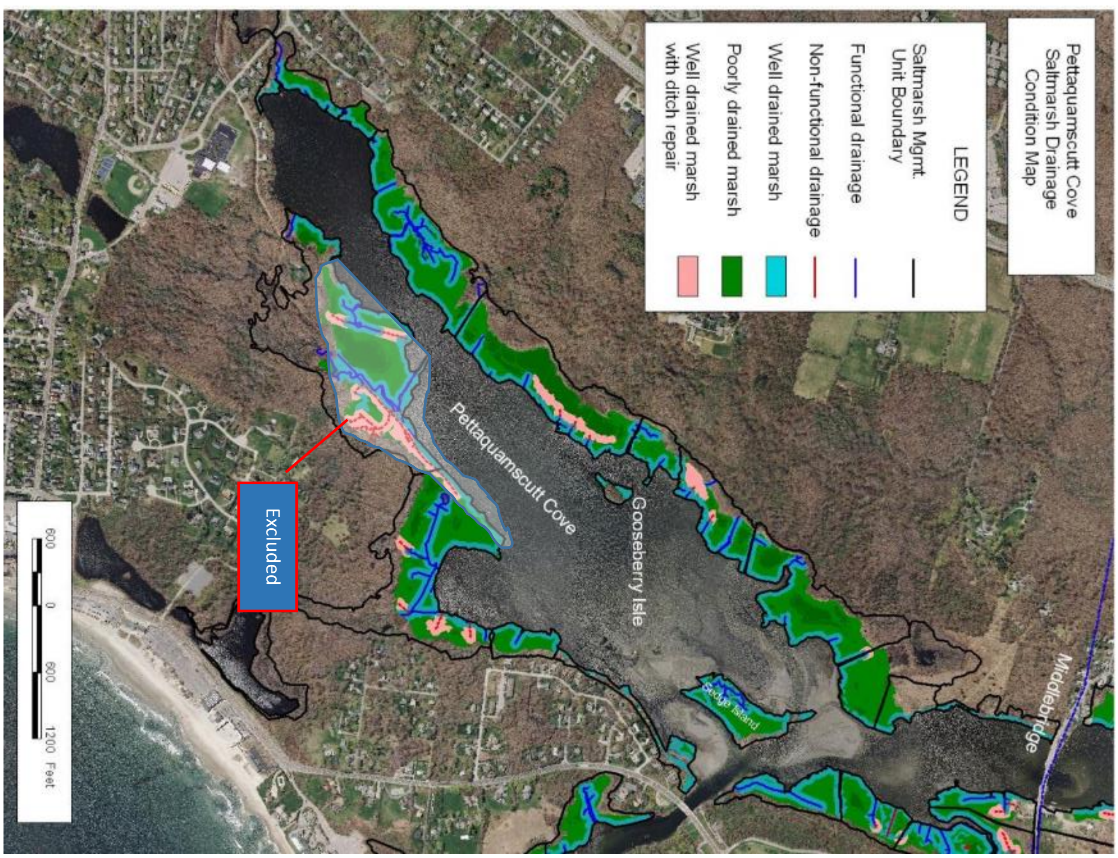
Figs. D1 – D5: Marsh Surface Drainage by River Reach



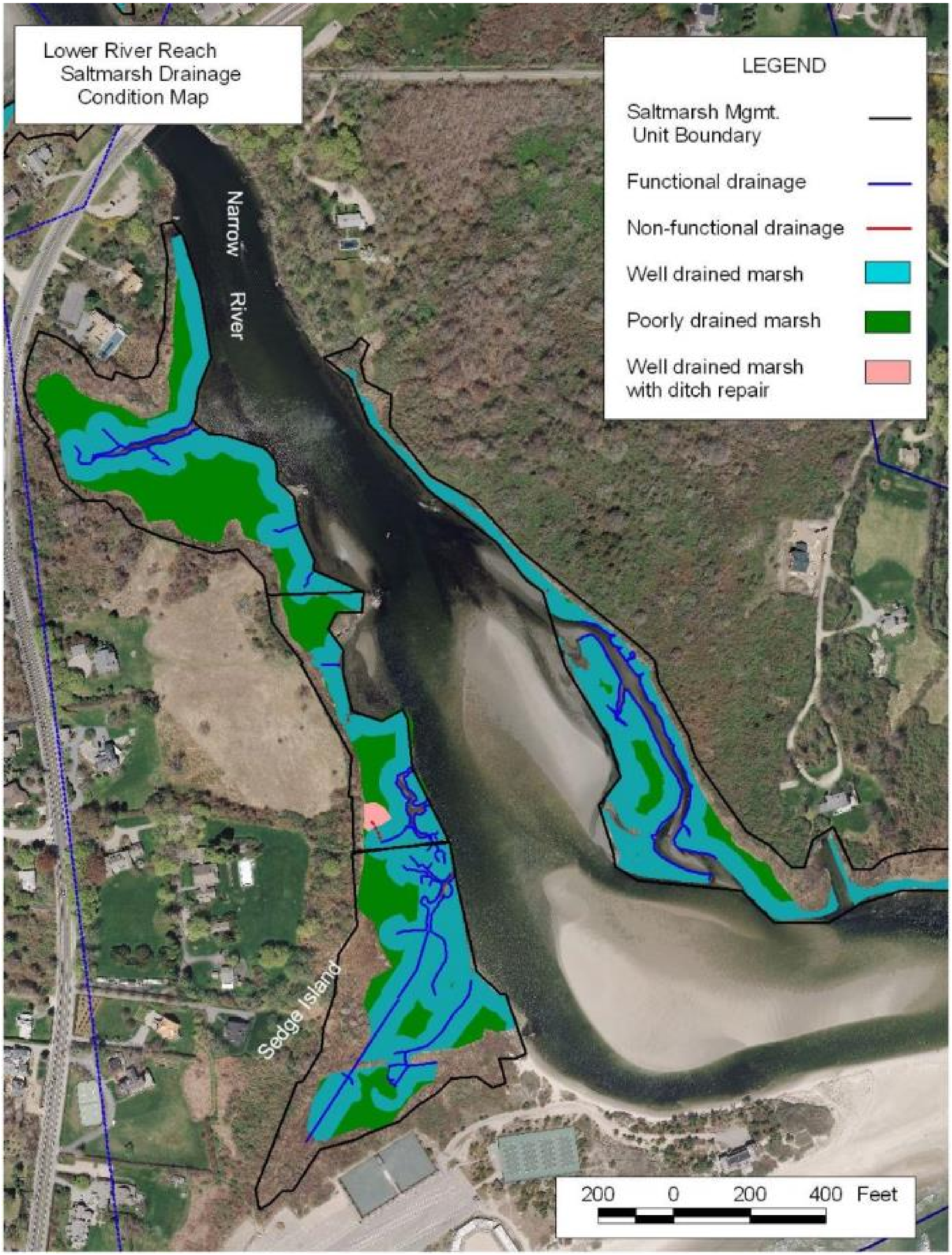




Refuge River Reach
Saltmarsh Drainage
Condition Map
Narrow
River
Sedge Island
Sprague Bridge
Middlebridge
Areas treated with TLD
LEGEND
Saltmarsh Mgmt. Unit Boundary
Functional drainage
Non-functional drainage
Well drained marsh
Poorly drained marsh
Well drained marsh with ditch repair
200 0 200 400 Feet



Pettaquamscutt Cove
Saltmarsh Drainage
Condition Map
LEGEND
Saltmarsh Mgmt. Unit Boundary
Functional drainage
Non-functional drainage
Well drained marsh
Poorly drained marsh
Well drained marsh with ditch repair
Pettaquamscutt Cove
Gooseberry Isle
Middlebridge
Sedge Island
Excluded
600 0 600 1200 Feet


Lower River Reach
Saltmarsh Drainage
Condition Map
LEGEND
Saltmarsh Mgmt. Unit Boundary
Functional drainage
Non-functional drainage
Well drained marsh
Poorly drained marsh
Well drained marsh with ditch repair
Narrow River
Sedge Island
200 0 200 400 Feet

ACTION E
RESTORE LOW MARSH, DEGRADED MARSH AND INTERTIDAL ELEVATIONS

This action will create low marsh habitats and enhance elevations on salt marsh surfaces to increase resilience to sea level rise and to improve currently degraded habitat conditions. Material generated from implementation of the eelgrass restoration (Action B) will be used here to achieve these objectives. Table E1 summarizes fill requirements and Figure E1 displays the management units.

<u>Rationale for the Use of Thin Layer Deposition (TLD) Techniques for Salt Marsh Enhancement</u>

TLD Site Selection: An inventory of salt marsh conditions was completed in the winter of 2013/2014 to detail current habitat conditions by mapping vegetation communities, marsh drainage conditions, and surface profiles (Appendix A). Long-term vegetation monitoring data collected over the past five years (USFWS 2014) was also analyzed to determine trends in vegetation on the marsh surface, where such data were available. This information was compared with sea level rise projections (Appendix E), historic habitat conditions based on old coast surveys and aerial photography, and recent site-specific studies in the estuary and Narragansett Bay (e.g. Watson *et al.* 2014; Raposa *et al.* 2014).

This information and other data were provided to a group of scientists with expertise in salt marsh ecology, estuarine systems, and restoration techniques. This group, which included representatives from the Service, US Environmental Protection Agency (USEPA), US Army Corps of Engineers (USACOE), Natural Resources Conservation Service (NRCS), RIDEM, RICRMC, University of Rhode Island, Center for Ecosystem Restoration, Save The Bay and The Nature Conservancy (TNC), formulated restoration strategies which included the use of thin layer deposition as a method to enhance degraded salt marsh conditions and improve resilience of salt marshes to sea level rise. This idea was based in part on successful applications in other areas, such as Jamaica Bay, NY and Pepper Creek, DE. Discussions with RICRMC dredging experts indicated that TLD would be practicable only within the Refuge Reach of the River, between Middlebridge and Sprague Bridge. The units proposed under this action are the result of these planning efforts.

Determination of Goals: Elevational targets were determined based on elevations where specific salt marsh species currently occur. Since this salt marsh community is considered inherently to be high marsh, given current surface elevations (Appendix D) and species composition, salt marsh hay (*S. patens)* and black grass (*Juncus spp.)* were identified as the target species for restoration. Higher marsh elevations, such as those commensurate with the distribution of high tide bush (*Iva fructescens*), were not targeted in order to avoid increase risks of invasion by common reed, *Phragmites australis,* on the salt marsh surface; to ensure protection of brackish marsh; and to ensure there will be no loss of wetland habitats. Additional conditions which were considered included the need to protect existing, productive stands of low marsh (dominated by the tall form variant of cordgrass, *S. alterniflora*), existing stands of healthy *S. patens,* protection of historical pools and pans, and conservation of brackish marshes.

Determination of Elevation Targets: Surface profile information, which included identification of species where elevations were taken (Appendix A), and the LiDAR (Light Detection and Ranging) evaluation of the estuary conducted by The Nature Conservancy (see Figure 2 in EA), were used to generate initial estimates of elevation targets, in consultation with the team which identified restoration ideas to pursue. It became apparent that, as is the case in other salt marshes, plant communities occurred at different elevations in different portions of the estuary, caused by such things as localized differences in tidal flow, drainage, water entrapment, and elevations. It appeared that clear associations could not be made to a specific elevation without refining the data available.

A professional land survey team, using real-time kinematic (RTK) equipment, conducted an intensive survey of the area to determine current elevations, and collected data regarding dominant species' occurrence at various points (n>900) throughout the salt marsh. This information was bolstered by intensive mapping of the vegetation on marsh surfaces by the Service.

This mapping in combination with elevations revealed that (a) specific plant communities occurred at higher elevations on the west side of the estuary than east; (b) *Juncus* occurred only at higher elevations; and (c) the distribution of *S. patens* seemed dependent on both elevation and drainage (well-drained areas within 50 feet of channels) in the estuary. This pattern was corroborated by Watson and others (2014) studying salt marsh vegetation in Pettaquamscutt Cove.

Therefore, since the objective of this project is to provide elevation capital and resilience to sea level rise, targeted elevations are those where *Juncus* occurs and *S. patens* is dominant. The specific elevation target was determined on a unit-by-unit basis and for west side versus east side comparisons.

Target elevations by unit are shown in Table E1. RTK elevations (NAVD88) and the results of vegetation mapping are shown Figures E2 – E10. Note that in the vegetation surveys, unclassified stands are those with a co-dominance of *S. alterniflora, Distichlis spicata, S. patens*, and/or *Salicornia spp*. Degraded marsh areas are those dominated by short-form variant of *S. alterniflora*, interspersed with stands of *Salicornia* and bare soil (pans).

Operational Description

This action will be accomplished using small conventional construction equipment and multiple management controls to avoid negative impacts to estuarine and marsh habitats within the estuary. A temporary staging area will be installed with a gravel surface at the river access point on the northwest side of Sprague Bridge on National Wildlife Refuge lands. A small, temporary floating dock will be installed at this location with temporary pilings and a simple access ramp. In order to minimize construction impacts from this work the Service intends to deploy small-scale mechanical, rather than hydraulic equipment to accomplish dredge and fill operations. All equipment and materials will be positioned and operated from floats in order to avoid equipment impacts on marsh surfaces or tide flats.

In instances where a fill operation is adjacent to a dredge area, the work will be accomplished through a simple sidecast operation, using an excavator on a float to dig the new channel, and to place the material in the old channel to be filled. Sediment re-suspension is expected to be minimal, due to the sandy nature of the material in these areas. Where needed, oyster shell bags or similar “living shoreline” materials will be used to contain the material that is being placed. Where sediments must be moved any distance from a dredge to a fill area, they will be placed in sealed containers (approx. 20 c.y.) on floats, and barged into position adjacent to application areas. In some cases dredged material may be stockpiled at the staging area in a non-wetland location for a period of several months for operational reasons. In such cases all storm water regulations and erosion control best practices will be observed to avoid sedimentation impacts to wetlands or surface waters. In restoring low marsh areas, where sediment application thicknesses will be 2-3 feet, the contractor will use oyster shell bags and coir logs as necessary to contain the applied sediments. Low marsh restoration areas will be planted with *S. alterniflora* on a 30” x 30” spacing or less where needed.

During the first construction season, expected to be winter, 2014-15, the Service will employ TLD at pilot scale in order to evaluate methods and results over the following year. Results of this experience will be used to refine and scale up methods during the second construction season, to ensure the intended restoration results are achieved with minimal impacts.

To restore degraded high marsh elevations, the Service’s contractor will apply thin layers of liquefied dredged material from the floating containers onto the surface of the marsh within narrowly targeted areas. To achieve designed elevations, the contractor will position coir logs around the perimeter of restoration areas, set to target elevations. In most areas, it is expected that TLD thicknesses will range from a minimum of 1-3”, to a maximum of approximately 9”. The contractor will also position coir logs within the restoration areas, to mimic the form of shallow natural tidal channels. The contractor will then pump the sand, liquefied with a high water content, into the application area until target elevations are reached. The coir logs around the perimeter will contain the sediments and prevent sedimentation of non-target areas, while the coir logs within the restoration area will create surface drainage patterns within it. It is expected that a 4-6" pipe will be adequate for applying the dredged material.

Stable benchmarks and survey equipment will be used to ensure that target elevations are achieved, and elevational monitoring over the following year will measure compaction and establish any need for further applications of TLD. Application areas will be surveyed using RTK survey equipment to establish target elevations, and will use on-site sediment controls to contain TLD sediments to target areas. Relatively thin applications will be sufficient to spur re-vegetation; TLD target thicknesses will range from a minimum of 1-3", to a maximum of approximately 9". Areas of application greater than 3" will be replanted with native marsh species such as *S. alterniflora* and *D. spicata.*

Within and adjacent to treated areas, hay bale swales will be installed every 200 feet within existing drainages at half of the bank height to retain sediments on site. Within treatment areas, coir logs or similar will be used and installed in a drainage pattern to retain materials sprayed on the marsh. These materials will essentially compartmentalize the treated area, so that application can proceed from one compartment to the other. Survey equipment will be used to monitor whether target elevations are met. Once material has settled, the coir logs will either be removed or retained in place, as site-specific conditions dictate, to provide long-term drainage patterns on the marsh surface.

Based on applications in other areas, materials once placed on the area will be expected to settle and compact over time. Initial applications will apply material so as to accommodate this settlement, and monitoring will help insure appropriate amounts of materials will be applied to best achieve target elevations.

This action is subject to the following management controls:

- Engineering designs approved by RICRMC will be finalized and followed to ensure widths, depths, and slopes are not exceeded.
- Placement of materials will occur only during the approved dredging seasons, typically November 15 - January 31;
- Receipt of all required permit requirements (see EA Sec. 6.3);
- Tree clearing at the staging area will be kept to the minimum necessary; all trees will be provided protection (wooden slats) during the construction period.
- The staging area will be regularly inspected for environmental compliance for erosion control, hazardous material containment, public safety, and other items.
- Gravel placed to develop the site will be removed, topsoil will be used to resurface the area, with native vegetation re-established on the site, including grasses, shrubs, and trees.
- Existing paths at Sprague Bridge used by the public will be kept in an open condition from March 30 through November 1 each year to the extent possible.
- Regular inspections of the lay down area, including erosion control devices, standards for HAZMAT containment and control, and other contractual requirements will be made on a regular basis at the staging/laydown area.
- All materials placed at the staging/laydown area will be removed, with topsoil no less than six inches in depth applied and seeded/planted with a mixture of native grasses, forbs, and 2+ year shrubs.
- In order to avoid impacts to estuarine fish and wildlife and recreational uses, the temporary construction dock will be placed no earlier than October 15, and removed by March 15 each year.
- The monitoring program used at Pepper Creek, DE, will be modified and used to evaluate the effectiveness of TLD applications on below-ground and above-ground features of salt marshes and vegetation. Data collected from treatment sites will be compared to information from control sites. Nekton sampling will occur in adjacent pools and drainages, and be compared with control sites. Vegetation monitoring will occur for a period of five years.

Figure E1. Management Units (3-8, 18, 19) for Restoring Low and Degraded Marshes Using TLD. Final layout may differ from what is shown here.

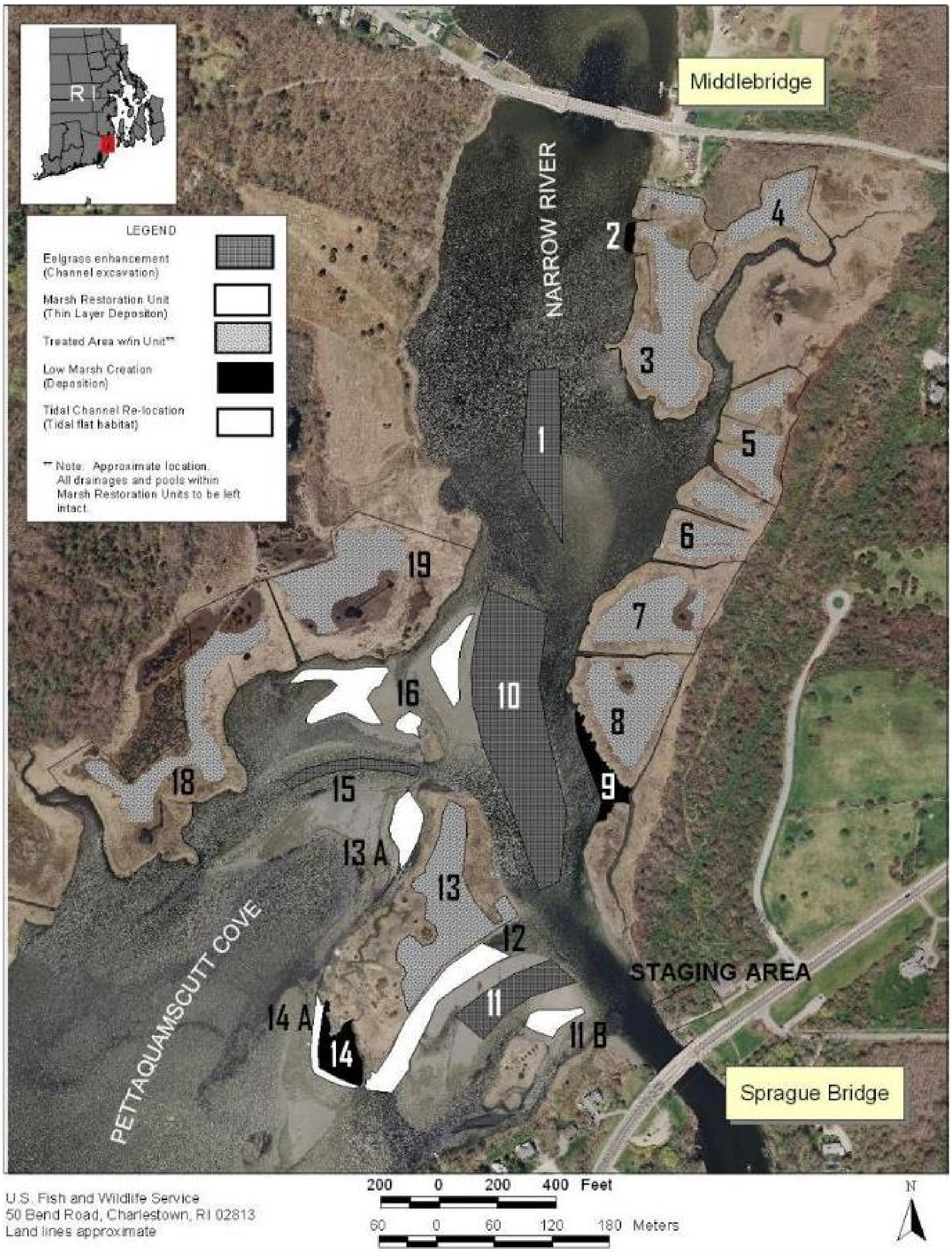
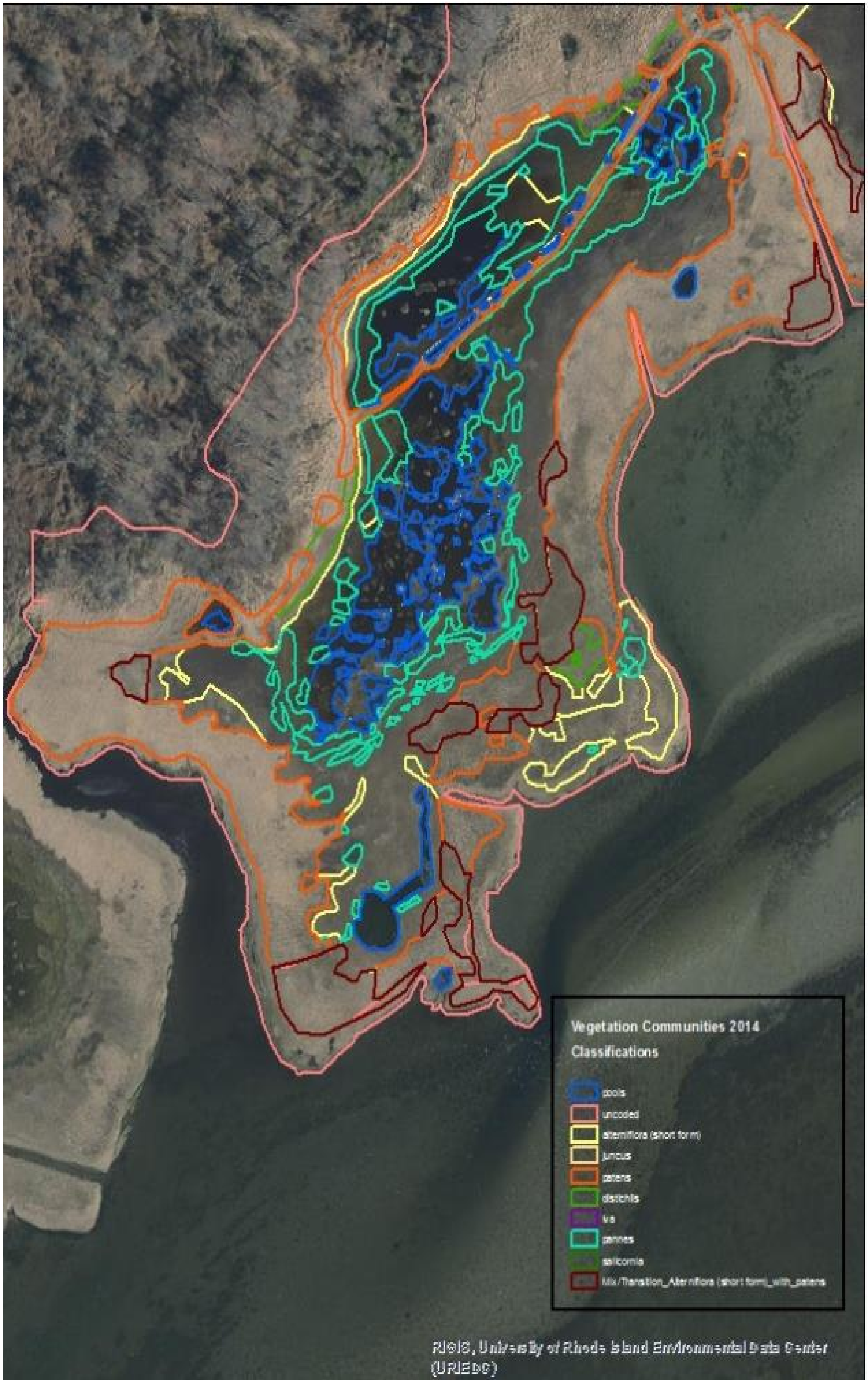


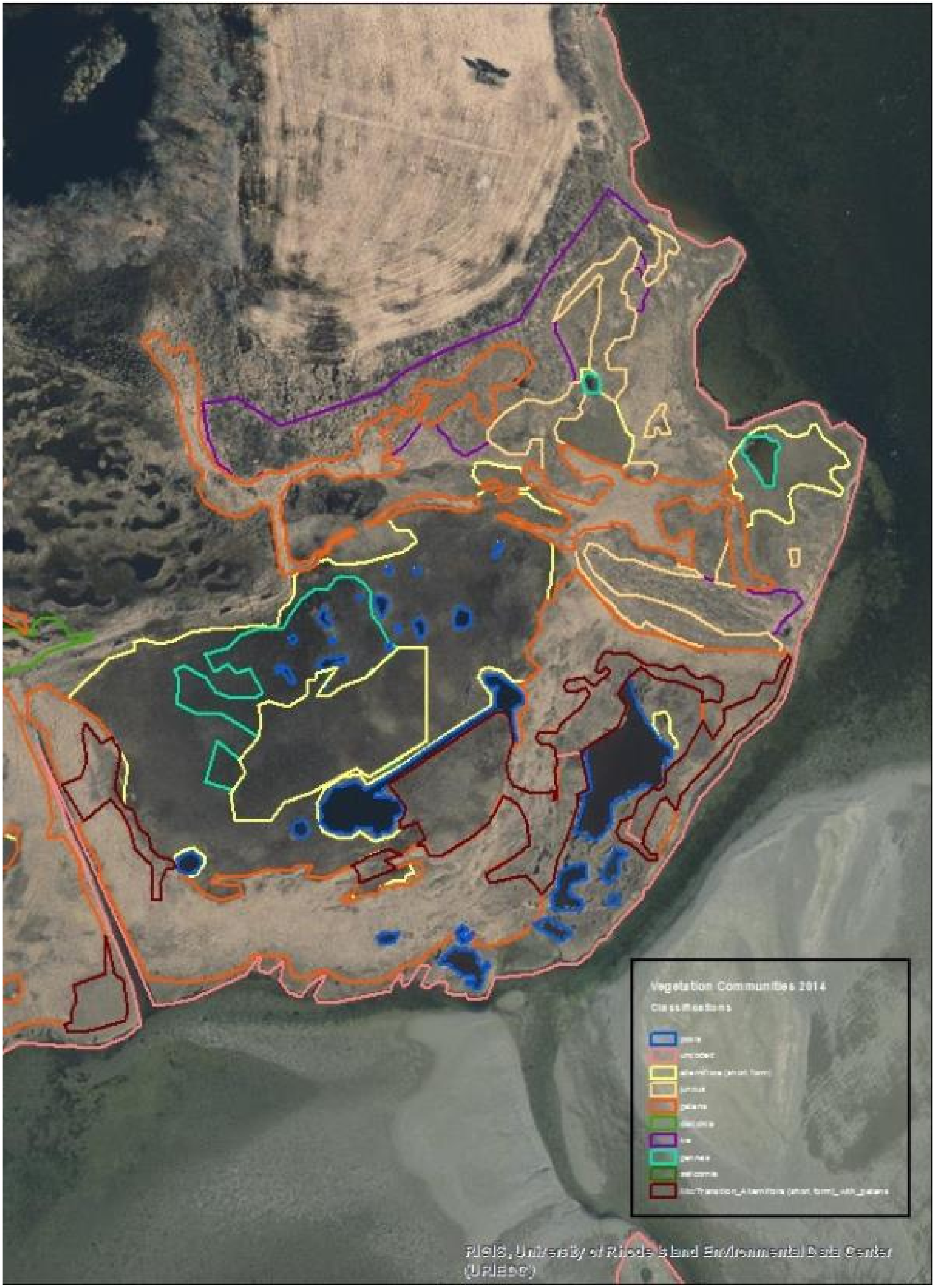
Table E1. Summary of Estimated Excavation and Fill Requirements for Proposed Actions

UNIT	GOAL	TREAT-MENT	CURRENT CONDITIONS						PROPOSED CONDITIONS						NOTES
			AREA (SQ. FT.)	AREA (ACRES)	WETTED AREA ABOVE -2FT (1)	WETTED AREA BELOW -2FT (2)	TOTAL WETTED AREA (ACRES)	AVERAGE ELEV / DEPTH (FT)	TARGET ELEV / DEPTH (FT)	EXCAVATE VOLUME (CYD)	FILL VOLUME (CYD)	WETTED AREA ABOVE -2FT	WETTED AREA BELOW -2FT	CHANGE IN WETTED AREA (ACRES)	
1	Eelgrass	Excavate	56,618	1.3	58,469	0	1.34	-1.25	-3.00	3,669.7		0	56,618	-0.04	
2	Low Marsh	Fill	3,015	0.1	n/a	n/a		-1.40	0.85		326.6				
3a	Marsh	Fill	85,930	2.0	n/a	n/a		1.25	1.55		1,241.2				
3b	Marsh	Fill	10,734	0.2	n/a	n/a		1.10	1.55		232.6				
4	Marsh	Fill	32,754	0.8	n/a	n/a		1.20	1.55		552.0				TLD only with clearence for saltmarsh sparrows.
5a	Marsh	Fill	39,017	0.9	n/a	n/a		1.25	1.60		657.5				
5b	Marsh	Fill	26,229	0.6	n/a	n/a		1.10	1.60		631.4				
6a	Marsh	Fill	16,382	0.4	n/a	n/a		1.10	1.55		354.9				
6b	Marsh	Fill	12,675	0.3	n/a	n/a		1.10	1.55		274.6				
6c	Marsh	Fill	8,149	0.2	n/a	n/a		1.10	1.55		176.6				
7a	Marsh	Fill	4,861	0.1	n/a	n/a		1.20	1.60		93.6				
7b	Marsh	Fill	50,277	1.2	n/a	n/a		1.00	1.60		1,452.4				
8	Marsh	Fill	67,454	1.5	n/a	n/a		1.00	1.60		1,948.7				
9	Low Marsh	Fill	20,410	0.5	n/a	n/a		-1.45	0.85		2,260.2				
10	Eelgrass	Excavate	194,235	4.5	197,179	2,944	4.59	-0.50	-4.00	25,510.4		2112	179,520	-0.42	Sideslope of 5:1 on western side.
16a	Tidal Flat	Fill	36,269	0.8	36,269	0	0.83	-0.30	0.40		1,222.4				
16b	Tidal Flat	Fill	4,969	0.1	4,969	0	0.11	-0.30	0.40		167.5				
16c	Tidal Flat	Fill	19,208	0.4	19,208	0	0.44	-0.30	0.40		647.4				
11	Eelgrass	Excavate	39,462	0.9	39,842	200	0.92	0.00	-4.00	5,156.4		1552	40,352	0.04	Sideslope of 3:1
11A	Tidal Flat	Fill	11,288	0.3	11,288	0	0.26	0.00	0.35		190.2				
12	Tidal Flat	Fill	47,496	1.1	47,496	0	1.09	-5.50	0.35		13,378.0				
13	Marsh	Fill	99,093	2.3	1,016	0	0.02	1.26	1.60		1,622.2				
14	Low Marsh	Fill	24,181	0.6	n/a	n/a		-1.45	0.85		2,677.8				
14A	Tidal Flat	Fill	9,757	0.2	9,757	0	0.22	-0.30	0.40		328.8				
13a	Tidal Flat	Fill	18,456	0.4	18,456	0	0.42	-0.30	0.40		622.0				
15	Eelgrass	Excavate	16,687	0.4	16,687	0	0.38	-1.00	-3.00	880.5		1724	1640	-0.31	Sideslope of 3:1 on western side.
18	Marsh	Fill	74,882	1.7	n/a	n/a		1.45	1.70		901.4				TLD only if runnels will not work.
19	Marsh	Fill	74,524	1.7	n/a	n/a		1.45	1.70		897.0				TLD only if runnels will not work.
17	cobble 1	Excavate	12,612	0.3	1,016	0	0.02	-0.50	-3.00	1,120.6				0.02	Current cobble/rock
17a	cobble 2	Fill	1,351	0.0	0	0	0.00	-2.00	0.00		130.1	1351		0.03	Change in sand/cobble/rock
17b	cobble 2	Fill	10,734	0.2	0	0	0.00	-2.00	0.00		1,033.6	10734		0.25	Change in sand/cobble/rock
TOTALS (AC):			25.93	25.93	10.60	0.07	10.67	-1.99	10.55	36,337.6	34,021.0	0.40	6.38	-0.43	

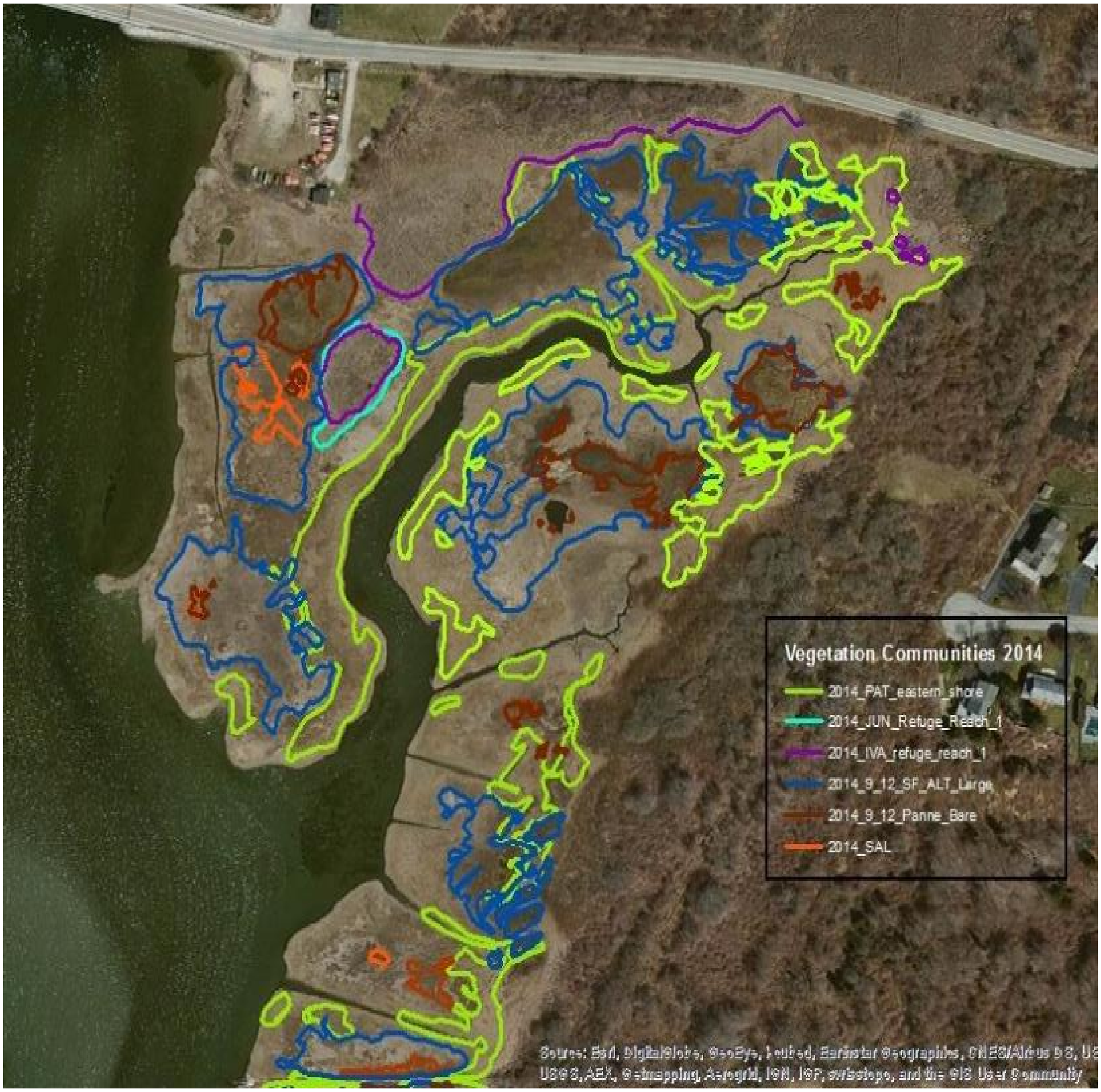
Figures E2-E3. Vegetation and RTK Data for Unit 18


Vegetation Communities 2014
Classifications
pools
uncoded
alterniflora (short form)
juncus
patens
distichlis
n/a
pannes
salicornia
Mix/Transition_Alterniflora (short form)_with_patens
RIGIS, University of Rhode Island Environmental Data Center (URIEDC)

Figures E4-E5. Vegetation and RTK Data for Unit 19


Vegetation Communities 2014
Classifications
RIGIS, University of Rhode Island Environmental Data Center (URIEDC)

Figures E6-E7. Vegetation Data for Units 3-5



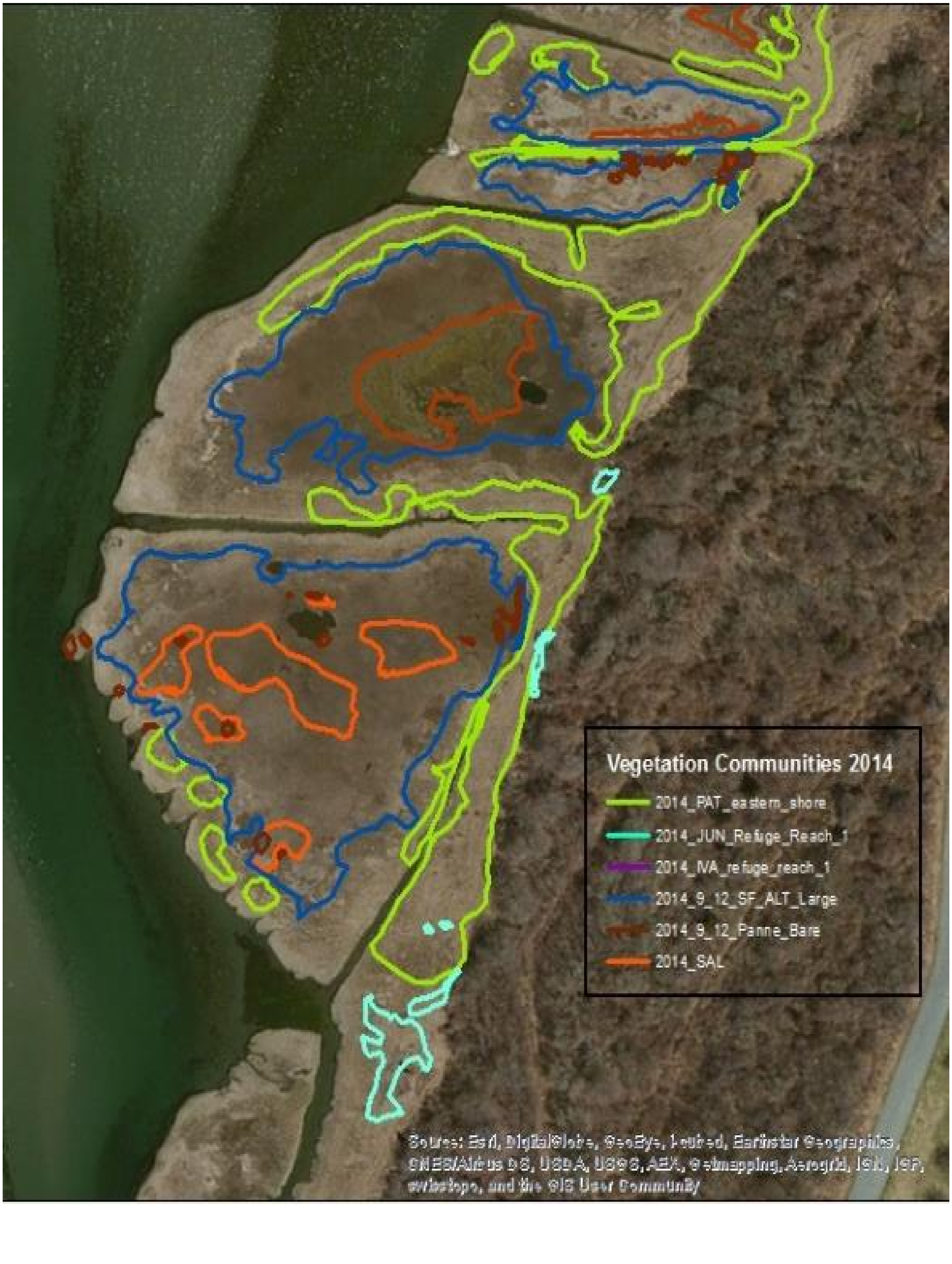
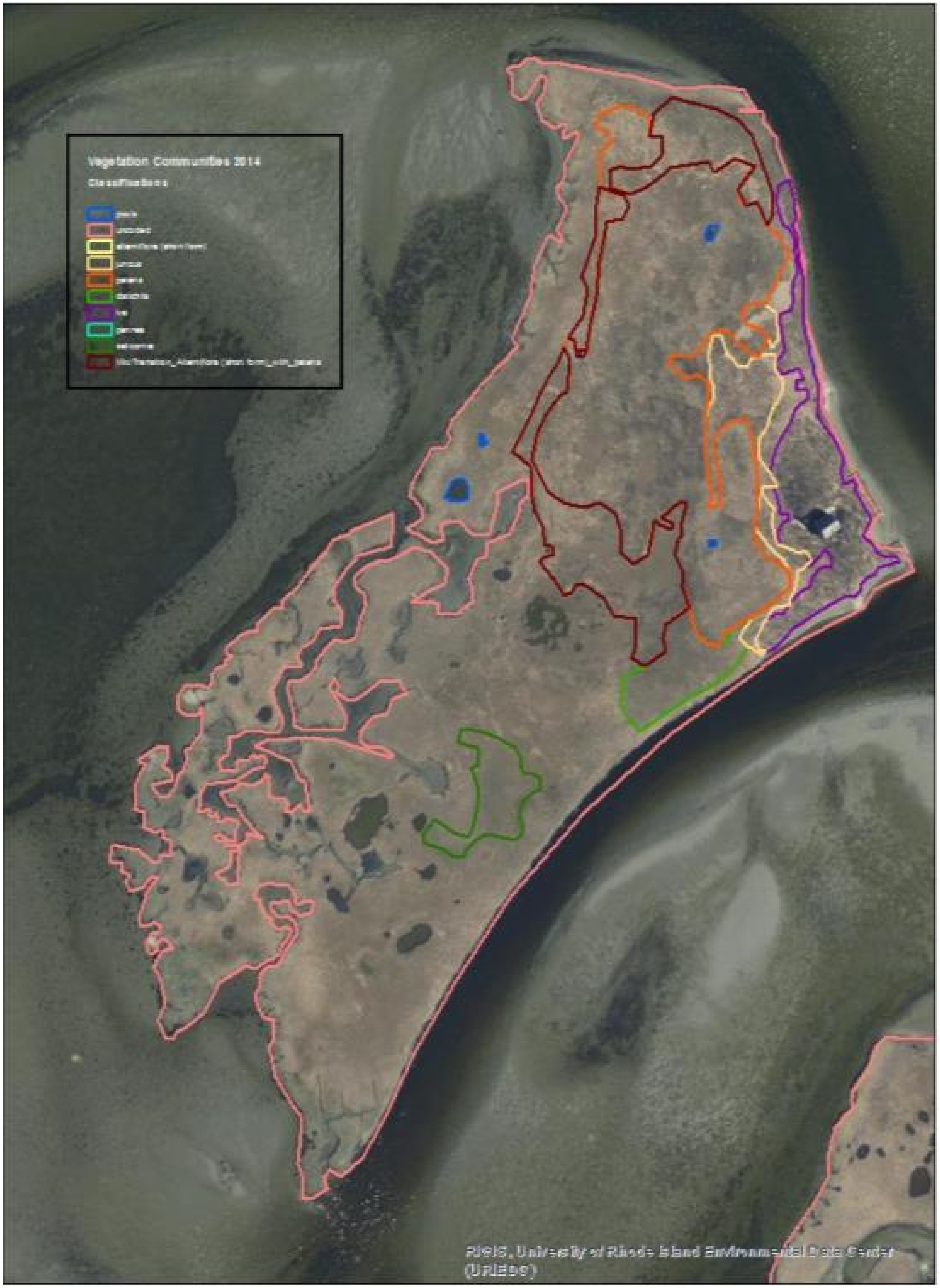

Vegetation Communities 2014
2014_PAT_eastern_shore
2014_JUN_Refuge_Reach_1
2014_IVA_refuge_reach_1
2014_9_12_SF_ALT_Large
2014_9_12_Panne_Bare
2014_SAL
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure E8. RTK Data for Units 3-5

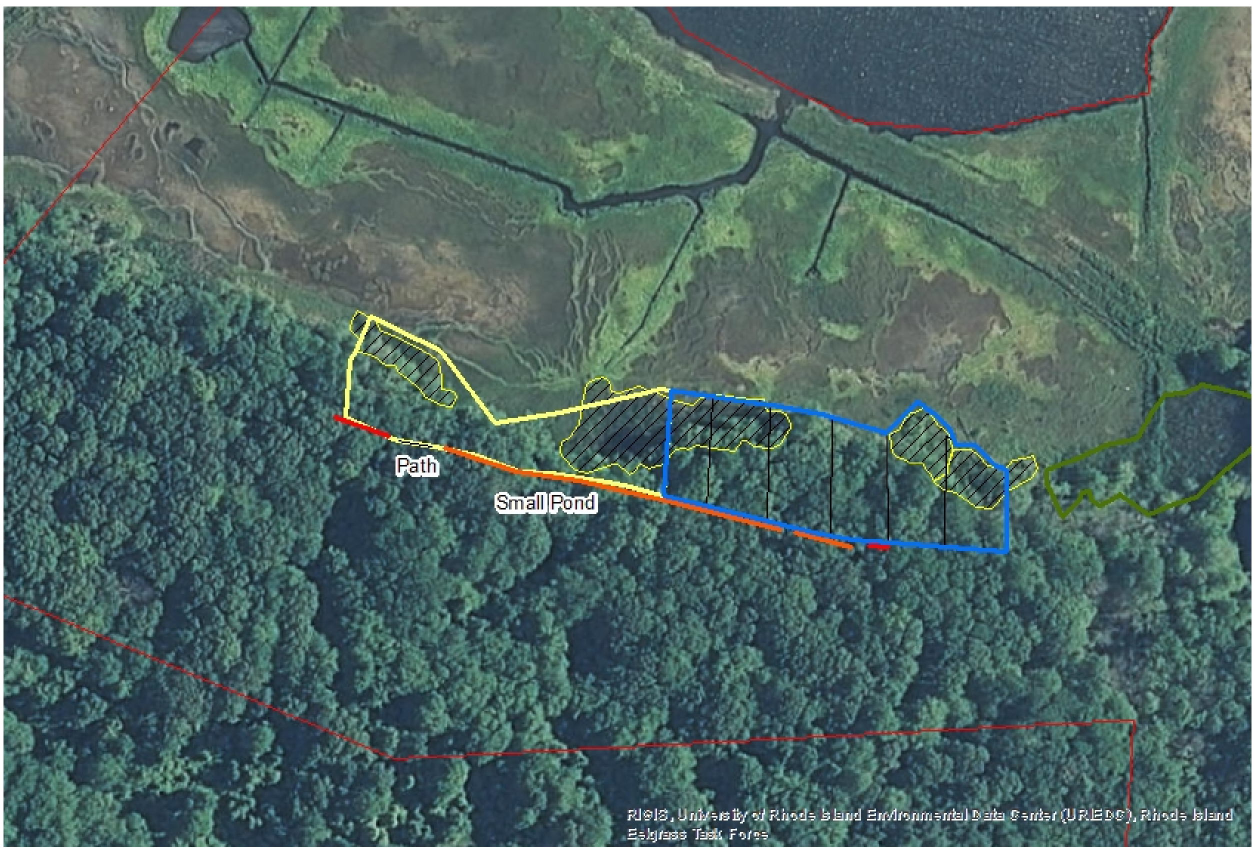
Figures E9-E10. Vegetation and RTK Data for Unit 13.




Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics,
DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo
User Community

ACTION F
TEST TREATMENTS TO ENHANCE MARSH MIGRATION

Within a two-acre site currently comprised of an oak forest overstory near salt marsh transition zones, trees will be girdled to stimulate shrub production in the understory. Adjacent control sites in untreated oak forest neat the salt marsh transition zone will be evaluated and compared to determine whether this treatment has the potential to enhance conditions for salt marsh migration. Within areas in blue in the figure below, approximately 24 trees will be girdled to allow understory release and determine whether this action facilitates marsh migration.



APPENDIX H

RESPONSE TO PUBLIC COMMENTS

A Draft of this Environmental Assessment (EA) for the Narrow River Resiliency Restoration Program was published on the Service's website (http://www.fws.gov/refuge/john_h_chafee) and Facebook page (https://www.facebook.com/rinwrc) on October 30, 2014, and made available for a 30-day public comment period from October 30, 2014, through November 30, 2014. Printed copies of the Draft EA were placed at the Kettle Pond Visitor Center in Charlestown, RI, and on November 4, 2014, additional printed copies of the Draft EA were made available at the Maury Loontgens Memorial Library in Narragansett, RI, and at the Peacedale Public Library in South Kingstown, RI. On November 7, 2014, the Narragansett Times published a story regarding the availability of the Draft EA for public comment; a legal advertisement also ran in the Narragansett Times that day indicating the availability of the Draft EA for public comment (Narragansett Times, Vol. 151, No. 90). On Friday, November 12, 2014, The South County Independent published a legal advertisement that provided notice of the availability of the Draft EA for public comment. A Draft Finding of NO Significant Impact was published on the Refuge Complex website, no comments were received on the draft document.

A total of 45 comments were received from two respondents. Most of the comments were specific technical comments, requests for source information, or editorial comments. One respondent requested extension of the public notice period on the EA. All comments are addressed in this Appendix. In addition, the Finding of No Significant Impact (FONSI) for this EA summarizes changes that were made from draft to final versions of the EA, in response to public and agency comments.

The following section restates (anonymously) all comments received, and provides the Service's response to each. Comments are restated in italics; Service responses in bold type. Page numbers in comments refer to the Draft EA.

Commenter #1

General Comment: The document should be refined to have discrete Purpose and Need for Action sections. For example, what specific actions do the Disaster Relief Appropriations Act of 2013 cover (versus not cover)? How is "resiliency" defined relative to the need for this project? The project purpose definition and description forms the basis for assessing project alternatives considered and evaluated by the document. As now presented, the description is more generic and less specific.

Editorial comments are acknowledged (e.g. request for discrete Purpose and Need sections). For more information on Disaster Appropriations Act, please see cited reference (PL 113-2). Resiliency is defined in this EA under Section 2.0, "Purpose and Need for Action." The Purpose and Need section is used to provide the reader with an overview, and is not intended to be specific to each action. Specifics of the actions can be found in the Chapter describing the alternatives considered.

Figure 1: Should be "Pettaquamscutt Cove Reach".

Figure 1 depicts the project area as noted in the caption, including areas north of Pettaquamscutt Cove.

p. 3, pars 2-4: The discussion of the Narrow River salt marshes and impacts with predicted sea level rise (SLR) needs to also include a brief explanation addressing: (1) general salt marsh substrate building processes relative to SLR; and (2) the limitations of the Narrow River conditions which are biogenic-dominated marshes with minimal mineral soils inputs, thus requiring consideration of restoration/ rehabilitation alternatives.

Please see Section 5.5, Salt Marsh Habitat, and associated references for a detailed discussion of both points.

P. 3, par 5: The discussion needs reference to published reports and brief synopsis of predicted conditions (e.g., IPCC 2013) such that this document can better explain the justification of the proposed restoration/rehabilitation alternatives.

The sea level rise estimate used in the EA is the basis for Rhode Island state coastal policy and is adequate to justify the proposed project.

p. 3, par 6: Recommend this discussion include greater detail on how coastal eutrophication affects marsh processes, loss, and sustainability (e.g., Deegan et al. 2012). Excess nitrogen loading is a substantial secondary impact that contributes to estuarine marsh degradation and loss, and is a key challenge to the Narrow River project.

Please see Section 7.2 for a detailed discussion of the impacts of water quality on salt marshes in the context of the proposed action.

pp. 3-4: The discussion of hydrologic changes to the Narrow River salt marshes needs to include (1) past mosquito ditching practices in the marshes, and (2) morphologic changes to the Narrow River tidal inlet which influence tidal flooding and ebbing throughout the estuary.

Please see Appendix A for information on these changes.

p. 4, par 5: This discussion needs refinement as it now reads as if the Narrow River conditions will result in the listing of salt marsh sparrow to ESA; the current narrative too abruptly transitions from site specificity to general statement. This narrative section also fails to discuss the importance of this estuary to the nursery and foraging habitat for river herring that utilize this system – one of the most important anadromous runs in Rhode Island (At least indicate the section further on in the report that covers this topic). Further, the Narrow River estuary also contributes substantial habitats for decapods and bivalves in addition to finfish species (Again, these resources are discussed later in the document, but the information is disjunct in the narrative).

Editorial comments acknowledged. Salt marsh sparrow population trends, Narrow River alewife runs, and shellfish resources are all discussed under Section 5.0, Affected Environment.

p. 5, Section 4 Issues and Concerns: The document lists questions relating to resource issues and concerns. Does this information include formal agency responses to these questions, and if yes, the narrative needs to better explain that these are formal responses. For example, the second item relates to storm water basin quality. Suggestion is provided in the document that basin maintenance is beyond the scope of this document. In contrast, the document indicates there are water quality problems in the estuary, so how can one indicate that a poorly functioning storm water management is "beyond the scope of this project"?

Public vs. Service issues and concerns, and Service responses, are clearly identified in the EA, which is identified as a formal NEPA document. We have edited the EA to state that *this particular existing* storm water structure is beyond the scope of this project.

p. 7, Overview of Narrow River Estuary: This section deserves a description of the salinity gradient in the estuary and more detail on the tidal hydrology affecting this estuary – these are data essential to evaluating salt marsh restoration alternatives in this document (or at least refer to sections later in document).

Please see reference cited in this section (ACOE 2007).

Figures 2 and 3: These figures only cover a portion of the project area. Recommend you either explain why only this area is depicted and addressed in this narrative; or include a description that refers the reader to the bathymetry and bottom mapping as appendices in the document.

The caption has been edited.

p. 9: Public Use and Recreation is better suited to follow the sections on the estuary description. Discuss the resources first, then how the resources are prized for public use and recreation.

Editorial comments, acknowledged.

p. 10, Water Quality Characteristics: Information should be provided on the time period(s) over which these data were collected.

This information has been added to the water quality tables in the EA and Appendix F.

p. 10, par 1: The estuary has been closed to shellfishing since the 1990s due to excessive fecal coliform levels posing a human health risk.

Edited.

pp. 10-11: Discussion is provided on the estuarine tidal hydrology, but you do not relate the ACOE tidal data results back to your statements that the Sprague Bridge is restricting tidal flow. The data presented in this document need to be more definitively qualified. For example, data are presented for tidal flow velocities, but not stated if these are mean data collected over what time period(s) and from what depth(s) in the bathymetry at each monitoring location.

Please see reference cited in this section (ACOE 2007). We have used the best available information.

p. 11: This section explains the loss of salt marsh habitat since 1869, but it is important to indicate, if data are available, how marsh loss has occurred at a much higher rate, more recently (Is this information contributed by Watson (2014))?.

The cited reference includes the best available available information on this trend.

pp. 11-12: Statement is provided that "The vast majority of saltmarsh is considered to be high marsh", and references source from 1990. The current conditions of the Narrow River include low marsh including low-form smooth cordgrass, as well as peat flats with varying extent of stressed plant cover (e.g., 39% referenced later in this document) typical of a low marsh plant community.

The word "vast" has been deleted.

Note typos and mislabeling in the plant species information.

Edits and corrections made.

Table 1: Need opening paragraph explaining the source of this information and current plant community characteristics. A total 344 acres of habitat are referenced but with a total of 242 marsh surface acres. What

constitutes the remaining 102 acres? This discrepancy causes confusion to the reader. Why does note 6 indicate "double counting" of marsh drainage?

Edits and corrections made.

p. 13: Waterlogging of the "marsh surface" is not necessarily the inherent problem. The problem is prolonged flooding attributed to poor drainage that causes a lack of air exchange with the plants in the plant community, including a functioning sub-surface rhizosphere by the plants.

Edits and corrections made.

This section regarding marsh health does not address potential regional land subsidence. Is there information available (e.g., from Boothryd, Watson, or USGS) to conclude whether or not land subsidence is or may be a factor in marsh health in the Narrow River, as it has been documented in other East Coast sites? This topic needs further discussion in the document. For fifth paragraph, the last sentence is incomplete.

Please see Raposa *et al*. (2014), cited in this section, for this discussion. Editorial correction made.

Relative to the sixth paragraph, freshwater inputs via groundwater may be as much, if not greater than, surface water inputs. One may presume that shallow groundwater input and upwelling occurs such that moat-like conditions have developed along or near the upper tidal wetland boundaries. This is a common occurrence in New England marsh systems.

Comment acknowledged.

p. 14 Marsh bank erosion is mostly episodic with chronic undercutting of mineral soils followed by calving of the upper peat layers breaking off in chunks. Waves induced by boats should also include jet skiers who often enter very shallow waters, exacerbating human-induced wave energies.

Please see the study cited in this section (USFWS 2009) for a thorough evaluation of this issue.

Table 3: Review and understanding would be easier if all data are in single units (ft), as opposed to yds, ft and inches.

Comment acknowledged.

p. 15: Retentive point here and elsewhere: "prop scarring" is not the impact, per se. The impact is prop dredging, prop incision, or equivalent, while scarring is the resulting indicator.

Comment acknowledged.

pp. 16-17: Winter flounder spawning and rearing habitats are present in the Narrow River, as indicated, but it would be helpful to provide greater specificity on benthic habitat types that support each condition and location(s) based on field data collected by Lake (2014) or others.

Please see NOAA report, Stevenson *et al.* (2014) cited in the EA and Appendix F, as well as the benthic habitat maps provided in the EA for this information.

p. 17: Anecdotal information (Turek observation, 2014 of illegal shellfishing) suggests that quahog densities in portions of the estuary have relatively high (in contrast to "very low") densities of quahog present.

Statements regarding shellfish densities are based on recent (Fall/Winter 2014) surveys, evaluation and conclusions by a project team representing fisheries and coastal management experts with USFWS, RICRMC, DEM and URI.

p. 20: Regarding the potential impacts to plover and tern, the statement presumes what restoration may occur. It would be more valuable to reference with a Section 7 consultation from the USFWS and a RINHP letter on potential effects (The project proponent does not make a conclusion, the review agencies and responsible staff do).

The EA's conclusion regarding potential impacts on piping plovers is based not on what, but rather where, restoration may occur, as stated in this section. Section 7 requirements have been met for this project.

p. 22: Secretive marsh birds: Statement about habitat preference needs clarification; they seek to utilize wetland habitat that is generally inaccessible or not accessed by people, not the birds, themselves.

Edited.

p. 25: Eliminated Alternative 2: It is difficult to comprehend that the USFWS concludes that the tidal inlet morphology may have a significant effect on restoration in the Narrow River, but concludes further analysis is not preferred because of "the limited timeframe which this project has for execution". If the tidal inlet is a significant feature determining potential restoration performance, how can one not reasonably address this issue?

The project timeframe was mentioned in the context of the potential for adverse impacts and need for extensive evaluation to fully evaluate such impacts. The full statement in the EA is as follows: "The interaction between the flood tidal delta at the mouth of the river, channel restrictions at Sprague Bridge, and flow attractions is a complex issue which would require intensive modeling and detailed engineering. The Service determined that the potential benefits to restoration in this river reach were outweighed by the potential adverse impacts and the planning detail and execution costs necessary to address the complexity of the situation, in light of the limited timeframe which this project has for execution."

p. 26: The No Action alternative fails to adequately explain conditions that would result if no action occurs. As written, the narrative fails to discuss anticipated conditions with no or limited resource management and/or conditions (climate change impacts) or other actions that will or may occur to affect the marshes and estuary.

Please see Section 7.1.4 under Affected Environment for this discussion. The Service feels this discussion is adequate.

p. 27: Preferred Alternative 2, Item 3: This structure should be described in the upfront portion of the document, rather than first introducing in the restoration approach. Add the structure/feature to a site map in appendix or elsewhere so the reviewer has better understanding of the project constraint.

Implementation details of all proposed actions are provided in Appendix G, sufficient for the purposes of this Environmental Assessment. More detailed plans will be developed as needed to meet environmental permitting and logistical requirements.

It is noted that the dredging window is November 15 through January 15, but in the winter flounder spawning period described above, it is inclusive of November – February timeframe. Such statement will prohibit dredging due to fishery impact concerns.

Error corrected.

p. 28: The proposed dredge area for eelgrass enhancement should refer to and be depicted on an aerial/plan view figure. Areas that were considered for dredging but eliminated from further consideration due to anticipated impacts should also be described.

Please see map in Appendix G.

This section needs greater explanation of the "large containers" and how dredged materials will be held, dewatered and moved for sediment placement in to key restoration sites. How, for example, will dewatering and sediment release be managed?

Please see Appendix G.

p. 29: For the marsh shoreline restoration techniques, there should be monitoring techniques employed to evaluate the reduced erosion rate, and any sediment accretion effects (or refer the reader to the monitoring section, later in the document).

Section 6.6 states that salt marsh shoreline condition surveys (USFWS 2012) will be re-run in 2015 and in 2016 to determine trends in salt marsh shoreline conditions within and outside of treatment areas.

Retentive note: Striped killifish (Fundulus majalis) (note the document typo) prefer sand-dominated sites, and use marshes substantially less than mummichog.

Comment acknowledged; typo corrected.

p. 31: For sediment placement sites, the technique discussion should explain placement of greater material to account for sediment dewatering and compaction to achieve the targeted marsh elevations. The intent here in description is to effectively plan for dewatering and compaction, such that project marsh restoration goals are met.

As stated in Section 1.0 of the EA, the purpose of the EA is to describe and evaluate potential environmental impacts of the alternatives considered for this proposed action (National Environmental Policy Act of 1969 (P.L. 91-190; 42 U.S.C. 4321 et. seq.). It is not intended to serve as a detailed operational planning document. Tables presented in Appendix G refer to increased deposition to account for subsidence.

p. 32: In the description of the TLD technique, it is unclear as to where "sediments" will come from. There needs to be explanation of the proposed ecological dredging and sediment volume that would be derived, to then describe the availability of sediment for achieving the intended marsh elevations.

Please see text, maps and tables the section in Appendix G under "Restore Low Marsh, Degraded Marsh and Intertidal Elevations."

p. 33: For nekton monitoring, how might the data be used to compare BACI conditions? Have control sites been established by USFWS to help in assessing the any restoration practices?

USFWS will establish appropriate control sites. As noted above, the purpose of the EA is to describe and evaluate potential environmental impacts of the proposed action as required by NEPA, not to serve as a detailed operational planning document.

Water quality monitoring should focus on specific BMP sites implemented for water quality improvements to the Narrow River.

Water quality monitoring is being carried out by the Narrow River Preservation Association with the assistance of the RI Dept. of Environmental Management, Office of Water Resources. Appropriate monitoring sites have been established.

p. 34: For low marsh creation sites, substrate elevations should be completed 4-6 months (and thereafter) after placement to assess dewatering and compaction effects relative to marsh plug plantings and survivorship.

Section 6.6 states that surveys will be implemented to determine whether salt marsh plug planting is successful, and that sites will be inspected three times per year over two years to determine whether objectives are being met.

As a general note regarding project alternatives that should be considered in this document, NOAA's Restoration Center recommends that the final RP/EA include a pilot project scale alternative to fully evaluate soil/sediment placement for salt marsh rehabilitation. We support an alternative that implements a scaled approach with varying sediment depths and locations to determine project performance over at least the 3-year project period. Such an action would involve comparable soil placement alternatives (suggest each ≤0.1 acre areas), as well as plant plug installation, seeding, and/or natural colonization. This scaled alternative would also allow an assessment of potential release of sediment acid sulfides and potential odor and plant mortality effects that may limit project performance.

Pilot-scale applications of marsh treatments are planned as part of the preferred alternative as described in Appendix G.

p. 35: Tidal Flow: This section fails to adequate address the potential changes at the tidal inlet that may affect the conditions in the estuary.

No intentional changes to the inlet are proposed as part of this project. Based on consultation with the RI Geological Survey, URI and RICRMC, natural changes to the inlet are not expected to significantly affect the project.

p. 39: Water quality: This section should explain how estuarine water quality will be improved by the restoration actions, not just the temporary water quality impacts that would result.

Please see Section 7.2.4, including Table 8, for this discussion.

p. 44, par 3: How are "historical pools and pans" defined? In comparison, what habitat would not fall under this category, and thus, would not necessarily be protected from project implementation?

Please see footnote to Table 2 which states, "New pools and pans have developed on marsh surface since 1939 (based on aerial photo interpretation). These pools and pans frequently dry up in the summertime, and could trap nekton such as small fish in summer. Depths are shallow with no developed banks."

Commenter #2

A specific detail that I find distressing is the proposal's failure to adequately address the potential of the invasive grass Phragmites taking over portions of the marshlands receiving sediment on their surface. The invasion of marshlands by Phragmites in Massachusetts is a major concern here, associated with aesthetic degradation and loss of wildlife habitat. The working remediation is to some equally alarming – application of herbicides to the invaded wetland. I suggest that the potential spread of Phragmites and its implications be addressed by scientifically qualified members of your staff.

Please see Appendix G, which addresses site selection considerations to reduce the potential for *Phragmites* expansion, and Section 6 of the EA, which describes vegetation monitoring to ensure that project goals are met. Phragmites control is covered under the John H. Chafee National Wildlife Refuge Comprehensive Conservation Plan, and therefore does not have to be addressed in another Environmental Document.

I also feel the period of public review you have offered is not adequate, given that the month of November contains religious and public holidays in a season of growing family commitments. For organizations such as NRPA whose Board meets once a month a dingle month of public review does not provide adequate opportunity for thoughtful review. I would request that you extend the public review period by at least six weeks.

The Service feels that the 30-day public review of the Draft EA was adequate. The Draft EA was provided directly to stakeholders such as the Narrow River Preservation Association at the beginning of the review period, providing ample time for comment. NRPA had also been involved in helping to develop portions of the restoration plan.

While many of us who have worked to protect the River for nearly half a century were relieved when the Chafee Reserve came under government protection, we are now concerned that a massive "management" program could be implemented without adequately addressing all possible outcomes.

The Service has determined that the EA adequately addresses all potential impacts of the project. Further, every action proposed in the EA has been, or will be, subject to additional regulatory review by state and local environmental agencies.