



HERRING RIVER RESTORATION PROJECT

DEVELOPMENT OF REGIONAL IMPACT

APPLICATION

--December 2019--

APPLICANT:
TOWN OF WELLFLEET



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Frequently Used Terms

Adaptive Management Plan—The plan under which adaptive management decision-making for continued project implementation will be based on system response to incremental increases in tidal exchange. See Section 5 of this application for a thorough discussion on Adaptive Management

Berm—A mound or bank of earth, used especially as a barrier.

Biota—The combined flora and fauna of a region.

Brackish water—Water containing a mixture of seawater and fresh water; contains dissolved materials in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses.

Brackish—A mixture of fresh and saltwater typically found in estuarine areas; of intermediate salinity.

Buffer zone—In general, a barrier between sensitive wildlife habitat and land uses such as agriculture or urban development. A transitional zone intended to provide for compatibility of nearby dissimilar uses. In regulatory context includes the 100-foot buffer zone regulated under the Massachusetts Wetlands Protection Act as well as the 50-foot filter strip regulated under the Wellfleet Environmental Protection Regulations.

Datum—A base elevation used as a reference from which to reckon heights or depths.

Ebb tide—The tide defined when the movement of the tidal current is away from the shore or down a tidal river or estuary.

Ecosystem—A basic functional unit of nature comprising both organisms and their nonliving environment, intimately linked by a variety of biological, chemical, and physical processes.

Ecological restoration—The return of an ecosystem to a close approximation of its condition prior to disturbance. Used specifically herein to refer to Ecological Restoration Limited Projects pursuant to 310 CMR 10.11.

Estuarine— Of, relating to, or found in an estuary.

Estuary—The wide part of a river where it nears the sea; where fresh and salt water mix in a semi enclosed body of water.

Fauna—Animals, especially the animals of a particular region or period, considered as a group.

Floodplain—An area adjacent to a lake, stream, ocean or other body of water lying outside the ordinary banks of the water body and periodically filled by flood flows. Often referred to as the area likely to be filled by the 100-year flood (base flood).

Flora—Plants considered as a group, especially the plants of a particular country, region, or time.

Freshwater wetlands—In context of WEPR, defined per 2.03(2) and including isolated wetlands and vernal pools

Groundwater—Water that penetrates the earth's surface from precipitation and from infiltration from streams; water present below ground from ponds and lakes; water that flows or ponds underground.

Halophyte—Salt-tolerant vegetation.

Hydraulic—Of or involving a fluid, especially water, under pressure.

Hydrodynamic modeling—The modeling of the flow field, circulation, and water surface elevations within a water body driven by external conditions, including tides, winds, inflows, outflows.

Hydrology—The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Intertidal habitat—The tidal area between the mean lower low water (MLLW) and mean higher high water (MHHW) which is alternately exposed and covered by water twice daily.

Invasive species—A species that is a non-native (exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Jurisdictional wetlands—Wetland resource areas under the jurisdiction of local, state or federal regulatory programs.

Marsh—A common term applied to describe treeless wetlands characterized by shallow water and abundant emergent, floating, and submerged wetland flora. Typically found in shallow basins, on lake margins, along low gradient rivers, and in calm tidal areas. Marshes may be fresh, brackish or saline, depending on their water source(s).

Mean sea level—The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.

MHHW— Mean Higher High Water, the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch or other specified shorter series.

MHW—Mean High Water, the average height of all the high tides.

MHWS—Mean High Water Spring, the average height throughout the year of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.

MLLW—Mean Lower Low Water, the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch or other specified shorter series.

MLW—Mean Low Water, the average height of all low water heights.

North American Vertical Datum (NAVD)—All elevations presented in this project are based on the NAVD88. NAVD88 replaced National Geodetic Vertical Datum of 1929 (NGVD 29) as a result of greater accuracy and the ability to account for differences in gravitational forces in different areas based on satellite systems. Within the project area, NAVD88 is 0.86 feet lower in elevation than NGVD 29.

Regulatory Oversight Group—A successor to the TWG established by MEPA, to continue the participation from representatives of regulatory authorities having jurisdiction over project activities under the Special Review Procedure after Class 1 infrastructure construction is commenced and the project begins the adaptive management phase.

Restoration—See Ecological Restoration

Saline—Of, relating to, or containing salt; salty.

Salinity—A measure of the salt concentration of water; higher salinity means more dissolved salts.

Salt marsh—A coastal habitat consisting of salt-resistant plants residing in an organic-rich sediment.

Sedimentation—The deposition or accumulation of sediment.

Species of concern (federal definition)—An informal term that refers to those species which USFWS believes might be in need of concentrated conservation actions (formerly known as Category 1 or 2 Candidate).

Spring tides—The tides resulting when the gravitational forces exerted on the Earth by the sun and moon are acting in the same direction.

Submerged aquatic vegetation (SAV)—Aquatic vegetation that cannot tolerate dry conditions and because of this, live with their leaves at or below the water surface.

Subsidence—The motion of a surface (usually, the Earth's surface) as it shifts downward relative to a datum such as sea level.

Subtidal habitat—Areas below mean lower low water MLLW that are covered by water most of the time.

Swamp—A seasonally flooded bottomland with more woody plants than a marsh and better drainage than a bog.

Threatened species (federal definition)—Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Tidal flushing—The action of saltwater entering an estuary during high tides. It renews the salinity and nutrients to the estuary and removes artificially introduced toxins in the environment.

Tidal marsh—Wetlands with fresh water, brackish water, or salt water along tidal shores.

Tidal prism—The volume of water that flows into and out of a marsh.

Topography—The general configuration of a land surface, including its relief and the position of its natural and man-made features.

Turbidity—The relative clarity of water, which depends in part on the material in suspension in the water.

Wetlands—Pursuant to the U.S. Army Corps of Engineers (Federal Register, 1982) and the Environmental Protection Agency (Federal Register, 1980) jointly define wetlands as: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands are also defined under applicable local and state regulatory programs.

Acronyms and Abbreviations

ACEC	Areas of Critical Environmental Concern
ADA-compliant	Americans with Disabilities Act compliant
APE	Area of Potential Effect
BMP	Best Management Practice
BVW	Bordering Vegetation Wetlands
CCC	Cape Cod Commission
CCNS	Cape Cod National Seashore
CES	Coastal Engineering Structure
CWA	Clean Water Act
CNR	Chequessett Neck Road
CYCC	Chequessett Yacht and Country Club
CZM	Massachusetts Office of Coastal Zone Management
DER	Massachusetts Division of Ecological Restoration
DRI	Development of Regional Impact
EFDC	Environmental Fluid Dynamics Code
EFH	Essential fish habitat
EIR	Environmental Impact Report
EIS	Environmental Impact Statement

EIS/EIR	Environmental Impact Statement / Environmental Impact Report
FEMA	Federal Emergency Management Agency
FHR	Friends of Herring River
GHG	Greenhouse gas
GIS	Geographic Information System
HREC	Herring River Executive Council
HRRP	Herring River Restoration Project
HRSG	Herring River Stakeholders Group
HRTT	Herring River Technical Team
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MHW	Mean High Water (see definition above)
MHHW	Mean Higher High Water (see definition above)
MHWS	Mean High Water Spring (see definition above)
MLW	Mean Low Water (see definition above)
MLLW	Mean Low Lower Water (see definition above)
MOU	Memorandum of Understanding
National Register	National Register of Historic Places
NEPA	National Environmental Policy Act
NHESP	Natural Heritage and Endangered Species Program
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	National Park Service
NRCS	Natural Resources Conservation Service
ROD	Record of Decision
SDM	Structured Decision-Making
SLAMM	Sea Level Affecting Marshes Model
SRP	Special Review Procedure

THPO	Tribal Historic Preservation Officer
TWG	Technical Working Group
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WEPR	Wellfleet Environmental Protection Regulations
WPA	Massachusetts Wetland Protection Act

1. Required Documents

1.A. Application cover sheet

(See following page. The original signed form is provided with the application package.)



CAPE COD
COMMISSION

Application Cover Sheet

Cape Cod Commission
3225 Main Street, PO Box 226
Barnstable, MA 02630
Tel: (508) 362-3828 • Fax: (508) 362-3136

For Commission Use Only

Date Received:
Fee (\$):
Check No:
File No:

A	Type of Application (check all that apply) <input checked="" type="checkbox"/> Development of Regional Impact (DRI) <input type="checkbox"/> DRI Scoping	<input type="checkbox"/> DRI Exemption <input type="checkbox"/> Hardship Exemption <input type="checkbox"/> Jurisdictional Determination	<input type="checkbox"/> Request for Joint MEPA/DRI Review <input type="checkbox"/> Decision Extension <input type="checkbox"/> Decision Modification															
B	Project Information Project Name: <u>Herring River Restoration Project</u> Total Site Acreage: _____ Project/Property Location: <u>Wellfleet and Truro, MA</u> Zoning: <u>National Seashore Park and Residential 1</u> Brief Project Description: Include total square footage of proposed and existing development, gross floor area, number of lots existing or to be created, specific uses, description of existing conditions, as applicable (attach additional sheets if necessary). The Project consists of the following elements necessary to allow restoration of tidal flow and restore 570 acres of coastal wetlands under Phase 1 of the Project: 1) removal of a portion of the Chequessett Neck Road dike and replacement with a bridge and tide gates; 2) installation of a water control structure with tide gates at Pole Dike Road where it crosses the entrance channel to Upper Pole Dike Creek; and 3) removal of a portion of High Toss Road where it crosses the marsh.																	
C	Owner(s) of Record List the following information for all involved parcels. Provide copies of each Deed and Purchase and Sale Agreement and/or evidence of leasehold interest, if applicable, for all involved parcels. Proof of ownership/legal rights for Applicant(s) to proceed with the proposed development must be documented prior to the Commission deeming any application complete. List the local, state, or federal agencies from which permits or other actions have been/will be filed (attach additional sheets if necessary). <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Map/Parcel</th> <th style="width: 30%;">Owner's Name</th> <th style="width: 15%;">Lot & Plan</th> <th style="width: 20%;">Land Court Certificate of Title #</th> <th style="width: 20%;">Registry of Deeds Book/Page #</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> There ARE ARE NOT (circle one) court claims, pending or completed, involving this property (if yes, please attach relevant information). Is there an existing CCC Decision for the Property? <input type="checkbox"/> yes <input checked="" type="checkbox"/> no (if so, recording information for decision, please attach relevant information).			Map/Parcel	Owner's Name	Lot & Plan	Land Court Certificate of Title #	Registry of Deeds Book/Page #										
Map/Parcel	Owner's Name	Lot & Plan	Land Court Certificate of Title #	Registry of Deeds Book/Page #														
D	Certification I hereby certify that all information provided on this application form and in the required attachments is true and accurate to the best of my knowledge. I agree to notify the Cape Cod Commission of any changes on the information provided in this application, in writing, as soon as is practicable. I understand failure to provide the required information and any fees may result in a procedural denial of my project. NOTE: For wireless communication facilities, a licensed carrier should be either an applicant or a co-applicant.																	
APPLICANT	Applicant(s) Name: <u>Town of Wellfleet</u> Tel: <u>508-349-0300</u> Fax: <u>508-349-0305</u> Address: <u>300 Main Street, Wellfleet, MA 02667</u> Signature: <u>Daniel R. Hoort</u> Date: <u>12-11-19</u>																	
CO-APPLICANT	Co-Applicant(s) Name: _____ Tel: _____ Fax: _____ Address: _____ Signature: _____ Date: _____																	
CONTACT	Contact: <u>Daniel R. Hoort, Town Administrator</u> Tel: <u>508-349-0300</u> Fax: <u>508-349-0305</u> Address: <u>300 Main Street, Wellfleet, MA 02667</u> Signature: <u>Daniel R. Hoort</u> Date: <u>12-11-19</u>																	
PROPERTY OWNER	Property Owner: <u>Town of Wellfleet and Cape Cod National Seashore</u> Tel: _____ Fax: _____ Address: _____ Signature: <u>See attached letter from Cape Cod National Seashore Superintendent</u> Date: _____ Text																	
BILLABLE ENTITY	Name: <u>Town of Wellfleet</u> Tel: <u>508-349-0300</u> Fax: <u>508-349-0305</u> Address: <u>300 Main Street, Wellfleet, MA 02667</u>																	

1.B. Letter from CCNS



United States Department of the Interior

NATIONAL PARK SERVICE
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
508.771.2144
508.349.9052 Fax

IN REPLY REFER TO:
N2219

December 9, 2019

Kristy Senatori
Executive Director
Cape Cod Commission
PO Box 226
Barnstable, MA 02630

Re: Town of Wellfleet, Development of Regional Impact Application for Herring River
Restoration Project, Phase 1

Dear Ms. Senatori:

The proposed restoration of the Herring River estuary is a project of unique significance to the region, and of vital importance to the Cape Cod National Seashore.

Prior to 1909, the Herring River estuary included roughly 1,000 acres of salt marsh, intertidal flats and open-water habitats. Construction of a dike at the mouth of the river has since severely limited tidal exchange between the estuary and Wellfleet Harbor, resulting in loss of wetland resource function, degradation of water quality and loss of habitat. Herring River today is designated as an Impaired Water under the Federal Clean Water Act, and the dike is a state-designated point source for bacterial contamination responsible for the closure of hundreds of acres of once-harvestable downstream shellfish beds. This degraded system is located in the towns of Wellfleet and Truro, and eighty percent of the flood plain is within the boundary of the Cape Cod National Seashore.

The Cape Cod National Seashore is working in partnership with the Town of Wellfleet, and state and federal partners, to implement a plan to restore Herring River. The plan is the result of more than two decades of scientific study led by National Park Service (NPS) scientists and extensive stakeholder engagement. The formal process began in 2005, when the seashore and Town of Wellfleet entered into a Memorandum of Agreement (MOU) to study whether restoration of Herring River is feasible. The resulting *Herring River Conceptual Restoration Plan* was accepted by the Town and NPS, and provided the basis for developing a detailed restoration plan. The detailed restoration plan successfully completed state and federal environmental

impact reviews in 2016. Recently, the Town and NPS entered into a new MOU (MOU IV) to implement the restoration plan.

In furtherance of MOU IV, the Project is seeking environmental permits for authorization to implement Phase 1 of the restoration. Phase 1 will restore 570 acres of tidal wetlands. Within the Phase 1 area, 540 acres or 95% is owned by the United States and managed by NPS. The success of this project will have a profound effect on resource health, habitat and recreational opportunities in the Cape Cod National Seashore.

The DRI application submitted by the Town of Wellfleet includes descriptions of work that will take place on land within the Congressionally-authorized NPS boundary. The Cape Cod National Seashore grants permission for this work to be described in the DRI application, and we pledge our continued support, coordination and cooperation in the implementation of the proposed restoration activities. Two structures described in the application, the Mill Creek Water Control Structure and the tide barrier to protect Way 672, are to be built on federal land by the federal government and, therefore, are not subject to Cape Cod Commission review. The NPS will seek all applicable permits for those activities.

Please let me know if the Commission needs additional information about the seashore's role in this important project.

Sincerely,



Brian Carlstrom, Superintendent
Cape Cod National Seashore

1.C. USGS Quadrangle Figures

(See following pages)



Path: J:\F451-003 Friends of Herring River - Cape Cod Commission DRI - 2016\0129\04 GRAPHICS\SWXDRI\F451_003_Fig01_ProjectArea.mxd
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Herring River Restoration Project
 Wellfleet and Truro, Massachusetts

USGS Locus

Source: 1) ESRI, USA Topo Map, 2017
 2) National Park Service, Basin and Park Boundaries, 2017

- Project Element
- Shown for Informational Purposes
- Town Boundary
- Cape Cod National Seashore Boundary

Figure 1-1 USGS Locus



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0 1,250 2,500 Feet

Herring River Restoration Project
 Wellfleet and Truro, Massachusetts

Source: 1) ESRI, USA Topo Map, 2017
 2) National Park Service, Basin and Park Boundaries, 2017
 3) Cape Cod Commission, Wetlands 2018

- Project Element
- Shown for Informational Purposes
- Town Boundary
- Cape Cod National Seashore Boundary
- Wetlands
- Wellhead Protection Area

Cape Cod Commission
Significant Natural Resources

Figure 1-2 Significant Natural Resource Areas

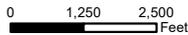


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Herring River Restoration Project
 Wellfleet and Truro, Massachusetts

Cape Cod Commission
Water Resources



Source: 1) ESRI, USA Topo Map, 2017
 2) National Park Service, Basin and Park Boundaries, 2017
 3) Cape Cod Commission, Wetlands 2018

Figure 1-3 Water Resources



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Herring River Restoration Project
 Wellfleet and Truro, Massachusetts

Source: 1) ESRI, USA Topo Map, 2017
 2) National Park Service, Basin and Park Boundaries, 2017
 3) NHESP, Estimated and Priority Data, 2017

- Project Element
- Shown for Informational Purposes
- Town Boundary

- Cape Cod National Seashore Boundary
- ▨ NHESP Priority Habitats of Rare Species

Natural Heritage Endangered Species Program Estimated and Priority Habitats

- ▨ NHESP Estimated Habitats of Rare Wildlife

Figure 1-4. NHESP Estimated and Priority Habitats

1.D Certified Abutters List

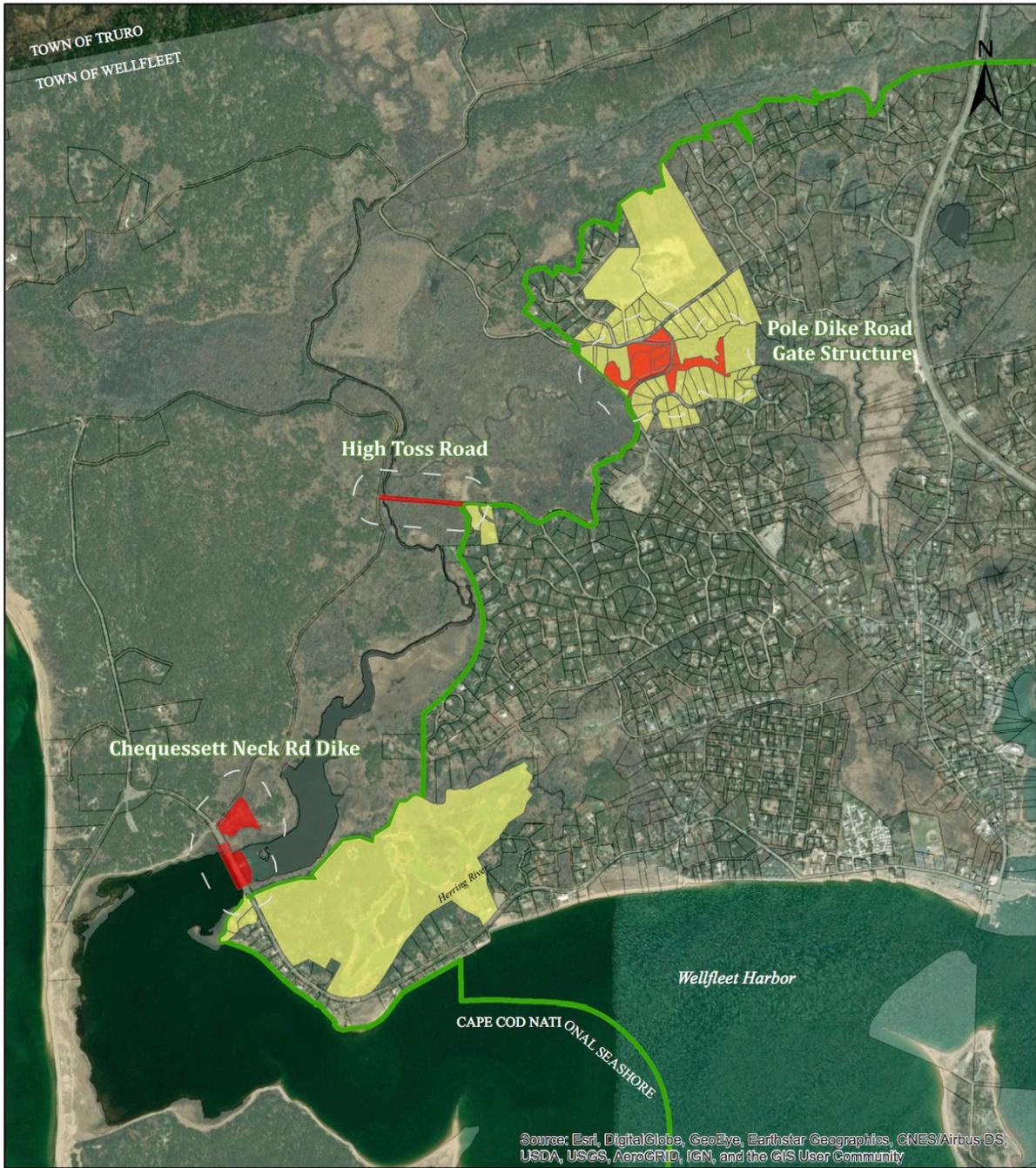
Abutters were identified as owners of parcels within 300 feet of the project water control elements: Chequessett Neck Road Bridge (including the adjacent construction staging area), Pole Dike Road water control structure, and High Toss Road removal. Parcels were identified as abutting if they were within:

- a) 300 feet of the property line where the limit of disturbance (LOD) extends beyond the Town-owned right-of-way (ROW); or
- (b) 300 feet of the edge of the ROW where the LOD does not extend beyond the ROW.

The abutting non-federal parcels are shown on Figure 1-5.

A corresponding list of abutters was compiled and certified by the Town of Wellfleet Assessor. Three sets of labels from the certified list of abutters are enclosed with the application. The list of abutters is provided on the following pages.

At the time the Cape Cod Commission mails the notice of the public hearing to the list of abutters, the Town will send a courtesy notice of the public hearing to other parcel owners in the Herring River flood plain.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 550 1,100 2,200 Feet

**Herring River Restoration Project
 Project Element Abutters**
 Wellfleet & Truro, Massachusetts

- 300 ft setback for abutter notification
- HR Phase 1 Limit of Disturbance
- Abutting Private Parcels
- CACO Boundary
- Town of Wellfleet



Source: 1) MassGIS, Orthoimagery, 2014
 2) MassGIS, Parcels, 2019
 3) NPS, Park Boundary, 2017

Figure 1-5. Abutting Non-federal Parcels, Phase 1



TOWN OF WELLFLEET

300 MAIN STREET WELLFLEET MASSACHUSETTS 02667
Tel (508) 349-0304 Fax (508) 349-0317
www.wellfleetma.org

BOARD OF
ASSESSORS

MEMORANDUM

TO: Hillary Lemos, Health & Conservation Agent
FROM: Nancy Vail, Assessor *NV*
DATE: 9/5/19
RE: DRI Abutters List sent 9/3/19

Please be advised that the above referenced abutters list emailed to you on September 3, 2019 was generated by me and is therefore, by definition, certified by me.

HEALTH DEPARTMENT
TOWN OF WELLFLEET

SEP 09 2019

RECEIVED BY: *[Signature]*

Town of Wellfleet
Herring River Restoration Project
Development of Regional Impact Application

Herring River Restoration Project | 300-foot Abutters | Certified 23 Aug 2019

MAP	PARCEL	EXTN	NAME	MAILING STREET	CITY	STATE	ZIP	LOCAL	
7	24	0	TOWN OF WELLFLEET TRANSFER STATION	300 MAIN ST	WELLFLEET	MA	02667	266	COLES NECK RD
7	25	0	WELLER LISA A	320 COLES NECK RD	WELLFLEET	MA	02667	320	COLES NECK RD
7	25	1	PECHUKAS ROLF	PO BOX 978	WELLFLEET	MA	02667	330	COLES NECK RD
7	26	0	BESWICK SCOTT & VERMEHREN TRUDY	340 COLES NECK RD	WELLFLEET	MA	02667	340	COLES NECK RD
7	27	0	AYOTTE STEPHEN R & THERESA A	74 WESTLEIGH DR	HARWINTON	CT	06791	360	COLES NECK RD
7	28	0	TOWN OF WELLFLEET TRANSFER STATION	300 MAIN STREET	WELLFLEET	MA	02667	370	COLES NECK RD
7	29	0	WEBSTER HELEN E	10 PHEASANT RUN	WELLFLEET	MA	02667	10	PHEASANT RUN
7	30	0	VANDERSCHMIDT GEORGE F	BOX 972	WELLFLEET	MA	02667	30	PHEASANT RUN
7	44	0	GIESE BENJAMIN S & BRAMSON RACHEL	1014 MADERA CIRCLE	COLLEGE STATION	TX	77840	49	PHEASANT RUN
7	45	0	GOLDMAN ISABEL P & NABATI LIDA	28 ESSEX ST APT 2	CAMBRIDGE	MA	02139	45	PHEASANT RUN
7	46	0	GREENE DIANE M & AXELROD NAOMI G	15 PHEASANT RUN	WELLFLEET	MA	02667	15	PHEASANT RUN
7	48	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	COLES NECK RD
7	49	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	BOUND BROOK ISLAND
7	50	0	TOWN OF WELLFLEET	300 MAIN ST	WELLFLEET	MA	02667	0	BOUND BROOK ISLAND
7	51	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	BOUND BROOK ISLAND
7	51	1	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	COLES NECK RD
7	52	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	BOUND BROOK ISLAND
7	53	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	BOUND BROOK ISLAND
7	54	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	POLE DIKE RD
7	55	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	POLE DIKE RD
7	56	0	VANDERSCHMIDT HANNELORE F	225 COLES NECK RD	WELLFLEET	MA	02667	239	COLES NECK RD
7	56	1	SAMUELSON MARNIE CRAWFORD C/O IN BALANCE	PO BOX 45	CHATHAM	MA	02633	339	COLES NECK RD
7	56	2	FAWKES ASHLEY E	319 COLES NECK RD	WELLFLEET	MA	02667	319	COLES NECK RD
7	56	3	SELDIN ABBE L & SCHNEIDER FARNY	BOX 842	WELLFLEET	MA	02667	299	COLES NECK RD
7	56	4	BERRY MARY C	BOX 95	S WELLFLEET	MA	02663	287	COLES NECK RD
7	56	5	CUMING JOYCE A TRUSTEE	100 RTE 6A	ORLEANS	MA	02653	275	COLES NECK RD
7	56	6	ADELSON KERIN B & GRODBERG DAVID M	77 EDGEHILL RD	NEW HAVEN	CT	06511	263	COLES NECK RD
7	56	7	CHARLTON ALDONA & ZIMILICKI ALAN	195 ERIE ST	CAMBRIDGE	MA	02139	251	COLES NECK RD
7	64	0	TOWN OF WELLFLEET	300 MAIN ST	WELLFLEET	MA	02667	0	POLE DIKE RD
7	65	0	TOWN OF WELLFLEET	300 MAIN ST	WELLFLEET	MA	02667	0	POLE DIKE RD
7	66	0	TOSCANINI ELAINE LIFE ESTATE C/O LIANA TOSCANINI	1553 HARTSVILLE-N MARLBORO RD	NEW MARLBOROUGH	MA	01230	1160	BROWNS NECK RD
7	67	0	JACOBSON SCOTT & SCHWAB HILLARY	3 GIBBS ST	BROOKLINE	MA	02446	1150	BROWNS NECK RD
7	68	0	WADSWORTH PAUL K & LISY JANE E	2906 KINGSLEY RD	CLEVELAND	OH	44122	1142	BROWNS NECK RD

Town of Wellfleet
Herring River Restoration Project
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Herring River Restoration Project | 300-foot Abutters | Certified 23 Aug 2019

MAP	PARCEL	EXTN	NAME	MAILING STREET	CITY	STATE	ZIP	LOCAL	
7	69	0	LARSEN P REED	161 CLINTON RD	BROOKLINE	MA	02446	1136	BROWNS NECK RD
7	70	0	KERBER JORDAN E & MORAN MARY H	19 WEST PLEASANT ST	HAMILTON	NY	13346	1130	BROWNS NECK RD
7	71	0	WOOD DARROW	75 HENRY ST #6K	BROOKLYN	NY	11201	1116	BROWNS NECK RD
7	72	0	THEILMAN WARD & THEILMAN MARYLOU E, TRUSTEES	40 VALLEY VIEW DR	AMHERST	MA	01002	1100	BROWNS NECK RD
7	73	0	ICKLAN WILLIAM & JOAN F C/O ICKLAN JOHN E & SAMUEL K	209 W 13TH ST APT 9	NEW YORK	NY	10011	1090	BROWNS NECK RD
7	74	0	PALINO CHRISTIAN & MARINI MICHELA, TRUSTEES	2936 MADELINE ST	OAKLAND	CA	94602	1080	BROWNS NECK RD
7	75	0	GOLDBERG MANUEL & HELEN A	514 LUMINARY BLVD	OSPREY	FL	34229	1070	BROWNS NECK RD
7	76	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	POLE DIKE RD
8	220	0	VANDERSCHMIDT HANNELORE F & GEORGE F	225 COLES NECK RD	WELLFLEET	MA	02667	225	COLES NECK RD
8	266	0	PODASKI ELIZABETH & KATE & BAKER RICHARD & LUBOW GENE & JACOBSON LAWRENCE & JACOBS LIN	115 WILLOW ST APT 2C	BROOKLYN	NY	11201	55	MARSH END
8	267	0	JACOBS LINDA & BARBARA & LUBOW GENE J	24 5TH AVE #1612a	NEW YORK	NY	10011	45	MARSH END
8	268	0	CARBONI BARBARA	122 ALBEMARLE RD	NEWTON	MA	02460	1060	BROWNS NECK RD
8	270	0	TOWN OF WELLFLEET CONSERVATION COMMISSION	300 MAIN STREET	WELLFLEET	MA	02667	0	COLES NECK RD OFF
8	310	0	CARIANI KAREN	629 WATERTOWN ST UNIT B	NEWTON	MA	02460	1050	BROWNS NECK RD
8	311	0	PALLEY MARIAN L & PALLEY HOWARD A, TRUSTEES	11 NORTH TOWNVIEW LANE	NEWARK	DE	19711	33	MARSH END
8	319	0	WELLFLEET CONSERVATION TRUST	PO BOX 84	WELLFLEET	MA	02667	0	BROWNS NECK RD OFF
12	231	0	MURRAY-BROWN ANDREW	10 MAST HILL RD	HINGHAM	MA	02043	245	HIGH TOSS RD
12	234	0	BESSETTE RODOLPHE G JR & JEAN C	BOX 141	WELLFLEET	MA	02667	255	HIGH TOSS RD
12	235	0	HIRSCH JONATHAN H & MEEK ROBERT P	72 WARREN AVE UNIT 202	BOSTON	MA	02116	25	WAY #672
12	252	0	ROSENKRANTZ LOUISE, TURITZ EUGENE & ROSENKRANTZ DEBORAH TRUSTEES	2124 DERBY ST	BERKELEY	CA	94705	1107	BROWNS NECK RD
12	253	0	KELLEY EVELYN S	1115 BROWNS NECK RD	WELLFLEET	MA	02667	1115	BROWNS NECK RD
12	254	0	LANGTON CHRISTINE & SPIELBERG IVAN	365 W 25TH ST APT 16J	NEW YORK	NY	10001	39	BROWNS NECK RD
12	255	0	MORRILL RICHARD C & FISH LESLIE ANN, TRUSTEES	BOX 413	WELLFLEET	MA	02667	1175	BROWNS NECK RD
12	266	0	BIRENBAUM HELEN B TRUSTEE	108 WILLOW ST	BROOKLYN	NY	11201	1162	BROWNS NECK RD
12	267	0	MITCHELL PAULA A TRUSTEE C/O INVESTORS SECURITY TRUST	5246 RED CEDAR DR STE 101	FT MEYERS	FL	33907	1170	BROWNS NECK RD
12	268	0	HOPKINS GRACE	1172 BROWN'S NECK RD	WELLFLEET	MA	02667	1172	BROWNS NECK RD
12	269	0	FORIST MELINDA D	1155 BROWN'S NECK RD	WELLFLEET	MA	02667	1155	BROWNS NECK RD
12	270	0	SPIELBERG IVAN & LANGTON CHRISTINE	365 W 25TH ST #16J	NEW YORK	NY	10001	1135	BROWNS NECK RD
18	5	0	HALLORAN KATHERINE H	9 COACH 79	LEXINGTON	MA	02420	1360	CHEQUESSETT NECK RD
19	81	0	CHEQ YACHT & COUNTRY CLUB	PO BOX 779	WELLFLEET	MA	02667	680	CHEQUESSETT NECK RD
19	91	0	EURICH DONALD A & LAZARUS JILL	7 WALNUT ST	NEWTONVILLE	MA	02460	1065	CHEQUESSETT NECK RD
19	92	0	CURRIER CHARLES B & LUCY A	1045 CHEQUESSETT NECK RD	WELLFLEET	MA	02667	1045	CHEQUESSETT NECK RD

1.E. List of Required Permits

Agency/Regulatory Authority	Permit/Approval	Status
Federal		
U.S. Department of the Interior – National Park Service	NEPA Review	Complete (Record of Decision published June 21, 2016)
U.S. Environmental Protection Agency	U.S. Clean Waters Act - NPDES Construction General Permit	To be filed
U.S. Army Corps of Engineers	Individual Permit pursuant to Section 404 of Clean Water Act and Section 10 of Rivers and Harbors Act	To be filed
U.S. Department of the Interior - National Park Service	Review under Section 106 of the National Historic Preservation Act	Complete
U.S. Fish and Wildlife Service	Review under Section 7 of the Federal Endangered Species Act	To be completed
NOAA Fisheries	Essential Fish Habitat Review -Magnuson-Stevens Fishery Conservation and Management Act	To be completed
Federal Consistency Review (through MA Coastal Zone Management)	Review under Coastal Zone Management Act of 1972	To be reviewed
U.S. Coast Guard	Bridge Permit	Determination of Non-Applicability to be requested.
U.S. EPA	National Pollution Discharge Elimination System (NPDES) Permit	To be filed
State		
Executive Office of Energy and Environmental Affairs	Massachusetts Environmental Policy Act (MEPA) (MGL C. 30, s 61-62H) Review	Complete (MEPA Certificate issued July 15, 2016)
Massachusetts Department of Environmental Protection - Wetlands and Waterways	Section 401 Water Quality Certification (314 CMR 9.00)	To be filed
Massachusetts Department of Environmental Protection - Wetlands and Waterways	Chapter 91 Waterways Licensing and Permitting (310 CMR 9.00)	To be filed
Massachusetts Department of Environmental Protection - Wetlands and Waterways	Massachusetts Wetlands Protection Act (MGL C 131, s 40 and 40A) – Orders of Conditions from Wellfleet and Truro Conservation Commissions	To be filed with local Conservation Commissions
Massachusetts Historical Commission	State Historic Register Review	PNF has been filed. Programmatic Agreement in place.

Massachusetts Department of Transportation	Bridge Permit for Chequessett Neck Road Bridge	To be filed
Massachusetts Natural Heritage and Endangered Species Program	Habitat Management and Monitoring Plan	MEPA Certificate notes NHESP comments that it appears that the Project qualifies for MESA Habitat Management Exemption. A Draft Habitat Management and Monitoring Plan will be submitted and reviewed by NHESP pursuant to 321 CMR 10.14(15)
Regional		
Cape Cod Commission	Development of Regional Impact Review: Scoping Determination	Scoping decision issued March 7, 2019
Cape Cod Commission	Development of Regional Impact Review	To be filed
Local - Wellfleet		
Wellfleet Conservation Commission	Order of Conditions – Massachusetts Wetlands Protection Act and Local Bylaws	To be filed
Local - Truro		
Truro Conservation Commission	Order of Conditions – Massachusetts Wetlands Protection Act and Local Bylaws	To be filed

2. Executive Summary

The Herring River system is a 1,100-acre tidally-restricted estuary located in the Towns of Wellfleet and Truro, in Barnstable County, Massachusetts. Prolonged tidal restriction caused by the Chequessett Neck Road dike in Wellfleet has resulted in severe habitat degradation and nearly complete loss of native tidal wetland habitat. As a consequence, Herring River is listed as an “Impaired Water” in violation of several Clean Water Act standards; and the Chequessett Neck Road Bridge is a state-designated point source for bacterial contamination responsible for closure of downstream shellfish areas. The Town of Wellfleet and the National Park Service (NPS) have entered into a Memorandum of Understanding to implement the Herring River Restoration Project (“Project”) to re-establish tidal exchange to the Herring River estuary and thereby remediate degraded conditions and restore native wetland habitats. The Project represents an unmatched opportunity to restore the environment of Cape Cod and revive the ecological and economic benefits provided by a healthy natural coastal river and tidal wetland system. Most of the area of proposed restoration is in the Cape Cod National Seashore (CCNS), and owned by the NPS.

The Project is the result of more than a decade of scientific study, extensive stakeholder involvement, federal, state and local collaboration and public discussions with local leadership. The Project design has been strengthened by the input of community and regional stakeholders. The Project team includes national experts in estuarine science, civil engineering and environmental resource management.

The Town of Wellfleet and CCNS are seeking environmental permits necessary to implement Phase 1 and restore approximately 570 acres of native tidal wetlands. All Phase 1 area is currently under wetlands jurisdiction, 95 percent (540 acres) is owned by the NPS, and two percent involves any private residential property. For purposes of this Development of Regional Impact (DRI) Application, the Town of Wellfleet is the sole applicant for the Project. The NPS will separately pursue all required permits for the Mill Creek water control structure, and a tide barrier structure, which are proposed on land owned by the NPS. While not a subject of this Application, the Mill Creek water control structure and Way 672 tide barrier structure are described in this Application for purposes of completeness.

The Project will re-establish tidal flow to the estuary incrementally using a carefully calibrated adaptive management approach that will balance ecological goals with water level control measures to allow the highest tide range practicable while protecting potentially vulnerable structures on public and private properties, including roads and homes. Tidal flow will be facilitated through (1) replacement of a portion of the existing earthen dike and tidal control structure at Chequessett Neck Road with a new bridge and tide gate system; (2) construction or alteration of other tidal control structures at the entrances to the Mill Creek and Upper Pole Dike Creek sub-basins; (3) removal of a portion of High Toss Road where it crosses the marsh between the Lower Herring River and Lower Pole Dike Creek sub-basins; (4) vegetation and marsh management; and (5) measures to prevent water intrusion impacts to structures on public and private properties. Project implementation will be governed by a locally-appointed decision-making council of Town and CCNS officials, and informed by extensive modeling, monitoring and analysis so that unexpected and/or undesirable responses can be detected early on and addressed with appropriate response actions. The Project will result in significant improvements in water quality,

rare species habitat, fisheries, and recreational opportunities throughout the Herring River floodplain while improving its resiliency and ability to adapt to the effects of climate change. Restored tidal wetlands will significantly reduce greenhouse gas emissions by reclaiming lost carbon storage and reducing methane emissions.

The Project has been developed over several years in partnership with the Town of Wellfleet, NPS, and members of the community. At each stage of project development, the Project team has worked closely with federal, state and local entities to account for their interests and potential concerns. The Project has completed review under the Massachusetts Environmental Policy Act (MEPA), and received its Certificate of Compliance on July 15, 2016 (EEA # 14272). Phasing of the Project is contemplated in the Final Environmental Impact Report (EIR), and the impacts of Phase 1 are within the scope of impacts identified in the Final EIR.

Because the Project was required to prepare an EIR under MEPA, the Project requires review before the Commission as a DRI. As the Commission stated in its comment letter (July 8, 2016) to the MEPA Office on the Project's Final EIR, "[t]he project's outcomes anticipated and desired by the proponents will bring broad ecological benefits to the Herring River system in Wellfleet and Truro, and as a result will likely benefit human health and the local and regional economy. However, the proposed changes associated with the project, including to the existing man-made structures within the estuary such as the Chequessett Neck Road (CNR) dike, and upstream dikes, culverts, and roadways, are not without impacts to natural resources." The Commission's MEPA comment letter also noted, "[t]his large-scale ecological restoration project does not fit neatly into the Cape Cod Commission's regulatory framework." Many of the issues typically applicable to DRI projects are not applicable to this Project. Accordingly, the Town applied for a Limited Scope Development of Regional Impact review on January 2, 2019. On March 7, 2019, the Commission issued a Development of Regional Impact Scoping Decision "establishing the goals and objectives from Section 6 of the 2019 RPP [Regional Policy Plan] that will be considered by the Commission during DRI review in determining the Project's consistency with the 2019 RPP."

The Project represents a unique opportunity to restore significant ecological resources and ecosystem services (including social and economic benefits to the community) provided by a healthy estuary. This Application demonstrates that the Project is consistent with the 2019 Regional Policy Plan (RPP).

This Application describes the Project in eight numbered sections. Section 1.0 provides required documentation. Section 2.0 consists of this summary. Section 3.0 provides a description of the Project, including phasing, tide control elements, mitigation, and governance. Section 4.0 contains an analysis of the Project's consistency with the RPP goals and objectives identified in the Commission's scoping decision. Section 5.0 provides a description of the Adaptive Management Plan that will guide implementation of tidal restoration. Section 6.0 provides information on Project budgeting and funding. Section 7.0 provides a complete list of references used in the development of the application. Section 8.0 contains documents referred to throughout the application including a Programmatic Agreement between the NPS and State Historic Preservation Office, Herring River Adaptive Management Plan, project chronology, letters of support, and design plans for tide control elements and mitigation.

3. Detailed Project Description

3.A Overview

The Herring River system is one of the largest tidally-restricted estuaries in the Northeast. The Herring River estuary encompasses a nearly 1,100-acre floodplain and more than 11 miles of waterways. Historically, the river supported a vibrant tidal river ecosystem and one of the largest nurseries for commercial and recreational fish and shellfish on Cape Cod. The 1909 construction of a 900-foot earthen dike and tide control structure across the main entrance to Herring River created the tidal restriction and ensuing environmental degradation. The Town of Wellfleet, Barnstable County, Massachusetts, and the National Park Service (NPS) propose to restore natural tidal wetland habitats to large portions of the Herring River estuary in and adjacent to Cape Cod National Seashore (CCNS), by re-establishing tidal exchange to the river and its connected sub-basins.

Due to a more than a century of tidal restriction, approximately 10 acres out of the original 1,100 acres of salt marsh remain. The Herring River Restoration Project (Project) represents a unique opportunity to restore a significant native tidal marsh system and the many ecological and community benefits a healthy estuary provides to surrounding communities and the region.

The Project will reconnect Herring River with Cape Cod Bay and the Gulf of Maine, thereby restoring the natural coastal food web that numerous fish, shellfish, birds and other wildlife depend on for their survival. Restoring the estuary is an important step to increase fish populations and enhance the region's commercial and recreational fisheries and shellfisheries. The Project is based on leading-edge estuarine science and will serve as a model for restoring other estuaries in Massachusetts and along America's coasts.

Increased tidal exchange will be achieved by replacing a portion of the Chequessett Neck Road dike with a new water control structure with tide gates to reconnect the Herring River estuary to Wellfleet Harbor and Cape Cod Bay. Additionally, new water control structures with tide gates will be constructed to control tides in the Mill Creek and Upper Pole Dike Creek sub-basins (See Figure 3-1). Tidal exchange will be increased incrementally over time, using an adaptive management process (See Section 5 and Section 8.B.) Marsh management (e.g., channel clearing to improve drainage and sediment supplementation to elevate substrate) and vegetation management activities also are proposed to enhance restoration.

3.A.1 History of Degradation

Historically, the Herring River was the largest tidal estuary complex on the Outer Cape and included about 1,100 acres of salt marsh, intertidal flats, and open-water habitats (HRTC 2007). The Herring River system was dramatically altered in 1909 when the Town of Wellfleet constructed the Chequessett Neck Road dike at the mouth of the Herring River with the goal of reducing the presence of salt marsh mosquitoes. The dike restricted tides in the Herring River and reduced the tide range from approximately 10 feet on the downstream harbor side to about two feet upstream of the dike. By

restricting the flow of ocean tides and salt water, the dike had immediate and devastating effects on the tidal system and the community benefits provided by the river and its associated estuarine wetlands.

By the mid-1930s, the Herring River, now artificially altered from a saltwater to mostly a freshwater system, was channelized and straightened. Between 1929 and 1933, the Chequessett Yacht and Country Club (CYCC) constructed a nine-hole golf course in the adjoining Mill Creek floodplain. Several homes were also built at low elevations in the former Herring River floodplain.

By the 1960s, the dike's original tide gates had rusted (frozen) in an open position, increasing tidal range and salinity in the lower Herring River. This caused periodic inundation of CYCC golf course and other private properties. In 1973, the Town of Wellfleet required that the dike be repaired to accommodate anadromous fish passage. As a result, the Massachusetts Department of Public Works rebuilt the dike in 1974 (HRTC 2007). Following reconstruction, tide height monitoring by the CCNS showed that the new tide gate opening was too small to achieve the tide heights required by the Order of Conditions issued by the Wellfleet Conservation Commission. In 1977, the Massachusetts Attorney General issued an injunction requiring the Town to cede control of the dike to the Massachusetts Department of Environmental Quality Engineering (now the Department of Environmental Protection [MassDEP]) so that increased tidal flow could be attained to the level mandated by the Order of Condition (HRTC 2007).

In 1980, a large die-off of American eels (*Anguilla rostrata*) and other fish drew attention to the poor water quality in the Herring River. The Massachusetts Division of Marine Fisheries (DMF) and NPS identified the cause of the fish kill as high acidity and aluminum toxicity resulting from diking and marsh drainage (Soukup and Portnoy 1986). The sluice gate opening was increased to 20 inches in 1983. That year, CCNS scientists documented summertime dissolved oxygen depletions and river herring (*Alosa* spp.) kills for the first time (Portnoy 1991). The NPS then implemented measures to protect river herring by blocking their emigration from upstream ponds to prevent the fish from entering anoxic waters (HRTC 2007).

Concerns about flooding of private properties and increased mosquito populations prevented the Town from opening the tide gate further. NPS mosquito breeding research conducted from 1981 to 1984 found that mosquitoes, (*Ochlerotatus cantator* and *O. canadensis*), were breeding abundantly in the Herring River. However, estuarine fish, important mosquito predators, could not access breeding areas because of low tidal range, low salinity, and high acidity (Portnoy 1984). In 1984, the Town increased the sluice gate opening to 24 inches, where it has since remained (HRTC 2007).

In 1985, the DMF classified shellfish beds in the river mouth as "prohibited" due to fecal coliform contamination. In 2003, water quality problems caused MassDEP to list Herring River as "impaired" under the federal Clean Water Act Section 303(d) for low pH, high metal concentrations, and pathogens. More recently, NPS researchers identified bacterial contamination as another result of restricted tidal flow and reduced salinity (Portnoy and Allen 2006).

3.A.2 Cumulative Effects of Tidal Restriction

Herring River's wetland resources and natural ecosystem functions have been severely altered and damaged by more than 100 years of tidal restriction and salt marsh drainage caused by the existing CNR

dike. A range of water quality and other ecological problems will continue until the Project reconnects the river and wetlands with the marine environment. The evidence of these problems include:

- Massachusetts DEP has designated Herring River as an “Impaired Water” in violation of Clean Water Act standards for high aluminum, low pH, high fecal coliform bacteria and a fish passage barrier.
- Water quality in the river is impaired year-round. Data measured by the US Geological Survey over multiple years show that dissolved oxygen in river water regularly falls below established thresholds for causing stress and mortality for fish and other aquatic life.
- The Massachusetts DMF has designated the CNR dike as a point source of bacterial contamination, resulting in the closure of once harvestable shellfish beds upstream and downstream of the dike due to poor water quality.
- Tidal restriction, along with stream channelization and ditch drainage, has lowered water levels above the dike causing the marsh plain to sink 2-3 feet. Because tidal restrictions radically affect the processes of sedimentation on the salt marsh surface and the accumulation of belowground organic material (peat), much of the diked Herring River floodplain has subsided up to three feet relative to current mean sea level (Portnoy and Giblin 1997). Coastal marshes must increase in elevation at a rate equal to or greater than the rate of sea-level rise to persist. This increase in elevation (accretion) must occur to promote the growth of salt marsh vegetation and gradually increase the elevation of the marsh surface. Diking has effectively blocked sediment from reaching the Herring River floodplain and prevented necessary accretion. In addition, drainage has increased the rate of organic peat decomposition by aerating the sediment and caused sediment pore spaces to collapse. These processes have contributed to the severe historic and continuing subsidence in the Herring River’s diked wetlands.
- Prolonged exposure of drained salt marsh peat to air causes it to decompose and release sulfuric acid into surrounding soils and receiving waters. Acid sulfate soils are a major problem covering hundreds of acres of original Herring River marshes. Absent regular saturation by salt water, these soils leach toxic acidity and aluminum into remaining surface water, killing aquatic animals.
- Coastal resiliency has been diminished due to alteration of natural sediment processes and salt marsh surface subsidence.
- Elimination of tidal flooding and salinity has resulted in a loss of salt marsh and other forms of estuarine habitat. As noted above, approximately 10 acres out of an original 1,100 acres of salt marsh remain.
- Lower salinity and loss of estuarine vegetation has allowed non-native *Phragmites* to invade the salt marsh above the dike, and upland shrubs and trees to invade above High Toss Road, where water levels rarely reach the original marsh surface.
- Changes in marsh vegetation have led to an increase in methane-emitting ponded freshwater wetlands and a reduction in carbon-storing tidal wetlands, contributing to a net warming effect on the climate.

- River herring and other anadromous fish species that once thrived in the river have been depleted due to poor water quality and obstructions to migratory passage.

Fortunately, the damaging environmental effects of disconnecting the river from the marine environment can be reversed over time with the return of tidal flow. As described below, the Town of Wellfleet and the CCNS have developed a restoration plan to reverse the degraded conditions in the Herring River system.

3.A.3 Local Project Governance

A local project governance structure has been established to oversee Phase 1 restoration and ensure compliance with regulatory requirements and permit conditions, including adherence to maximum water levels. The Town of Wellfleet and CCNS recently entered into a new Memorandum of Understanding (MOU IV in 2019) to provide the management framework for implementation.¹

MOU IV sets forth the structure and decision-making process for the Project. MOU IV establishes a Herring River Executive Council (HREC) consisting of three members from Wellfleet and two from CCNS to be responsible for approving all major Project implementation decisions and activities. The HREC's responsibilities include, but are not limited to, establishing and providing policy direction; reviewing and approving the Project's Adaptive Management Plan; monitoring Project progress; modifying or altering Project infrastructure water control structure openings (after receiving technical input from the members of the Herring River Technical Team (HRTT)), and ensuring that the Project complies with applicable regulations and laws. The HREC members have been appointed, and will continue to meet as needed during the permitting and construction phases.

The HREC is the entity responsible for implementation decision-making during Phase 1 restoration. The HREC may seek input from various sources, including, but not limited to, the HRTT. Current participants in the HRTT include the Town of Wellfleet, National Park Service, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, USDA/Natural Resources Conservation Service, and Massachusetts Department of Fish and Game - Division of Ecological Restoration. MOU IV also identifies the Herring River Stakeholder Group (HRSG) as a source for advisory input on Project implementation issues. HREC meetings are also open to the public and the HREC will consider public comment in its decision-making.

Among its responsibilities, the HREC will adopt a tide gate management policy to achieve Phase 1 restoration, after receiving technical input from the members of the HRTT. The tide gate management

¹ The Towns of Wellfleet and Truro and the Cape Cod National Seashore (CCNS) entered into successive memoranda of understanding (MOUs) to study the feasibility of restoration (MOU I in 2005), develop a conceptual restoration plan (MOU II in 2007) and agree to implement the restoration plan (MOU III in 2016). Truro is not a party to the superseding MOU IV and has adopted a new role as an interested municipal stakeholder fully supporting the ecological restoration objectives of the Project.

policy will include protocols for ongoing restoration activity and for assessing possible responses during emergency storm events. The policy will set forth proposed tide gate configurations and other management actions and identify the parties responsible for each action. The policy will ensure adherence to environmental permit conditions and the operation and maintenance requirements for each structure. It is envisioned that an initial tide gate management policy of sufficient detail will be included in wetlands permit applications.

Once the HREC has approved a tide gate management policy, it will designate the parties responsible for: (1) coordinating with the NPS and Town to carry out authorized actions and (2) analyzing, compiling, and summarizing monitoring data, modeling output, field observations, and other information. During this process, members of the HRTT will provide ongoing advisory technical input to the HREC. Third-party organizations may be engaged to implement approved management actions, field monitoring, data analysis, and public outreach activities.

MOU IV also confirms that CCNS and the Town of Wellfleet, respectively, will continue to own the infrastructure they own today or to be built on land they each own. For example, Mill Creek water control structure and Way 672 tide barrier will be built on CCNS property and owned by NPS. The Chequessett Neck Road and Pole Dike Road water control structures, and the elevated road segments and culverts in Wellfleet will be owned by the Town of Wellfleet. Owners will have long-term responsibility for infrastructure maintenance. In accordance with MOU IV, the owners of the different elements of Project infrastructure may engage the services of third-party entities to construct, operate and maintain Project infrastructure, or perform these functions themselves. The owners also agree to work cooperatively to ensure compliance with all permit conditions, noticing requirements and other environmental compliance obligations.

3.A.4 Extensive Project Benefits

The Herring River Restoration Project is the result of rigorous scientific study, extensive stakeholder involvement and public discussions with local leadership. A strong commitment to local engagement has marked the decade-long journey from idea to concept, and from concept to design. Project planning and evaluation began in 2005 and has included more than 50 community meetings and presentations, 100 one-on-one meetings with property owners, 125 technical meetings with project technical team members and consultants, and Town and NPS staff. A chronology of events in the community-based restoration effort is presented in Section 8.F. This outreach has helped to build strong, broad based support for the Project, evidenced by the support letters also found in Section 8.G.

The community commitment and broad-based support of the Project stem from the extensive ecological and community benefits that the return of tidal flow to the Herring River system will generate including, but not limited to:

- Reconnecting the Herring River estuary to Cape Cod Bay and the Gulf of Maine to recover the estuary's functions as: (1) a nursery for marine animals, and; (2) a source of organic matter for export to near-shore waters.

- Restoring the natural coastal food web to support numerous fish and bird species and other wildlife that depend on healthy coastal marsh habitats and processes for their migration and survival.
- Reopening waterways to improve migration and spawning for a variety of fish species including River Herring, American Eel, Striped Bass and Winter Flounder, as well as Diamond-back Terrapin.
- Enhancing habitat to increase local fish production; and remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs.
- Protecting and enhancing harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Harbor. Re-opening and expanding shellfish beds will benefit the local economy; in 2018 the shellfish harvest in Wellfleet was valued at \$7.2 million. Shellfish habitat restoration will also help to sustain local shellfishing jobs, which are estimated to number 400-450.²
- Enhancing coastal resiliency by restoring normal sediment deposition needed to allow the marsh to gain elevation and mitigate impacts of sea level rise, and by constructing state-of-the-art tidal control infrastructure to protect low-lying roads and other structures.
- Re-establishing the estuarine gradient of native salt, brackish, and freshwater marsh habitats in place of the invasive non-native and upland plants that have colonized most parts of the degraded floodplain.
- Enhancing opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats including 6 miles of waterways for recreation and tourism. Tourism accounts for nearly \$11 million annually to the local community and supports jobs.
- Generating approximately \$624 million in local and regional economic benefits over the life of the project based on economic studies of other coastal restoration projects.
- Combating climate change by returning lost carbon storage volume and reducing methane emissions from deteriorated salt marsh. A preliminary estimate indicates that, since the CNR dike was built in 1909, the Herring River has emitted 730,000 metric tons of CO² equivalents, comparable to emissions from 155,000 US autos operating for one year.³
- Re-establishing the natural control of nuisance mosquitoes by restoring tidal range and flushing to conditions that are not conducive to mosquito habitat, and by increasing access for fish that prey on mosquito larvae. Another unfortunate consequence of the 1909 diking of Herring River has been to increase freshwater swamp habitat suitable for the mosquito species more likely to carry viruses. Restoration of tides and salty water will replace much of this habitat that is conducive to virus-bearing freshwater mosquitoes with healthy salt marshes throughout much of the estuary.

3.A.5 Science-based Plan Presented for DRI Approval

The Project is the result of more than three decades of scientific study including more than 230 technical

² Civetta, Nancy. Wellfleet Shellfish Department. Presentation to Herring River Stakeholder Group. November 6, 2019.

³ Kroeger, KD, Gonnee, ME, et al. 2019. Climatic impacts of tidal restriction and restoration: Full carbon and greenhouse gas budgets, with radiative forcing calculations. Society of Wetland Scientists Annual Meeting, Baltimore, MD.

studies, peer-reviewed scientific articles, and other data sources, which are listed on twenty-two pages contained in the Final Environmental Impact Report (FEIR), and a decade of stakeholder engagement. Strong technical direction and technical input from dozens of national experts in environmental management and estuarine science have shaped the Project.

Hydrodynamic modeling studies by the consulting firm Woods Hole Group form the basis of design requirements for the overall restoration program, including the need for infrastructure modifications and additions to protect existing infrastructure and structures from increased water levels. The primary flood protection objective is to prevent adverse flooding impacts to the built environment from increased water levels throughout the Project area, including during storm events. All flood protection mitigation measures have been designed to prevent impacts up to the modeled storm-of-record tidal surge with appropriate freeboard.⁴ This storm surge has only been sustained through multiple tide cycles once, during the blizzard of 1978, and thus is a very conservative flood protection design standard.

In 2016, the Project obtained federal and state approvals of its FEIR developed in accordance with the National Environmental Policy Act (NEPA); NPS Director's Order 12; and the Massachusetts Environmental Policy Act (MEPA). The FEIR selected a preferred alternative for the Herring River Restoration Project. The selected alternative is supported by extensive assessment of existing conditions as well as modeling and predictions for restored ecological conditions. The scientific basis for the FEIR was largely drawn from a series of studies conducted by NPS researchers and others, beginning in the 1980s and summarized in the Herring River Conceptual Restoration Plan in 2007. A two-dimensional hydrodynamic model was developed that established the feasibility of tidal restoration and analyzed the effects of restoring tidal flow to different parts of the estuary. This included three different scenarios for sea level rise over the next 50 years and analysis of numerous combined storm events. The model was also used to develop and analyze alternatives for the FEIR based on balancing degrees of tidal restoration with necessary measures to prevent inundation of structures. Since the completion of the FEIR, the Town, CCNS and others have engaged additional input from stakeholders, abutters, and technical experts, which has helped to refine Project plans.

Because the Project was required to prepare an EIR under MEPA, the Project requires review before the Cape Cod Commission as a DRI.

The Town now seeks DRI authorization to implement all Phase 1 project elements and associated mitigation as described in this application. On March 7, 2019, the Commission issued a Development of Regional Impact Scoping Decision "establishing the goals and objectives from Section 6 of the 2019 RPP

⁴ The storm-of-record refers to a model simulation of the significant coastal flooding event in February 1978 (Woods Hole Group (WHG), 2012). It should be noted that the storm-of-record has no correlation to the FEMA Flood Insurance Rate Map 100-year event (1% annual probability of occurrence). FEMA-predicted flood levels during the 100-year storm event are at elevations ten feet to 13 feet throughout the Project Area. The current CNR dike is not a FEMA-designated flood control structure and the redesigned structure will likewise not be a FEMA-designated flood control structure. For these reasons, the Project will have no effect on the FEMA-predicted 100-year flood elevations or the extent of the 100-year FIRM flood plain within the Herring River basin. See Section 4.2.E for more discussion.

[Regional Policy Plan] that will be considered by the Commission during DRI review in determining the Project's consistency with the 2019 RPP.” The application responds to the scope of review set forth in the Commission’s March 7, 2019 decision.

Since the Commission began its review of the Project during the MEPA process, the Project has evolved in ways that provide greater protection of floodplain properties and structures. The scope of the Project has been further defined, detailed plans have been developed for measures to protect public and private structures, and further discussions and agreements with property owners have taken place.

3.A.6 On-going Monitoring and Adaptive Management

The proposed adaptive management plan is a rigorous science-based process of predicting system responses to restoration actions; monitoring system conditions before, during and after management actions are implemented; comparing the predicted and observed system responses to update the understanding of the system response to management actions; and using the results to inform and refine management actions. Information obtained from monitoring improves the ability to predict future outcomes and make better ‘adaptive’ decisions regarding the selection of appropriate management actions throughout the course of implementation.

Extensive monitoring is underway or is being planned to document baseline conditions and, once implementation begins, measure ongoing system responses to restoration of tidal flow. Table 8B-1 found in Section 8.B of this application provides a summary of the performance measures, prediction tools and monitoring methods that will be employed for each restoration objective and sub-objective.

By way of example to demonstrate how achievement of a particular restoration goal will be monitored, shellfish issues are described below.⁵ Restoration objectives include maximizing habitat quality for native estuarine animals, including shellfish, and also minimizing adverse impacts to shellfish beds in Wellfleet Harbor. Extensive monitoring will occur during implementation to measure enhancements to shellfish resources and to protect against unanticipated impacts to shellfish resources. Monitoring activities have been presented in multiple public forums co-sponsored by FHR and the Wellfleet Shellfish Advisory Board.⁶

Recent and ongoing monitoring efforts to address shellfish habitat objectives are described below. Each of these, along with additional work that is still under consideration, will continue or will be repeated at the appropriate stage after the restoration project begins.

- National Seashore Monthly Water Quality Monitoring: Since 2005, scientists from the National Seashore have sampled water quality at 6 - 11 stations from Route 6 to Wellfleet Harbor each month. Variables analyzed include dissolved oxygen, pH (acidity), nitrogen, phosphorus, silica, iron,

⁵ Monitoring efforts for other restoration objectives and sub-objectives are summarized in Table 8B-1 of the Herring River Adaptive Management Plan, found in Attachment 8.B.

⁶ Video recordings of these meetings can be seen at <http://www.friendsofherringriver.org/Videos>.

chlorophyll, and suspend sediment. The data provide a long-term trend of water quality throughout the Herring River floodplain.

- Continuous Real-Time Water Level and Water Quality Network: In 2017 Friends of Herring River installed 5 stations (4 in Herring River, 1 in Wellfleet Harbor) equipped with instruments that measure water level, salinity, temperature, dissolved oxygen, and pH at 15-minute intervals. The data provide both long-term trends (months to years) and short-term changes (hours to days) at each location. Data can be viewed on a public website to allow anyone to track changes as the Project is implemented. (<https://v2.wqdatalive.com/public/820>)
- 2013-2015 Water Quality and Estuarine Habitat Assessment from High Toss to the Harbor: The National Seashore conducted two studies between 2013 and 2015; one to assess movement of nutrients, carbon, and sediment in the downstream and upstream reaches of the river, and the other to study baseline inventories of benthic invertebrates and food webs. These studies provide information on nutrient status and particle movement from the river to the harbor and will be repeated as the restoration project is implemented. A NPS publication documenting this work is under review.
- USGS Water Quality Monitoring: The U.S. Geological Survey collected data at the Chequessett Neck Road dike from 2015 into 2018. Data collection will be reinitiated in 2020. This study uses an automated device to sample water passing through the dike during ebb and flood tides to separately analyze water moving in and out of the river and during varied tidal events. Samples are analyzed for nutrients and suspended sediment. A USGS report covering data collected so far is currently under review and will be released in 2020.
- Surficial Sediment Samples in Aquaculture Areas: Samples of the top 2-3 inches of sediment were taken at multiple sites near Mayo Beach, Egg Island, and Powers Landing by National Seashore scientists in 2006, 2010, and 2017. The samples analyzed the percent of organic material and the amounts of fine and coarse sediment. Describing these baseline sediment characteristics of Wellfleet Harbor is key to understanding current sedimentation trends to inform how the system may respond to reconnection with the Herring River.
- Harbor Sediment and Bathymetric Mapping: In 2019 the National Seashore, Friends of Herring River, and Center for Coastal Studies began a multi-parameter study to describe the sediment characteristics and seafloor elevation in aquaculture areas close to the river. This study involves high resolution and highly accurate data obtained by GPS-based ground survey, drone-based aerial photography, and boat-based side-scan sonar. The data product will be a detailed map of the area depicting bottom elevations, channel dimensions, tidal shoals, and flats that will show how Wellfleet Harbor changes from season-to-season and as the restoration project is implemented.
- Characterization of Herring River Sediment: Similar to the harbor mapping project, the National Seashore is examining sediment from the river and floodplain upstream of Chequessett Neck Road

and is surveying elevations across the marsh to understand the pre-restoration conditions and assess how sediment may migrate throughout the system when the restoration project is underway.

- Fecal Coliform: National Seashore and cooperating scientists collected data that were published in 2009 that documented how the restoration project would improve water quality in shellfishing areas that are now closed to harvest due to bacterial contamination. The sampling conducted for this research will be repeated at least once prior to the beginning of the restoration project and will be repeated again throughout the implementation period to quantify and confirm the conclusions cited in the publication (Portnoy and Allen 2009).

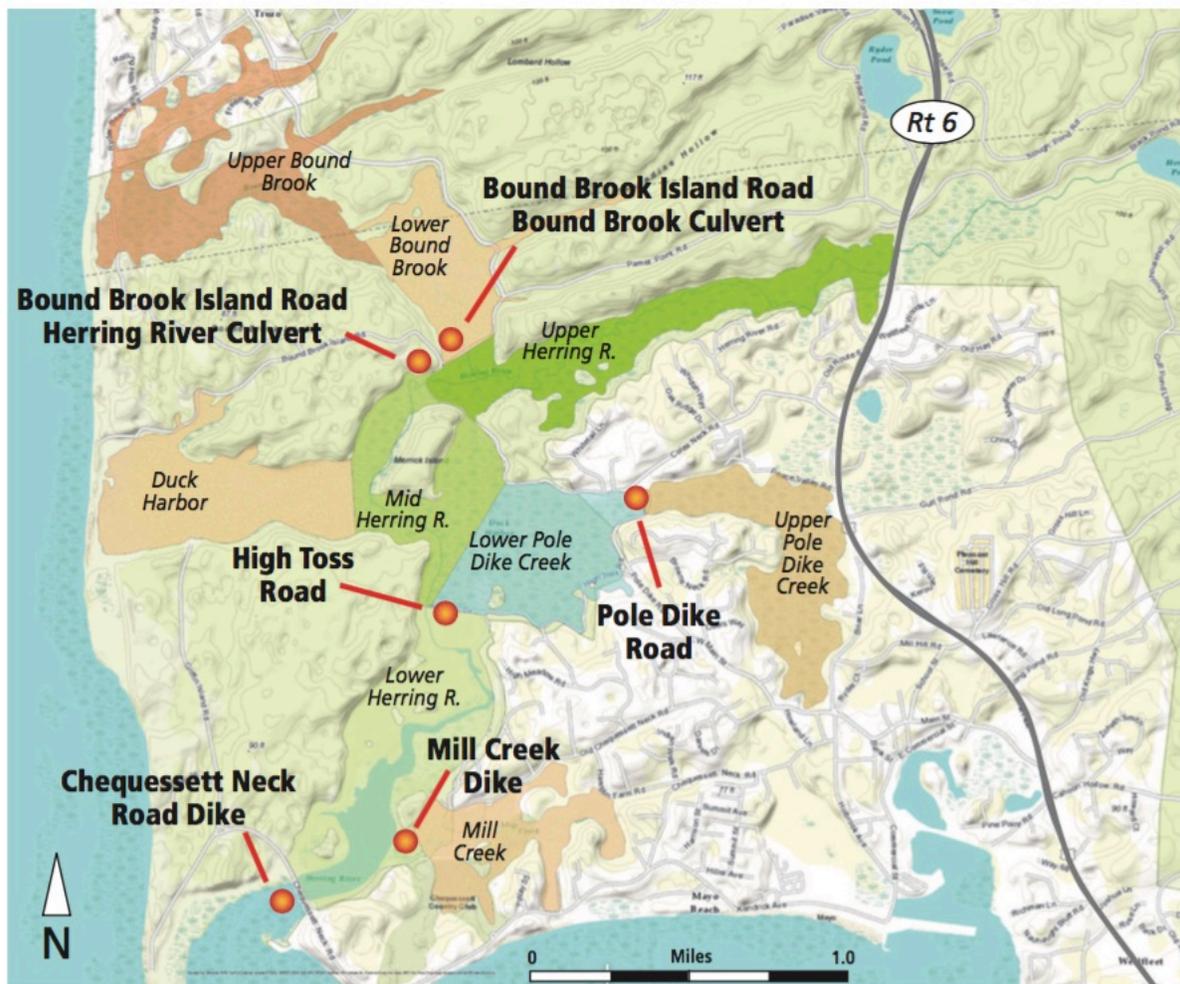


Figure 3-1. Project Features and Herring River Sub-basins

Chequessett Neck Road and Pole Dike Road water control structures are to be owned by Town of Wellfleet. Road/culvert work is on roads owned by either Town of Wellfleet or Town of Truro. Mill Creek Water Control Structure is to be owned by NPS.

3.B Project Elements and Phasing

The Town of Wellfleet is seeking a DRI permit to implement Phase 1 of the restoration: 1) **tide control elements** to construct or retrofit water mill control structures or remove restrictions in order to incrementally restore and control tidal exchange; 2) **mitigation measures** to prevent impacts to public

or private structures resulting from restored tidal flow, and 3) **vegetation and marsh management measures** implemented within the Project area to maximize the benefits of restored tidal flow and enhance estuarine habitats. This section starts with a discussion of project phasing, and then describes the three types of elements necessary to proceed with Phase 1.

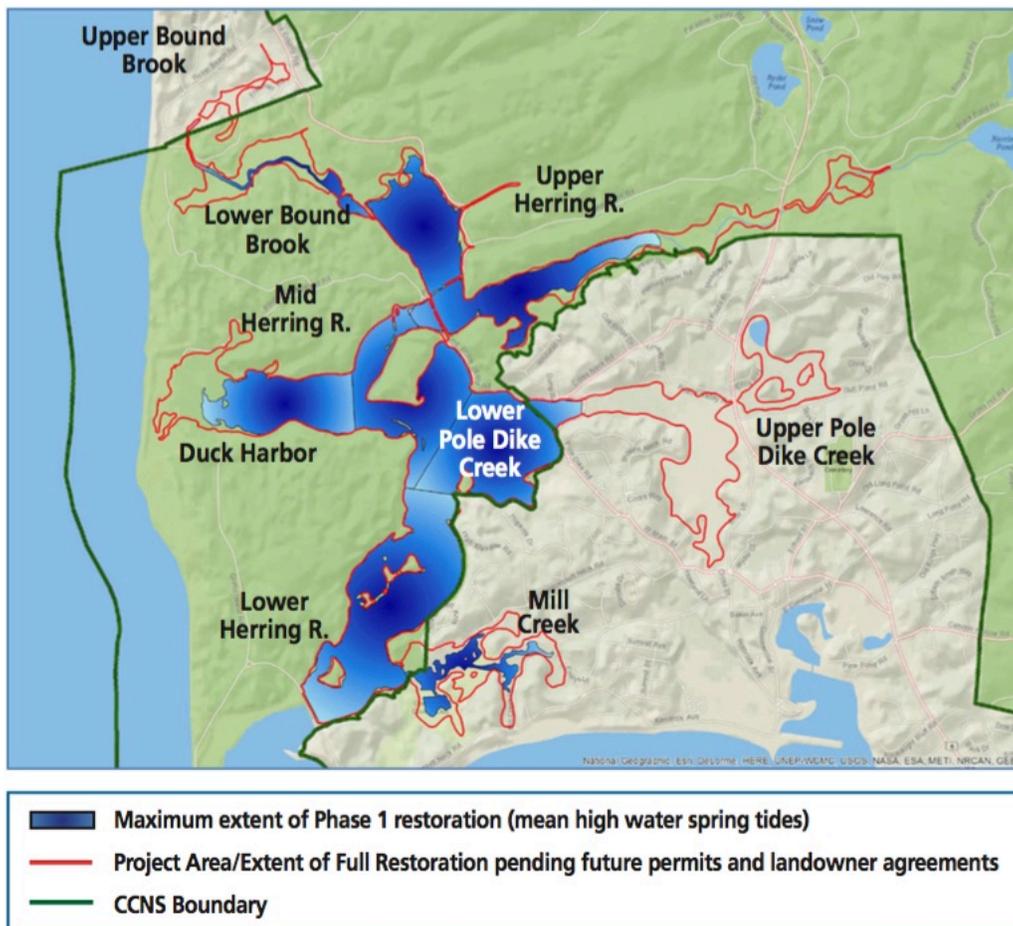


Figure 3-2. Extent of Herring River Restoration Project, Phase 1

3.B.1 Phasing

The Project’s MEPA certificate contemplates that the Project restoration will occur in phases. The environmental permit applications presently being developed seek approval to implement Phase 1 of the Project. Any proposed future increases in water levels beyond those approved in permits for Phase 1 would require permit amendments or new permits—with full regulatory review and opportunities for public input—as well as agreements with property owners for any necessary measures to protect structures from the effects of tidal restoration.

3.B.1.1 Phase 1

Phase 1 of the Project proposes to restore up to approximately 570 acres of tidal wetlands (Figure 3-2). During Phase 1, the new Chequessett Neck Road Bridge and tide gates and the Mill Creek water control structure will eventually be configured to allow partial tidal flow into Herring River and Mill Creek up to

a maximum water level specified for each respective basin. Thus, Phase 1 includes partial restoration of tides in the Mill Creek sub-basin following implementation of mitigation measures designed to prevent tidal water intrusion impacts to the CYCC golf course resulting from the Project. Tidal flow in Mill Creek will be managed by tide gate settings at the Mill Creek water control structure so that water levels will not impact any private structures. Phase 1 will exclude tides from the Upper Pole Dike Creek sub-basin to protect several low-lying private properties that would require mitigation measures to prevent tidal flow impacts. The Pole Dike Creek crossing will be equipped with tide gates that allow unidirectional flow (drainage only) while preventing any tidal flow from entering Upper Pole Dike Creek basin as a result of Phase 1 restoration. Maximum water levels in all areas of the estuary affected by Phase 1 tidal restoration will be kept below elevations that could impact any structures that are not protected by Phase 1 flood protection measures. As noted above, water levels will be continuously monitored throughout the system using an established Continuous Real-Time Water Level and Water Quality Network. If data show that water levels are higher than anticipated levels during early stages of restoration, this could be addressed by slowing the pace or reducing the size of tide gate openings, or closing gates entirely. Such actions would reduce the tide range as management alternatives are evaluated.

Predicted mean water surface elevations in each sub-basin at the end point of Phase 1 are presented in Table 3-1 below. These water surface levels were established using multiple hydrodynamic modeling scenarios to determine the maximum Phase 1 area of restoration that can be achieved while preventing impacts to unprotected structures. The overall Phase 1 restoration objectives will be achieved by the following actions:

- Opening tide gates (i.e., number of gates opened and size of openings) on the new Chequessett Neck Road Bridge. Under Phase 1, mean high water will be increased to a maximum level of 3.6 feet NAVD88 in the Lower Herring River, which will restore approximately 570 acres. The tide gates will be opened incrementally over a number of years while careful monitoring of ecosystem responses is undertaken, and may be closed at any time if conditions warrant.

The mean high water (MHW) value of 3.6 feet NAVD88 was based on the current 19-year tidal epoch and determined using the hydrodynamic model (Woods Hole Group, 2012) for a specific gate configuration representing the Phase 1 endpoint. This predicted value of MHW represents the condition at the endpoint of Phase 1. It is expected that there would be numerous other restoration steps in the adaptive management process with MHW values less than 3.6 feet NAVD88. The water levels in Lower Herring River will be continuously monitored throughout the restoration project and short-term tidal benchmarks will be computed and updated for each month for a given gate configuration. As noted above, monitoring equipment used to measure water levels in the lower river and Mill Creek is already in place and data can be viewed in real-time.⁷

- Restoring approximately 21 acres (included in the 570 acres noted above) in the Mill Creek sub-basin with a water level of 2.5 feet during Mean High Water Spring (MHWS).⁸ Hydrodynamic

⁷ Ibid.

⁸ Mean High Water Spring is a defined tidal datum that is the average of the successive pair of highest tides during spring tide range. This value was determined using the hydrodynamic model (Woods Hole Group, 2012) for the

modeling projections indicate that for normal tides concurrent with a 100-year rainfall event, the peak water surface elevation would be 3.1 feet, and for a 10-year storm surge concurrent with a 100-year rainfall event, the peak water surface elevation would be 3.7 feet. This theoretical peak water surface elevation of 3.7 feet for a combined 10-year storm surge/100 year rainfall event has never been recorded. Even if it were to occur, this water surface elevation would not adversely affect any structures in the Mill Creek sub basin.⁹

- Drainage will be significantly improved during Phase 1 by clearing channels to remove accumulated sediment in Mill Creek and by other measures that decrease low tides in the main river basin.
- No tidal restoration is proposed for the Upper Pole Dike Creek sub-basin under current permit applications for Phase 1. Hydrodynamic models show that Phase 1 Project implementation will not cause an increase in peak water levels over existing conditions during combined tidal surge and precipitation storm events. At full Phase 1 tidal flow, the peak water level during a combination 10-year storm and 100-year precipitation event is 2.9 feet in Upper Pole Dike Creek, which is the same as existing conditions for a 100-year precipitation event (storm surge would not reach Upper Pole Dike Creek under existing conditions.) Drainage data collected from Upper Pole Dike Creek indicated that the peak of the surge and the precipitation would not occur at the same time. This information was incorporated into the model to produce the water surface elevations for the combined events. The tide control at Pole Dike Road and improved drainage in Lower Pole Dike Creek will lower the mean water surface elevation before the storm to a lower starting point, providing more volume of water storage in Upper Pole Dike Creek than is presently available.
- Maximum water levels (including under storm conditions) during Phase 1 will be kept below the elevation of the lowest-lying unprotected structure. Once implementation begins, hydrodynamic models will be updated based on continuous monitoring of water levels as the tide gates at the Chequessett Neck Road Bridge are opened incrementally. This will allow ongoing hydrodynamic model refinement during the early stages of tidal restoration to verify that the permitted maximum Phase 1 water levels for the main Herring River basin correspond with observed conditions.

If, during the early stages¹⁰ of Phase 1 tidal restoration, refined modeling indicates that the permitted maximum Phase 1 water levels for the main Herring River basin could cause water levels anywhere in the Project area to exceed elevations of the lowest low-lying structures, proactive adaptive management actions will be implemented to prevent impacts. Adaptive management actions could include reducing the permitted maximum Phase 1 water levels allowed in the main Herring River basin by closing tide gates, drainage improvements within sub-basins, and/or additional on-site mitigation for low-lying structures (such as raising structures or constructing berms). Refined modeling results and

current 19-year tidal epoch.

⁹ The combination of precipitation and surge conditions used in this analysis have never occurred in the observed historic record. This indicates the extreme nature of the conditions being considered and the overall conservative nature of the assessment. It is likely that these combination conditions may never occur. (Woods Hole Group, 2017)

¹⁰ The duration of the first stage of Phase 1 restoration depends on multiple variables related to system response to restoration and adaptive management decisions made during implementation.

adaptive management actions will be determined and implemented (if necessary) during the early stages of Phase 1 tidal restoration, well before water levels have any potential to impact low-lying structures.

Table 3-1. Average Water Elevations under Maximum Phase 1 Restoration Conditions by Sub-basin

Sub-Basin	Phase I		Full Restoration		
	Mean High Water Spring		Mean High Water Spring		Storm-of-Record
	Average Water Elevation (feet)	Area (acres)	Average Water Elevation (feet)	Area (acres)	Area (acres)
Lower Herring River	4.2	147	5.6	156	165
Mid Herring River	3.4	84	4.5	87	73
Lower Pole Dike Creek	3.8	103	4.8	106	146
Upper Pole Dike Creek	N/A	0	4.1	92	120
Mill Creek	2.5	21	4.7	71	80
Duck Harbor	3.5	68	4.3	108	119
Upper Herring River	3.0	68	3.4	103	132
Lower Bound Brook	2.5	63	4.2	71	86
Upper Bound Brook	2.4	12	2.9	56	148

This application and other local, state and federal permit applications being developed for the Project seek authorization to implement Phase 1 of the restoration. Any increase in tide levels beyond the levels specified in Phase 1 permits would require permit amendments or new permits, and would be subject to agreements with landowners for any measures necessary to protect structures from the effects of tidal restoration.

3.B.1.2 Potential Future Phases

Future phases may propose to increase water levels above the maximum water level authorized in Phase 1 and may include increasing/initiating tidal restoration in the Mill Creek and Upper Pole Dike Creek sub-basins. Any future proposals to increase water levels above the maximum water level authorized in Phase 1 will require permit amendments or new permits as well as consent of property owners for site-based mitigation of potential structural impacts.

3.B.2 Tide Control Elements

Phase 1 of the Project will involve construction of all major water control infrastructure and allow tidal restoration to nearly two-thirds (570 acres) of the full restoration area (890 acres), while minimizing

effects on private land. The extent of Phase 1 restoration is shown in Figure 3-2. Approximately 540 acres or 95% of the Phase 1 restoration area is within the CCNS and owned by the NPS.

For the purposes of this DRI application, the project site consists of the parcels within the limits of disturbance for the construction of three water control elements:

- The existing Chequessett Neck Road water control structure (replacing a portion of the dike with a new bridge and tide gates);
- High Toss Road (removing the portion that crosses the estuary and blocks tidal flow; and
- Pole Dike Creek water control structure where it crosses Pole Dike Road (installing a tide gate).

These three water control elements are described in further detail below. Plans showing existing conditions and proposed limits of disturbance for the project elements are provided in Section 8.H.

A fourth water control measure, the Mill Creek water control structure, is not subject to Cape Cod Commission Act review because construction of the water control structure by NPS on federal land constitutes a purely federal activity. Moreover, the federal government will retain ownership of the structure once built. Pursuant to fundamental principles of federal supremacy and sovereign immunity, such federal activities are not governed by state or local regulations absent an explicit waiver by Congress of sovereign immunity. Accordingly, NPS will pursue all permits for this structure that are applicable. However, to provide a full picture of the restoration project, the Mill Creek water control structure is described herein.¹¹ The Mill Creek, Chequessett Neck Road and Pole Dike Road water control structures will be constructed and operable when restoration commences.

The limits of disturbance include the footprint of the respective water control element and any ancillary area necessary during construction (i.e., staging areas). The limits of disturbance for the Chequessett Neck Road Bridge and High Toss Road tide control elements consist entirely of land owned by either the Town of Wellfleet or National Park Service. The Pole Dike Creek element will have impacts beyond the Right-of-Way that will require temporary and permanent easements; the need for easements has been discussed with owners of the affected properties, each of whom has provided written consent to show work on their property on permit applications. The limits of disturbance are distinguished from areas of mitigation activity adjacent to or in the vicinity of the water control elements, which include measures such as road elevation/culvert enlargement work, or marsh/channel work, necessary to enhance the restoration process and protect public and private structures from damage resulting from the return of

¹¹ Other aspects of the Project on federal land or involving NPS are subject to Cape Cod Commission Act review because either: (1) Principles of federal supremacy do not govern because the action is not a purely federal activity on federal land, but rather an activity undertaken by a non-federal entity to improve a non-federally owned structure (e.g., Chequessett Neck Road bridge) or right-of-way (e.g., road elevation work on town roads), even where the structure or right of way is otherwise on federal land or (2) a purely federal activity on federal land must nevertheless comply with state or local requirements because Congress has explicitly waived sovereign immunity with respect to the particular type of regulation or activity (e.g., under the Clean Water Act, Congress has waived sovereign immunity with respect to regulations addressing solely water quality; accordingly, some federal activities such as vegetation management or channel clearing are subject to state and local laws that regulate water quality).

tidal flow. The Commission's review may encompass tide control elements, mitigation activities, and the broad regional benefits associated with the Phase 1 570-acre wetland restoration.

Additional details concerning construction sequencing and resource impacts and benefits associated with the tide control elements are addressed in Section 4.0 of this application.

3.B.2.1 Chequessett Neck Road (CNR) Bridge and Water Access Facility

The primary tide control element is the Chequessett Neck Road Bridge and tide gates. The Project will remove a portion of the existing earthen dike and three-bay culvert structure at Chequessett Neck Road, and install a 165-foot wide bridge with adjustable tide gates. The new bridge and tide gates will allow for the gradual transition from the presently restricted tidal flushing regime to conditions more closely resembling the River's natural flow prior to construction of the Chequessett Neck Road dike. The bridge and tide gate design was selected following an analysis of possible structural alternatives to replace the existing dike and tide gates and to determine which would be best suited to achieve the restoration objectives.¹²

Based on this analysis, a new pre-cast box beam bridge structure equipped with adjustable and removable tide gates was selected as the preferred design concept. This proposed structure is comprised of two outer spans of approximately 49.5 feet and one center span of approximately 66 feet, for a total hydraulic opening potential of approximately 165 feet. There would be 4-foot wide piers at both ends of the bridge separating the inner and outer spans. The number of spans and their respective lengths were determined based on relative span length ratios required by the Massachusetts Department of Transportation (MassDOT) LRFD Bridge Manual. The design includes adequately-sized stone armor embankment slope protection and channel bottom scour protection designed to resist scour and wave action. Plans for the innovative bridge/tide control structure are found in Section 8.H.

The tide control structure consists of multiple elements including: slide gates, combination flap/slide gates, and removable concrete panels. Per the management and governance principles set forth in the MEPA Certificate on the FEIS/FEIR, restoration will be achieved through incremental removal/manipulation of these gates and panels would be opened incrementally according to in the decision analysis process reflected in the Project's Adaptive Management Plan (See Sections 5 and 8.B.)

Several alternative gate types/configurations and operating scenarios were evaluated to determine the optimal number/type of gates to be constructed with the proposed structure (WHG 2013). Numerous gate types and configurations were also analyzed, each offering varied features, and functionality, and requiring varying levels of operation and maintenance. Based on the evaluation, it was determined that the preferred gate type, configuration, and operation would include:

- A total of two combination slide/flap gates (shown by the green areas in Figure 3-3). The combination gates would be six feet wide and ten feet in height (at maximum hydraulic opening) and positioned in the center span. These gates would be mounted on removable pre-cast concrete

¹² An evaluation of design options, geotechnical analyses and scour/wave analyses can be found in Appendix K of the FEIR (25% Engineering Design Report Herring River Tidal Restoration Project).

panels. The combination gates provide increased control of the low water, mean tide level, and tidal range within the Herring River system. The combination gates allow for additional flow out of the system, providing the ability for non-linear exchange of water flux that can shift the mean tide level and allow for increased drainage capacity if desired. Additionally, the two combination flap/slide gates will allow the new bridge structure to approximate existing conditions at the current dike, which consist of a single slide gate and two timber flap gates.

- A total of seven slide gates (shown by the yellow areas in Figure 3-3). The slide gates would also be six feet wide and ten feet in height (maximum hydraulic opening) and mounted on removable pre-cast concrete panels. Five of these gates would be positioned in the center span, while one gate would be contained in each of the outer spans. Although only six gates would be required, a seventh gate would be added for redundancy and in case of operation failure of one of the other primary gates. This additional gate would also allow for continued operation of a damaged or compromised gate structure that is scheduled for, or undergoing, repair or maintenance.

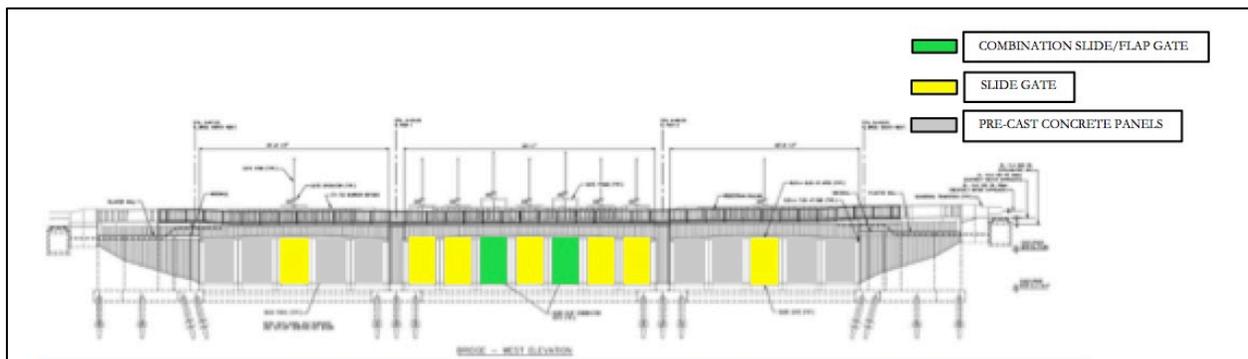


Figure 3-3. Box Beam Bridge Layout with Tide Control Structures

- A total of eight removable pre-cast concrete panels (shown by the gray areas in Figure 3-3). Each of these panels would be approximately 12.5 feet wide. There would be 4 panels in each of the outer spans.

This proposed configuration was developed by identifying the maximum and minimum water levels attainable within the Herring River system given the forcing tidal levels in Wellfleet Harbor using tidal control. The flexibility of this design model allows for any feasible water level to be attainable through the range of adjustable gate openings and/or removed panels enabled by the proposed design configuration. An Operations and Maintenance (O&M) Plan will be developed as part of final design and will be submitted in conjunction with the Notice of Intent, as required by Wetlands Protection Act regulations. An initial tide gate management policy will be submitted with the Notice of Intent, and the subsequent selection of tide gate openings will be guided by the Project's Adaptive Management Plan (see Section 5).

The new bridge will also include enhanced parking, pedestrian access, and viewing/fishing platforms, improved stormwater management, and improved aesthetics from burial of overhead utilities (See Figure 3-4 and as described in Section 4.0 of this application.)

In addition to the structural alternatives analysis that led to selection of the box beam bridge structure (FAO 2013), other aspects of bridge design evolved through an assessment of alternatives conducted with input from CCNS and Wellfleet officials and local citizens. Preliminary bridge designs were presented and discussed at public annual meetings of the Friends of Herring River in 2014 and 2015. A series of alternatives for water access and portage design elements were evaluated in light of multiple design objectives including cost, ADA accessibility, resource area impacts and visual impacts (FAO 2015). The water access and portage design alternatives were reviewed in a 2015 meeting with town Police, Fire and Public Works Departments, Selectboard members and CCNS officials for comment and selection of a preferred approach. The input from this meeting provided the project team with direction on bridge design, materials and aesthetics.

Like the existing CNR dike, the new design is not proposed to serve as a designated FEMA flood control structure (See Section 4.2.E for more discussion). The new bridge will have a final surface elevation similar to the existing dike (sloped between 11.7 and 12.6 feet, compared to the present 11.3 feet). According to the Flood Insurance Rate Maps (FIRM) released by FEMA, during 100-year storm event tides when the current CNR dike would be overtopped, floodwater also would enter the Herring River floodplain at other locations along Cape Cod Bay. Therefore, increasing the height of the Chequessett Neck Road structure would not prevent flooding in the estuary during a storm surge. Retaining the existing elevation of the roadway and structure will also preserve rural character, which was a community design objective.



Figure 3-4. Visualization of Chequessett Neck Road Bridge, looking southwest (Fuss & O'Neill)

The proposed bridge /tide gate structure has been reviewed by MassDOT and is designed to comply with the requirements of the MassDOT Load and Resistance Factor Design (LRFD) Bridge Manual and the American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design as well as the following design criteria:

- To serve a 75-year design life with proper maintenance;
- To minimize temporary and long term environmental impacts;
- To provide a safe and secure mechanism for adjusting and controlling flow into the Herring River;
- To allow for the reconfiguration of the bridge/gate structure to provide a maximum hydraulic opening measuring 10 feet in height by 165 feet in width;
- To provide a stream bed invert elevation of -4.0 feet;
- To provide a structure that can withstand, at a minimum, a potential sea level rise of up to 2.1 feet (the predicted maximum sea level rise over 50 years);
- To provide a structure capable of providing similar or enhanced public access;
- To provide a structure requiring minimal maintenance and low future costs; and
- To design the bridge and gate structures to withstand significant lateral loads from tidal fluctuations, storm surge events (such as the 100-year and 500-year frequency flood events), and to withstand a saltwater environment with wave action.

3.B.2.2 Removal of High Toss Road Causeway

The Herring River passes under High Toss Road, the second road that crosses the river, approximately one mile upstream from Chequessett Neck Road (Figure 3-1). The western portion of the road is an earthen berm causeway that was built across the salt marsh in the 19th century. It is unpaved and infrequently traveled by vehicles. The River passes under High Toss Road through a five-foot-diameter concrete culvert. Hydrodynamic modeling has shown that the culvert will cause a major restriction when tidal flow is increased at Chequessett Neck Road. The causeway would be overtopped daily by seawater under any restoration scenario, and would impede ebb tide drainage.

Complete removal of the earthen causeway and culvert crossing of Herring River at High Toss Road is a tide control component of the Project. A natural channel will be restored to its prior width of approximately 30 feet for tidal water conveyance.

Project proponents considered several alternatives to protect the portion of the road over the marsh surface from tidal flow. These alternatives ranged from elevating the road above the level of the predicted high tides to removing it entirely. The alternatives considered were ultimately not supported by the Wellfleet Board of Selectmen for a combination of reasons, most notably that as compared to the Project Proposal, the alternatives could not provide access for emergency response personnel, would conflict with overall restoration goals and additional environmental impacts associated with elevating

the roadway, and involved increased long-term maintenance and replacement costs. The Board of Selectmen voted to abandon and not replace the earthen causeway and culvert crossing of Herring River (MOTION 216-592, May 24, 2016). Accordingly, roadbed fill and the Herring River culvert will be removed and the channel will be restored to match the natural channel width and depth above and below the roadway crossing. Further channel modifications, as may be necessary to achieve Project goals, will be carried out under the Adaptive Management Plan. Work along High Toss Road will then progress from west to east, with the fill within the floodplain of Herring River removed and stockpiled elsewhere within the work area. Fill removal will only extend to a point where the final grade matches the adjacent wetland plain. No other excavation or soil amendments are proposed within the footprint of the earthen causeway. Upon reaching the proposed final grade, all disturbed areas will be seeded with a native wetland seed mixture.

As noted above, to maintain access to existing properties located on Way #672, a portion of High Toss Road from Way #672 to Pole Dike Road (travelway) will be elevated above the modeled storm-of-record. High Toss Road will be elevated to a minimum of 6-inches above the predicted water surface during the modeled storm event (6 inches above 7.0 feet.)

3.B.2.3 Water Control Structure at Pole Dike Road

After consultation with potentially affected property owners within the Upper Pole Dike Creek sub-basin, a water control structure was included at the Pole Dike Road crossing to prevent potential impacts to private structures in the Upper Pole Dike Creek sub-basin. Based on hydrodynamic assessment of post-restoration conditions using adaptive management simulations (Wood Hole Group, 2015), it was determined that by raising the road and increasing the culvert opening as described below, a tide gate structure should be installed at the culvert to restrict flow into Upper Pole Dike Creek. Accordingly, the Pole Dike Road culvert has been designed to have a hydraulic gate structure to restrict upstream flow. Therefore, Pole Dike Road will function similarly to a coastal levee during storm events up to the storm-of-record.

The proposed design at Pole Dike Road is to raise the roadway from 4.7 to 8.8 feet NAVD 88 and to increase the size of the culvert from a 36-inch circular culvert to an eight-foot high by seven-foot wide box culvert with a combination flap/slide gate (Section 13). The proposed freeboard for this roadway segment is two feet. The combination flap/slide gate will be able to regulate tidal flow to the Upper Pole Dike sub-basin, thereby avoiding or limiting water elevations. An Operations and Maintenance (O&M) Plan will be developed as part of final design and will be submitted in conjunction with the Notice of Intent, as required by Wetlands Protection Act regulations. Again, this flow control structure will only protect against flooding when water elevations are less than or equal to the storm-of-record.

No tidal restoration is proposed for the Upper Pole Dike Creek sub-basin as part of Phase 1. Hydrodynamic models show that water levels (including under storm conditions) during Phase 1 will not affect the lowest-lying unprotected structure. Based on modeling, at full Phase 1 tidal flow, the peak water level during a combination 10-year storm and 100-year precipitation event is lower than existing conditions for the same event.

3.B.2.4 Mill Creek Water Control Structure

A secondary water control structure equipped with tide gates across Mill Creek will allow a partial, controlled re-introduction of tidal exchange in the Mill Creek sub-basin to restore 21 acres of tidal wetlands in Phase 1 while protecting structures on private properties. The Mill Creek water control structure will be located entirely on property owned by the NPS. Therefore, the NPS will prepare the final design, pursue all necessary permitting and will secure funding to construct the water control structure with tide gates. The Mill Creek structure is not the subject of this permit request, and is described herein for informational purposes.

The design of the structure and tide gates was selected following an analysis of several design alternatives. Each alternative was evaluated based on environmental, constructability, aesthetic, sustainability, and cost factors. After evaluation of costs and benefits, a single sheet pile wall was selected. Design plans depicting the layout, dimension, tide gate structure (capable of allowing controlled, bi-directional tidal exchange between the Herring River and Mill Creek), and access road are found in Section 8.H. The design was revised so that the layout for the structure is contained within the CCNS boundary.

The new Mill Creek water control structure will be constructed with a crest height of 9.5 feet. This is based on a maximum, storm-of-record high tide on the downstream side of 7.5 feet, thereby providing two feet of freeboard against an extreme storm event. The structure design contains five culverts or openings, each five feet wide, for a 25-foot wide opening in total, and with adjustable combination flap-slide gates, as described below. The tide gates can be completely closed to inflowing tidal water if warranted based on predicted severe storm conditions. In such a case, freshwater would still be able to drain out of Mill Creek.

Heavy-gauge steel sheet piles are proposed, which is the most common material used for sheet pile walls due to its inherent strength which increases service life, and availability and familiarity to local contractors, which reduces costs. Since a steel sheet pile wall at this location would be subject to potential corrosion, the wall will be specified to use weathering steel or ASTM A-690 high-nickel steel with a sacrificial thickness. Sacrificial thickness is an accepted engineering method for providing corrosion protection in a marine environment. The sacrificial thickness will allow the wall to be subject to corrosive action over the life of the wall and not result in a structural failure of the sheet pile construction. This approach was selected to minimize future maintenance, operating efforts and costs.

A cantilevered steel walkway platform will be attached to the upstream side of the structure to provide a safe means for staff completing inspections, maintenance or other operating functions. This platform will be secured from access by unauthorized users and be designed to comply with relevant OSHA requirements.

Scour protection in the form of soil-filled, vegetated stone armor will be installed immediately upstream and downstream of the structure and its hydraulic opening, and soil-filled, vegetated articulated concrete block matting will provide a stable surface along the sheeting for equipment to access the hydraulic opening to remove debris and complete other required maintenance. These Project elements

are critical to protect the foundation and stability of the structure, and to assure that maintenance staff can safely complete required activities to maintain unobstructed flow through the structure's hydraulic opening.

The structure's tidal control mechanism will consist of five electrically-operated, rising stem combination slide/flap gates, each opening measuring approximately five feet in width by six feet in height. The gates will be mounted to a cast-in-place concrete structure, which will be structurally integrated into the steel sheet structure. This concrete structure will be supported by a foundation of timber piles and will be configured with a narrow (less than three-feet wide) concrete apron forming an invert where channel flow transits across the footprint of the structure, to avoid scour and other potential damage. Functional benefits provided by the tide gates include a safe and secure mechanism for adjusting and controlling flow into and out of the Mill Creek sub-basin; and mechanisms that are easily operated, allowing persons of varying technical background and physical ability to operating the gates.

Slide-flap gates are structures that combine the features of a slide gate with the functionality of flap gate by allowing the sliding leaf to rotate about a horizontal transverse axis at the top of the gate opening. This functionality is typically provided to allow storm flow drainage from a tidal estuary, while limiting tidal surge or high tides into an estuary that could otherwise result in damage to the built environment. For example, when the gate is partially open, the open area below the gate leaf allows for bi-directional flow, while the upper portion of the gate opening (where the leaf is located) restricts flow in one direction to a greater degree. As the gate moves to a more fully closed position, the open area (and bidirectional flow) decreases, resulting in the flow becoming predominately or entirely one-directional due to the function of the flap gate. Each gate will offer options to be locked in a closed or open position for security.

Access to the water control structure will be provided by a 12-foot wide drive that will extend approximately 1,200 feet from Old Chequessett Neck Road to a location near the north end of the structure, where a turn-around area will be constructed to allow adequate room for operation/maintenance vehicle maneuvers. A security gate will be provided at the access drive's entrance to prevent access by unauthorized vehicles.

Proposed Project elements have been designed to meet the following objectives:

- Provide a 75-year design life with proper maintenance;
- Minimize temporary and long-term environmental impacts;
- Accommodate modifications to withstand potential future overtopping;
- Facilitate ease of operation and maintenance, and;
- Minimize future maintenance costs.

Ancillary work includes grading and stabilization of the tidal channel immediately adjacent to the structure, dredging of accumulated sediment within existing tidal channels upstream and downstream

of the structure, and removal of an earthen dike remnant on the north side of the channel upstream of the proposed structure.

Tidal channels upstream and downstream of the structure will be excavated to remove accumulated sediment; channels will not be widened as part of this activity. The channel dredging is expected to improve freshwater drainage out of Mill Creek. Removed sediment will be side-cast, dispersed onto the adjacent marsh areas or, alternately hauled from the site to be beneficially reused within the Herring River basin, consistent with environmental permits.

3.B.3. Mitigation Measures

This section describes the mitigation measures associated with Phase 1 tidal restoration. All mitigation measures are designed to protect the subject structures under full tidal restoration conditions. For the purposes of DRI review, the mitigation activities are not within the project site area, which consists of the parcels within the limits of disturbance for the construction of the primary water control measures needed to restore tidal flow in the estuary.

3.B.3.1 Chequessett Yacht and Country Club

CYCC is a semi-private club with a nine-hole golf course located in the Mill Creek sub-basin of the Herring River. Currently, portions of the CYCC golf course experience occasional flooding by groundwater and surface water in the area of Mill Creek. Hydrodynamic modeling also shows that under certain conditions and absent mitigation measures, portions of the CYCC golf course would be affected by the increased water levels in the Mill Creek sub-basin as currently proposed in Phase 1. To address this, for a number of years, representatives of the project team and CYCC have engaged in dialogue to develop a detailed plan to: (1) see the restoration project succeed, and; (2) protect the CYCC golf course from potential adverse impact.

A key element of this multi-year effort is a plan to elevate low golf course holes. This plan includes:

- Raising and renovating portions of the five lower fairways, tees, greens, roughs, sand traps and cartpaths (Holes #s 1, 6, 7, 8 & 9) to mitigate against water levels up to the elevation 6.4 feet NAVD 88. This 6.36-foot elevation represents the maximum water level that would occur under storm-of-record conditions with tide gates in the Mill Creek water control structure open 3 feet high and the tide gates in the Chequessett Neck Road water control structure open 10 feet high, and full Project restoration (beyond Phase 1) has occurred;
- Excavation and then reconstruction of one upland CYCC golf course hole (Hole #2) which will provide a portion of fill needed for the Project (approximately 180,000 cubic yards), to be used in raising the five lower holes of the golf course. Approximately 73,000 cubic yards of fill will be used for other Project-related needs outside of the CYCC Property. The total amount of fill removed from hole #2 and other areas totals approximately 253,000 cubic yards;

- Installation of new irrigation on Holes #s 1, 2, 6, 7, 8 & 9 and relocation of the practice area to an upland portion of the CYCC Property; and
- Clearing channels and managing natural vegetation on the course and in the Mill Creek sub basin as may be needed to improve drainage and augment restoration (some channels will be identified and cleared mechanically to improve drainage, and others will be cleared naturally as restoration proceeds).

In addition, the plan includes improvements on holes #3, 4 and 5, which are not impacted by inundation, to make them compatible with other re-constructed holes. Plans for the golf course work are contained in Section 8.H.

CYCC and Project representatives have jointly acknowledged that the regulatory approvals and funding to implement the golf course work are dependent on actions beyond the control of either party. Accordingly, this work and other potential aspects of mitigation, including but not limited to contingency measures that may be employed and would be necessary if permits and funding for the golf course work described above are not secured, remain under discussion between CYCC, the Town and CCNS.

3.B.3.2 Low-Lying Road Crossings and Culverts (Pole Dike, Bound Brook Island and Old County Roads)

The Project area consists of several low-lying roadways (LLR) that are vulnerable to high tide water levels under the proposed Project. The primary design objective of this mitigation measure is to elevate the roadways to prevent overtopping during the storm-of-record. The road segments are to be elevated to a minimum of 6 inches above the predicted water surface during the modeled storm event. Current design plans are presented in Section 8.H.

To prevent over-topping, the road surfaces and culverts need to be elevated. Approximately 24,500 linear feet of roadway are included in the Project area. Of this, approximately 10,850 linear feet of road will be raised. Elevating these roads also requires widening the road bases and replacing six existing culverts and installing the Pole Dike Road water control structure with tide gate. The 10,850 linear feet (approximately two miles) of roadway is not continuous and is made of smaller road segments. While impacts to wetlands will be necessary to widen road bases, the impacts are far outweighed by the overall wetlands benefits of the Project. Additionally, a traffic management plan will be implemented to minimize disruption to residents and businesses. These issues are addressed in Section 4.0 of this application.

A geotechnical investigation of existing low-lying road segments and associated culverts was conducted to assist in the development of construction plans for the Project site, including the cut and fill operations. The existing road surface at low-lying areas ranges from 2.3 to 5.2 feet, which will be elevated to 4.25 to 7.5 feet. The goal is to elevate the existing roadway segments above the storm-of-record within the Project area (3.72 to 6.88 feet) including freeboard. Freeboard of 0.5 feet above the storm-of-record was selected to elevate these roadway segments. The actual increase in elevation varies throughout the Project area. About 0 to 4.5 feet of fill is required over existing ground elevations to achieve the final site grading. As part of the re-grading, existing culverts will be replaced with upgraded pipes and box culvert structures.

To accommodate the increase in road elevation, a side slope treatment of 3:1 (horizontal to vertical) ratio was selected to blend the side slopes into existing grades, and avoid abrupt, steep transitions between the road and adjacent land for the safety of pedestrians, cyclists, and equestrians. A 3:1 side slope provides a slope that can be stabilized with natural vegetation without concerns to slope stability, and requires only limited scour protection. The Bound Brook Island Road culvert at Herring River is the only location where 3:1 side slope ratio was not attainable. Gabion basket walls are to be included at this location on each side of the road, on the side of the culvert where the wingwalls are set close to the edge of the road.

Design of the replacement culverts include a headwall and wing walls at the three box culverts. The wing walls are necessary due to the height of the culvert opening and slope down from the road toward the water surface. Construction of the replacement culverts will require open cuts through the existing roadway to install the replacement culvert at the stream crossings. The box culverts will be installed over a layer of geotextile fabric and 12 inches of crushed stone within common borrow and will be covered by 12 inches of select gravel and flexible pavement. The 24-inch reinforced concrete pipes will also be installed over geotextile fabric and 12 inches of crushed stone and will be overlaid with 24-inches of select gravel and flexible pavement.

A temporary bypass for water flow will be required at each stream crossing during culvert installation. The hydraulic capacity of the bypass culverts will meet or exceed the capacity of the existing culverts. Dredging requirements to install the Project's culverts, associated wing walls, gabion basket walls, riprap apron, and foundation support for each of these components include removal of existing material beneath the structure and riprap locations.

Construction will be performed in stages to manage traffic flow during construction. A Maintenance Protection of Traffic Plans was developed in accordance with the Federal Highway Manual Uniform Traffic Control Devices. The Detour Plans and MPOT, which show all required road closures and detours, are contained in Section 8.H.

Compliance with state stormwater regulations is required to the maximum extent practicable for redevelopment projects. Generally, an alternative is practicable if it can be implemented within the site being redeveloped, taking into consideration cost, land area requirements, soils, and other site constraints. The primary constraints for this Project are the limited right-of-way, elevated groundwater and adjacent resource areas. Practices that will require either additional resource area impacts or impacts to private property will be defined as not practicable for the purposes of stormwater compliance.

The stormwater treatment shown on the plans consists of the inclusion of vegetated swales along the constructed road sections, taking into account the transverse pitch of the road, land available along the roadside, and other physical features. Swales will be designed to meet Stormwater Management Standards to the maximum extent practicable. Due to high elevation of groundwater, the swales will be conveyance swales, not bio-infiltration swales. The Project will fully comply with the provisions of the Stormwater Management Standards requiring the development and implementation of a construction-

period erosion and sedimentation control plan, a pollution prevention plan, an operation and maintenance plan, and the prohibition of illicit discharges.

The criteria used to size the seven proposed replacement culverts were based upon recommendations established by Woods Hole Group (WHG) in its “Herring River Hydrodynamic Modeling Model Report” (2012). The proposed culverts are based upon the specific recommendations from WHG, included in a January 23, 2015 letter report, except for the Driveway culvert. Data on the existing and proposed culverts are presented in Table 3-2. Unlike the other six culverts, the Pole Dike Road culvert has been designed to have a hydraulic gate structure.

Table 3-2. Existing and Proposed Low Lying Roads and Culvert Size and Elevation

Location	Existing Culvert	Existing Invert Elevation (ft)	Existing Road Elevation (ft)	Proposed Road Elevation (ft)	Proposed Culvert Height by Width (ft)	Proposed Invert Elevation (ft)	Proposed Crown Elevation (ft)	Annual High Water (ft)	Storm-of-Record (ft)
Pole Dike Road	36-inch	-1.3	4.7	8.82	8 by 7	-1.2	6.8	4.94	6.82
Bound Brook Island Road at Herring River	54-inch	-3.5	4.0	7.7	8 by 6	-2.7	5.3	4.73	6.44
Bound Brook Island Road at Bound Brook	24-inch	-2.3	2.4	6.4	6 by 6	-2.2	3.8	4.11	5.53
Old County Road Paradise Hollow	12-inch	0.3	3.5	6.53	24-inch	0.3	2.3	4.13	5.75
Old County Road Lombard Hollow (S)	Unknown	1.05	4.4	5.89	24-inch	1.0	3.0	2.85	3.72
Old County Rd Lombard Hollow (N)	Not Found	Not Found	4.9	5.44	24-inch	1.1	3.1	2.85	3.72
Bound Brook Island Road Private Driveway	Not found	Not found	4.2	7.2	24-inch	0.0	2.0		6.70

3.B.3.3 Elevation of High Toss Road

High Toss Road, in its current condition, is approximately two feet above the surrounding grade, and given its elevation, will be overtopped at high tides greater than approximately three feet. In order to maintain access to existing properties located on High Toss Road or Way #672 (also known as Rainbow Lane and Snake Creek Road), the portion of High Toss Road from approximately Way #672 to Pole Dike Road will be elevated to a minimum of 6 inches above the predicted water surface during the modeled storm event (6 inches above 7.0 feet).

The proposed work at High Toss Road has three primary objectives to:

- Restore Herring River and its floodplain to a naturalized and unrestricted state in the vicinity of High Toss Road through the removal of the culvert on Herring River and the fill associated with the causeway within the floodplain.
- Elevate the alignment of High Toss Road between Pole Dike Road and Way #672 water control structure to elevation 7.5 feet to prevent overtopping of the roadway. This includes 0.5 feet of freeboard above the elevation of the modeled storm-of-record of 7.0 ft. Current design plans are presented in Section 8.H.
- Replace an existing culvert located approximately 460 feet west of Pole Dike Road with a larger diameter culvert to promote hydraulic connection of wetlands on both sides of High Toss Road at this location.

3.B.3.4 Mitigation Work on Other Private Property

Mitigation measures to protect structures on three private properties from potential impacts of tidal restoration are described below. Letters of consent to describe this work in permit applications have been obtained from each property owner.

Bound Brook Island Road

A private property located off of Bound Brook Island Road is a low-lying property with a structure vulnerable to tidal inundation under Phase 1 restoration. The Project has reached agreement with the property owners to provide measures to fully protect the structure.

The property has two dwellings with individual gravel driveways; proposed mitigation measures include relocating and elevating the existing driveway serving the lower of the two dwellings. A bench-wall barrier will be installed around a patio area of said dwelling to protect the lower entrance. Following construction and site restoration, the property will be very similar to existing conditions. No detrimental effects on use of the property are anticipated and the beneficial effects of reduced potential for water intrusion are permanent.

The property is accessed via a gravel road off of Bound Brook Island Road. As part of the LLR roadwork described above, a portion of Bound Brook Island Road in the vicinity of the subject property will be elevated, as will the gravel access road to the dwellings; and a culvert near the beginning of the gravel

access road will be replaced. Construction on the property will likely not occur in phases. The driveway and patio may be constructed simultaneously.

Mill Creek Sub-basin

Private wells serving properties at 70 and 80 Mill Creek Lane, respectively, could be overtopped by tidal water during Phase 1 restoration. Consistent with agreements reached with the subject property owners, each of the two wells will be relocated to a site above maximum water levels under both Phase 1 and also for full restoration.

3.B.3.5 Tide Barrier to Protect Way #672

Way #672 (a portion of which is also known as Rainbow Lane or Snake Creek Road) is located adjacent to the Herring River, approximately one mile upstream of Chequessett Neck Road. The following section addresses the evaluation, selection, and design of alternative structural configurations to protect Way #672 from impacts related to restoration of tidal flow.

A structure is being proposed to protect the road and residential properties along Way #672 from restored tidal flow, while minimizing wetland impacts, construction costs, and operation/maintenance requirements. Like the Mill Creek water control structure, this structure is entirely on land owned by the NPS, and is not subject to Cape Cod Commission Act review because construction of the structure by NPS on federal land constitutes a purely federal activity. NPS will pursue all permits for the structure that are applicable. A description of the structure is provided herein for informational purposes.

The assessment of potential impacts to low-lying structures indicated that tidal flow could temporarily reach two private driveways off of Way #672, a private low-lying well and both High Toss Road and Way #672, during larger coastal storm events under Phase 1 restoration. Several conceptual design alternatives were evaluated for a tide barrier to be located on CCNS property to protect the above-mentioned structures from tidal flow under all Phase 1 conditions.

The following five potential structural configurations were evaluated: earthen dike, precast concrete wall, cast-in-place concrete wall, steel sheeting wall, and timber barrier wall. Based on seven selection criteria that encompassed physical site conditions, natural resource impacts, constructability, cost, maintenance requirements and site compatibility, two of the five alternatives (steel sheeting wall and timber barrier wall) were selected for further evaluation, as well as a third “hybrid” wall utilizing a combination of a steel sheeting (below grade) and timber barrier wall (above grade). The three alternatives are all single walls and therefore will have similar a footprint and layout. Based on the assessment, the NPS selected the hybrid steel/timber alternative.

The proposed structure will be designed to satisfy the following specific criteria that serve as minimum standards for design and construction:

- Minimize temporary and long-term environmental impacts;
- Top of dike set at elevation 7.5 feet;
- Minimize future maintenance costs;

- Maximize the structure's ability to adapt to future conditions (e.g., ease and cost of future alterations);
- Allow for positive upland drainage, as determined necessary subsequent design phases;
- Provide seepage cutoff, as and if determined necessary in future phases of design, and;
- Withstand lateral loads and salt water environment.

3.B.4 Secondary Vegetation and Marsh Management Actions

This permit application also encompasses potential secondary management actions on the marsh plain that are needed to enhance ecosystem function in concert with tidal restoration. Proposed actions include additional drainage improvements (e.g., vegetation removal and channel excavation to remove accumulated sediments), vegetation management, and sediment supplementation to increase marsh elevation. At the time of permit submittals, the precise locations, methods and timing of these activities are unknown as they depend in part on system responses to the return of tidal flow. Uncertainties about the implementation details of these actions will be resolved as tidal restoration progresses and the response of the system is evaluated in accordance with the Adaptive Management Plan described in Section 5.0 and contained in full in Section 8.B.

3.B.4.1 Vegetation Management

Vegetation management is a class of project activities, along with incremental tidal restoration and facilitating the recovery of natural tidal marsh channel networks and elevation that are being pursued as part of the adaptive management plan. This section provides a general description of activities, methods, and effects. A more detailed draft Vegetation Management plan is found in Appendix F. This information will be supplemented and refined during project implementation and presented by the HRRC when appropriate in detailed, site-specific Vegetation Treatment Plans (VTPs) for review and comment by the Regulatory Oversight Group and Herring River Stakeholder Group (HRSRG), and approval by the HREC.

As Phase 1 is implemented, salt water will cause decline and mortality to much of the herbaceous and woody freshwater-dependent and upland vegetation that has colonized the floodplain. If left standing, dying and dead trees and larger shrubs could hamper the re-colonization of native salt marsh plant communities. In some areas currently dominated by herbaceous, freshwater-dependent emergent plant species, the non-native, invasive common reed (*Phragmites australis*) could expand which would have a number of deleterious ecological and socioeconomic effects, including displacement of native vegetation and a reduction in habitat quality for fish and wildlife. The specific goal for managing vegetation as part of the Herring River Restoration Project is to support the long-term, sustainable re-colonization of native estuarine vegetation as tidal range, salinity and sediment transport processes are restored.

Vegetated areas that will be affected at each stage of tidal restoration were identified by comparing NPS vegetation cover type data with spatial data output from the EFDC hydrodynamic model. Active removal and management of vegetation will be limited to the emergent marsh areas with existing occurrences of

common reed, as well as shrub-lands and woodlands. Within the area of the Herring River floodplain affected by regular tidal inundation up to the Phase 1 project limit, approximately 43 acres is currently dominated by common reed, most of which occurs within the Lower Herring River sub-basin. Shrub-lands comprise about 179 acres and are scattered throughout all of the Herring River sub-basins with the exception of Bound Brook. The largest contiguous stands of shrub-land currently occur in portions of Duck Harbor, Lower Pole Dike Creek, and the Upper Herring River sub-basins. Woodlands currently make up approximately 126 acres of the Phase 1 project area, with most stands occurring in the Lower Herring River, Mid-Herring River and Lower Pole Dike Creek sub-basins. In total, up to approximately 348 acres within the Herring River floodplain could require some form of vegetation management as part of Phase One of the project.

Vegetation management will be conducted incrementally. It will be closely coordinated with Chequesett Neck Road tide gate management and the resulting increases in water surface elevations, tidal range, and salinity. Generally, vegetation management operations would be conducted before tidal flows are reintroduced to a given area before the ground surface is affected by salt or brackish water. Inundation with saltwater that promptly follows vegetation removal is expected to be highly effective for preventing or limiting regrowth of undesirable species and is expected to foster re-colonization of native estuarine plant communities.

3.B.4.2 Marsh Management

Restoration of natural stream channel connectivity and marsh surface elevation is a major component of the Herring River Restoration Project. Marsh management is a class of project activities, along with incremental tidal restoration and vegetation management, that will be pursued as part of the coordinated adaptive management program.

These activities cannot be described in detail at a site-specific level prior to commencing the restoration and adaptive management program. Many of the locations where this work could potentially be necessary are remote and currently either covered in dense, shrubby vegetation or under water. The work is also dependent on specific vegetation, micro-topography, and tidal flow characteristics. Attempting to evaluate potential treatment sites and design future marsh surface restoration actions based on existing conditions is a fruitless exercise, since these conditions will change after tidal exchange is restored. Conditions will also vary greatly among different locations and at different stages of the restoration process. Therefore, this broad summary is based on the best information available and current projections of how restored tidal flow will generally affect the project area as well as the types of interventions that are expected to be necessary for restoring natural stream networks and marsh elevation.

4. Regional Policy Plan Analysis

The following section discusses each of the RPP Goals and Objectives identified in the March 2019 DRI Scoping Decision issued for this Project. The RPP goals and objectives are addressed in the order in which they are listed in the Scoping Decision. For each category of RPP topics, the narrative describes existing conditions, post restoration conditions, and the ways in which restoration responds to and satisfies specific RPP Goals and Objectives.

4.A Water Resources (WR)

This section reviews the existing condition of water resources in the Herring River system and demonstrates how post restoration conditions meet the RPP Water Resources (WR) goal and applicable WR objectives.

4.A.1 Existing Conditions

4.A.1.1 Salinity of Surface Waters

The existing Chequessett Neck Road dike has limited the upstream mean tide range in Herring River to only 2.2 feet compared to 10.3 feet in Wellfleet Harbor. In Wellfleet Harbor, salinity typically ranges between 30 and 32 parts per thousand (ppt) (NPS data, as presented in WHG 2009). Under current conditions, saline water from Wellfleet Harbor only reaches upstream to approximately High Toss Road, approximately 1.2 miles upstream of the dike (Figure 3-1 in the FEIS). Based on the analysis of roots and rhizomes from peat cores, salinity penetration supported smooth cordgrass (*Spartina alterniflora*) throughout the historic floodplain (Orson and Roman in Roman 1987). CCNS monitoring data confirm that waters within the upper estuary are now consistently fresh as a result of tidal restriction. Downstream of the Chequessett Neck Road dike, waters are brackish to marine with monthly mean salinities of 15 to 27 ppt during low tide. Section 3.2 of the FEIS provides a more detailed discussion on existing surface water salinity in the Herring River floodplain (HRRC 2016).

4.A.1.2 Water and Sediment Quality

The Massachusetts Surface Water Quality Standards have designated the lower portion of the Herring River up to High Toss Road as Class SA waters (314 CMR 4.05). These standards reflect the status of water quality needed to support designated uses of the waters. Class SA waters are required to have excellent habitat for aquatic life and conditions for recreational use. In addition, the Herring River estuary is designated by the Commonwealth as Outstanding Resource Waters (314 CMR 4.04). The Herring River reach from High Toss Road to the outlet of Herring Pond has been designated as Class B water. Class B waters are designated as habitat for fish, wildlife, and other aquatic life, including for their reproduction, growth and other critical functions, migration, and primary and secondary contact recreation. In some cases, where designated, Class B waters are a suitable source of public water supply

with the appropriate treatment. Outstanding Resource Waters include waters designated for protection based on their high socio-economic, recreational, ecological, and aesthetic values.

Plainly none of these standards are satisfied in current conditions. The Herring River estuary currently does not meet the targeted designation criteria because of degraded water quality conditions. Over the last 100 years, surface water quality in the Herring River estuary has declined because of the severely restricted tidal flushing of the estuary, as well as drainage of marsh soils and sediments. Restricted tidal influence and marsh drainage have resulted in low pH, increased mobilization of aluminum and iron, sustained periods of low dissolved oxygen, and high levels of fecal coliform bacteria. Water quality concerns, including high aluminum, low pH, and high fecal coliform bacteria, have also resulted in the listing of the Herring River on the 303(d) list of impaired waters under the federal Clean Water Act (CWA). A more detailed discussion on dissolved oxygen, pH and sulfate, nutrients, and fecal coliform within the Project area can be found in section 3.3.5 of the FEIS (HRRC 2016). The following bulleted section provides a brief summary of current conditions for water quality.

- **Dissolved oxygen:** Anoxic and near-anoxic conditions exist regularly along the main stem of the river (Portnoy 1991). Dissolved oxygen levels collected at the Chequessett Neck Road dike by the USGS in 2016-17 show that concentrations frequently fall below the 6.0 mg/l standard for Class SA waters (314 CMR 4.05). Dissolved oxygen levels vary with the tides and at nearly every low tide during the summer, dissolved oxygen levels are highly stressful to fish and other aquatic animals. Low dissolved oxygen results from the combination of high oxygen demand and greatly reduced tidal flushing. Restored tidal conditions would import copious volumes of oxygen-saturated seawater.
- **pH and Sulfate:** Salt marsh soils in the Herring River estuary are naturally rich in sulfur because salt marsh microbes use sulfate as an oxidizing agent to decompose organic matter in anoxic marsh sediments. The process produces dissolved sulfide, a large fraction of which is sequestered as iron-sulfide. The mineral is not stable in the current aerobic environment created by diking and drainage of the salt marsh. As a result, the sulfide has reacted with oxygen to form sulfuric acid which has acidified the soil to pH levels less than 3 (roughly the same acidity as a lemon), compared with the range of 6.5 to 8.5 stipulated for Class SA waters (314 CMR 4.05). Acidic water can result in a loss of aquatic vegetation, as well as the killing of fish and other organisms.
- **Fecal Coliform:** The Herring River is listed as impaired for fecal coliform in a 0.39 square mile area between Griffin Island and Wellfleet Harbor (MassDEP et al. 2009). MassDEP has designated the Chequessett Neck Road dike as a point source for bacterial contamination. In 2005, fecal coliform concentrations at nine stations between High Toss Road and Egg Island were found to be elevated, reaching up to 1,000 colonies per 100 ml during an outgoing tide (Portnoy & Allen 2006). For reference, shellfish harvesting is prohibited if fecal coliform concentrations exceed 14 colonies per 100 ml of water. High fecal coliform concentrations have kept the Herring River downstream of the Chequessett Neck Road dike permanently closed to shellfishing in some areas and only conditionally approved in other areas (FEIS 3.3.6) Given the low development density fecal coliform bacteria probably originate from wildlife in the estuary and watershed rather than from humans.

- **Nutrients:** Although there is no documentation of specific anthropogenic or natural inputs, potential sources of excessive nutrients within the Herring River watershed include animal waste and atmospheric deposition. Watershed loading from septic systems and run-off is believed to play a smaller role in Herring River compared with other more developed estuarine watersheds. Nutrients have accumulated in the Herring River marsh soils due to the lack of tidal flushing. Re-flooding sediments may release ammonium-nitrogen and phosphorus (Portnoy & Gilbin 1997) so monitoring of ammonium-nitrogen levels is planned during restoration

Sediment testing for metals and pesticides was conducted in 2007 and 2014, and this information is characterized in the FEIS. To more comprehensively depict existing conditions, additional sampling of sediment chemical characteristics is currently underway in consultation with MassDEP and US Army Corps of Engineers. These data will be incorporated in Sediment Management Plans submitted for review and approval by MassDEP and US Army Corps of Engineers under Section 401 Section 404 Water Quality Certification permit regulations.

4.A.2 Post Restoration Conditions

4.A.2.1 Salinity of Surface Waters

The return of tidal flow to Herring River will begin to re-establish the salinity gradient necessary for a healthy estuary. Impacts on surface water salinity resulting from Project activities are based primarily on a hydrodynamic model that was developed for the Herring River floodplain (WHG 2012). The model includes a simulation of water surface elevations, salinities, and flow velocities throughout the Herring River. See section 4.2.1 of the FEIR for a detailed description of hydrodynamic modeling methods used to predict future salinities throughout the estuary. Model results are summarized in table 4-3 of the FEIR and reported in detail in the FEIR (Appendix B). Under the proposed conditions, the Herring River floodplain upstream of High Toss Road will change from a freshwater system to a tidally influenced, saline environment, increasing the areal extent of tidal exchange by an order of magnitude in comparison to current conditions. However, because of the lack of a salinity gradient throughout the system under existing conditions, calibration and validation of the modeled salinities for the mixing, transport, and diffusion processes have a degree of uncertainty. As restoration progresses, increasing the size of opening at the Chequessett Neck Road water control structure may also result in greater salt penetration than predicted by the model because of natural erosion (deepening) of the tidal channels, intentional channel improvements undertaken as marsh management actions, and improved low tide drainage, all effectively increasing the rate of tidal flushing. With each incremental tide gate opening and associated monitoring of water elevations and salinity, the model can be further validated and the level of uncertainty reduced for future incremental openings. Specific uncertainties, hypotheses, monitoring strategies, and potential management actions aimed at addressing impacts associated with changes in salinity will be addressed in the Project's adaptive management plan.

4.A.2.2 Water and Sediment Quality

Tidal restoration will substantially improve water and sediment quality by increasing the range of seawater flows, thereby creating higher tides and enhancing low tide drainage. In addition, the proposed conditions will substantially decrease residence times of flows from the Herring River floodplain to Wellfleet Harbor by at least a factor of 25, which is expected to maintain dissolved oxygen concentration above state water quality standards at all times. Water and sediment quality improvements are major objectives of the Project and are integral for the restoration of habitat conditions required for the re-establishment of native fish, shellfish and other estuarine animal populations. Improved dissolved oxygen concentrations will benefit migratory diadromous fish as well as resident fish and invertebrates. The impact analysis for this section has been based on published studies of the Herring River and other estuaries, unpublished water quality and sediment data collected by CCNS and USGS, and hydrodynamic modeling (WHG 2012). The following bulleted section provides a brief summary of water and sediment quality. A more detailed discussion on impacts to water and sediment quality proposed by the Project, including individual discussions on soil chemistry, nutrients, pesticides, and fecal coliform within the Project area, can be found in section 4.3 of the FEIR.

- **Soil Chemistry:** Restored tidal flushing is expected to reduce acidification within the mid-portion of the Herring River estuary where saline water will again saturate drained peat. The rate of aerobic decomposition and acid production within the soil will decrease substantially, and the pH of porewater and surface water will increase (Portnoy and Giblin 1997). With restored salinities, aluminum and iron will no longer be leached from the soil to receiving waters in concentrations that stress aquatic life. Decreased decomposition and increased saturation of soil pore spaces with water will also prevent further subsidence of the marsh surface.
- **Fecal Coliform:** Regular tidal flushing will substantially decrease fecal coliform concentrations in the Herring River due to increased flushing rates, lower water temperature, and higher salinity and dissolved oxygen. (Portnoy and Allen, 2006) The reduction of bacteria concentrations will result from the dilution of cleaner inflowing water into the system, as well as the significantly reduced life span of bacteria in more saline waters. Greatly reduced fecal coliform concentrations within Herring River and Wellfleet Harbor are expected to eventually allow for removal of the river from the 303(d) list for impairment by pathogens and lead to the reopening of once productive areas for shellfish harvesting.
- **Nutrients:** Concentrations of nitrogen in the wetland sediments of Herring River have remained high. Renewed tidal flushing of acid sulfate soils will allow ammonium-nitrogen to be released into receiving waters over the short term (Portnoy and Giblin 1997). However, with the increased volume of tidal flushing, nutrients will be diluted and removed from the system with each tide cycle. Overall, released nutrients will benefit growth of salt marsh vegetation in the restored marsh.
- **Pesticides and other Organic Compounds:** The project proponents are not seeking authorization to use any pesticides including herbicides.

4.A.3 Response to RPP Water Resources Goal and Objectives

The RPP Water Resources goal is “to maintain a sustainable supply of high quality untreated drinking water and protect preserve or restore the ecological integrity of fresh and marine surface waters.”

The Commission’s scoping decision identifies this goal, in addition to WR1, WR2 and WR3 as applicable to this Project. The Scoping Decision also identifies WR4 as applicable, but limited to the stormwater management associated with the Project’s proposed water control structures and low-lying roadway segments. The stormwater management is proposed in the context of redevelopment to improve stormwater management over existing conditions, rather than as part of a new development. Stormwater management design for engineered stormwater structures is described in Section 8.D.

Objective WR1 – Protect, preserve and restore groundwater quality

This objective seeks to ensure that the project protects, preserves and restores groundwater quality. The Project meets the objective to protect, preserve and restore groundwater quality, as described below.

The Project is not in a Wellhead Protection Area, or Potential Public Water Supply Area as identified on the RPP Data Viewer. Therefore, the methods of demonstrating compliance with objective WR1 for projects within such areas do not apply.

The Project is not proposing a private wastewater system or wastewater treatment facility. Therefore, the methods for demonstrating compliance with objective WR1 for projects that contain a private wastewater system or wastewater treatment facility do not apply.

The Project will not result in the generation of wastewater; and the site-wide nitrogen loading concentration will not exceed 5 ppm. In fact, the Project will overall benefit nitrogen loading. The Wellfleet Local Comprehensive Plan Committee estimates a reduction in nitrogen load in Wellfleet Harbor as a result of implementing the Herring River restoration project. (Cape Cod Commission Watershed Report: Wellfleet Harbor, 2017)

Nitrogen loading from runoff associated with project elements will not increase due to enhanced stormwater management (see WR4). Stormwater management measures included in the bridge design will improve treatment of runoff. Elevated low-lying roadways will reduce uncontrolled run-off into wetlands and improve conveyance. All construction contracts will include appropriate stormwater Best Management Practices. (see WR4).

The Project complies with objective WR1 in that it will protect and preserve groundwater quality, and otherwise have no adverse impact to down-gradient existing or proposed drinking water wells. This conclusion is based on the following information.

WR1 Response 1. The Project protects all private wells. The Project has studied the potential impact of

restoration on private wells under Phase 1 and full restoration conditions. (Martin et al, 2019, See Section 8.C). The study incorporates recent investigations for Herring River which correctly evaluated the effect of tidal restoration on groundwater beneath and adjacent to an intermittently flooded intertidal estuary. These studies found that tidal restoration is expected to increase the mean water level in the river and streams, resulting in a slight increase of the water table elevation and consequent increase in thickness of the freshwater zone in the aquifer. These investigative findings support the conclusion that only wells exposed to salt water inundation at the ground surface around the casing are likely to experience water quality impacts resulting from tidal restoration at Herring River.

Based on this understanding of impact risk, a total of seven wells were identified with the potential for saltwater inundation at the ground surface resulting from full tidal restoration of the Herring River Estuary. Two of the seven wells will be plugged and abandoned. Two other of the seven wells would not be affected under Phase 1 restoration. Mitigation actions have been identified to fully protect the remaining three wells potentially affected under Phase 1 restoration. Owners of two of the three wells have consented to relocation of their wells. The third well will be protected from intermittent saltwater inundation by a tide control barrier location on Cape Cod National Seashore property.

WR1 Response 2. The RPP Water Resources I Data Viewer identifies a “potential plume” emanating from the capped Wellfleet town landfill located on Coles Neck Road as an impaired area. This plume is not located within the project area. In its comment letter on the FEIS the Cape Cod Commission requested “more analysis about the relationship between higher water levels and tidal exchange in the Herring River, and potential effect on any remaining contaminants with the Town of Wellfleet’s closed landfill site on Cole’s Neck Road.

Analysis of the 2018 Biennial Post-Closure Monitoring Report for the Wellfleet Municipal Landfill (The Johnson Company, 2019, See Section 8.C) concluded that based on current data there does not appear to be a contaminated groundwater plume associated with the landfill. The 2005 landfill closure was successful and that landfill leachate has been reduced and/or stopped. The vast majority of organic and inorganic data was either non-detect or significantly below the drinking water criteria. The only constituents that exceed any type of standard are pH, iron, manganese, and 1,4-dioxane. In general, it appears that the up-gradient wells have similar levels of contamination to wells that are down-gradient of the landfill. The restoration of the Herring River into a saltwater marsh will have some effect on the tidal cycle in the vicinity of the landfill. However, tidal restoration will bring surface water no closer to the landfill than it is today, >500 feet; and groundwater levels and flow direction at the landfill will not change as a result of the tidal restoration.

WR1 Response 3. The Project does not use, treat, generate, handle, store or dispose of Hazardous Materials or Hazardous Wastes. Phase 1 permits for the Project will not include use of irrigation, chemical fertilizers, or pesticides. During construction, all contractors will be required to comply with federal and state statutes and best management practices for treatment, handling, storage or reporting of any hazardous materials or hazardous wastes as applicable.

Objective WR2 – Protect, preserve and restore freshwater resources

This objective seeks to ensure that the Project protects, preserves and restores freshwater resources. The Project is not within a Freshwater Recharge Area as identified on the RPP Data Viewer. Therefore, the methods for demonstrating compliance with WR2 for projects in such areas do not apply.

However, the Project will enhance and improve naturally occurring freshwater resource conditions in the upper reaches of the Herring River system and therefore complies with WR2. This conclusion is based on the following information.

WR2 Response 1. The Project will restore the natural salinity gradient to the Herring River system, and will improve naturally-occurring freshwater resources in the upper reaches of the Herring River system. The return of tidal flow to Herring River will begin to re-establish the salinity gradient necessary for a healthy estuary. Impacts on surface water salinity resulting from Project activities are based primarily on a hydrodynamic model that was developed for the Herring River floodplain (WHG 2012). The model includes a simulation of water surface elevations, salinities, and flow velocities throughout the Herring River. See section 4.2.1 of the FEIR for a detailed description of hydrodynamic modeling methods used to predict future salinities throughout the estuary. Model results are summarized in table 4-3 of the FEIR and reported in detail in the FEIR (Appendix B). Under the proposed conditions, the Herring River floodplain upstream of High Toss Road will change from a freshwater system to a tidally influenced, saline environment, increasing the areal extent of tidal exchange by an order of magnitude in comparison to current conditions. However, because of the lack of a salinity gradient throughout the system under existing conditions, calibration and validation of the modeled salinities for the mixing, transport, and diffusion processes have a degree of uncertainty. As restoration progresses, increasing the size of opening at the Chequessett Neck Road water control structure may also result in greater salt penetration than predicted by the model because of natural erosion (deepening) of the tidal channels, intentional channel improvements undertaken as marsh management actions, and improved low tide drainage, all effectively increasing the rate of tidal flushing. With each incremental tide gate opening and associated monitoring of water elevations and salinity, the model can be further validated and the level of uncertainty reduced for future incremental openings. Specific uncertainties, hypotheses, monitoring strategies, and potential management actions aimed at addressing impacts associated with changes in salinity will be addressed in the Project's Adaptive Management Plan (Section 5).

Tidal restoration will substantially improve water and sediment quality by increasing the range of seawater flows, thereby creating higher tides and enhancing low tide drainage. In addition, the proposed conditions will substantially decrease residence times of flows from the Herring River floodplain to Wellfleet Harbor by at least a factor of 25, which is expected to maintain dissolved oxygen concentration above state water quality standards at all times. Even in the upper reaches of the estuary where significant change in the salinity gradient is not anticipated, the increase in tidal influence will improve dissolved oxygen. Water and sediment quality improvements are major objectives of the Project and are integral for the restoration of habitat conditions required for the re-establishment of native fish, shellfish and other estuarine animal populations. Improved dissolved oxygen concentrations

will benefit migratory diadromous fish as well as resident fish and invertebrates. The impact analysis for this section has been based on published studies of the Herring River and other estuaries, unpublished water quality and sediment data collected by CCNS and USGS, and hydrodynamic modeling (WHG 2012).

Objective WR 3 – Protect, preserve and restore marine water resources

As described above, Herring River is designated by the Commonwealth as Outstanding Resource Waters. However, under existing conditions, Herring River is included on the 303(d) list of impaired waters under the federal Clean Water Act (CWA), and the existing Chequessett Neck Road dike is a designated point source for bacterial contamination of shellfish beds in Wellfleet Harbor. Marine water quality is severely degraded based on several measures, including persistent anoxic conditions, high acidity, metals, bacterial contamination, and accumulated nutrients due to lack of tidal flushing.

This objective seeks to ensure that the Project protects, preserves and restores marine water resources. The Project meets this objective in that the resulting restoration of near natural tidal flow will result in significant improvements in the health and sustainability of marine water resources. This conclusion is based on the following information.

WR3 Response 1. The return of tidal flow to Herring River will begin to re-establish the salinity gradient necessary for a healthy estuary. (see WR-2, finding 1 above)

WR3 Response 2. Tidal restoration will substantially decrease residence times of flows from the Herring River floodplain to Wellfleet Harbor by at least a factor of 25, which is expected to maintain dissolved oxygen concentration above state water quality standards at all times.

WR3 Response 3. Restored tidal flushing is expected to reduce acidification within the mid-portion of the Herring River estuary where saline water will again saturate drained peat. With restored salinities, aluminum and iron will no longer be leached from the soil to receiving waters in concentrations that stress aquatic life.

WR3 Response 4. Regular tidal flushing will substantially decrease fecal coliform concentrations in the Herring River due to increased flushing rates, lower water temperature, and higher salinity and dissolved oxygen.

WR3 Response 5. There will be little change in nutrient flux, and dependent phytoplankton, on the seaward side with tidal restoration. In greenhouse microcosm experiments NPS did observe that re-salination of acid sulfate soils, typical of the drained wetlands above High Toss Road, mobilized ammonium-nitrogen; however, this should be a short-term phenomenon. (Portnoy and Giblin 1997). The ammonium is presently adsorbed to clay particles. To the extent that seawater reaches these sediments, ammonium will desorb and will be available as a nitrogen source to primary producers, both phytoplankton and wetland vascular plants. However, with an incremental and slow restoration of tidal exchange, any increases in ammonium will be gradual, i.e. not a large pulse. However, with the

increased volume of tidal flushing, nutrients will be diluted and removed from the system with each tide cycle. Overall, released nutrients will benefit growth of salt marsh vegetation in the restored marsh. Also, with the high flushing rate in Wellfleet Harbor proper, this nitrogen is not expected to cause excess algae blooms. (Draft CWMP, 2014)

WR3 Response 6. Coastal resource restoration (i.e., restoration of salt marsh) is non-traditional method of nutrient removal. The project will restore 570 acres of salt marsh and other estuarine wetlands. The Cape Cod Commission Watershed Report for Wellfleet Harbor cites that the Wellfleet Local Comprehensive Plan Committee estimates a reduction in nitrogen load in Wellfleet Harbor as a result of implementing the Herring River and Mayo Creek restoration projects.

Objective WR4¹³ – Manage and treat stormwater to protect and preserve water quality

This objective seeks to ensure that the project protects, preserves and restores groundwater quality. The project elements and associated roadway elevation work necessary to protect roadways from impacts resulting from tidal restoration meet the state’s definition for redevelopment with respect to stormwater management under this objective, as described below. Thus, the applicable standard for stormwater management for redevelopment is to improve stormwater management over existing conditions. The project meets this standard by incorporating upgraded stormwater management in the design of the CNR bridge, and by enhancing stormwater management in the design of elevated segments of low-lying roads. This conclusion is based on the following information:

WR4 Response 1. The Project improves site conditions to enhance stormwater retention, water quality treatment and recharge compared with existing conditions. The improvements in stormwater management are described below:

- The Chequessett Neck Road bridge will be designed to improve stormwater management and treatment over current conditions.
- Under current conditions, stormwater runoff generated by the roadway approaches to the Chequessett Neck Road dike drains to the River/Harbor with little to no pretreatment. The proposed stormwater management system for the CNR bridge will consist of a “treatment train” approach that will remove 80% TSS prior to discharge to the River/Harbor. In the “treatment train,” runoff generated by the proposed approaches (as well as the new bridge) will be captured by proprietary vortex separator inlet units that will function as the first level of pretreatment prior to discharging to stormwater planter/filter areas. These pretreatment units will remove sediment/total suspended solids (TSS), floating trash/debris, oils, and hydrocarbons from the stormwater runoff without washing out previously captured pollutants. Treated flow from these BMPs will then be conveyed by new drain piping to stormwater planters/filters located on each side

¹³ The Limited Scoping Decision (March 7, 2019) states that review of this objective “is limited to the stormwater management associated with proposed water control structures and low-lying roadways.”

of the bridge that will function as a secondary level of pretreatment. Runoff discharged to these planters will be filtered by approximately 24 inches of soil media prior to percolating into the underlying soils.

- Treated stormwater beyond the infiltrative capacity of the underlying soils and weep holes will be captured by under-drain systems and conveyed to the Herring River and Wellfleet Harbor. It should be noted that the surface area of the planters, depths of filter media, and depths of ponding above the surface of the media were designed to fully contain runoff generated by contributing drainage areas during storm events up to, and including, the water quality storm event (without overtopping the walls of the planters).
- Existing low-lying roads to be elevated currently have no stormwater management measures in place. In proposed plans, vegetated swales have been added to sections of the roadway along the marsh wherever possible to provide for non-erosive conveyance and minimize runoff directly into the adjacent vegetated wetlands. Drainage improvements on Hopkins Drive at the intersection with High Toss Road will include the installation of 4 deep-sump catch basins connected via manifold to underground infiltration chambers; this system, combined with a pair of dry wells to be installed further up the hill, will capture and infiltrate existing runoff from Hopkins Drive before it reaches High Toss Road.
- Proposed elevation of low roadways would meet the definition of a Redevelopment Project as defined in the MassDEP Stormwater Handbook and regulated per SW Management Standard 7 in the WPA and 401 WQC permitting processes. Stormwater management plans for roadway elevation projects will attempt to meet each of the state stormwater management standards to the maximum extent practicable. As required by Wetland Protection Act regulations, a stormwater report will be submitted with the Notice of Intent to demonstrate that all reasonable efforts to meet the stormwater management standards have been made, including a complete evaluation of possible stormwater management measures to comply with all standards, adequately document standards that could be met only to the maximum extent practicable, and be designed at a minimum to improve existing conditions.
- Pretreatment of stormwater will be provided to the extent practicable along low-lying roads given the adjacency of wetlands and high groundwater.
- Strict adherence to all stormwater management standards would impose a hardship on the Project by significantly increasing costs and construction timelines, and would result in additional impacts to wetland resources.

4.B Wetland Resources (WT)

4.B.1 Existing Wetland Resources Conditions

4.B.1.1 Sediment Transport and Soils

The geomorphology surrounding the Herring River has been primarily determined by relatively recent glacial processes and associated sea-level fluctuations, which caused the deposition of marine sands, silts and clays. As sea level rise slowed about 4,000 years ago, salt marsh plants were able to colonize and accumulate peat, which provided the base for salt marshes to develop (Roman 1987). Material derived from decaying salt marsh plants, diurnal tidal exchange, and coastal storm surges eventually resulted in the accumulation of approximately 10 feet of peat in the Herring River estuary. When the Herring River was diked more than 100 years ago, these processes were interrupted and both the salt marsh and the underlying peat began to subside. The dike's blockage of tidal currents has also reduced the dimensions of the Herring River channel. The restricted tidal exchange at the Chequessett Neck Road dike has degraded the ecological functions of the Herring River estuary that are dependent on and linked to the river's proximity and connections to Cape Cod Bay and Wellfleet Harbor as sources of sediment.

There are two sediment-related issues relevant for this restoration project. First, restoring tidal exchange at the dike will mobilize sediment that has accumulated within the existing channels as a natural tidal channel system begins to be re-established. Second, because the tidal restriction has caused subsidence of the former marsh surface during the last 100 years, future changes in the tidal water surface elevations in the Herring River will need to be managed to assure a successful transition back to a healthy salt marsh community. The following bulleted section provides a brief summary of sediment transport and soils. A more detailed discussion on tidal channels, marsh surface elevations, and soils within the Project area can be found in Section 3.4 of the FEIS (HRRC 2016).

- **Tidal channels:** Because the volume of water flowing through the estuary was greatly reduced by the construction of the Chequessett Neck Road dike, the tidal creeks in the Herring River estuary that existed prior to the construction of the dike have completely or partially filled with sediment. Sediment transport analyses of the existing system found that current tidal flow velocities are sufficient to re-suspend sediment, but only near the dike.
- **Marsh surface elevations:** Coastal marsh elevations must increase at a pace equal to or greater than the rate of sea level rise to promote the growth of salt marsh grasses. In the Herring River estuary, the 1909 dike construction greatly reduced the upstream transport of inorganic marine sediment from reaching the salt marshes within the basin. Additionally, marsh drainage increased the rate of organic peat decomposition by aerating and drying the peat which has caused soil pore spaces to collapse and marsh elevations to subside. Much of the former salt marsh surface is approximately one to three feet lower than the mean high-water elevation of 4.8 feet in Wellfleet Harbor (Portnoy and Giblin 1997). Ultimately, to restore a healthy salt marsh in the Herring River, the process of marsh surface accretion needs to be restored in conjunction with restored tide levels.

- **Methane emissions:** The tidally restricted Herring River is contributing large volumes of methane (a greenhouse gas) into the atmosphere. Unlike healthy salt marshes, which produce little methane, microbial decomposition in freshwater wetland sediment releases copious methane. It is estimated that the Herring River is currently emitting 184 metric tons of methane each year (Walker 2015). Methane is estimated to be twenty times more potent as a greenhouse gas than carbon dioxide (FEIR, 3.4.4).

4.B.1.2 Wetland Habitats and Vegetation

Over the last century, reductions in tidal exchange caused by the Chequessett Neck Road dike have dramatically changed the vegetation of the Herring River floodplain, primarily resulting in the conversion of salt marsh to less salt-tolerant, upland woodland plant communities and freshwater emergent marsh and shrub wetlands. The former extensive tidal marsh is currently comprised of palustrine (freshwater) wetlands with a smaller amount of remnant salt marsh in the Lower Herring River sub-basin. Estuarine systems are those in which salinities during the period of average annual low flow exceed 0.5 ppt (Cowardin et al. 1979). Re-establishing estuarine wetlands to replace native and non-native and vegetation that has colonized the Herring River will help restore the estuary's functions as a nursery and feeding ground for marine and estuarine animals.

The Project has developed a suite of ecosystem models that could integrate with the Herring River hydrodynamic model (WHG 2012) and provide predictions of expected future state conditions for the adaptive management plan (see Section 5, Adaptive Management). As part of that effort, Woods Hole Group (WHG) was contracted to apply the Sea Level Affecting Marshes Model (SLAMM, Warren Pinnacle 2012) to the Herring River project area. SLAMM was designed and is typically used to estimate expected changes to regional coastal wetland types resulting from predicted long-term sea level rise (e.g., 50-100 years). Its use for the Herring River project is a unique application of SLAMM. For the Herring River, potential wetland changes, driven by increased tidal range caused by tide gate management, are simulated over a 5 to 25 year time frame for a relatively small spatial area. The process for adapting SLAMM and preparing input files for this purpose is described in detail in a final report prepared by WHG (WHG 2018).

To set-up SLAMM, an input file representing existing wetland cover types was required. For the Herring River SLAMM application, two wetland data sources were used: recent vegetation map data developed by CCNS and the National Wetland Inventory (NWI) wetland maps. These data were supplemented with additional analyses using LiDAR elevation data for ground elevation and canopy height, as well as tidal datums to differentiate between regularly- and irregularly-flooded marsh. The final resulting wetland input layer is shown in Figure 4-3 below. Existing wetland cover type categories are described below and summarized in Table 4-1 below. Figure 4-4 shows sub-basin locations.

Marine Sub-Tidal: The SLAMM input data identifies 33 acres of open water within the Lower Herring River subbasin which supports an extensive bed of submerged aquatic vegetation including widgeon grass (Portnoy, Phipps, and Samora 1987; Snow 1975).

Low and High Salt marsh: The previously extensive areas of salt marsh within the approximately 1,100-acre floodplain have nearly all developed into freshwater herbaceous and wooded habitats. Currently only 70 acres of salt marsh persist upstream of the dike, mostly within the Lower Herring River sub-basin. In New England, salt marshes support salt-tolerant vegetation such as smooth cordgrass (*Spartina alterniflora*), salt marsh hay (*Spartina patens*), glasswort (*Salicornia virginica*), spikegrass (*Distichlis spicata*), black grass (*Juncus gerardii*), marsh elder (*Iva frutescens*), and groundsel bush (*Baccharis halimifolia*) (Niering and Warren 1980; Tiner 1987). Much of the Herring River salt marsh area is dominated by invasive common reed (*Phragmites australis*). Of the 70 acres classified as salt marsh for SLAMM, approximately 59 acres are low marsh and 11 acres are high marsh.

Brackish marsh: Twelve acres of brackish marsh occur within the Project area, mostly within the Lower Herring River sub-basin. The remaining smaller areas lie within the Mill Creek, Bound Brook, and Pole Dike Creek sub-basins. In the Herring River, brackish marsh consists of dense stands of invasive common reed (*Phragmites australis*) with common three-square (*Schoenoplectus pungens*).

Freshwater Sub-Tidal: Thirty-six acres of freshwater aquatic habitat occurs upstream of High Toss. Although water column salinity is undetectable in these areas, bi-directional flow influenced by tidal forcing is apparent.

Fresh Emergent Marsh: There are 334 acres of freshwater marsh/meadow occurring within the Project area. Freshwater marsh habitats within the Project area are typically dominated by narrowleaf cattail (*Typha angustifolia*) with the following common associates: wool grass (*Scirpus cyperinus*), bluejoint (*Calamagrostis canadensis*), rushes (*Juncus* spp.), and American bur-reed (*Sparganium americana*). About 222 acres of fresh emergent marsh would be impacted in Phase 1 of the project.

Shrub-Scrub Freshwater Wetlands: There are 149 acres of shrubland habitat in the Project area. Common woody species within this cover type include highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), swamp azalea (*Rhododendron viscosum*), water-willow (*Decodon verticillatus*), buttonbush (*Cephalanthus occidentalis*), alder (*Alnus* spp.), and leatherleaf (*Chamaedaphne calyculata*). Common woody species within the dry shrubland habitat include northern bayberry (*Morella pensylvanica*), black oak saplings (*Quercus velutina*), and shadbush (*Amelanchier* spp.). About 102 acres of shrub-scrub wetlands would be impacted in Phase 1 of the project.

Non-Tidal Wooded Swamp: A total of 302 acres of woodland habitat currently occurs in the Project area. Woodland habitat within the Herring River floodplain represents a combination of several forested cover types dominated by black cherry (*Prunus serotina*), red maple (*Acer rubrum*), shadbush, northern arrowwood (*Viburnum recognitum*), sweet pepperbush, and swamp azalea. About 245 acres of non-tidal wooded swamp wetlands would be impacted in Phase 1 of the project.

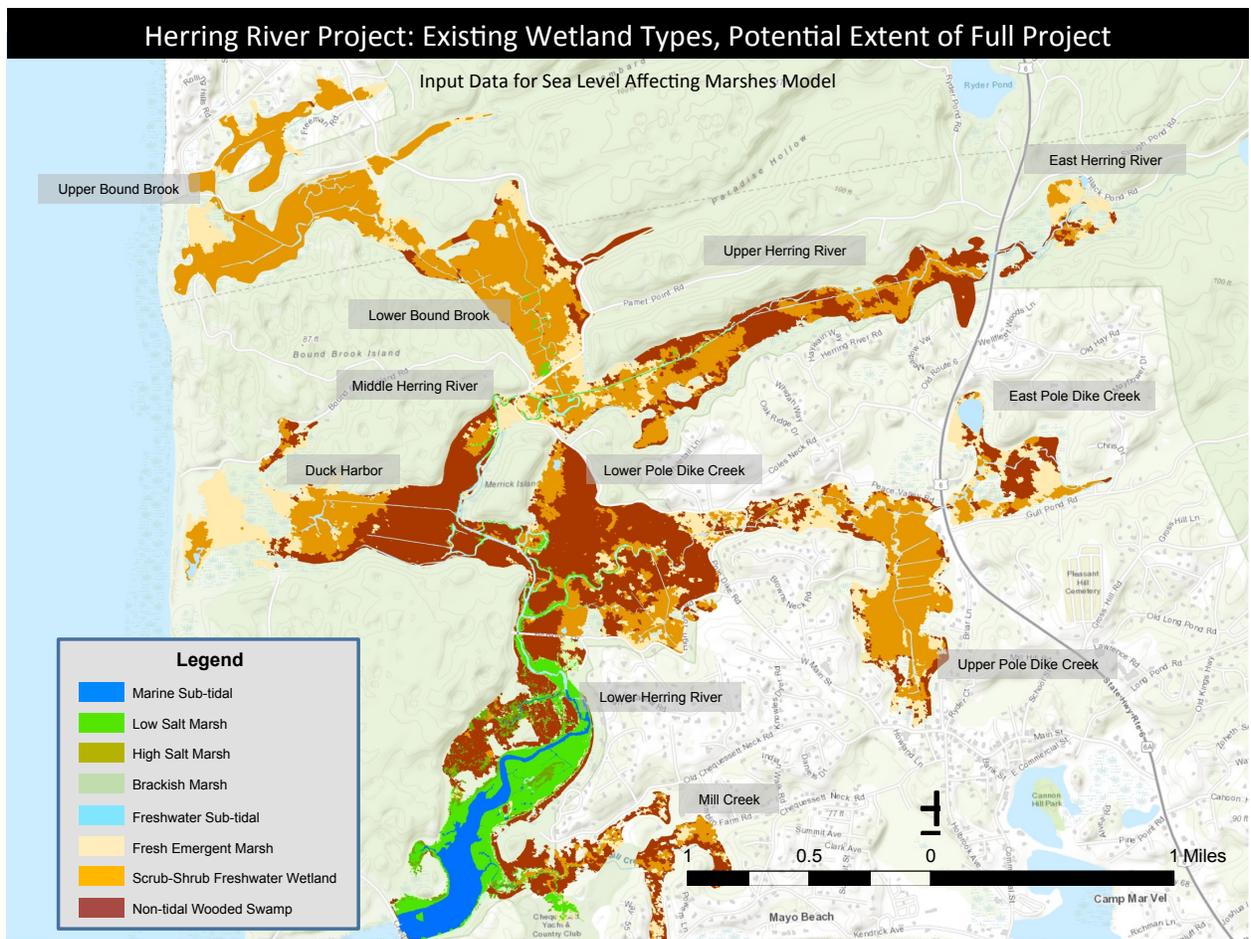


Figure 4-1. Existing Wetland Types, Potential Extent of Full Project

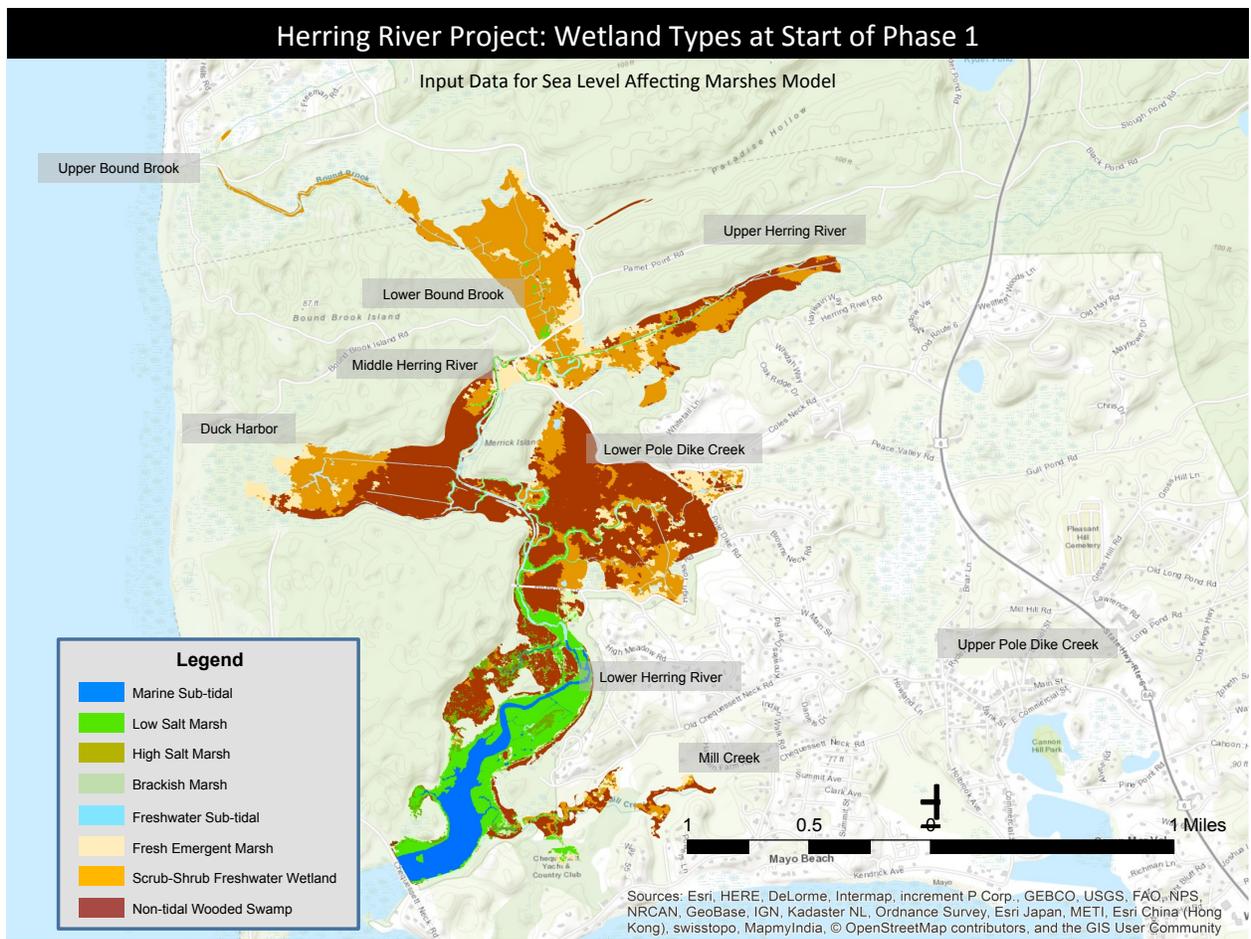


Figure 4-2. Wetland Types at Start of Phase 1

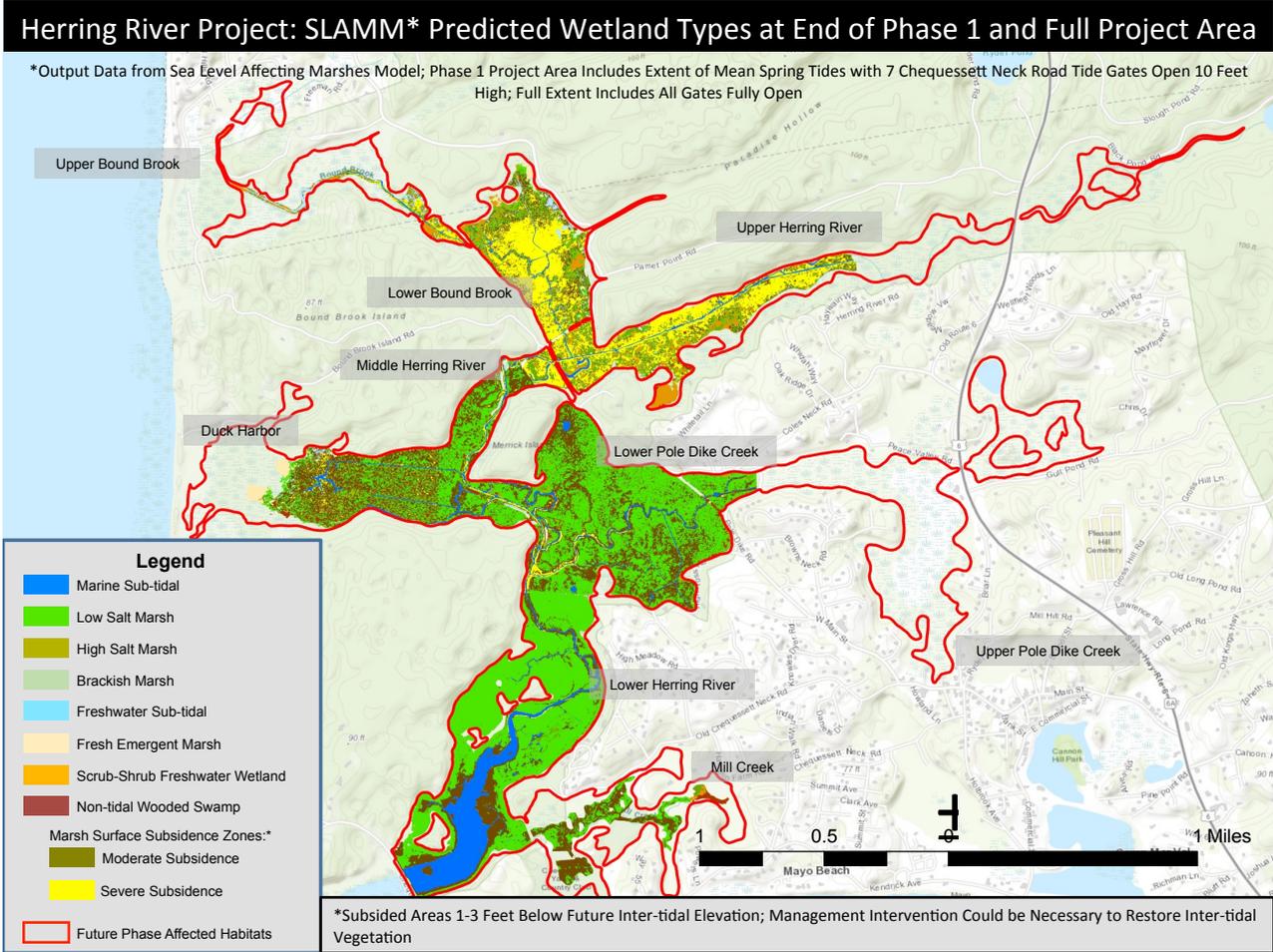


Figure 4-3. Wetland Types at End of Phase 1 and Full Project Area

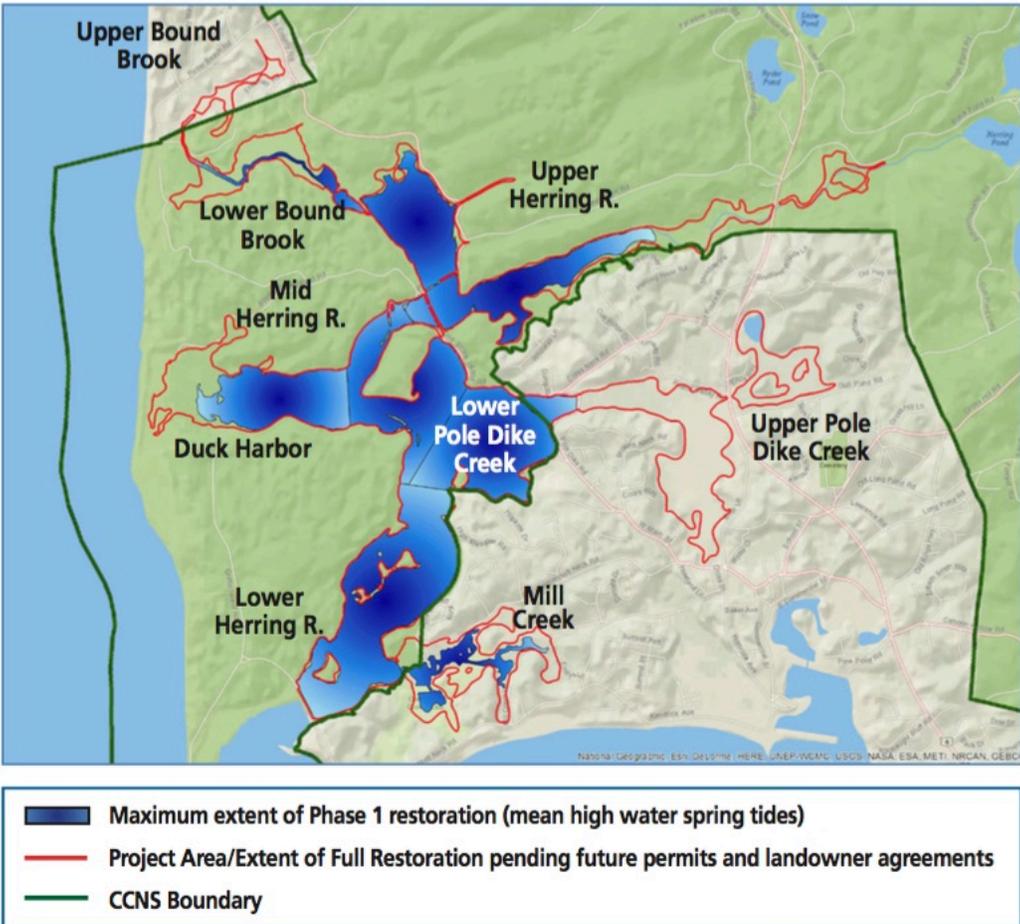


Figure 4-4. Extent of Herring River Restoration Project, Phase 1

Table 4-1. Existing and Proposed Wetland Habitat Types, Phase 1 Proposed Conditions (Acres)

	Marine Subtidal			Low Salt Marsh			High Salt Marsh			Brackish Marsh			Fresh Emergent Marsh			Scrub-Shrub Freshwater Wetland			Nontidal Wooded Swamp			Freshwater Subtidal			Subsided Areas Requiring Marsh Surface Management During Phase 1*	
	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Ext.		Ph.1	Moderate Subsidence	Severe Subsidence
	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End	Full Proj.	Start	End		
Lower Herring River	32.5	32.5	29.3	46.9	46.9	93.7	10.2	10.2	1.6	10.1	10.1	<0.1	1.8	1.8	<0.1	1.8	1.8	0.0	37.1	37.1	0.4	1.3	1.3	0.0	20.6	0.9
Mid Herring River	<0.1	<0.1	4.6	3.9	3.9	31.5	0.0	0.0	0.3	0.2	0.2	0.0	5.8	5.8	0.3	5.0	5.0	<0.1	45.1	45.1	3.5	6.4	6.4	<0.1	19.7	4.6
Upper Herring River	0.0	0.0	3.3	1.9	1.9	7.6	0.0	0.0	3.2	0.0	0.0	0.5	50.0	32.9	8.4	14.4	11.9	0.2	46.4	16.7	1.9	5.6	3.4	0.3	8.8	33.1
Mill Creek	0.0	0.0	0.0	2.4	1.8	8.5	0.4	0.2	0.4	1.2	0.6	0.0	9.7	4.6	0.4	6.4	2.4	0.0	25.1	7.7	0.8	0.0	0.0	0.0	11.3	0.0
Duck Harbor	0.0	0.0	1.8	0.0	0.0	15.8	0.0	0.0	<0.1	0.0	0.0	0.2	26.3	21.1	0.7	28.3	7.5	3.1	23.6	20.4	2.6	3.2	1.9	0.5	24.4	3.7
Lower Pole Dike Creek	0.0	0.0	3.4	2.4	2.4	84.7	0.0	0.0	0.6	<0.1	<0.1	<0.1	31.7	31.7	0.6	15.0	15.0	<0.1	82.3	82.3	2.4	3.8	3.8	<0.1	39.4	1.8
Upper Pole Dike Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.6	56.6	56.6	24.5	24.5	24.5	14.8	14.8	14.8	3.6	3.6	3.6	0.0	0.0
Lower Bound Brook	0.0	0.0	1.4	1.0	1.0	8.7	0.0	0.0	0.6	0.0	0.0	0.5	54.0	47.1	4.3	12.3	9.1	1.1	8.8	3.7	1.2	1.6	1.6	1.5	13.5	29.7
Upper Bound Brook	0.0	0.0	0.7	0.0	0.0	1.1	0.0	0.0	<0.1	0.0	0.0	0.2	86.7	8.9	2.9	18.4	1.4	0.3	1.3	0.2	<0.1	3.4	1.6	2.7	1.5	2.4
East Pole Dike	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	7.8	7.8	15.3	15.3	15.3	13.1	13.1	13.1	5.5	5.5	5.5	0.0	0.0
East Herring River	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7	7.7	7.7	7.7	4.1	4.1	4.1	2.0	2.0	2.0	0.0	0.0
Total	32.5	32.5	44.5	58.5	57.9	251.6	10.6	10.4	6.7	11.5	10.9	1.4	334.1	222.0	85.7	149.1	101.6	52.2	301.7	245.2	17.2	36.4	31.1	16.1	139.2	76.2

*Subsided areas 1-3 feet below future inter-tidal elevation; management intervention could be necessary to restore inter-tidal vegetation

Source: National Park Service

4.B.2 Post Restoration Wetland Resource Conditions

4.B.2.1 Sediment Transport and Soils

Restoration of sediment transport processes is a critical aspect of the Project because it will foster processes needed to rebuild subsided marsh plains and restore the dimension (width and depth) and pattern of tidal channels. In addition, the mobilization of suspended load fine materials will help to revitalize ecological processes and resources in Herring River and Wellfleet Harbor. Sediment deposition on the marsh plain and a concurrent increase in elevation to the subsided salt marsh surface is critical for the re-establishment and long-term sustainability of marsh habitat. In addition, restored sediment transport processes will concurrently result in the return of natural geomorphology of tidal channels within the Project area. This impact analysis is based primarily on findings from a quantitative sediment transport study of the Herring River system (see Appendix B in the FEIS). The bulleted section below summarizes general impacts to sediment transport and soil. Section 4.4 of the FEIS analyzes the potential impact of mobilized sediments to the former Herring River salt marsh and tidal channel system in additional detail, including changes to tidal channels, marsh surface elevation, organic and inorganic matter, upland sediment sources, and blue carbon.

- **Impacts on Sediment Transport:** In response to increased tidal flow, the fine sediments that have accumulated in the tidal channels upstream and downstream of the new water control structure will be mobilized as suspended load and suspended fines. This process is expected to be temporary and will diminish considerably once the hydrologic system reaches equilibrium with restored tidal conditions. Over a longer period, bank and bed erosion is expected to increase the dimensions of the restored tidal channels. Much of this sediment movement will take place as bedload and suspended load, and the duration of this process will largely depend on the rate at which tides are incrementally restored, as well as the size and configuration of the final Chequessett Neck Road tide gate opening. In addition, the increased size of the Chequessett Neck Road tide gate opening will alter the long-term sediment transport patterns in the marsh. Because the system is flood-dominated, the restoration of sediment transport processes will provide a source of marine sediment to the marsh surface and will be crucial to the establishment of a sustainable tidal marsh system.
- **Blue Carbon:** Changes to sediment transport and associated accretion of marsh surface elevations will also affect carbon cycling dynamics within the Herring River. Re-establishing tidal exchange will substantially increase the volume of carbon stored within the Herring River marshes. This process involves the storage of carbon from outside of the system (sequestration) and the uptake of carbon dioxide from the atmosphere through primary production within restored tidal habitats and burial in the salt marsh peat soils. It is estimated that at full restoration, several hundred metric tons of carbon would be buried beneath the floodplain each year, which is equivalent to the eliminating the emissions of several hundred cars. As noted above, the restoration will result in a substantial reduction of methane emissions, which is an even more potent greenhouse gas.

- **Impacts on Soils:** Anticipated physical and chemical changes in the soil will interact with the vegetation and wildlife that will grow on and in the soil to re-establish the complex marsh ecosystem. There will be physical changes such as when pore space redevelops as the dried soil responds to being saturated again by the tides. There will be chemical changes such as the increase in the soil pH as seawater returns to the area; this will be especially important for the highly acid Maybid Variant Silty Clay Loam soil type. There will also be changes in soil texture as the surface either loses or gains sand, silt, or clay depending on whether tidal sedimentation processes erode or deposit those materials. The organic content of the soil is likely to increase as fresh and/or salt marsh peats once again are created. While some of the characteristics used to classify the soil into named types may rapidly or slowly change, a number of characteristics will not change because they are based on the soil's parent material. Overall, there may not ultimately be enough difference to rename a soil, but the changes are of great importance to the restoration.

4.B.2.2 Wetland Habitats and Vegetation

Re-introduction of tidal flows to the Herring River floodplain will result in the widespread restoration of degraded coastal wetlands to estuarine sub-tidal and intertidal habitats. Based on hydrodynamic modeling (Appendix B in the FEIS), salinity within restored intertidal habitat will range from near full-strength seawater (approximately 30 ppt) in the lower portions closer to Wellfleet Harbor to freshwater (<5 ppt) in the upper reaches. Mid-range salinities (5 to 18 ppt) will occur predominantly in the middle portions of the floodplain. High salinity (generally 18 ppt and higher) will kill salt-intolerant plants that have become established on the former salt marsh floodplain and support the re-colonization of native salt marsh plants. In areas further upstream where low to mid-range salinities will be present, a mix of brackish and freshwater hydrophytes is expected to persist (FEIR, Section 4.5). The uppermost reaches of the floodplain will likely show little to no change in the existing plant community.

Increased tidal exchange resulting from the implementation of Phase 1 of the Project will have a profound effect on the Herring River ecosystem. The majority of the floodplain is comprised of former tidally-dependent salt marshes that are now dominated by invasive common reed (*Phragmites australis*), emergent freshwater plants, and upland tree and shrub species. Restoring tidal flow to the floodplain will largely displace these plant communities with the polyhaline inter-tidal habitats that naturally occurred prior to construction of the Chequessett Neck Road dike in 1909.

SLAMM Modeling of Habitat Changes: The primary purpose for setting up and running SLAMM for the Herring River project is to develop predictions of wetland habitat change under each of the seven tide gate management policies incorporated into the adaptive management plan at several time steps over project implementation time spans ranging from 5 to 25 years (see Section 5). The resulting model outputs can also inform a detailed analysis of expected habitat types at the end of the Phase 1 implementation period.

However, because SLAMM is a relatively simple model, several ecosystem processes that are critical for restoration of inter-tidal habitats within the Herring River project area cannot be directly simulated. For example, SLAMM does not provide the ability to predict future inter-tidal habitats influenced by an

estuarine salinity gradient. To overcome this for the Herring River application, direct output from SLAMM was filtered by output from the salinity module of the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model (WHG 2012) to create subclasses of potential future habitat types influenced by fresh, brackish, and marine salinity ranges (WHG 2018). The SLAMM outputs depicted in Figures 4-2 and 4-3 above reflect this filtering process.

The Herring River SLAMM application predicts future habitat types using future tidal range and salinity levels without changes to the present marsh surface elevations. Since areas of the Herring River floodplain have subsided by up to three feet due to tidal restrictions and marsh ditching, SLAMM outputs are biased toward lower elevation habitats. This includes prominent areas of sub-tidal and inter-tidal mudflat habitats.

The Herring River SLAMM application outputs are not precise projections of future wetland habitat types. While marsh accretion will certainly occur as the restoration project is implemented, the rate of accretion is not known and cannot feasibly be modeled due to the inherent uncertainties associated with multiple variables that will affect accretion rates in the Herring River system. Marsh surfaces will increase in elevation as salt marsh vegetation recolonizes the floodplain and below ground biological activity in the root zone contributes to marsh elevation. The tide gate management policy to maintain artificially low tide ranges for two or more growing seasons as plants become established (i.e., “policy 2G”, described in Section 11(D)(2)) is intended to hasten this process. In addition, the areas with the greatest degree of subsidence are expected to function as sediment “sinks”, receiving higher levels of natural sediment deposition as tide range is increased and thereby accreting at faster rates than other zones. Similar to the “2G” tide gate management policy, the “Sediment” tide gate policy (see Section 11(D)(2)) is also designed to favor increased sediment deposition and retention in subsided areas.

In summary, the specific habitat conditions predicted by SLAMM are not the precise desired or expected habitat outcomes for the project because they don’t account for marsh accretion during restoration. Nonetheless, the SLAMM outputs are useful for illustrating general habitat changes (i.e., from non-tidal to tidal marsh) and for targeting zones for enhanced monitoring and potential implementation of secondary management actions. The most subsided areas are expected to receive the greatest degree of sediment deposition as tidal flow is increased. If supported by hydrodynamic (i.e., tide range, hydroperiod) and sediment (i.e., total suspended sediment, soil bulk density, accretion and surface elevation) monitoring data, tide gate policies and secondary management actions (such as supplementation of the sediment budget) will be implemented to favor increased marsh elevations. The objectives for management of subsided area is to establish marsh elevations that support as much inter-tidal vegetated habitat as possible.

Summary of Habitat Changes: Existing wetland habitat types are shown in Figure 4-1 for the full project area and in Figure 4-2 for the Phase 1 project area. Potential future habitat types at the end of Phase 1 are shown in Figure 4-3. Figure 4-3 also depicts areas of moderate and severe subsidence which were projected by SLAMM to be tidal flat and sub-tidal habitats, respectively. In general, moderately subsided

areas are located in the Duck Harbor, Middle Herring River, and Lower Pole Dike Creek sub-basins. These areas, shown in brown on Figure 4-3, are approximately 1-2 feet below the expected inter-tidal zone where salt marsh vegetation can grow. Through natural accretion associated with restored tidal flow and potential management intervention, these areas are expected to eventually develop into inter-tidal salt marsh. Severely subsided areas, shown in yellow on Figure 4-3, located primarily in the Lower Bound Brook sub-basin, are 2-3 feet below future inter-tidal elevations and will take longer and likely a greater degree of management to recover sufficient elevation.

Coverage of existing and potential future habitat types projected by SLAMM are compared for each sub-basin in Table 4-1. In addition to the moderate and severely subsided areas shown on Figure 4-3, elevations are expected to generally increase on marsh surfaces and decrease in marsh channels throughout the floodplain. The SLAMM outputs are biased toward lower elevation estuarine wetland types and should be considered approximate, relative projections of future wetland habitats. SLAMM analyses and other methods of predicting future conditions will improve as the project is implemented and data from the actual response of the system are collected and assessed.

Restoration will lead to significant transitions in habitat types system-wide. These include a 12-acre increase in marine sub-tidal habitat and a 193.7-acre (330%) increase in low salt marsh. Virtually all other habitat types will decrease system-wide, including a 3.7-acre decrease in high salt marsh, a 9.5-acre decrease in brackish marsh, a 136.3-acre decrease in fresh emergent marsh, a 49.5-acre decrease in scrub shrub, and a 228 acre decrease in non-tidal wooded swamp. The relative degree of change in water level and salinity influences the particular habitat changes in each sub-basin.

- **Lower Herring River:** Closest to the tidal opening at Chequessett Neck Road, low salt marsh will increase 46.8 acres (100%) and marine sub-tidal habitat will increase 3.2 acres. A comparable amount of decreased acreage will occur in the categories of scrub-shrub freshwater (1.8 acres), non-tidal wooded swamp (36.7 acres), and freshwater sub-tidal swamp (1.3 acres). There is no change in fresh emergent marsh.
- **Mid Herring River:** The effects of increased salinity will also be apparent in Mid Herring River, with a 4.5-acre increase in marine sub-tidal where less than one-tenth of an acre currently exists; a 27.6 acres increase of low salt marsh; and a slight 0.3-acre increase in high salt marsh. Corresponding decreases in the following habitat types will occur: brackish marsh (0.2 acre), Fresh emergent marsh (5.5 acres), scrub-shrub freshwater (5 acres), freshwater sub-tidal (6.4 acres; and non-tidal wooded swamp (41.6 acres).
- **Upper Herring River:** In Upper Herring River, marine sub-tidal habitat will increase 3.3 acres and brackish marsh will increase .5 acres, where currently none of these habitat types exists. There also will be a 5.7-acre increase in low salt marsh and a 3.2-acre increase in high salt marsh. These habitat gains correspond to a 24.5-acre decrease in fresh emergent marsh; an 11.8-acre decrease in scrub-shrub freshwater wetland; a 14.8-acre decrease in non-tidal wooded swamp and 3-acre decrease in freshwater sub-tidal marsh.

- **Mill Creek:** Limited restoration in Mill Creek will result in less dramatic changes in habitat types. A 6.9-acre decrease in non-tidal wooded swamp and a 2.4-acre decrease in scrub-shrub freshwater wetland will be offset by a 6.7-acre gain in low salt marsh and a .2-acre gain in high salt marsh.
- **Duck Harbor:** In Duck Harbor marine sub-tidal (1.8-acres) and low salt marsh (15.8-acres) will appear where none previously existed. These gains offset decreases in fresh emergent marsh (20.4-acres), scrub-shrub freshwater wetland (4.4-acres) and non-tidal wooded swamp (17.8-acres).
- **Lower Pole Dike Creek:** Lower Pole Dike Creek will see a 3.4-acre increase in marine subtidal habitat and an 82.3-acre increase in low salt marsh where less than three acres currently exists. These gains offset decreases in less salt-tolerant habitat types, including losses of freshwater emergent marsh (31.1 acres), scrub-shrub marsh (15 acres) and non-tidal wooded swamp (79.9 acres)
- **Upper Pole Dike Creek:** Tidal restoration will be prevented from entering Upper Pole Dike Creek. As a result, habitat changes will be very limited in that sub-basin, and mainly attributable to improved drainage.

4.B.2.3 Wetland Impacts Associated with Tidal Control Elements and Mitigation

In addition to the restoration-driven changes in wetland vegetation described above, there will be permanent and temporary (construction-related) impacts to wetland resource areas associated with the tide control elements and mitigation measures. These impacts are necessary to achieve the benefits of restoring 570 acres of tidal wetland resources. The designs of tide control measures and elevated tide protection mitigation actions are based on a careful alternatives assessment to select measures capable of supporting restoration objectives while avoiding or minimizing impacts to wetland resources. Table 4-2 provides a summary of wetland resource alteration associated with tide control project elements, and Table 4-3 provides a summary of wetland resource alteration associated with elevated tide protection mitigation measures. Table 4-4 provides a summary of tide control and mitigation impacts. Supporting tables providing wetland resource alterations for each project element and mitigation measure are provided following the discussion of wetland resource objectives.

Table 4-2. Summary of Wetland Protection Act Resource Area Impacts for Tide Control Elements¹

Resource Area		Units	CNR Bridge		Mill Creek Water Control Structure		High Toss Road Causeway		Pole Dike Rd Water Control Structure		Total Impact	
			Impact		Impact		Impact		Impact		P	T
			P	T	P	T	P	T	P	T		
Coastal	Land Under Ocean	SF	15,066	6,274	491	8,958	N/A	N/A	N/A	N/A	15,557	15,232
	Salt Marsh	SF	12,909	4,393	4,274	23,115	N/A	N/A	N/A	N/A	17,183	27,508
	Coastal Beach (Tidal Flats)	SF	7,971	1,078	N/A	N/A	N/A	N/A	N/A	N/A	7,971	1,078
	Land Containing Shellfish ²	SF	36,713	11,060	N/C	N/C	N/A	N/A	N/A	N/A	36,713	11,060
	Land Subject to Coastal Storm Flowage ³	SF	88,128	103,089	60,586	59,730	N/C	N/C	N/C	N/C	148,714	162,819
Inland	Bordering Vegetated Wetlands	SF	948	2,419	16,614	7,862	N/A	5,250	15,348	14,183	32,910	29,714
	Land Under Water	SF	N/A	N/A	N/A	N/A	N/A	120	618	85	618	205
	Inland Bank	LF	N/A	N/A	N/A	N/A	N/A0	100	99	12	99	112
	Riverfront Area ⁴	SF	50,444	45,832	39,064	29,967	N/A	8,170	N/C	N/C	89,508	83,969

N/A = Not applicable

N/C = Not calculated at this time

¹Summary table does not include resource area impacts associated with habitat conversion project-wide. Impacts to Buffer Zones and Coastal Bank are not available at this time. Impacts to Fish Run will be included in Coastal Bank, Land Under Ocean, inland Bank and/or Land Under Water, as appropriate.

² Land Containing Shellfish refers to the total project site area within the boundaries of the mean higher high water (MHHW) levels upstream and downstream of the CNR dike.

³ Land Subject to Coastal Storm Flowage refers to the total project site area within the boundaries of the FEMA Flood Insurance Rate Map 100-year flood zone.

Note: Land Subject to Coastal Storm Flowage (LSCSF) and Riverfront Area overlap with each other and with other resource areas; therefore, any given square-foot of impacted area might be counted in more than one table row, i.e., impact to Bordering Vegetated Wetland (BVW) for the High Toss Road causeway removal is also impact to LSCSF and may be impact to Riverfront Area depending on the location.

⁴ Riverfront Area refers to the total project site area within 200-feet of the mean high water (MHW) line of perennial streams (for tidal rivers) or within 200-feet of the mean annual high water (MAHW) line of perennial streams (for inland rivers)

Table 4-3. Summary of Wetland Protection Act Resource Area Impacts for Mitigation Elements¹

Resource Area	Units	Drainage Associated with Mill Creek WCS	CYCC		High Toss Road Elevation		Low Lying Road Elevations		Way #672 Tide Barrier		Total Impact			
			Impact		Impact		Impact		Impact		Impact			
			P	T	P	T	P	T	P	T	P	T		
Coastal	Land Under Ocean	SF	N/A	575	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	575
	Salt Marsh	SF	N/A	2,530	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,530
	Coastal Beach (Tidal Flats)	SF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Land Containing Shellfish ²	SF	N/A	N/C	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/C
	Land Subject to Coastal Storm Flowage ³	SF	N/A	49,530	888,900	N/C	178,848	N/C	N/C	N/C	N/C	N/C	N/C	1,067,748
Inland	Bordering Vegetated Wetlands	N/A	N/A	37,140	12,000	N/C	11,000	18,930	98,685	33,370	9,050	1,110	130,735	90,550
	Land Under Water	N/A	N/A	9,285	600	N/C	0	160	618	3,043	485	N/A	1,703	12,488
	Inland Bank	N/A	N/A	N/A	400	N/C	20	20	99	227	77	N/A	596	247
	Riverfront Area ⁴	N/A	N/A	39,670	N/A	145,736	16,390	1,150	N/C	N/C	N/C	N/C	16,390	186,556

N/A = Not applicable

N/C = Not calculated at this time

¹Summary table does not include resource area impacts associated habitat conversion project-wide. Impacts to Buffer Zones and Coastal Bank are not available at this time. Impacts to Fish Run will be included in Coastal Bank, Land Under Ocean, Inland Bank and/or Land Under Water, as appropriate.

² Land Containing Shellfish refers to the total project site area within the boundaries of the mean higher high water (MHHW) levels upstream and downstream of the CNR dike.

³ Land Subject to Coastal Storm Flowage refers to the total project site area within the boundaries of the FEMA Flood Insurance Rate Map 100-year flood zone.

⁴ Riverfront Area refers to the total project site area within 200-feet of the mean high water (MHW) line of perennial streams (for tidal rivers) or within 200-feet of the mean annual high water (MAHW) line of perennial streams (for inland rivers).

⁵ Mitigation at CYCC will permanently impact 476,100 SF of Isolated Vegetated Wetland (IVW) regulated under the local WPA bylaw and at the state level through the Water Quality Certification program.

Table 4-4. Summary of Combined Wetland Resource Area Impacts Associated with Tide Control and Mitigation Elements¹

Resource Area		Units	Total Impact	
			P	T
Coastal	Land Under Ocean	SF	15,557	15,807
	Salt Marsh	SF	17,183	30,038
	Coastal Beach (Tidal Flats)	SF	7,971	1,078
	Land Containing Shellfish ²	SF	36,713	11,060
	Land Subject to Coastal Storm Flowage ³	SF	1,216,462	212,349
Inland	Bordering Vegetated Wetlands	N/A	163,645	120,664
	Land Under Water	N/A	4,261	10,135
	Bank	N/A	746	209
	Riverfront Area ⁴	N/A	105,898	270,525

N/A = Not applicable

N/C = Not calculated at this time

¹Summary table does not include resource area impacts associated with habitat conversion project-wide. Impacts to Buffer Zones and Coastal Bank are not available at this time. Impacts to Fish Run will be included in Coastal Bank, Land Under Ocean, Inland Bank and/or Land Under Water, as appropriate.

² Land Containing Shellfish refers to the total project site area within the boundaries of the mean higher high water (MHHW) levels upstream and downstream of the CNR dike.

³ Land Subject to Coastal Storm Flowage refers to the total project site area within the boundaries of the FEMA Flood Insurance Rate Map 100-year flood zone.

⁴ Riverfront Area refers to the total project site area within 200-feet of the mean high water (MHW) line of perennial streams (for tidal rivers) or within 200-feet of the mean annual high water (MAHW) line of perennial streams (for inland rivers).

4.B.3 Response to Wetland Resources Objectives

The Wetlands Resources goal of the RPP is to protect, preserve, or restore the natural values and functions of inland and coastal wetlands and their buffers. The Project meets this goal by restoring the health and functioning of coastal wetland resources in the Herring River floodplain. Restoration will be accomplished by returning tidal flow to the system incrementally and in accordance with an adaptive management program. The restoration of tidal flow and reconnection of the estuary to Cape Cod Bay will repair the substantial damage to natural wetland functions and ecology caused by the construction of artificial tide control structures throughout the floodplain (See section 3.A of this Application.) The existing structures were expressly designed to prevent tidal flow and undermine the natural functioning and health of coastal wetlands resources. Phase 1 of the restoration, which is the subject of this Application, would restore the health and natural functioning of 570 acres of degraded tidal wetlands, including elevation of more than 200 acres of severely subsided marsh plain. All water control measures and mitigation measures have been designed to avoid or minimize temporary and permanent impacts to inland and coastal wetland resources, which are necessary to achieve the expansive benefits of tidal wetlands restoration. It is noted that Phase 1 encompasses all tide control infrastructure necessary for

full tidal restoration of 890 acres of degraded tidal wetlands pending additional permits, permit amendments and agreements with property owners for any mitigation measures necessary to protect vulnerable structures from potential impacts under full restoration conditions.

Objective WT 1 – Protect wetlands and their buffers from vegetation and grade changes

Wetlands and their buffers must not be altered except in the limited circumstances set forth in the Commission’s Wetland Resources Technical Bulletin, and where the applicant can show that there is a public benefit, that there is no feasible alternative, and the impacts from the alteration have been mitigated. The limited circumstances outlined in the Commission’s bulletin include water dependent structures and uses “designed to achieve a public benefit such as water quality improvement.” For such projects, “[w]here alterations cannot be avoided, a public benefit should be demonstrated, development impacts should be minimized, and applicant (sic) must show there is not feasible alternative.”

The Restoration Project meets objective WT 1 as shown by the following information:

WT1 Response 1. The tide control structures and mitigation measures that are the subject of this permit application are water dependent structures and/or uses. Each of the tide control structures is necessary to implement the restoration of tidal flow incrementally while avoiding harm to resource areas and private and public structures. Similarly, the mitigation measures are needed to protect public and private structures from potential adverse impacts associated with the return of tidal flow. The role each tide control structure and mitigation measure plays in the restoration project is described in Section 3.B.

WT1 Response 2. Proposed water dependent structures and uses are necessary to achieve a substantial public benefit. The broad public benefits associated with the restoration facilitated by the tide control structures and protective mitigation measures includes: improved marine water quality; restoration of 570 acres of wetlands and associated aquatic and avian habitat; increased carbon storage and substantially reduced methane emissions; restoration of shellfish habitat, reconnection of estuarine wetlands and habitat with the marine environment; elevation of subsided marsh and elimination of acid sulfate soils; and increased waterways access and recreational opportunities.

WT1 Response 3. The design of water dependent structures is based on extensive analysis of alternatives (see Section 3.B). The design approaches selected reflect the designs deemed most effective at achieving restoration goals while avoiding or minimizing adverse impacts, including avoidance and minimization of alteration to wetland resource areas and buffers. Selected designs have been further modified to avoid or minimize alteration of wetland impacts to the maximum extent possible.

WT1 Response 4. Development activity proximate to wetlands that is necessary to accomplish the restoration of tidal wetlands will result in minor changes in vegetation, grade, or sun exposure or nutrient inputs to wetland or buffer areas, as described below. The development activity is necessary to achieve the broader public benefits associated with restoration of 570 acres of tidal wetlands: Each

project element has been design to achieve the benefits of restoration and avoid or minimize negative impacts to wetland resources to the maximum extent practicable.

- Sun exposure may be altered by the Mill Creek water control structure, where no structure currently exists; and at the new Chequessett Neck Road bridge, which will include a larger platform area. Sun exposure will not be altered for any wetland resource or buffer proximate to construction of High Toss Road, Pole Dike Creek water control structure, or low road elevation work.
- Grades adjacent to elevated roadways will be increased slightly, to 3:1. The increase in grade is necessary to accommodate the elevation and provide safe passage for autos, equestrians, bicycles and pedestrians, while minimizing the increase in road surface area and associated impact to wetland resource or buffer area (see Section 3.B).
- Areas adjacent to elevated roadways and tide control structures will be re-graded and re-vegetated with indigenous species, subject to Orders of Condition issued by the Conservation Commissions of the Towns of Wellfleet and Truro, respectively (see Section 3.B).
- The CNR bridge will incorporate enhanced stormwater management measures which capture and treat stormwater run-off and reduce nutrient inputs to wetland resource areas and buffers (see WR-4, finding 1, above)

Objective WT 2 – Protect wetlands from changes in hydrology

The Project will restore historic hydrology, which had been altered by the introduction of tidal obstructions. The Restoration Project meets this objective based on the following information:

WT2 Response 1. This Project does not propose water withdrawals greater than 20,000 gpd in proximity to wetlands. Therefore, the methods for demonstrating compliance with WT 2 for such projects do not apply.

WT2 Response 2. The Project will improve stormwater management over existing conditions. As described in WR-4, finding 1, the project meets the definition of redevelopment under the state stormwater regulations. The standard for stormwater management for redevelopment projects is improvement over existing conditions. As described in Section 3.B and WR-4, finding 1, the project will substantially improve stormwater management over existing conditions, resulting in greater infiltration and reduced potential for inputs in adjacent wetland resources and buffer areas.

WT2 Response 3. Restoration of tidal flow will restore wetland hydrology in a manner that serves a public purpose by restoring estuarine wetland habitat and improving water quality in a Commonwealth designated Outstanding Resource Water. The current tidally restricted environment of the Herring River is an artificial condition created by the installation of the Chequessett Neck Road dike. The Project is

seeking permits under the MA Wetlands Protection Act (WPA) regulations. These and other applicable regulations protect wetlands and the important public interests they serve, including clean water, protection from storm damage, and provision of fisheries, shellfish, and wildlife habitat. For example, the WPA Ecological Restoration Limited Project provisions explicitly allow approval of tidal restoration projects while also ensuring that the “built environment”, including structures and infrastructure, is not impacted by significant increases in water levels and storm damage. In the case of the Herring River, where the estuary and the public interests it supports have become so severely degraded over the past century, the WPA allows regulators to approve the return of tidal flow to revive the damaged river and its wetlands, so long as the proposed work complies with applicable WPA provisions.

Objective WT 3¹⁴ – Protect wetlands from stormwater discharges

The Restoration Project meets this objective based on the following information:

WT3 Response 1. The Project will improve stormwater management over existing conditions. As described in WR-4, finding 1, the Project meets the definition of redevelopment under the state stormwater best management practices. The standard for stormwater management for redevelopment projects is improvement over existing conditions. As described in Section 3.B and WR-4, finding 1, the Project will substantially improve stormwater management over existing conditions, resulting in greater infiltration and reduced potential for inputs in adjacent wetland resources and buffer areas.

WT3 Response 2. The CNR bridge design includes stormwater best management practices that will capture and treat runoff from the bridge and also from Griffin Island that currently flows directly into Salt Marsh and the Herring River. Drainage improvements at the intersection of High Toss Road and Hopkins Drive will also capture and treat existing runoff from beyond the Project footprint, much of which currently flows untreated into BVW. The elevation of low-lying roadways is designed to direct the majority of runoff to swales instead of allowing it to continue flowing directly into adjacent wetlands.

Objective WT 4 – Promote the restoration of degraded wetland resource areas

According to the Wetland Resources Technical Bulletin, the Regional Policy Plan “encourages the restoration of degraded natural habitats and natural communities...Measures to restore altered or degraded inland or coastal wetlands, including.... restoration of tidal flushing are encouraged.” Phase 1 of the Herring River Restoration Project is the largest coastal wetland restoration project on Cape Cod. The Restoration Project meets this objective based on the following information:

¹⁴ The Limited Scoping Decision (March 7, 2019) states that review of this objective “is limited to the stormwater management associated with proposed water control structures and low-lying roadways.”

WT4 Response 1. The Project will restore degraded wetlands and improve natural wetland functions, restore native vegetation, enhance natural coastal processes, function and sediment movement. By restoring native tidal wetland habitat to large portions of the Herring River estuary, the Project will:

- To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the natural tidal range, salinity distribution, and sedimentation patterns of the former 1,100-acre estuary;
- Improve estuarine water quality for resident estuarine and migratory animals including fish, shellfish, and waterbirds;
- Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Harbor;
- Restore the connection between the estuary and the larger marine environment to recover the estuary's functions as (1) a nursery for marine animals and (2) a source of organic matter for export to near-shore waters;
- Remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs;
- Re-establish the estuarine gradient of native salt, brackish, and freshwater marsh habitats in place of the invasive non-native and upland plants that have colonized most parts of the degraded floodplain;
- Restore normal sediment accumulation on the wetland surface and the accumulation of below ground organic material (peat) to counter subsidence of the former saltmarsh and to allow the Herring River marshes to accrete in the face of sea-level rise;
- Re-establish the natural control of nuisance mosquitoes by restoring tidal range and flushing, water quality, and predatory fish access;
- Restore the expansive marshes and tidal waters that were once a principal maritime focus of both Native Americans and European settlers of outer Cape Cod in a manner that preserves the area's important cultural resources;
- Minimize adverse impacts to cultural resources during project construction and adaptive management phases;
- Minimize adverse impacts to surrounding land uses, such as domestic residences, low-lying roads, wells, septic systems, commercial properties, and private property, including CYCC;
- Educate visitors and the general public by demonstrating the connection between productive estuaries and salt marshes and a natural tidal regime;
- Improve finfishing and shellfishing opportunities; and
- Enhance opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats.

WT4 Response 2. The Project will remove structures currently located in the flood hazard area. The structures to be removed include a portion of High Toss Road that crosses the floodplain. The removal of this segment of dirt roadway will eliminate an impediment to tidal flow. In addition, two residential structures currently located in the flood hazard area will be removed. These structures are within the boundary of CCNS in the Lower Herring River basin and would be inundated by restoring tidal flow to the main river basin. These properties are at very low elevations and would be affected early on in the restoration process. Unlike potentially affected structures elsewhere in the floodplain, there are no tide control structures that can minimize or prevent impacts. In light of the importance of these parcels for achieving the goals of the restoration, and the lack of options for protecting the structures, the CCNS negotiated with the private owners and acquired the two properties. The structures and onsite wastewater treatment systems on each property will be removed prior to tidal restoration.

WT4 Response 3. The Project will remove invasive species from wetland resource areas where it will improve the natural functions of the wetland. The roughly 1,100-acre Herring River floodplain currently contains approximately 45 acres of common reed. Restoration of tidal exchange will increase water column salinity in the Lower Herring River sub-basin to 20 ppt and higher. This rapid increase in salinity and the higher water levels are expected to quickly stress common reed and lead to die-off and eventual re-colonization of native salt marsh species. Consequently, in the Lower Herring River sub-basin, the restoration of tidal flow will be the primary means of common reed control. However, cutting and removal of material prior to the return of tidal flow will also be considered. (See Section 5., Adaptive Management, subsection on vegetation management for information on the proposed treatment and monitoring of common reed.)

4.C Wildlife and Plant Habitat (WPH)

4.C.1 Existing Conditions

4.C.1.1 Aquatic Species

In terms of the number and diversity of species, estuaries rank along with coral reefs and tropical rain forests as the most productive ecosystems on earth. They serve as a nursery for forage species and help support the food chain for a sustainable fishery. However, the loss of tidal flow and resulting changes in salinity have profoundly influenced the diversity of estuarine species in Herring River. In general, the area immediately downstream of the Chequessett Neck Road dike is characterized by estuarine species that are dependent on marine conditions. The abrupt change in salinity and tidal flushing in the Lower Herring River basin between the dike and High Toss Road results in a dramatic change in species richness and abundance, with species more tolerant of lower salinities becoming more dominant as one moves landward. Upstream of High Toss Road only freshwater-dependent or migratory anadromous/catadromous species are found (HRRC 2016).

Section 3.6 of the FEIS includes inventories and observations of aquatic fauna that currently exist within the Herring River estuary and the receiving waters of Wellfleet Harbor (HRRC 2016). Estuarine fish, macroinvertebrates, anadromous/catadromous fish, and shellfish are briefly summarized below.

- **Estuarine fish:** Compared to conditions prior to the construction of the Chequessett Neck Road dike, existing conditions in the Herring River estuary provide greatly reduced habitats for spawning, nursery, and feeding for many young and adult fish and shellfish species. Common estuarine fish that currently use the lower Herring River include Atlantic menhaden (*Brevoortia tyrannus*), four-spine stickleback (*Apeltis quadracus*) and mummichog (*Fundulus heteroclitus*) (Gwilliam 2005 unpublished data in Roman and James-Pirri 2011).
- **Shellfish and Other Macroinvertebrates:** Oysters (*Crassostrea virginica*), quahogs (*Mercenaria mercenaria*), and softshell clams (*Mya arenaria*) constitute the most common shellfish in Wellfleet Harbor and Herring River downstream of the dike, with oyster and quahog being the two most abundant and economically important species. No softshell clams were found in Herring River upstream of the Chequessett Neck Road dike in a 1984 survey. Other species, including blue mussels, razor clams, surf clams, and bay scallops are found downstream of the Chequessett Neck Road dike (Town of Wellfleet 1995). Due to degraded habitat conditions, harvesting of shellfish in Herring River is prohibited. DMF has designated the Chequessett Neck Road dike as a point source for bacterial contamination and closed shellfish beds downstream of the Chequessett Neck Road dike to harvesting due to high bacteria concentrations in the water. A study conducted by CCNS between 2013 and 2015 showed that the benthic community composition differed among three sections of the river, with the freshwater Upper Herring River having a completely different community composition than the saltier Lower Herring River and Downstream sections which were quite similar. Amphipods dominated the salty estuarine sections with significant co-occurrence of

gastropods, polychaetes, and bivalves. In the benthos of the fresh, upstream section, larval insects dominated with significant co-occurrence of isopods and bivalves (Fox et. al. 2017).

- **Anadromous/catadromous fish:** Six migratory fish including five anadromous species – alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), hickory shad (*Alosa mediocris*), white perch (*Morone americana*), and striped bass (*Morone saxatilis*), along with one catadromous species – American eel (*Anguilla rostrata*) – are found in the Herring River.

Historically, the Herring River was home to a robust river herring fishery. Town records report the annual river herring harvest to be 200,000-240,000 fish (the total run would have been much larger) (Wellfleet Town Reports, 1889, 1890). More recently, annual herring counters using Massachusetts DMF sample-census methodology have estimated the river herring run to be 17,035 (2009), 12,523 (2010), 12,523 (2011), and 8,044 (2017) (Association to Preserve Cape Cod). The headwater ponds of the Herring River provide approximately 157 acres of spawning habitat for river herring. However, the current two-foot by six-foot sluice gate opening at the Chequessett Neck Road dike is undersized, making it more difficult for fish to reach spawning areas. While other factors, such as offshore fishing and abundance of predators, have likely contributed to some of the decrease in river herring runs in Herring River and other areas throughout the northeast United States, construction of the dike has been a major factor in the decrease in river herring within the Herring River system (Curley et al. 1972).

4.C.1.2 Rare, Threatened, and Endangered Species

As part of the permitting process, the project proponents will complete consultations required under the Federal and Massachusetts Endangered Species Acts. The HRRP will require completion of a Biological Evaluation under Section 7 of the Endangered Species Act, which will be completed in consultation with the USFWS. Additionally, the HRRP will develop a Habitat Management Plan for state-listed species in coordination with the Massachusetts Natural Heritage and Endangered Species Program (NHESP).

To date, two federally threatened species have been identified as potentially utilizing portions of the Project area, including the rufa red knot (*Calidris canutus rufa*) and the northern long-eared bat (*Myotis septentrionalis*).

- **Rufa red knot:** The rufa red knot is a medium-sized shorebird which has been recorded as a spring migrant on Cape Cod, but is more commonly present as a mid-summer to early fall migrant (Harrington et al. 2010a; Harrington et al. 2010b).
- **Northern long-eared bat:** The northern long-eared bat is a widespread species found from Maine to North Carolina on the US Atlantic Coast. During the summer, northern long-eared bats roost in forested habitat underneath bark. During the evening, northern long-eared bats can be found foraging in a variety of forested and non-forested habitats. During winter, northern long-eared bats hibernate in caves and mines. The northern long-eared bat is one of the species of bats most impacted by the disease white-nose syndrome, which was the primary reason behind the species' listing in 2015.

Currently, six state-listed wildlife species occur within the Herring River Project area: three birds, American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), and northern harrier (*Circus cyaneus*); two reptiles, diamondback terrapin (*Malaclemys terrapin*) and eastern box turtle (*Terrapene c. carolina*); and one invertebrate, water-willow stem borer (*Papaipema sulphurata*).

- **American bittern:** The American bittern is a medium-sized bird that spends most of its time hidden among marshland vegetation. Despite the presence of potential nesting habitat and call-playback survey results that have previously indicated the presence of American bitterns (Erwin, Conway, and Hadden 2002), there is no documentation of nesting activity of this species within the Herring River Project area.
- **Least bittern:** The least bittern is the smallest member of the heron family. Suitable habitats include fresh and brackish water marshes (Gibbs et al. 2009). Although call-playback survey results indicate the presence of least bitterns (Erwin, Conway, and Hadden 2002), there is no documentation of nesting activity within the Herring River Project area. However, more recent sightings of the least bittern in the Herring River floodplain during the breeding season may indicate that the species could be nest in some years (Broker n.d.; unpublished data).
- **Northern harrier:** Northern harriers, a slim, long-legged accipiter, are uncommon summer residents or migrants in Massachusetts. Field surveys from 2004 to 2006 indicated a relatively small breeding population at CCNS and one to two nesting locations within the Bound Brook sub-basins (Bowen 2006).
- **Diamondback terrapin:** The diamondback terrapin, a marine turtle, uses brackish marsh habitats for foraging and sandy shoreline habitats for nesting. The brackish marshes along the periphery of Wellfleet Harbor support the northernmost population on the East Coast. Terrapin populations were decimated in the 19th century by overharvesting for food. They recovered by the mid-20th century, but now face renewed pressures from loss or degradation of nesting habitats to development, increased nest predation by raccoons and skunks, and increased adult mortality from road kills (Cook 2008a).
- **Eastern box turtle:** Although listed as a Species of Special Concern under the Massachusetts Endangered Species Act (MESA), eastern box turtles are relatively common terrestrial reptiles on Cape Cod that use dry and moist woodland and freshwater marsh habitats (R. Cook pers. comm. 2011, as reported in HRRRC 2016). Pine barrens and oak thickets present in areas adjacent to the Herring River estuary are optimal habitat types for this species.
- **Water-willow stem borer:** The water-willow stem borer is a globally rare, noctuid moth found only on the coastal plain of southeastern Massachusetts and Cape Cod. Water-willow stem borer larvae feed almost exclusively on water-willow (*Decodon verticillatus*), a freshwater wetland plant widely distributed throughout New England. Numerous stands of water-willow support the stem borer along the margins of the Herring River and its tributaries.

Section 3.7 of the FEIS describe the protected species and their current status within the Herring River estuary in greater detail (HRRC 2016).

4.C.1.3 Terrestrial Wildlife

Over 450 species of amphibians, reptiles, fish, birds, and mammals are known to inhabit the diverse array of upland, wetland, and coastal ecosystems found in CCNS and the Herring River floodplain. The Project area provides year-round habitat for many of these species, and for others provides seasonal nesting, migration, and/or over-wintering habitat. Information on the birds, mammals, and reptiles and amphibians present in the Project area are briefly described below. Section 3.8 of the FEIS provides a more detailed discussion on the occurrence of terrestrial wildlife, marine mammals and sea turtles, waterbirds, and other species that inhabit Seashore woodlands, heathlands, grasslands, swamps, marshes, and vernal pools (HRRC 2016).

- **Birds:** CCNS provides a wide diversity of freshwater, marine, and upland habitats for roughly 370 species of birds. About 80 of these bird species nest on CCNS during the spring and summer months, with the remainder using CCNS for migratory stopovers or to overwinter. Freshwater marsh birds, upland birds, and salt marsh birds are found in the Herring River estuary. The most commonly detected freshwater marsh birds during a 1999 and 2000 survey of the area were sora (*Porzana carolina*), pied-billed grebe (*Podilymbus podiceps*), and Virginia rail (*Rallus limicola*) (Erwin, Conway, and Hadden 2002).
- **Mammals:** Small mammals, such as mice, voles, and shrews are very abundant in marsh grasses around Herring River. Small mammals play a major role in trophic dynamics, consuming plant material and invertebrates, and in turn serving as prey for snakes, raptorial birds, and small to mid-sized carnivorous mammals. The most common group of mammals found in coastal marsh habitats in the New England region are rodents, which are an important prey species for raptors. Common mammals of coastal marshes include the meadow vole (*Microtus pennsylvanicus*), red fox (*Vulpes vulpes*), opossum (*Didelphis virginiana*), chipmunk (*Tamias* spp.), and muskrat (*Ondatra zibethicus*) (Smith 1997).
- **Reptiles and amphibians:** In addition to its importance to the five species of migratory marine turtles foraging the offshore waters of Cape Cod, there are 23 species of reptiles and amphibians living their entire life at CCNS within the Herring River project vicinity. Turtles present on CCNS include the diamondback terrapin, eastern box turtle, freshwater painted turtle (*Chrysemys picta*); snapping turtle (*Chelydra serpentina*); the less common musk turtle, (*Sternotherus odoratus*); and spotted turtle (*Clemmys guttata*) (Cook 2008b). Frogs, snakes, and salamanders, including green frog (*Rana clamitans melanota*), Fowler's toad (*Bufo woodhousii fowleri*), eastern spadefoot (*Scaphiopus holbrooki*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), and the four-toed salamander (*Hemidactylium scutatum*), use coastal marsh habitats similar to those found at the Herring River estuary.

4.C.2 Post Restoration Conditions

4.C.2.1 Aquatic Species

Potential impacts to aquatic species were evaluated based on available literature concerning life histories and habitat requirements. Additional information concerning past and present occurrence of estuarine fish and macroinvertebrates, anadromous and catadromous fish, shellfish in the Herring River estuary and Wellfleet Harbor also was obtained from CCNS, and Wellfleet town officials based on field work. The analysis also integrated the findings of the hydrodynamic modeling of the estuary, using the predicted mean high spring tide as the best approximation of the extent of tidal influence and the areal extent of estuarine habitat. Based on this analysis, under full restoration the proposed areal extent of estuarine habitat will increase approximately 12 to 13 times over the current extent. Additionally, the fully restored habitat will include approximately 11.5 miles of mainstem tidal creek for use by resident, as well as, migratory and anadromous species, providing access to 160 acres of pond habitat for spawning.

The design of the new Chequessett Neck Road bridge will dramatically improve passage for species such as river herring (alewives and blueback herring), hickory shad, white perch, American eels, and possibly sea run brook trout. Several species of shellfish that rely on saline conditions will be able to recolonize tidal creek habitat upstream of the new bridge and tide gate structure. The restoration of tidal exchange to the Herring River system will result in permanent increases (when compared to existing conditions) in spawning and nursery habitat for fish species and estuarine macroinvertebrates. Consequently, the HRRP is expected to lead to corresponding increases in abundance and will constitute a significant beneficial impact for those aquatic species. For shellfish and resident estuarine fish these beneficial impacts will be local and limited to the estuary. For diadromous fish, the benefits will be regional. In accordance with the Magnuson-Stevens Fisheries Conservation and Management Act, an Essential Fish Habitat Assessment has been completed and can be found in the FEIS (Appendix F). An impact analysis on aquatic species is briefly summarized in the bulleted section below and can be found in more detail in section 4.6 of the FEIS (HRRC 2016).

- **Estuarine fish and macroinvertebrates:** The restored estuarine waters and salt marsh will provide substantially more spawning and nursery habitats for both resident and transient fish species as well as for estuarine macroinvertebrates, thereby greatly increasing their abundance. The HRRP will also improve access to 160 acres of pond habitat for diadromous fish at full restoration. The new bridge and tide gates at Chequessett Neck Road will provide better fish passage (11.5 miles of tidal creek channels at full restoration) for all fish including anadromous and catadromous species. This, combined with improved water quality and access to the headwaters of the river, will likely enhance the size of the run of river herring and allow for the possible reintroduction of sea-run brook trout into the Herring River estuary.
- **Shellfish:** Re-introduction of tidal flow will vastly improve shellfish habitat. By greatly increasing the flow of clean saline water from Cape Cod Bay into the Herring River, the restoration is expected to reduce bacterial concentrations, which cause the current closure of the shellfishery, to levels that

are safe for shellfish harvesting. The reduction of bacteria concentrations will result from dilution with clean marine water, as well as significantly reducing the life span of bacteria in the more saline and better-oxygenated waters. Restored tidal range and salinity upstream of the CNR bridge and tide gates will also allow shellfish to spread into areas of the estuary where they are currently not found. Ultimately, the restoration is expected to improve water quality in Wellfleet Harbor by reducing bacterial concentrations, and likely will increase the area in the Harbor where shellfish could be harvested. The restoration of hundreds of acres of productive tidal marsh will also greatly increase the flow of nutrients which should benefit shellfish growth in Wellfleet Harbor.

There is currently no evidence that sedimentation of shellfish beds and grants will occur. Studies and modeling conducted by researchers from Boston University, University of Rhode Island and the Woods Hole Group have consistently demonstrated that the net direction of sediment movement following the restoration will be upstream into Herring River. Any fine silts that may travel on outgoing and incoming tides are expected to remain suspended during tidal exchange such that they would take weeks or months to settle and by then would either flow back into Herring River or be transported out of the system into Cape Cod Bay. The predominant upstream movement of sediments will contribute to deposition on, and restoration of the salt marsh, which will contribute nutrients and provide habitat for the wild shellfishery. Channel bathymetry and bottom elevations of areas near the Wellfleet Harbor aquaculture beds will be monitored for sediment deposition throughout the restoration. Adaptive Management measures will be implemented, if necessary, to avoid or minimize adverse impacts.

4.C.2.2 Rare, Threatened, and Endangered Species

The degraded conditions of the Herring River floodplain support several species listed as rare, threatened or endangered by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) or the USFWS that are dependent on freshwater and upland habitats and probably did not occur on a regular basis in the Herring River before construction of the Chequessett Neck Road dike in 1909. Federal and state-listed species were identified through informal consultation with the USFWS and NHESP and formally through comments submitted to MEPA by the NHESP in 2008. The Project is continuing to work in coordination with NHESP on the development of a Habitat Management Plan for the state-listed species, which will be integrated with the Adaptive Management Plan and described in subsequent permit applications. A draft Habitat Management Plan outline that has been developed in consultation with NHESP is provided in Attachment 8.H.

Based on consultations with USFWS and NHESP and the refined vegetation change analysis discussed previously in Section 4.B, projected habitat changes resulting from the proposed conditions are described on a species-by-species basis briefly in the bulleted section below. Additional detail is provided in sections 4.6 and 4.7 of the FEIS.

- **American bittern/least bittern:** Although both American and least bitterns primarily use freshwater marsh habitats, both species also use brackish marsh habitats. Overall, the Project will have minimal impact on the quantity and quality of bittern nesting habitat and will substantially increase salt

marsh habitat used by these birds for foraging, nesting, and other non-breeding behaviors. Nesting activity by American Bitterns (State endangered) and Least Bitterns (State Endangered) has not been detected recently; nonetheless nesting habitat is expected to slightly decrease in the lower parts of the floodplain and shift upriver as wet shrublands become wetter and develop into emergent marshes. In the Lower Herring River, Mill Creek, Middle Herring River, Lower Pole Dike Creek sub-basins, existing cat-tail and other freshwater emergent plant species will be replaced by salt marsh vegetation. In the upper sub-basins, existing freshwater marsh habitat should persist. Additionally, tidal freshwater and low salinity brackish marsh are anticipated to expand as the existing shrubland and woodland habitats become wetter and are replaced by herbaceous emergent vegetation.

- **Northern harrier:** Historically, several pairs of Northern harriers have been recorded as nesting within the Bound Brook sub-basin (Bowen 2006). Small habitat changes within Bound Brook sub-basin due to tidal restoration are not expected to hinder future nesting activity. Northern harrier nesting sites in the Upper Bound Brook sub-basin are anticipated to remain unchanged in Phase 1. Other plant community changes throughout the Herring River Project area likely will restore and enhance harrier foraging habitat as existing forest is replaced by herbaceous tidal fresh, brackish, and salt marsh wetlands.
- **Diamondback terrapin:** Full restoration will expand habitat by more than 750 acres for Diamondback Terrapins (State Threatened). Terrapins use the river and fringing marshes for foraging, breeding and nesting. In the short term, the small amount of salt marsh habitat occurring upstream of the Chequessett Neck Road dike, which has recently been used by nesting terrapins, (unpublished MA Audubon data) will likely be impacted as tidal range increases. In addition, terrapin passage upstream may be impeded while the bridge is being constructed and could be affected by construction noise, vibrations, and other activities. However, over the long term, tidal restoration is expected to restore hundreds of acres of nesting, nursery, wintering, and foraging habitat, allowing diamondback terrapins to almost fully reoccupy their historic distribution within the Herring River floodplain.
- **Eastern box turtle:** Increased salinities and higher water levels are expected to alter portions of the degraded floodplain that serves as habitat for Eastern Box Turtle (State Special Concern). However, these areas are adjacent to other suitable Eastern Box Turtle habitat, including 3,500 acres protected by CCNS. Restoration of tidal conditions throughout the Herring River floodplain are expected to affect eastern box turtles by restoring more saline and/or wetter conditions in areas that have dried out in response to diking of the river and drainage of salt marsh soils. Restored tidal influence may also limit the ability of box turtles to access freshwater for thermoregulation and hydration. During periods of high storm-driven tides, it is possible that groups of turtles that occur on Griffin, Bound Brook, and Merrick Islands may be restricted to those islands. However, during normal tidal conditions, eastern box turtles are expected to be able to move among the islands and the mainland along the upper boundaries of the floodplain where areas are expected to remain as freshwater and periodically dry. The Project team and NHESP are currently working closely to

monitor Box Turtle movements under existing conditions and are developing a Monitoring Plan to track movement of turtles during restoration.

- **Water-willow stem borer:** Assessment of impacts to water-willow (*Decodon*) serves as a proxy for direct impacts to the water-willow stem borer. *Decodon* has low tolerance to frequent inundation by salt water; therefore, any long-term exposure to salt water influence is likely to adversely affect its distribution. However, increased water levels and subsequent change from forested to palustrine shrub- and emergent-dominated habitats is expected to increase the occurrence of *Decodon* in the upstream areas where salinity of tidally influenced water is expected to remain low.
- **Rufa red knot:** There are no records confirming the presence of red knot in the Herring River Project area, but because they have been observed on Cape Cod, they are assumed to be present. In general, the habitat changes associated with restoration will benefit red knot.
- **Northern long-eared bat:** Habitat changes associated with restoration will reduce the acreage in the Project area that is suitable for northern long-eared bats feeding and roosting. However, the wooded habitat types that will be restored to other estuarine habitats will occur slowly, over many years, are currently degraded and are common in other parts of Cape Cod. If northern long-eared bats are present in the Project area, it is unlikely that loss of a limited number of acres of degraded woodlands will have a detectable effect on individuals or population of bats.

4.C.2.3 Terrestrial Wildlife

Even in its degraded state, the Herring River floodplain supports diverse habitats for a wide array of invertebrate, reptile, amphibian, bird, and mammal species. Tidal restoration will initiate changes to many of these habitats that could potentially affect certain wildlife populations. Mammals, reptiles, and amphibians are expected to gradually relocate to suitable habitat as the estuary undergoes the expected transition from a degraded freshwater wetland to a functioning estuarine wetland. Because of the gradual pace of environmental change and the animals' mobility, no significant adverse impacts on regional populations are anticipated. For birds, there will be a substantial change in the diversity of species using the estuary. Species dependent on estuarine wetlands will become more abundant, while species dependent on woodland, shrubland, or heathland will become less abundant. This estuary-wide, permanent change in species composition, in the context of restoring a now-rare and ecologically critical estuarine wetland ecosystem, is considered to be a significant beneficial impact.

Due to the lack of data regarding the local status of most wildlife species and their specific use of the Herring River floodplain, this impact analysis is necessarily based on a broad view of general wildlife habitat changes predicted to result from tidal restoration, including the previously discussed analyses on wetland habitats and vegetation and on hydrodynamic modeling of the estuary (WHG 2011). A brief discussion on impacts to birds, mammals, reptiles, and amphibians resulting from increased tidal range and varying salinity levels throughout the Project area can be found in the bulleted section below, and in additional detail in section 4.8 of the FEIS (HRRC 2016).

- **Birds:** Shifts in avian community structure following tidal restoration and increases in open-water habitat generally include an overall increase in avian abundance and an accompanying transition from a community dominated by generalists and passerines to one dominated by waterfowl, shorebirds, and wading birds (Seigel et al. 2005). Several high priority salt marsh- and tidal creek-dependent species such as salt marsh sparrows (*Ammodramus caudacutus*), willets (*Tringa semipalmata*), great egrets (*Ardea alba*), snowy egrets (*Egretta thula*), osprey (*Pandion haliaetus*), and common terns (*Sterna hirundo*) are expected to benefit directly through restoration of nesting and/or foraging opportunities in the Herring River. Tidal restoration will also restore wetland and open-water habitats for resident and migratory waterfowl such as black ducks (*Anas rubripes*), common mergansers (*Mergus merganser*), and bufflehead (*Bucephala albeola*), as well as for shorebirds such as willets, greater yellowlegs (*Tringa melanoleuca*), and lesser yellowlegs (*Tringa flavipes*).
- **Mammals:** Adequate habitat for foraging, cover and breeding sites would remain for most species following restoration. The gradual restoration of tidal flow would allow these animals to adjust or shift their local range within the River and floodplain, if needed shift to the abundant upland habitat adjacent to the project area. Small animals like mice and rabbits, and larger species such as deer and coyotes, will persist on marsh hummocks and edges, and are expected to use the marsh habitats during low tides. Salt meadow cord grass, for example, is a valuable forage plant for white-tailed deer and provides habitat for meadow voles, which then are an important food source for northern harriers and other raptors.

Initial restoration will result in gradual return of tidal flow to habitat and affect movements of meadow voles, white-footed mice and other small rodents, but eventually preferred habitats will be restored and expanded. In the short term, medium and large mammal species such as raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), muskrat (*Ondatra zibethicus*), river otter (*Lontra canadensis*), and white-tailed deer (*Odocoileus virginianus*) may be displaced from currently occupied habitat. However, increased tidal range and salinity, restored salt, brackish, and freshwater marsh habitats are anticipated to provide long-term benefits with improved water quality, more abundant and diverse prey species, and a more open, expansive habitat structure.

- **Reptiles and amphibians:** Snapping turtles (*Chelydra serpentina*), spotted turtles (*Clemmys guttate*), and northern water snake (*Nerodia sipedon*) inhabit the freshwater areas upstream of High Toss Road, but can survive in brackish water and salt marsh habitats. Amphibians are not present within high salinity portions of coastal environments. Increases in tidal range associated with restoration may, in the short term, limit and disrupt reptile and amphibian breeding, foraging, and nesting in the lower areas of the floodplain. However, these areas are less likely to be occupied initially and restoration is planned to proceed at a gradual pace, allowing any affected populations to relocate to suitable habitat. In the long term, reptile and amphibian populations are anticipated to shift and adjust their ranges, but no significant declines in species diversity or abundance is expected.

4.C.3 Response to Wildlife and Plant Habitat Objectives

The Wildlife and Plant Habitat goal of the Regional Policy Plan is to protect, preserve, or restore wildlife and plant habitat to maintain the region's natural diversity. The Project achieves this goal by significantly improving habitat for a wide variety of terrestrial, avian and aquatic wildlife. Restoration of up to 570 acres of inter-tidal marsh in Phase 1 will expand habitat for species that thrive in salt and brackish marsh environments. Salt marshes are among the most productive ecosystems on the planet and provide food, shelter, nesting sites, and migratory habitat for many species of birds, mammals, and reptiles. Restoring tides to the Herring River will enhance the quality and quantity of these resources and improve their resiliency in the face of increased threats by sea level rise and land-based pollution and encroachment.

The Project's Environmental Impact Statement/Report contains an inventory of wildlife and plant habitats, and includes projections of potential changes in habitat related to the restoration. The FEIS/FEIR is augmented by additional information contained in this application. As described below, the HRTT is working closely with Massachusetts Natural Heritage and Endangered Species Program (NHESP) and other experts to estimate changes to habitats of state-listed rare wildlife species, and to develop a Habitat Management Plan. Importantly, the Project has been designed to ensure that any changes in tidal flow occur slowly and incrementally so that aquatic, avian and land-based wildlife have the ability to relocate to appropriate nearby habitat. Expected changes to habitat are limited in the upstream portions of the Project area because salinity levels there will remain low and will experience no or a relatively small tidal range. Additionally, tidal flow will not be restored in the Upper Pole Dike Creek sub-basin during the Project's first phase.

The tide control structure and mitigation activities are within the Wellfleet Harbor Area of Critical Environmental Concern (ACEC). Therefore, the Project has been designed to avoid or minimize impacts to important resources. The restoration process will be guided by the Project's permit conditions and Adaptive Management Plan and has included rigorous monitoring of existing conditions (many of which are degraded) and the future conditions that will occur during the restoration process. The overall objective of the adaptive management process is to balance the outcomes of the many project objectives which then will guide management decisions.

Objective WPH 1 – Maintain existing plant and wildlife populations and species diversity

The restoration of tidal flow will alter wetland plant habitat as described in table 4-1 and figures 4-1, 4-2 and 4-3 (Section 4.B.3) in order to achieve the overarching goal of restoring 570 acres of native tidal wetland habitats and improving the resiliency of the Herring River floodplain. As set forth in the FEIS (Section 3.5), wetland habitats and vegetation cover within the Herring River floodplain have changed dramatically since European settlement and the construction of structures have restricted tidal exchange throughout the system, most notably the building of the Chequessett Neck Road dike in 1909. Historically, salt marsh once extended east of present day Route 6. Due to tidal restriction, this once-extensive tidal marsh (previously dominated by cord grasses), has been displaced by woody vegetation, invasive species and emergent freshwater plants, particularly in the upper portion of the floodplain.

The Project meets this objective based on the following information:

WPH1 Response 1. As noted in response to the Wetland Resources goals and objectives above, increased tidal exchange resulting from the implementation of Phase 1 of the Project will have a profound effect on the Herring River ecosystem. The majority of the floodplain is comprised of former tidally-dependent salt marshes that are now dominated by invasive common reed (*Phragmites australis*), emergent freshwater plants, and upland tree and shrub species. Restoring tidal flow to the floodplain will largely displace these plant communities with the polyhaline inter-tidal habitats that naturally occurred prior to construction of the Chequessett Neck Road dike in 1909.

WPH1 Response 2. Clearing of invasive common reed and extensive woody vegetation will be undertaken to achieve restoration objectives. As Phase 1 is implemented, salt water will cause decline and mortality of much of the herbaceous and woody freshwater dependent and upland vegetation that has colonized the floodplain. If left standing, dying and dead trees and larger shrubs could hamper the re-colonization of native salt marsh plant communities. In some areas currently dominated by herbaceous, freshwater-dependent emergent plant species, non-native, invasive common reed could expand, which would have a number of deleterious ecological and socioeconomic effects, including displacement of native vegetation and a reduction in habitat quality for fish and wildlife. The distribution of common reed will be closely monitored and integrated management actions will be undertaken to prevent colonization elsewhere in the project area.

WPH1 Response 3. Vegetation management will be conducted in accordance with a Vegetation Management Plan. The specific goal for managing vegetation as part of the Herring River Restoration Project is to support the long-term, sustainable re-colonization of native estuarine vegetation as tidal range, salinity and sediment transport processes are restored.

WPH1 Response 4. There are no known specimen trees in the Phase 1 restoration area. Much of the second-growth forest in the upper reaches of the Phase 1 restoration area as well as areas immediately adjacent will be unaffected.

WPH1 Response 5. Marsh management activities will be undertaken to augment tidal restoration and reverse other previous direct and indirect alterations of the system's topography, bathymetry, and drainage capacity. Marsh management will be undertaken in a three-step process to minimize disturbance: passive management that allows natural tidal flow to transport and deposit sediment on the salt marsh surface; tide gate manipulation to augment natural tidal flows; and active marsh management (See Sections 5.0 and 8.B). The primary issues to be addressed with marsh management include:

- Loss/subsidence of the former salt marsh surface elevation
- Sediment entrained in marsh channels, channel blockages
- Historic grid ditching, channelization, water logged soils

- Spoil piles adjacent to ditches and channelized reaches of the Herring River

WPH1 Response 5. The Project will re-grade and replant areas disturbed during construction with native vegetation as needed to enhance or restore wildlife habitat.

WPH1 Response 6. As described above and summarized below, the Project will enhance wildlife habitat and maintain or enhance opportunities for wildlife passage. The Project will not erect fencing or other barriers to wildlife passage, or result in fragmentation of wildlife and plant habitat.

Fish:

- Phase 1 of the Project will remove barriers for all fish including anadromous and catadromous species at Chequessett Neck Road dike and High Toss Road and, and at full restoration will result in the restoration of 11.5 miles of tidal creek channels. At full restoration there will be substantially more spawning and nursery habitat (enhanced access to 160 acres of coastal pond at full restoration) for both resident and transient fish species as well as for estuarine macroinvertebrates, greatly increasing their abundance.

Shorebirds and Migratory Birds:

- Tidal restoration and an increase in open water habitat is expected to lead to an overall shift in the composition of bird species from generalists that thrive in many habitats, to waterfowl, shorebird and wading bird species that rely on salt marshes. According to the Massachusetts Division of Fisheries and Wildlife, the American black duck, in particular, should benefit from salt marsh restoration at Herring River.
- The upper reaches of Herring River is currently freshwater marsh, in which habitat for birds that are dependent on emergent salt marsh has been severely degraded. Restoration will benefit nesting and foraging habitat for several high priority salt-marsh and tidal-creek dependent species such as willets, salt marsh sparrows, great and snowy Egrets, osprey and Common terns, as well as migratory waterfowl.
- Freshwater and brackish marsh used for nesting areas by northern harriers (State Threatened), American bitterns (state endangered) and least bitterns (State Endangered status) will slightly decrease in the lower parts of the floodplain and shift upriver as wet shrublands become wetter and develop into emergent marshes. Overall, the Project will have minimal impact on the quantity and quality of bittern nesting habitat, and will substantially increase salt marsh habitat used by these birds for foraging, nesting and other non-breeding behaviors.
- Restoration of high salt marsh (dominated by *Spartina patens*), which is declining throughout Wellfleet Harbor and other parts of Cape Cod, will provide critical nesting habitat for the saltmarsh sparrow, a declining species completely reliant on this habitat for breeding.
- If no action is taken, continued forest and shrub growth and expansion of non-native, invasive *Phragmites* will displace the more open, herbaceous habitats in the upper part of the system that are relied upon by harriers and bitterns for nesting.

Reptiles:

- The full restoration of Herring River will expand habitat by more than 750 acres for diamondback terrapins (State Threatened). Terrapins use the river and fringing marshes for foraging, breeding and nesting.
- Increased salinities and higher water levels are expected to alter portions of the degraded floodplain that serves as habitat for Eastern Box Turtle (State Special Concern). However, these areas are adjacent to other suitable Eastern Box Turtle habitat, including 3,500 acres protected by the Cape Cod National Seashore. The Project team and NHESP are working closely to develop a Habitat Management Plan and for state listed species that will include monitoring movements of Eastern Box Turtles.

Mammals:

- Adequate habitat for foraging, cover and den sites would remain for most species following restoration. The gradual restoration of tidal flow would allow these animals to adjust or shift their local range within the River, floodplain, and the abundant upland habitat adjacent to the project area. Small animals like mice and rabbits, and larger species such as deer and coyotes, will persist on marsh hummocks and edges, and will use the restored marsh during low tides. Salt meadow cord grass, for example, is a valuable forage plant for white-tailed deer and provides habitat for meadow voles, which in turn are an important food source for harriers and other raptors.

WPH1 Response 7. The Project will not alter large, contiguous un-fragmented areas, and there will be no new development proposed for Key Sites as defined in the State Wildlife Action Plan, and BioMap2 Core Habitat and Critical Natural Landscapes as defined by the Massachusetts Natural Heritage and Endangered Species Program.

Objective WPH 2 – Restore degraded habitats through use of native plant communities

The Project meets this objective based on the following information:

WPH2 Response 1. As has been described above, the Project will return tidal flow to the Herring River floodplain incrementally, and this will result in the restoration of 570 acres of native tidal marsh at the end of Phase 1. Concurrently, management actions will be implemented that will result in the elimination or removal of degraded habitat, including acid sulfate soils; degraded water quality; and invasive species of vegetation that has displaced salt marsh.

WPH2 Response 2. Transitions in wetland habitat types have been analyzed and demonstrated to result in beneficial wildlife and plant habitat changes as detailed in section 4.B.3, Table 4-1 and Figures 4-1 and 4-2, and 4-3, and in responses one through three to Wetland Resources (WT) objective 4 (WT4).

WPH2 Response 3. Restoration objectives and management actions will be guided by permitting conditions and facilitated by an adaptive management plan that includes monitoring, modeling, and evaluation of vegetation management and marsh management activities.

WPH2 Response 4. The Project will remove two residential structures currently located in the flood hazard area. These structures are within the boundary of CCNS in the Lower Herring River basin and would be inundated by restoring tidal flow to the main river basin. These properties are at very low elevations and would be affected early in the restoration process. Unlike potentially affected structures elsewhere in the floodplain, there are no tide control structures that can minimize or prevent these impacts. In light of the importance of these parcels for achieving the goals of the restoration, and the lack of options for protecting the structures, the CCNS negotiated with the private owners and acquired the two properties. The structures and onsite wastewater treatment systems on each property will be removed prior to tidal restoration. (See WT 4, Finding 2)

Objective WPH 3 – Protect and preserve rare species habitat, vernal pools, 350-foot buffers to vernal pools

The Project meets this objective based on the following information:

WPH3 Response 1. The Project will not result in a take under the Massachusetts Endangered Species Act (MESA). The Project’s MEPA Certificate notes that according to NHESP the Project qualifies for a MESA Habitat Management Exemption. Accordingly, HRTT is working collaboratively with NHESP on the development of a Habitat Management Plan for state-listed species, which will be submitted and reviewed by NHESP pursuant to 321 CMR 10.14(15). The Project also will complete reviews under Section 7 of the Federal Endangered Species Act, and Essential Fish Habitat Review under the Magnuson-Stevens Fishery Conservation and Management Act.

WPH3 Response 2. Increased salinity following restoration will eliminate some stands of water willow, which is the host plant for the water-willow stem borer, a State-threatened moth, endemic to southeastern Massachusetts. However, this habitat loss will be limited in upstream areas, where salinity levels will remain low, and because tidal flow will not be restored in the 174-acre Upper Pole Dike Creek during the Project’s first phase. In addition, stands where water willow is common are found along the edges of ponds and vernal pools near the project area, so large areas of habitat are available for the moth to colonize. The HRTT, National Seashore and NHESP are working closely to develop a Habitat Management Plan that will monitor changes in water willow habitat and implement collaboratively developed management measures that will ensure the long-term viability of the species within the area.

WPH3 Response 3. There are no know vernal pools or buffers to vernal pools in the Project area or adjacent to areas of mitigation activities.

Objective WPH 4 – Manage Invasive species

The Project meets this objective based on the following information:

WPH4 Response 1. The Project will remove invasive species from wetland resource areas where it will improve the natural functions of the wetland. The roughly 1,100-acre Herring River floodplain currently contains approximately 48 acres of common reed, most of which occurs in the Lower Herring River sub-basin. Restoration of tidal exchange will increase water column salinity in this sub-basin to 20 ppt and higher. This increase in salinity and the higher water levels are expected to quickly stress common reed and lead to die-off and eventual re-colonization of native salt marsh species. Consequently, in the Lower Herring River sub-basin, the restoration of tidal flow will be the primary means of common reed control. However, cutting and removal of material prior to the return of tidal flow will also be considered. (See Section 5., Adaptive Management, subsection on vegetation management for information on the proposed treatment and monitoring of common reed.)

WPH4 Response 2. The Project will re-establish the estuarine gradient of native salt, brackish, and freshwater marsh habitats in place of the invasive non-native and upland plants that have colonized most parts of the degraded flood plain upstream of the Project Site.

Pursuant to 310 CMR 10.12(1)(f), the Notice of Intent will include a plan for invasive species prevention and control. Invasive vegetation includes any plant species recognized by the Massachusetts Invasive Plant Advisory Group (MIPAG) as invasive, likely invasive, or potentially invasive in The Evaluation of Non-Native Plant Species for Invasiveness in Massachusetts (MIPAG, 2005).

Specific management measures that will be instituted during construction include:

- To minimize the potential for introduction of invasive species to the project area, contractor vehicles, equipment, and materials will be inspected and cleaned of any visible soil, vegetation, insects, and debris before bringing them to the project site. Cleaning methods will include, but not be limited to, brushing, scraping, and/or the use of compressed air to remove visible soils and vegetation.
- Contractors will be instructed to minimize ground disturbance and vegetation removal as much as possible, and to remain within designated access ways and work areas.
- All disturbed soils will be stabilized and seeded with a native seed mix immediately following completion of work in that area. All seed mixes shall be free of invasive, non-native plant species.
- Plant and seed materials will be of regional, southern New England genotype stock.
- Any invasive vegetation disturbed during construction will be stockpiled within the work area and removed from the site following completion of work in a given area to prevent spread of invasive species from one portion of the work area to another.

Management of invasive species following construction and throughout the restoration and adaptive management periods will be addressed in the Vegetation Management Plan and Adaptive Management Plan developed for the Project.

Objective WPH 5 – Promote best management practices to protect wildlife and plant habitat from the adverse impacts of development

The Project meets this objective based on the following information:

WPH5 Response 1. Road elevation sites will be restored to existing conditions following construction. Existing signage will be restored as necessary. Seeding and soil stabilization measures will be installed along roadways in accordance with planting plan, details and specifications. Project soil stabilization and plantings include use of salt tolerant seed mix along the roadways, as well as low marsh plantings (*Spartina alterniflora* plugs) and high marsh plantings (*Spartina patens* and *Distichlis spicata* plugs) at specific wetland elevations disturbed within the vicinity of the three box culverts openings. Staging areas will be restored to original conditions. Final pavement restoration will be conducted, and all remaining disturbed areas will be restored.

WPH5 Response 2. Bid documents will require contractors to employ erosion control and other best practices, avoid unnecessary disturbance of sensitive habitat, and adhere to all permit requirements and conditions to ensure the protection of wetland resources, habitat, and wildlife.

4.D Community Design (CD)

4.D.1 Existing Conditions

Currently, there are approximately 700 acres of woodlands and shrublands in the Herring River floodplain, while open water and salt and brackish marsh account for 88 acres primarily located in the Lower Herring River sub-basin. Freshwater marsh and meadows account for approximately 433 acres within the floodplain. The existing landscape character differs markedly between the upper and lower portions of the floodplain, with vegetation changing dramatically from north to south.

An abundance of highly visible dying trees in the Lower Pole Dike Creek and mid-Herring River sub-basins is a good example of how a salt marsh that becomes artificially isolated behind a dike results in vegetation changes that do not support a stable and productive ecosystem.

The dead trees are mostly black cherry, an upland species that cannot tolerate water-saturated soils. The species has invaded the floodplain between Bound Brook Island and Pole Dike Roads to the north, and High Toss Road to the south. The trees took root following diking and intense mosquito-control drainage activities that effectively de-watered the wetland. Around 1984, the Cape Cod Mosquito Control Project voluntarily stopped the drainage activities



Figure 4-5. Acres of dead trees visible from Pole Dike Road

There has been no further dredging of the river or its tributaries since then. Over time, shoaling and plant growth in the river and other waterways has slowed drainage and allowed the wetland to again become wet. The re-wetting of soils would in turn cause plants like black cherry, which require an unsaturated root zone, to die. A closer look may show that other upland plants are dying too.

Note that all the dead trees are at low floodplain elevations, while the same species at higher elevations along Pole Dike Road look fine. This supports the idea that the mortality is caused by root-zone flooding and not disease or insect infestation, although these latter two could be secondary stresses on already flood-stressed trees.

4.D.2 Post Restoration Conditions

Based on Project modeling of expected changes to vegetation and hydrology, and the observed effects of other coastal habitat restoration projects in the region and nationally, the Project is expected to result in long-term viewscape benefits. These benefits include the ability to observe broad expanses of open water (at high tide), salt marsh, and salt meadows. To reduce aesthetic effects during the temporary marsh transition period, the Project will remove woody vegetation on public lands (and with prior permission on private lands) before trees and shrubs are killed by salt water. This work will be done in stages corresponding the planned increments of tidal restoration.

The restoration of tidal flow resulting from the Project will likely improve the value of properties abutting the floodplain, while generating significant ecological, social, and economic benefits for the communities and region. Evidence supports enhancement —not devaluing—of property values. Other coastal locations in Wellfleet provide many examples of residential and commercial properties in close proximity to intertidal landforms, from mud flat, to open water, to intertidal salt marsh. None of these properties are adversely affected by their close proximity to intertidal areas. To the contrary, the value and rental income potential of properties abutting intertidal areas are typically higher than comparable properties that are not in close proximity to intertidal areas. Short-term aesthetic effects during the marsh transition period will be mitigated by the removal of woody vegetation which will hasten the growth of salt-tolerant vegetation and accelerate the appearance of marsh and river vistas.

4.D.3 Response to Community Design Objective

Objective CD3 – Avoid adverse visual impacts from infrastructure and scenic resources

The Project meets this objective based on the following information:

CD3 Response 1. The Project will result in an overall increase in scenic views of tidal marsh and open water available to the public from the Chequessett Neck Road Bridge, Old County Road, High Toss Road and Pole Dike Road. The Project also will result in the removal of hundreds of acres of currently dead woody vegetation, which is currently visible from these local roads. None of the proposed tidal control or mitigation activities will interfere with an existing viewscape.

CD3 Response 2. The Project will co-locate infrastructure with existing infrastructure and utilize previously developed impervious areas:

- The Chequessett Neck Road Bridge will be built on the site of the existing Chequessett Neck Road

dike. Any increase in footprint and impervious surface area is necessary to accommodate public access viewing, kayak portage and stormwater management.

- The Pole Dike Road water control structure will be built under the existing Pole Dike Road surface, with minimal increase in footprint.
- All roadway elevations provided for mitigation will retain the same road profile and curvature. (See T1, findings)

CD3 Response 3. The Project will relocate electrical and telephone utilities underground and under the bridge deck of the Chequessett Neck Road Bridge. The utilities currently are strung on polls that cross the Chequessett Neck Road dike.

CD3 Response 4. Aesthetics were taken in to consideration in the design of all project elements with the objective of minimizing visual intrusion and blending into the rural environment. The CNR bridge/tide control structure is designed to incorporate the necessary components for tide control, safe pedestrian/vehicular access, public viewing while reflecting the rural character of Chequessett Neck Road. The width and curvature of roadways was retained to the extent practicable.

4.E Coastal Resiliency (CR)

4.E.1 Existing Conditions

Measurements indicate that, relative to sea level, much of the diked Herring River floodplain is up to 3 feet below its pre-dike elevation, and likewise below the current elevation of salt marsh seaward of the dike. Coastal marshes must increase in elevation at a pace equal to, or greater than, the rate of sea-level rise in order to persist. Man-made artificial tidal restriction has blocked the important process of sedimentation on the salt marsh. Additionally, marsh drainage has increased the rate of organic peat decomposition by aerating the sediment and caused sediment pore spaces to collapse. All of these processes have contributed to severe historic and continuing subsidence in the Herring River diked wetlands.

The subsidence and degradation of the salt marsh resulting from decreased tidal flow has created large, low-lying areas vulnerable to sea level rise and associated storm surge. FEMA has designated the estuary as a “Special Flood Hazard Area.” The Cape Cod Commission has created a mapping tool to assess risk and vulnerability, as well as visualizations that show potential impacts of hurricanes and sea level rise. Building on that information, and in view of concerns over severe winter storms and coastal flooding in 2018, the towns of Wellfleet and Truro and the Cape Cod Commission held a Municipal Vulnerability Preparedness stakeholder workshop in March 2019. The workshop considered major environmental and infrastructure threats to the region due to sea level rise, severe weather and associated storm surge. Workshop participants, including local officials, community stakeholders and regional resiliency planners, found that “Addressing climate change impacts is an urgent matter for these neighboring Outer Cape communities . . . the towns are vulnerable to storm surges, coastal erosion, and sea level rise that threatens the built environment, drinking water aquifer, biodiversity and natural resources.” The workshop designated restoration of salt marsh and replacement of culverts as the top recommendation to improve community resilience.

4.E.2 Post Restoration Conditions

The replacement of degraded, outdated infrastructure, including the existing Chequessett Neck Road dike and tide gates, as well as undersized culverts, will improve ecosystem and community resiliency to climate change and rising sea levels. Since the dike was constructed in 1909, the upstream salt marsh has subsided significantly and sea level has increased resulting in an effective increase in water height upstream of the existing dike. A primary objective of the project is to restore natural sedimentation processes upstream, allowing the marsh to once again accrete and keep up with rising sea level. The restored marsh will act as a natural buffer to storms and wave action. It will also displace the existing methane-emitting freshwater wetlands and serve as a carbon sink that reduces greenhouse gases currently contributing to climate change. Tidal restoration will also allow floodwaters from coastal storms to recede more quickly. The following project outcomes are directly related to resilience:

- Restoration of 570 acres salt marsh and tidal wetlands during Phase 1 will enhance natural storm attenuation and flood storage.
- Measurable increases in the elevation of the now-subsided marsh plain through natural accretion of sediments and possibly thin layer deposition.
- Replacement of undersized culverts at Chequessett Neck Road, Pole Dike Road, and other low-lying roads.
- Pole Dike Creek tide gates will be closed to allow drainage only, and will improve drainage following storm events.
- Chequessett Neck Road and Mill Creek tide gates will also allow for quicker drainage of sub-basins following heavy precipitation and storm events.
- Improved storm water management will be built into the Chequessett Neck Road bridge and road improvements, to improve storm drainage and avoid negative impacts to wetlands and water quality.

The Project will also result in the removal of three structures from the floodplain. Two single-family residences on Way 672 have been acquired by CCNS. The structures, including sub-surface septic systems, will be removed from the properties. In addition, the portion of High Toss Road constructed across the marsh plain will be removed to restore tidal flow.

Below is a description of the hydrodynamic modeling parameters used to design project elements and mitigation, and of the Project's relationship to FEMA 100-year floodplain and to sea level rise.

4.E.2.1 Hydrodynamic Modeling Parameters

Hydrodynamic modeling undertaken by Woods Hole Group is the core analysis used to predict water level changes and potential for structural impacts due to restoration of tidal flows. This modeling provides the basis for the predicted tidal water level datums in Table 3-2 and described throughout the document. This section summarizes the parameters used in the modeling, and its relationship to FEMA floodplain maps and predictions of sea level rise.

Hydrodynamic modeling for the Project considers the following model variables:

- **Normal tidal conditions:** Cases that utilize normal tidal conditions represent average tides occurring within the Herring River system based on normal forcing tides occurring in Wellfleet Harbor. Data utilized to develop the normal tidal conditions were collected in 2007 and 2010. These conditions correspond to the same normal tidal conditions utilized in modeling efforts (Woods Hole Group, 2012). The normal tidal conditions included assessment of tidal benchmarks based on the National Tidal Datum Epoch of 1983 through 2001 using tidal constituents only. Therefore, these simulations represent an average condition that would occur under normal circumstances. These cases do not represent every specific tidal variation that could occur.
- **Storm surge conditions:** Two distinct storm surge conditions were used to specify the peak water surface elevation corresponding to coastal storm surge events in Wellfleet Harbor. The events

correspond to the 10-year return period storm surge (8.3 feet) and the storm of record for the region (9.3 feet, Blizzard of 1978)(USACE). These storm events were specified in Wellfleet Harbor and represent a reasonable expected range of storm surges that may affect the Herring River system. More specific details on the development of these boundary conditions are presented in detail in Woods Hole Group (2012).

- **Precipitation conditions:** In addition to the storm surge scenarios, return period precipitation-based events were developed. Rainfall conditions were based on the extreme precipitation tables developed by Cornell University (<http://precip.eas.cornell.edu/>) for a 10-year (moderate) and 100-year (extreme) return period precipitation over a 24-hour period. Average values for the 24-hour total precipitation amount for the area were estimated from these data and values of 5 inches and 8 inches were used for the 10-year and 100-year return period precipitation amounts, respectively. Precipitation is added to the model in two modes: (1) direct input over the model surface, which accounts for rain that falls directly in the model area, and (2) discharge of freshwater from the greater watershed of each sub-basin. These discharge conditions are different for Mill Creek and Upper Pole Dike Creek based on the watershed of each sub-basin.
- **Combination precipitation and storm surge conditions:** Combined coastal storm surge and precipitation conditions were also modeled. Combinations included: a) the storm of record return period surge with a 10-year return period precipitation event and b) a 10-year return period surge with a 100-year return period precipitation event. These combinations were selected based on ongoing studies evaluating the joint probability between precipitation amounts and storm surge levels (Douglas, 2015). These studies have evaluated daily and accumulated 2-day and 3-day precipitation amounts in correlation with observed surge water levels in Boston Harbor. The highest rainfalls are generally associated with water levels within the interquartile range of the distribution (between 75th percentile and 25th percentile), which means that the largest precipitation events don't occur in concert with the largest storm surge events. Outliers and extreme outliers (storm surge events) in water levels are associated with rainfall of approximately 50 to 100 mm (or approximately 2 to 4 in, which is approximately a 2 to 10-year precipitation return period). These data support the co-occurrence of a storm of record surge with a 10-yr precipitation event as a conservative analysis. Additionally, these combination conditions have never occurred in Boston or Provincetown over approximately the last 100 years. This illustrates the extreme (and highly conservative) nature of the conditions being considered.

4.E.2.2 Relationship to FEMA 100-Year Flood Plain

The Project does not affect the FEMA Flood Insurance Rate Maps (FIRMs) 100-year Base Flood Elevation (i.e., "A zone"). The latest FEMA Flood Insurance Study (FIS) and FIRMs for Wellfleet approved by the Town in 2014 indicate that changes to tidal hydrology resulting from the Project will have no effect on FEMA's regulatory 100-year floodplain and will not alter FEMA flood insurance requirements. The reasons for this are (1) FEMA does not recognize the existing Chequessett Neck Road dike as a flood control structure and (2) their most recent FIS predicts the 100-year coastal storm surge entering the Herring River by over-topping the dike, breaching barrier dunes at Ryder Beach and Duck Harbor (Secret Beach), and overwashing a low segment of Chequessett Neck Road near Powers Landing. Therefore, the

FEMA-predicted flood levels in the Herring River basin are governed by water flowing over low points around the edge of the floodplain (i.e. Chequessett Neck Road dike, Ryder Beach, Duck Harbor, and Powers Landing), not the amount of water flowing through the Chequessett Neck Road dike. The current Chequessett Neck Road dike is not a FEMA-designated flood control structure and the redesigned structure will likewise not be a FEMA-designated flood control structure. For these reasons, the Project will have no effect on the FEMA-predicted 100-year flood elevations or the extent of the 100-year FIRM floodplain within the Herring River basin. Since it is not practical to construct flood protection that could be certified by FEMA at Ryder Beach, Duck Harbor, and Powers Landing, it is similarly not practicable or cost-effective to construct the new Chequessett Neck Road bridge and tide gates for FEMA certification. Therefore the new Chequessett Neck Road bridge will be rebuilt to a similar crest height as the existing dike.

4.E.2.3 Relationship to Sea Level Rise

With respect to Sea Level Rise, The Woods Hole Group hydrodynamic model also applied guidance provided by the U.S. Army Corps of Engineers (USACE; 2009, 2011) to account for the effects of various rates of sea level rise over the next 50 years specifically for the Wellfleet Harbor area. The upstream sub-basins (e.g., Pole Dike Creek, Bound Brook, Duck Harbor, Upper Herring River) that are currently non-tidal remain relatively unaffected by the sea level rise increase. Although over the long-term it may be theorized that the mean water surface elevation would increase uniformly throughout the system, the broad, flat marsh plains of the Herring River system create hypsometry that does not produce uniform water level increases in the system. This analysis, combined with the extreme coastal storm modeling described previously, indicates that the freeboard incorporated into the Project's infrastructure designs will prevent surface water impacts to structures and infrastructure for at least the next 50 years under the most severe sea level rise scenario analyzed. Additionally, the Chequessett Neck Road bridge and tide gates has been designed as a water control structures that can be managed as necessary in response to future sea level rise to keep maximum water levels below elevations that could impact structures. For example, through gate management the Project has the ability to manage (lower) future mean high water and maximum water levels in the Lower Herring River and other sub-basins.

The longer-term effects of sea level rise beyond 50 years, are more uncertain and difficult, if not impossible, to analyze with precision. As sea level changes, managers and stakeholders for the Herring River will need to revise the tide gate operations, management plans, and potential mitigation measures. Dikes, tide gates, and other project elements will require maintenance and possibly replacement or modification. At that time, planners will need to assess the condition of the estuary, the tidal conditions in Wellfleet Harbor and Cape Cod Bay, and other related factors and plan for a course of action that continues to support the ecological health and function of the Herring River while also protecting vulnerable private property and public infrastructure.

It is important to note that potential increases in sea level to the extent suggested by the MA CZM report and others would have effects that greatly alter the entire Cape Cod groundwater and surface water system independent of the physical status of dikes, bridges, and water control structures in the Herring River. These effects are outside the influence and scope of the restoration project and include a

higher groundwater table, increased surficial freshwater discharge into the river, and the potential for overwash of storm surges at several points including the Chequessett Neck Road dike, Duck Harbor, Bound Brook and Powers Landing.

4.E.3 Response to Coastal Resiliency Objectives

The Community Resiliency goal of the RPP is to prevent or minimize human suffering and loss of life and property or environmental damage resulting from storms, flooding, erosion, and relative sea level rise. The Project meets this goal by restoring the vitality of coastal resources and the beneficial functions they provide for protection from storm surge and sea level rise; by designing water dependent structures to be resilient to storm surge and relative sea level rise; and by avoiding non-water dependent development in the floodplain.

Objective CR2 - Plan for sea level rise, erosion and floods

The Project meets this objective based on the following information:

CR2 Response 1. The Project restores natural coastal resources to function and provide the natural beneficial functions of resilience and storm surge protection. A primary objective of the Project is to restore natural sedimentation processes upstream, allowing the marsh to accrete and maintain elevation with rising sea level. The restored salt marsh will, in turn, enhance coastal resilience as a natural buffer to storms and wave action to reduce erosion. Tidal restoration will also allow floodwaters from coastal storms to recede more quickly. This will help to protect roadways, wells, and other infrastructure.

CR2 Response 2. All Project tide control elements and mitigation measures have been designed to accommodate sea level rise. As described above, hydrodynamic modeling studies form the basis of design requirements for the overall restoration program, including the need for infrastructure modifications and additions to protect existing infrastructure and structures from increased water levels. The freeboard incorporated into the Project's infrastructure designs will prevent surface water impacts to structures and infrastructure for at least the next 50 years under the most severe sea level rise scenario analyzed. All measures intended to protect structures from the potential effects of tidal restoration are designed to protect the subject structures under full tidal restoration conditions. Additional infrastructure protection will occur with undergrounding of utilities in designated areas.

CR2 Response 3. The Project contributes to the reduction of greenhouse gas emissions that contribute to climate change. Blue carbon refers to the carbon naturally stored in coastal wetlands and seagrass beds that would otherwise contribute to atmospheric carbon dioxide loading and global climate change. Historically, the Herring River salt marshes absorbed large volumes of carbon in peat soils, which accumulated year after year as sea level slowly increased. However, decades of artificial tidal restriction have led to massive release of carbon by altering sediment deposition and tidal circulation patterns.

Blockage of tidal flow, and accompanying carbon-laden sediment, has allowed carbon to remain suspended in the water column where portions of it are released to the atmosphere as carbon dioxide. In addition, conversion of hundreds of acres of salt marsh to freshwater marsh has likely increased methane emissions, adding further to greenhouse gas emissions associated with the degraded Herring River floodplain. Over a forty-year period, the restoration of the entire Herring River floodplain could result in greenhouse gas emissions reductions of 300,00 metric tons of CO² equivalent. For Phase 1 restoration, the greenhouse gas emissions reduction benefit is 150,000 metric tons of CO² equivalent.¹⁵

Objective CR3 - Reduce vulnerability of built environment to coastal hazards

The Project meets this objective based on the following information:

CR3 Response 1. As described above, the Project will enhance coastal resiliency by restoring normal sediment deposition needed to allow the marsh plain to gain elevation and mitigate impacts of sea level rise, and by constructing state-of-the-art tidal control infrastructure to protect low-lying roads and other public and private structures. The resilient design of tide control structures is described in Section 3.B.2 of this application.

CR3 Response 2. The Project does not site non-water dependent development in a coastal resource area. Two existing non-water dependent residential dwellings in the floodplain within the CCNS boundary have been acquired by the NPS. The structures and associated sub-surface septic systems located on Way 672 (aka Rainbow Lane or Snake Creek Road) will be removed prior to restoration. In addition, a segment of High Toss Road (referred to herein as High Toss Road causeway) where it crosses the Herring River marsh plain will be excavated and removed. The existing causeway and blocks tidal flow and its removal will restore tidal flow between Lower Herring River (currently downstream of the causeway) and Mid-Herring River and Lower Pole Dike Creek (currently upstream of the causeway).

CR3 Response 3. Project mitigation measures include elevation of segments of low-lying roads within the Herring River floodplain that may be susceptible to inundation after tidal exchange is restored. In combination these segments constitute approximately two miles of roadway. These are public roads that cross the river and various tributary streams and link upland areas that surround the estuary. They range from infrequently traveled fire roads to moderately busy paved roads. The major low-lying roads identified as affected by the Project are portions of High Toss Road, Old County Road, Bound Brook Island Road, Pole Dike Road, Old Chequessett Neck Road, Duck Harbor Road, and Ryder Hollow Road. All of the roads are low volume roads. With respect to the road segment elevations, the Commission's FEIR comment letter notes that "the proposed alterations are necessary and appropriate." Low-lying road designs are described in Section 3.B.3 of this application, and plans are provided in Section 8.H.

In addition, as described in section 3.B.3, mitigation measures to protect against water intrusion will be installed at CYCC and on three other private properties. These measures have been designed with the

¹⁵ Herring River Carbon Project Feasibility Study. TerraCarbon. Version 1.4. August 2019

support and consent of property owners, and have been designed using the modeling parameters above and will be designed to protect against impacts under full tidal restoration conditions. These measures are described in section 3.B.3 of this application. Plans for proposed work on CYCC property are provided in section 8.H of this application.

4.F Transportation (TR)

4.F.1 Existing Conditions

Chequessett Neck Road and Pole Dike Road, where new tide control elements are proposed, are existing paved town roads. High Toss Road is an unpaved sand berm used primarily as a fire road, and it also provides access to a small number of private properties on adjacent unpaved ways, and recreational access to Griffin Island.

In addition, several segments of low-lying roads occur within the Herring River floodplain and may be susceptible to inundation after tidal exchange is restored. In combination these segments constitute approximately two miles of roadway. These are public roads that cross the river and various tributary streams and link upland areas that surround the estuary. They range from infrequently traveled fire roads to moderately busy paved roads. The major low-lying roads identified as affected by the Project are portions of High Toss Road, Old County Road, Bound Brook Island Road, Pole Dike Road, Old Chequessett Neck Road, Duck Harbor Road, and Ryder Beach Road.

4.F.2 Post Restoration Conditions

Construction of the Project's primary tide control element involves the removal of approximately 165 feet of the existing earthen dike and tide control elements currently installed under Chequessett Neck Road, and constructing a new bridge equipped with tide gates. Additional tide control elements and mitigation actions will require the elevation of existing low-lying roadways. The construction of tide control elements and mitigation will be managed to ensure public safety and minimize disruption of automobile, bicycle and pedestrian traffic during all phases of construction, as described below.

4.F.2.1 Chequessett Neck Road Bridge

The Chequessett Neck Road Bridge Replacement Project will be constructed in the following five stages¹⁶:

- **Stage 1A:** This stage will include the preparation necessary for installation of the temporary bypass/traffic diversion roadway. Erosion controls will be installed along with temporary steel sheeting required to construct the approach embankments for the temporary bypass bridge and water control cofferdams. Stone channel bottom scour protection will also be installed on the eastern side of the temporary sheeting at the bridge opening/exit area. This stage of construction is expected to last 4-6 weeks.
- **Stage 1B:** This stage will consist of the installation of the temporary bypass/traffic diversion bridge and the completion of its approach embankments (within the limits of temporary sheeting). Overhead electrical utilities will be temporarily diverted during this stage along the temporary

¹⁶ Sheet CS-120 – Construction Sequence & Water Control Plan of the Project Plans

bypass route. At the end of this stage of construction, traffic flow will be diverted from Chequessett Neck Road onto the bypass bridge. This stage of construction is expected to last 4-6 weeks.

- **Stage 2:** This stage will consist primarily of the installation of temporary steel sheeting along the harbor side of the dike; the construction of the proposed southern bridge pier, abutment, and wingwalls; the installation of stone channel bottom scour protection within the bridge's southern span as well as the bridge's western entrance/exit approach area; the installation of stone armor embankment protection along both sides of the bridge's southern approach; and the installation of the concrete stairway on the eastern side of the roadway embankment. Additionally, temporary tide gates will be installed on the harbor side of the southern bridge span to control flow for Stage 3. This stage of construction is expected to last 8-10 weeks.
- **Stage 3:** This stage will consist primarily of the construction of the proposed northern bridge pier, abutment, and wingwalls; the installation of stone channel bottom scour protection within the bridge's northern and center spans; the installation and stone armor embankment protection along both sides of the bridge's northern approach; the removal of temporary sheeting on the western side of the embankment; and the installation of the access stairway on the western side of the roadway embankment and the upper portion of the access stairway on the eastern side of the roadway embankment. This stage of construction is expected to last 10-12 weeks.
- **Stage 4:** This stage will consist primarily of the installation of the bridge's superstructure, approach slabs, and recreational/viewing platforms; the removal of any remaining temporary cofferdams that were installed for diverting tidal flows; the construction of the new roadway (including roadway base course), its associated improvements, and guardrail system; the installation of new electric and telecommunication utilities; the installation of tide gates/panels; and the installation of the project's new stormwater management system including pre-treatment catch basins and stormwater planters. This stage of construction is expected to last 14-16 weeks.
- **Stage 5:** This stage will consist primarily of the removal of temporary utilities along the temporary bypass route; the redirection of traffic onto the new bridge and the removal of temporary signal; the installation of the lower portion of the access stairway on the eastern side of the roadway embankment and portion of the boardwalk within the limits of sheeting; the removal of the temporary bridge structure; and the restoration of the Project Site. This stage of construction is expected to last 6-8 weeks.

Construction staging: The Chequessett Neck Road Bridge project's primary staging area on property owned by the NPS will be located within the Project's limits of disturbance on the northern side of the Herring River. The majority of this area consists of upland wooded area. The preferred staging area is also within the vicinity of eastern box turtle habitat mapped by NHESP, as well as areas of potential cultural resource and archaeological sensitivity (Herbster and Heitert 2011). A Phase 1B Cultural Resources Assessment was conducted in spring of 2015 with the goal of identifying the most appropriate construction staging and laydown areas during the construction of the new bridge. Project

staging will work around any archaeologically or ecologically sensitive areas and avoid impacts to these resources.

Other off-site staging areas to the north of the Project site are deemed provisional and subject to revision or exclusion pending initiation and completion of discussions with the Town of Wellfleet and/or NPS (as to the extent, type, and seasonality of potential staging/storage activities associated with the Project). In addition to the specific locations shown within the Project plans, additional off-site staging areas may be utilized, subject to discussion and agreement with respective property owners, the Town of Wellfleet, and the NPS. These include a public parking area at the end of Duck Harbor Road, a former borrow pit on Pole Dike Road (currently owned by the Town of Wellfleet), and a parking area on Griffin Island Road (also owned by the Town of Wellfleet).

Barges will be mobilized to the site for additional staging of materials (e.g., steel sheeting, pipe piles) and to provide operating platforms for crane equipment at various stages of construction. It is expected that the majority of barges, if not all barges, will be located on the harbor-side of the embankment; however, one or more barges may be deployed on the river-side of the embankment, subject to the engineer's review and acceptance of the contractor's proposed access plan submittal prior to construction. Any barges mobilized to the site will be required to be cleaned immediately prior to transport, be equipped with spuds to secure the barge from waves, currents, and tidal fluctuations, and be provided with a site-specific fueling protocol, spill control and countermeasure plan and appropriate spill containment/cleanup materials.

Pedestrian/Canoe/kayak access: The Chequessett Neck Road Bridge project will enhance the ease and safety of public pedestrian and canoe/kayak access to the river. Design features to improve pedestrian access include:

- ADA-compliant viewing platforms on both sides of the bridge structure along with multiple stairways that will provide recreational users (i.e. canoers and kayakers) with access to the Harbor and River at varying tide levels.
- 10-foot wide level bench areas on both sides of the embankment that can serve as viewing/fishing areas at the full tidal range.
- A new permeable gravel parking lot (adjacent to the intersection of Chequessett Neck Road and Duck Harbor Road) with a permeable gravel pathway and boardwalk that will provide full accessibility for recreational users on the riverside of the bridge.
- A wider roadway embankment crest that will accommodate (2) 11'-0" travel lanes that will tie into existing lane widths at the limits of construction (refer to Sheet CS-121 of the Project Plans); an 8'-0" wide parking lane and adjacent 5'-0" wide sidewalk that will be constructed on the western side of the bridge structure; a 5'-0" wide sidewalk will be constructed on the eastern side of the bridge structure; and multiple cross walks to provide safe pedestrian access to both sides of the bridge.

Public water access facilities are incorporated as part of the overall project, providing safe portage of hand carried recreational watercraft between Wellfleet Harbor and Herring River. Provisions for a parking area on the inland side, north of the bridge (along Duck Harbor Road) with access to the Herring River is included as part of the CNR bridge construction. Adding public water access facilities at the proposed CNR bridge site is intended to improve safety of recreational watercraft users. The following considerations were taken into account during the development of the proposed portage route alternatives to account for safe access and maneuverability while portaging:

- Avoiding sharp turns;
- Avoiding egress near parked cars;
- Providing a path that is a minimum of five feet width that is easily traversed by a single person utilizing a wheeled cart to help maneuver his/her craft;
- Minimizing longitudinal slopes to 8.33% or less (as steeper slopes exceeding 15% will make transition from land to water difficult);
- Providing an accessible launch between 9-inches and 2-feet from the highest expected tidal water level; and
- Providing handrails or other support structures including step-down designs or ropes.

Portage routes between Wellfleet Harbor and Herring River were narrowed down to two primary locations: (1) from the harbor side of the roadway embankment to the river side via the installation of ramp and/or step structures (adjacent to the north end of the proposed bridge); and (2) from the planned unpaved parking area near the temporary staging area to a new landing/launch structure on the upstream side of the embankment. It was noted that recreational access to Wellfleet Harbor (on the harbor side of the dike) is currently provided at the gravel access area that exists to the west of the Chequessett Neck Road and Duck Harbor Road intersection. In addition, the new CNR bridge includes a new canoe/kayak portage and access area on the Griffin Island side of the new structure.

Traffic control during construction: Traffic and pedestrian flow across the CNR dike will be provided throughout the construction period. Two major alternatives were evaluated to bypass traffic on CNR during the period of construction: (1) the construction of a temporary bridge crossing over Herring River (parallel to the existing dike) and (2) the closure of Chequessett Neck Road bridge and the diversion of traffic to Duck Harbor and High Toss Roads following substantial improvements to accommodate diverted traffic.

Temporary bridge crossing over the Herring River: Installing a temporary bridge adjacent to CNR which would cross the Herring River and connect traffic on both sides of the existing dike would result in less of a temporary impact to on-site wetland areas as compared to the non-preferred alternative. The other major advantage to this approach is that traffic is moved to the side, outside of the proposed structure's footprint, allowing the contractor greater flexibility during construction. This would result in a shorter duration of construction as compared to a phased construction approach that utilized one lane (per

phase) of the existing dike to pass traffic throughout the construction period. A shorter duration of construction would result in less of a temporary impact to on-site wetland resource areas.

In order to minimize the Project's limit of disturbance to on-site wetland resource areas as a result of this method of traffic management, the temporary by-pass bridge layout was designed to just meet the minimum radius requirements to safely accommodate the turning movements of a WB-62 (truck) vehicle while staying within the limits of scour protection recommended by WHG. This approach safely accommodates emergency vehicles and school buses. To further minimize impacts to on-site wetland resources, the temporary bridge system has been designed with a temporary bridge superstructure system that will span above a significant section of the river. To achieve this, substructure elements consisting of piers/pile bents will be used to elevate a significant portion of the superstructure while earthen abutments encompassed by steel sheeting will be used to create the temporary approaches.

While the preferred approach will require the rental of a temporary bridge system and construction of temporary piers/pile bents to support the superstructure, this on-site alternative to traffic management was selected as the preferred alternative (in comparison to the off-site Duck Harbor/High Toss Road approach) as it will result in less of an impact on wetland resources compared to the off-site alternative of making improvements to Duck Harbor Road and High Toss Road to accommodate diverted traffic.

4.F.2.2 Mill Creek Water Control Structure – Construction Staging and Traffic Management

The Mill Creek structure is not a subject of this application, but is described below for informational purposes.

The Project's primary staging area is on property owned by the NPS and will be located within the Project's limits of disturbance on the north of the proposed access road, approximately 400 feet north of the new structures. This area consists of an upland wooded area. Construction associated with the Mill Creek water control structure is expected to last between six to eight months, subject to applicable Time of Year restrictions and weather conditions. Because the proposed work would occur off of public roads, no traffic management is proposed.

4.F.2.3 High Toss Road – Construction Staging and Traffic Management

All construction vehicles and personnel will access the work area via Pole Dike Road, on the eastern end of High Toss Road. Work will begin on the western end of High Toss Road. Traditional construction equipment including excavators and bulldozers will be used to remove the roadbed fill and the Herring River culvert. Work along High Toss Road will then progress from west to east, with the fill within the floodplain of Herring River removed and stockpiled elsewhere within the work area. After the removal of roadbed fill within the floodplain has been completed and final design grades have been achieved, the elevating of High Toss Road will begin in areas as shown on the Project plans. Construction equipment will be used to transport fill material to be added to the road surface in areas that are currently below the minimum target elevation until the entire remaining road surface is above elevation 7.5 feet. The culvert on the unnamed stream on the eastern end of High Toss Road will be removed and replaced with a new culvert. The proposed culvert opening at High Toss Road is 18 inches in diameter to

allow for increased hydraulic capacity and ease of maintenance. Based on the size of the existing wetland south of the roadway at this location, this size should be adequate to support future tidal exchange.

Following the completion of construction work, all disturbed areas will be graded and stabilized. All construction vehicles, equipment, and materials, including erosion controls, will be removed from the site, and these areas will be restored to pre-construction conditions.

The first phase of construction will involve the installation of erosion controls in the work areas as shown on the drawings. At the Herring River culvert removal location, a silt curtain will be placed across the Herring River. At locations uphill of cut slopes, straw wattles, erosion control measures, or similar will be placed to divert runoff around the cut slope until it is stabilized. The installed erosion controls will be inspected and maintained in accordance with NPDES Construction General Permit and other permit approvals until the construction area is stabilized.

Based on the results of the geotechnical analysis, it is envisioned that most material removed from the floodplain will be used for the elevating the travelway of High Toss Road. While the selected contractor will determine the means and methods of construction, it is assumed the likely filling operation for the travelway will proceed from west to east to minimize the haul distance for the material that is removed from the floodplain. The fill material will be stockpiled at a location to be determined and then used on the travelway. Work in the floodplain and travelway are likely to proceed simultaneously once sufficient material has been removed from the floodplain to start work on the travelway.

Once the floodplain work and the filling operation for the travelway are complete, the road will be brought to final grade and stabilized with gravel material. After the area is stabilized, erosion controls will be removed, and construction will be complete. It is assumed all aspects associated with the High Toss Road will be completed in a single construction season.

High Toss Road is a very low volume road; therefore; large-scale traffic management measures are not anticipated to be required. Appropriate construction signage and barriers will be implemented and maintained by the selected contractor and limited police details or flagmen will be used as directed by the Town. Since High Toss Road provides access to residents on and near Way #672, the ability to travel over High Toss Road will be maintained to the maximum extent possible throughout construction. Any limitations on work hours for construction will be determined by the Town.

4.F.2.4 Pole Dike Road Water Control Structure and Other Low-lying Road Work

The proposed roadway alignments maintain the existing horizontal geometry with minor adjustments in vertical alignment to accommodate the increased elevation and culvert crossings. The centerline of the proposed road segments matches the centerline of the existing roads. The elevated roadway segments are designed to transition back into existing geometric alignments. Horizontal and vertical alignment of the elevated road segments follows published standards by the MassDOT, American Association of State

Highway and Transportation Officials (AASHTO) Green Book (2011), and the Federal Highway Administration.

The proposed design maintains a consistent cross-section design for the elevated roads: two 11-foot travel ways and two three-foot unpaved shoulders. The MassDOT design criteria (2006) recommend a travel lane width of ten- to twelve feet. The existing roadway has an average width of 10.5 feet. For safety purposes, the proposed travel lane width was increased to 11 feet. The proposed alignment is based upon two 11-foot paved travel ways and two 3-foot unpaved shoulders.

The existing roadways have limited guardrails along the alignment. The existing roadways are unposted and are located in an uncongested area. Based on input received from the local police departments, the existing speed limit is 40 MPH. It is recommended that the elevated roadways have a posted speed limit of 35 MPH. Per MassDOT Highway Design Manual, Section 3.6.5, the design speed will be 5 MPH over posted speed to limit which accounts for traffic volumes and anticipated driver characteristics.

To comply with MassDOT standards, the proposed design includes installation of guardrails along the edge of the roadway in the areas where the road will be filled to raise alignment above the storm-of-record elevation. MassDOT standards require that for a roadway with a design speed of less than 40 mph guardrails are necessary if the clear zone is less than 7-feet wide. Since the clear zone is defined as an area with traversable, recoverable slope (4H:1V or flatter), it is necessary to put up guardrails along nearly the entire southbound section of proposed elevated roadway and some portions of the northbound proposed elevated lanes. The design includes approximately 11,900 linear feet of guardrail, comprised of approximately 7,500 linear feet of guardrail on the southbound side and 4,400 linear feet on the northbound lanes.

Construction will be performed in stages to manage traffic flow during construction. A Maintenance Protection of Traffic Plans (MPOT) was developed in accordance with the Federal Highway Manual Uniform Traffic Control Devices (MUTCD). The Detour Plans and MPOT, which show all required road closures and detours, are contained in Section 8.H.

4.F.3 Response to Transportation Objective

The transportation goal of the RPP is to provide and promote a safe, reliable, and multi-modal transportation system. The Project advances this goal by incorporating auto, pedestrian and bicycle safety into the design of the Chequessett Neck Road Bridge and road elevation measures. As a coastal restoration project, the Herring River Restoration Project will not generate new traffic trips or impose any additional burden on the local or regional roadway network.

The Project will enhance transportation safety and efficiency by providing significant improvements to existing road infrastructure, including the new CNR Bridge and approaches, removal of a portion of High Toss Road and (by mitigation) elevation and culvert replacements along of segments of low roads. The Commission's FEIR comment letter states that "[i]mpacts of this project on the roadway network should

continue to be detailed in subsequent work and submissions to the Cape Cod Commission under DRI review. Where paved roadways are significantly altered, accommodation for non-motorists should be maintained and, to the extent feasible, improved. In addition to permanent impacts, temporary construction impacts on the roadway network should be addressed in subsequent analysis and submissions to the Commission.”

A description of this work and related traffic management during construction is provided above and is further detailed on plans for the bridge and all roadway elevation work proposed as mitigation (see Section 13). In all cases, stormwater management and safety are improved, and accommodation of non-motorists is maintained. The roadway design plans maintain existing road dimensions in order to maintain the rural character of local roads and to minimize impacts to adjacent wetlands. Traffic management plans developed to maintain safe vehicular and non-motorist access during road construction are described below and are provided in Section 8.H.

Objective TR1 – Improve safety and eliminate hazards for all users of Cape Cod’s transportation system

The Project meets this objective based on the following information:

TR1 Response 1. The Restoration Project will not generate new traffic trips and therefore preparation of a Traffic Impact Assessment (TIA) is not warranted. According to the Commission’s Transportation Technical Bulletin, “[t]he scope of a TIA is largely informed by the scale of the potential impact to the transportation system as approximated by the anticipated new peak hour trips generated by the project.” The Project is not anticipated to generate 50 or more new peak hour trips, and therefore is not required to present a detailed analysis of off-site safety impacts of the development at Study Area locations and implement appropriate safety improvements.

TR1 Response 2. Road designs incorporate all required MassDOT and FHA standards for safety:

- The proposed bridge /tide gate structure has been reviewed by MassDOT and is designed to comply with the requirements of the MassDOT LRFD Bridge Manual and the American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design (See section 3.B.2 of this Application):
- To design the bridge and gate structures to withstand significant lateral loads from tidal fluctuations, storm surge events (such as the 100-year and 500-year frequency flood events), and to withstand a saltwater environment with wave action.
- Horizontal and vertical alignment of the elevated road segments follows published standards by the MassDOT, American Association of State Highway and Transportation Officials (AASHTO) Green Book (2011), and the Federal Highway Administration.

- In accordance with MassDOT standards, design low road elevations includes installation of guardrails along the edge of the roadway in the areas where the road will be filled to raise alignment above the storm-of-record elevation

TR1 Response 3. The Project has developed traffic management plans for all roadway construction that maintain safe vehicular, pedestrian and bicycle access during all stages of construction. All properties that rely on these roadways for access will have safe access during all stages of construction.

- A temporary bypass/traffic diversion bridge will provide vehicular, pedestrian and bicycle traffic over the portion of Chequessett Neck Road that crosses Herring River during all stages of construction.
- For all low-lying roadwork, a Maintenance Protection of Traffic Plans (MPOT) was developed in accordance with the Federal Highway Manual Uniform Traffic Control Devices (MUTCD).
- High Toss Road is a very low volume road; therefore; large-scale traffic management measures are not anticipated to be required. Appropriate construction signage and barriers will be implemented and maintained by the selected contractor and limited police details or flagmen will be used as directed by the Town.

TR1 Response 4. Roadway profiles will be retained to the maximum extent possible to maintain the rural character of the roads.

- Where public roads or access roads to private property are elevated, the design of these measures has maintained clear lines of sight and avoided creating sight distance obstructions.
- The proposed design maintains a consistent cross-section design for the elevated roads: two 11-foot travel ways and two three-foot unpaved shoulders. The MassDOT design criteria (2006) recommend a travel lane width of ten- to twelve feet. The existing roadway has an average width of 10.5 feet. For safety purposes, the proposed travel lane width was increased to 11 feet.

4.G Cultural Heritage (CH)

4.G.1 Existing Conditions

Identification and preservation of cultural resources within the Project area are highly important components of the Project. To initiate consultation with the Massachusetts Historical Commission (MHC), a Project Notification Form (PNF) was completed by the CCNS and filed in 2008. Based on recommendations from the MHC, cultural resources within the Project Area were assessed through a Phase 1A archaeological background research and cultural resources sensitivity assessment that was completed for the Project area in 2011. This resulted in a Programmatic Agreement between the MHC and NPS (see Section 8.0 of this application) that established the Area of Project Effect (APE)¹⁷ and the identification of archaeological resources and resolution of any potential impacts resulting from the Project. Section 3.9 of the FEIS includes a detailed discussion of the unique stewardship role of the NPS for cultural resources, guiding regulations and policies, and the two categories of cultural resources that were retained for analysis: archaeological resources and historic structures. Topics covered in detail in the FEIS are briefly summarized below.

- **Guiding regulations and policies:** The National Historic Preservation Act (NHPA) (1966, as amended) is the principal legislative authority for managing cultural resources associated with National Park Service projects. Generally, Section 106 of the act requires all federal agencies to consider the effects of their actions on cultural resources listed on or determined eligible for listing in the National Register of Historic Places (National Register). Other important laws or Executive Orders designed to protect cultural resources include the NPS Organic Act, American Indian Religious Freedom Act, Archaeological Resources Protection Act, National Environmental Policy Act (NEPA), Executive Order 11593 (Protection and Enhancement of the Cultural Environment), and Executive Order 13007 (Indian Sacred Sites).
- **Archeological resources:** Archeological resources in the Project area have been assessed using a combination of archival research, site file research, and walkover surveys. These were used to document known archeological resources within the Herring River restoration area and to identify areas where unknown archeological resources may exist. This information, in combination with predictive models developed for archeological resources elsewhere in the region, was then used to plot areas of archeological sensitivity. Steps to identify, evaluate, and mitigate any adverse effects on significant properties are defined in the final Programmatic Agreement developed among the consulting parties (See Section 8.A of this application).
- **Historic structures:** Although there are no historic structures listed in the National Register in the Herring River estuary, a dike apparently spanned Mill Creek near its confluence with the Herring River. The Colonial period Atwood-Higgins House and other buildings associated with the house lie

¹⁷ The APE is defined as the areas in the estuary below the 10-foot contour elevation, and certain upland areas where project impacts may occur, such as areas around CYCC, Chequessett Neck Road dike, and several low-lying roads including High Toss Road, Bound Brook Island Road and Pole Dike Road. Source: FEIR Section 3.9.2

within 100 meters of the Area of Project Effect (APE) of the restoration project near the confluence of Bound Brook and the Herring River on the eastern tip of Bound Brook Island (Herbster and Heitert 2011). Recent work has defined an Atwood-Higgins Historic District, which has been nominated for the National Register. Other historic structures may be identified and evaluated as the extent of project effects are finalized; steps necessary to identify and evaluate historic structures in the area of potential effect are defined in the final Programmatic Agreement (See Section 8.A of this application).

4.G.2 Post Restoration Conditions

The CCNS submitted a Project Notification Form (PNF) for the Project to the MHC in 2008. Subsequently in 2014, the CCNS and MHC executed a Programmatic Agreement to identify and resolve effects on archaeological resources resulting from the Project (See Section 8.A of this application).

In 2011, the Public Archaeology Laboratory (PAL) completed a Phase IA Archeological Background Research and Sensitivity Assessment report (Herbster and Heitert 2011) within the Area of Potential Effect (APE) to determine the potential for impact on cultural resources resulting from full tidal restoration. The results of the Phase IA survey determined that several previously known archeological sites have been identified adjacent to proposed project impact areas. Portions of the proposed project impact areas are therefore considered sensitive for the presence of pre-Contact Native American and post-Contact (Historic Period) archeological resources. Effects to cultural resources will be resolved in accordance with the stipulations described in the Programmatic Agreement in compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA). The section below briefly summarizes expected impacts to cultural resources and the project's approach to protecting sensitive cultural resources from potential impacts. Section 4.9 of the FEIS contains a more complete discussion on the effects of increased tidal elevations and tidal flows, changes to the Chequessett Neck Road dike, impacts of adaptive management actions, and potential impacts that will be avoided, minimized, or mitigated (HRRC 2016).

Increased tidal elevations and tidal flow: Modeled erosional patterns expected to occur because of increased tidal flows do not overlap with any archaeologically sensitive areas or known sites along the margins of the APE, and only resources which cross the existing channels are likely to be affected. Considering the greatest level of erosion potential as it relates to archeological resources, the only archeological resources that could potentially be impacted by increased erosion are along High Toss Road, and at the intersection of Bound Brook Island Road and the former Cape Cod Railroad alignment. No areas of pre-contact sensitivity fall within modeled erosional zones under any of the modeling scenarios.

Chequessett Neck Road dike: The dike and roadway are not considered historic resources. An archaeological survey of the surrounding areas where staging or stockpiling may occur identified low-density archaeological deposits that are deeply buried and would not be affected by surface activities associated with the construction (Herbster et al 2016).

Impacts of management actions: The only management actions that could potentially affect archaeological resources are those actions which will necessitate ground disturbance that will primarily occur within existing and former transportation corridors through the modification of roadway elevations or the replacement of culverts beneath these roadways.

Potential adverse impacts to be avoided, minimized, or mitigated: To minimize potential impacts, any archaeologically sensitive areas or sites will be avoided. If avoidance is not possible, then additional archeological assessment and/or survey will be conducted where ground-disturbing activities are to be conducted. This will include construction footprints and any ancillary areas associated with construction, if these areas correspond to archeological sites or sensitive areas. Archaeological monitoring will also be conducted during construction in some potentially sensitive areas. If significant archeological sites are identified, then in accordance with the Programmatic Agreement, actions to mitigate impacts will need to be developed for these specific resources.

In 2015, PAL completed Phase IB archeological investigations within portions of the project area at the privately-owned CYCC property and two CCNS parcels on the north side of the Chequessett Neck Road dike (Herbster et al 2016). One potentially significant pre-contact archeological site was identified on the CYCC property. Proposed improvements in the CCNS impact area were found not to affect significant cultural resources and no additional archaeological investigations were recommended.

In 2016, PAL completed an Addendum Phase IB archeological survey within a proposed work area on federally-owned property on the north side of the river from CYCC that will provide access to the Mill Creek area. No archeological resources or cultural deposits were identified within the project area, and no additional archeological investigations were recommended (Herbster 2016).

In 2018, PAL completed a second Addendum Phase IB archeological survey within additional areas of CYCC property where work may be proposed (Herbster and Lüttge 2018) that identified a potentially significant site. To the extent possible, any future ground disturbance will avoid impacts to either of the two CYCC sites. If avoidance is not possible and in accordance with the Programmatic Agreement, additional archeological testing will be completed to fully delineate the boundaries of the site.

4.G.3 Response to Cultural Heritage Objectives

The Cultural Heritage goal of the RPP is to protect and preserve the significant cultural, historic, and archaeological values and resources of Cape Cod. The Project responds to this goal by restoring a native ecosystem and the environmental and community benefits supported by the ecosystem. Traditionally the ecosystem supported commercial and recreational shellfishing, finfishing, and numerous recreational pursuits that are important to residents and regional tourism. Moreover, every element of the Project has been designed to retain and reflect the rural character of the roadways and surrounding area.

Objective CH2 – Protect and preserve archeological resources and assets from alteration and relocation

The Project meets this objective based on the following information:

CH2 Response 1. The Project’s activities related to archaeological sites and historic structures are dictated by a Programmatic Agreement executed between the Department of Interior and Massachusetts Historical Commission, found in Section 8.A. In accordance with the Programmatic Agreement, all construction activity and disturbance will be directed away from significant archaeological sites so they are not disturbed. Any potential impacts will be avoided, minimized and mitigated as described above and in accordance with the Programmatic Agreement.

CH2 Response 2. Major construction activity for tide control and elevated tide mitigation is proposed to occur primarily in and adjacent to existing travelways and areas of previous disturbance (Chequessett Neck Road, Pole Dike Road, High Toss Road, Old County Road, Bound Brook Island Road). Additional activity proposed to occur on property owned by the existing golf course at CYCC, including excavation of fill for elevating portions of the golf course and low roads, has proceeded subject to cultural assessments undertaken by PAL in accordance with the Programmatic Agreement.

CH2 Response 3. Significant archaeological sites will be protected from development. Approximately 540 of the 570 acres restored in Phase 1 are within the CCNS owned by the NPS, and any significant archaeological sites on that land will be protected from development. Wellfleet Conservation Trust owns an additional 9 acres and any significant archaeological sites on that land also will be protected from development. Any significant archaeological sites on approximately 10 acres owned by CYCC will be protected from development in accordance with the Programmatic Agreement. There are no significant cultural resources identified on the remaining 17 acres of privately owned land.

Objective CH3 – Preserve and enhance public access and rights to and along the shore

The Project meets this objective based on the following information:

CH3 Response 1. Currently, there is no waterway access into Herring River, and no safe portage for members of the public to access Herring River for canoeing or kayaking. The bridge will restore historic public waterway access to Herring River, which existing prior to installation of the dike in 1909. As detailed in Section 3.B.2, the new CNR bridge will enhance the ease and safety of public pedestrian and canoe/kayak access to the Herring River. The bridge will also provide a safe pedestrian platform area for fish casting, which is a popular activity on the existing dike.

CH3 Response 2. The removal of High Toss Road will restore historic waterway access between Lower Herring River and Lower Pole Dike Creek. Recreational access over the High Toss Road causeway to Griffin Island will be redirected to Chequessett Neck Road. The new bridge is designed with added features to accommodate recreational access to Herring River.

CH3 Response 3. Portions of low roads to be elevated are designed to maintain the same width and curvature to the maximum extent possible, in order to retain the rural character of the roads while ensuring vehicular and pedestrian access and minimizing impacts to adjacent natural resources.

CH4 Response 4. The Project will restore scenic historic landscapes.

- Restoration of tidal flow will lead to the removal of fresh water and invasive species that are not salt tolerant. Herbaceous and woody vegetation will be removed in accordance with a Vegetation Management Plan. As these species are removed and tidal flow is increased, salt tolerant wetland vegetation species will colonize. By the end of Phase 1 of the restoration, 570 acres of scenic tidal marsh will be restored or in transition.
- The underground and under bridge relocation of electrical and telephone wires currently strung on poles across Chequessett Neck Road will help to restore the historic scenic character of Chequessett Neck Road. The undevelopment of two residential structures in Lower Herring River will also reopen a portion of historic landscape.

CH4 Response 5. The Project will apply for Chapter 91 Waterways licenses or permits for structures, fill or dredging in Commonwealth tidelands, and will adhere to all applicable requirements for public access to and along the shore.

Objective CH4 – Protect and preserve traditional agriculture and maritime development and uses

The Project meets this objective based on the following information:

CH4 Response 1. The Project maintains and restores a traditional industry that contributes to economic diversity and preserves historical traditions in the region. Shellfishing is annually a \$5 million industry in the Town of Wellfleet, and an important element of the community’s quality of life and visitor appeal. Current conditions have resulted in documented damage to shellfishing in the community. Currently, water flowing out through the dike into Wellfleet Harbor at low ebb tide contains very high concentrations of Fecal Coliform bacteria, and the Chequessett Neck Road dike is a designated point source for this pollutant. These high bacterial concentrations negatively impact shellfish beds and grants, and have led the Massachusetts Division of Marine Fisheries to close hundreds of acres of once-harvestable beds seaward of the dike over the past decades. The restoration will result in a 13-fold increase in the volume of tidal water entering Herring River. By introducing clean saline water from Cape Cod Bay into the Herring River, the restoration will reduce bacterial concentrations that account for current shellfish closures to limits that are safe for shellfish harvesting. The reduction of bacteria concentrations will result from the dilution of cleaner inflowing water into the system, as well as the significantly reduced life span of bacteria in more saline waters. Restored tidal flow will also allow shellfish to spread into areas of the estuary where they are currently not found, forming new shellfish beds. Ultimately the restoration will improve water quality in Wellfleet Harbor by reducing bacterial concentrations, and may increase the area in the Harbor where shellfish may be harvested. Over time and in accordance with procedures set forth by MassDMF, it is anticipated that these resources may be reopened to public recreational shellfishing.

CH4 Response 2. The Project will not interfere with any existing maritime activity, and will restore and enhance historic public access to Herring River. The proposed design of the CNR bridge includes a

pedestrian platform and portage areas to enhance recreational maritime activities such as canoeing, kayaking and fishing. Currently there is no safe public access to launch a canoe or kayak in Herring River.

CH4 Response 3. There are no known farmlands noted in historic or cultural landscape inventories or listed in the National Register of Historic Places.

CH4 Response 4. No existing maritime industrial structures or maritime industrial buildings are located in the Phase 1 restoration area.

5. Overview of Adaptive Management

This Project proposes to use a rigorous form of adaptive management to guide the restoration of tidal flow in the Herring River system. Adaptive management is a valuable and versatile approach for many environmental restoration projects implemented over a long timeframe. For example, in order for a nutrient management plan to be considered consistent with the Cape Cod Area Wide Water Quality Management Plan Update, the Commission requires that plans incorporate an adaptive management approach, “to be responsive to changes in environmental quality, relative effectiveness of implemented approaches, identification of new technology, and unforeseen community needs.”¹⁸

Adaptive management provides the framework within which alternative management actions can be systematically evaluated during consideration of multiple project objectives, thereby allowing for informed local management decisions. Following adaptive management guidelines, the Project will restore tidal flow incrementally while water quality, vegetation, tide levels, salinity, sediment movement and many other environmental factors are monitored and compared with pre-restoration conditions and expected changes. The rate of tidal restoration can be slowed, reversed, or increased based on the system response as indicated by monitoring data.

The Herring River Adaptive Management Plan (HRAMP) is contained in Section 8.B. This section is intended to provide an overview of the HRAMP and serve as a guide to the more detailed document.

5.A What is Adaptive Management?

Adaptive management is an iterative process of (1) making predictions regarding outcomes of management actions, (2) monitoring system responses once management actions are implemented, (3) comparing predicted outcomes to observed outcomes of management actions, and (4) using the result to update our understanding of system responses to guide future management actions. Information obtained from post-implementation monitoring improves our ability to predict future outcomes and make better decisions regarding the selection of appropriate future management actions.

Adaptive management differs from a ‘trial and error’ and other reactive processes by comparing predicted outcomes to observed system responses in order to improve our understanding of system behavior through collection of data used to update predictive models, rather than simply rejecting an action that failed to elicit the desired outcome. Thus, adaptive management is a process for decision making under evolving conditions that promotes flexibility by adjusting decisions as outcomes from management actions and other events become better understood. Characteristics of the Herring River Restoration Project provide the conditions appropriate for using an adaptive management approach. These include a broad range of potential system responses to management that make it difficult to

¹⁸ Cape Cod Commission, Guidance on Section 208 Plan Update. Obtaining a Consistency Determination, April 2018.

determine the best restoration policy and a series of water-control decisions repeated over time. Therefore, an adaptive management framework is the most productive method to address restoration decisions related to managing tidal exchange within the Herring River estuary.

5.B Structure of the HRAMP

The HRAMP was developed by the project team in collaboration with the US Geological Survey (USGS). The HRAMP establishes the framework for decision making on how to operate adjustable tide gates at a new CNR bridge to maximize the ecological benefits of restoring tides to the Herring River estuary while minimizing adverse impacts.

The HRAMP consists of two phases: the setup phase and the implementation or iterative phase. The setup phase consists of several steps that must be taken prior to implementation of any management action:

1. Define the problem to be addressed by the Project;
2. Identify specific objectives to be achieved by the Project;
3. Select potential policies or management actions capable of achieving objectives;
4. Identify predicted outcomes or consequences of each potential action with respect to the stated restoration objectives, based on extensive baseline monitoring and modeling;
5. Develop a method for assessing trade-offs among competing objectives and identifying the policy, decision, or action that is most likely to achieve the objectives; and
6. Develop and implement a monitoring program to track outcomes of selected management activities and compare outcomes with predictions.

The balance of this section summarizes each of these six steps, and describes additional detail contained in the HRAMP Plan found in Section 8.B.

5.C Define the Problem

An effective adaptive management plan requires a clear definition of the problem, or problems, to be addressed in order to identify why the decision needs to be made, and the individuals who can make the decision. Individuals or groups that have an interest in the resources affected and a willingness to work with others on the problem (i.e., stakeholders) should be identified.

The Project has evolved over more than three decades of scientific study and more than a decade of stakeholder engagement led by the Town of Wellfleet and CCNS. The responsive and transparent community planning process has helped to clarify the ecological and socio-economic problems that have developed under current tidally restricted conditions, and are to be addressed by the Project. These issues are described in detail in the FEIS/FEIR and are summarized in Section 3.A of this Application. The community planning process also has identified issues of concern associated with restoration (e.g., visual changes, property impacts, traffic management during construction) that need to be taken into consideration in Project design and implementation.

As described in the HRAMP contained in Section 8.B, the decision-making process (Section 5.H) enables local decisions to be made in based on best available science and information, and in consideration of stakeholder input.

5.D Identify Objectives, Performance Measures and Management Outcomes

Defining project objectives starts with considering what you care about: what is to be achieved and what to avoid. The focus is on achieving ecological and socio-economic objectives using quantifiable metrics to evaluate progress towards achievement of well-defined restoration goals. Clearly defined objectives are the foundation of any decision process. In adaptive management, predicting the consequences of available actions in terms of measurable objectives provides a clear path for identifying the best performing strategy. Thus, the analysis starts with defining the objectives.

The fundamental objectives of the Herring River Restoration Project are shown in Figure 5-1. The fundamental objectives are derived, in part, from NPS management policies as articulated in the current General Management Plan for the CCNS, which states that the objective for managing coastal wetlands is to “Restore the natural hydrography and ecology of estuaries in consultation with affected municipalities” (NPS 1998). This broad policy has been applied to the Herring River project more explicitly through the HRAMP, with development of a set of overarching fundamental objectives to restore the ecosystem.

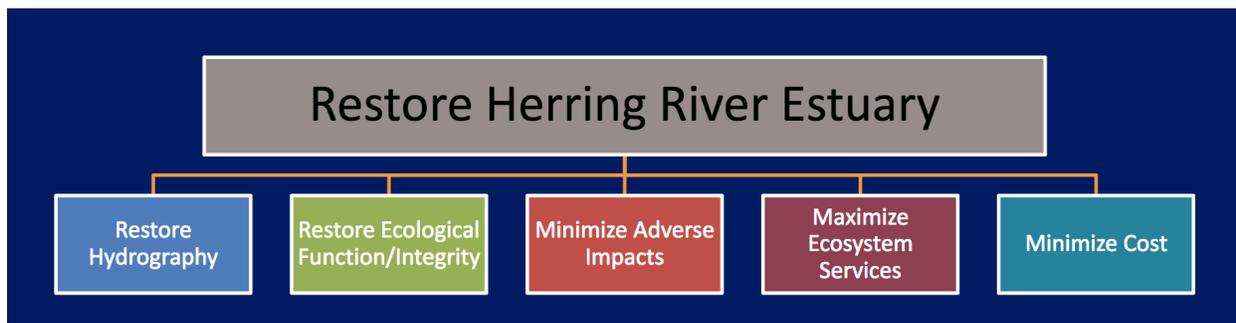


Figure 5-1. Fundamental objectives of the Herring River Restoration Project

The fundamental objectives of the HRAMP are compatible with RPP goals and objectives. This suggests that Project implementation in accordance with the HRAM will further the goals and objectives of the RPP. Table 5-1 lists the fundamental objectives with corresponding RPP objectives.

Fundamental Objective of Herring River Adaptive Management Plan	Corresponding Regional Policy Plan Objectives
Restore natural hydrography, including tide range and topography/bathymetry	WR3: Protect, preserve and restore marine water resources WT4: Promote the restoration of degraded wetland resources
Restore ecological function and integrity, including salinity, water quality, and aquatic habitat	WT4: Promote the restoration of degraded wetland resources WP2: Restore degraded habitats through use of native plant communities WP4: Manage invasive species
Minimize adverse impacts to ecological, cultural, and socio-economic resources; Minimize the costs of restoration	TR1: Improve safety and eliminate hazards for all users of Cape Cod’s transportation system CD3: Avoid adverse visual impacts from infrastructure and scenic resources CH2: Protect and preserve archaeological resources and assets from alteration or relocation CH4: Protect and preserve traditional agricultural and maritime development and uses
Maximize eco-system services (i.e., benefits people receive from the estuary)	CR2: Plan for sea level rise, erosion and floods CR3: Reduce vulnerability of built environment to floods CH3: Preserve and enhance public access and rights to and along the shore
Maximize understanding of the project effects to federal- and state-listed rare, threatened, and endangered species	WP1: Maintain and protect existing plant and wildlife populations and species diversity WP3: Protect and preserve rare species habitat, vernal pools, 350-foot buffers to vernal pools WP5: Promote best management practices to protect wildlife and plant habitat from the adverse impacts of development

Table 5-1. Comparison of Adaptive Management Plan and Regional Policy Plan Objectives

For each fundamental objective, a series of sub-objectives has been identified. Sub-objectives are intended to provide further definition of fundamental objectives. As an example, to illustrate the relationship of fundamental objectives and sub-objectives, Figure 5-2 shows the sub-objectives identified for the fundamental objective of Restoring Hydrography.

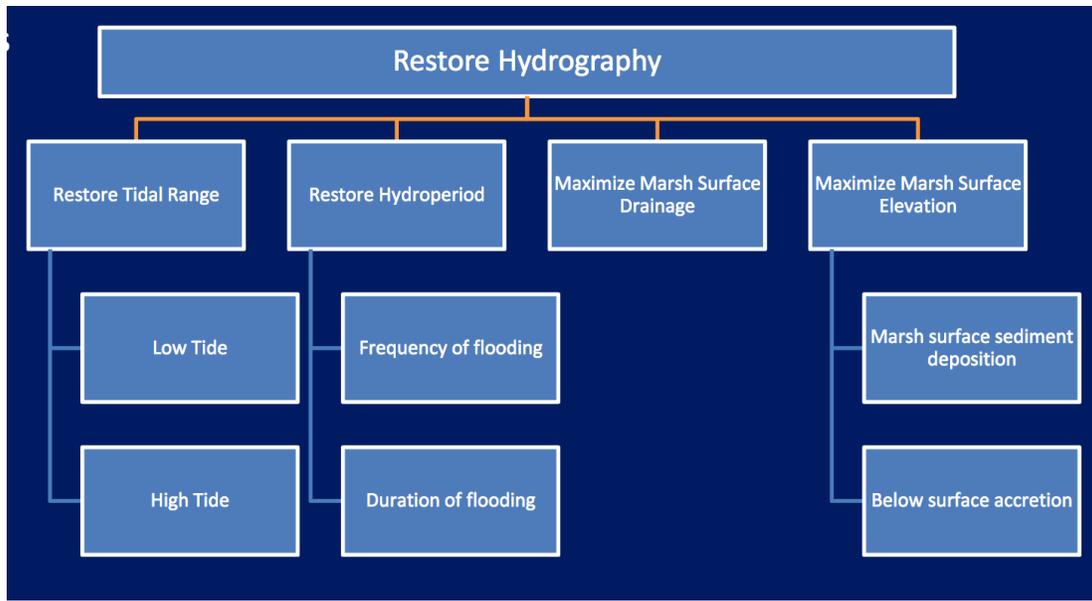


Figure 5-2. Sub-objectives and performance measures for fundamental objective: Restore Hydrography

Performance measures are then identified to measure performance of the fundamental objectives and sub-objectives directly. Performance measures must serve two purposes: 1) to predict how well a management strategy is expected to meet each of the objectives (i.e., models are used to make predictions), and 2) to provide metrics useful for monitoring; i.e., to determine how the system is responding to implementation of a management action and to evaluate progress towards achieving stated objectives. The monitoring needs for adaptive management will be matched to on-going and planned monitoring programs to identify gaps and avoid duplication. An example of performance measures for the fundamental objective of restoring hydrography is provided in Table 5-2.

A complete list of fundamental objectives, sub-objectives and performance measures is contained in Attachment 8.B.

Fundamental Objective #1: Restore Hydrography					
<i>Sub-Objectives</i>	<i>Performance Measures</i>	<i>Desired direction</i>	<i>Spatial scale</i>	<i>Predictions</i>	<i>Monitoring</i>
Restore Tidal Range					
<i>Restore Low Tide</i>	Minimum water surface elevations (ft) averaged for sub-basins and at key locations	Minimize	Sub-basin	EFDC Hydrodynamic Model	Electronic water level data loggers for sub-basins and at key locations
<i>Restore High Tide</i>	Maximum water surface elevations (ft) averaged for sub-basins and at key locations	Maximize	Sub-basin	EFDC Hydrodynamic Model	Electronic water level data loggers for sub-basins and at key locations
Restore Hydroperiod					
<i>Flooding extent</i>	Marsh area inundated by tides (%)	Maximize	Sub-basin	EFDC Hydrodynamic Model	Electronic water level data loggers for sub-basins and at key locations
<i>Duration of flooding</i>	Duration (h) of inundation of marsh surface at key locations	Maximize	Sub-basin	EFDC Hydrodynamic Model	Electronic water level data loggers for sub-basins and at key locations
Maximize Marsh Surface Drainage	Extent of ponded water at low tide (%)	Minimize	Sub-basin	EFDC Hydrodynamic Model	Electronic water level data loggers in areas of predicted ponding

Table 5-2. Illustrative performance measures, predictive methods and monitoring approach for sub-objectives

5.E Select Management Actions and Policies

The Project has identified management actions designed to achieve the full range of restoration objectives (Section 8.B). These management actions consist of 1) tide gate management, 2) vegetation management, and 3) marsh management. Tide gate management is considered the primary management action. Vegetation and marsh management are considered secondary actions that will be undertaken as necessary to enhance restoration and achieve specific Project objectives.

Tide Gate Management

The primary management actions under consideration involve decisions regarding the volume of tidal flow permitted through of a series of newly constructed tide gates at the three different locations; these actions involve decisions regarding the number, location, magnitude of opening, and flow direction at the individual tide gate openings at any given time. Timing and frequency of gate operations can be periodic or episodic, coincident with extreme predicted high tides and coastal storm events. At each decision point, one or more gates can be raised or lowered or not changed.

To investigate a range of plausible gate management strategies, the USGS and representatives of partner agencies developed a series of seven potential restoration trajectory scenarios, referred to as “platform policies”, that encompass a representative range of restoration timelines, frequency and size of gate adjustments, and management priorities. Figure 5-3 below shows a comparison of the Mean High Water (MHW) Levels for the Full Herring River Restoration Project in the Lower Herring River Sub-basin Among Different Platform Policies. It is important to note that certain water surface elevations have specific ecological significance. For example, 1) only after MHW reaches an elevation of 1.8 feet¹⁹ will water rise above the Herring River channel banks and flow out over the existing marsh surface; 2) a MHW elevation of 2.6 feet is approximately the highest MHW elevation that would not require

¹⁹ All tidal metrics are expressed relative to NAVD 88.

mitigation of low-lying roadways or properties; and 3) at a MHW elevation of 3.6 feet, most of the Lower Herring River marsh would be flooded during spring tides.

It should be noted that the HRAMP has been designed to meet the project needs for full restoration. However, during Phase 1, the selected tide gate policy would not allow water levels to exceed levels allowed under permits. To achieve water levels above those permitted for Phase 1 restoration would require new permits or permit amendments.

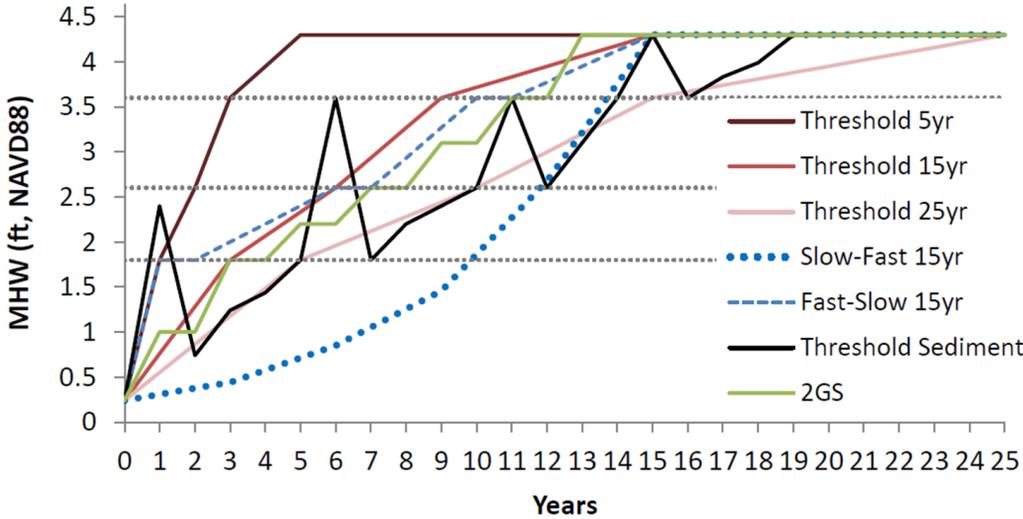


Figure 5-3. Comparison of the Mean High Water (MHW) Levels for the Full Herring River Restoration Project in the Lower Herring River Sub-basin Among Different Platform Policies (Maximum MHW elevations would be adjusted to 3.6 feet (NAVD88) for Phase 1 of the Project)

Tide gate management strategies are referred to as “platform” policies because they provide the baseline conditions for analysis of project impacts to which secondary management activities can be added to improve performance with respect to specific project objectives. Secondary management actions, described below, are those other than changes to tide gate configuration and include direct management of vegetation and sediment, connectivity of tidal channels and pools, and mitigation of potentially adverse project impacts. Secondary actions would be implemented in addition to tide gate management to improve overall policy performance. The purpose of the decision analysis process is to identify the best performing tide-gate management approach and incorporate secondary actions to improve performance, and to select the overall policy (tide-gate management plus secondary actions) that provides the best outcomes across the objectives. The location, timing, and other details of secondary actions cannot be anticipated in most cases until an initial policy is implemented and some degree of tidal exchange is restored. The ability to direct secondary actions in reaction to system responses to the implemented tide gate policy is one way of learning from and adapting management as restoration progresses.

The HRAMP found in Section 8.B contains a detailed description of the full range of potential tide gate

management policies and the process by which a selected tide gate management policy will be selected. The varied effects of fully opening the tide gates using different management policies that encompass time spans ranging from 5 to 25 years are being analyzed to identify the most advantageous policy for tide gate management. Decision support software has been developed for use by the Project team to compare policy options by evaluating trade-offs and risk as represented by Project objectives. Although development and testing of the decision framework has been completed, improving predictions for the full suite of ecological and socio-economic objectives and conducting trade-off, and risk and sensitivity analyses using the improved predictions is required before a fully operational adaptive management process can be implemented. This process is ongoing and will continue through 2020.

It should be noted that decisions about tidal gate adjustments will be legally mandated and subject to regulatory oversight under the US Clean Water Act, the Coastal Zone Management Act, the MA Wetlands Protection Act and Waterways regulations, the Towns of Wellfleet and Truro wetland by-laws, and the MA Endangered Species Act. Tide gate management decisions will be constrained by actions deemed necessary to protect public and private structures within the Project area; e.g., at the end of the permitted Phase 1 of the project, the maximum mean daily high tide elevations would be limited to 3.6 feet in the Lower Herring River and 2.5 feet within the Mill Creek sub-basin while no tidal flow would be allowed into Upper Pole Dike Creek.

Secondary Vegetation and Marsh Management Actions

As noted above, the restoration outcomes of tide gate management policies will be augmented by the selection of secondary management actions. Secondary management actions are designed to accelerate or maximize the recovery of estuarine habitats, enhance the benefits of tidal restoration, and avoid or reduce potential adverse ecological and socioeconomic impacts of restored tidal flow. Secondary actions include management of floodplain vegetation, modification of marsh surface elevations through management of sediment supply and distribution, and restoration of connectivity and natural sinuosity of tidal creeks to enhance the circulation of salt water through the system. Decisions regarding secondary actions will involve where and when to implement management measures, what techniques to use, and how to best coordinate the actions with the tide gate management. Specific details for most of these measures cannot be known until some degree of tidal flow is restored and monitoring information is gathered about how the Herring River system is responding.

The HRAMP found in Section 8.B provides detail on the range vegetation management and marsh management activities, how they will be selected, and how they will be undertaken. The HRAMP also discusses the potential interaction between secondary management actions with tide gate management policies.

5.F Predict Outcomes and Consequences

Decision making is future oriented – decisions are made after considering “what will happen if an action or an alternate action is taken?” Thus, predicting consequences is an essential part of any decision, with the type or complexity of the prediction dependent on the significance of the outcomes. Performance,

or the response of a measurable attribute for each Project objective, is predicted under each tide gate platform policy. Comparing predicted performance across all objectives provides the basis for selecting a policy. Recall that each objective has a performance metric (measurable attribute), including a unit of measure, desired direction of response, and spatial and temporal scales. For each objective, a method of prediction is needed as well as a method for monitoring to determine what actually happens after implementing the policy in order to assess, learn, and adapt.

In the development of methods of prediction and monitoring for the Herring River, a tiered approach was used. Tier 1 predictions are best professional judgments developed the HRRC. Tier 2 predictions are those provided through formal elicitation methods by subject matter experts and, where appropriate, community stakeholders. Tier 3 predictions are generated by quantitative models. For the Herring River, Tier 1 predictions have already been compiled, but are only being used to assess and develop future decision analyses. Tier 2 and 3 predictions will be used for the actual adaptive management plan and functional decision analysis. Tier 3 predictions can only be applied when a cost-effective quantitative model exists for a given objective. As shown in Table 5-3 shown above, Tier 3 predictions exist or are planned for about two-thirds of the Herring River objectives. Where no quantitative model is available, Tier 2 predictions will be elicited from technical subject matter experts and community stakeholders through formal elicitation processes. This process is under and will continue through 2020.

More detail on predicted outcomes for objectives and sub-objectives, and the numerical models used, is found in the HRAMP contained in Section 8.B.

5.G Evaluate Predicted Outcomes Considering Tradeoffs and Risks

Tradeoff analysis is the process of evaluating which of several potential courses of action (i.e., Herring River platform policies) offers the best possible outcome. The process of this evaluation can also offer insight into where information deficiencies exist – or what actions must be taken to improve resource outcomes. Tradeoff analysis is typically performed before any action is taken, and it therefore depends on predictions of how a given action will affect one or more objectives. Accurate predictions are therefore a foundation of quantitative decision analysis, and among the goals of a tradeoff analysis is to base decisions on the best available information.

Trade-off analysis software will be used to evaluate the expected performance and trade-offs of various management strategies. The trade-off analysis will help identify which platform policies are most advantageous for achieving the objectives based on weighted preferences and attitudes toward risk taking. The software produces numeric scoring of “preferred” management strategies, but it will be up to the Project technical team to evaluate the results, along with input from stakeholders, permitting agencies and other sources to make informed and transparent decisions about the most appropriate actions at any given point in the project implementation timeline.

More information about the trade-off analysis decision-tool and other factors that will be weighed in

trade-off analyses is provided in the HRAMP found in Section 8.B.

5.H Decision-making During Implementation

The governance and administrative structure for implementing the HRAMP is described in a memorandum of understanding (MOU-IV) between CCNS and the Town of Wellfleet. MOU IV explicitly acknowledges the responsibility of the Town and CCNS by establishing the HREC as the formal, decision-making authority for the Project. The HREC is comprised of two Selectboard members and the Town Administrator from Wellfleet, the CCNS Superintendent, and one additional CCNS representative. MOU IV identifies the HRTT as an informal, intergovernmental staff technical working group formed for the purpose of providing technical input for project-related decisions as necessary or appropriate. In September 2017, the HREC established a formal Herring River Stakeholder Group (HRSRG), a 19-member body representing a broad range of local and regional interests. The purpose of the HRSRG is to communicate with stakeholders within the community to ensure that their respective interests and views are well represented and considered by the HREC and to provide advisory input to the HREC on key implementation issues.

A Regulatory Oversight Group will assist in the preparation and review of the HRAMP and will review implementation progress on an ongoing basis. The Regulatory Oversight Group is called for under the Secretary's MEPA Certificate to include, at a minimum, representative(s) from the following agencies:

- Federal: NPS, USFWS, NOAA, NRCS, EPA, USACE;
- State: MEPA, DER, DMF, NHESP, MassDEP, CZM, State Historic Preservation Officer (SHPO);
- Regional: Cape Cod Commission;
- Local: Town of Wellfleet, Town of Truro: and
- Tribal: Mashpee Wampanoag Tribe

The decision-making process is grounded on the collection and evaluation of monitoring data intended to measure performance of the specific objectives formulated for the adaptive management plan. The approach for monitoring and data collection is discussed in the following section. Scientists at CCNS will be primarily responsible for guiding data collection. Members of the project team will review monitoring data as the basis for providing technical support to the HREC. As management actions are implemented by the HREC and the response of the system is monitored, the members of the project team will continue to assess the performance of models and other predictive tools by comparing those outputs to actual, observed outcomes. These results will be summarized in written reports by CCNS and others, and will be shared with the HREC to inform the selection of management actions to be implemented during the subsequent time period. Written reports to the HREC will describe previous management actions, data analysis, and recommendations for future management actions. The HREC will either approve the recommendations or request additional data collection and/or analysis for further review and possible reconsideration of recommended management actions.

More detail on the content of management recommendation to the HREC is contained in the HRAMP found in Section 8.B.

5.1 Design and Implement Targeted Monitoring Program

The collection, analysis, and application of credible monitoring data to compare with predictions from modeling is the primary means in adaptive management to assess progress towards meeting project objectives. Equally important is the ability to predict the variation of expected outcomes across a range of alternative management actions that are under consideration. As previously described, in adaptive management output data from models and other predictive methods are used to conduct trade-off analyses so that predictions of how management actions influence objectives can be compared. After management actions are implemented, monitoring data are used to determine real outcomes, evaluate how models performed, and refine model predictions about the outcomes of future actions.

Detail on the monitoring plan that has been undertaken to establish baseline conditions for each objective, and the future monitoring that will be undertaken to track responses to management actions for each objective is contained in the HRAMP found in Section 8.B.

6. Project Budgeting and Funding Information

In its comment letter concerning the FEIR, the Commission asked the Project applicant to provide further detail concerning project budgeting and funding. In particular, the Commission requested detail about funding sources and timelines, a breakdown of costs, including costs of mitigation necessary to protect structures, and a phasing/funding plan that would allow the project to commence prior to full implementation. In response to this request, the following preliminary estimates are provided based on best available information at the time of this application, and are subject to change.

6.A Breakdown of Costs

The preliminary estimated cost to construct and implement Phase 1 of the restoration is \$47 million over five years. The cost per acre of area restored is on par with other restoration projects in the Commonwealth. All estimated costs are subject to change as Project plans evolve.

Phase 1 includes all major infrastructure elements necessary for tidal restoration: the Chequessett Neck Road bridge and tide gates, Mill Creek water control structure, Pole Dike Road water control structure, road segment elevation work, removal of a portion of High Toss Road, vegetation management, protection for structures on low properties and adaptive management (including ongoing monitoring and modeling).

The largest single cost element is the Chequessett Neck Road bridge and tide gates at an estimated cost of \$15M. By contrast, the Mitchell River Bridge in Chatham was \$14M; and the Muddy Creek Bridge, a much less sophisticated structure, was \$6M. Table 10-1 shows a breakdown of major costs elements.

Table 6-1. Breakdown of Costs for Phase 1

Chequessett Neck Road Bridge	\$15 M (33%)
Mill Creek Water Control Structure	\$3 M (6%)
CYCC	\$5.5 M (12%)
Pole Dike Road WCS and Low Road Work	\$8 M (17%)
High Toss Road	\$1 M (2%)
Low Property Mitigation	\$1.1M (2%)
Cultural/Archeological	\$0.5 M (1%)
Contingency	\$2 M (4%)
Adaptive Management 5 years	\$7.5 M (16%)
Project Management	\$2.5 M (5%)
Total	\$47 M (100%)

6.B Mitigation

All work necessary to protect structures on public or private property from the effects of tidal restoration during Phase 1 is included in the Phase 1 implementation budget. This includes \$8 million in low road elevation and culvert work on town roadways accounting for 17% of the implementation budget; \$5.5 million in mitigation work on CYCC accounting for 12% of the implementation budget; and \$1.1 million in prevention for low properties, including the construction of the Way #672 protection structure, accounting for 2% of the implementation budget.

6.C Phasing and Funding

Although Phase 1 will be permitted for partial restoration, all infrastructure elements are needed to control tide levels. Therefore, for the implementation budget for Phase 1 includes all major infrastructure elements needed for full restoration.

The Project already has a jumpstart on construction and implementation funding. The Commonwealth of Massachusetts has included \$11 million for construction as part of the state capital investment plan, which accounts for roughly 25% of Phase 1 cost. The Cape Cod National Seashore is seeking funding to cover the cost of constructing the Mill Creek water control structure, which is located on property owned by the NPS. The NPS is not eligible to fund infrastructure that is not located on land it owns. However, the NPS will continue to provide technical and adaptive management support. Most of the remaining funding for Phase 1 implementation is expected to come from a combination of federal sources, potentially augmented by private grant sources. The NPS/CCNS is helping to coordinate discussions with other federal agency partners about how the Project meets shared agency and program-specific objectives. Through these discussions, existing and potential funding opportunities are being explored.

The USDA Small Watersheds Program has previously provided technical assistance funding for design and permitting, and has been identified as a potential source of significant implementation funding. USDA Small Watersheds Program officials have visited the site and confirmed that implementation of the Project is eligible and would be consistent with funding goals of the program. Conversations with the USDA Small Watersheds Program will continue as the Project moves further into permitting.

Through the USFWS, the National Coastal Wetlands Conservation Program, and the North American Wetlands Conservation Act have been identified as potential sources. The Project may be able to apply for multiyear funding under these programs.

The NOAA Coastal Resiliency and NOAA Restoration programs which have already invested in the design and permitting of the Project, also will be pursued for implementation funding potential.

The Project also is in communications with the National Parks Foundation, Ducks Unlimited, National Fisheries and Wildlife Foundation, The Nature Conservancy and other non-governmental and private entities to explore funding strategies and opportunities.

Based on the progress to date, the Project is on track for the remaining funding to be in place for a construction start in calendar year 2022. The Project team has an established and successful track record working with federal and state partners and non-governmental organizations, having raised funds for environmental assessments, monitoring, modeling, engineering design and permitting.

7. References

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8. Attachments

8.A Project Management Form and Programmatic Agreement

(See following pages)

950 CMR: OFFICE OF THE SECRETARY OF THE COMMONWEALTH

APPENDIX A

MASSACHUSETTS HISTORICAL COMMISSION
220 MORRISSEY BOULEVARD
BOSTON, MASS. 02125
617-727-8470, FAX: 617-727-5128

PROJECT NOTIFICATION FORM

Project Name: Herring River Tidal Restoration Project

Location / Address: Refer to USGS Locus Map

City / Town: Wellfleet/Truro

Project Proponent: National Park Service and Towns of Wellfleet and Truro

Name: William Burke, Seashore Historian, Cape Cod National Seashore

Address: 99 Marconi Site Road City/Town/Zip/Telephone: Wellfleet, MA 02667

Agency license or funding for the project (list all licenses, permits, approvals, grants or other entitlements being sought from state and federal agencies).

Agency Name

Type of License or funding (specify)

Massachusetts Environmental Policy Act (MEPA)

Environmental Impact Report

National Environmental Policy Act (NEPA)

Environmental Impact Study

Cape Cod Commission

Developments of Regional Impact

Wetlands Protection Act

Notice of Intent/Order of Conditions

Massachusetts Endangered Species Act Review (MESA)

MESA Review

Chapter 91 Waterways

Chapter 91 License(s)

401 Water Quality Certification

Certificate

ACOE Section 404 Application

Permit

CZM Coastal Consistency

Consistency Review

Project Description (narrative): The original 1,100 acre Herring River estuary has been severely impacted by long-standing tidal restrictions (See USGS Locus Map). The project seeks to restore the estuary and natural functions to the maximum extent practicable. Measures proposed to change current tidal controls will be developed, during during which public input will be solicited as part of both the Massachusetts Environmental Policy Act (MEPA) and National Environmental Policy Act (NEPA) environmental review processes.

Does the project include demolition? If so, specify nature of demolition and describe the building(s) which are proposed for demolition:

The development of the preferred alternative is dependent upon more detailed hydrodynamic modeling, further planning, and additional public input. Existing tidal restrictions such as the Chequesset Neck Road dike structure and crossings along High Toss, Bound Brook Island, Pole Dike, and Old Country Roads may be reconstructed. Low lying properties and roadways potentially affected by restoration activities have been identified.

Does the project include rehabilitation of any existing buildings? If so, specify nature of rehabilitation and describe the building(s) which are proposed for rehabilitation. Does the project include new construction? If so, describe (attach plans and elevations if necessary). To be determined in the future.

950 CMR: OFFICE OF THE SECRETARY OF THE COMMONWEALTH

APPENDIX A (continued)

To the best of your knowledge, are any historic or archaeological properties known to exist within the project's area of potential impact? If so, specify. Historic archaeological resources are likely contained within the project area. It is anticipated that restoration activities will require further coordination with the Massachusetts Historic Commission (MHC).

What is the total acreage of the project area? Roughly 1100 Acres. See Attached Vegetation Figure.

Woodland _____ acres	Productive Resources:
Wetland _____ acres	Agriculture _____ acres
Floodplain _____ acres	Forestry _____ acres
Open space _____ acres	Mining/Extraction _____ acres
Developed _____ acres	Total Project Acreage _____ acres

What is the acreage of the proposed new construction? _____ acres

What is the present land use of the project area? Primarily open space.

Please attach a copy of the section of the USGS quadrangle map which clearly marks the project location.

This Project Notification Form has been submitted to the MHC in compliance with 950 CMR 71.00.

Name: William Burke, Seashore Historian

Address: 99 Marconi Site Road

City/Town/Zip: Wellfleet, MA 02667

Telephone: (508) 255 3421 x 16

REGULATORY AUTHORITY

950 CMR 71.00: M.G.L. c. 9, §§ 26-27C as amended by St. 1988, c. 254.



USGS Topographic Quadrangle
Wellfleet, MA

N

0 1,250 2,500 5,000 Feet

Site Locus		
Herring River Tidal Restoration Project Conceptual Restoration Plan Wellfleet and Truro, MA		
SCALE	DATE	PROJECT NO.
1:30000	May 2007	04479-003-300

ENSR | AECOM

Figure Number

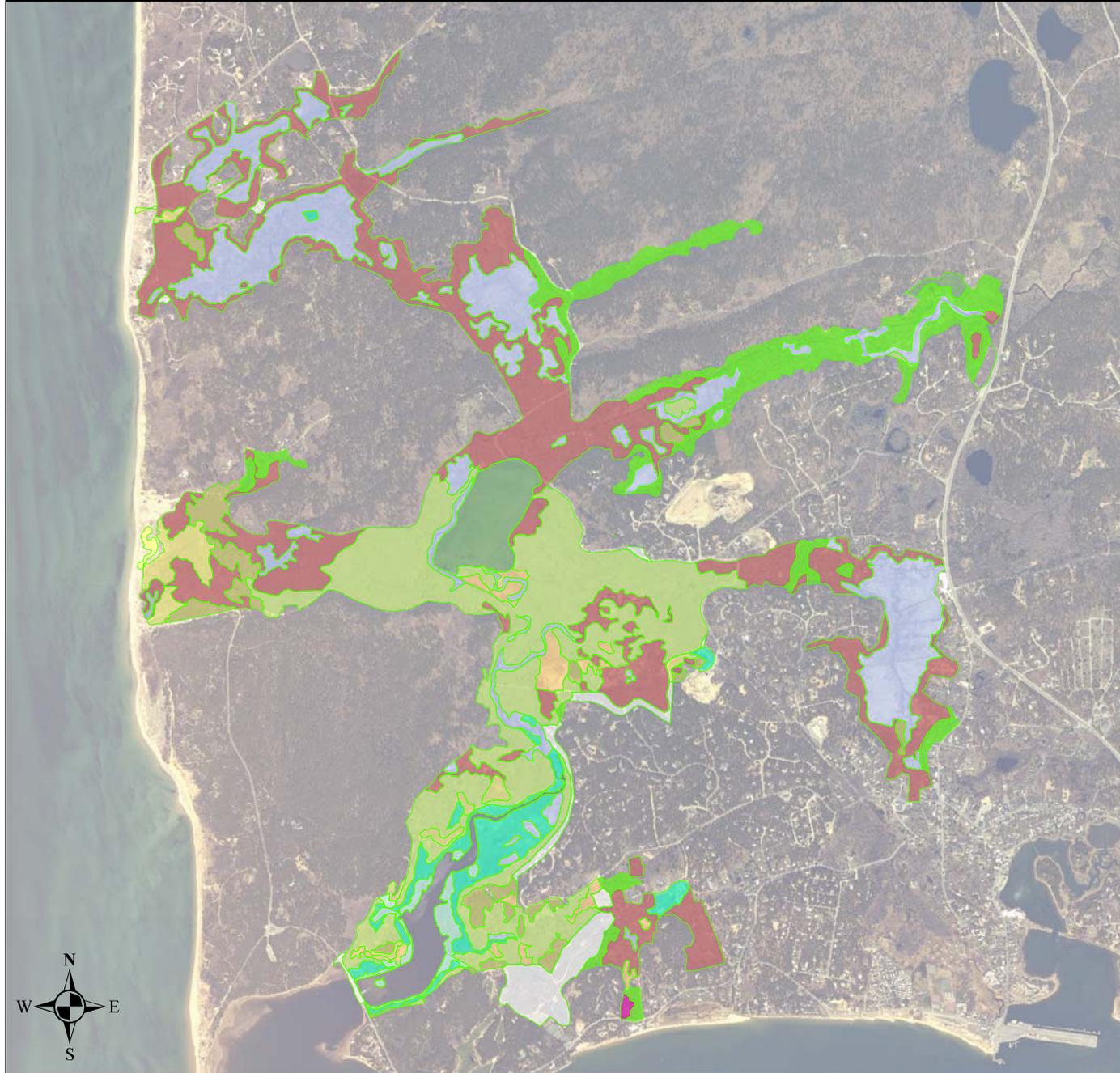
1

Herring River Vegetation

Updated from 2000 aerial photos with 2007 field observations .

Figure 11

Cape Cod National Seashore
National Park Service
U.S. Department of the Interior



Legend

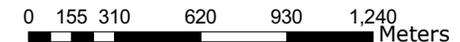
- FRESHWATER MARSH
- BRACKISH MARSH
- SALT MARSH
- DUNE GRASSLAND
- HEATHLAND GRASSLAND
- OLD FIELD HERBACEOUS
- WET SHRUB
- DRY SHRUBLAND
- PINE WOODLAND
- DRY DECIDUOUS WOODLAND
- DRY DECIDUOUS FOREST
- WET DECIDUOUS FOREST
- DEVELOPED

TYPE	TYPICAL SPECIES
FRESHWATER MARSH	<i>Typha angustifolia</i> , <i>Scirpus cyperinus</i> , <i>Calamagrostis canadensis</i> , <i>Juncus</i> spp., <i>Sparganium americanum</i> .
BRACKISH MARSH	<i>Phragmites australis</i> , <i>Scirpus pungens</i> , <i>Spartina alterniflora</i> , <i>Spartina patens</i> .
SALT MARSH	
DUNE GRASSLAND	<i>Ammophila breviligulata</i> , <i>Deschampsia flexuosa</i> .
HEATHLAND	<i>Arctostaphylos uva-ursi</i> , <i>Morella pensylvanica</i> , <i>Vaccinium angustifolium</i> , <i>Hudsonia ericoides</i> , <i>Hudsonia tomentosa</i> , <i>Corena conradii</i> .
OLD FIELD HERBACEOUS	<i>Schizachyrium scoparium</i> , <i>Deschampsia flexuosa</i> , <i>Holcus lanatus</i> , <i>Festuca rubra</i> .
WET SHRUBLAND	<i>Vaccinium corymbosum</i> , <i>Clethra alnifolia</i> , <i>Rhododendron viscosum</i> , <i>Decodon verticillatus</i> , <i>Cephalanthus occidentalis</i> , <i>Ainus</i> spp., <i>Chamaedaphne calyculata</i> .
DRY SHRUBLAND	<i>Morella pensylvanica</i> , <i>Quercus velutina</i> , <i>Amelanchier</i> spp.
PINE WOODLAND	<i>Pinus rigida</i> , <i>Gaylussacia baccata</i> , <i>Deschampsia flexuosa</i> , <i>Vaccinium angustifolium</i> .
DRY DECID. WOODLAND	<i>Prunus serotina</i> , <i>Amelanchier</i> spp., <i>Viburnum</i> spp.
DRY DECIDUOUS FOREST	<i>Quercus velutina</i> , <i>Quercus alba</i> , <i>Ficus grandifolia</i> , <i>Robinia pseudoacacia</i> .
WET DECIDUOUS FOREST	<i>Acer rubrum</i> , <i>Rhododendron viscosum</i> , <i>Clethra alnifolia</i> .

HOW THIS MAP WAS MADE:

Seemingly "natural" vegetation communities often contain unexpected assemblages of species because of habitat alterations caused by human intervention. For example, Herring River's diked and drained floodplains have dry woodland communities where wet shrubs and marshes would be expected to occur. This general vegetation map of Herring River shows these human-influenced plant communities which are very different from the floodplain types that would result from restoration of tidal influences.

To make this map, color infra red aerial photos were interpreted and assigned vegetation types from a broad classification system of New England plant communities (Sneddon, Leslie, *Vegetation of Cape Cod National Seashore Natureserve*, 2004). New vegetation classes were then added based on extensive field observations to reflect actual vegetation within the tidal-deprived floodplain. In particular, the apparent wet woodland types dominated by red maple interpreted from aerial photography are actually dry woodlands dominated by black cherry and shadbush.



Programmatic Agreement
Among
The Massachusetts State Historic Preservation Officer,
The Mashpee Wampanoag Tribe,
The Wampanoag Tribe of Gay Head-Aquinnah,
And
Cape Cod National Seashore
Regarding
The Identification and Resolution of Effects Upon Archeological Resources
Resulting From the Herring River Tidal Restoration Project

WHEREAS, the National Park Service (NPS) in 2008 entered into a Programmatic Agreement with the Advisory Council on Historic Preservation (ACHP) and the National Conference of State Historic Preservation Officers; and

WHEREAS, Cape Cod National Seashore (CACO), a unit of the National Park Service as a part of the U. S. Department of the Interior, is a party to that Programmatic Agreement, and has stewardship responsibilities for the natural and cultural resources within the lands comprising the CACO; and

WHEREAS, CACO, under terms of a Memorandum of Understanding, joined the towns of Truro and Wellfleet, the U.S. Fish and Wildlife Service, the Natural Resources Conservation Service, the National Atmospheric and Oceanic Administration, and the Massachusetts Division of Ecological Restoration to form the Herring River Restoration Committee (HRRC); and

WHEREAS, CACO, as a partner in the HRRC, is planning to restore tidal exchange to the Herring River estuary (the Herring River Tidal Restoration Project, hereafter referred to as the Undertaking), located in the towns of Wellfleet and Truro, Massachusetts, and containing lands in federal, municipal, and private ownership (36 CFR 800.16(y)); and

WHEREAS, the Memorandum of Understanding that established the HRRC identified NPS as lead federal agency for purposes of National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) compliance, and the towns as co-applicants under the Massachusetts Environmental Policy Act (MEPA) and Cape Cod Commission Development of Regional Impact (DRI) Review Process; and

WHEREAS, CACO and the HRRC desire to simultaneously comply with NEPA and Section 106 of the National Historic Preservation Act (specifically 36 CFR 800) through preparation of an EIS; and

WHEREAS, the office of the Massachusetts State Historic Preservation Officer (SHPO) is reviewing the Undertaking in compliance with applicable federal and state regulations; and

WHEREAS the Advisory Council on Historic Preservation (ACHP) and the Tribal Historic Preservation Officers (THPOs) of the federally recognized Wampanoag Tribe of Gay Head

(Aquinnah) and the federally recognized Mashpee Wampanoag Tribe have been invited to consult on the Undertaking; and

WHEREAS, the Area of Potential Affect (APE) for the Undertaking is the portion of the project area subject to restored tidal exchange in the Herring River estuary as simulated by a hydrodynamic model developed by the Woods Hole Group, Inc. (WHG 2012), and designated upland areas where construction-related impacts may occur, as designated on the attached Appendix A; and

WHEREAS, the potential remains for the presence of unidentified archeological resources that may be eligible for the National Register of Historic Places within the APE for the Undertaking, and this programmatic agreement will guide the identification, evaluation, and protection processes for these resources to comply with the requirements of the combined NEPA/NHPA process and Massachusetts state regulations; and

NOW, THEREFORE, the SHPOs, THPOs and CACO agree that the project shall be implemented in accordance with the following stipulations in order to take into account the effects of the undertaking on the archeological resources of Herring River Basin.

Stipulations

CACO shall ensure that the following measures are carried out:

1. Scaled existing and proposed conditions Project plans for the preferred alternative shall be provided to all signatories for their review and comment as they are developed;
2. An intensive (locational) archaeological survey shall be conducted by an archaeological consultant meeting qualifications standards within the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation. The survey will be performed within all archeologically sensitive portions of the Undertaking's impact area as defined within "Phase IA Archeological Background Research and Sensitivity Assessment, Herring River Tidal Restoration Project, Cape Cod National Seashore, Towns of Wellfleet and Truro, Barnstable County, Massachusetts. (PAL, Inc. 2011). This survey shall meet all requirements for such an investigation stipulated within 950 CMR 70;

This investigation will be conducted under an Archaeological Resources Protection Act (ARPA; 16 U.S.C. 470aa-mm and its regulations (43 CFR 7) permit and a State Archaeologist's permit for intensive (locational) archaeological testing (950 CMR 70.11);

Prior to issuance of permits, detailed plans for the intensive (locational) archaeological survey shall be developed in consultation between CACO, the SHPO, THPOs, and as appropriate, other consulting parties. The survey will be implemented in archeologically sensitive areas of proposed ground disturbance prior to any construction activities;

Archaeological collections recovered from NPS lands within the survey area will be cataloged using NPS systems to Northeast Region standards and shall be curated at CACO; materials recovered from non-federal public or private lands will be cataloged

and curated according to 950 CMR 70 guidelines. The NPS and its consultant will make every effort to ultimately keep all federal and non-federal collections together at CACO. It is anticipated that given the limited amount of non-federal lands identified as being archeologically sensitive and subject to project disturbance that the NPS and its consultant will be able to work on a case-by-case basis with state, town and private landowners to achieve this goal.

The completion of intensive survey testing on private property will be contingent on permission of the landowner.

If archaeological resources are identified, CACO shall apply the National Register Criteria of Eligibility (36 CFR 60), and consult with the SHPO and THPOs to develop and implement a plan, that may include archaeological site examination and/or archaeological data recovery, to avoid, minimize, or mitigate any adverse effects to significant and National Register eligible archaeological resources (36 CFR 800.4 -5).

3. CACO shall provide the SHPO and the THPOs with review copies of the technical report(s) of all field and laboratory investigations (including monitoring) in accordance with the State Archaeologist's permit regulations (950 CMR 70) and according to a schedule to be specified in the State Archaeologist's permit application and technical proposal. The final technical report will be prepared by the archeology contractor. To expedite the review process, management summaries and end-of-field letters may be used to communicate the findings for individual phases of the project. No ground disturbing activities will occur in areas subject to archaeological investigations until the results of archeological investigations for that area have been reviewed by the NPS, SHPO and THPOs. Two copies of the final technical report(s), MHC archaeological site inventory forms, and a CD-ROM with the report abstract and bibliographic information will be submitted to the MHC for all technical reports produced as a result of the Project.
4. CACO shall ensure the performance of all archeological activities associated with that portion of the design/build contractor's construction work that relates to the stipulations in this PA and to resource preservation. Personnel from the Northeast Region Archeology Program (NRAP) will provide technical oversight to assist the permittee in compliance with all aspects of the ARPA and State Archeologists permits that will guide this investigation.
5. CACO shall insure compliance with NPS Management Policies and adherence to the policies of the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation and to the NPS's Cultural Resources Management Guidelines, Release 5, 1998. CACO will coordinate all submissions to the SHPO and THPOs for review and concurrence.
6. TRIBAL CONSULTATION

The Tribal Historic Preservation Officers (THPOs) of the Wampanoag Tribe of Gay Head-Aquinnah and the Mashpee Wampanoag Tribe will be consulted on all ground disturbing activities resulting from the restoration of the Herring River estuary and will be given the opportunity to comment on the development of and subsequent results of all

archeological investigations and any prehistoric and historic materials uncovered during archeological excavations.

The Mashpee Wampanoag tribe maintains a NAGPRA database that documents known burials that may be present within and around the current APE. This database shall be consulted during the development of the plans for the intensive (locational) survey. Any known burials shall be avoided during the survey. Unknown burials that may be discovered either during the survey or during construction shall be treated in compliance with the terms of Stipulation 8 below.

Ground disturbing activities will be considered to include archeological testing, and THPOs will be notified a minimum of two weeks in advance of the initiation of testing and construction.

7. SHPO REVIEW SPECIFICATIONS:

All submittals to the SHPO shall be in paper format and shall be delivered to the SHPO's office by US mail, by a delivery service, or by hand. Plans and specifications submitted to the SHPO shall measure no larger than 11" x 17" paper format (unless another format is specified in consultation). The SHPO shall review and comment on all adequately documented project submittals within thirty (30) calendar days of receipt.

8. POST-REVIEW DISCOVERIES:

8a. CACO shall notify SHPO, THPOs and other signatories if previously unidentified archaeological resources or if human remains are discovered during archeological and construction activities, and shall cease all work at that location, and protect the location from further impacts. CACO, SHPO, THPOs and signatories shall consult pursuant to 36 CFR 800.13. CACO shall apply the National Register Criteria of Eligibility (36 CFR 60), and consult with the SHPO and federally recognized Indian tribes that may attach religious or cultural significance to the affected property to develop and implement a plan to identify and evaluate, and to avoid, or mitigate any adverse effect to, the historic or archaeological property, or to the human remains found on non-federal property consistent with the Native American Graves Protection and Repatriation Act (NAGPRA, 25 U.S.C. 3001 et seq and implementing regulations at 43 CFR 10), and the Massachusetts Unmarked Burial Law (Massachusetts General Laws, Chapter 38, § 6; Chapter 9, §§ 26A and 27C; and, Chapter 7, § 38A; all as amended) and in a manner consistent with the ACHP "Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects" (February 23, 2007; <http://www.achp.gov/docs/hrpolicy0207.pdf>).

8b. Any non-Native American human remains found on non-federal property shall be treated in accordance with the Massachusetts Historical Commission "Policy and Guidelines for Non-Native Human Remains Which Are Over 100 Years Old or Older," and in a manner consistent with the ACHP "Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects" (February 23, 2007; <http://www.achp.gov/docs/hrpolicy0207.pdf>).

9. Should disagreements arise between NPS and SHPO during the course of the undertaking or implementation of this Programmatic Agreement, comments will be requested from the ACHP.
10. Amendments. Any party to this PA may propose to CACO that this PA be amended, whereupon CACO shall consult with the other parties to this PA to consider such an amendment.
11. Termination.
 - 11A. If CACO determines that it cannot ensure implementation of the terms of this PA, or if the SHPO determines that the PA is not being properly implemented, CACO or SHPO may propose that this PA be terminated.
 - 11B. The party proposing to terminate the PA shall so notify all parties to this PA, explaining the reasons for termination and affording them at least thirty (30) days to consult and seek alternatives to termination.
 - 11C. If the terms of this PA have not been implemented by January 1, 2017, this PA shall be considered null and void, and CACO, if it chooses to continue with its participation in the restoration, shall re-initiate its review in accordance with 36 CFR 800.

Massachusetts State Historic Preservation Office:

Brona Simon

October 30, 2014

 Brona Simon, SHPO, Massachusetts State Historic Preservation Officer Date

Advisory Council on Historic Preservation:

 Reid Nelson, Director, Office of Federal Agency Programs Date

Mashpee Wampanoag Tribal Historic Preservation Department:

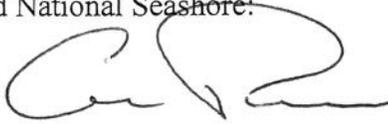
 Ramona Peters, THPO Date

Wampanoag Tribe of Gay Head-Aquinnah Cultural Resource Protection Department:

Bettina Washington, Tribal Historic Preservation Officer

Date

Cape Cod National Seashore:



11/6/14

George Price, Superintendent

Date

8.B Herring River Adaptive Management Plan

(See following pages)

8.B. Herring River Adaptive Management Plan

The Project proposes to use a process called “adaptive management” to aid in its performance of the Project. Following adaptive management guidelines, decisions about restoration of tidal flow will be formally analyzed and evaluated while water quality, vegetation, tide levels, salinity, sediment movement and other environmental and socioeconomic factors are monitored and compared with pre-restoration conditions and expected changes. The rate of tidal restoration can be slowed, reversed, or increased based on the system response as indicated by monitoring data. The Project’s approach to adaptive management is described below.

A. What is Adaptive Management?

Adaptive management is an inclusive and formal iterative process of making predictions regarding outcomes of management, monitoring the system after management actions are implemented, comparing the predicted outcomes to the observed outcomes, and using the result to formally update our understanding of the system response to our actions. Information obtained from post-implementation monitoring improves our ability to predict future outcomes and make better decisions regarding the selection of appropriate future management actions.

Adaptive management is an extension of the general principles of structured decision-making (SDM), an approach that was developed in the mid-20th century for applications in engineering, operations research, and economics. Adaptive management is a specific application of SDM characterized by those conditions mentioned above, with a focus on reducing the specific uncertainties that hinder our ability to make the best management decisions (Williams and Johnson 1995). Having been applied to natural resource management since the 1970s (Walters and Hilborn 1978), SDM is a logical framework for making decisions by distinguishing those components of a decision that are subjective and values-oriented from those that are objective and science-based. A SDM framework guides a transparent decision-making process by explicitly linking the anticipated outcomes of management alternatives to well-defined objectives and factoring how varied stakeholder viewpoints value these outcomes.

Adaptive management requires careful planning, which can be described as a two-step process: a setup phase and an implementation or iterative phase. In the setup phase, essential components of the decision or problem being faced are identified and developed. The components of the setup phase include:

1. A clear definition of the problem being addressed;
2. Specific objectives to be achieved;
3. Potential policies or management actions (also referred to as alternatives or decisions) that can be selected;
4. Predicted outcomes or consequences of each action with respect to the stated objectives;
5. A method for assessing trade-offs among competing objectives and identifying the policy, decision, or action that is most likely to achieve the objectives; and
6. A monitoring program designed to track outcomes of selected management activities to assess progress towards achieving objectives and to compare with predictions.

The iterative phase involves implementing management actions and the directed monitoring program so that progress can be measured and the predicted outcomes of the action taken can be compared with the actual observed outcomes. As the iterative phase progresses, knowledge of the resource and the

effectiveness of the selected management activities is increased, thereby reducing uncertainty and enhancing the ability to predict the outcomes of subsequent management actions. Reassessment of management alternatives with improved predictions of outcomes can lead to identification of a different strategy as the best management approach to achieving the objectives. Additionally, information and understanding gained during the iterative phase can be used to reassess elements of the initial setup phase, potentially leading to modified or refined objectives, new management actions, or changes to the monitoring approach.

B. Rationale for Adaptive Management for the Herring River

Adaptive management differs from 'trial and error' and other reactive decision-making processes. Trial and error approaches simply reject an action that failed to elicit a desired outcome. Adaptive management is a process for decision making under evolving conditions that promotes flexibility by adjusting decisions as outcomes from management actions and other events become better understood. By collecting data to track the system's response to management we can compare our predicted the actual outcomes and improve our understanding of system behavior.

The Herring River Restoration Project is highly conducive to an adaptive management approach. The project involves a broad range of potential system responses to management that make it difficult to determine the best restoration policy and the need to repeat decisions over time. Therefore, an adaptive management framework is the most efficient method for evaluating restoration decisions related to managing tidal exchange within the Herring River estuary.

Collaboration and support of the US Geological Survey (USGS) was initiated by the HRRC in 2014 to begin development of a formal adaptive management decision structure that will help guide management decisions and measure progress toward specific ecological and sociological objectives during restoration of the Herring River. USGS decision scientists are working collaboratively with the project team, Friends of Herring River, other scientists, stakeholders and other interest groups to develop the Herring River Adaptive Management Plan (HRAMP). The HRAMP establishes the framework for decision making on how to operate adjustable tide gates at the new CNR bridge to maximize the ecological benefits of restoring tides to the Herring River estuary while minimizing adverse impacts. The varied effects of opening the tide gates using different management policies encompassing time spans ranging from 5 to 25 years are being analyzed to identify the most advantageous policy for tide gate management. Decision support software has been developed for use by the project team to compare policy options and evaluate trade-offs and uncertainties represented by a comprehensive set of project objectives. Development and testing of the decision framework has been completed. Predictions for the full suite of ecological and socio-economic objectives are being developed and trade-off and risk sensitivity analyses are being conducted to complete a fully operational decision-analysis framework.

The technical team is the primary group that will analyze monitoring data, complete project assessments, and formulate management options for the consideration by the formal decision making group, the Herring River Executive Council (HREC). Tide gate management is expected to continue to the point when gates are open to their fullest extent to achieve the maximum allowable tidal range. In addition to the primary restoration action of increasing tide range, secondary actions will also be implemented before, during, and after the period of tide gate management.

The development of the HRAMP follows a structure common to a decision analysis process:

- Define a comprehensive problem statement,

- Identify management objectives and policy options,
- Predict consequences of the policies,
- Evaluate predicted outcomes considering trade-offs and risk in order to recommend implementation of a preferred policy,
- Design and implement targeted monitoring program to first evaluate baseline conditions and then assess outcomes of management actions.

Each of these is discussed in the following sections.

C. Define a Comprehensive Problem Statement

An effective adaptive management plan requires a clear definition of the problem, or problems, to be addressed in order to identify why the decision needs to be made, and the individuals who can make the decision. Individuals or groups that have an interest in the resources affected and a willingness to work with others on the problem (i.e., stakeholders) should be identified. The problem statement should briefly state the potential range of actions that can be taken, the spatial and temporal scale of the problem, the frequency and timing of the decision(s), the complexity of the problem, uncertainties that make decision making difficult, and any legal, financial, regulatory, or political constraints.

The HREC is the decision-making body that will determine how to manage tide gates while seeking to maximize benefits and minimize adverse impacts over some finite length of time for restoring the Herring River estuary. It is comprised of 2 CCNS representatives (the superintendent and his/her appointee), two Town of Wellfleet (“Town”) Selectboard representatives, and the Town manager.

The primary management actions involve decisions regarding the volume of tidal flow permitted through a series of newly constructed tide gates at the three different locations; these actions involve decisions regarding the number, location, magnitude of opening, and flow direction at the individual tide gate openings at any given time. Timing and frequency of gate operations can be periodic or episodic, coincident with extreme predicted high tides and coastal storm events. At each decision point, one or more gates can be raised or lowered or not changed.

The Project will also implement secondary management actions to accelerate or maximize the recovery of estuarine habitat, enhance the benefits of tidal restoration, and avoid or reduce potential adverse ecological and socioeconomic impacts of restored tidal flow. Secondary actions include management of floodplain vegetation, modification of marsh surface elevations through management of sediment supply and distribution, and restoration of connectivity and natural sinuosity of tidal creeks to enhance the circulation of salt water through the system. Decisions regarding secondary actions will involve where and when to implement management measures, what techniques to use, and how to best coordinate the actions with the tide gate management. Specific details for most of these measures cannot be known until some degree of tidal flow is restored and monitoring information is gathered about how the Herring River system is responding.

Tide gate management is expected to continue until the point when gates are open to the extent permitted under Phase 1 and the maximum allowable tidal range has been reached. Secondary actions may be implemented before, during, and after the period of tide gate management. Within the project area, decisions involving management of the tide gates will be spatially and temporally separated by the sub-basins. Tide gate management will begin soon after construction of the tidal control structures is

complete. The temporal and spatial resolution of monitoring data outputs used to make condition-based decisions will drive the frequency and timing of tide gate operations.

Secondary actions may range from simple independent decisions, to complex decisions that are conditionally linked to other management actions. The timing of some secondary actions may have a temporal relationship with the tide gate operations, thus requiring coordination with the tide gate management process. For example, removal of vegetation may be recommended to occur prior to restoration of extensive tidal exchange to facilitate work in more conducive, drier conditions.

Tide gate management decisions and secondary action decisions will be based on:

1. Predicted outcomes for multiple project objectives that result from tide gate changes; and
2. The expected range of outcomes in system response to the actions taken.

In general, the range of expected outcomes for tidal conditions (e.g., water surface elevations, tide range) are quite narrow for specific tide gate configurations. However, the ranges of outcomes driven by salinity and sediment transport are broader for individual tide gate openings.

Decisions about tidal gate adjustments will be legally mandated and subject to regulatory oversight under the US Clean Water Act, the Coastal Zone Management Act, the MA Wetlands Protection Act and Waterways regulations, the Towns of Wellfleet and Truro wetland by-laws, and the MA Endangered Species Act. Tide gate management decisions will be constrained by actions deemed necessary to protect public and private structures within the project area; e.g., at the end of the permitted Phase 1 of the project, the maximum mean daily high tide elevations would be limited to 3.6 feet in the Lower Herring River and 2.5 feet NAVD88 within the Mill Creek sub-basin while no tidal flow would be allowed into Upper Pole Dike Creek.

D. Identify Policy Objectives and Management Outcomes

1. Objectives

Defining project objectives starts with considering what you care about: what is to be achieved and what to avoid. The focus is on achieving ecological and socio-economic objectives using quantifiable metrics to evaluate progress towards achievement of well-defined restoration goals. Clearly defined objectives are the foundation of any decision process. In adaptive management, predicting the consequences of available actions in terms of measurable objectives provides a clear path for identifying the best performing strategy. Thus, the analysis starts with defining the objectives.

To facilitate the analysis, complex sets of objectives are organized hierarchically. Fundamental objectives articulate the over-arching reasons decision-makers are interested in a particular decision. The fundamental objectives can be generically categorized as benefits (restored ecosystem functions and services) and costs or constraints (potential adverse effects and project costs). Each fundamental objective is made up of, or is influenced by, several sub-objectives and each sub-objective is matched to a performance measure.

Performance measures are developed at the most logical level in the hierarchy, with the aspiration to measure performance of the fundamental objectives directly.

Performance measures must serve two purposes: 1) to predict how well a management strategy is expected to meet each of the objectives (i.e., models are used to make predictions), and 2) to provide

metrics useful for monitoring; i.e., to determine how the system is responding to implementation of a management action and to evaluate progress towards achieving stated objectives. Comparison of the projected and observed performance measure is the basis for learning in adaptive management. The monitoring needs for adaptive management will be matched to on-going and planned monitoring programs to identify gaps and avoid duplication.

Beginning in 2014, the USGS decision-analysis technical team began to collaborate with project technical advisors, Friends of Herring River, Woods Hole Group, and community stakeholders to identify, define, and specify the objectives hierarchy for the HRAMP. This process was conducted over numerous phone conferences, in-person workshops, and public meetings. A process to develop a prototype adaptive management framework was substantially completed by the end of 2017. Objectives and their measurable attributes will continue to be refined and modified as the AM planning process continues and the project moves into the implementation phase. In addition to identifying fundamental objectives and their associated sub-objectives, the team developed detailed definitions and specifications for each objective including performance measures, monitoring methods, units of measurements, spatial and temporal scales of measurement, and desired direction of change (i.e. minimize or maximize).

For the Project, the fundamental objectives are derived, in part, from NPS management policies as articulated in the current General Management Plan for the CCNS, which states that the objective for managing coastal wetlands is to “Restore the natural hydrography and ecology of estuaries in consultation with affected municipalities” (NPS 1998). This broad policy has been applied to the Herring River project more explicitly through the Adaptive Management Plan, with development of a set of overarching fundamental objectives to restore the ecosystem by:

- Restoring natural hydrography, including tide range and topography / bathymetry;
- Restoring ecological function and integrity, including salinity, water quality, and aquatic habitat quality;
- Minimizing adverse impacts to ecological, cultural, and socioeconomic resources;
- Maximizing ecosystem services (i.e., benefits people receive from the estuary);
- Minimizing the costs of restoration; and
- Maximizing understanding of the project effects to federal- and state-listed rare, threatened, and endangered species.

The hierarchy of fundamental objectives, sub-objectives, performance measures, predictive methods, and monitoring design is summarized in Table 8B-1.

Table 8B-1. Objectives and Performance Measures for Herring River Adaptive Management Plan

Fundamental Objective #1: Restore Hydrography			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
Restore Tidal Range			
<i>Restore Low Tide</i>	Maximum/Minimum Water Surface Elevations Averaged for Sub-Basins and at Key Locations	EFDC ¹ Hydrodynamic Model	Electronic Water Level Data Loggers for Sub-Basins and at Key Locations
<i>Restore High Tide</i>			
Restore Hydroperiod			
<i>Frequency of flooding</i>	Wetting/Drying of Marsh Surface Averaged at Key Locations	EFDC Hydrodynamic Model	Electronic Water Level Data Loggers for Sub-Basins and at Key Locations
<i>Duration of flooding</i>	Duration of Inundation of Marsh Surface at Key Locations		
Maximize Marsh Surface Drainage	Extent of Poned Water at Low Tide	EFDC Hydrodynamic Model	Electronic Water Level Data Loggers in Areas of Predicted Ponding
Maximize Marsh Surface Elevation			
<i>Marsh surface sediment deposition</i>	Accumulation of Sediment at Key Marsh Surface Locations	Baseline Data; Published Values; Expert Judgment/Elicitation	Deposition/Elevation at Surface Elevation Tables and Markers
<i>Below ground organic matter & pore space volume</i>	Soil Organic Matter and Bulk Density	Baseline Data; Published Values; Expert Judgment/Elicitation	Soil Sampling Associated with Marsh Surface Elevation Monitoring Sites
Fundamental Objective #2: Restore Ecological Function/Integrity			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
Maximize area restored			
<i>Appropriate salinity gradient</i>	Water Column Salinity Values Averaged for Sub-Basins and at Key Locations	EFDC Hydrodynamic Model	Conductivity Data Loggers for Sub-Basins and at Key Locations

¹ Environmental Fluid Dynamics Code (Hamrick, J. M., and T. S. Wu. 1997)

Fundamental Objective #2: Restore Ecological Function/Integrity			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
<i>Coverage of New England halophytes</i>	Coverage of Native Estuarine Vegetation Types	SLAMM ² Informed by EFDC Model Output	Transect/Plot Cover Estimates; Habitat Mapping
Maximize habitat quality for native estuarine animals			
<i>Water Quality</i>	Dissolved Oxygen, pH, Residence Time (Flushing), Ammonium	USGS Nutrient Flux Model ³ ; Expert Judgment/Elicitation Informed by EFDC Model	Synoptic Surface Water Quality Monitoring at Key Locations
<i>Benthic Community</i>	Species Composition of Benthic Invertebrate Community	Published Values; Expert Judgment/Elicitation	Benthic Sampling at Key Locations
Maximize connectivity for diadromous fish	Flow Velocity at Culverts/Crossings	EFDC Hydrodynamic Model	Fish Passage Success; Velocity at Culverts

Fundamental Objective #3: Minimize Adverse Impacts			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
Minimize risk to public safety			
<i>Minimize risk to public at water control structures</i>	Probability of Water-related Incidents	Tidegate Configuration	Observations of Activity During Peak-use Periods
<i>Minimize risk to public elsewhere</i>	Probability of Boating, Transportation, Recreation Incidents in Project Area	Expert Judgment/Elicitation	Observations of Activity During Peak-use Periods
Minimize adverse impacts to shellfish beds in harbor			
<i>Minimize excess nitrogen export</i>	Ammonium Concentration Near Aquaculture Areas	Baseline Data; Published Values; Expert Judgment/Elicitation	Surface Water Quality Monitoring Near Aquaculture Areas

² Sea Level Affecting Marshes Model (Clough, J. et al. 2012)

³ USGS Nutrient Model (Colman, J. in proc.)

Fundamental Objective #3: Minimize Adverse Impacts			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
<i>Minimize fecal coliform levels</i>	Fecal Coliform Counts Near Aquaculture Areas	Baseline Data; Published Values; Expert Judgment/Elicitation	Surface Water Quality Monitoring Near Aquaculture Areas
Minimize loss of privacy for abutting property owners	Probability of Complaints	Water Surface Elevations and Vegetation Change from Models	Documentation of Incidents
Maximize aesthetics			
<i>Maximize views from public vantage points</i>	Horizontal Viewing Distance from Key Locations	Vegetation Change from SLAMM	Time Series Photo Stations
<i>Minimize negative appearance of dead woody veg</i>	Probability of Complaints	Vegetation Change from SLAMM	Time Series Photo Stations
<i>Minimize hydrogen sulfide smell</i>	Probability of Complaints	Expert Judgment/Elicitation	Documentation of Complaints
Minimize community conflict	Probability of Issues Lacking Community Consensus	Expert Judgment/Elicitation	Documentation of Conflicts and Resolutions

Fundamental Objective #4: Maximize Ecosystem Services			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
Maximize Natural Mosquito Control	Species Composition and Abundance	EFDC Output for Ponding and Salinity; Expert Elicitation	Larvae Counts in Breeding Areas
Maximize greenhouse gas sequestration	Rate of Horizontal and Vertical GHG Fluxes	WBNERR GHG Model ⁴ Informed by EFDC Hydro Model Output; Expert Elicitation	Atmospheric Carbon Exchange; Soil Carbon Accumulation
Maximize shellfishing opportunities (above & below dike)	Acres of Open Shellfishing Areas	EFDC Hydrodynamic Model	Fecal Coliform Counts
Maximize recreational opportunities			

⁴BWM Wetland GHG Model (Abdul-Aziz, O. and Ishtiaq, K. 2015)

Fundamental Objective #4: Maximize Ecosystem Services			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
<i>Minimize loss of existing recreational opportunities</i>	Number of Access Points, Parking Areas	Expert Judgment/Elicitation	Documentation of Lost/Gain of Access Points
<i>Maximize newly created recreational opportunities</i>	Rate of Increased Recreation Use of Project Area	Expert Judgment/Elicitation	Car Counts; User Surveys; Observations of Activity During Peak-use Periods

Fundamental Objective #5: Minimize Cost			
<i>Sub-Objectives:</i>	<i>Performance Measures:</i>	<i>Predictions</i>	<i>Monitoring</i>
Minimize time to reach fullest extent of restored tide range	Time to reach maximum tide range	Expert Judgment/Elicitation	Project Timeline/Financial Records
Minimize cost for secondary actions	Cost for secondary actions	Expert Judgment/Elicitation	Project Timeline/Financial Records
Minimize cost for tide gate operations	Cost for tide gate operations	Expert Judgment/Elicitation	Project Timeline/Financial Records
Minimize cost for monitoring	Cost for monitoring	Expert Judgment/Elicitation	Project Timeline/Financial Records

2. Policy Options

Tide Gate Management Policies

The need to control tidal exchange at the Chequessett Neck Road inlet to the Herring River system resulted in the design of a unique bridge and tide gate structure that consists of a number of tidal control elements that reside beneath the road of the proposed bridge. The complex nature of the proposed structure is the key for allowing the adaptive approach to incrementally restore tidal influence to Herring River. The structure design allows varied flow dynamics due to the large number of available tide gate configurations.

To investigate a range of plausible gate management strategies, the USGS and the HRRC developed a series of seven potential restoration trajectory scenarios, referred to as “platform policies”, which encompass a representative range of restoration timelines, frequency and size of gate adjustments, and management priorities. Figure 8B-1 outlines the annual projected mean high water (MHW) elevation in the Lower Herring River sub-basin for each policy at each year of implementation

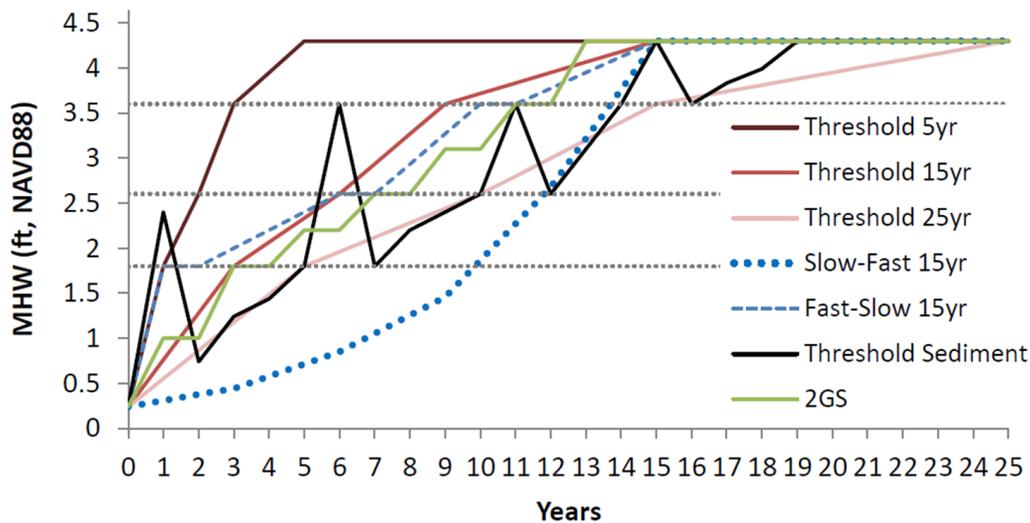


Figure 8B-1. Comparison of Predicted Mean High Water (MHW) Levels for the Full Herring River Restoration Project in the Lower Herring River Sub-basin Among Different Platform Policies. Maximum MHW elevations would not exceed 3.6 feet (NAVD88; top dotted line) for Phase 1 of the Project

Platform policies titled “Threshold 5 year”, “Threshold 15 year” and “Threshold 25 year” consist of a time series of incremental tide gate openings that uniformly increase the MHW level in the Lower Herring River sub-basin from the existing elevation to a fully open (i.e. all tide gates set at a 10-foot height opening across the structure’s 165-foot width) MHW condition of 4.3 feet in the defined number of years (i.e. 5, 15, or 25 years) in a relatively linear manner (Figure 8B-1). The “Slow-Fast 15 year” and “Fast-Slow 15 year” policies take contrasting approaches; the “Slow-Fast 15 year” policy changes the tidal range slowly at first, requiring 10 years to reach the 1.8 feet MHW elevation, and then increases the MHW quickly in the last few years to reach a fully

open MHW condition of 4.3 feet (3.6 feet for Phase 1) by the 15th year, while “Fast-Slow 15 year” alters the tidal range quickly to reach the 1.8 feet MHW threshold in the first year, and the proceeds slowly to the final MHW elevation of 4.3 feet (3.6 feet for Phase 1) over the next 14 years. The “2GS” and “Threshold Sediment” policies have specific ecological objectives. The “2GS” platform policy is designed so that each gate opening configuration would remain in place for two growing seasons, with the assumption that vegetation would have time to establish during the new interim conditions. The “Sediment” platform policy is designed to have periodic but temporary large tide gate openings (concurrent with annual or storm tide events) that would promote large amounts of marine-derived sediments to be transported into the Herring River estuarine system to enhance deposition on the subsided former salt marsh surface, followed by periods when the gates would be reconfigured to reduce the tidal range in Herring River. As outlined in Figure 8B-1, these larger tide ranges (i.e. larger gate openings) would occur years 1, 6 and 11 for analytical purposes only; the actual implementation of this policy is dependent on the occurrence of unpredictable tidal events. To achieve a particular MHW elevation, a particular combination of tide gate openings is necessary. Table 8B-2 outlines the number and height of open tide gates that would be necessary to achieve the interim water surface elevations for each of the platform policies.

Table 8B-2. Lower Herring River Mean High Water (MHW) Estimated Modeled Elevations (NAVD88, feet) Predicted for Various Tide Gate Configurations at Chequessett Neck Road

Tide Gate Configuration		MHW Elevation (ft, NAVD88)
Number of Gates	Gate Height (ft)	
1	1	-0.96
1	2	-0.27
1	8	0.37
2	1	-0.27
2	2	0.59
4	1	0.6
7	1	1.43
2	6	1.81
5	2	1.95
6	2	2.19
3	10	2.51
4	6	2.76
4	8	2.94
5	6	3.03
6	6	3.23
7	10	3.63

These tide gate management strategies are referred to as “platform” policies because they provide the baseline conditions for analysis of project impacts to which secondary management activities can be added to improve performance with respect to specific project objectives. Secondary management actions are those other than changes to tide gate configuration and

include direct management of vegetation and sediment, connectivity of tidal channels and pools, and mitigation of potentially adverse project impacts. Secondary actions would be implemented in addition to tide gate management to improve overall policy performance. The purpose of the decision analysis process are to (1) identify the best performing tide-gate management approach, (2) incorporate secondary actions to improve performance, and (3) select the overall management strategy (tide-gate policy plus secondary actions) that provides the best outcomes across the objectives. The location, timing, and other details of secondary actions cannot be anticipated in most cases until an initial policy is implemented and some degree of tidal exchange is restored. The ability to direct secondary actions in reaction to system responses to the implemented tide gate policy is one way of learning from and adapting management as restoration progresses.

Vegetation Management

Vegetation management is a class of project activities, along with incremental tidal restoration and facilitating the recovery of natural tidal marsh channel networks and elevation that are being pursued as part of the adaptive management plan. This section provides a general description of activities, methods, and effects. This information will be supplemented and refined during project implementation and presented by the project team when appropriate in detailed, site-specific Vegetation Treatment Plans (VTPs) for review and comment by the Regulatory Oversight Group and Herring River Stakeholder Group (HRSRG), and approval by the HREC.

As Phase 1 is implemented, salt water will cause decline and mortality to much of the herbaceous and woody freshwater-dependent and upland vegetation that has colonized the floodplain. If left standing, dying and dead trees and larger shrubs could hamper the recolonization of native salt marsh plant communities. In some areas currently dominated by herbaceous, freshwater-dependent emergent plant species, the non-native, invasive common reed (*Phragmites australis*) could expand which would have a number of deleterious ecological and socioeconomic effects, including displacement of native vegetation and a reduction in habitat quality for fish and wildlife. The specific goal for managing vegetation as part of the Herring River Restoration Project is to support the long-term, sustainable recolonization of native estuarine vegetation as tidal range, salinity and sediment transport processes are restored.

Vegetated areas that will be affected at each stage of tidal restoration were identified by comparing NPS vegetation cover type data with spatial data output from the hydrodynamic model. Active removal and management of vegetation will be limited to the emergent marsh areas with existing occurrences of common reed, as well as shrublands, and woodlands. Within the area of the Herring River floodplain affected by regular tidal inundation up to the Phase 1 project limit, approximately 43 acres is currently dominated by common reed, most of which occurs within the Lower Herring River sub-basin. Shrublands comprise about 179 acres and are scattered throughout all of the Herring River sub-basins with the exception of Bound Brook. The largest contiguous stands of shrubland currently occur in portions of Duck Harbor, Lower Pole Dike Creek, and the Upper Herring River sub-basins. Woodlands currently make up approximately 126 acres of the Phase 1 project area, with most stands occurring in the Lower Herring River, Mid-Herring River and Lower Pole Dike Creek sub-basins. In total, up to approximately 348 acres within the Herring River floodplain could require some form of vegetation management as part of Phase 1 of the Project.

Vegetation management will be conducted incrementally and be closely coordinated with CNR Road tide gate management and the resulting increases in water surface elevations, tidal range, and salinity. Generally, vegetation management operations would be conducted before tidal flows are reintroduced to a given area before the ground surface is affected by salt or brackish water. Inundation with saltwater that promptly follows vegetation removal is expected to be highly effective for preventing or limiting regrowth of undesirable species and is expected to foster re-colonization of native estuarine plant communities.

In general, woody species management will be conducted under the oversight and guidance of the CCNS Fire Management Program, contingent on availability of future funding to augment personnel and equipment above present levels. The CCNS Fire Program is implemented according to the Fire Management Plan (FMP), which was reviewed and approved by the National Park Service through the National Environmental Policy Act. The Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for this program (NPS 2007) authorize mechanical and prescribed fire treatment of up to 500 acres per year within the CCNS boundary. The FMP identifies and maps 21 treatment area categories where activities are authorized for specific purposes, including all tidally restricted wetlands under NPS jurisdiction for the purpose of resource management and maintaining a safe urban-wildlife interface. The entirety of the federally-managed portion of the Herring River project area is within the authorized area for FMP activities. In collaboration with the NPS Integrated Pest Management Program, management of common reed, is also authorized by the FMP.

Prior to the reintroduction of tidal influence to the Herring River, vegetated areas expected to be affected at a given stage will be delineated into manageably-sized treatment units. Site-specific Vegetation Treatment Plans (VTP's) will be developed for each treatment unit. VTP's will include, but not be limited to a description of the methods for the removal of above ground tree and shrub material, secondary treatment of downed wood and slash, and the potential use of prescribed fire. Prior to implementation, individual VTP's will be submitted to the Regulatory Oversight Group for comment and approval. Ecological evaluations will be incorporated into the VTP before any treatment activity occurs. An ecological evaluation is an overall assessment of a proposed treatment area which will review possible impacts to vegetation, water resources, and wildlife, and appropriate mitigation measures. Mitigation measures may include, among other elements, specific timing of treatments to minimize impacts and leaving residual coarse, woody debris for animal cover.

If use of prescribed fire is recommended as part of a VTP, prescribed burn plans will be developed to address a full range of factors concerning conditions under which an area will or will not be burned. All burn plans will be based on the guidelines of the CCNS Fire Management Program and will delineate parameters that address how a burn would be implemented including safety factors, a site description, burn objectives, fuel types, weather factors, size of crew, skill set of crew members, and types of required equipment. Additionally, the burn plan would describe conditions that would not allow a burn to take place, including but not limited to smoke exposure to sensitive areas such as residences and roads and firefighter and public safety.

About 31 acres of the Phase 1 restoration area is in private ownership. As tidal range and salinity are progressively restored, the Project will consult with the affected landowners to develop site-specific VTPs for each property that meets both the Project's overall ecological objectives and the owner's preferences. All planning, permitting and on-the-ground work will be funded by the

restoration project. With landowner concurrence, the project will submit individual Notices of Intent with the Wellfleet Conservation Commission and any other required permits. No active vegetation management will be pursued on private lands without landowner approval.

The project will employ measures to avoid adverse ecological and socioeconomic impacts that could potentially be caused by vegetation management. These include:

- Maximizing the amount of work done in winter and during the periods of low visitation by the public
- Maximizing work performed in dry conditions
- Maximizing work done by hand
- Specify use of low ground pressure/amphibious equipment
- Use of erosion controls, including hay bales, silt fences, fiber matting, and other ground surface protections
- Avoiding stump removals and ground disturbance
- Maximizing worker safety

Phragmites Control

Common reed is currently not a dominant plant species within the Herring River floodplain. The roughly 1,100-acre Herring River floodplain currently contains only about 45 acres of common reed. Restoration of tidal exchange will increase water column salinity in the Lower Herring River sub-basin to 20 ppt and higher. This rapid increase in salinity and the higher water levels are expected to quickly stress common reed and lead to die-off and eventual re-colonization of native salt marsh species. Consequently, in the Lower Herring River sub-basin, the restoration of tidal flow will be the primary means of common reed control. However, cutting and removal of material prior to tidal flooding will also be considered.

Because there currently is no salinity in sub-basins upstream of the Lower Herring River, future changes in the coverage, distribution and density of common reed are difficult to predict. As a result, predictions of plant community and habitat changes in the upper portions of the Herring River driven by future incremental increases in salinity are less certain. Following adaptive management protocols, this uncertainty will be reduced as the project is implemented and new monitoring data is collected to refine the salinity component of the hydrodynamic model. Based on documented changes in common reed distribution after tidal restoration commences, it is possible that additional management actions, beyond tidal inundation by high salinity seawater, may be necessary to limit its expansion. During each stage of restoration, as extant freshwater and upland dependent species succumb from low to moderate levels of salinity (approximately 5 to 20 ppt) new areas may become susceptible to common reed colonization.

The initial efforts of a common reed control program in the Herring River will be robust monitoring and early detection involving both:

1. Subbasin specific monitoring of the hydrologic conditions which will be driving vegetation change and,

2. Direct ground and aerial observation and quantification of changes to common reed occurrence and distribution using established transects and plots.

As tides are restored and observations of actual salinity changes are made, the ability to predict subsequent salinity changes will be improved. These improved predictions will direct vegetation monitoring to the areas where the anticipated salinity range would make it more likely for common reed to colonize. If new patches or expanding common reed stands are detected, a decision will be made about whether or not to initiate management. The project team will review all data and other available information and make a management recommendation to the HREC. Since the majority of cases where common reed control will be needed occur within the boundary of CCNS, the NPS will consult with its Integrated Pest Management Program and Exotic Plant Management Team to determine the available Best Management Practices for the given situation.

Generally, some degree of long-term control of common reed can be achieved using a combination of methods to be repeated as necessary. Combined control methods typically involve some form of physical removal followed by techniques that inhibit or limit regrowth. Examples include mowing followed by covering areas with black plastic sheeting or mats and digging out roots followed by regrading and planting of more desirable vegetation that can occupy the site and make it harder for common reed to get established. For the Herring River, one novel method that may be appropriate in some cases would be to mow or cut the stand and then use the Chequessett Neck dike tide gates to maintain high water levels to “drown” the cut stems. Similar techniques have demonstrated some success in other low salinity areas (Smith 2005), but its use in the Herring River will need to be balanced and assessed in concert with other ecological and socioeconomic objectives that may be adversely affected by holding high water levels for extended periods. These and other mechanical and hydrologic-based control methods will be undertaken on a case-by-case basis. Factors to be considered when choosing appropriate methods will be the size and density of the common reed stand, the location and physical character of the site (i.e. accessibility, proximity to the river, degree of soil saturation, etc.), surrounding vegetation and habitat types, and the extent of associated impacts from carrying out the control program, such as erosion and soil compaction from machinery. Common reed control areas will be delineated and specific control methods will be described in Vegetation Treatment Plans, as described previously.

Marsh Management

Restoration of natural stream channel connectivity and marsh surface elevation is a major component of the Herring River Restoration Project. Marsh management is a class of project activities, along with incremental tidal restoration and vegetation management that will be pursued as part of the coordinated adaptive management program.

These activities cannot be described in detail at a site-specific level prior to commencing the restoration and adaptive management program. Many of the locations where this work could potentially be necessary are remote and currently either covered in dense, shrubby vegetation or under water. The work is also dependent on specific vegetation, microtopography, and tidal flow characteristics. Attempting to evaluate potential treatment sites and design future marsh surface restoration actions based on existing conditions is not appropriate since these conditions will change after tidal exchange is restored. Conditions will also vary greatly among locations and for different stages of the restoration process. Therefore, this broad summary is based on the best information available and current projections of how restored tidal flow will generally affect the

project area as well as the types of interventions that are expected to be necessary for restoring natural stream networks and marsh elevation.

Decisions about implementing any of the proposed management methods described herein will be made by the HREC, based on recommendations from the project team and will be based on the overarching ecological and socioeconomic objectives articulated in the Adaptive Management Plan. In a similar manner to what is proposed for the vegetation management program, specific plans for restoration of stream channel networks and marsh elevation will be presented in Marsh Treatment Plans (MTPs) for specific management areas that will be identified and delineated after tidal flow is restored.

Justifications for Marsh Management

Although reintroduction of tidal exchange and salinity is the primary component and main driver for restoration of the Herring River floodplain, several other actions would likely be necessary to reverse other previous direct and indirect alterations of the system's topography, bathymetry, and drainage capacity. After tidal restoration is initiated, these factors could inhibit circulation of saltwater, prevent recolonization of tidal marsh vegetation, create freshwater impoundments, and expand mosquito breeding habitat if not properly managed. The primary issues to be addressed through marsh management are:

- **Loss/subsidence of marsh surface elevation:** Areas of the Herring River are currently up to three feet lower than saltmarsh surfaces around Cape Cod Bay relative to current sea level. This is the result of three factors: 1) on-going sea level rise in Wellfleet Harbor, 2) lack of sediment supply to maintain marsh elevation, and 3) drainage and erosion of saltmarsh peat. At the current elevations with tidal flow restored, these areas would not support saltmarsh vegetation communities and would not drain properly.
- **Sediment entrained in marsh channels, channel blockages:** Lack of tidal flushing for more than 100 years has allowed the accumulation of sediment and organic matter in tidal channels and ditches throughout the floodplain. Normally this material would be distributed and deposited on the marsh plain by tidal flow or remain part of the suspended sediment load of the tidal prism flowing between the river and Wellfleet Harbor. With tidal exchange restored, this trapped sediment could cause obstructions to flow in some locations, especially during early stages when flow velocity may not be fast enough to mobilize material.
- **Historic grid ditching, channelization, water-logged soils:** Like most tidal wetlands in New England, the Herring River floodplain has been dramatically altered by grid ditches created and maintained by regional mosquito control programs since the 1930s. Many stretches of the Herring River have also been channelized to drain the marshes. Ditching and channelization have re-routed the flow of water throughout the floodplain, resulting in drained soils in some locations and continuously saturated, water-logged soils in others. Extensive marsh ditching has also contributed to greater marsh surface subsidence in some locations (see Figure 8B-2).
- **Spoil piles:** As a customary practice, when channels and mosquito ditches were created or maintained the dredged sediment (a/k/a "spoil") was disposed in linear mounds adjacent to the channel being worked on. These spoil piles are frequent along the river and channels and in some places are identifiable by topographic mapping (see Figure 8B-3). With tidal exchange restored, spoil piles could block the circulation of saltwater and impede drainage.

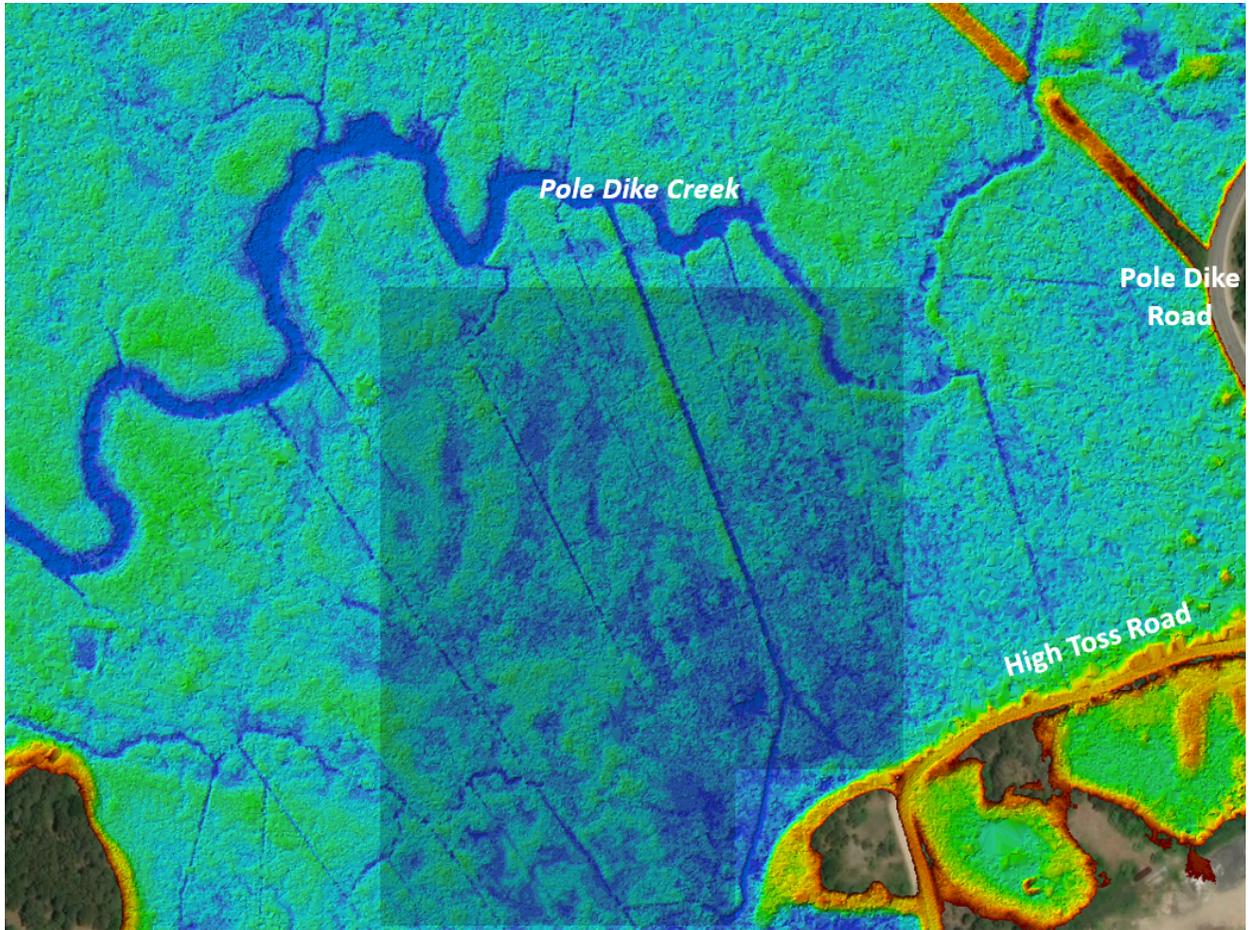


Figure 8B-2. Area North of High Toss Road Where Extensive Grid Ditching Has Led to Severe Subsidence of Marsh Surface (Shaded Area)

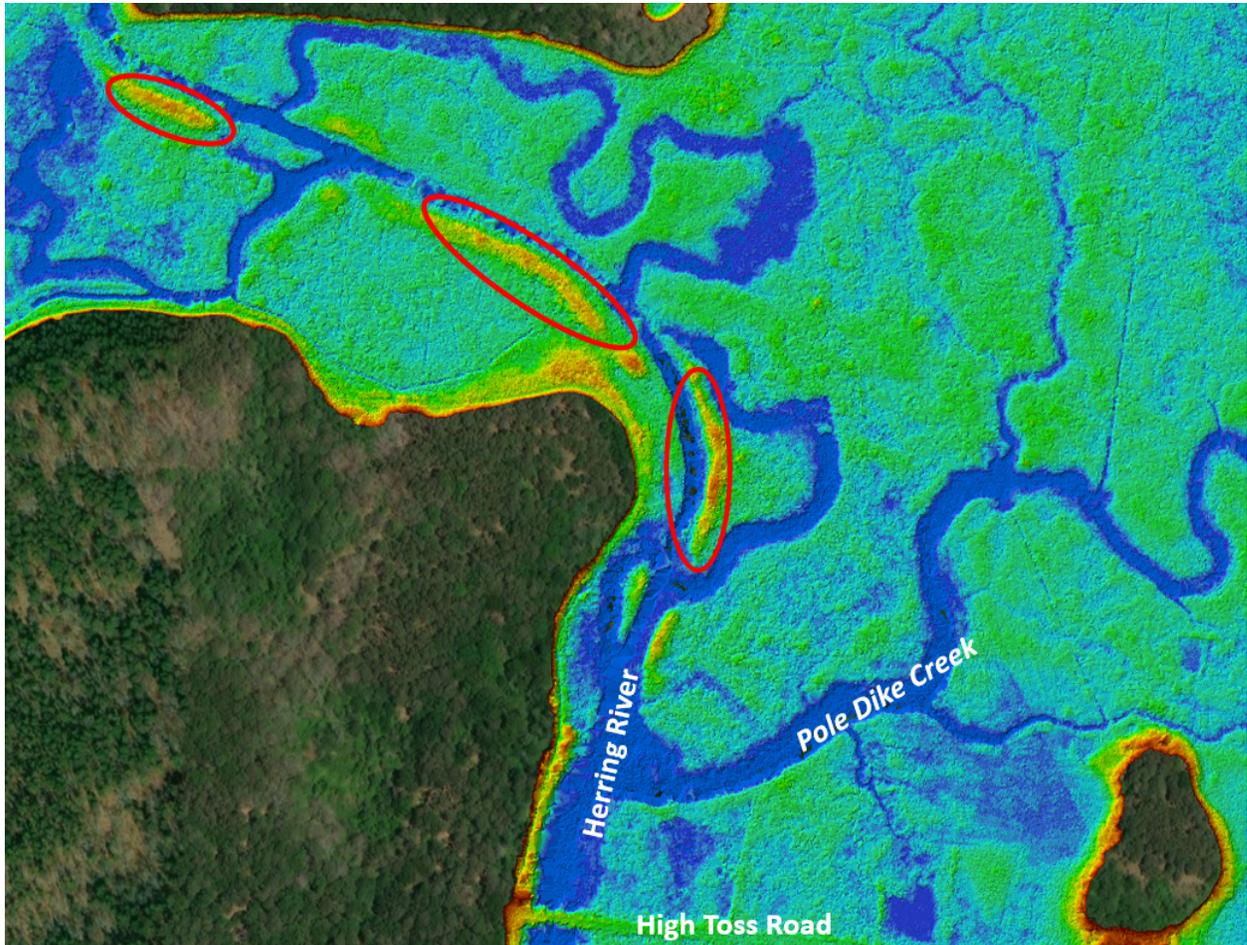


Figure 8B-3. Dredge Spoil Berms (Red Circles) Along Channelized Segments of the Herring River Recognizable with High Resolution LIDAR Imagery; Some of These Will Be Breached or Removed to Improve Tidal Circulation

Marsh assessment and management will be addressed by a three-step process. The initial step is based on the effects of tidal restoration and the degree to which increased tidal flow passively influences sediment transport dynamics. Second, tide gate management policies (discussed above) will be temporarily altered to facilitate increased sediment deposition and vegetation growth. Extensive monitoring systems will be in place to evaluate how marsh sediment and surface processes are affected by changes to tidal flow. Based on knowledge gained with this information, the third step of marsh restoration methods will be designed and implemented. These will involve direct mechanical manipulations on the marshes and in tidal channels. The three steps are described in detail in the following sections.

Step One: Passive Marsh Management

The first tier action is simply to restore tidal flow. In a normal estuary, tidal flow supports the basic ecosystem functions needed to establish and maintain marsh channel networks and surface elevation. Restored tidal exchange in the Herring River will increase flow velocities and will move trapped sediment and erode channels that have narrowed since tides were restricted, resulting in

deeper and wider channels and greater flow volume. A portion of the sediment mobilized by this process will be deposited on marsh surfaces adjacent to the channels and contribute to rebuilding marsh elevation. Although natural deposition rates at saltmarshes in New England are typically low, on average approximately 2-3 millimeters per year, it is reasonable to expect that areas of moderately and severely subsided marsh surfaces would receive greater volumes of accumulated sediment since they are artificially lower than other marsh surfaces and would experience longer periods of inundation and slower flow velocities. Several studies have also documented higher accretion rates at marshes immediately following tidal restoration (i.e., Anifield 1999). Finally, as saltmarsh vegetation is reestablished, accumulation of below-ground organic matter is expected to accelerate. These subsurface metabolic processes are the dominant factor contributing to marsh surface elevation, making up to five times the volume of sediment compared to inorganic surface deposition (Turner et. al., 2000). The vertical and horizontal increase of vegetated saltmarsh would roughen the marsh surface, slowing down tidal flow and further contributing to sediment deposition, which in turn would facilitate below-ground accumulation.

Step Two: Alternate Tide Gate Management Policies

Seven discrete policies of management for new tide gates at the new Chequessett Neck Road bridge have been developed and are being currently analyzed to identify the gate configurations that result in the greatest overall ecological and socioeconomic benefit. Five of the policies (5 year, 15 year, 25 year, 15 year-slow/fast, 15 year-fast/slow) would generally increase tide range in a step-wise fashion over varying lengths of time. The two other policies (“Sediment” and “2GS”) are intended to specifically target sediment dynamics and growth of marsh vegetation. Under the Sediment policy, tide gate openings would normally be made according to the 15-year linear policy. However, during certain coastal storm events and/or predicted astronomical high tides, the gates would be strategically managed to take advantage of high, sediment-laden flows into the river. Gates would remain open throughout the high tide cycle to allow inflowing water and then be closed as tides beginning to recede. Combination slide-flap gates incorporated into the design of the CNR structure would allow water to drain, but the flow would be slower than the incoming tide. This fast-flowing flood tide and slow-flowing ebb tide cycle would produce an asymmetrical tidal hydrology that could deliver and retain a substantial volume of inorganic marine sediment to the Herring River floodplain.

Under the two-growing season tide gate policy (“2GS”), the CNR tide gates would be opened following a generally linear pattern. When the tide range reaches a specified level (still to be determined), tidal hydrology would be maintained at those conditions for a minimum of two growing seasons. This would provide a relatively stable tidal regime during which salt marsh plants could colonize and become established in some areas. The new vegetation would increase surface roughness and promote both surficial deposition of suspended sediment as well as enhanced marsh accretion from below-ground production of organic matter. After a period of maintaining stable marsh hydrology, tide range would be increased again and the process would be repeated within a higher elevation zone. This policy would in effect restore vegetation that would ultimately be sacrificed, but is expected to contribute to marsh surface accretion that would enhance conditions for the establishment of vegetation during later phases of the restoration. Monitoring data collected during the stable tide regime periods would be used to evaluate the effectiveness of the strategy and to refine implementation details for subsequent periods.

Step Three: Active Marsh Management

Based on monitoring results documenting changes to marsh surface elevation and tidal circulation, active marsh management measures may be necessary to address all of the project's objectives. Monitoring variables to be assessed include flood frequency, flood duration, salinity of ponded water, suspended sediment concentration, marsh surface elevation, soil bulk density, and estuarine vegetation species diversity and distribution. If any of these suggest that passive marsh restoration is not occurring at an acceptable trajectory or pace in response to tidal restoration or strategic manipulations to tidal hydrology, implementation of some or all of the active marsh management actions described below will be considered. Because of the spatial and temporal uncertainty in their future application, the descriptions of the actions are necessarily general at this time. If or when any of these are proposed for a specific location, individually or in combination with other management actions, details will be specified in site-specific Marsh Treatment Plans, to be prepared by the HRRC and submitted to the ROG and HRSG for review and comment. Any subsequent permit modifications or amendments would then be submitted for approval by the HREC. In general, active marsh management actions include techniques to maximize tidal circulation and accelerate increases to marsh surface elevation.

Maximize Tidal Circulation and Connectivity: More than 100 years of tidal restriction has led to infilling of the Herring River's tidal channel network. Virtually all of the natural stream channels have also been compromised by channelization (i.e. straightening) and mosquito ditching. Many, if not most, of the anthropogenic ditches have also accumulated sediment and organic matter. If these channels are not flushed out naturally by increased tidal exchange, active measures to dredge material may be necessary. This could be accomplished with small, tracked, low ground pressure machinery designed especially for this type of work. The overall goals of this effort will be, to the extent practicable, to restore the natural channel network that existed prior to extensive ditching and channelization. This would first require identifying which stream reaches are "natural" and which are anthropogenic. Natural streams would be dredged to the depth of the apparent natural bottom, with the dredge spoil used to fill adjacent mosquito ditches. In some instances, anthropogenic channels would be maintained and improved where no other natural connection is apparent. A preliminary assessment of anthropogenic and natural channels and volume of potentially available sediment for beneficial reuse is provided in Table 8B-3 (note; this assessment is for planning purposes only and assumes an average depth of one foot of entrained sediment throughout all apparent anthropogenic channels).

Table 8B-3. Preliminary Assessment: Existing and Proposed Channel Length and Area, by Sub-Basin, Phase 1 Proposed Conditions

Sub-Basin	Existing		Proposed, Phase 1	
	Length (miles)	Area (acres)	Length (miles)	Area (acres)
Lower Herring River	4.2	33.8	2.6	32.0
Middle Herring River	3.6	7.7	2.2	6.9
Lower Pole Dike Creek	5.9	8.0	2.4	3.3
Duck Harbor	4.6	3.7	1.6	2.0

Sub-Basin	Existing		Proposed, Phase 1	
	Length (miles)	Area (acres)	Length (miles)	Area (acres)
Upper Herring River	3.7	6.1	2.4	5.4
Lower Bound Brook	3.6	3.3	1.4	2.1
Upper Bound Brook	1.4	2.1	1.1	1.9
Mill Creek	1.2	1.6	1.2	1.6
Total	28.2	66.3	14.9	55.2

In some locations, spoil material that was side cast during the channelization of the Herring River and construction of the mosquito ditches may also be found to prevent tidal circulation and connectivity for estuarine animals. As tidal restoration progresses, these channel blockages if not breached passively by the reintroduction of tides will be removed using small, tracked, low ground pressure machinery. Active improvements to tidal circulation could also include opening up flow to, and in some cases creating, small pannes and pools on the marsh plain to provide habitat for small estuarine fish species, such as mummichogs (*Fundulus heteroclitus*) that are predators of salt marsh mosquito larvae. Small radial and connector ditches may also be designed to ensure that these pools and pannes are hydraulically connected to the tidal drainage network and that physical access for the fish is maintained.

Accelerate Increases to Marsh Surface Elevation: Tidal restoration is expected to reintroduce large volumes of inorganic marine sediment that will deposit on the Herring River floodplain to enhance the restoration of estuarine vegetation, which in turn will stimulate below ground accumulation of organic matter in the root zone. Both of these processes will eventually contribute to the accretion of the marsh surface. However, the rate at which these processes might occur is dependent on a number of ecological processes that are difficult to predict. Existing rates of sediment deposition and marsh accretion from functional saltmarshes around New England have been estimated to be in the range of 2-6 millimeters per year (Bricker-Urso 1989) and higher in marsh under going tidal restoration (Gonneea, pers. comm. and in press). With the degree of marsh subsidence that has occurred in the Herring River over the last century, natural accretion rates that could occur during the passive processes of sediment transport may be insufficient for the Herring River floodplain to reach elevations to support saltmarsh vegetation. Therefore, it is expected that supplemental supplies of sediment may be necessary to achieve significant gains in saltmarsh and other estuarine vegetation within the current implementation timeline of the project (i.e. up to 25 years). The “Threshold Sediment” policy has been developed to promote accretion of the marsh surface and may be implemented during the restoration process or alternatively, the restoration timeline could be extended beyond 25 years. Rigorous monitoring of salt marsh accretion using Sediment Elevation Tables (SET’s) and feldspar horizon markers being used to document temporal changes in elevation of the restored salt marsh. Other than sediment that may be available from stream channel dredging, the redistribution of historic spoil materials, and the natural erosion (widening and deepening) of tidal channels during the restoration process, no specific sources of external sediment to actively restore marsh surface elevations have yet been identified. The Project may consider linkage to the planned Wellfleet

Harbor dredging project, however no feasibility studies or formal discussions with the Town or U.S. Army Corps of Engineers are currently underway.

E. Predict Consequences of the Policies

Decision making is future oriented – decisions are made after considering “what will happen if an action or an alternate action is taken?” Thus, predicting consequences is an essential part of any decision, with the type or complexity of the prediction dependent on the significance of the outcomes. Performance, or the response of a measurable attribute for each Project objective, is predicted under each tide gate platform policy. Comparing predicted performance across all objectives provides the basis for selecting a policy. Recall that each objective has a performance metric (measurable attribute), including a unit of measure, desired direction of response, and spatial and temporal scales. For each objective, a method of prediction is needed as well as a method for monitoring to determine what actually happens after implementing the policy in order to assess, learn, and adapt.

Prediction of system responses can be quantitative or qualitative. As such, it is imperative to be explicit about underlying predictive models and their assumptions. The degree of uncertainty in these predictions is one significant (but not the only) impediment to making good decisions. Being explicit in predicting outcomes encourages explicit recognition of evolving conditions.

In the development of methods of prediction and monitoring for the Herring River, a tiered approach was used. Tier 1 predictions are best professional judgments developed by the project team. Tier 2 predictions are those provided through formal elicitation methods by subject matter experts and, where appropriate, community stakeholders. Tier 3 predictions are generated by quantitative models. For the Herring River, Tier 1 predictions have already been compiled, but are only being used to assess and develop future decision analyses. Tier 2 and 3 predictions will be used for the actual adaptive management plan and functional decision analysis. Tier 3 predictions can only be applied when a cost-effective quantitative model exists for a given objective. As shown in Table 8B-1, Tier 3 predictions exist or are planned for about two-thirds of the Herring River objectives. Where no quantitative model is available, Tier 2 predictions will be elicited from technical subject matter experts and community stakeholders through formal elicitation processes. This process is underway and will continue into 2020.

The foundational numerical model for the Herring River project is a two-dimensional hydrodynamic model developed by the Woods Hole Group (WHG 2012) using the Environmental Fluid Dynamics Code (EFDC) software package (Hamrick 1996). The EFDC model spatially represents the entirety of the historic Herring River floodplain and has been calibrated and validated to a set of tidal observations collected over full lunar cycles in 2007 and 2010. The model has been used to identify the optimal size of the tide gates at the new Chequessett Neck Road bridge, the Mill Creek dike, and the road culverts to be replaced as part of the restoration project. It has also been used to simulate the extent of tidal exchange under a range of full and partial restoration scenarios. Outputs from the EFDC model include tidal metrics under normal and storm-driven tidal forcing, including water surface elevations, tide range, water column salinity, flow direction and velocity, and hydroperiod (e.g. residence time, flood frequency, flood duration). Data outputs are available for virtually any Herring River location within the model domain and for any time step within the lunar tide cycle.

The EFDC model has also been run to simulate 17 different tide gate configurations at the Chequessett Neck Road bridge in order to understand the hydrodynamic effects of incremental tide gate management (Table 8B-2). Output for these simulations also provide predictions of low and high tide water surface elevations, and other hydrodynamic metrics, averaged by sub-basin and for individual and grouped model nodes. In addition to tabular data output, spatial data have also been compiled to graphically depict the extent of tidal exchange under each of the 17 tide gate configurations. These data were also used to develop the previously-described seven tide gate management platform policies.

In addition to the EFDC hydrodynamic model, other computer-based models have been applied to the Herring River project. The Sea Level Affecting Marshes Model (SLAMM) is open-source software that was originally developed with EPA funding in the 1980s (Warren Pinnacle Consulting 2016). It incorporates a number of input parameters, including Light Detection and Ranging (LiDAR) survey elevations, existing wetland classifications, sea-level rise rates, tide range, and accretion and erosion rates for various wetland habitat types to simulate the dominant processes involved with wetland conversions due to sea-level rise.

Although typically utilized to project wetland changes due to sea-level rise, SLAMM was applied in a unique approach to advance the understanding of how the changing tidal regimes associated with various tide gate scenarios could potentially impact ecological resources and wetland types throughout the Herring River system (WHG 2018). Used in combination, land elevation and tide range are the main drivers of the modeled vegetation predictions. Rather than using SLAMM to predict water level increases that are projected to occur because of sea level rise, this application of SLAMM used different tidal ranges resulting from various tide gate configurations at the Chequessett Neck Road Dike to project how the vegetation would likely respond to changes in tidal conditions. Spatially variable water levels throughout the Herring River system from the EFDC model results were generated for the suite of likely gate openings being considered during adaptive management of the project.

Elicitation planning is currently underway to develop predictions for objectives where use of a quantitative model is not possible or otherwise suitable. Elicitation is a formal process where technical subject matter experts or stakeholders are asked to provide their own informed judgements about how a specific management action, integrated within a platform policy, may influence a specific objective. There are varied methods for conducting formal elicitation, but the basis of the process is to develop data that allow for quantification of uncertainty and also expresses the range of predictions among multiple experts or responders. For the Herring River, two separate elicitation processes are currently being undertaken; one for scientific experts to provide predictions for a number of measurable attributes for several ecological objectives and another for local stakeholders in order to develop information about socioeconomic outcomes that are not addressed by existing ecological models. Table 8B-1 provides a summary of predictive data to be generated through these elicitation processes.

F. Evaluate Predicted Outcomes Considering Tradeoffs and Risks

Tradeoff analysis is the process of evaluating which of several potential courses of action (i.e., Herring River platform policies) offers the best possible outcome. The process of this evaluation can also offer insight into where information deficiencies exist – or what actions must be taken to improve resource outcomes. Tradeoff analysis is typically performed before any action is taken, and it therefore depends on predictions of how a given action will affect one or more objectives.

Accurate predictions are therefore a foundation of quantitative decision analysis, and among the goals of a tradeoff analysis is to base decisions on the best available information.

USGS decision scientists have developed the Herring River Decision Support Tool (Smith et al., in press), an application for the HRAMP to facilitate trade-off analyses by performing the comparative scoring automatically and presenting the results in a flexible and informative manner. Although this is only one element of a comprehensive tradeoff analysis it may be one of the more cognitively difficult components because of the need to track outcomes for numerous policies, objectives, and weighting schemes.

Utility functions transform performance metrics into a standardized scale while representing preference for levels of performance and tolerance for levels of risk. Utility curves can take a variety of shapes depending on risk attitude ranging from risk averse to risk acceptance. Default utility curves were created for each objective based on a range of risk attitudes and can be adjusted within the application prior to conducting a trade-off analysis.

Objectives can all be quantified in some way, usually by measuring some physical attribute. For example, mean high water (MHW) elevations and dissolved oxygen (DO) exceedances are both measurable attributes; MHW is measured in feet relative to mean sea level, and DO exceedances are presented as the number of samples with a DO concentration of less than 5 milligrams per liter. It is impossible to compare how well a management strategy (i.e. Herring River tide gate management policy) satisfies both the desired outcomes for MHW and DO because in their measured units there is no natural scale on which the water level and the dissolved oxygen concentration can be directly compared. To accomplish this comparison, an artificial scale, which is referred to as a utility scale is developed.

The utility scale always scores the most undesirable measurement as 0 and the most desirable measurement as a 1, regardless of the original units of measurement. In order to apply this scale, there is a need to define in advance what constitutes a desirable resource outcome. For some objectives we may desire the highest measurements, while for others we would want the lowest measurements. The desirable direction is toward attaining the resource outcome and there is often a point at which an objective has been adequately achieved.

In addition to the advance recording of the direction of the resource response, risk attitude must also be quantified. Risk attitude is harder to assess than direction because it exists on a subjective gradient that must be characterized by carefully considering how various outcomes affect a level of satisfaction. Thinking of risk attitude in terms of satisfaction is a good way to conceptualize terms like “risk accepting” and “risk averse”, which describe how quickly we transition from a utility of 0 to a utility of 1. To identify our risk attitude we need to examine whether our satisfaction grows at a constant rate with increasingly satisfying measurements (which would be a “linear” risk attitude) or whether small initial changes are more satisfying than large changes later on (which could be a “risk accepting”), or even the opposite case in which we are not happy with small initial changes and are only happy with large changes later on (“risk averse”). For example, if 1 DO exceedance makes us twice as happy as 2 exceedances, and 2 makes us twice as happy as 4, we could characterize our attitude as “linear”. If 2 exceedances make us 4 times as happy as 4 exceedances we might be “risk averse.”

Risk attitude is a difficult concept to comprehend, and describing it simply as satisfaction leaves us prone to misinterpretation as we attempt to visualize converting measured values to utility.

G. Recommend Implementation of a Preferred Policy

The governance and administrative structure for implementing the Herring River adaptive management plan is described in a memorandum of understanding (MOU-IV) between CCNS and the Town of Wellfleet.

The executed MOU IV explicitly acknowledges the responsibility of the town and Cape Cod National Seashore by establishing the Herring River Executive Council (HREC) as the formal, decision-making authority for the project. The HREC is comprised of two select board members and town administrator from Wellfleet, and the Cape Cod National Seashore superintendent, and one additional CCNS representative. MOU-IV identifies the Herring River project team as an informal, intergovernmental technical working group formed for the purpose of providing technical input for Project-related decisions as necessary or appropriate. In September 2017, the HREC established a formal Herring River Stakeholder Group (HRSG), a 19-member body representing a broad range of local and regional interests. The purpose of the HRSG is to communicate with stakeholders within the community to ensure that their respective interests and views are well represented and considered by the HREC and to provide advisory input to the HREC on key implementation issues.

The HREC is the entity primarily responsible for executing the adaptive management plan, with technical input from the project team. Simply stated, the team will provide management recommendations to the HREC which will be responsible for authorizing actions at each major decision point. The team will be responsible for coordinating with the NPS and town to carry out authorized actions in accordance with the guidelines outlined in the adaptive management plan and regulatory permit requirements. The team will also have the role of analyzing, compiling, and summarizing monitoring data, modeling output, field observations, and other information, and providing advisory input to the HREC. The HREC and project team may work with third-party organizations to implement agreed upon management actions, field monitoring, data analysis, and public outreach activities.

The Regulatory Oversight Group will assist in the preparation and review of the final AMP and will review implementation progress on an ongoing basis. The Regulatory Oversight Group is called for under the Secretary's MEPA Certificate to include, at a minimum, representative(s) from the following agencies:

- Federal: NPS, USFWS, NOAA, NRCS, EPA, USACE;
- State: MEPA, DER, DMF, NHESP, MassDEP, CZM, State Historic Preservation Officer (SHPO);
- Regional: CCC;
- Local: Town of Wellfleet, Town of Truro; and
- Tribal: Mashpee Wampanoag Tribe

The decision-making process is grounded on the collection and evaluation of monitoring data intended to measure performance of the specific objectives formulated for the adaptive management plan. The HREC may designate the parties responsible for (1) coordinating with the NPS and Town to carry out authorized actions and (2) analyzing, compiling, and summarizing monitoring data, modeling output, field observations, and other information. During this process, members of the HRTT

will provide ongoing advisory technical input to the HREC. Third-party organizations may be engaged to implement approved management actions, field monitoring, data analysis, and public outreach activities. Data collection will be guided primarily by scientists at CCNS and available to, the project team as the basis for technical advisory input to the HREC. As management actions are implemented and the response of the system is monitored, the project team will assess the performance of models and other predictive tools by comparing those outputs to actual, observed outcomes. These results will be summarized in written reports and form the basis for recommended management actions to be implemented during the subsequent time period. The project team will submit written reports to the HREC that will describe previous management actions, data analysis, and recommendations for future management actions. The HREC will either approve the project team recommendations or request additional data collection and/or analysis for further review and possible reconsideration of recommended management actions.

H. Decision Making During Implementation

The project team will use the USGS trade-off analysis software to evaluate the expected performance and trade-offs of various management strategies. The trade-off analysis will help identify which platform policies are most advantageous for achieving the objectives based on weighted preferences and attitudes toward risk taking. The software produces numeric scoring of available management strategies, but it will be up to the HREC and project team to evaluate the results, along with input from the HRSG and other sources to make informed and transparent decisions about the most appropriate actions at any given point in the project implementation timeline. This recognizes the potential that some decisions may carry higher risk than others and that it could be necessary to tolerate some less advantageous effects in the short-term in order to achieve broader, long-term project objectives.

In addition to evaluating trade-offs, while reviewing monitoring data and formulating management options available for advancing the objectives of the Herring River project, the project team will consider:

- The current state of the system including:
 - Cumulative changes that occurred since commencement of the restoration process
 - Specific changes that occurred since implementation of the most recent management actions
 - Effects of natural and anthropogenic events that are unrelated to tidal restoration
 - Comparison of observed changes with model predictions
 - Status and effectiveness of mitigation measures employed to prevent adverse impacts
 - Compliance with regulatory requirements and permit conditions
 - Stakeholder comments, concerns, and interactions
- Predicted outcomes of recommended management actions:
 - Specific details of management actions (e.g., changes in tide gate configurations; methods of proposed secondary management actions)
 - Temporal context of management actions (e.g., implications of seasonal effects; anticipated tidal forcing, weather conditions, storms, etc.)

- Spatial context of management actions (e.g., area predicted to be affected by increased tidal exchange; locations of proposed secondary management actions, juxtaposition with other management)
- Expected changes/impacts to be measured through field monitoring (e.g., changes in water surface elevations, salinity, water quality, sediment movement, and vegetation/habitat)
- Confirmation that required mitigation measures are in place to prevent adverse impacts
- Anticipated stakeholder reaction and plans for public outreach/education
- The operational and administrative structure for supporting recommended management actions:
 - Review of monitoring effort (e.g., set up of sensors, data loggers, and monitoring studies, and operational needs for assessing predictions derived from hydrodynamic models)
 - Assessment of available resources (e.g., staff, equipment, funding, contracts, availability for implementation of management actions, including reversing actions, if needed, to address unforeseen effects)
 - Assessment of personnel and funding needs during implementation, monitoring of performance, data analysis, and reporting of results
 - Assessment of personnel and funding needs for public outreach and communications
 - Permit compliance and regulatory approval during implementation of management actions

The entity designated by the HREC will provide written reports to the HREC as the basis for recommended management actions to be implemented. Reports will be prepared and delivered at the end of the calendar year and will include a cumulative documentation of all data and project results to date with detailed emphasis on changes that occurred during the latest reporting period. Reports will be posted online and provided to the HRSG and Regulatory Oversight Group. Best Available Data will be included, but all data may not be fully analyzed, assessed for quality assurance and quality control, or peer-reviewed.

Management Recommendations to the HREC will include:

- A brief summary of all results since Project inception
 - Ecological monitoring data: water levels, salinity, water quality, vegetation change, etc.
 - Socioeconomic data: public safety, visual impacts (aesthetics), public access (privacy), recreation, odors, and resolution of conflict among stakeholders, etc.
 - Review of all prior management action
 - Performance assessment of models and other predictive tools
- A detailed analysis for the reporting period (prior calendar year)
 - Statement of previously proposed management actions (“We planned to do...”)
 - Description of executed management actions (“We did...”)
 - Statement of expected outcomes, i.e. model hypothesis (“We expected to see....”)

- Data presentation of actual observations (“We did see...”)
- Analysis of expected vs. actual outcome
- New management recommendations
 - Proposal for new tide gate settings, secondary actions
 - Modeled predictions and expected outcomes of proposed management
 - Potential vulnerabilities warranting special attention
 - Changes or modifications to monitoring plan
 - Assessment of financial and personnel resources for continuing management and monitoring plan

I. Design and Implement Targeted Monitoring Program, Evaluate Baseline Conditions, and Assess Outcomes of Management Actions

The collection, analysis, and application of credible monitoring data to compare with predictions from modeling are the primary means in adaptive management to assess progress towards meeting project objectives. Equally important is the ability to predict the variation of expected outcomes across a range of alternative management actions that are under consideration. As previously described, in adaptive management output data from models and other predictive methods are used to conduct trade-off analyses so that predictions of how management actions influence objectives can be compared. After management actions are implemented, monitoring data are used to determine real outcomes, evaluate how models performed, and refine model predictions about the outcomes of future actions.

Since the 1970’s, the CCNS has collected most of the research and monitoring data in the Herring River. Much of this work has been done as part of the NPS Northeast Coastal and Barrier Network Inventory & Monitoring Program and CCNS’ Cape Cod Ecosystem Monitoring Program which has included both long-term monitoring and focused research projects. USGS, along with a number of university- and NGO-based study groups, have also contributed significantly to the broad database of pre-restoration monitoring data. CCNS will continue to provide leadership and direction for the science and monitoring program as the Herring River enters the construction phase and as the project is implemented. To conduct all of the monitoring required during the long-term implementation of the adaptive management plan, additional resources including staff time, equipment, technical consultation, and funding will be necessary from the NPS, other federal and state agencies, and other sources.

Table 8B-1 provides an overview of available monitoring methods and predictive tools for each objective within the adaptive management plan. These methods are discussed in detail in this section. Both pre- and post-restoration monitoring activities are addressed.

Objectives – Hydrography and Water Quality. Existing and future tidal conditions and water quality are and will continue to be monitored using electronic sensors and data loggers in a number of monitoring applications for the Herring River project. Electronic sensors are highly accurate (when maintained and calibrated), cost-effective, and capable of unattended continuous logging and data storage for several months. Their use is extremely common in any type of water-related environmental study. There are several types of instruments, but the most commonly used for the Herring River are devices for measuring water surface elevation and

water column salinity levels. Other instruments for continuous data collection in the Herring River are used to collect water quality variables (i.e., temperature, dissolved oxygen, pH, nutrients, and turbidity), other hydrologic data (i.e., flow velocity), and non-water data (i.e., air temperature, atmospheric pressure, and weather variables).

Data provided by automated instruments are the basis for the EFDC hydrodynamic model and many other hydrologic-related predictions incorporated into the trade-off analysis tool (see Table 8B-1). As the restoration project is implemented new data collected through the network of automated sensors will be used to compare the original set of predictions with observed conditions. Observed outcomes will be incorporated into the models and to develop revised predictions to improve subsequent decision-making. Objectives and their measured attributes most reliant on data collection from automated sensors are:

- Tide range
- Hydroperiod
- Marsh surface drainage
- Salinity
- pH
- Dissolved oxygen
- Prevention of flooding of private structures and public roads

In addition to these specific objectives continuous data may also be used for analysis of other water quality and habitat suitability assessments.

Starting in 2017 the Seashore began collaborating with FHR to expand the network of tide monitoring locations as the project advanced toward the construction phase. Several long-term tide, salinity, and water quality monitoring stations were installed. These stations include radio telemetry systems to provide real-time data to the public via Internet. As Phase 1 of the project is implemented, coverage of tide monitoring will expand throughout the floodplain. If or when tidal influence expands beyond the extent of the Phase 1 project area, the tidal monitoring network can be extended into other sub-basins of the Herring River.

Objective – Water Quality: In addition to data collected by automated loggers for dissolved oxygen and pH, water quality data will be supplemented with synoptic grab samples taken from the river and Wellfleet Harbor at several points throughout the floodplain. CCNS has collected seasonal water quality samples since 2005 with the number of locations and frequency of sampling varying because of changes in funding levels and personnel availability. Pending future funding, synoptic sampling will continue up to the construction start and throughout the implementation period of the project. In addition, USGS has installed, and has been operating and maintaining surface water-quality and streamflow monitoring sites in the Herring River since November 2015. The goals of this data collection program are to establish a pre-restoration baseline water-quality dataset, and to evaluate differences in concentrations of nutrients and other water-quality indicators between the Herring River and the receiving waters of Wellfleet Harbor. CCNS and USGS staffs are collaborating to integrate long-term CCNS data and the

USGS nutrient flux data and to develop a strategy for the long-term monitoring of water quality of the river and Wellfleet Harbor as the Project is implemented.

Water quality sampling will also include levels of fecal coliform bacteria to monitor the expected reduction of bacteria exported from the Herring River to Wellfleet Harbor. This will build on a prior study (Portnoy & Giblin 2006) which demonstrated that dilution with seawater resulting from increased tidal exchange would reduce the occurrence of bacteria originating from the river. Additional baseline data for fecal coliform bacteria will be collected before construction begins and will be repeated seasonally as tidal flow is restored. This will be conducted to evaluate the objective to avoid impacts to Wellfleet Harbor aquaculture areas.

Objective – Habitat Quality: Shellfish habitat suitability will be assessed based on changes in tide range, salinity, and substrate condition (i.e. mud, sand, gravel, etc.) in order to quantify expected increases to potential shellfish growing habitat, independent of whether the area can be opened to harvest based on fecal coliform counts.

Objective – Habitat Quality: A comprehensive survey of benthic macroinvertebrates was completed by CCNS as part of a comprehensive assessment of aquatic habitat of the Herring River between 2013 and 2015 (Fox, et. al. 2017). Samples were taken from 92 stations from above High Toss Road and extended seaward to Wellfleet Harbor. This monitoring effort will be repeated periodically as tidal exchange is restored to assess the objective of maximizing habitat quality for native estuarine animals.

Objective – Marsh Surface Elevation Change: Data relating to sediment dynamics and marsh elevation have been collected by CCNS since at least the early 2000s. The most prominent of these datasets are from an array of surface elevation tables (SETs) installed at three locations in the Herring River floodplain. These are part of the larger network established and administered by the NPS to document long-term changes to marsh elevation and accretion rates at coastal parks throughout the Northeast Region. SETs are used in conjunction with feldspar marker horizons to provide information about the vertical position of marsh surfaces in relation to local sea level. These stations will be maintained throughout CCNS, including the Herring River project area, for the duration of the restoration project. The Herring River SET array has been augmented by an additional station, installed in the tidally unrestricted Blackfish Creek salt marsh system to serve as a reference site for the Herring River. Additional SETs and other methods for documenting accretion and marsh surface elevation changes resulting from the Herring River project are also being considered. Alternate methods include direct ground survey measurements along established transects throughout the floodplain. These data will address the objective of marsh surface elevation change. They are also linked to other sediment-related data focused on Wellfleet Harbor, discussed below.

Objectives – Habitat Quality and Marsh Surface and Benthic Elevation Changes: In addition to the sediment deposition and accretion monitoring methods for the marsh surface areas of the Herring River floodplain, information on sediment grain-size; suspended sediment load; and harbor bottom elevations has been collected – and is planned to assess whether any future changes to sediment transport in Wellfleet Harbor are the result of increased tidal exchange in the Herring River. In 2005, 2010 and 2017 sediment samples were collected from the surface of the tidal flats near the Wellfleet Harbor aquaculture areas in order to evaluate grain-size distribution and organic content. As the restoration project proceeds, this sampling will be

repeated and the results compared to the baseline data to help understand whether the restored flow in the Herring River may affect sediment composition in the harbor. Additional sediment related monitoring that will help inform river and harbor sediment dynamics during restoration and to avoid impacts to Wellfleet Harbor aquaculture areas includes benthic habitat mapping to be conducted by the Center for Coastal Studies and USGS suspended sediment sampling at the CNR dike.

Objective – Emergent Vegetation: Long-term vegetation transects and multispectral and low altitude imagery classification are being used to monitor changes to vegetation in the Herring River floodplain resulting from restored tidal exchange. Long-term vegetation transects were established by CCNS in 2004 and vegetation data have been collected at approximate five-year intervals. This will provide at least four data sets of species coverage and distribution before the project is implemented. During the restoration, sampling along the same transects will be conducted at shorter intervals as tidal range is increased. Vegetation transect-plot data will monitor species level changes that occur over the long-term and will be used to assess the objective to restore native halophytic vegetation.

Broad scale changes to wetland habitats will also be monitored using seasonal multispectral imagery and low altitude aerial photography. This will build on the classification and quantification of baseline wetland habitat conditions conducted by CCNS using remote sensing data from 2013 and completed in 2018. This analysis resulted in a stream-lined process for image classification and ground-truthing that will be repeated to update conditions prior to project implementation and as tidal exchange is restored. As a complement to the detailed species-based inventory of the transect-plot sampling, multispectral analysis will provide a more general assessment of changes in habitat types and structure for the entire project area. Aerial based mapping will also provide the ability to monitor a number of hydrologic metrics (e.g. areas of ponded water, changes to tidal channel morphology) and possibly marsh elevation and sediment dynamics.

Objective – Connectivity for Diadromous Fish: Surveys of river herring (*Alosa* spp.) have been conducted by volunteers managed by Friends of Herring River since 2009 using methods developed by the MA Division of Marine Fisheries and the Association to Preserve Cape Cod. These semi-quantitative counts provide information about the relative abundance of migrating herring from year to year and comparisons with similar herring runs on Cape Cod. In addition, researchers from USGS and UMASS-Amherst have conducted a detailed study of herring movements along the Herring River (Castro-Santos and Alcott, in press) using electronic tagging methods. FHR volunteer counts are expected to continue as long as volunteers are available and the program can be managed. Additional intensive surveys could be performed after tidal flow is restored, pending availability of funding and personnel. In concert with other, indirect hydraulic metrics, such as configuration of tide gates and resulting flow velocities, these data will be used to assess the objective to maximize anadromous fish passage.

Objectives – Recreation and Public Safety: Observations of visitor activity will be used to assess the socio-economic objectives of maximizing recreational opportunities while minimizing risk of injuries or accidents. Potential new recreational opportunities include, but are not limited to, increased access for and quality of kayaking/canoeing, fishing, shellfishing, and hiking. Potential risks include, but are not limited to, increased boating activity near the new CNR bridge, changes in tidal flows that affects recreation, and the inherent increased risk resulting from expected increased activity levels. Refinement of recreational and other socio-economic objectives and

their associated monitoring techniques for baseline and future conditions are still under development by the project team and USGS decision scientists.

Objective – Public Satisfaction: Refinement of objectives and monitoring techniques related to general public satisfaction of project effects, including changes to viewscales, potential changes in odors, and perceived loss of privacy for residents are under development. It is likely that monitoring will occur through a combination of public surveys and by tracking and documenting incidents and complaints presented to project managers.

Objective – Public Viewscales: Time series photo documentation used in combination with public surveys are planned to evaluate a number of aesthetically based objectives, including viewsheds from both private residences and public access points. Fixed stations will be established and photographs will be made at regular intervals to track vegetation changes and other factors that contribute to viewshed quality.

Objective – Climate Change: Detailed measurements of carbon storage and fluxes between water, soil, and the atmosphere have been made by the Bringing Wetlands to Market project team since 2016. In addition to establishing the baseline understanding of carbon dynamics in the Herring River, these data will also be applied to a carbon flux model (Abdul-Aziz and Ishtiaq 2015). This model uses relatively simple inputs of salinity, water depth, water temperature, and light to generate predictions of Net Ecosystem Productivity (NEP) under future tidal conditions. Pending available funding and personnel, carbon flux measurements will be repeated until the NEP model can be verified.

Objective – Natural Mosquito Control: Mosquitoes have been monitored in the Herring River by CCNS and Barnstable County Mosquito Control Project primarily using larval counts. Counts of adult mosquitoes and larvae are standard methods for species distribution and population estimates. Other metrics relating to mosquito breeding (i.e., ponded water, salinity levels) will also be used to assess the extent of breeding habitat for fresh, brackish, and saltwater species. Mosquito counts will also continue for the duration of the project.

Objective – Cost: Actual costs, including financial expenditures, human resources, and other costs will be modeled and monitored in the same manner as ecological and socioeconomic objectives. Cost estimates will serve as the model, or prediction, and actual expenditures will provide the monitoring data. As the project is implemented, actual costs will be tracked and compared to cost estimates in a systematic manner to improve future cost estimates and increase efficiency.

Objective – Threatened and Endangered Species: In order to understand how populations of state-listed rare, threatened, and endangered species respond to tidal restoration, implementing monitoring plans for these species and their habitats is a fundamental Project objective. The capacity of the Project to implement these plans and provide timely information to the MA Natural Heritage and Endangered Species Program (NHESP) will be tracked and used to assess the probability that monitoring and reporting can be completed to predict the effects of future management actions. This information will be presented in a detailed Habitat Management Plan, which is under development and will be subject to approval by NHESP.

8.C Groundwater Studies

Technical Memorandum on Wellfleet Landfill Leachate
The Johnson Company. May 21, 2019.

Evaluation of the Potential for Private, Domestic Wells to be Affected by Restoration of Tidal
Flow in the Herring River Basin, Cape Cod, Massachusetts
Martin, Larry. December 2018

(See following pages)

TECHNICAL MEMORANDUM

TO: Brian Carlstrom, National Park Service

FROM: The Johnson Company

DATE: May 21, 2019

RE: Wellfleet Municipal Landfill Memorandum

This memorandum provides an overview of the current status of groundwater contamination within the immediate vicinity of the Wellfleet Municipal Landfill in Wellfleet, Massachusetts, and how the landfill may be affected by Herring River restoration activities. The 2018 Biennial Post-Closure Monitoring Report for the Wellfleet Municipal Landfill and the PowerPoint slides put together by John Portnoy were reviewed for this assessment. It is not clear when the slideshow was put together, but based on current data there does not appear to be a contaminated groundwater plume associated with the landfill. The vast majority of organic and inorganic data was either non-detect or significantly below the drinking water criteria. The only constituents that exceed any type of standard are pH, iron, manganese, and 1,4-dioxane. In general, it appears that the upgradient wells have similar levels of contamination to wells that are downgradient of the landfill.

Figure 1 (attached) shows the analytical results and groundwater flow for the Wellfleet Municipal Landfill. The tables shown on the figure show the results only for an analyte that was detected above a standard in one of the samples in the most recent sampling round. Wells CSAW-3D, CSAW-2D/2S and CSAW-4S appear to be the upgradient wells. Please note that the groundwater elevations are the average of the 1998/1999 sampling events, which are the sampling events with the most recent groundwater elevation data available. The analytical results are from the September 2017 sampling event. Note that the Herring River is located to the north and west of the landfill.

It appears that pH and chloride standard exceedances are unrelated to the landfill: the highest chloride concentration was detected in upgradient well CSAW-4S, and the lowest pH concentration (the concentration furthest outside of the Standard range) was also detected in this well. Regarding iron and manganese, these results were for total metals rather than dissolved, and the high values are likely associated with suspended sediment. In addition, it is not clear that the landfill is the source of these higher values, as upgradient well CSAW-2D had the highest concentration of total Iron, and a higher concentration of total manganese than two out of three downgradient wells.

Regarding 1,4-dioxane, the only well it was measured in above detection limits during the September 2017 sampling was downgradient well CSAW-1D at 0.904 ug/L. This well also had detections of 1,4-dioxane in April 2013, April 2014, and September/December 2016. Upgradient well CSAW-3D had one detection of 1,4-dioxane in October 2014. Downgradient well MW-1 had two detections of 1,4-dioxane, one in April 2015 and one in September 2016. The table inserted on the following page from the 2018 Biennial Report summarizes these results.

<i>Sampling Date</i>	Apr 2013	Oct 2014	Apr 2015	Sept/Dec 2016	Sept/Dec 2017
<i>CSAW-1D</i>	0.3	ND	0.6	0.866/1.05	0.904/0.514
<i>CSAW-3D</i>	ND	0.3	ND	ND	ND
<i>MW-1</i>	ND	ND	0.3	4.76/ND	ND

Note: All results in µg/L

The biennial report concluded that based on the low concentrations detected, and the lack of private wells in the vicinity, there are no potential human receptors or human health risk of ingestion associated with the 1,4-dioxane in groundwater. Unlike manganese and iron which are naturally occurring, 1,4-dioxane is a synthetic industrial chemical most commonly used as a stabilizer for chlorinated solvents. As 1,4-dioxane has been detected historically in upgradient well CSAW-3D, it is not clear if the concentration encountered in downgradient well CSAW-1D is reflective of landfill leachate. Furthermore, stable isotope monitoring indicates that landfill leachate is not reaching the Herring River, as detailed in the Portnoy slideshow.

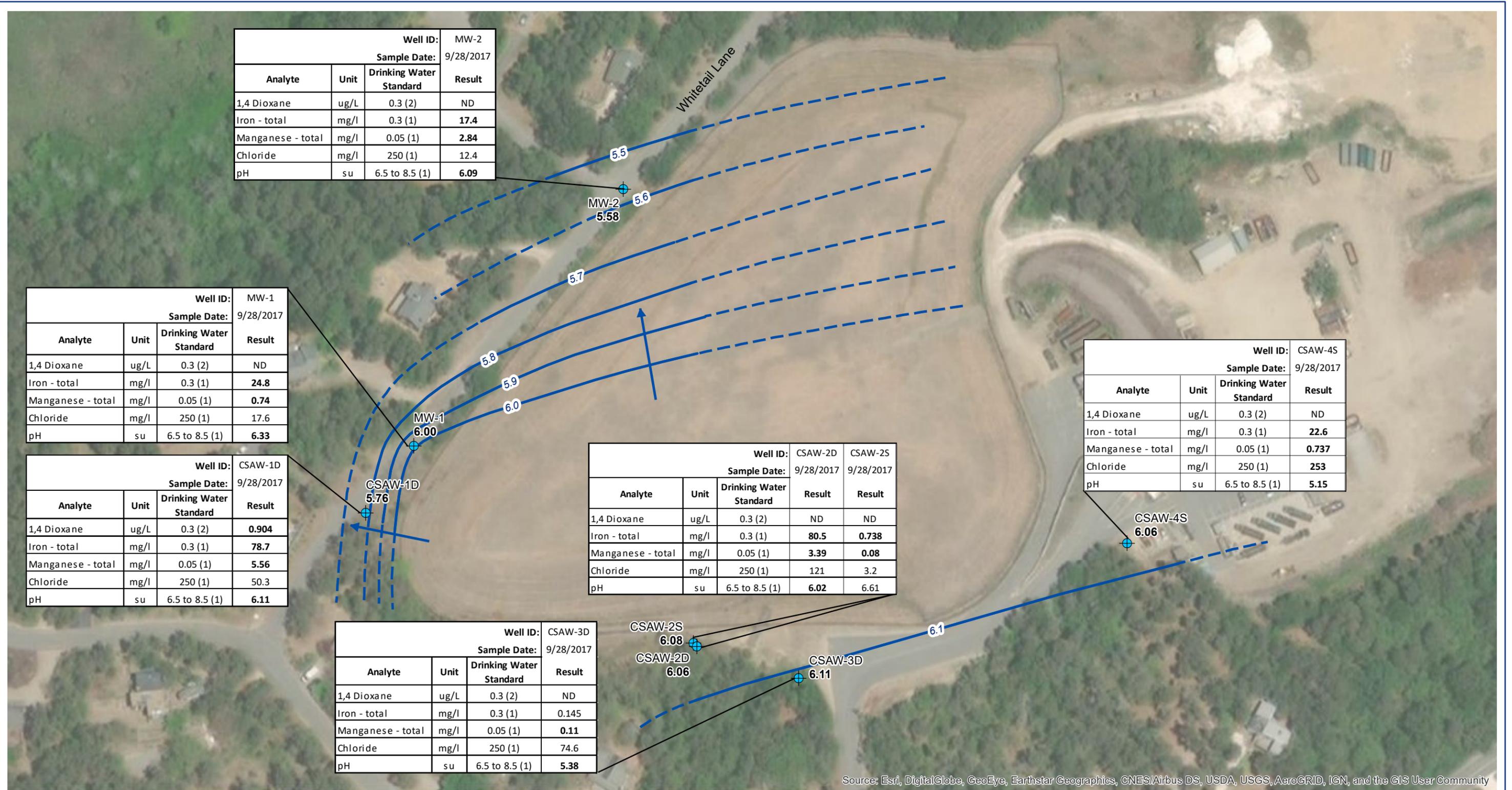
In conclusion, it appears that the 2005 landfill closure was successful and that landfill leachate has been reduced and/or stopped. Furthermore, it appears that there is no longer a contaminated groundwater plume associated with the landfill. There was most likely a contaminated groundwater plume in the past and the landfilling of waste, more likely than not, did have an impact on the environment and the groundwater during landfill operation. However, current conditions indicate very minor, if any, groundwater contamination. The restoration of the Herring River into a salt water marsh, rather than a fresh water marsh, will have some effect on the tidal cycle in the vicinity of the landfill; I believe any affect will be minor and should not significantly impact the groundwater flow from the landfill to the river.

The observations of limited groundwater contamination from this closed landfill may seem unexpected to some; however, I am currently evaluating the groundwater at several historical landfills and they surprisingly also have limited groundwater contamination. It may be that the landfills have been flushed over the years with rain or, in this case, the closure activities have been successful.

Therefore, for the reasons summarized above, I concur with three of Mr. Portnoy's observations:

- There is no detectable contamination plume in groundwater;
- Tidal restoration will bring surface water no closer to the landfill than it is today, >500 ft;
- Groundwater levels and flow direction at the landfill will not change as a result of the tidal restoration.





Well ID: MW-2			Sample Date: 9/28/2017
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	ND
Iron - total	mg/l	0.3 (1)	17.4
Manganese - total	mg/l	0.05 (1)	2.84
Chloride	mg/l	250 (1)	12.4
pH	su	6.5 to 8.5 (1)	6.09

Well ID: MW-1			Sample Date: 9/28/2017
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	ND
Iron - total	mg/l	0.3 (1)	24.8
Manganese - total	mg/l	0.05 (1)	0.74
Chloride	mg/l	250 (1)	17.6
pH	su	6.5 to 8.5 (1)	6.33

Well ID: CSAW-1D			Sample Date: 9/28/2017
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	0.904
Iron - total	mg/l	0.3 (1)	78.7
Manganese - total	mg/l	0.05 (1)	5.56
Chloride	mg/l	250 (1)	50.3
pH	su	6.5 to 8.5 (1)	6.11

Well ID: CSAW-3D			Sample Date: 9/28/2017
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	ND
Iron - total	mg/l	0.3 (1)	0.145
Manganese - total	mg/l	0.05 (1)	0.11
Chloride	mg/l	250 (1)	74.6
pH	su	6.5 to 8.5 (1)	5.38

Well ID:		Sample Date: 9/28/2017	
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	ND
Iron - total	mg/l	0.3 (1)	80.5
Manganese - total	mg/l	0.05 (1)	3.39
Chloride	mg/l	250 (1)	121
pH	su	6.5 to 8.5 (1)	6.02

Well ID: CSAW-4S			Sample Date: 9/28/2017
Analyte	Unit	Drinking Water Standard	Result
1,4 Dioxane	ug/L	0.3 (2)	ND
Iron - total	mg/l	0.3 (1)	22.6
Manganese - total	mg/l	0.05 (1)	0.737
Chloride	mg/l	250 (1)	253
pH	su	6.5 to 8.5 (1)	5.15

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Legend**
- Monitoring Well with Groundwater Elevation¹ (ft)
 - Groundwater Equipotential¹ (dashed where inferred)
 - Groundwater Flow Direction

Notes:
 (1) Denotes EPA Drinking Water Secondary MCL/guideline.
 (2) Denotes Massachusetts Drinking Water MCL
 Results are shown for all analytes which had an exceedance of one of the standards listed in tables above in a sample during the most recent sampling round.
 Bold result in table indicates above standard.
¹Groundwater elevation data only available for the 1998/1999 sampling round. The average GW elevation from the four sampling events for each well was used for the flow map.

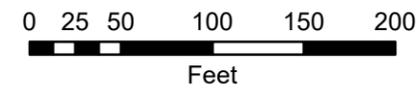


Figure 1: Groundwater Flow Map and Analytical Results
 Wellfleet Municipal Landfill
 Wellfleet, Massachusetts

	Drawn by: DEB Reviewed by: SJH	Date: 05/01/2019 Date: 05/02/2019
	Scale: 1" = 100'	Project: 58345.10

Evaluation of the Potential for Private, Domestic Wells to be Affected by Restoration of Tidal Flow in the Herring River Basin, Cape Cod, Massachusetts

Larry Martin, Hydrogeologist

Ft. Collins, CO

December 2018

Summary

This report reviews the findings and conclusions of multiple prior investigations into the effects of tidal influence on groundwater and adjacent private domestic water-supply wells at several locations on Cape Cod, Massachusetts. The findings of these investigations were used to evaluate the potential effects of tidal restoration on drinking water wells from the planned Herring River Estuary Restoration Project in Wellfleet, MA.

Importantly, the understanding of interactions between various tidal restoration settings and adjacent groundwater conditions has evolved significantly over the nearly three decades spanned by these investigations. Multiple studies evaluated the effects of tidal restoration on water quality for wells adjacent to a permanently flooded ocean shoreline. This approach was subsequently determined to be inapplicable for evaluating the effects of tidal restoration on groundwater in an intertidal estuary, where the dynamics between tidal flow and groundwater differ substantially from those that occur in an ocean shoreline setting.

More recent investigations for Herring River correctly evaluated the effect of tidal restoration on groundwater beneath and adjacent to an intermittently flooded intertidal estuary. These studies found that tidal restoration is expected to increase the mean water level in the river and streams, resulting in a slight increase of the water table elevation and consequent increase in thickness of the freshwater zone in the aquifer. These investigative findings support the conclusion that only wells exposed to salt water inundation at the ground surface around the casing are likely to experience water quality impacts resulting from tidal restoration at Herring River.

Based on this understanding of impact risk, a total of seven wells were identified with the potential for salt water inundation at the ground surface resulting from full tidal restoration of the Herring River Estuary. Two of those wells will be plugged and abandoned. Mitigation actions have been identified for the other five wells, two of which would not be affected by Phase 1 of the Project. Installation of new wells on these properties in upland locations, and with screened intervals located at proper elevations in the aquifer's freshwater zone, will maintain quality drinking water for the affected properties.

1.0 Purpose and Scope

The purpose of this report is to (1) review the basic science of the freshwater/saltwater relationship in aquifers on Cape Cod, addressing the potential effect of restored tidal flow in the Herring River on groundwater quality, and (2) summarize the key findings of previous hydrological assessments of the effects of tidal restoration in private, domestic wells that are in low-lying areas within the Herring River basin and within a short distance of saltwater at high tide. This report incorporates the work of many investigators over the past several decades. Previous investigations include work by the U.S. Geological Survey, National Park Service, Cape Cod Commission, and others, as noted in the text and attached list of references.

2.0 General Science of the Saltwater-Freshwater Relationship in Coastal Aquifers:

The relationship between freshwater and saltwater in coastal aquifers has been studied by many investigators (e.g. see Fetter (2001), pp. 331-338). Freshwater, being less dense than saltwater, floats on top of saltwater in the shape of a lens within the groundwater system. Infiltration of precipitation provides the source of freshwater. A good example of this type of separation of two liquids with different densities is a bottle of vinegar and oil salad dressing.

The relation between the height of the water table and the thickness of the freshwater lens was discovered independently by W. Badon-Ghyben and A. Herzberg; and is generally referred to as the Ghyben-Herzberg relationship. This relationship expressed as an equation is;

$$h_s = \frac{\rho_f}{\rho_s - \rho_f} (h_f)$$

where; h_s is the depth of freshwater below sea level

ρ_f is the density of freshwater, 1.000 g/cm³

ρ_s is the density of saltwater, 1.025 g/cm³

h_f is the elevation of the water table above sea level

Substituting the values for density of freshwater and saltwater into the equation;

$$h_s = \frac{1.000}{1.025 - 1.000} (h_f)$$

Yields;

$$h_s = 40h_f$$

Thus, the freshwater lens should extend to a depth below sea level equal to 40 times the height of the water table above mean sea level. Figure 1 shows an example of a freshwater lens in a cross-section through the Truro area (Barlow, 2003). Freshwater in this area extends to a depth of more than 150 feet below sea level.

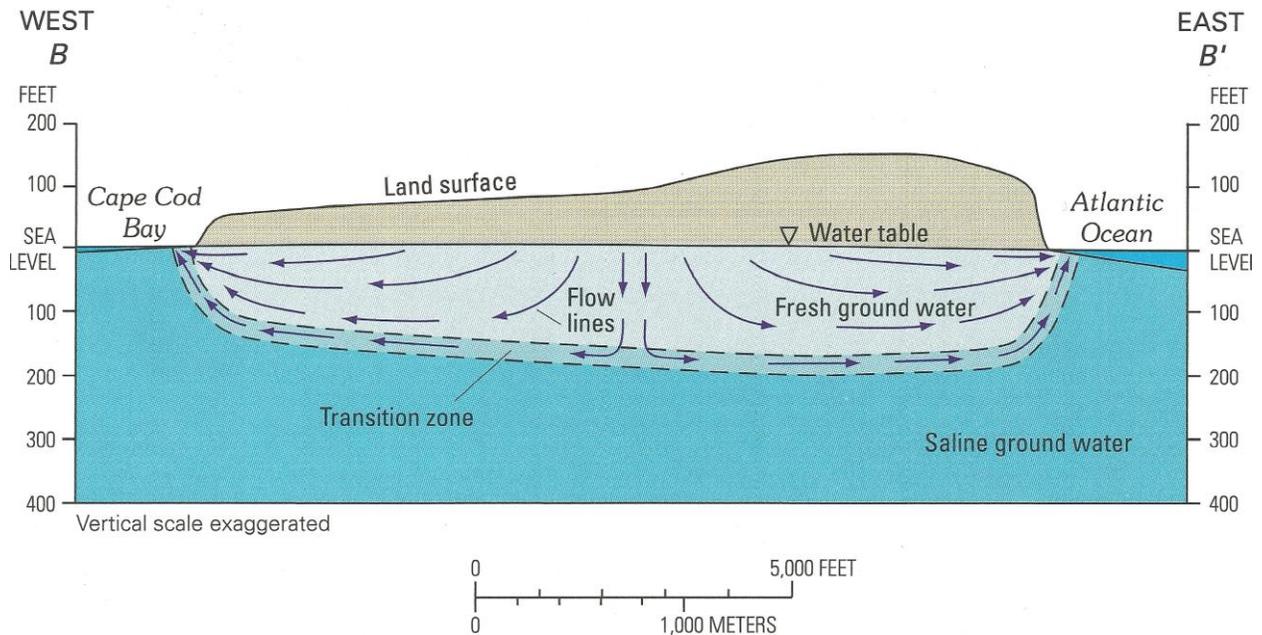


Figure 1. Cross-section through the Truro area showing an example of a freshwater lens floating on saltwater. Vertical exaggeration 10X. From Barlow (2003).

On most areas of Cape Cod, there is sufficient thickness of the freshwater aquifer to supply water for domestic wells. Only wells that are located very near permanent saltwater bodies, such as Cape Cod Bay or the Atlantic Ocean, are at risk of saltwater intrusion. Martin (2004) concluded that domestic wells located more than about 200 feet from ocean shorelines and having their screened interval a significant distance above the bottom of the freshwater zone in the aquifer generally produce good quality water. At a distance of 200 feet from a high salinity ocean shoreline, the thickness of the freshwater zone in the Cape Cod aquifer is expected to be 25-30 feet. The relationship between freshwater and saltwater in the near-shore environment is shown in Figure 2. However, in estuaries where there is a salinity gradient with saltwater at the mouth of the estuary and freshwater farther upstream, the freshwater aquifer can be much thicker (see Fitterman and Dennehy, 1991 below).

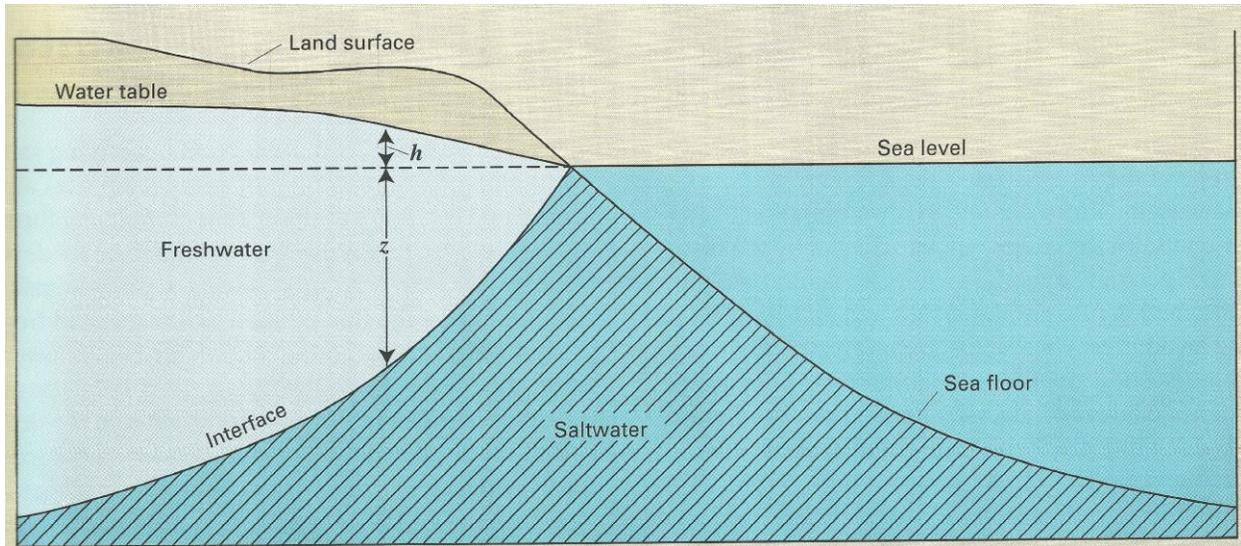
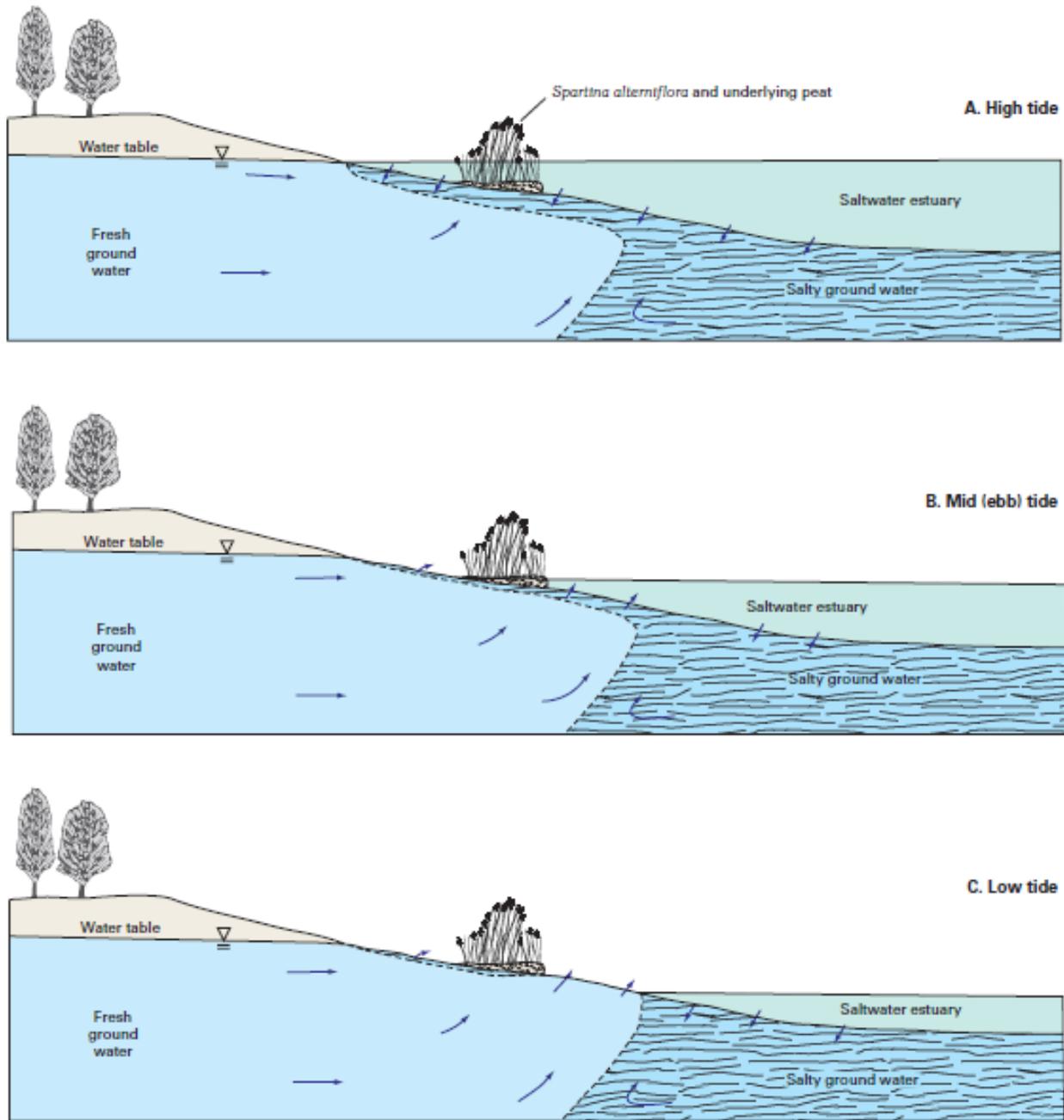


Figure 2. Cross-section showing the relationship between freshwater and saltwater adjacent to a permanent saltwater body. The thickness of the freshwater zone in the aquifer (z) is equal to 40 times the elevation of the water table above sea level (h). (Barlow, 2003, Figure B-1)

2.1 Saltwater-Freshwater Relationship in Estuaries and Salt Marshes

Niedoroda and April (1975) investigated the relationship of salt and fresh groundwater underlying salt marshes at three locations on the outer part of Cape Cod. They found that the zone of high salinity water from tidal inundation infiltrated only a few feet into the marsh peats and underlying sandy sediments. Salinity at depths of more than 5 feet below the marsh surface showed brackish to almost fresh groundwater. They surmised that the flow of freshwater from adjacent upland areas counteracted the infiltration of saltwater during high tide. Saltwater that had infiltrated the marsh sediments was partially flushed and diluted by the much larger flow of fresh groundwater beneath the marsh peat. Infiltration of saltwater through the marsh sediments occurs only at high tide, whereas the flow of fresh groundwater from the upland areas is continuous.

Barlow (2003) summarized the work of Portnoy and others (1998) and other investigators regarding the relationship of saltwater and freshwater in areas adjacent to estuaries. Groundwater discharge to the estuary is affected by the tidal cycle of the estuary. At high tide, saltwater infiltrates into the near-surface sediments. The saltwater cannot infiltrate very far into the sediments because high tide lasts only a few hours and fresh groundwater is flowing in the opposite (seaward) direction (Figure 3, top). As the tide recedes, fresh groundwater flows from the aquifer, discharging at the estuary shoreline. This flow of fresh groundwater begins to flush saltwater from the near-surface sediments (Figure 3, middle). At low tide, mostly freshwater is being discharged from the aquifer into the estuary. A small amount of saltwater may remain in the near-surface sediments (Figure 3, bottom). This cycle of infiltration of a small amount of saltwater at high tide and flushing by freshwater discharge is repeated with each tide cycle.



Figures modified from Portnoy and others (1998) and Urish and Garbar (1997)

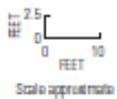


Figure 62. Ground-water discharge and saltwater infiltration at the aquifer-estuary boundary during a tidal cycle: (A) high tide; (B) mid (ebb) tide; and (C) low tide.

Figure 3. Reproduction of Figure 62 from Barlow (2003) showing the effects of tides on underground freshwater and saltwater flow at an estuary shoreline.

Barlow (2003) also summarized the work of previous investigators regarding groundwater flow near, and discharge of fresh groundwater to, salt marshes. A typical example of groundwater flow at a salt marsh is provided from investigations at Namskaket Marsh near Orleans (MA), on Cape Cod. A conceptual model of groundwater flow and discharge to the marsh is shown in Figure 4.

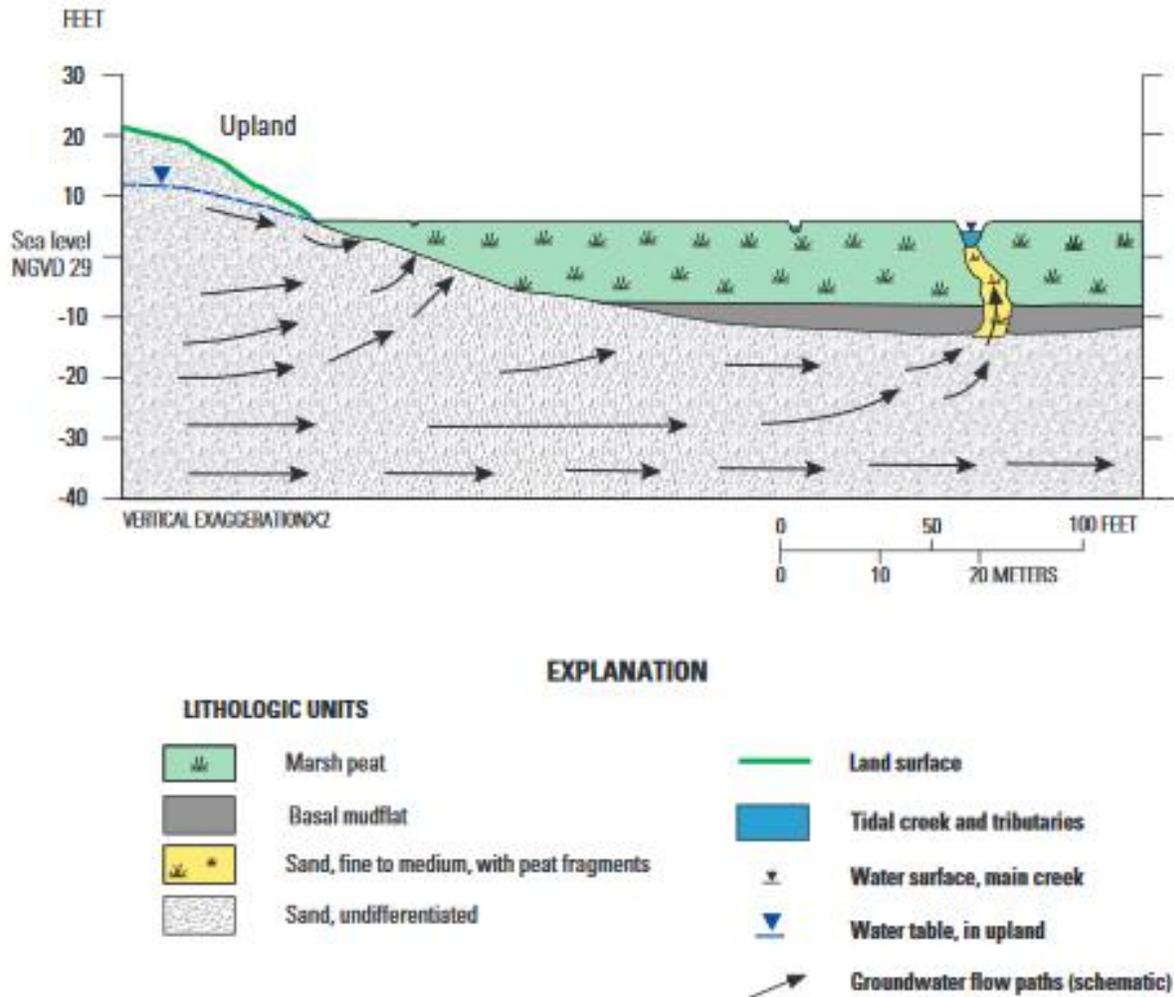


Figure 3. Inner Namskaket Marsh cross section *B-B'*, showing major sediment types inferred from sediment sampling and subsurface probing with a steel rod. Arrows show inferred directions of groundwater flow, and observed zones of groundwater discharge near the marsh-upland boundary and at the main creek bottom. See figure 1 for location of cross section.

Figure 4. Groundwater flow pattern (freshwater) in a typical salt marsh environment.
(From Weiskel and others, 2016)

Most of the groundwater discharge occurs at the estuary boundary between the upland areas and the edge of the peat beds, and as upward flow through the permeable sediments underlying the creek. Groundwater discharge in the interior vegetated areas of the marsh is limited because the thick overlying marsh peat beds have a low permeability. The low permeability of the peat beds also impedes downward percolation of saltwater at high tide. Additionally, the hydraulic gradient in the peat beds is upward as the fresh groundwater underlying the peat beds is under pressure due to the confining nature of the low-permeability peat beds. This is in contrast with a sandy ocean shoreline beach with no marsh border and where full-strength seawater percolates into the shoreline aquifer up to the elevation of high tide.

2.2 Conceptual model of existing conditions in the Herring River basin

Currently there is no significant amount of tidal inflow to the diked Herring River basin. It is essentially at a continuous state of low tide. Fresh groundwater from adjacent upland areas flows toward and discharges into the stream channels. The stream channels essentially act as drainage ditches, causing the water table in adjacent areas to be lowered. After tidal flow is restored, there will be significant portions of each day when fresh groundwater will not be able to discharge into the stream channels because they are flooded with tidal water. During the period when fresh groundwater flow toward the stream channels is reduced, the water table will rise because there is still groundwater flowing toward the stream channels from adjacent upland areas. In effect, the high tide acts as a dam to freshwater outflow. The net result is a slight rise of the mean water table elevation.

According to the Ghyben-Herzberg relationship, described previously, the thickness of the freshwater zone in the aquifer is directly related to the height of the water table above sea level. The ratio is 1:40; for every foot that the water table is above sea level, the depth to the freshwater-saltwater interface will be 40 feet deep. For example, if restoring tidal flow to the Herring River basin increased the mean water table elevation by 3 inches ($\frac{1}{4}$ foot), then the thickness of the freshwater aquifer would increase by 10 feet. The result could improve existing water quality in wells that currently have their screened interval deep in the freshwater aquifer, near the current transition zone from freshwater to saltwater, because the freshwater-saltwater transition zone will be forced downward.

2.3 Summary of Section 2

A lens of freshwater floats above the saltwater in the Cape Cod aquifer. The freshwater zone in the aquifer extends below sea level a distance equal to 40 times the elevation of the water table above sea level. In general, wells located more than 200 feet from the ocean shoreline will encounter a freshwater zone that is thick enough to provide good quality groundwater for domestic use. The thickness of the freshwater zone in the aquifer is expected to be 25-30 feet at a distance of 200 feet from a high salinity ocean shoreline.

Tidal estuaries will have salty water in the near-surface sediments from infiltration of seawater during high tide. However, groundwater underlying the low-permeability peat and marsh sediments will be fresh. The low permeability of peat coupled with upward pressure of fresh groundwater limits the infiltration of saltwater.

Current tidal restriction in Herring River causes a perpetual “low tide” condition that allows groundwater to discharge into stream beds unrestricted by higher tides, thereby lowering the water table. By reintroducing a more natural tidal cycle, the Herring River restoration will cause the water table to rise, and consequently the thickness of the freshwater aquifer will increase.

The basic groundwater science described above suggests that restoration of tidal flow to the Herring River would increase the elevation of the surrounding water table, lower the freshwater/saltwater interface, and thus increase the thickness of the freshwater zone in the aquifer. Hydrogeologic investigations in the Herring River and Mill Creek helped to validate this prediction. Two key points in reaching these conclusions are; 1) there will be a salinity gradient between the mouth of the river and upstream reaches, and 2) tidal restoration will result in an increase in the mean water level in the streams.

3.0 Hydrogeologic Investigations in the Herring River Basin, Mill Creek, and similar hydrogeologic settings

The effect of tidal restoration in the Herring River basin on the freshwater/saltwater relationship in the underlying aquifer has been addressed by several studies using different methods. Some of these studies are summarized in this section.

3.1 Geophysical monitoring wells; Fitterman and others (1989), Fitterman and Dennehy (1991)

Fitterman and others (1989) conducted geophysical surveys on the highlands to the east of the Herring River. They determined that the freshwater aquifer was at least 10 meters (33 feet) thick at the very edge of the flood plain and increased with distance away from the river. They used an analytical equation to evaluate how increased tidal fluctuation in the river would affect the water table adjacent to the stream. They concluded that completely opening the existing tide gates would have no effect on wells in the uplands east of the river because the mean river level would not change, and the area affected by water table fluctuations would be limited to “a few tens of meters” from the river. The distance is of little importance as they were only considering the distance within which tidal flow in the river would affect water table elevations at nearby wells. They did not evaluate the potential effect of tidal restoration on the freshwater/saltwater interface or the thickness of the freshwater zone in the aquifer.

In a subsequent study, Fitterman and Dennehy (1991) installed monitoring wells that verified the results of the geophysical investigation conducted in 1989. They found that the thickness of the freshwater aquifer at four monitoring wells (Figure 5, wells labeled WNW 115-118)) ranged from 18-22 meters (56-72 feet). At two monitoring wells immediately landward of the flood

plain of the Herring River (WNW-115 & WNW-117), the thickness of the freshwater aquifer was determined to be approximately 65 and 56 feet respectively.

Fitterman and Dennehy (1991) assumed that completely opening the existing tide gates would cause both static-water and high-tide levels in the Herring River to increase by less than 0.5 meter. They then concluded that such a small increase, compared to the large thickness of the freshwater aquifer, makes it unlikely that the thickness of the freshwater aquifer or the position of the fresh/salty groundwater interface would change at wells in the highlands east of the Herring River. They did acknowledge that wells in the former tidal flood plain areas along High Toss Road could potentially draw salty water due to infiltration of saltwater from the surface or repositioning of the fresh/salty groundwater interface (Fitterman and Dennehy, 1991). Subsequent investigations by Howes and others (1996), Weiskel and others (2016), and Martin (2007) show that infiltration of saltwater penetrates only a few meters below the ground surface in an estuary flood plain and occurs only within the immediate vicinity of areas flooded by saltwater at high tide. Thus, unless a well is flooded at high tide and experiences saltwater infiltration around the casing, it is unlikely to be affected as the screened interval is typically 15-20 feet below ground surface.

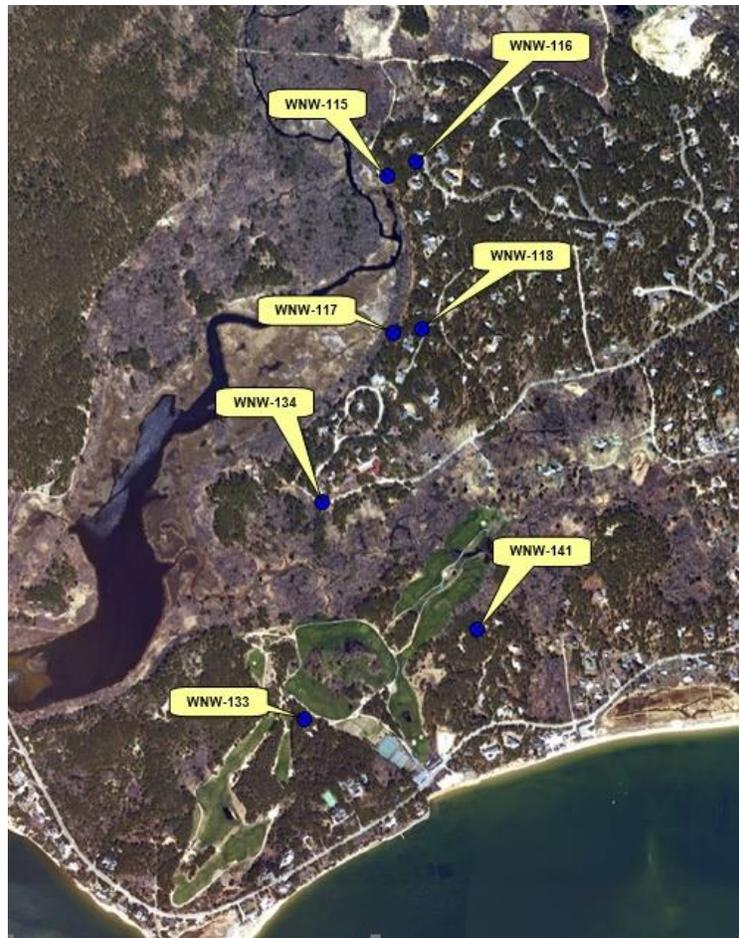


Figure 5. Location of USGS geophysical monitoring wells in the Herring River and Mill Creek basins

Two additional geophysical monitoring wells were constructed in September 2003 to facilitate monitoring the depth of the freshwater/saltwater interface in other areas near the flood plain that might be affected by restoration of tidal flow in Herring River and Mill Creek (Wells WNW-133 and WNW-134). Well WNW-141 was constructed in 2004. The locations of wells installed by Fitterman and Dennehy, and subsequent wells installed in 2003 and 2004 are shown on Figure 5.

Figure 6 shows an example of the geophysical log from one of those wells located in upland adjacent to the estuary flood plain. The log clearly shows the low conductivity of the freshwater zone to a depth of about 65 feet, then a transition zone from 65-75 feet, then high conductivity below 75 feet, indicative of salt water.

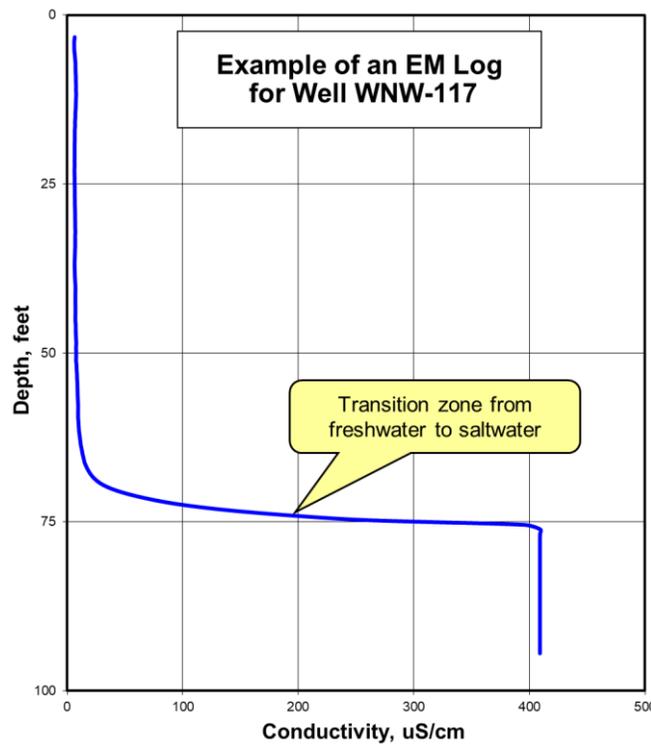


Figure 6. Example of electromagnetic induction log at Well WNW-117

3.2 Namskaket Marsh; Howes and others (1996)

Howes and others (1996) showed that the area in which saltwater infiltrates into the sediments underlying a tidal salt marsh is limited to the area that is regularly inundated and to a depth of 2-3 meters (Figure 7). Deeper sediments adjacent to the tidal flooding are consistently saturated with freshwater, as shown in Figures 3, 4, and 7.

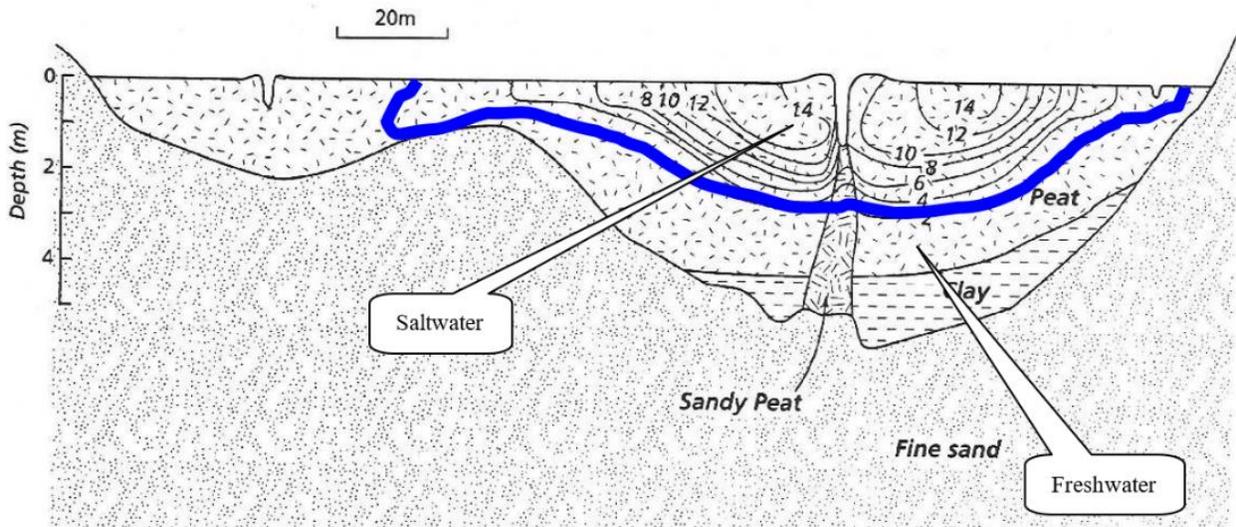


Figure 7. Salinity of groundwater in sediments underlying Namskaket Marsh. Contour lines are labeled in ppt salinity. (From Howes and others, 1996)

3.3 Wellfleet Harbor; (Portnoy and Martin, 2007)

Portnoy and Martin (2007) investigated tidal fluctuations in groundwater at various distances from a salt-marsh fringed ocean shoreline (Figure 8). They showed that the tidal fluctuation of groundwater levels was greatly dampened, even at short distances from the shoreline in Wellfleet Harbor where the tidal range is 9 feet. Additionally, they showed that there was fresh groundwater ($245 \mu\text{S}/\text{cm}$) at Well # 3, located just 59 feet from the edge of the salt marsh, despite biweekly seawater inundation of the salt marsh during spring tides.

National Park Service staff recently started monitoring groundwater levels and salinity in these wells. Data from these wells are expected to verify the presence of fresh groundwater underlying areas that are regularly inundated by tidal flow.



Figure 8. Well locations downstream of the Herring River dike. Portnoy and Martin (2007)

3.4 USGS computer modeling of potential effects of tide restoration in the Herring River

Masterson (2004) conducted a regional investigation of the lower Cape Cod aquifer system. The investigation was designed to improve the understanding of the hydrogeology of the aquifer system and to assess the effects of changing groundwater pumping, recharge conditions, and sea level rise on the groundwater flow system. Near the end of the investigation, after the first draft of the report had been written, Masterson was asked to include an assessment of the effects of tidal restoration in the Herring River basin. The computer model that had been constructed to evaluate the original objectives of the investigation did not include the site-specific data that would be needed to perform the local-scale analyses to assess the effects of tidal restoration.

Output from the hydrodynamic model of tidal flow developed by Spaulding and Grilli (2001) was used to develop four scenarios to assess the effect of restoring tidal flow in the Herring River basin on the altitude of the freshwater/saltwater interface. The four computer model

scenarios evaluated combinations of increasing the mean water elevation and changing the salinity distribution in the Herring Basin.

Computer modeling produced mixed results in predicting future conditions of the elevation of the fresh/salt groundwater interface and the thickness of the freshwater zone in the aquifer. The predictions produced by these modeling scenarios are not applicable to the planned restoration of tidal flow in the Herring River system because the model parameter inputs that were used do not reflect the hydrologic conditions of an intertidal estuarine system. The computer model was designed to assess groundwater flow on a regional scale, not to evaluate conditions on a local scale. The model does not mimic the salinity gradient and ebb and flow of saltwater that occur in an intertidal estuary

3.5 Summary of Section 3

Hydrologic investigations in the Herring River basin show that the freshwater zone in the aquifer adjacent to the river flood plain is 33-72 feet thick. Investigations at other locations with similar hydrogeologic conditions show that the area in which saltwater infiltrates into the sediments underlying a tidal marsh is limited to the area that is regularly inundated, and in those locations, infiltration only occurs to a depth of 2-3 meters. The aquifer underlying tidally flooded areas will continue to have a zone of freshwater after tidal flow is restored. Tidal restoration is expected to increase the mean water level in the river and streams, thus slightly raising the surrounding water table, increasing the thickness of the freshwater lens, and lowering the elevation of the salt/freshwater interface. Restoration of tidal flow in the Herring River is not expected to affect adjacent water-supply wells unless a well were regularly inundated by tidal flow at the ground surface.

Masterson (2004) attempted to model the potential effect of tidal restoration in the Herring River system on the depth to the fresh/saltwater interface and thickness of the freshwater lens; however, the model did not mimic the ebb and flow of saltwater in the river system. Therefore, the model outputs are not valid predictions of expected future conditions after tidal restoration in Herring River. Results from multiple investigations strongly support the conclusion that water quality in all wells above the reach of predicted surface-water flooding will not be affected by tidal restoration.

4.0 Investigations of potential effects of restored tidal flow on domestic water-supply wells:

The basic groundwater science described in Section 2 and the hydrogeologic assessments described in Section 3 show that restoration of tidal flow in the Herring River basin is not expected to have an impact on domestic water-supply wells unless the well heads were inundated with salt water at the ground surface.

Larry Martin, author of this report and retired National Park Service Hydrogeologist, conducted several investigations to further assess the potential for restored tidal flow to affect private domestic wells in the Mill Creek and Herring River (Martin, 2004; Martin, 2007).

4.1 Martin (2004)

Martin (2004) evaluated the potential for saltwater intrusion by comparing hydrogeologic conditions in the Herring River basin with other, similar areas (Namskaket Marsh, Lieutenant Island, Wellfleet Harbor along Chequessett Neck Road) that are adjacent to saltwater bodies and tidal estuaries. Evaluation included computer modeling of the local groundwater flow system using the predicted tidal conditions that would result from various alternatives of opening or removing the existing tidal control structures (as described in Spaulding and Grilli, 2001). This investigation relied on findings from previous computer modeling of the groundwater flow system (Masterson 2004) that indicated that the thickness of the freshwater aquifer could become thinner for certain simulated conditions.

As a worst-case condition, Martin (2004) evaluated the potential extent of saltwater intrusion as if the restored tidal areas were permanently flooded with seawater, creating a new ocean shoreline at the margin of tidally flooded areas. Analytical modeling of the depth of the freshwater/saltwater interface at various distances from the tidally flooded areas showed that any change in the thickness of the freshwater aquifer would be restricted to an area underlying and immediately adjacent to the newly restored tidal estuaries (within about 200 feet), because the thickness of the freshwater aquifer increases quickly inland from ocean shorelines.

After examining available data for wells at properties adjacent to the ocean shoreline (for example along Chequessett Neck Road west of Wellfleet town center and the Indian Neck area), it was determined that wells constructed less than about 200 feet from the ocean and/or screened near the bottom (less than 10 feet above the freshwater/saltwater interface) of the freshwater aquifer could be susceptible to saltwater intrusion. Wells located more than about 200 feet from ocean shorelines and having their screened interval a significant distance (more than 15 feet) above the bottom of the freshwater zone in the aquifer generally produce good quality water.

Further investigation of existing wells in the Wellfleet area that are located adjacent to salt-water bodies (Wellfleet Harbor and Cape Cod Bay) showed that wells with poor quality water are typically; 1) located less than 100-150 feet from a high salinity oceanic water body, where the freshwater aquifer is thin, and/or 2) have well screens deep enough below the water table to draw water from the transition zone between fresh and salty groundwater. Wells providing good quality groundwater are typically located more than 150 feet from a salt-water body and have the well screen located only a few feet below the water table, which is far above the transition zone.

The 200-foot distance from ocean shorelines was considered a conservative scenario for evaluation of potential impacts on wells in the Herring River and Mill Creek areas because, as has been discussed in previous sections of this report, numerous investigations have shown that there is generally fresh groundwater underlying tidal estuaries. Salt water floods estuaries for only a few hours during each tidal cycle, unlike an ocean shoreline setting where saltwater is continuously present, such as at the edge of Wellfleet Harbor or Cape Cod Bay. In the Herring River estuary, the upward flow of fresh groundwater underlying the salt marshes impedes the

infiltration of saltwater. The extent of saltwater in sediments underlying tidal marshes and estuaries is limited to the area flooded with saltwater at high tide, as shown in Figure 7.

In Figures 4 and 19 of the report, Martin (2004) showed conceptual illustrations of the upward relocation of the freshwater/saltwater interface to a higher elevation following tidal restoration. Subsequent field studies have shown that those conceptual illustrations are incorrect. For example, investigations of saltwater infiltration at Namskaket Marsh (Weiskel and others, 2016) clearly show that saltwater infiltrates only a few meters and that freshwater occurs in deeper sediments below the tidal estuary.

4.2 Martin (2007)

After the 2004 report, it was decided that further investigations would be conducted to identify any private domestic wells that could potentially be affected by full tidal restoration. The work began in 2006 by examining well records for homes along Chequesset Neck Road, south of the Herring River dike which border Wellfleet Harbor and the Indian Neck area on the east side of the harbor. Both areas represent the worst-case condition for changes of the fresh/salt water interface, assuming a permanent saltwater body adjacent to the upland. Because the freshwater lens is thinner at the shoreline of a permanent saltwater body, the well's setback from the shoreline generally needs to be greater than it does for wells within the Herring River estuary.

Basic water chemistry from 24 wells at Indian Neck showed variation in their salt content, but all were below EPA's maximum limit for drinking water. Many of the wells were less than 250 feet from the shoreline and still yielded good quality drinking water. The wells along Chequesset Neck Road also varied in water quality. Some of the wells within 100-150 feet from the harbor had poor water quality because their screens were set too deep, probably approaching the fresh/saltwater interface. Those that were further from the shoreline had acceptable water quality.

Using the results of the first part of the 2007 report, additional analyses within the Herring River basin were then conducted to identify private properties within 250 feet of areas that would potentially be flooded by salt water during high tides, following restoration of tidal flow. Previous work had shown that the freshwater zone in the aquifer would have sufficient thickness to provide good quality water to wells located more than 200 feet from a saltwater shoreline. However, in order to ensure a conservative and comprehensive analysis, Martin used a distance of 250 feet in the 2006-07 investigation. Those parcels were then individually examined to determine the location of the well on the parcel, the depth of the well, depth of the screened interval, water table elevation, and the salt content of well water. That information allowed an assessment of the potential for saltwater intrusion at those wells on an individual basis.

In the summer 2007, the location of domestic wells adjacent to the Herring River flood plain basin was determined by examination of Assessors' Atlas maps, information on file at the Truro and Wellfleet Health Departments, and field inspections of individual properties. Wells that were located more than 20-30 feet away from, and at an elevation more than a few feet higher than, potentially flooded areas were deemed to be beyond the area of potential impact from tidal flooding. These criteria were based on the numerous investigations cited previously in this report

and from observations of other areas on the outer Cape Cod where there are domestic wells close to tidal wetlands.

The office and field investigations in 2007 showed that most of the private domestic wells identified as potentially “at risk” in the report by Martin (2004) were outside the area of potential tidal flooding and, thus, would not be impacted by restoration of tidal flow. A small number of properties were identified as having wells that could potentially be impacted by full restoration of tidal flow. Wells on seven parcels were identified as at risk of surface inundation by salt water from restoration of full tidal flow. They include three wells on the eastern side of the Lower Herring River sub-basin and four wells in the Mill Creek sub-basin, one on the northern side and three on the southern side. Two of the properties (70 Way 672 and 90 Way 672) on the eastern side of the Lower Herring River have been, or are anticipated to be, acquired by the National Park Service, with buildings removed and wells plugged.

The five remaining wells would be susceptible to saltwater inundation at the ground surface of the casing at various points during the restoration of tidal flow. Since the restoration will proceed in phases, not all these wells would need to be protected at the same time in the restoration. Phase 1 restores a smaller portion of the flood plain with a lower maximum water surface elevation than the full restoration. It covers only a portion of the Mill Creek sub-basin and excludes the Upper Pole Dike Creek sub-basin. The maximum water levels for Phase 1 would only reach three of the five wells in the absence of protective actions. Those include one well in the Lower Herring River sub-basin and two in Mill Creek sub-basin. The other two wells would not be vulnerable to tidal inundation until later phases of the restoration. Options to protect all five of the wells in advance of when water levels would reach them are discussed below.

4.3 Water-supply well at 505 Old Chequessett Neck Road in Mill Creek:

The water-supply well for this property is located about 60 feet east of the house at a surveyed elevation of 4.0 feet NAVD88 (Figure 9). A tributary of Mill Creek called Snake Creek, is south and east of the house. Current plans for tidal restoration are to limit mean high spring tides in the Mill Creek sub-basin to 2.4 feet NAVD88 and the maximum water surface elevation during extreme storm events to 3.7 feet NAVD88 to prevent flooding of unprotected structures. Both tidal elevations are below the ground elevation at the well casing.

In October 2014, I compiled all the available information and wrote a summary report to assess the potential for the well at this property to be affected by tidal restoration (Martin, 2014). The report was not published or distributed.

The report (Martin, 2014) provides clear evidence that the well was drilled too deep. The perforated interval of the well is at a depth of 52-55 feet below ground surface, near the transition zone between the freshwater aquifer and the underlying saltwater. Water pumped from the well has higher concentrations of sodium (115 mg/l) and higher conductivity (683 umhos/cm) than water pumped from the freshwater aquifer at adjacent properties. Based on tide-height model predictions, mean water level in the restored estuary will increase, causing the mean groundwater table elevation in adjacent locations to increase slightly. Based on the

Ghyben-Herzberg relationship (see Section 1 of this report), this will result in a thicker freshwater lens and lower elevation of the fresh-salt groundwater interface in areas abutting the estuary, possibly improving water quality at the well.

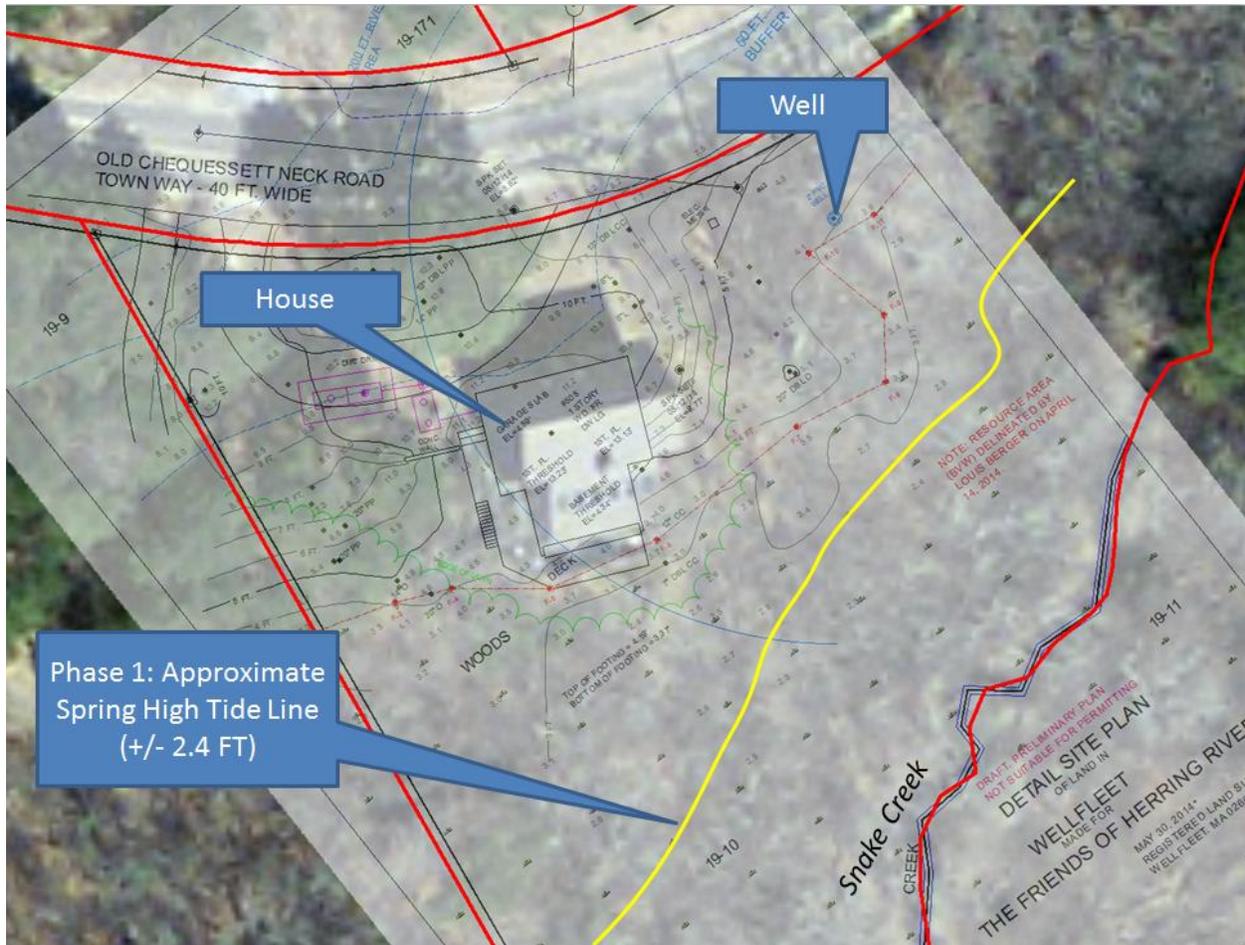


Figure 9. Site plan of the property at 505 Chequessett Neck Road.

Earlier in this report, several examples were provided to show that tidal marshes are underlain by freshwater, and that saltwater generally does not infiltrate from the surface because it is opposed by the seaward flow of freshwater toward tidal streams. The well at 505 Chequessett Neck Road will not be threatened from surface infiltration of saltwater during Phase 1 of restoration because maximum normal and storm tide water levels will remain below the land surface at this well.

4.4 Water-supply well at 27 Way 672 in the Lower Herring River sub-basin

The property at 27 Way 672 is south of High Toss Road, on the east side of the Herring River valley (Figure 10). The existing water-supply well is located in the lowland area on the west side of Way 672. Land surface elevation at the well is 3.2 feet NAVD88.



Figure 10. Site plan of the 27 Way 672 property.

The well completion report for the well is shown in Figure 11. The well is 26 feet deep. The geologic log shows a clay layer from the land surface to a depth of 15 feet. Presumably, sand underlies the clay, as the completion report identifies the water bearing zone from 19-26 feet. The well was completed with PVC casing to a depth of 23 feet and with a well screen from 23-26 feet. Infiltration of rainfall on the adjacent upland areas recharges the freshwater aquifer. Fresh groundwater flows from recharge areas in the uplands toward discharge areas in the stream valley as shown in Figure 4. Figure 12 shows the addition of the well to the schematic cross-section from Figure 4 of this report.

Department of Environmental Management/Division of Water Resources
WELL COMPLETION REPORT 1680

WELL LOCATION		GEOGRAPHIC DESCRIPTION	
Address: <u>SN 12 PCL 235</u>		(feet) N S E W of _____ (circle)	
City/Town: <u>WILMINGTON</u>		(road) _____	
Well owner: <u>JUDY ELLIS</u>		(mic. in tenths) N S E W of _____ (circle)	
Address: _____		Intersect. w/ _____ (road)	
Board of Health permit obtained: yes <input checked="" type="checkbox"/> no <input type="checkbox"/>			
WELL USE		WELL DATA	
Domestic <input checked="" type="checkbox"/> Public <input type="checkbox"/> Industrial <input type="checkbox"/>		Total well depth: <u>26</u> ft.	
Monitoring <input type="checkbox"/> Other _____		Depth to bedrock: _____ ft.	
Method drilled: <u>HAUER</u>		Water-bearing rock/unconsolidated material: _____	
Date drilled: <u>9-6-97</u>		Description: _____	
CASING		Water-bearing zones:	
Type: <u>POC</u>		1) From: <u>19</u> To: <u>26'</u>	
Length: <u>28</u> ft. Dia (I.D.): <u>4</u> in.		2) From: _____ To: _____	
Length into bedrock: _____ ft.		3) From: _____ To: _____	
Protective well seal: _____		Gravel pack well: _____ dia.	
Grout <input type="checkbox"/> Other _____		Screen: _____ dia.	
		Slot# <u>12</u> length <u>3</u> from <u>23-26</u>	
STATIC WATER LEVEL (all wells)			
Static water level below land surface: <u>4</u> ft. Date: <u>9-6-97</u>			
WELL TEST (production wells)			
Drawdown: <u>3</u> ft. after pumping <u>1</u> hr. <u>41</u> min. at <u>41</u> gpm			
How measured: <u>WHP</u> Recovery: <u>3</u> ft. after <u>8</u> hr. <u>8</u> min.			
LOG OF FORMATIONS		COMMENTS	
Materials	From	To	(Please use one)
<u>Clay</u>	<u>0</u>	<u>10</u>	
		Driller: <u>JOSEPH A. CROSSLAND</u> Firm: <u>DE CIPPELLOW WILMINGTON</u> Address: <u>PO BOX 293</u> City/Town: <u>WILMINGTON MA 02090</u> Supervising Driller Reg.#: <u>271</u> <u>Joseph A. Crossland</u> <small>Signature of supervising registered well driller</small>	

BOARD OF HEALTH COPY

Figure 11. Well completion report for the Way 672 well.

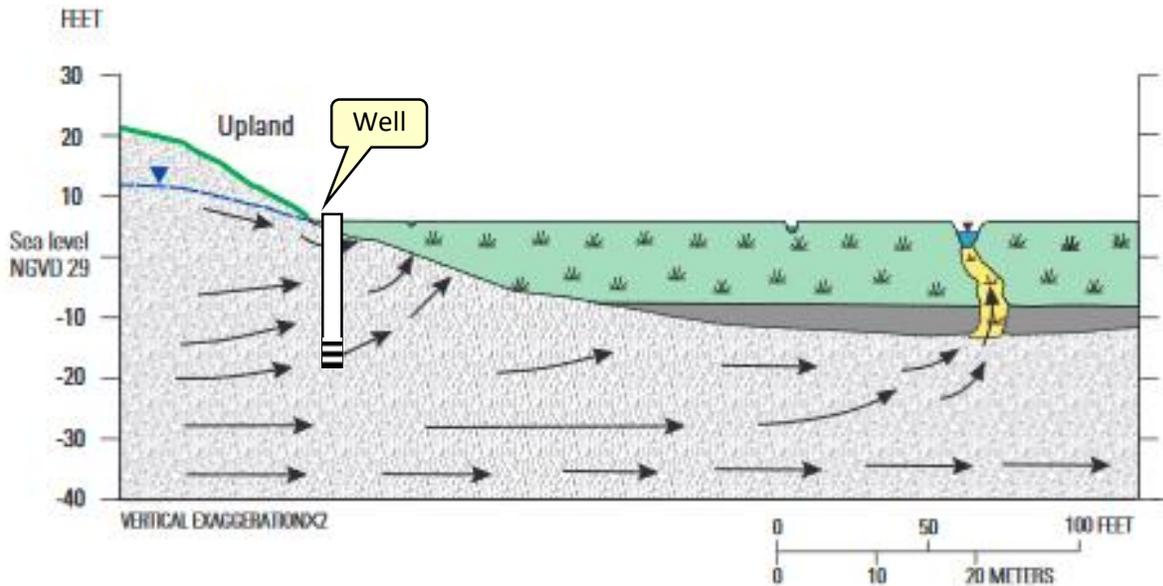


Figure 12. Schematic cross-section showing the relationship of the existing well serving Way 672 to hydrogeologic features.

Records of water quality from two tests of the well are available. In 1997, the sodium concentration was 35 mg/l and the specific conductance was 284 umhos/cm. In 2015, the sodium concentration was 40 mg/l and the specific conductance was 320 umhos/cm. Specific conductance of water from the well can easily be monitored as a surrogate for salinity. If saltwater was getting into the well, the conductance would increase.

The water quality of the well can be compared with that from a neighboring well serving 255 High Toss Road. That well was constructed and tested in 1988. The well is screened from 31-34 feet below ground surface, but since the ground surface is higher than at the well serving 27 Way 672, the well is screened higher in the freshwater aquifer. The well serving 255 High Toss Road had a sodium concentration of 15 mg/l and specific conductance of 129 umhos/cm, typical of high-quality Cape Cod groundwater.

The well serving 27 Way 672 is located at a ground surface elevation that, absent mitigation measures, would be inundated during Phase 1 of the restoration. In discussions of mitigation options with the landowner, the Project proponents proposed to relocate the well to an upland area on the property that is outside the area of tidal inundation and that would provide good quality potable water for the residence (Figure 13). The water quality data from a comparably located well serving a neighboring property show that relocating the well to the upland location and screening the new well higher in the freshwater aquifer would likely result in water quality equal to or better than the existing well. However, as of the publication date of this report, the property owner has not agreed to the well relocation.

Phase 1 plans include construction of a physical barrier on adjacent NPS property to prevent tidal flow from inundating the properties at #25 and #27 Way 672. This barrier will also prevent salt water inundation of the well at #27 Way 672 and therefore prevent adverse effects on well water quality from tidal restoration. The physical barrier will be built with adequate freeboard above the elevation of the storm of record.

4.5 Water-supply wells at 60, 70, and 80 Mill Creek Lane in the Mill Creek sub-basin:

The land surface elevations at two wells that are on the southern side of the Mill Creek sub-basin are below the maximum water surface elevation under full restoration (3.7' NAVD88) and near the elevation of the spring high tide (2.4' NAVD88) for Phase I restoration. Land surface elevation at the wells providing water to the residences at 70 Mill Creek Lane and 80 Mill Creek Lane is 2.6' NAVD88 for both wells. Wells at 70 and 80 Mill Creek Lane will be replaced with new wells, consistent with the property owners' permission, at locations above the maximum water surface elevation of even full restoration.

The well serving the residence at 60 Mill Creek Lane is at an elevation of 5.6' NAVD88, nearly two feet higher than the projected water surface elevation at full restoration. It is unlikely that this well would be affected by the tidal restoration project, but it will be monitored for potential

water quality changes. If necessary, project proponents would work with the landowner to either protect this well in place or relocate the well at a higher elevation.

4.6 Summary of Section 4:

The vulnerability criteria of wells in a worst-case situation, i.e. adjacent to a permanent saltwater body, were applied to the estuary landscape throughout the Herring River basin, resulting in a conservative vulnerability screening analysis. Properties within 250 feet of areas that would be inundated by tidal flow were evaluated to assess the potential vulnerability of water-supply wells to salt water inundation. Most wells evaluated are located in upland areas or with sufficient setback from areas that will be inundated and therefore will not be affected by restoration of tidal flow in the Herring River and Mill Creek basins.

Seven wells were identified as having potential impacts during full tidal restoration. Two of those wells are located on properties now, or soon to be, owned by NPS and will be capped and abandoned. Of the five remaining wells identified, three would be susceptible to tidal inundation under Phase 1 of the restoration. One well in Lower Herring River will be protected by a physical barrier that will prevent tidal flow from inundating the well casing. The two wells at risk during Phase 1 in Mill Creek will be replaced with new wells located at higher elevations on those properties.

The two other wells that could be susceptible to water quality impacts in future restoration phases, are located in the Mill Creek basin and are not at risk of inundation during Phase 1.

Summary of findings for the seven wells discussed in Section 4:

- 70 and 90 Way 672: these properties have been, or will be, acquired by the National Park Service prior to tidal restoration, and the wells will be plugged and abandoned.
- 27 Way 672: an offer to relocate this well was declined by the property owner; this well will be protected from salt water inundation by construction of a physical barrier on National Park Service property.
- 505 Old Chequessett Neck Road: the maximum water surface elevation under Phase 1 restoration will be lower than the elevation of the ground surface at the well head and so protection from tidal inundation is not necessary until later phases of the Project.
- 70 and 80 Mill Creek Lane: since these wells would be overtopped by tidal water during Phase 1 restoration, they will be relocated to a location above maximum water levels under both Phase 1 and also for full restoration, consistent with permissions granted by property owners.
- 60 Mill Creek Lane: the well is at a higher elevation than the projected water surface elevation at full tidal restoration and is unlikely to be affected.

5.0 Conclusions

Assessment of the potential for tidal restoration to affect private, domestic wells in the Herring River basin has proceeded in a sequential and methodical manner over the past several decades. Numerous analytical and modeling evaluations, and field investigations have been conducted to enhance the scientific understanding of the interaction between tidal flow and groundwater hydrology in the Herring River and other similar Cape Cod estuaries. These studies evolved over time to provide a solid basis for assessing the risk of impacts to water quality in drinking water wells during the restoration of tidal flow into the Herring River estuary.

1. Field investigations and analytical modeling using the Ghyben-Herzberg relationship determined that the freshwater zone in the Cape Cod aquifer should generally be 25-30 feet thick at a distance of 200 feet from a permanently flooded ocean shoreline. However, salinity gradients within estuaries can result in adjacent freshwater aquifers being much thicker than those adjacent to permanently flooded, sandy ocean shorelines. This has been confirmed by test wells driven at the edge of the Herring River estuary.
2. Hydrogeologic conditions of intertidal estuaries differ substantially from those of permanently flooded ocean shorelines. Intertidal estuaries maintain a freshwater aquifer beneath the surface sediments. The intermittent ebb and flood cycles of tidal inundation in an estuary, combined with low permeability of peat and upward pressure of fresh groundwater, limit the infiltration of saltwater to shallow surface sediments.
3. Initial efforts to assess potential effects of tidal restoration in the Herring River basin on nearby domestic water-supply wells assumed (incorrectly) that saltwater fully penetrates sediments underlying tidal estuaries. In addition, some investigations used data inputs and produced findings that are not applicable to the Herring River intertidal estuarine setting because they assumed and/or applied hydrogeologic conditions found along oceanic shorelines with consistently high surface-water salinity.
4. Current tidal restriction in the Herring River basin creates a perpetual “low tide” condition that allows groundwater to continuously discharge to stream channels, unrestricted by high tides. These conditions create an artificially low water table compared to an unrestricted tidal estuary that is flooded by high tides twice daily. By reintroducing a substantially larger, more natural tidal range, the restoration project will increase the mean water level in the system. An increase in mean water level in Herring River will cause the water table within and directly adjacent to the flood plain to rise slightly. Thus, per the Ghyben-Herzberg relationship, the thickness of the aquifer’s freshwater zone, as well as the depth to the fresh/salt groundwater interface, will both increase in locations adjacent to areas of increased tide range.
5. Most private, domestic wells near Herring River are located in upland areas, outside the limits of proposed tidal flooding. These wells will not be affected by restoration of tidal flow.

6. Domestic water-supply wells at seven properties were identified as potentially at risk from full restoration of tidal flow. These wells are located in the flood plains of estuarine streams and could be inundated at the ground surface by salt water. Mitigation measures have been identified to protect water quality for five wells that would be susceptible to inundation during Phase 1 of the restoration. The two other wells that could be inundated during future phases of restoration beyond Phase 1 would require mitigation measures (relocation or protection) before additional tidal restoration is implemented.

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This report was prepared under contract to the Friends of the Herring River by
Larry Martin, retired National Park Service Hydrologist

Mr. Martin has 40 years of experience as a professional hydrogeologist, including 25 years with the National Park Service. During that time, he authored or coauthored 13 peer reviewed reports along with numerous memos and trip reports specific to the hydrology and hydrogeology of Cape Cod National Seashore.

During his 25-year career with the National Park Service, He conducted investigations at more than 90 different park units, resulting in more than 200 reports.

8.D Stormwater Calculations for Engineered Stormwater Management Structures

(See following pages)

Stormwater Management Design Information for Chequessett Neck Road Bridge
Fuss & O'Neill

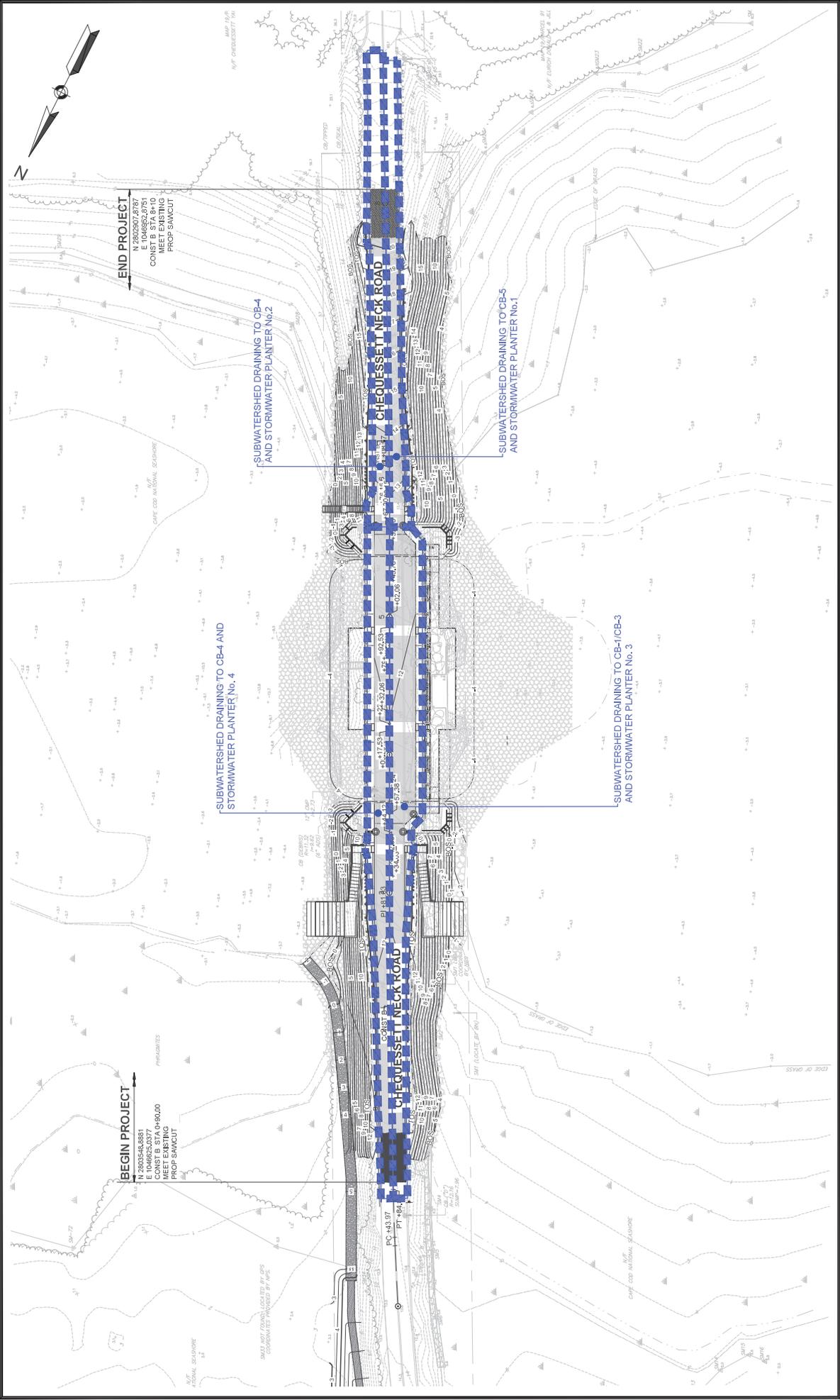
Stormwater Operation & Maintenance Plan, High Toss Road and Hopkins Drive
ESS Group

Attachment F

Stormwater Management System Design Information

Subwatershed Delineation Figure
Runoff Coefficient Calculations
Pipe Sizing Spreadsheet
Stormwater Standard 3 & 4 Compliance Spreadsheet
Supporting Stormwater Planter Sizing Calculations
Stormwater Standard 6 Compliance Spreadsheet
Supporting Proprietary Treatment System Certification and Documentation

Subwatershed Delineation Figure



SEAL	SEAL	SEAL	SEAL	SEAL	SEAL	SEAL	SEAL
DESIGNER	REVIEWER	DESIGNER	REVIEWER	DESIGNER	REVIEWER	DESIGNER	REVIEWER
No.	DATE	DESCRIPTION	DESIGNER	REVIEWER	DESIGNER	REVIEWER	DESIGNER

SCALE HORIZ. 1" = 30'

VERT. 1" = 3'

DATUM MGS 83

VERT. DATUM NAVD83

GRAPHIC SCALE

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FRIENDS OF HERRING RIVER

POST-IMPROVEMENT SUBWATERSHED MAP

HERRING RIVER TIDAL RESTORATION PROJECT

BRIDGE CONSTRUCTION PROJECT

CHEQUESSETT NECK ROAD

WELLFLEET, MASSACHUSETTS

PROJ. NO.: 20170056A17
DATE: JUNE 2018

SUB-1

Runoff Coefficient Calculations

Composite Runoff Calculations
Herring River Tidal Restoration Project
Wellfleet, Massachusetts

Inlet No.	Cover Description	Area (SF)	% of Total Area	Runoff Coefficient (C)	Composite C	Total Area (Acres)	C*A
CB-1 & CB-3	Exist. Impervious	5200.0	62.4	0.95	0.59		
	New Impervious	3130.0	37.6	0.95	0.36		
Totals:		8330.0	100.0		0.95	0.19	0.18

Inlet No.	Cover Description	Area (SF)	% of Total Area	Runoff Coefficient (C)	Composite C	Total Area (Acres)	C*A
CB-2	Exist. Impervious	5087.0	76.8	0.95	0.73		
	New Impervious	1534.0	23.2	0.95	0.22		
Totals:		6621.0	100.0		0.95	0.15	0.14

Inlet No.	Cover Description	Area (SF)	% of Total Area	Runoff Coefficient (C)	Composite C	Total Area (Acres)	C*A
CB-4	Exist. Impervious	4270.0	98.6	0.95	0.94		
	New Impervious	62.0	1.4	0.95	0.01		
Totals:		4332.0	100.0		0.95	0.10	0.09

Inlet No.	Cover Description	Area (SF)	% of Total Area	Runoff Coefficient (C)	Composite C	Total Area (Acres)	C*A
CB-5	Exist. Impervious	3237.0	89.2	0.95	0.85		
	New Impervious	393.0	10.8	0.95	0.10		
Totals:		3630.0	100.0		0.95	0.08	0.08

Pipe Sizing Spreadsheet

Pipe Sizing Spreadsheet
Herring River Tidal Restoration Project
Chequesset Neck Road, Wellfleet, Massachusetts

PIPE SEGMENT			DRAINAGE AREA		TIME		RUNOFF		PROPOSED PIPE DESIGN VARIABLES									
U/S Struct.	Pipe	D/S Struct.	Increment CA	CA	Tc (min)	Time In Section	Intensity (In/Hr)	100Yr Storm Event Design Flow	Diam (In.)	Length (Ft.)	Slope (Ft./Ft.)	Manning Coeff.	Capacity (Cfs)	Velocity (Fps)	Depth (Ft.)	Velocity (Fps.)	Angle	Hydraulic Radius
INLET-5	to	Planter No. 1	0.08 0.00 0.08	0.08	5.0 0.0 5.0	0.0 5.0	7.5	0.59	12	6	0.020	0.013	5.05	6.4	0.26	4.5	2.12	0.15
INLET-4	to	Planter No. 2	0.09 0.00 0.09	0.09	5.0 0.0 5.0	0.0 5.0	7.5	0.71	12	6	0.020	0.013	5.05	6.4	0.27	4.7	2.18	0.16
INLET-1 & INLET-3	to	Planter No. 3	0.18 0.00 0.18	0.18	5.0 0.0 5.0	0.0 5.0	7.5	1.36	12	6	0.007	0.013	2.92	3.7	0.48	3.6	3.06	0.24
INLET-2	to	Planter No. 4	0.14 0.00 0.14	0.14	5.0 0.0 5.0	0.0 5.0	7.5	1.08	12	6	0.020	0.013	5.05	6.4	0.32	5.1	2.39	0.18

PEAK FLOW SUMMARY:
100-YEAR FLOW
INLET-1 & INLET-3 1.36 CFS (COMBINED)
INLET-2 1.08 CFS
INLET-4 0.71 CFS
INLET-5 0.59 CFS

Stormwater Standard 3 & 4 Compliance Spreadsheet



**Herring River Tidal Restoration Project
Wellfleet, Massachusetts**

Objective: Size stormwater planters to infiltrate the required recharge volume (Mass Stormwater Standard 3) and provide treatment for the required water quality volume (Standard 4).

Stormwater Planter No. 1

1) Calculate Water Quality Volume (WQv)
WQv = 167.6 cf (refer to following sheet)

2) Volume of Storage Provided by Planter
Open Storage Provided = 172.3 cf
Storage Provided within Media = 316.0 cf
Total Storage Provided = 488.3 cf

Since the volume of storage provided by the planter exceeds the WQV, the planter is adequately sized to meet 80% TSS Requirement.

3) Calculate Required Groundwater Recharge Volume (Rev) - Stormwater Standard 3

$$REV = ((1' * (\text{Impervious Area}) * \text{Recharge Factor})) / 12 =$$

Impervious Area = 3630 sf (refer to following sheet)

Recharge Factor = 0.6 (from Mass Stormwater Handbook for Type A Soils - Carver Coarse Sand and Ipswich-Pawcatuck Matunuck Complex)

Rev = 182 cf < 488.3 cf provided

Since the volume of storage provided by the planter exceeds the required recharge volume, Standard 3 is met as this volume will be allowed to percolate through the media to the underlying ground. Treated stormwater beyond the capacity will be collected by the underdrain and discharged to the River/Harbor.

Stormwater Planter No. 2

1) Calculate Water Quality Volume (WQv)
WQv = 183.1 cf (refer to following sheet)

2) Volume of Storage Provided by Planter
Open Storage Provided = 129.0 cf
Storage Provided within Media = 236.7 cf
Total Storage Provided = 365.7 cf

Since the volume of storage provided by the planter exceeds the WQV, the planter is adequately sized to meet 80% TSS Requirement.

3) Calculate Required Groundwater Recharge Volume (Rev) - Stormwater Standard 3

$$REV = ((1' * (\text{Impervious Area}) * \text{Recharge Factor})) / 12 =$$

Impervious Area = 4332 sf (refer to following sheet)

Recharge Factor = 0.6 (from Mass Stormwater Handbook for Type A Soils - Carver Coarse Sand and Ipswich-Pawcatuck Matunuck Complex)

Rev = 217 cf < 365.73 cf provided

Since the volume of storage provided by the planter exceeds the required recharge volume, Standard 3 is met as this volume will be allowed to percolate through the media to the underlying ground. Treated stormwater beyond the capacity will be collected by the underdrain and discharged to the River/Harbor.

Stormwater Planter No. 3

1) Calculate Water Quality Volume (WQv)
WQv = 477.5 cf (refer to following sheet)

2) Volume of Storage Provided by Planter

Open Storage Provided =	172.3 cf
Storage Provided within Media =	312.6 cf
Total Storage Provided =	484.9 cf

Since the volume of storage provided by the planter exceeds the WQV, the planter is adequately sized to meet 80% TSS Requirement.

3) Calculate Required Groundwater Recharge Volume (Rev) - Stormwater Standard 3

$$REV = (1'' * (\text{Impervious Area} * \text{Recharge Factor})) / 12 =$$

Impervious Area= 8330 sf (refer to following sheet)

Recharge Factor= 0.6 (from Mass Stormwater Handbook for Type A Soils - Carver Coarse Sand and Ipswich-Pawcatuck Matunuck Complex)

Rev= 417 cf < 484.9 cf provided

Since the volume of storage provided by the planter exceeds the required recharge volume, Standard 3 is met as this volume will be allowed to percolate through the media to the underlying ground. Treated stormwater beyond the capacity will be collected by the underdrain and discharged to the River/Harbor.

Stormwater Planter No. 4

1) Calculate Water Quality Volume (WQv)
WQv = 339.8 cf (refer to following sheet)

2) Volume of Storage Provided by Planter

Open Storage Provided =	129.0 cf
Storage Provided within Media =	234.1 cf
Total Storage Provided =	363.1 cf

Since the volume of storage provided by the planter exceeds the WQV, the planter is adequately sized to meet 80% TSS Requirement.

3) Calculate Required Groundwater Recharge Volume (Rev) - Stormwater Standard 3

$$REV = (1'' * (\text{Impervious Area} * \text{Recharge Factor})) / 12 =$$

Impervious Area= 6621 sf (refer to following sheet)

Recharge Factor= 0.6 (from Mass Stormwater Handbook for Type A Soils - Carver Coarse Sand and Ipswich-Pawcatuck Matunuck Complex)

Rev= 331 cf < 484.9 cf provided

Since the volume of storage provided by the planter exceeds the required recharge volume, Standard 3 is met as this volume will be allowed to percolate through the media to the underlying ground. Treated stormwater beyond the capacity will be collected by the underdrain and discharged to the River/Harbor.

Supporting Stormwater Planter Sizing Calculations



HERRING RIVER RESTORATION - CNR BRIDGE

PER SECTION 2.2.3 OF THE MASS HIGHWAY STORMWATER HANDBOOK, STORMWATER MANAGEMENT STRUCTURES/PLANTER DESIGNED TO TREAT THE FIRST HALF-INCH OF RUNOFF OVER EXIST. PAVED SURFACES AND THE FIRST ONE-INCH OF RUNOFF OVER NEW PAVED SURFACES (OR AREA OF PAVEMENT IN EXCESS OF EXIST. PAVED AREA).

PLANTER NO. 1

$$WQV = \left[3237 \text{ SF (EXIST. PAVEMENT)} \times \frac{0.5''}{12} \right] + \left[393 \text{ SF (NEW PAVEMENT)} \times \frac{1''}{12} \right] = 167.6 \text{ CF}$$

$$\text{PLANTER SURFACE AREA} = 344.5 \text{ SF}$$

$$\text{VOL. CONTAINED IN MEDIA} = 344.5 \text{ SF} \times (\text{EL. } 8.63 - \text{EL. } 5.85) \times 0.33 = 316.0 \text{ CF}$$

$$\text{OPEN STORAGE IN PLANTER} = 344.5 \text{ SF} \times (\text{EL. } 9.13 - \text{EL. } 8.63) = 172.3 \text{ CF}$$

$$\left. \begin{array}{l} 316.0 \text{ CF} + 172.3 \text{ CF} = 488.3 \text{ CF} \end{array} \right\}$$

$$\therefore \text{VOL. OF STORAGE PROVIDED (488.3 CF)} > \text{VOL. OF STORAGE REQD. (167.6 CF)}$$

PLANTER NO. 2

$$WQV = \left[4270 \text{ SF (EXIST. PAVEMENT)} \times \frac{0.5''}{12} \right] + \left[62 \text{ SF (NEW PAVEMENT)} \times \frac{1''}{12} \right] = 183.1 \text{ CF}$$

$$\text{PLANTER SURFACE AREA} = 258 \text{ SF}$$

$$\text{VOL. CONTAINED IN MEDIA} = 258 \text{ SF} \times (\text{EL. } 8.63 - \text{EL. } 5.85) \times 0.33 = 236.7 \text{ CF}$$

$$\text{OPEN STORAGE IN PLANTER} = 258 \text{ SF} \times (\text{EL. } 9.13 - \text{EL. } 8.63) = 129.0 \text{ CF}$$

$$\left. \begin{array}{l} 236.7 \text{ CF} + 129.0 \text{ CF} = 365.7 \text{ CF} \end{array} \right\}$$

$$\therefore \text{VOL. OF STORAGE PROVIDED (365.7 CF)} > \text{VOL. OF STORAGE REQD. (183.1 CF)}$$

PLANTER NO. 3

$$WQV = \left[5200 \text{ SF (EXIST. PAVEMENT)} \times \frac{0.5''}{12} \right] + \left[3130 \text{ SF (PROP. PAVEMENT)} \times \frac{1''}{12} \right] = 477.5 \text{ CF}$$

$$\text{PLANTER SURFACE AREA} = 344.5 \text{ SF}$$

$$\text{VOL. CONTAINED IN MEDIA} = 344.5 \text{ SF} \times (\text{EL. } 8.00 - \text{EL. } 5.25) \times 0.33 = 312.6 \text{ CF}$$

$$\text{OPEN STORAGE IN PLANTER} = 344.5 \text{ SF} \times (\text{EL. } 8.50 - \text{EL. } 8.00) = 172.3 \text{ CF}$$

$$\left. \begin{array}{l} 312.6 \text{ CF} \\ 172.3 \text{ CF} \end{array} \right\} 484.9 \text{ CF}$$

$$\therefore \text{VOL. OF STORAGE PROVIDED (484.9 CF)} > \text{VOL. OF STORAGE REQD. (477.5 CF)}$$



Prepared By SDA	Date 6/19/16	Checked By NSW	Date 9/15/16	Project No 20120096.A17
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Herring River Retention - CUR BRIDGE

Sheet No
2 of 2

PLANTER NO. 4

$$WQV = \left[5087 \text{ SF (EXIST. PAVEMENT)} \times \frac{0.5''}{12} \right] + \left[1534 \text{ SF (PROP. PAVEMENT)} \times \frac{1''}{12} \right] = 339.8 \text{ CF}$$

PLANTER SURFACE AREA = 258 SF

$$\begin{aligned} \text{VOL. CONTAINED IN MEDIA} &= 258 \text{ SF} \times (\text{EL. } 8.00 - \text{EL. } 5.25) \times 0.33 = 234.1 \text{ CF} \\ \text{OPEN STORAGE IN PLANTER} &= 258 \text{ SF} \times (\text{EL. } 8.50 - \text{EL. } 8.00) = 129.0 \text{ CF} \end{aligned} \quad \left. \vphantom{\begin{aligned} \text{VOL. CONTAINED IN MEDIA} \\ \text{OPEN STORAGE IN PLANTER} \end{aligned}} \right\} 234.1 \text{ CF} + 129.0 \text{ CF} = 363.1 \text{ CF}$$

∴ VOL. OF STORAGE PROVIDED (363.1 CF) > VOL. OF STORAGE REQD. (339.8 CF)

Stormwater Standard 6 Compliance Spreadsheet





Herring River Restoration Project

High Toss Road & Hopkins Drive Stormwater Management Report

Wellfleet, Massachusetts

PREPARED FOR:

Friends of Herring River
PO Box 796
Wellfleet, Massachusetts 02667

PREPARED BY:

ESS Group, Inc.
100 Fifth Avenue, 5th Floor
Waltham, Massachusetts 02451

ESS Project No. F451-004

June 30, 2017



2017.06.29

Jason Gold

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**Stormwater Management Report
Herring River Restoration Project
High Toss Road & Hopkins Drive**

Prepared For:

Friends of Herring River
PO Box 796
Wellfleet, Massachusetts 02667

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June 30, 2017



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SITE PLANS (BOUND SEPARATELY)



1.0 INTRODUCTION

ESS Group, Inc. has performed a stormwater management analysis on behalf of The Friends of Herring River for a segment of the proposed Herring River restoration project, specifically the portion of the project located on High Toss Road and Hopkins Drive in Wellfleet, Massachusetts (referred to as the "Site"). The objective at this Site is to elevate the High Toss Road travelway in advance of restoration of tidal flow to the Herring River and to improve stormwater runoff control on a portion of Hopkins Drive (the "Project").

The goal of the proposed stormwater management system is to implement low impact development (LID) techniques to the maximum extent practicable within the constraints of the proposed High Toss Road roadway design. The proposed stormwater management system is designed to provide treatment of stormwater runoff through detention and infiltration into the existing subsurface soils.

The following sections describe the proposed stormwater management plan and analysis conducted to ensure compliance with the stormwater requirements of the Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards, which apply a different set of criteria to projects that meet the definition of redevelopment with respect to stormwater management. Through its design, the stormwater management system will mitigate stormwater runoff impacts on water quantity and quality and provide water quality treatment to the maximum extent practicable, as is the requirement for redevelopment. A water quality analysis was performed to estimate the extent to which the required sediment removal can be achieved by the stormwater management system.

2.0 EXISTING STORMWATER CONDITIONS

High Toss Road is an unpaved public way approximately 200 feet easterly of Snake Creek Lane, running westerly to the end at Duck Harbor Lane. Refer to Figure 1, Site Locus. This site falls within the limits of a FEMA flood hazard zone AE as depicted in the FEMA Flood Insurance Rate Map (FIRM) included in Appendix E. Under MassDEP Wetlands Protection regulations, land subject to any inundation caused by coastal storms up to and including that caused by the 100-year storm, surge of record or storm of record, whichever is greater, is protected as Land Subject to Coastal Storm Flowage (LSCSF)

The entire project area is located within the Wellfleet Harbor Area of Critical Environmental Concern (ACEC). The Wellfleet Harbor ACEC, established in 1989, consists of approximately 12,500 acres in the towns of Wellfleet, Truro, and Eastham. The ACEC was established to protect important habitats including barrier beaches, islands, marsh ecosystems, saltwater and freshwater ponds, rivers, bays, and tidal flats.

The Site's topographic elevation as indicated by the site survey ranges from approximately 2 to 30 feet above the North American Vertical Datum of 1988 (NAVD 88).

High Toss Road does not have any open or closed drainage systems. Hopkins Drive, which is paved, has six leaching basins installed in the shoulder of the road that will be upgraded and replaced in proposed conditions.

This section of the report summarizes specific predevelopment site conditions related to stormwater management including hydrologic soil type, presence of wetlands and vegetation, and drainage to discharge points on site.

The existing stormwater system in Hopkins Drive is comprised of three sets of catch basins (one on each side of the road) between Quail Run and High Toss Road. The catch basins have Massachusetts standard

grates with no apparent pipe connection between the catch basins, and no apparent outfall, based on our site observations. Therefore, it appears the catch basins are leaching catch basins. ESS did observe that the catch basins contained accumulated sediment and some standing water, indicating that they need to be cleaned out. It was also noted that pine needles and other vegetative debris accumulate around each catch basin. Pictures of the catch basins from December 2015 are shown below.



Catch basins at High Toss Road-Hopkins Drive intersection (note accumulated sediment in road and erosion of High Toss Road)



Catch basin on east side of Hopkins Drive midway between High Toss Road and Quail Run



Catch basin on west side of Hopkins Drive midway between High Toss Road and Quail Run



Catch basin at northwest corner of High Toss Road-Hopkins Drive intersection (note reflection indicating standing water in catch basin)

Quail Run appears to only have one catch basin, and it is located on the south side of the road about midway between Hopkins Drive and the Quail Run cul-de-sac.



2.1 Soils

The Site is generally characterized as low density development with moderate to flat slopes and forested areas with well drained soils. According to the Natural Resources Conservation Service (NRCS) Web Soil Survey, the soils within the majority of the watershed are comprised of Carver Coarse Sand. These soil types are classified as Hydrologic Soil Group A. The low lying wetland areas are comprised of Maybid variant silty clay loam and Freetown and Swansea mucks coastal lowland which are classified as Hydrologic Soil Groups A/D and B/D, respectively, The NRCS Soil Survey of the Site is provided in Appendix D.

2.2 General Characterization of Wetlands and Vegetation

The existing conditions watershed is comprised of woods and roads with varying surface treatments. Jurisdictional vegetated wetland resource areas in the vicinity of the project area were delineated by others in 2015 and were subsequently field-verified by an ESS wetland scientist in 2016.

The project area is also located entirely within the Cape Cod National Seashore Outstanding Resource Water (ORW). ORWs are established by MassDEP and include Class A Public Water Supplies and their tributaries and other waters that provide outstanding socio-economic, recreational, ecological, and/or aesthetic values.

Primary vegetation species along High Toss Road include pitch pine (*Pinus rigida*), pin oak (*Quercus palustris*), red maple (*Acer rubrum*), white oak (*Quercus alba*), black cherry (*Prunus serotina*), black locust (*Robinia pseudoacacia*), shadbush (*Amelanchier* sp.), winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*), scrub oak (*Quercus ilicifolia*), bayberry (*Myrica pennsylvanica*), sweet pepperbush (*Clethra alnifolia*), southern arrowwood (*Viburnum recognitum*), poison ivy (*Toxicodendron radicans*), Tatarian honeysuckle (*Lonicera tatarica*) and Japanese honeysuckle (*Lonicera japonica*).

3.0 PROPOSED STORMWATER CONDITIONS AND MANAGEMENT

3.1 Proposed Conditions

The proposed development includes raising the elevation of High Toss Road to 7.5 feet NAVD88 to prevent inundation of the roadway. A portion of Hopkins Drive will also be raised to tie into the proposed elevation of High Toss Road, and to reduce the velocity and volume of Hopkins Drive runoff that crosses High Toss Road.

3.2 Proposed BMPs

The stormwater management system for the High Toss Road travelway is designed to mimic existing conditions due to the limited right-of-way width available, the presence of wetlands resources directly adjacent to the travelway, and the Town's objective to elevate the road while maintaining its current rural character.

The stormwater management system for Hopkins Drive is designed to improve conditions by reducing the amount of runoff that currently is not collected and runs across and erodes the High Toss Road travelway gravel surface. The design also includes improvements in terms of suspended solids collection and runoff infiltration.



High Toss Travelway Level Spreaders

Construction of the Travelway will require earthwork on both sides of the travelway to allow the raised travelway grades to meet the existing ground elevations. Where necessary, level spreaders – a low point with a level lip - will be placed between the shoulder and the adjacent slopes to capture runoff and reduce its velocity and encourage sheet flow prior to crossing the travelway surface. Level spreaders will be installed in accordance with the latest Massachusetts Stormwater Handbook. Runoff that does not overtop the lip of the level spreaders will infiltrate.

Hopkins Drive Drywells

There are two leaching catch basins approximately midway up the roadway slope between Quail Run and High Toss Road. These structures will be removed and replaced with solid bottom, deep sump catch basins to provide for sediment collection. Each catch basin structure will also have a vented hooded inlet to reduce the amount of floatables, trash, free oils, etc. leaving the deep dump catch basin. The new catch basins will be connected to new drywell structures that will be installed beneath the Hopkins Drive pavement. Dry well structures are pre-cast concrete barrels with uniform perforations surrounded with stone designed to infiltrate captured stormwater.

Hopkins Drive ChamberMaxx Infiltration Chamber

At the bottom of Hopkins Drive, the four existing catch basins will be replaced with four solid bottom, deep sump catch basins, which will also be equipped with oil hoods. The four new catch basins will be connected to a ChamberMaxx infiltration chamber that will be installed below the Hopkins Drive pavement via 10 inch high-density polyethylene (HDPE) header pipes at each end of the chamber. Three rows of chambers will be used, and the footprint of the chamber system and surrounding stone will be approximately 16 feet wide by 31 feet long (496 square feet). The chamber system will accommodate the 10-year storm event.

4.0 MASSDEP STORMWATER MANAGEMENT STANDARDS

The Project has been designed to meet the MassDEP Stormwater Management Standards to the maximum extent practicable in accordance with Standard 7 Redevelopment. A synopsis of how each standard is met is summarized below; Standard 7 is presented first because its provisions affect the other standards.

Standard 7: A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

For purposes of the Stormwater Management Standards, redevelopment projects are defined to include maintenance and improvement of existing roadways, including improving existing drainage systems. As described below, the Project meets the requirements of Standards 1, 2, 3, 4, 5, and 6 to the maximum extent practicable.

The two primary constraints for this project are the limited right of way and adjacent resource areas. Practices that would require either additional resource area impacts or impacts to private property would



be defined as not practicable for the purposes of stormwater compliance. The stormwater management plan attempts to meet each of the standards, adequately document standards that could be met, and is designed at a minimum to improve existing conditions.

Standard 1: *No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.*

No new discharges from stormwater conveyances are proposed for this project.

Standard 2: *Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.*

The High Toss Road travelway is located within Land Subject to Coastal Storm Flowage. In addition, once the Herring River restoration is implemented, the wetlands along High Toss Road will be subject to daily tidal action. The Project will not change the amount of impervious cover in the Project Area. For these reasons, the Project is not required to match post-development peak discharge rate to the pre-development peak discharge rate. However, where possible, the design seeks to maintain or improve post-development peak discharge rates to the maximum extent practicable.

Standard 3: *Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from the pre-development site conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.*

The MassDEP Stormwater Handbook states that, for sites comprised solely of C and D soils and bedrock at the land surface, proponents are required to infiltrate the required recharge volume only to the maximum extent practicable. The High Toss Road and Hopkins Drive site is comprised solely of A soils surrounded by A/D and B/D soils within resource areas. The footprint of the proposed level spreader improvement of High Toss Road and of the catch basin and infiltration improvements of Hopkins Drive have been minimized in an attempt to meet this standard to the maximum extent practicable. Infiltration from the BMPs will further aid in groundwater recharge as ground conditions permit.

Standard 4: *Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when: (a.) Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained; (b.) Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and (c.) Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.*

Suitable practices for source control and pollution prevention are identified in the attached long-term pollution prevention plan included in Appendix F. Infiltration Stormwater BMPs with a minimum of 80 percent TSS removal rates were selected for use on Hopkins Drive. This removal rate is accomplished with a



treatment train comprising a deep sump catch basin pretreatment (25 percent TSS removal) dry wells, and ChamberMaxx storm chambers. The treatment train will provide the required water quality volume. Stormwater runoff along the High Toss Road travelway will either sheet flow across the travelway as it does in the existing condition or naturally infiltrate on the landward side of the travelway.

Standard 5: *For land uses with higher potential pollutant loads source control and pollution prevention shall be implemented. The use of infiltration practices without pretreatment is prohibited.*

The project does involve land uses with higher potential pollutant loads.

Standard 6: *Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas.*

Specific source control and pollution prevention measures are identified in the attached long-term pollution prevention plan included in Appendix F.

The site is located within the following resource areas:

- Wellfleet Harbor Area of Critical Environmental Concern (ACEC)
- Cape Cod National Seashore Outstanding Resource Water (ORW)

The Project involves elevating the High Toss Road travelway along its existing alignment and improving the existing stormwater system at the lower end of Hopkins Drive to reduce sheet flow runoff across High Toss Road to the wetlands. The Project will not adversely affect these resources areas and will provide stormwater management improvements where possible.

Standard 7 – see above.

Standard 8: *A plan to control construction related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.*

A comprehensive system of erosion and sedimentation controls will be implemented during construction to minimize short-term, construction-related impacts as well as stabilize conditions for permanent operation of the development. These measures include silt fence and silt sock placement along disturbed areas of the property, site stabilization, and a stabilized construction entrance. An online registration and Stormwater Pollution Prevention Plan (SWPPP) in accordance with the National Pollutant Discharge Elimination System (NPDES) Construction General Permit will be submitted prior to construction.

Standard 9: *A long term operation and maintenance plan shall be developed and implemented.*

An operations and maintenance plan for the proposed stormwater BMPs is attached.

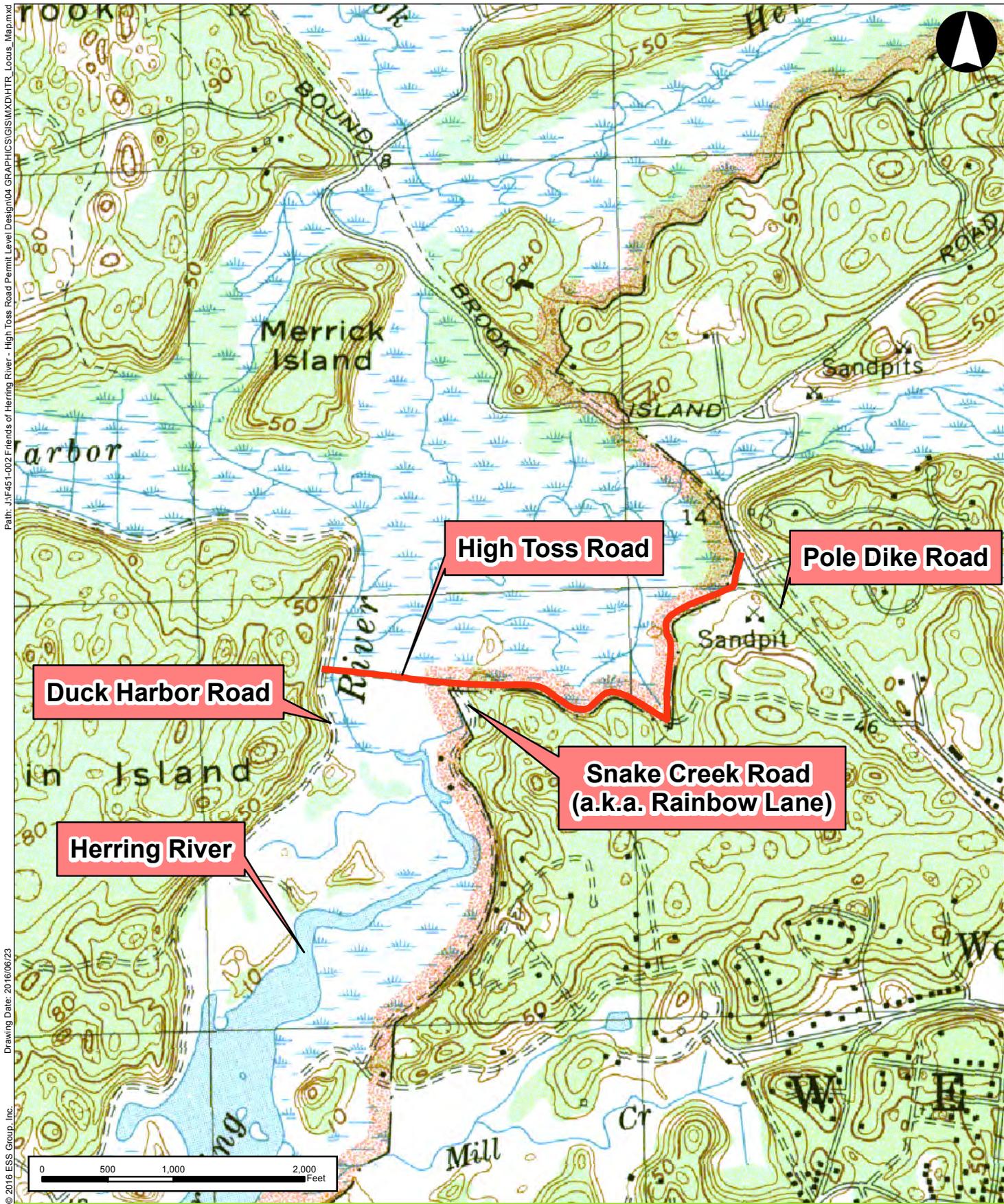
Standard 10: *All illicit discharges to the stormwater management system are prohibited.*



No known illicit discharges currently exist on the Site. There will be no illicit discharges allowed into the stormwater management system.

Figures





Path: J:\F451-002 Friends of Herring River - High Toss Road Permit Level Design\04_GRAPHICS\GIS\MXD\HTR_Locus_Map.mxd
 Drawing Date: 2016/06/23
 © 2016 ESS Group, Inc.



Herring River Restoration Project

Wellfleet and Truro, Massachusetts

1 inch = 1,000 feet

Source: 1) ESRI, Basemap 2016

Legend	
	Project Location

High Toss Road Locus Map

Figure 1

Appendix A
MassDEP Checklist for Stormwater Report





Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the [Massachusetts Stormwater Handbook](#). The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.¹ This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8²
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

¹ The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

² For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.



Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

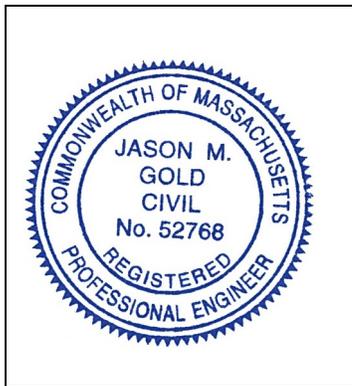
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



2017.06.29
Jason Gold 20:02:50
-04'00'

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

- New development
- Redevelopment
- Mix of New Development and Redevelopment



Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- No disturbance to any Wetland Resource Areas
- Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- Reduced Impervious Area (Redevelopment Only)
- Minimizing disturbance to existing trees and shrubs
- LID Site Design Credit Requested:
 - Credit 1
 - Credit 2
 - Credit 3
- Use of “country drainage” versus curb and gutter conveyance and pipe
- Bioretention Cells (includes Rain Gardens)
- Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- Treebox Filter
- Water Quality Swale
- Grass Channel
- Green Roof
- Other (describe): Deep sump catch basins, dry wells, ChamberMaxx storm chambers.

Standard 1: No New Untreated Discharges

- No new untreated discharges
- Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.



Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

- Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
- Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
- Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

- Soil Analysis provided.
- Required Recharge Volume calculation provided.
- Required Recharge volume reduced through use of the LID site Design Credits.
- Sizing the infiltration, BMPs is based on the following method: Check the method used.
 - Static
 - Simple Dynamic
 - Dynamic Field¹
- Runoff from all impervious areas at the site discharging to the infiltration BMP.
- Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
- Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
- Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:
 - Site is comprised solely of C and D soils and/or bedrock at the land surface
 - M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
 - Solid Waste Landfill pursuant to 310 CMR 19.000
 - Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
- Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
- Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

¹ 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.



Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

- The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.
- Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
 - Provisions for storing materials and waste products inside or under cover;
 - Vehicle washing controls;
 - Requirements for routine inspections and maintenance of stormwater BMPs;
 - Spill prevention and response plans;
 - Provisions for maintenance of lawns, gardens, and other landscaped areas;
 - Requirements for storage and use of fertilizers, herbicides, and pesticides;
 - Pet waste management provisions;
 - Provisions for operation and management of septic systems;
 - Provisions for solid waste management;
 - Snow disposal and plowing plans relative to Wetland Resource Areas;
 - Winter Road Salt and/or Sand Use and Storage restrictions;
 - Street sweeping schedules;
 - Provisions for prevention of illicit discharges to the stormwater management system;
 - Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
 - Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
 - List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.
- A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.
 - Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:
 - is within the Zone II or Interim Wellhead Protection Area
 - is near or to other critical areas
 - is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
 - involves runoff from land uses with higher potential pollutant loads.
 - The Required Water Quality Volume is reduced through use of the LID site Design Credits.
 - Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.



Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

- The BMP is sized (and calculations provided) based on:
 - The ½" or 1" Water Quality Volume or
 - The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.
- The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.
- A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

- The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.
- The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted **prior to** the discharge of stormwater to the post-construction stormwater BMPs.
- The NPDES Multi-Sector General Permit does **not** cover the land use.
- LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.
- All exposure has been eliminated.
- All exposure has **not** been eliminated and all BMPs selected are on MassDEP LUHPPL list.
- The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

- The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.
- Critical areas and BMPs are identified in the Stormwater Report.



Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

- The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:
 - Limited Project
 - Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
 - Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
 - Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
 - Bike Path and/or Foot Path
 - Redevelopment Project
 - Redevelopment portion of mix of new and redevelopment.
- Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.
- The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
 - Construction Period Operation and Maintenance Plan;
 - Names of Persons or Entity Responsible for Plan Compliance;
 - Construction Period Pollution Prevention Measures;
 - Erosion and Sedimentation Control Plan Drawings;
 - Detail drawings and specifications for erosion control BMPs, including sizing calculations;
 - Vegetation Planning;
 - Site Development Plan;
 - Construction Sequencing Plan;
 - Sequencing of Erosion and Sedimentation Controls;
 - Operation and Maintenance of Erosion and Sedimentation Controls;
 - Inspection Schedule;
 - Maintenance Schedule;
 - Inspection and Maintenance Log Form.
- A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.



Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

- The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has **not** been included in the Stormwater Report but will be submitted **before** land disturbance begins.
- The project is **not** covered by a NPDES Construction General Permit.
- The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.
- The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

- The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:
 - Name of the stormwater management system owners;
 - Party responsible for operation and maintenance;
 - Schedule for implementation of routine and non-routine maintenance tasks;
 - Plan showing the location of all stormwater BMPs maintenance access areas;
 - Description and delineation of public safety features;
 - Estimated operation and maintenance budget; and
 - Operation and Maintenance Log Form.
- The responsible party is **not** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:
 - A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
 - A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

- The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;
- An Illicit Discharge Compliance Statement is attached;
- NO Illicit Discharge Compliance Statement is attached but will be submitted **prior to** the discharge of any stormwater to post-construction BMPs.

Appendix B Operation & Maintenance Plan





Stormwater Operation & Maintenance Plan

High Toss Road & Hopkins Drive

Wellfleet, Massachusetts

PREPARED FOR:

Friends of Herring River
PO Box 796
Wellfleet, Massachusetts 02667

PREPARED BY:

ESS Group, Inc.
100 Fifth Avenue, 5th Floor
Waltham, Massachusetts 02451

ESS Project No. F451-004

June 2017





**STORMWATER OPERATION & MAINTENANCE PLAN
High Toss Road and Hopkins Drive**

Prepared for:

Friends of Herring River
PO Box 796
Wellfleet, Massachusetts 02667

Prepared by:

ESS Group, Inc.
100 Fifth Avenue, 5th Floor
Waltham, Massachusetts 02451

ESS Project No. F451-004

June 2017



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ATTACHMENTS

- Attachment A ChamberMaxx Inspection and Maintenance Guide
- Attachment B O&M Checklist



OPERATION AND MAINTENANCE PLAN

The operation and maintenance (O&M) plan is required by the Stormwater Management Plan subject to the Massachusetts Department of Environmental Protection (MADEP) Stormwater Handbook. The plan for the proposed infiltrating BMPs is included below.

Contact Information

Parties Responsible for Maintenance:

Town of Wellfleet Department of Public Works
220 West Main Street
Wellfleet, MA 02667

Hopkins Drive Homeowner's Association
Wellfleet, MA 02667

Prepared By:

ESS Group, Inc.
100 Fifth Avenue, 5th Floor
Waltham, MA 02451

Access and Safety Issues

No access or safety issues are anticipated due to the nature of the proposed BMP. No public safety features will be present.

Applicable Easements

No easements will be required for this proposed project.

Funding Source

Funding for Project construction will come from the Friends of Herring River. The Town of Wellfleet and the Hopkins Drive Homeowner's Association will be responsible for all maintenance activities thereafter the project.

Maintenance Activities Description:

Maintenance activities are adapted from the MADEP Stormwater Handbook.

Deep Sump Catch Basins and Dry Wells

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Dry wells shall be inspected after every major storm in the first few months after construction to ensure proper stabilization and function. Thereafter, dry wells shall be inspected annually.

ChamberMaxx Stormwater Chamber System

Refer to the Attachment A: ChamberMaxx Inspection and Maintenance Guide provided by Contech.



Operations and Maintenance Budget

The Operations and Maintenance Budget will be determined as part of the annual budgeting processes performed by the Town of Wellfleet and the Hopkins Drive Homeowner's Association.

**O&M Plan Appendix A
ChamberMaxx Inspection and Maintenance Guide**





ChamberMaxx[®] Inspection and Maintenance Guide



ChamberMaxx®

Safety

Before entering into any storm sewer or underground retention/detention system check to make sure all OSHA and local safety regulations and guidelines are observed during the maintenance process. Hard hats, safety glasses, steel-toed boots and any other appropriate personal protective equipment shall be worn at all times.

Inspection Frequency

Inspections are recommended at a minimum annually. The first year of operation may require more frequent inspections. Frequency of inspections will vary significantly on the local site conditions. An individual inspection schedule should be established for each site.

Inspections

Inspection is the key to effective maintenance and is easily performed. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to rapid sediment accumulations, or in equipment washdown areas. It is very useful to keep a record of each inspection. A sample inspection log is included for your use.

The entire treatment train should be inspected and maintained. The treatment train may consist of an upstream sump manhole, manifold system or pre-treatment HDS device. Inspections should start at the upstream device and continue downstream to the discharge orifice if incorporated into the chamber system.

Pre-Treatment Device Inspection

Inspection and maintenance procedures provided by the manufacturer should be followed for pre-treatment systems such as a CDS®, Vortechs®, VortSentry® or VortSentry® HS. Expected pollutants will be floatable trash, sediment and oil and grease. Pre-treatment devices are recommended for all detention/retention devices regardless of type.

Containment Row™ Inspection

The optional Containment Row consists of a diversion concrete manhole with a weir and a drain down orifice, and a row of chambers placed on woven geotextile. The diversion weir directs the first flush flows into the Containment Row of chambers. The majority of sediment will be captured in the Containment Row due to the extended detention time which allows the particles to settle out. Higher flows overtop (bypass) the weir into the manifold system.

The Containment Row will typically be located in the first row of chambers connected to the diversion manhole. Inspection can be done through accessing the diversion manhole and visually inspecting the Containment Row through the inlet pipe. Inspection ports throughout the system can be used for visual observation and measurement of sediment accumulation using a stadia rod. When the depth of sediment accumulates over 4-inch (102 mm), cleanout is recommended.

Manifold System Inspection

The main manifold pipe can be inspected from the diversion manhole upstream. When a quarter of the pipe volume has been filled with sediment the header system should be maintained.

Visual Inspection

Maintenance or further investigation may be required if any of the following conditions exist:

- Evidence of an unusual amount of silt and soil build-up on the surface.
- Clogged outlet drainpipe.
- System does not drain to the elevation of the lowest pipe in dry conditions.
- Evidence of potholes or sinkholes

Maintenance

Underground stormwater retention/detention systems should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities rather than the size or configuration of the system. If accumulated silt is interfering with the operation of the detention system (i.e.: blocking outlet pipes or deposits significantly reduce the storage capacity of the system) it should be removed.

It is easiest to maintain a system when there is no flow entering. For this reason, cleanout should be scheduled during dry weather.

A vacuum truck or other similar devices can be used to remove sediment from the treatment train. Starting upstream, maintain manholes with sumps and any pre-treatment devices (following manufacturer recommended procedures). Once maintenance is complete, replace all caps, lids and covers. It is important to document maintenance events on the Inspection and Maintenance Log.

Header System Maintenance:

If maintenance is required, use a high pressure nozzle with rear facing jets to wash the sediments and debris into the diversion manhole. Use the vacuum hose stinger nozzle to remove the washed sediments from the sump of the diversion manhole. It is important to not flush sediments into the chamber system during the maintenance process.

Containment Row™ Maintenance

If maintenance is required, a JetVac truck utilizing a high pressure nozzle (sledge dredging tool) with rear facing jets will be required. Insert the nozzle from the diversion manhole into the Containment Row through the inlet pipe. Turn the water feed hose on and feed the supply hose until the nozzle has reached the end of the Containment Row. Withdraw the nozzle slowly.

The tool will backflush the Containment Row forcing debris into the diversion manhole sump. Use the stringer vacuum hose to remove the sediments and debris from the sump of the diversion manhole. Multiple passes may be required to fully cleanout the Containment Row. Vacuum out the diversion manhole and remove all debris. See Figure 1.



Figure 1— Containment Row shown with high pressure cleaning nozzle

Inspection & Maintenance Log Sample Template

ChamberMaxx		Location:		
Date	Depth of Sediment	Accumulated Trash	Name of Inspector	Maintenance Performed/Notes

CHAMBERMaxx®

SUPPORT

- Drawings and specifications are available at www.ContechES.com.
- Site-specific support is available from our engineers.



800.338.1122

www.ContechES.com

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The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; related foreign patents or other patents pending.

**O&M Plan Appendix B
O&M Checklist**



Infiltration System Operation, Maintenance, and Management Inspection Checklist

Project:

Location:

Site Status:

Date:

Time:

Inspector:

MAINTENANCE ITEM	SATISFACTORY / UNSATISFACTORY	COMMENTS
1. Debris Cleanout (Annual)		
Trench/chamber or basin surface clear of debris		
Inflow pipes clear of debris		
Overflow spillway clear of debris		
Inlet area clear of debris		
2. Deep Sump Catch Basin (Annual)		
Obviously trapping sediment		
Greater than 50% of storage volume remaining		
3. Dewatering (Annual)		
Trench/chamber or basin dewateres between storms		
4. Sediment Cleanout of Trench/Chamber or Basin (Annual)		

MAINTENANCE ITEM	SATISFACTORY / UNSATISFACTORY	COMMENTS
No evidence of sedimentation in trench/chamber or basin		
Sediment accumulation doesn't yet require cleanout		
5. Inlets (Annual)		
Good condition		
No evidence of erosion		
6. Outlet/Overflow Spillway (Annual)		
Good condition, no need for repair		
No evidence of erosion		
7. Aggregate Repairs (Annual)		
Surface of aggregate clean		
Top layer of stone does not need replacement		
Trench/Chamber or basin does not need rehabilitation		

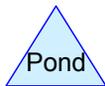
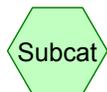
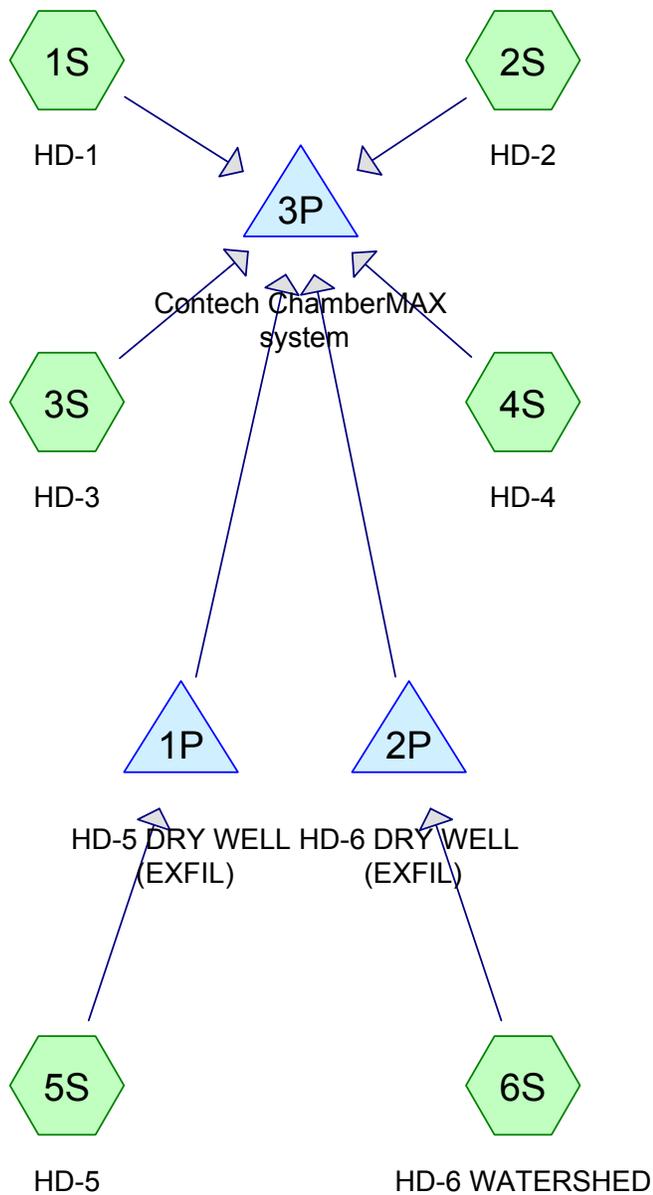
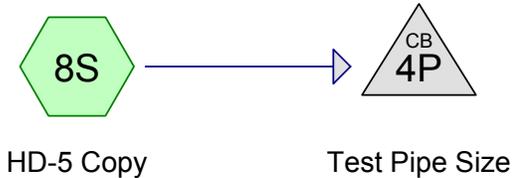
Comments:

Actions to be Taken:

End of Operations & Maintenance Plan

Appendix C Stormwater Calculations





Hopkins Drive

Prepared by ESS Group, Inc.

HydroCAD® 10.00-20 s/n 01446 © 2017 HydroCAD Software Solutions LLC

Type III 24-hr 10-yr Rainfall=4.80"

Printed 6/29/2017 7:07:55 PM

Page 2

Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: HD-1	Runoff Area=7,914 sf 6.87% Impervious Runoff Depth=0.47" Flow Length=321' Tc=0.9 min CN=47 Runoff=0.05 cfs 0.007 af
Subcatchment 2S: HD-2	Runoff Area=8,646 sf 6.55% Impervious Runoff Depth=0.47" Flow Length=170' Tc=7.8 min CN=47 Runoff=0.04 cfs 0.008 af
Subcatchment 3S: HD-3	Runoff Area=11,730 sf 9.51% Impervious Runoff Depth=0.51" Flow Length=214' Tc=0.6 min CN=48 Runoff=0.09 cfs 0.012 af
Subcatchment 4S: HD-4	Runoff Area=9,570 sf 11.70% Impervious Runoff Depth=0.56" Flow Length=222' Tc=10.0 min CN=49 Runoff=0.07 cfs 0.010 af
Subcatchment 5S: HD-5	Runoff Area=4,262 sf 61.52% Impervious Runoff Depth=2.46" Flow Length=45' Slope=0.1330 '/' Tc=4.3 min CN=77 Runoff=0.30 cfs 0.020 af
Subcatchment 6S: HD-6 WATERSHED	Runoff Area=9,333 sf 6.85% Impervious Runoff Depth=0.47" Flow Length=144' Tc=11.4 min CN=47 Runoff=0.05 cfs 0.008 af
Subcatchment 8S: HD-5 Copy	Runoff Area=4,262 sf 61.52% Impervious Runoff Depth=2.46" Flow Length=45' Slope=0.1330 '/' Tc=4.3 min CN=77 Runoff=0.30 cfs 0.020 af
Pond 1P: HD-5 DRY WELL (EXFIL)	Peak Elev=22.00' Storage=0.009 af Inflow=0.30 cfs 0.020 af Discarded=0.01 cfs 0.019 af Primary=0.02 cfs 0.001 af Outflow=0.03 cfs 0.020 af
Pond 2P: HD-6 DRY WELL (EXFIL)	Peak Elev=22.00' Storage=0.005 af Inflow=0.05 cfs 0.008 af Discarded=0.00 cfs 0.007 af Primary=0.00 cfs 0.000 af Outflow=0.01 cfs 0.007 af
Pond 3P: Contech ChamberMAX system	Peak Elev=5.22' Storage=0.016 af Inflow=0.22 cfs 0.038 af Discarded=0.03 cfs 0.038 af Primary=0.00 cfs 0.000 af Outflow=0.03 cfs 0.038 af
Pond 4P: Test Pipe Size	Peak Elev=7.00' Inflow=0.30 cfs 0.020 af 10.0" Round Culvert n=0.013 L=5.0' S=0.0000 '/' Outflow=0.30 cfs 0.020 af

Hopkins Drive

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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 1S: HD-1

Runoff = 0.05 cfs @ 12.07 hrs, Volume= 0.007 af, Depth= 0.47"

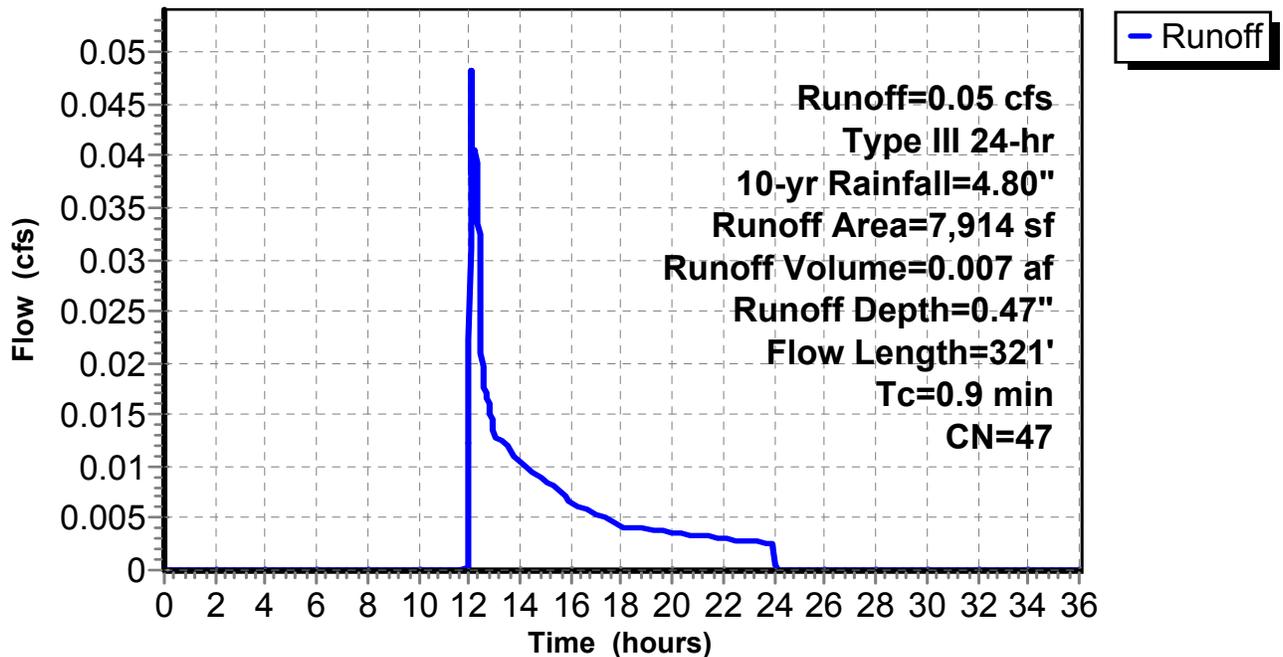
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
7,370	43	Woods/grass comb., Fair, HSG A
544	98	Paved parking, HSG A
7,914	47	Weighted Average
7,370		93.13% Pervious Area
544		6.87% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	124	0.1000	5.09		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.3	106	0.1100	5.34		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	91	0.2600	8.21		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.9	321	Total			

Subcatchment 1S: HD-1

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 2S: HD-2

Runoff = 0.04 cfs @ 12.30 hrs, Volume= 0.008 af, Depth= 0.47"

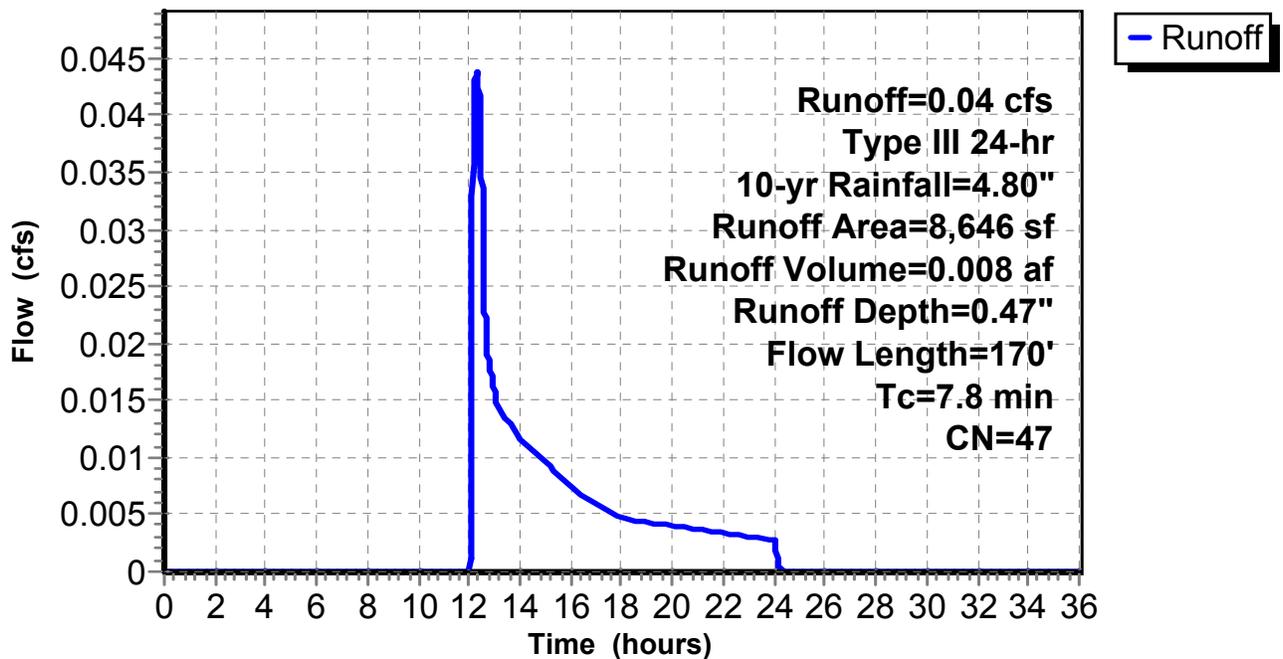
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
8,080	43	Woods/grass comb., Fair, HSG A
566	98	Paved parking, HSG A
8,646	47	Weighted Average
8,080		93.45% Pervious Area
566		6.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.6	100	0.1600	0.22		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 4.80"
0.2	70	0.1300	5.80		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
7.8	170	Total			

Subcatchment 2S: HD-2

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 3S: HD-3

Runoff = 0.09 cfs @ 12.06 hrs, Volume= 0.012 af, Depth= 0.51"

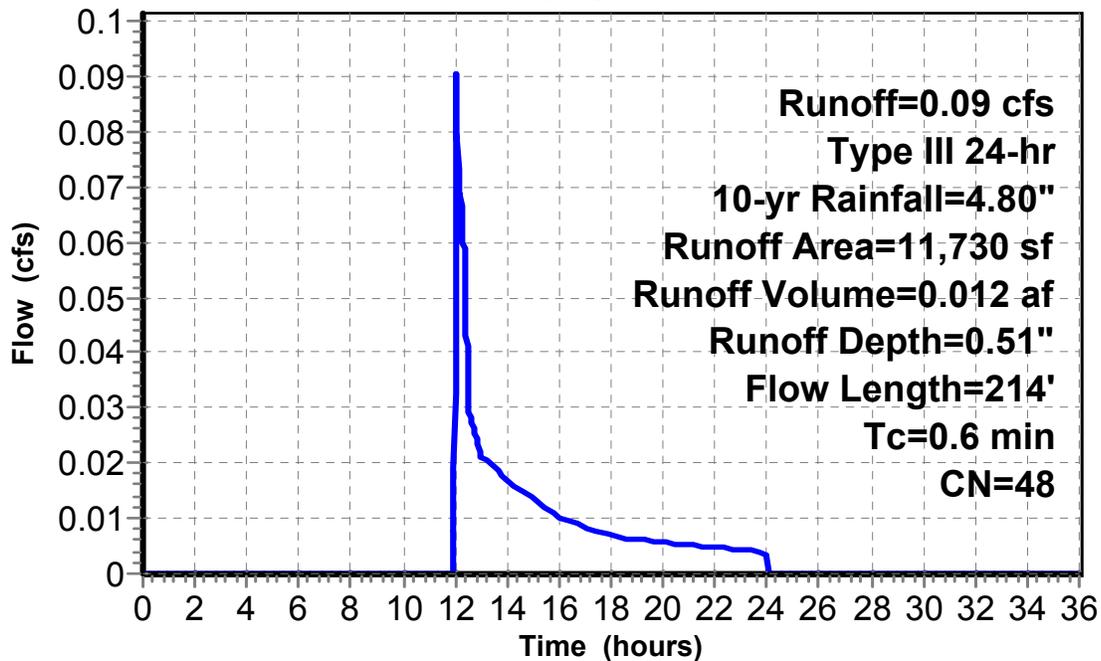
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
10,615	43	Woods/grass comb., Fair, HSG A
1,115	98	Paved parking, HSG A
11,730	48	Weighted Average
10,615		90.49% Pervious Area
1,115		9.51% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	83	0.0720	4.32		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.3	131	0.2300	7.72		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.6	214	Total			

Subcatchment 3S: HD-3

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 4S: HD-4

Runoff = 0.07 cfs @ 12.22 hrs, Volume= 0.010 af, Depth= 0.56"

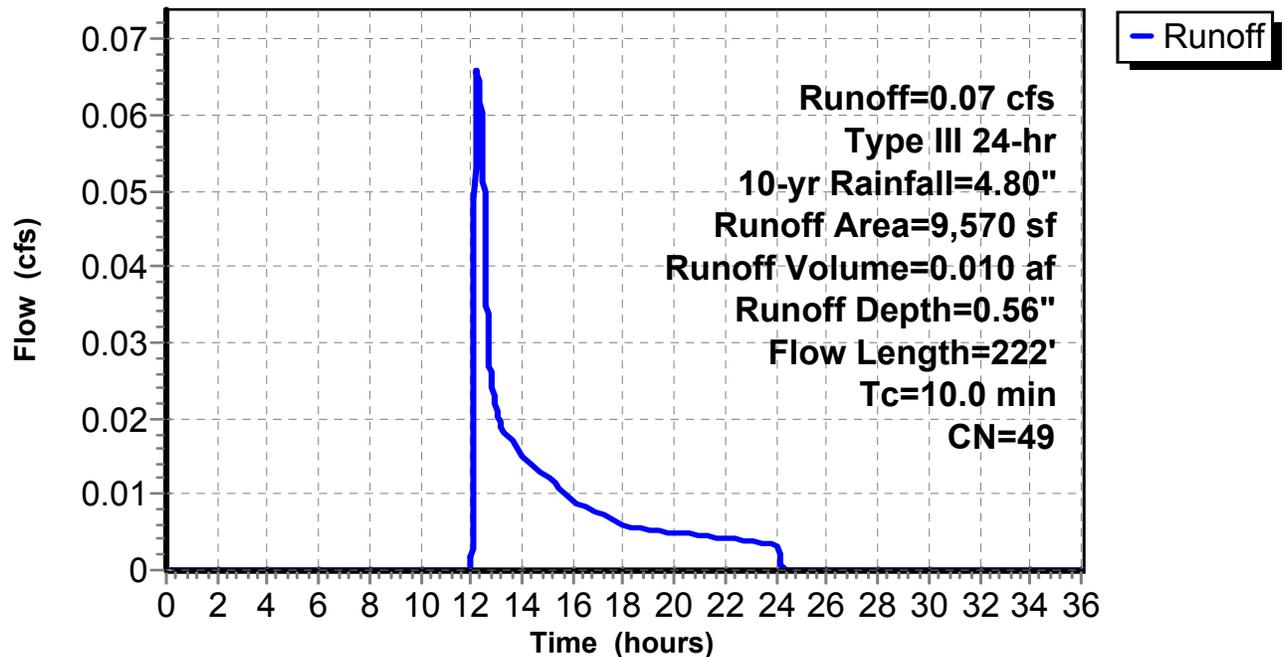
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
8,450	43	Woods/grass comb., Fair, HSG A
1,120	98	Paved parking, HSG A
9,570	49	Weighted Average
8,450		88.30% Pervious Area
1,120		11.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	92	0.0760	0.16		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 4.80"
0.2	40	0.0500	3.60		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.2	90	0.1100	6.73		Shallow Concentrated Flow, Paved Kv= 20.3 fps
10.0	222	Total			

Subcatchment 4S: HD-4

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 5S: HD-5

Runoff = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af, Depth= 2.46"

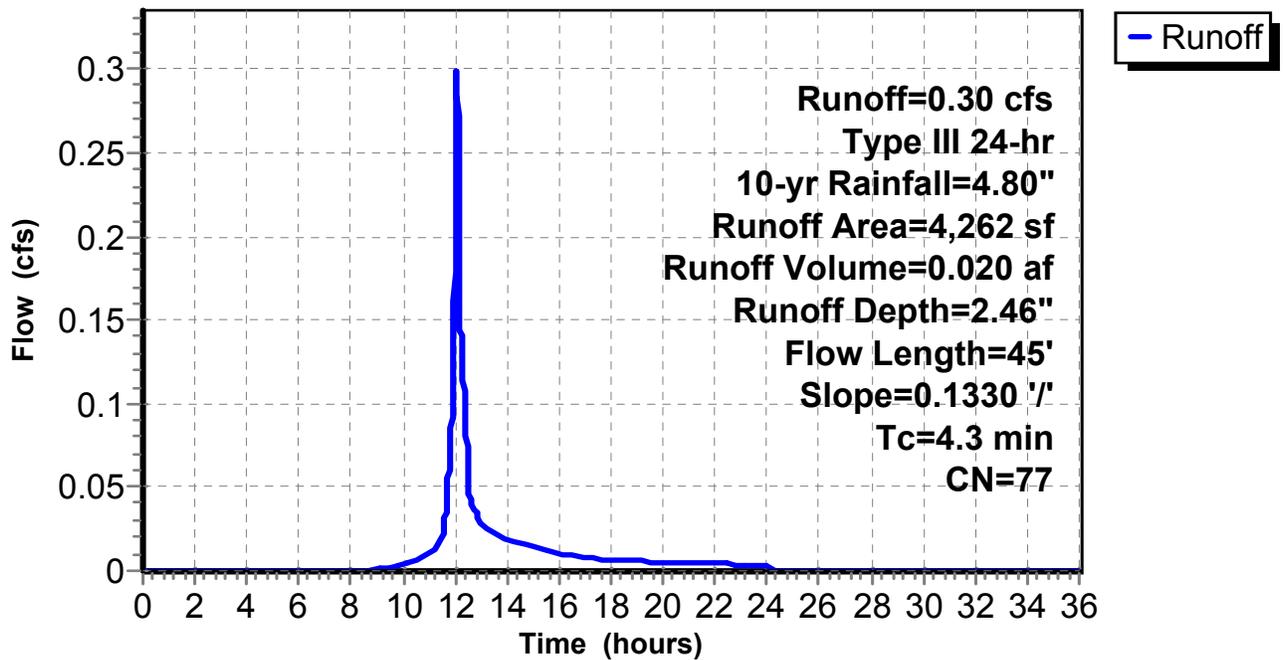
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
1,640	43	Woods/grass comb., Fair, HSG A
2,622	98	Paved parking, HSG A
4,262	77	Weighted Average
1,640		38.48% Pervious Area
2,622		61.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	45	0.1330	0.17		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 4.80"

Subcatchment 5S: HD-5

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 6S: HD-6 WATERSHED

Runoff = 0.05 cfs @ 12.37 hrs, Volume= 0.008 af, Depth= 0.47"

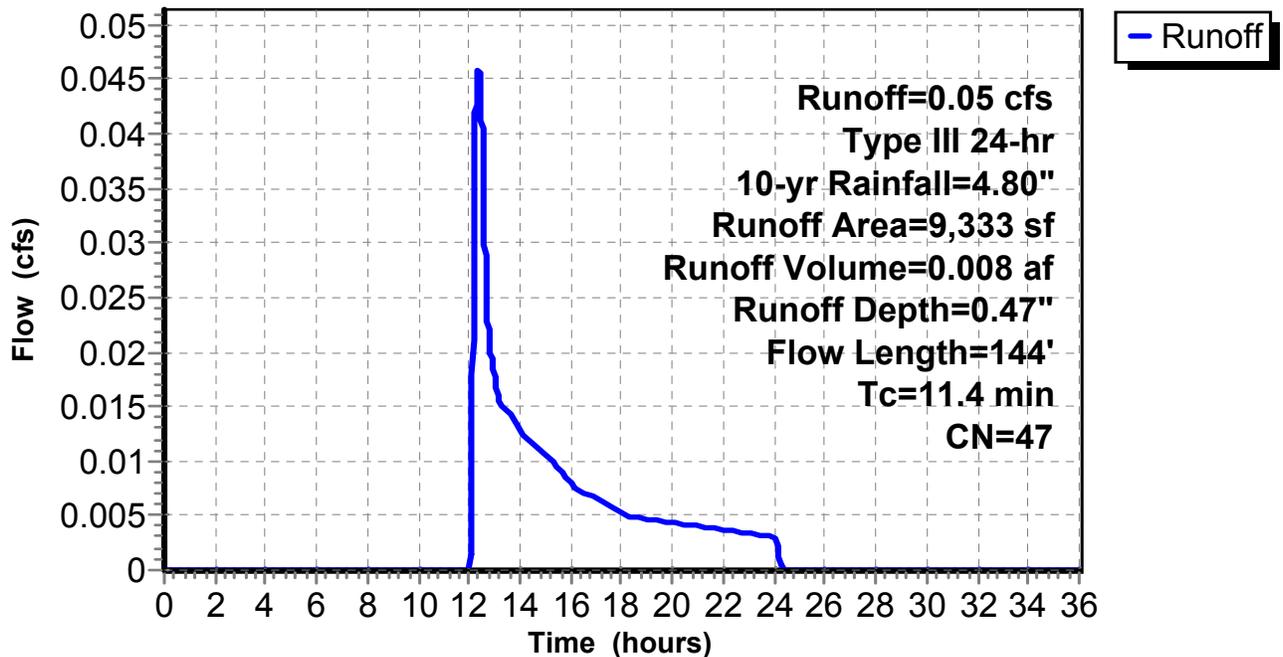
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
8,694	43	Woods/grass comb., Fair, HSG A
639	98	Paved parking, HSG A
9,333	47	Weighted Average
8,694		93.15% Pervious Area
639		6.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.3	100	0.0600	0.15		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 4.80"
0.1	29	0.0600	3.94		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.0	15	0.0670	5.25		Shallow Concentrated Flow, Paved Kv= 20.3 fps
11.4	144	Total			

Subcatchment 6S: HD-6 WATERSHED

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Subcatchment 8S: HD-5 Copy

Runoff = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af, Depth= 2.46"

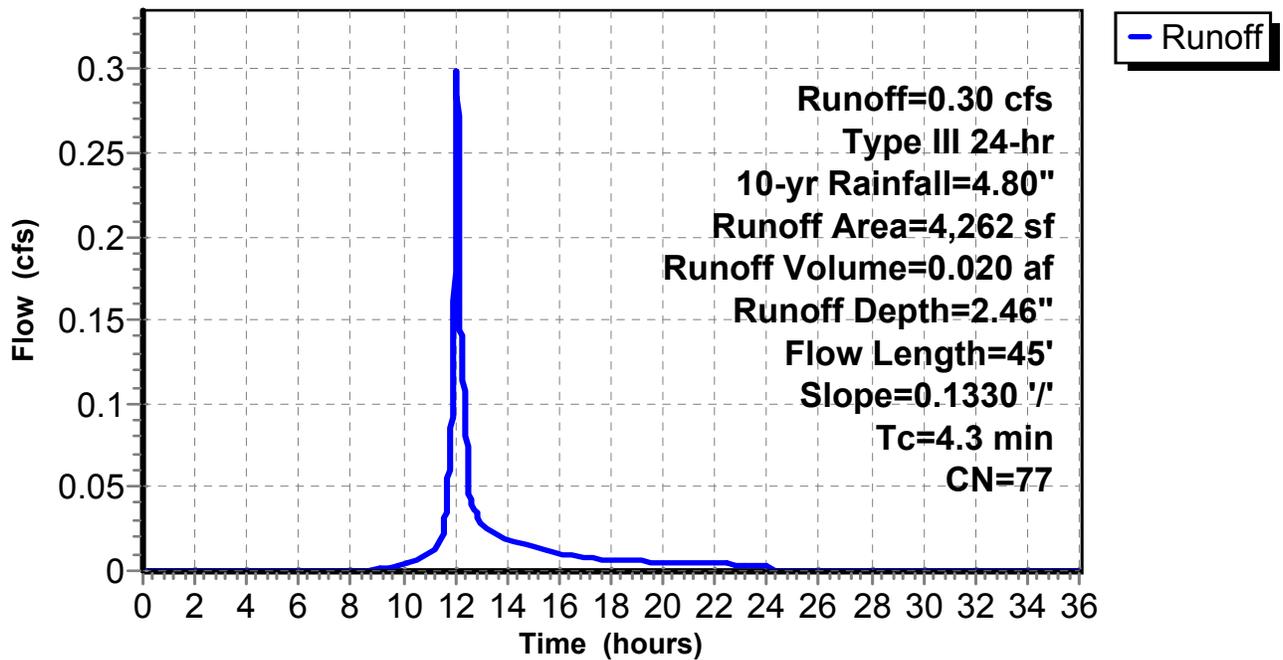
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.80"

Area (sf)	CN	Description
1,640	43	Woods/grass comb., Fair, HSG A
2,622	98	Paved parking, HSG A
4,262	77	Weighted Average
1,640		38.48% Pervious Area
2,622		61.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	45	0.1330	0.17		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 4.80"

Subcatchment 8S: HD-5 Copy

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Pond 1P: HD-5 DRY WELL (EXFIL)

Inflow Area = 0.098 ac, 61.52% Impervious, Inflow Depth = 2.46" for 10-yr event
 Inflow = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af
 Outflow = 0.03 cfs @ 13.18 hrs, Volume= 0.020 af, Atten= 89%, Lag= 66.8 min
 Discarded = 0.01 cfs @ 11.33 hrs, Volume= 0.019 af
 Primary = 0.02 cfs @ 13.18 hrs, Volume= 0.001 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 3
 Peak Elev= 22.00' @ 13.18 hrs Surf.Area= 0.003 ac Storage= 0.009 af
 Flood Elev= 22.00' Surf.Area= 0.003 ac Storage= 0.009 af

Plug-Flow detention time= 278.6 min calculated for 0.020 af (100% of inflow)
 Center-of-Mass det. time= 278.7 min (1,108.8 - 830.0)

Volume	Invert	Avail.Storage	Storage Description
#1	13.50'	0.002 af	8.00'W x 8.00'L x 4.50'H Prisma toid x 2 0.013 af Overall - 0.009 af Embedded = 0.004 af x 39.0% Voids
#2	14.00'	0.008 af	7.33'D x 4.00'H Vertical Cone/Cylinder x 2 Inside #1 0.009 af Overall - 4.0" Wall Thickness = 0.008 af
		0.009 af	Total Available Storage

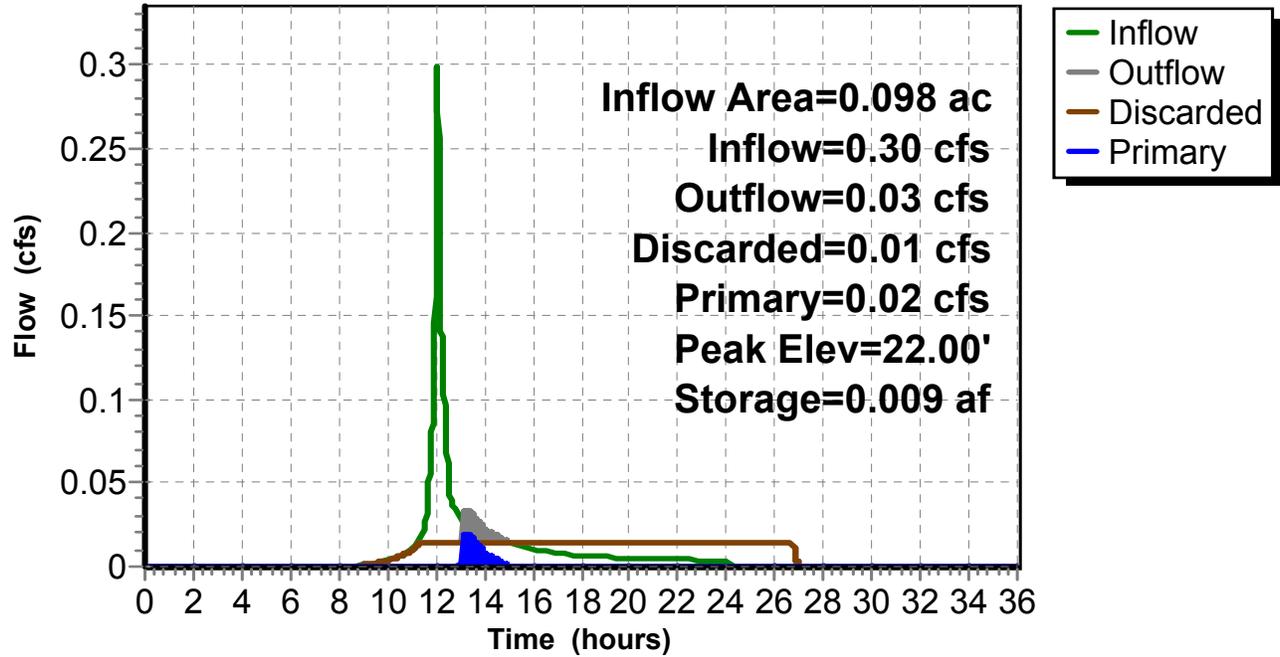
Device	Routing	Invert	Outlet Devices
#1	Discarded	13.50'	2.410 in/hr Exfiltration X 2.00 over Horizontal area Phase-In= 0.01'
#2	Primary	22.00'	24.0" x 24.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.01 cfs @ 11.33 hrs HW=13.59' (Free Discharge)
 ↑1=**Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 13.18 hrs HW=22.00' (Free Discharge)
 ↑2=**Orifice/Grate** (Weir Controls 0.00 cfs @ 0.17 fps)

Pond 1P: HD-5 DRY WELL (EXFIL)

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Pond 2P: HD-6 DRY WELL (EXFIL)

Inflow Area = 0.214 ac, 6.85% Impervious, Inflow Depth = 0.47" for 10-yr event
 Inflow = 0.05 cfs @ 12.37 hrs, Volume= 0.008 af
 Outflow = 0.01 cfs @ 18.54 hrs, Volume= 0.007 af, Atten= 89%, Lag= 370.3 min
 Discarded = 0.00 cfs @ 12.14 hrs, Volume= 0.007 af
 Primary = 0.00 cfs @ 18.54 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
 Peak Elev= 22.00' @ 18.54 hrs Surf.Area= 0.001 ac Storage= 0.005 af
 Flood Elev= 22.00' Surf.Area= 0.001 ac Storage= 0.005 af

Plug-Flow detention time= 551.8 min calculated for 0.007 af (87% of inflow)
 Center-of-Mass det. time= 492.2 min (1,436.4 - 944.1)

Volume	Invert	Avail.Storage	Storage Description
#1	13.50'	0.001 af	8.00'W x 8.00'L x 4.50'H Prismatic 0.007 af Overall - 0.005 af Embedded = 0.002 af x 39.0% Voids
#2	14.00'	0.004 af	7.33'D x 4.00'H Vertical Cone/Cylinder Inside #1 0.005 af Overall - 4.0" Wall Thickness = 0.004 af
		0.005 af	Total Available Storage

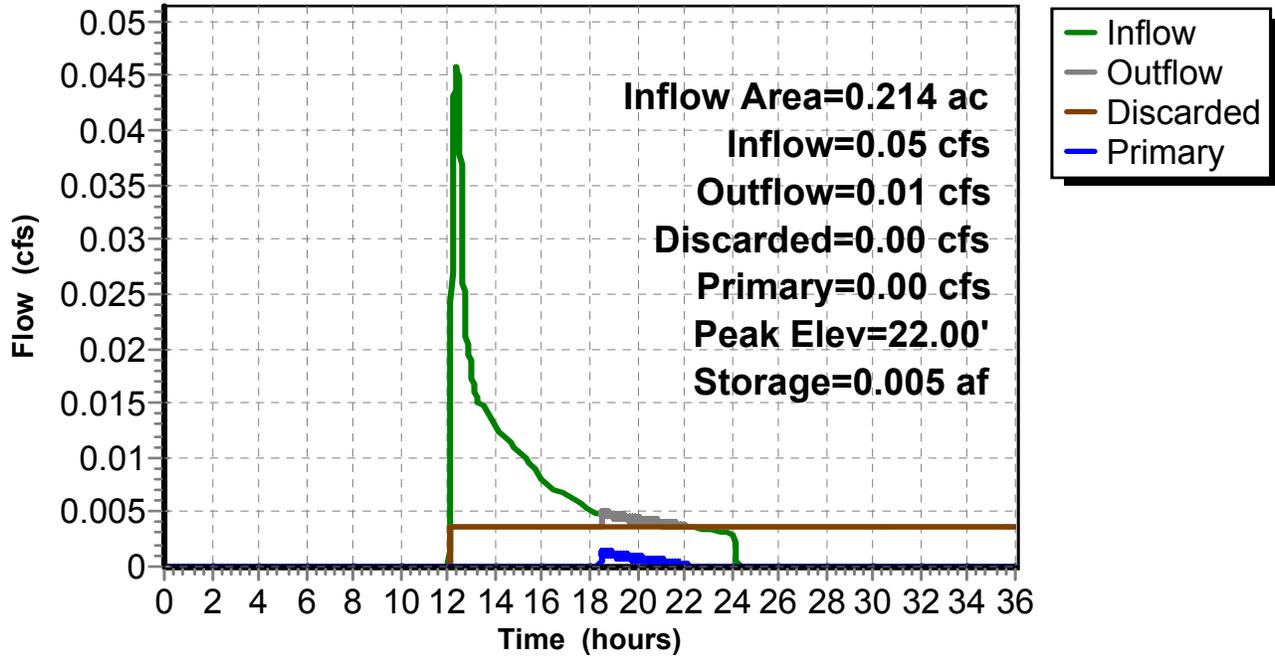
Device	Routing	Invert	Outlet Devices
#1	Discarded	13.50'	2.410 in/hr Exfiltration over Horizontal area Phase-In= 0.01'
#2	Primary	22.00'	24.0" x 24.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.00 cfs @ 12.14 hrs HW=13.60' (Free Discharge)
 ↑1=Exfiltration (Exfiltration Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 18.54 hrs HW=22.00' (Free Discharge)
 ↑2=Orifice/Grate (Weir Controls 0.00 cfs @ 0.05 fps)

Pond 2P: HD-6 DRY WELL (EXFIL)

Hydrograph



Hopkins Drive

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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Pond 3P: Contech ChamberMAX system

Inflow Area = 1.181 ac, 12.84% Impervious, Inflow Depth = 0.38" for 10-yr event
 Inflow = 0.22 cfs @ 12.21 hrs, Volume= 0.038 af
 Outflow = 0.03 cfs @ 12.03 hrs, Volume= 0.038 af, Atten= 88%, Lag= 0.0 min
 Discarded = 0.03 cfs @ 12.03 hrs, Volume= 0.038 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
 Peak Elev= 5.22' @ 17.05 hrs Surf.Area= 0.011 ac Storage= 0.016 af

Plug-Flow detention time= 292.1 min calculated for 0.038 af (100% of inflow)
 Center-of-Mass det. time= 292.1 min (1,223.6 - 931.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	3.15'	0.010 af	15.78'W x 30.78'L x 3.52'H Field A 0.039 af Overall - 0.014 af Embedded = 0.026 af x 40.0% Voids
#2A	3.65'	0.013 af	Contech ChamberMaxx 2016 x 12 Inside #1 Inside= 49.6"W x 25.2"H => 6.63 sf x 7.12'L = 47.2 cf Outside= 49.6"W x 30.0"H => 6.92 sf x 7.12'L = 49.3 cf Row Length Adjustment= +0.32' x 6.63 sf x 3 rows
		0.023 af	Total Available Storage

Storage Group A created with Chamber Wizard

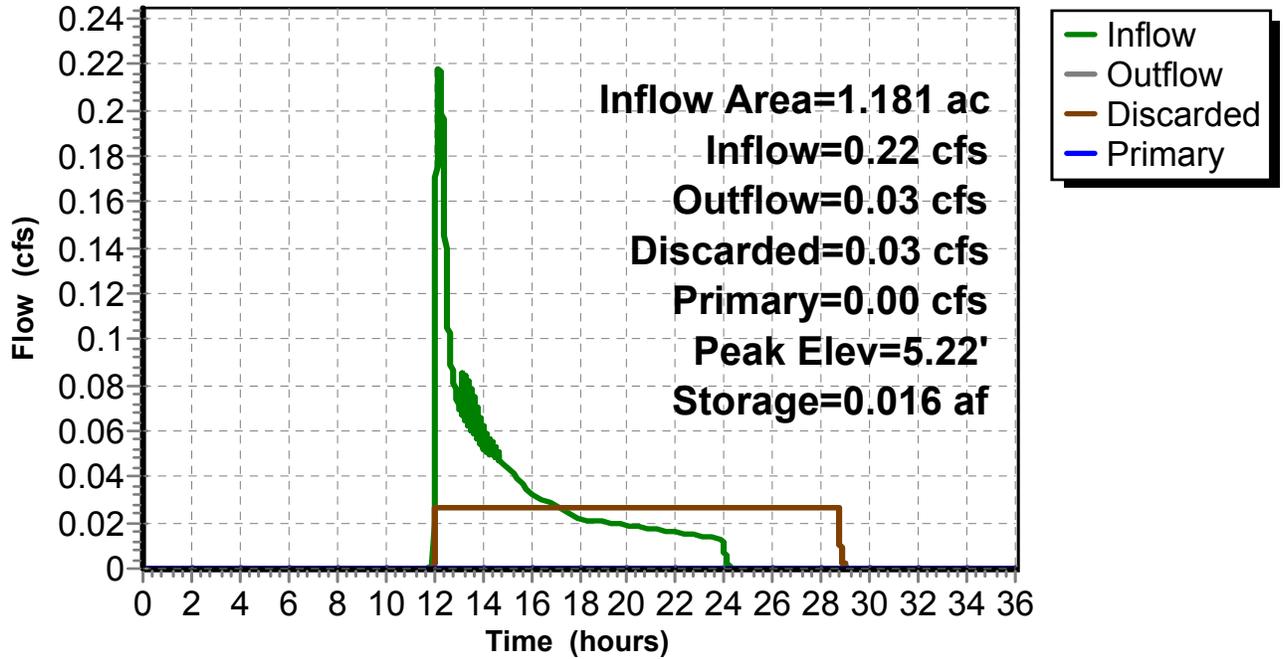
Device	Routing	Invert	Outlet Devices
#1	Discarded	3.15'	2.410 in/hr Exfiltration over Horizontal area
#2	Primary	7.90'	24.0" x 24.0" Horiz. Orifice/Grate X 2.00 C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.03 cfs @ 12.03 hrs HW=3.21' (Free Discharge)
 ↑1=Exfiltration (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3.15' (Free Discharge)
 ↑2=Orifice/Grate (Controls 0.00 cfs)

Pond 3P: Contech ChamberMAX system

Hydrograph



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Type III 24-hr 10-yr Rainfall=4.80"

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Summary for Pond 4P: Test Pipe Size

Inflow Area = 0.098 ac, 61.52% Impervious, Inflow Depth = 2.46" for 10-yr event
Inflow = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af
Outflow = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af, Atten= 0%, Lag= 0.0 min
Primary = 0.30 cfs @ 12.07 hrs, Volume= 0.020 af

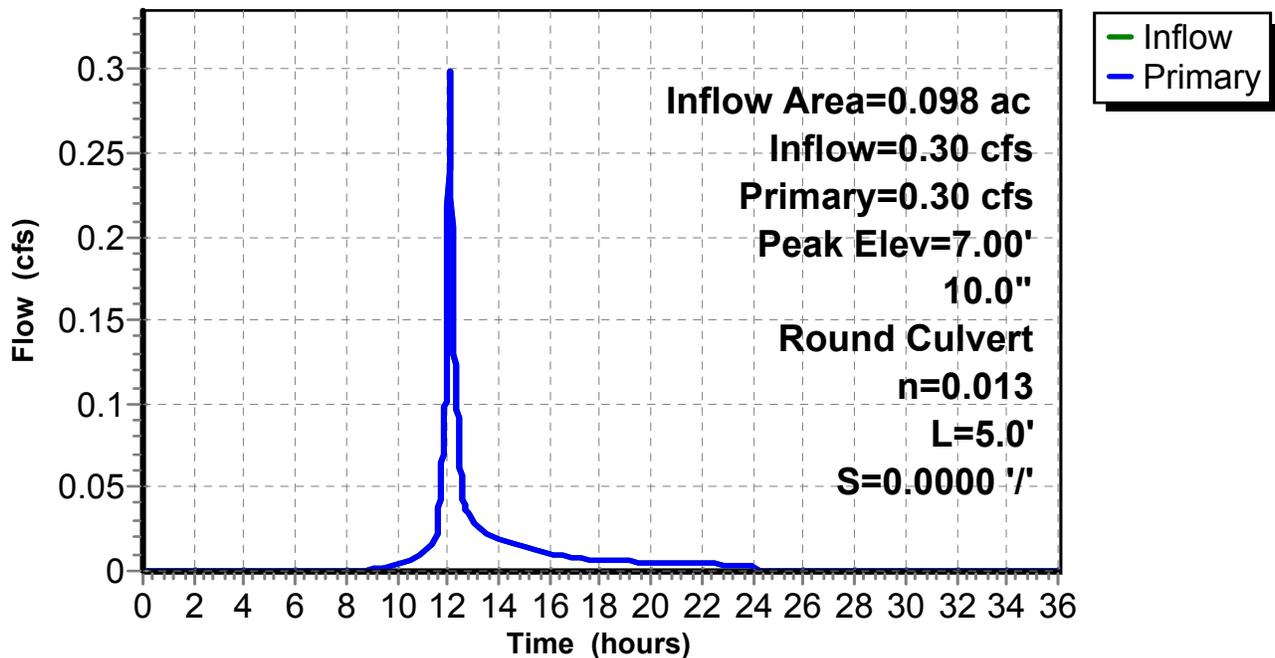
Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Peak Elev= 7.00' @ 12.07 hrs
Flood Elev= 7.90'

Device	Routing	Invert	Outlet Devices
#1	Primary	3.65'	10.0" Round Culvert L= 5.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3.65' / 3.65' S= 0.0000 '/' Cc= 0.900 n= 0.013, Flow Area= 0.55 sf

Primary OutFlow Max=0.32 cfs @ 12.07 hrs HW=7.00' TW=6.98' (Fixed TW Elev= 6.98')
↑1=Culvert (Inlet Controls 0.32 cfs @ 0.59 fps)

Pond 4P: Test Pipe Size

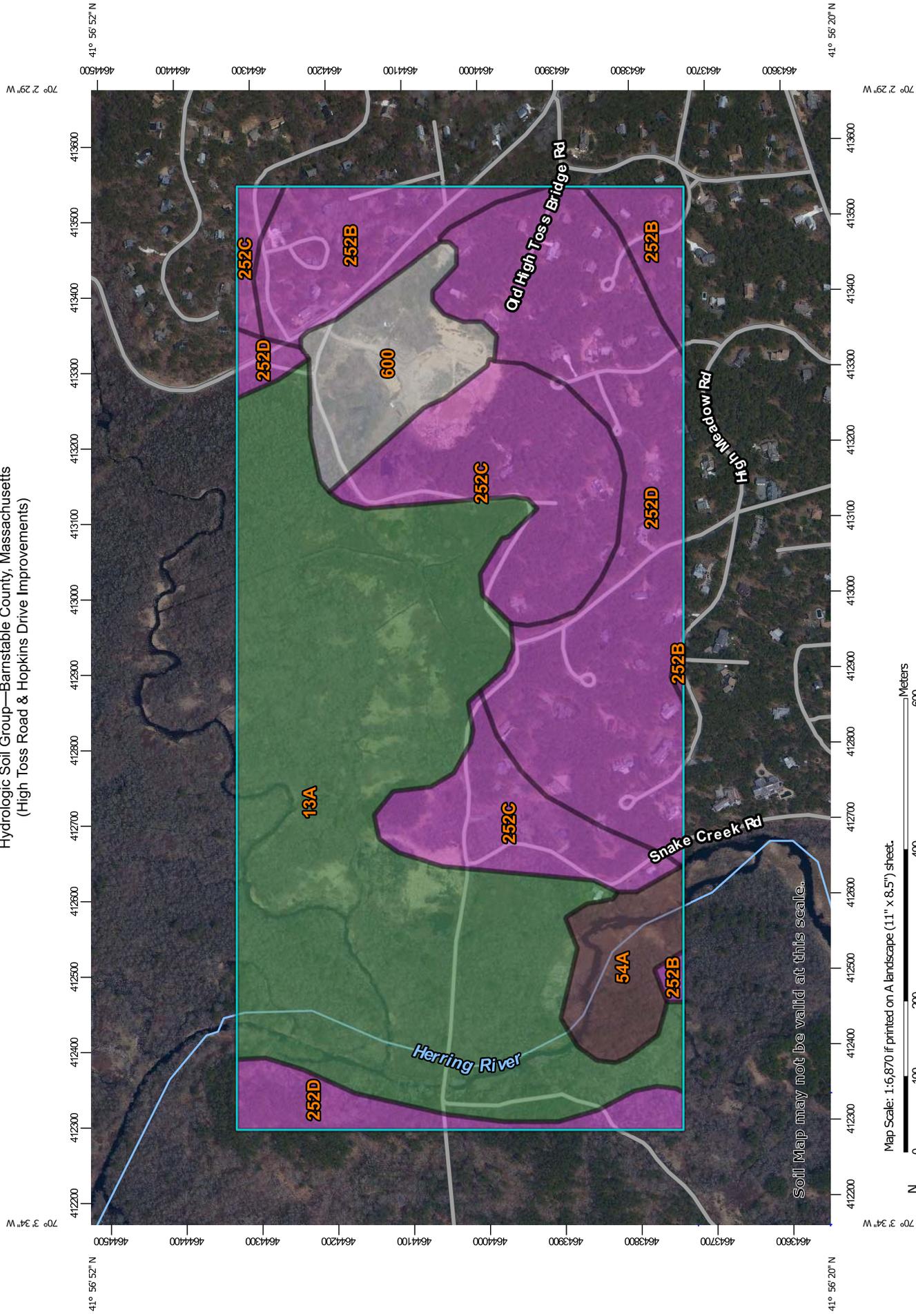
Hydrograph



Appendix D
NRCS Soil Report



Hydrologic Soil Group—Barnstable County, Massachusetts
(High Toss Road & Hopkins Drive Improvements)

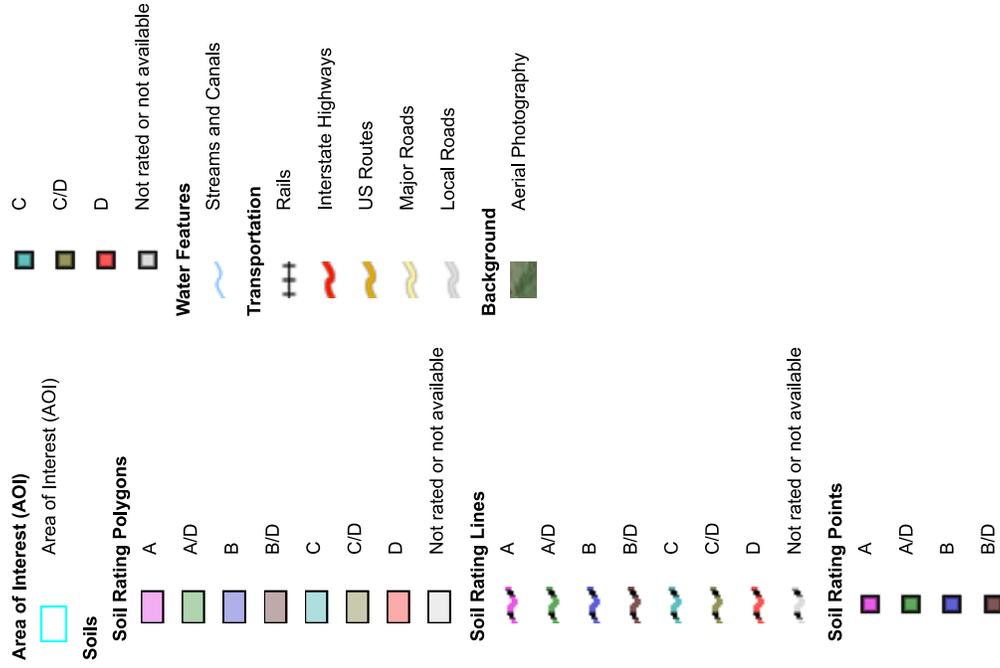


Map Scale: 1:6,870 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND



MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Barnstable County, Massachusetts
 Survey Area Data: Version 13, Sep 14, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 30, 2011—Oct 8, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Barnstable County, Massachusetts (MA001)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
13A	Maybid variant silty clay loam, 0 to 1 percent slopes	A/D	76.9	42.1%
54A	Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes	B/D	7.1	3.9%
252B	Carver coarse sand, 3 to 8 percent slopes	A	13.9	7.6%
252C	Carver coarse sand, 8 to 15 percent slopes	A	29.1	15.9%
252D	Carver coarse sand, 15 to 35 percent slopes	A	45.2	24.7%
600	Pits, sand and gravel		10.6	5.8%
Totals for Area of Interest			182.8	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

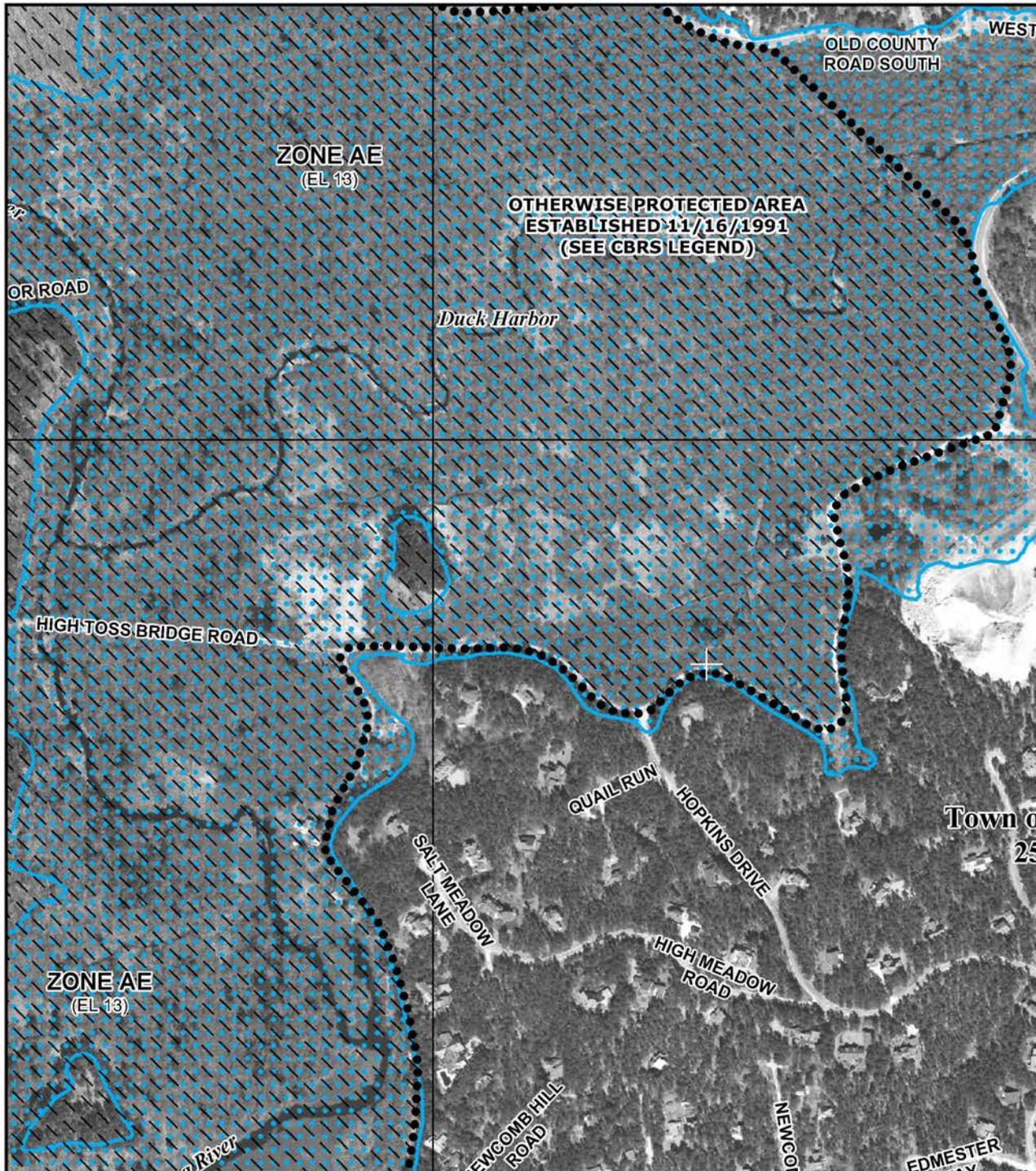
Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix E
FEMA Flood Insurance Rate Map





MAP SCALE 1" = 500'



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0233J

FIRM
 FLOOD INSURANCE RATE MAP
 BARNSTABLE COUNTY,
 MASSACHUSETTS
 (ALL JURISDICTIONS)

PANEL 233 OF 875
 (SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
TRURO, TOWN OF	255222	0233	J
WELLFLEET, TOWN OF	250014	0233	J

-NOTE-
 THIS MAP INCLUDES BOUNDARIES OF THE COASTAL BARRIER RESOURCES SYSTEM ESTABLISHED UNDER THE COASTAL BARRIER RESOURCES ACT OF 1982 AND/OR SUBSEQUENT ENABLING LEGISLATION.

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.



MAP NUMBER
 25001C0233J
 EFFECTIVE DATE
 JULY 16, 2014

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Appendix F Long Term Pollution Prevention Plan





Long-Term Pollution Prevention Plan – High Toss Road and Hopkins Drive

Herring River Restoration Project
Truro and Wellfleet, Massachusetts

PREPARED FOR:

Don Palladino
President
Friends of Herring River
PO Box 496
Wellfleet, Massachusetts 02667

PREPARED BY:

ESS Group, Inc.
10 Hemingway Drive, 2nd Floor
East Providence, Rhode Island 02915

ESS Project No. F453-002

June 30, 2017





**Long-Term Pollution Prevention Plan
Herring River Restoration Project
Truro and Wellfleet, Massachusetts**

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PURPOSE

The Long-Term Pollution Prevention Plan has been prepared in general compliance with Minimum Standards 4 and 6 of the Massachusetts Department of Environmental Protection (MassDEP) Stormwater Handbook, which states:

Standard 4:

The Long-Term Pollution Prevention Plan shall include the proper procedures for the following:

- Good housekeeping;
- Storing materials and waste products inside or under cover;
- Vehicle washing;
- Routine inspections of stormwater Best Management Practices (BMPs);
- Spill prevention and response;
- Maintenance of lawns, gardens, and other landscaped areas;
- Storage and used fertilizers, herbicides, and pesticides;
- Pet waste management;
- Operation and management of septic systems;
- Proper management of deicing chemicals and snow;

Standard 6:

Source control and pollution prevention are particularly important for critical areas. All projects that have the potential to impact critical areas shall implement a source control and pollution prevention program that includes proper management of snow and deicing chemicals. To protect critical areas, road salt must be properly stored within a Zone II or Interim Wellhead Protection Area or near an Outstanding Resource Water, Special Resource Water, shellfish growing area, bathing beach or cold-water fishery. The use of salt for the deicing of impervious surfaces must be minimized within water supply protection areas and any area near an Outstanding Resource Water, Special Resource Water, fresh water beach, or coldwater fishery. The long-term pollution prevention strategies for sites near critical areas must also incorporate designs that allow for shutdown and containment where appropriate to isolate the system in the event of an emergency spill or other unexpected event.

The Plan is intended to cover High Toss Road and the elevated portion of Hopkins Drive (Project Area)

1.0 INTRODUCTION

This Long-Term Pollution Prevention plan was prepared by ESS Group, Inc. for the High Toss Road and Hopkins Drive portion of the Herring River Restoration Project at the Herring River estuary in the Town of Wellfleet, Massachusetts.

The Town and Hopkins Drive Subdivision (Owners) shall implement this Long-Term Pollution Prevention Plan and proactively conduct operations at the site in an environmentally responsible manner. Compliance with this Long-Term Pollution Prevention Plan does not in any way dismiss the Owner from compliance with other applicable Federal, State or local laws. Certain conditions of other approvals affecting the long term management of the property will be considered part of this Long-Term Pollution Prevention Plan. The owner will become familiar with those documents and comply with the guidelines set forth in those documents.

2.0 GOOD HOUSEKEEPING

The Owners will follow good housekeeping procedures to reduce the possibility of accidental releases and to reduce safety hazards within the Project Area.



2.1 Material Handling and Waste Management

No waste materials will be handled or stored within the Project Area.

2.2 Equipment/Vehicle Fueling

There is no anticipated equipment or vehicle fueling within the Project Area.

3.0 ROUTINE INSPECTION AND MAINTENANCE OF STORMWATER BMPS

Catch basin grates shall be inspected a minimum of twice per year. Catch basin grates shall be inspected in the spring following snow-melt and in the fall following leaf-drop to verify that inlet openings are not clogged by debris. Additionally, catch basin grates shall be inspected following heavy rainfalls, defined as a storm event exceeding one inch of rainfall within a 24-hour period, to verify that inlet openings are not clogged with debris. Debris shall be removed and disposed of properly.

Refer to the Operation and Maintenance Plan in Appendix B for information regarding stormwater BMPs maintenance requirements.

4.0 SPILL PREVENTION AND RESPONSE

Refer to the most recent version of the *Massachusetts Unified Response Manual for the Massachusetts Highway System* for spill response procedures, as applicable.

Should materials be used or stored within the Project Area, the following material management practices will be used to reduce the risk of spills or other accidental exposure of materials and substances to stormwater runoff:

1. An effort will be made to store only enough products required to complete the job.
2. All materials stored on site must be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.
3. Materials will be kept in their original containers with the original manufacturer's label.
4. Substances will not be mixed with one another, unless recommended by the manufacturer.
5. Manufacturer's recommendations for proper use and disposal will be followed.
6. The Operator will perform inspections to ensure the proper storage, use and disposal of materials.
7. Whenever possible, materials which are considered hazardous will be used per the manufacturer's recommendations in their entirety before disposing of the container.
8. On-site vehicles will be monitored for leaks and receive regular preventative maintenance to reduce the chance of leakage.
9. Petroleum products will be stored in tightly sealed containers that are clearly labeled.
10. All containers will be tightly sealed and stored when not in use. Excess paint will be properly disposed of according to the manufacturer's instructions or state and local regulations.

The Owner will be responsible for preventing spills in accordance with the project specifications and applicable federal, state and local regulations and will identify an appropriately trained site employee involved with the day-to-day site operations to be the Spill Prevention and Cleanup Coordinator. The name(s) of the responsible spill personnel will be posted in the material storage area(s) and the on-site office. Each employee will be instructed that all spills are to be reported to the Spill Prevention and Cleanup Coordinator.



Materials and equipment necessary for spill cleanup and control will be kept in the on-site material storage area. Equipment and materials will include, but not be limited to, absorbent booms or mats, brooms, dust pans, mops, rags, gloves, goggles, sand and plastic and metal trash containers, specifically for this purpose. It is the responsibility of the Operator to ensure the inventory will be readily accessible and maintained.

Spills will be contained with granular sorbent materials, sand, sorbent pads, booms, or all of the above to prevent spreading. Spill clean-up should be completed by trained, certified clean-up contractors. Manufacturers' recommended methods for spill cleanup will be clearly posted and site personnel will be made aware of the procedures and the location of the information and cleanup supplies. Following a spill of oil or hazardous material the Operator will fill out a spill report form. Upon completion of clean-up, spill reports and appropriate completion forms shall be provided to the proper authorities.

5.0 MAINTENANCE OF LANDSCAPED AREAS

The maintenance of landscaped areas in the Project Area Right of Way should use a system that reduces the amount of pesticides and fertilizers used. Pesticide and fertilizer should be avoided. Grass clippings, pruned branches, and any other landscaped waste should be disposed of or composted in an appropriate location. Avoid application of chemicals prior to rainfall events.

6.0 STORAGE OF FERTILIZERS, HERBICIDES, AND PESTICIDES

No fertilizers, herbicides, or pesticides will be stored in the Project Area.

7.0 PET WASTE MANAGEMENT

Residents should be encouraged to pick up after their pets and dispose of waste in the trash.

8.0 MANAGEMENT OF DEICING CHEMICALS AND SNOW

Roadways shall be maintained by the Owners. Snow will not be stock piled on top of stormwater BMPs or near wetland resource areas.

Sand and salt for roadway deicing will not be stored in the Project Area.

Alternatives to sodium chloride (commonly used salt) such as sand or calcium chloride, and reduced application, should be considered and implemented if public safety is not jeopardized.

Before winter begins, the Owners should review snow plowing, deicing, and stockpiling procedures. Areas designated for stockpiling should be cleaned of any debris.

9.0 EMERGENCY CONTACT

TBD

**Stormwater Standard Compliance (Standard 6)
Herring River Tidal Restoration Project
Wellfleet, Massachusetts**

STANDARD:

STORMWATER DISCHARGES TO OUTSTANDING RESOURCE WATERS, SHELLFISH GROWING AREA, ZONE II OR INTERIM WELLHEAD PROTECTION AREAS, COLD-WATER FISHERIES, BATHING BEACHES, ETC. MUST ACHIEVE AT LEAST 44% TSS REMOVAL PRIOR TO DISCHARGE TO INFILTRATION BMP.

CONFORMANCE:

IN LIEU OF USING DEEP-SUMP, HOODED CATCH BASINS THAT ONLY PROVIDE 25% TSS REMOVAL, PROPRIETARY STORMWATER INLET DEVICES (FIRST DEFENSE HC BY HYDRO INTERNATIONAL OR APPROVED EQUAL) ARE PROPOSED. THESE PRETREATMENT INLET DEVICES ARE CERTIFIED BY NJDEP AT A TSS REMOVAL RATE OF 50%. THE FD-4HC MODEL IS REQUIRED TO TO ACHIEVE THIS TSS REMOVAL RATE GIVEN A MAXIMUM PEAK FLOW RATE OF 0.76 CFS DURING THE WATER QUALITY STORM EVENT AND 1.36 CFS DURING THE 100-YEAR STORM EVENT.

THUS, 50% TSS REMOVAL WILL BE ACHIEVED PRIOR TO DISCHARGE TO STORMWATER PLANTERS (WHICH EXCEEDS 44% TSS REMOVAL REQUIREMENT). THE STORMWATER PLANTERS, IN CONJUNCTION WITH THE PROPRIETARY INLET TREATMENT DEVICES, WILL PROVIDE A TOTAL OF 80% TSS REMOVAL PRIOR TO DISCHARGE TO THE HERRING RIVER AND WELLFLEET HARBOR.

Supporting Proprietary Treatment System Certification and Documentation





State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Nonpoint Pollution Control

Division of Water Quality

401-02B

Post Office Box 420

Trenton, New Jersey 08625-0420

609-633-7021 Fax: 609-777-0432

http://www.state.nj.us/dep/dwq/bnpc_home.htm

CHRIS CHRISTIE

Governor

KIM GUADAGNO

Lt. Governor

BOB MARTIN

Commissioner

April 4, 2016

Lisa Lemont, CPSWQ
Business Development Manager
Hydro International
94 Hutchins Drive
Portland, ME 04102

Re: MTD Lab Certification
First Defense® HC (FDHC) Stormwater Treatment Device by Hydro International

TSS Removal Rate 50%

Dear Ms. Lemont:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7 (c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Hydro International has requested an MTD Laboratory Certification for the First Defense® HC Stormwater Treatment Device.

The projects falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advance Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix (dated February 2016) for this device is published online at <http://www.njcat.org/verification-process/technology-verification-database.html>.

The NJDEP certifies the use of the First Defense® HC Stormwater Treatment Device by Hydro International at a TSS removal rate of 50% when designed, operated and maintained in accordance with the information provided in the Verification Appendix and the following conditions:

1. The maximum treatment flow rate (MTFR) for the manufactured treatment device (MTD) is calculated using the New Jersey Water Quality Design Storm (1.25 inches in 2 hrs) in N.J.A.C. 7:8-5.5.

2. The First Defense® HC Stormwater Treatment Device shall be installed using the same configuration reviewed by NJCAT and shall be sized in accordance with the criteria specified in item 6 below.
3. This First Defense® HC Stormwater Treatment Device cannot be used in series with another MTD or a media filter (such as a sand filter) to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.
4. Additional design criteria for MTDs can be found in Chapter 9.6 of the New Jersey Stormwater Best Management Practices (NJ Stormwater BMP) Manual which can be found on-line at www.njstormwater.org.
5. The maintenance plan for a site using the First Defense® HC Stormwater Treatment Device shall incorporate, at a minimum, the maintenance requirements noted in the attached document. However, it is recommended to review the maintenance website at http://www.hydro-int.com/UserFiles/downloads/FD_O%2BM_F1512.pdf for any changes to the maintenance requirements.
6. Sizing Requirements:

The example below demonstrates the sizing procedure for the First Defense® HC Stormwater Treatment Device:

Example: A 0.25 acre impervious site is to be treated to 50% TSS removal using a First Defense® HC Stormwater Treatment Device. The impervious site runoff (Q) based on the New Jersey Water Quality Design Storm was determined to be 0.79 cfs.

Maximum Treatment Flow Rate (MTFR) Evaluation:

The site runoff (Q) was based on the following:

time of concentration = 10 minutes
i=3.2 in/hr (page 5-8, Fig. 5-3 of the NJ Stormwater BMP Manual)
c=0.99 (curve number for impervious)
 $Q=ciA=0.99 \times 3.2 \times 0.25 = 0.79$ cfs

Given the site runoff is 0.79 cfs and based on Table 1 below, the First Defense® HC Model 4-ft with a MTFR of 1.5 cfs would be the smallest model approved that could be used for this site that could remove 50% of the TSS from the impervious area without exceeding the MTFR.

The sizing table corresponding to the available system models is noted below. Additional specifications regarding each model can be found in the Verification Appendix under Table A-1 and Table A-2 of the NJCAT Verification Report.

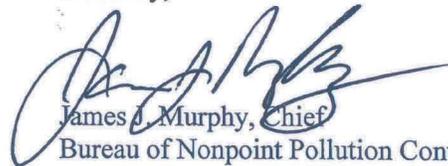
Table 1 First Defense® HC Models

First Defense® Model	Manhole Diameter (ft)	Maximum Treatment Flowrate, MTFR (cfs)
4-ft	4-ft	1.50
6-ft	6-ft	3.38
8-ft	8-ft	6.00

Be advised a detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all of the items identified in the Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Practices Manual.

If you have any questions regarding the above information, please contact Mr. Titus Magnanao of my office at (609) 633-7021.

Sincerely,



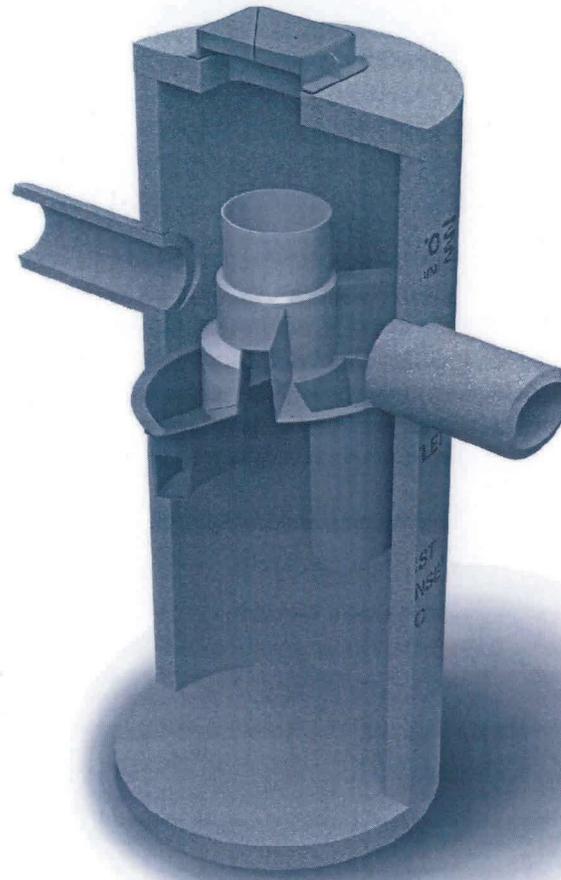
James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

Attachment: Maintenance Plan

- C: Chron File
- Richard Magee, NJCAT
- Vince Mazzei, DLUR
- Ravi Patraju, NJDEP
- Gabriel Mahon, BNPC
- Titus Magnanao, BNPC



Hydro
International 



Operation and Maintenance Manual

First Defense[®] and First Defense[®]-HC

Vortex Separator for Stormwater Treatment

Stormwater Solutions
Turning Water Around ...[®]

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4	Model Sizes & Configurations <ul style="list-style-type: none">- First Defense® Components
5	Maintenance <ul style="list-style-type: none">- Overview- Maintenance Equipment Considerations- Determining Your Maintenance Schedule
6	Maintenance Procedures <ul style="list-style-type: none">- Inspection- Floatables and Sediment Clean Out
8	First Defense® Installation Log
9	First Defense® Inspection and Maintenance Log

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DISCLAIMER: Information and data contained in this manual is exclusively for the purpose of assisting in the operation and maintenance of Hydro International plc's First Defense®. No warranty is given nor can liability be accepted for use of this information for any other purpose. Hydro International plc has a policy of continuous product development and reserves the right to amend specifications without notice.

I. First Defense® by Hydro International

Introduction

The First Defense® is an enhanced vortex separator that combines an effective and economical stormwater treatment chamber with an integral peak flow bypass. It efficiently removes total suspended solids (TSS), trash and hydrocarbons from stormwater runoff without washing out previously captured pollutants. The First Defense® is available in several model configurations (refer to *Section II. Model Sizes & Configurations*, page 4) to accommodate a wide range of pipe sizes, peak flows and depth constraints.

Operation

The First Defense® operates on simple fluid hydraulics. It is self-activating, has no moving parts, no external power requirement and is fabricated with durable non-corrosive components. No manual procedures are required to operate the unit and maintenance is limited to monitoring accumulations of stored pollutants and periodic clean-outs. The First Defense® has been designed to allow for easy and safe access for inspection, monitoring and clean-out procedures. Neither entry into the unit nor removal of the internal components is necessary for maintenance, thus safety concerns related to confined-space-entry are avoided.

Pollutant Capture and Retention

The internal components of the First Defense® have been designed to optimize pollutant capture. Sediment is captured and retained in the base of the unit, while oil and floatables are stored on the water surface in the inner volume (Fig.1).

The pollutant storage volumes are isolated from the built-in bypass chamber to prevent washout during high-flow storm events. The sump of the First Defense® retains a standing water level between storm events. This ensures a quiescent flow regime at the onset of a storm, preventing resuspension and washout of pollutants captured during previous events.

Accessories such as oil absorbent pads are available for enhanced oil removal and storage. Due to the separation of the oil and floatable storage volume from the outlet, the potential for washout of stored pollutants between clean-outs is minimized.

Applications

- Stormwater treatment at the point of entry into the drainage line
- Sites constrained by space, topography or drainage profiles with limited slope and depth of cover
- Retrofit installations where stormwater treatment is placed on or tied into an existing storm drain line
- Pretreatment for filters, infiltration and storage

Advantages

- Inlet options include surface grate or multiple inlet pipes
- Integral high capacity bypass conveys large peak flows without the need for "offline" arrangements using separate junction manholes
- Proven to prevent pollutant washout at up to 500% of its treatment flow
- Long flow path through the device ensures a long residence time within the treatment chamber, enhancing pollutant settling
- Delivered to site pre-assembled and ready for installation

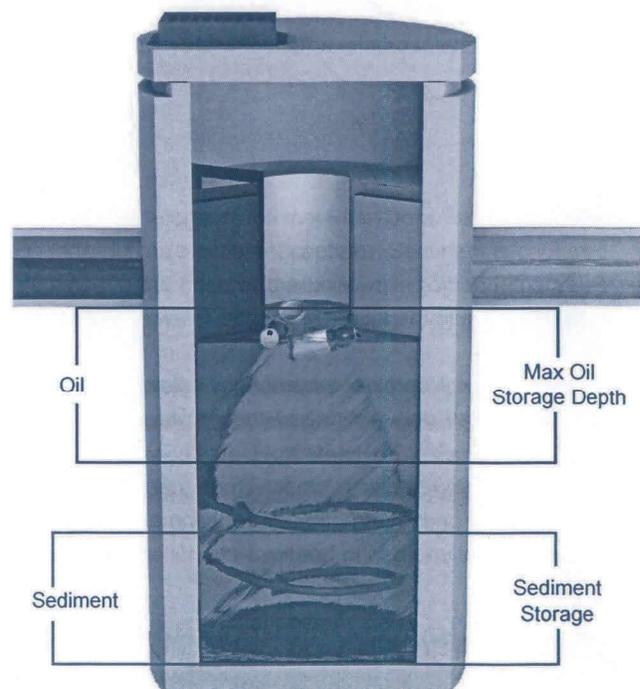


Fig.1 Pollutant storage volumes in the First Defense®.

II. Model Sizes & Configurations

The First Defense® inlet and internal bypass arrangements are available in several model sizes and configurations. The components of the First Defense®-4HC and First Defense®-6HC have modified geometries as to allow greater design flexibility needed to accommodate various site constraints.

All First Defense® models include the internal components that are designed to remove and retain total suspended solids (TSS), gross solids, floatable trash and hydrocarbons (Fig.2a - 2b). First Defense® model parameters and design criteria are shown in Table 1.

First Defense® Components

- 1. Built-In Bypass
- 2. Inlet Pipe
- 3. Inlet Chute
- 4. Floatables Draw-off Port
- 5. Outlet Pipe
- 6. Floatables Storage
- 7. Sediment Storage
- 8. Inlet Grate or Cover

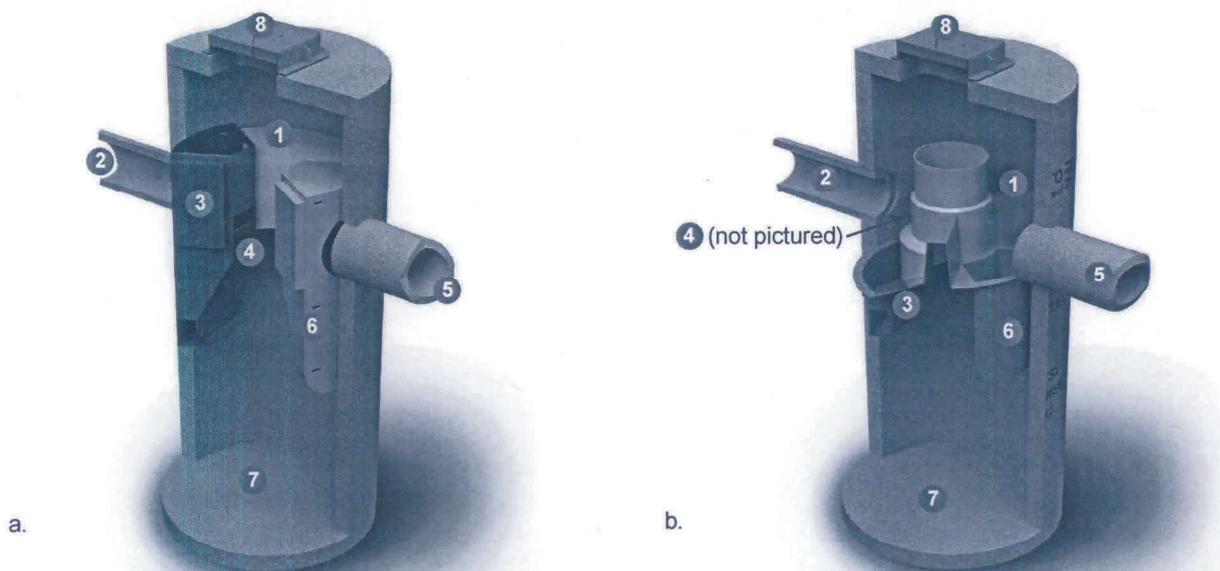


Fig.2a) First Defense®-4 and First Defense®-6; b) First Defense®-4HC and First Defense®-6HC, with higher capacity dual internal bypass and larger maximum pipe diameter.

Table 1. First Defense® Pollutant Storage Capacities and Maximum Clean out Depths

First Defense® Model Number	Diameter (ft / m)	Oil Storage Capacity (gal / L)	Oil Clean Out Depth (in / cm)	Maximum Sediment Storage Capacity ¹		Recommended Sediment Clean-out Capacity	
				Volume (yd ³ / m ³)	Depth (in / cm)	Volume (yd ³ / m ³)	Depth (in / cm)
				FD-4	4 / 1.2	180 / 681	<23.5 / 60
FD-4HC	191 / 723	<24.4 / 62					
FD-6	6 / 1.8	420 / 1,590	<23.5 / 60	3.3 / 2.5	37.5 / 95	1.6 / 1.2	18 / 46
FD-6HC		496 / 1,878	<28.2 / 72				

NOTE

¹ Sediment storage capacity and clean out depth may vary, as larger sediment storage sump volumes are provided when required.

III. Maintenance

Overview

The First Defense® protects the environment by removing a wide range of pollutants from stormwater runoff. Periodic removal of these captured pollutants is essential to the continuous, long-term functioning of the First Defense®. The First Defense® will capture and retain sediment and oil until the sediment and oil storage volumes are full to capacity. When sediment and oil storage capacities are reached, the First Defense® will no longer be able to store removed sediment and oil. Maximum pollutant storage capacities are provided in Table 1.

The First Defense® allows for easy and safe inspection, monitoring and clean-out procedures. A commercially or municipally owned sump-vac is used to remove captured sediment and floatables. Access ports are located in the top of the manhole.

Maintenance events may include Inspection, Oil & Floatables Removal, and Sediment Removal. Maintenance events do not require entry into the First Defense®, nor do they require the internal components of the First Defense® to be removed. In the case of inspection and floatables removal, a vactor truck is not required. However, a vactor truck is required if the maintenance event is to include oil removal and/or sediment removal.

Maintenance Equipment Considerations

The internal components of the First Defense®-HC have a centrally located circular shaft through which the sediment storage sump can be accessed with a sump vac hose. The open diameter of this access shaft is 15 inches in diameter (Fig.3). Therefore, the nozzle fitting of any vactor hose used for maintenance should be less than 15 inches in diameter.

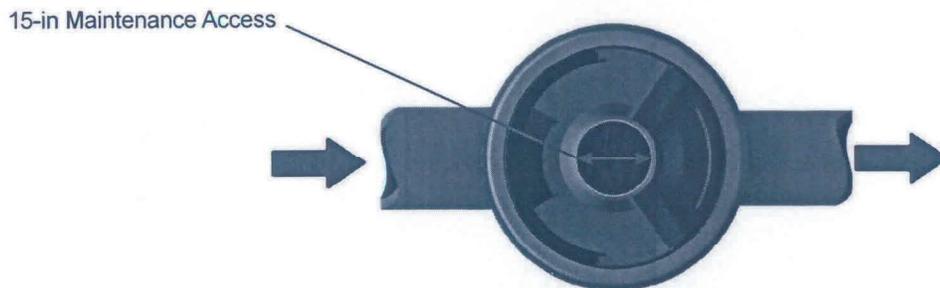


Fig.3 The central opening to the sump of the First Defense®-HC is 15 inches in diameter.

Determining Your Maintenance Schedule

The frequency of clean out is determined in the field after installation. During the first year of operation, the unit should be inspected every six months to determine the rate of sediment and floatables accumulation. A simple probe such as a Sludge-Judge® can be used to determine the level of accumulated solids stored in the sump. This information can be recorded in the maintenance log (see page 9) to establish a routine maintenance schedule.

The vactor procedure, including both sediment and oil / floatables removal, for a 6-ft First Defense® typically takes less than 30 minutes and removes a combined water/oil volume of about 765 gallons.

Inspection Procedures

1. Set up any necessary safety equipment around the access port or grate of the First Defense® as stipulated by local ordinances. Safety equipment should notify passing pedestrian and road traffic that work is being done.
2. Remove the grate or lid to the manhole.
3. Without entering the vessel, look down into the chamber to inspect the inside. Make note of any irregularities. Fig.4 shows the standing water level that should be observed.
4. Without entering the vessel, use the pole with the skimmer net to remove floatables and loose debris from the components and water surface.
5. Using a sediment probe such as a Sludge Judge®, measure the depth of sediment that has collected in the sump of the vessel.
6. On the Maintenance Log (see page 9), record the date, unit location, estimated volume of floatables and gross debris removed, and the depth of sediment measured. Also note any apparent irregularities such as damaged components or blockages.
7. Securely replace the grate or lid.
8. Take down safety equipment.
9. Notify Hydro International of any irregularities noted during inspection.

Floatables and Sediment Clean Out

Floatables clean out is typically done in conjunction with sediment removal. A commercially or municipally owned sump-vac is used to remove captured sediment and floatables (Fig.5).

Floatables and loose debris can also be netted with a skimmer and pole. The access port located at the top of the manhole provides unobstructed access for a vactor hose and skimmer pole to be lowered to the base of the sump.

Scheduling

- Floatables and sump clean out are typically conducted once a year during any season.
- Floatables and sump clean out should occur as soon as possible following a spill in the contributing drainage area.

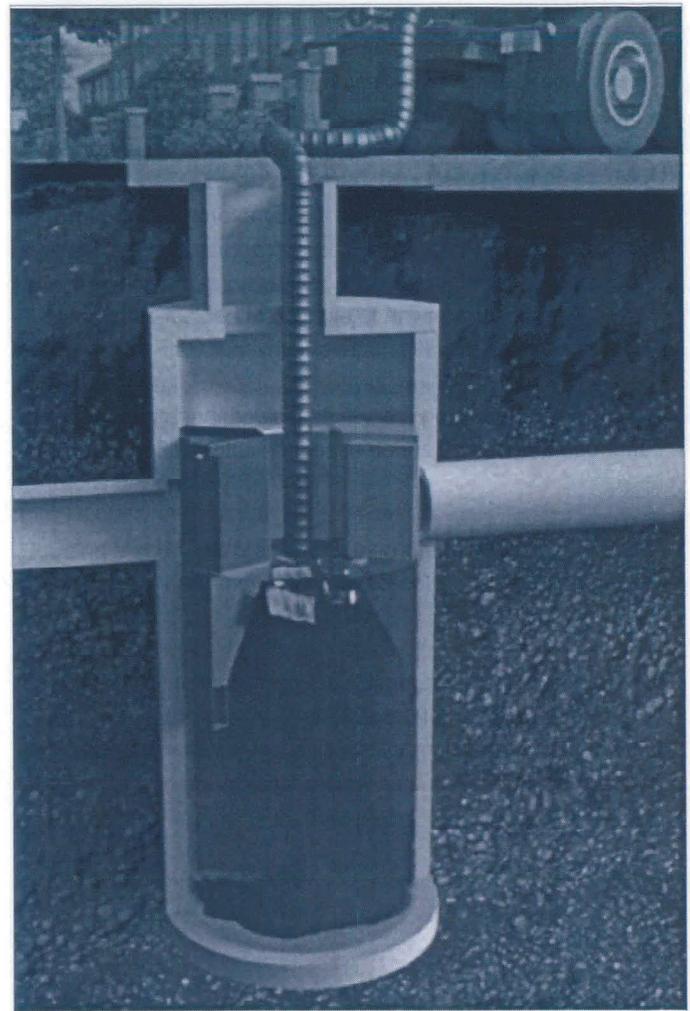


Fig.4 Floatables are removed with a vactor hose (First Defense model FD-4, shown).

Recommended Equipment

- Safety Equipment (traffic cones, etc)
- Crow bar or other tool to remove grate or lid
- Pole with skimmer or net (if only floatables are being removed)
- Sediment probe (such as a Sludge Judge®)
- Vactor truck (flexible hose recommended)
- First Defense® Maintenance Log

Floatables and sediment Clean Out Procedures

1. Set up any necessary safety equipment around the access port or grate of the First Defense® as stipulated by local ordinances. Safety equipment should notify passing pedestrian and road traffic that work is being done.
2. Remove the grate or lid to the manhole.
3. Without entering the vessel, look down into the chamber to inspect the inside. Make note of any irregularities.
4. Remove oil and floatables stored on the surface of the water with the vactor hose (Fig.5) or with the skimmer or net (not pictured).
5. Using a sediment probe such as a Sludge Judge®, measure the depth of sediment that has collected in the sump of the vessel and record it in the Maintenance Log (page 9).
6. Once all floatables have been removed, drop the vactor hose to the base of the sump. Vactor out the sediment and gross debris off the sump floor (Fig.5).
7. Retract the vactor hose from the vessel.
8. On the Maintenance Log provided by Hydro International, record the date, unit location, estimated volume of floatables and gross debris removed, and the depth of sediment measured. Also note any apparent irregularities such as damaged components, blockages, or irregularly high or low water levels.
9. Securely replace the grate or lid.

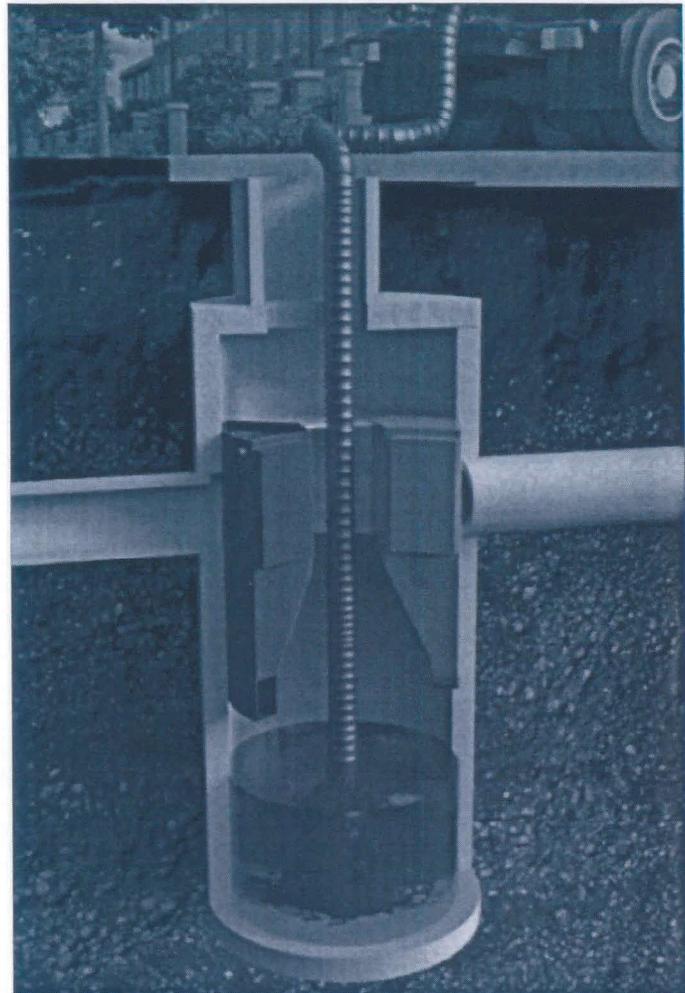


Fig.5 Sediment is removed with a vactor hose (First Defense model FD-4, shown).

Maintenance at a Glance

Activity	Frequency
Inspection	- Regularly during first year of installation - Every 6 months after the first year of installation
Oil and Floatables Removal	- Once per year, with sediment removal - Following a spill in the drainage area
Sediment Removal	- Once per year or as needed - Following a spill in the drainage area

NOTE: For most clean outs the entire volume of liquid does not need to be removed from the manhole. Only remove the first few inches of oils and floatables from the water surface to reduce the total volume of liquid removed during a clean out.



First Defense® High Capacity

A Simple Solution for your Trickiest Sites

Product Profile

The First Defense® High Capacity is an enhanced vortex separator that combines an effective stormwater treatment chamber with an integral peak flow bypass. It efficiently removes sediment total suspended solids (TSS), trash and hydrocarbons from stormwater runoff without washing out previously captured pollutants. The First Defense® High Capacity is available in several model configurations to accommodate a wide range of pipe sizes, peak flows and depth constraints (**Table 1**, next page).

Applications

- Stormwater treatment at the point of entry into the drainage line
- Sites constrained by space, topography or drainage profiles with limited slope and depth of cover
- Retrofit installations where stormwater treatment is placed on or tied into an existing storm drain line
- Pretreatment for filters, infiltration and storage

Advantages

- Inlet options include surface grate or multiple inlet pipes
- Integral high capacity bypass conveys large peak flows without the need for "offline" arrangements using separate junction manholes
- Proven to prevent pollutant washout at up to 450% of its treatment flow
- Long flow path through the device ensures a long residence time within the treatment chamber, enhancing pollutant settling
- Delivered to site pre-assembled and ready for installation

How it Works

The First Defense® High Capacity has internal components designed to remove and retain gross debris, total suspended solids (TSS) and hydrocarbons (**Fig.1**).

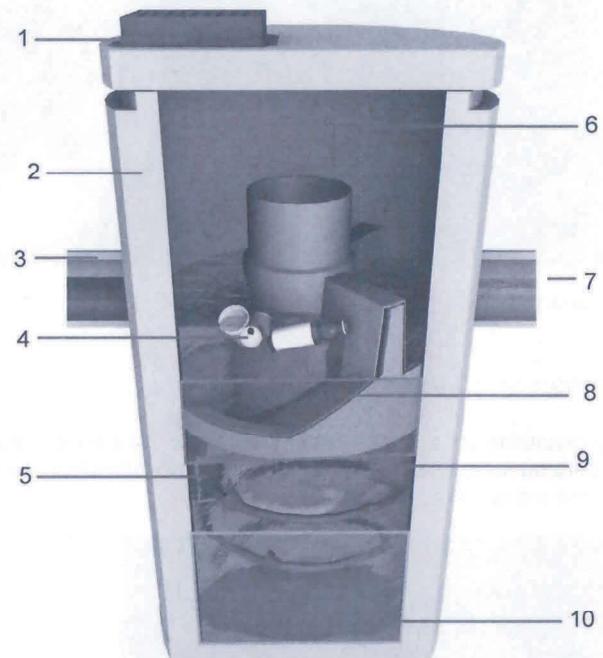
Contaminated stormwater runoff enters the inlet chute from a surface grate and/or inlet pipe. The inlet chute introduces flow into the chamber tangentially to create a low energy vortex flow regime (magenta arrow) that directs sediment into the sump while oils, floating trash and debris rise to the surface.

Treated stormwater exits through a submerged outlet chute located opposite to the direction of the rotating flow (blue arrow). Enhanced vortex separation is provided by forcing the rotating flow within the vessel to follow the longest path possible rather than directly from inlet to outlet.

Higher flows bypass the treatment chamber to prevent turbulence and washout of captured pollutants. An internal bypass conveys infrequent peak flows directly to the outlet eliminating the need for, and expense of, external bypass control structures. A floatables draw off slot functions to convey floatables into the treatment chamber prior to bypass.

Verified by NJCAT and NJDEP

Fig.1 The First Defense® High Capacity has internal components designed to efficiently capture pollutants and prevent washout at peak flows.



Components

- | | |
|---|-------------------------------|
| 1. Inlet Grate (optional) | 6. Internal Bypass |
| 2. Precast chamber | 7. Outlet pipe |
| 3. Inlet Pipe (optional) | 8. Oil and Floatables Storage |
| 4. Floatables Draw Off Slot
(not pictured) | 9. Outlet chute |
| 5. Inlet Chute | 10. Sediment Storage Sump |

First Defense® High Capacity

Sizing & Design

This adaptable online treatment system works easily with large pipes, multiple inlet pipes, inlet grates and now, contains a high capacity bypass for the conveyance of large peak flows. Designed with site flexibility in mind, the First Defense® High Capacity allows engineers to maximize available site space without compromising treatment level.

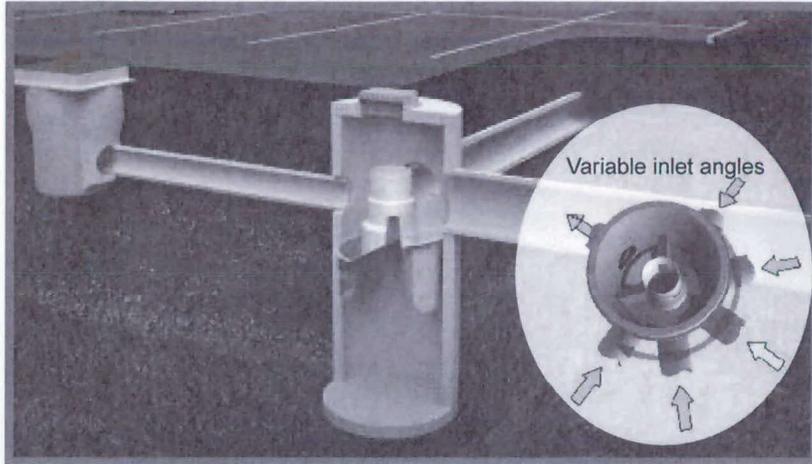


Fig 2. Works with multiple inlet pipes and grates

Inspection and Maintenance

Nobody maintains our systems better than we do. To ensure optimal, ongoing device performance, be sure to recommend Hydro International as a preferred service and maintenance provider to your clients.

Call 1 (800) 848-2706 to schedule an inspection and cleanout or learn more at hydro-int.com/service

Free Stormwater Separator Sizing Calculator for Engineers



This simple online tool will recommend the best separator, model size and online/offline arrangement based on site-specific data entered by the user.

Go to hydro-int.com/sizing to access the tool.

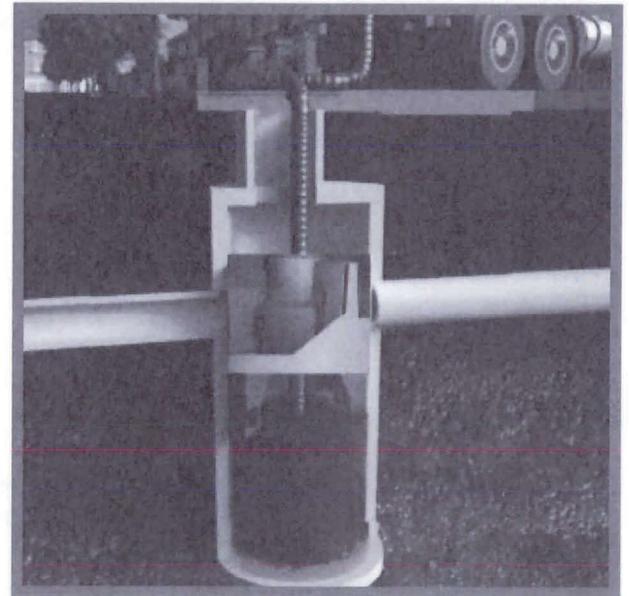


Fig 3. Maintenance is done with a vactor truck

Table 1. First Defense® High Capacity Design Criteria.

First Defense® High Capacity Model Number	Diameter (ft / m)	Typical TSS Treatment Flow Rates			Peak Online Flow Rate (cfs / L/s)	Maximum Pipe Diameter ¹ (in / mm)	Oil Storage Capacity (gal / L)	Typical Sediment Storage Capacity ² (yd ³ / m ³)	Minimum Distance from Outlet Invert to Top of Rim ³ (ft / m)	Standard Distance from Outlet Invert to Sump Floor (ft / m)
		NJDEP Certified (cfs / L/s)	106µm (cfs / L/s)	230µm (cfs / L/s)						
FD-3HC	3 / 0.9	0.84 / 23.7	0.3 / 8.77	0.53 / 15.0	15 / 424	18 / 457	125 / 473	0.4 / 0.3	2.0 - 3.5 / 0.6 - 1.0	3.71 / 1.13
FD-4HC	4 / 1.2	1.50 / 42.4	0.7 / 20	1.2 / 34	18 / 510	24 / 600	191 / 723	0.7 / 0.5	2.3 - 3.9 / 0.7 - 1.2	4.97 / 1.5
FD-5HC	5 / 1.5	2.34 / 66.2	1.3 / 37.9	2.2 / 62.2	20 / 566	24 / 609	300 / 1135	1.1 / .84	2.5 - 4.5 / 0.7 - 1.3	5.19 / 1.5
FD-6HC	6 / 1.8	3.38 / 95.7	2.2 / 63	3.8 / 108	32 / 906	30 / 750	496 / 1,878	1.6 / 1.2	3.0 - 5.1 / 0.9 - 1.6	5.97 / 1.8
FD-8HC	8 / 2.4	6.00 / 169.9	5.1 / 144	8.6 / 243	50 / 1,415	48 / 1219	1120 / 4239	2.8 / 2.1	3.0 - 6.0 / 0.9 - 1.8	7.40 / 2.2

¹Contact Hydro International when larger pipe sizes are required.

²Contact Hydro International when custom sediment storage capacity is required.

³Minimum distance for models depends on pipe diameter.

8.E NHESP Correspondence and Draft Habitat Management Plan Outline

(See following pages)



MassWildlife

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

Jack Buckley, *Director*

July 8, 2016

Secretary Matthew A. Beaton
Executive Office of Environmental Affairs
Attention: MEPA Office
Holly Johnson, EOE No. 14272
100 Cambridge St, Suite 900
Boston, MA 02114

Project Name: Herring River Restoration Project
Proponent: Cape Cod National Seashore and the Herring River Restoration Committee
Project Location: Truro & Wellfleet
Project Description: Tidal restoration of large portions of the Herring River flood plain
Document Reviewed: Final Environmental Impact Report/ Final Environmental Impact Statement
EEA File Number: 14272
NHESP Tracking No: 04-15126

Dear Secretary Beaton:

The Natural Heritage & Endangered Species Program (NHESP) of the Massachusetts Division of Fisheries & Wildlife has reviewed the Final Environmental Impact Report (FEIR) / Final Environmental Impact Statement (FEIS) for the *Herring River Restoration Project*. At this time, the NHESP would like to offer the following comments regarding state-listed species and their habitats.

The project site is located within *Priority* and *Estimated Habitat* as indicated in the 13th Edition of the MA Natural Heritage Atlas and therefore requires review by the NHESP for compliance with the Massachusetts Endangered Species Act (MESA 321 CMR 10.00).

The NHESP has been actively involved in the review of the proposed restoration plan through on-going participation in the Herring River Restoration Technical Working Group. While the NHESP strongly supports habitat restoration, care must be taken to reduce impacts to state-listed species and their habitats. It appears that the proposed project will qualify for a MESA Habitat Management Exemption (321 CMR 10.14 (15)), however, the proposed Habitat Management and Monitoring Plan must be submitted to the NHESP for final review and approval. As stated in Chapter 5, the NHESP is continuing to work closely with the proponent to establish appropriate monitoring and survey activities, as well as design specific sampling protocols. Preliminary data collected to date and over the course of the project implementation will assist in identifying opportunities for avoiding, minimizing, and mitigating impacts to state-listed species.

The NHESP looks forward to continued careful coordination with the proponent on the proposed project. We appreciate the opportunity to comment on this project. Please contact Eve Schlüter, Ph.D., Chief of

www.mass.gov/nhesp

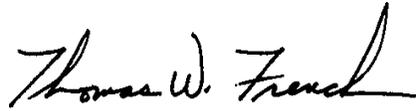
Division of Fisheries and Wildlife

Field Headquarters, 1 Rabbit Hill Road, Westborough, MA 01581 (508) 389-6300 Fax (508) 389-7890

An Agency of the Department of Fish and Game

Regulatory Review, of our office with any questions about this letter at (508) 389-6346 or eve.schluter@state.ma.us

Sincerely,

A handwritten signature in black ink that reads "Thomas W. French". The signature is written in a cursive, flowing style.

Thomas W. French, Ph.D.
Assistant Director

cc: Margo Fenn, Herring River Restoration Committee
George Price, Cape Cod National Seashore
Truro Board of Selectmen
Truro Conservation Commission
Truro Planning Board
Wellfleet Board of Selectmen
Wellfleet Conservation Commission
Wellfleet Planning Board
Heather McElroy, Cape Cod Commission
DEP Southeastern Regional Office, MEPA Coordinator

Herring River Restoration Project Habitat Management Plan for Phase One Project Activities

for

MA Natural Heritage and Endangered Species Program

Outline, DRAFT – October 2, 2018

1. Introduction
 - 1.1. Brief Phase One Project Description
 - 1.2. Purpose of Habitat Management Plan
 - 1.3. Integration with CCNS Natural Resource Management Program
 - 1.4. Habitat Management In Relation to Adaptive Management Plan
 - 1.4.1. Tidegate Management Policies
 - 1.4.2. Vegetation Management
 - 1.4.3. Marsh Management
2. Historic Habitat Conditions
 - 2.1. Ecological Setting Prior to Dike Construction
 - 2.2. Ecological Change Since 1909
3. Current Status of Listed Species
 - 3.1. Diamond-back terrapin
 - 3.1.1. Brief species description
 - 3.1.2. Preferred Habitat(s)
 - 3.1.3. Pre-restoration monitoring data
 - 3.1.3.1. Brennessel data?
 - 3.1.3.2. Wellfleet dredge project data?
 - 3.2. Eastern box turtle
 - 3.2.1. Brief species description
 - 3.2.2. Preferred Habitat(s)
 - 3.2.3. Pre-restoration monitoring data
 - 3.2.3.1. R. Cook Database (NPS)
 - 3.2.3.2. Oxbow data since 2015
 - 3.3. American Bittern
 - 3.3.1. Brief species description
 - 3.3.2. Preferred Habitat(s)
 - 3.3.3. Pre-restoration monitoring data
 - 3.3.3.1. Erwin et. alt. 2002
 - 3.3.3.2. MacDougall 2015
 - 3.3.3.3. Broker Observations

- 3.3.3.4. MASSBird Records
 - 3.4. Least Bittern; **treat bitterns separate or together?**
 - 3.4.1. Brief species description
 - 3.4.2. Pre-restoration monitoring data
 - 3.4.3. Status in Herring River
 - 3.4.3.1. Erwin et. alt. 2002
 - 3.4.3.2. MacDougall 2015
 - 3.4.3.3. Broker Observations
 - 3.4.3.4. MASSBird Records
 - 3.5. Northern Harrier
 - 3.5.1. Brief species description
 - 3.5.2. Preferred Habitat(s)
 - 3.5.3. Pre-restoration monitoring data
 - 3.5.3.1. Byrne 2006
 - 3.5.3.2. Bowen 2006
 - 3.5.3.3. MacDougall 2015
 - 3.5.3.4. MASSBird Records
 - 3.6. Water Willow Stem-borer
 - 3.6.1. Brief species description
 - 3.6.2. Preferred Habitat(s)
 - 3.6.3. Pre-restoration monitoring data
 - 3.6.3.1. Mello 2006
 - 3.6.3.2. Mello 2015
 - 3.7. Northern Long-eared Bat
 - 3.7.1. Brief species description
 - 3.7.2. Preferred Habitat(s)
 - 3.7.3. Pre-restoration monitoring data
 - 3.7.3.1. SUNY-ESF Data?
- 4. Habitat Delineation for Each Species in Herring River (**habitat types based on SLAMM categories**)
 - 4.1. Diamond-back Terrapin: Marine Subtidal, Brackish Marsh, Low Salt Marsh, High Salt Marsh, Tidal Flat
 - 4.2. Eastern Box Turtle: Upland, Non-tidal Wooded Swamp, Scrub-Shrub Freshwater Wetland
 - 4.3. American and Least Bittern (nesting): Brackish Marsh, Tidal Fresh Emergent Marsh, Fresh Emergent Marsh; **is there enough overlap to treat these species together or should they be separate?**
 - 4.4. Northern Harrier (nesting): Tidal Fresh Emergent Marsh, Fresh Emergent Marsh
 - 4.5. Water Willow Stem-borer (Decodon): Non-tidal Wooded Swamp, Scrub-Shrub Freshwater Wetland
 - 4.6. Long-eared Bat: Non-tidal Wooded Swamp
- 5. GIS Analysis of NHESP Priority/Estimated Habitats Incrementally Restored to Tidal Marsh

- 5.1. SLAMM Derived Habitat Changes at Selected Restoration Increments
- 5.2. Implications of Tidegate Management Policies/Temporal Analysis
- 5.3. Vegetation Management
- 5.4. Marsh Management
- 5.5. Direct Impacts vs. Indirect Effects of Restored Tidal Habitat

- 6. Monitoring
 - 6.1. Species Monitoring During Adaptive Management Phase; **Each species to include methods, locations, time of year, frequency, and assessments occupied and unoccupied habitat**
 - 6.1.1. Diamond-back terrapin
 - 6.1.2. Eastern box turtle
 - 6.1.3. American bittern
 - 6.1.4. Least bittern; **treat bitterns together or separate?**
 - 6.1.5. Northern harrier
 - 6.1.6. Water willow stem-borer
 - 6.1.7. Northern long-eared bat
 - 6.2. Long-term Monitoring Regional: Population Trend/Context

- 7. Potential Habitat Management Actions to Minimize Adverse Effects
 - 7.1. Direct Construction Impacts
 - 7.1.1. Time of Year Restrictions
 - 7.1.2. Pre-construction "Sweeps" Prior to Activities in Designated Habitats
 - 7.1.3. Construction Practices That Minimize Ground Disturbance and Erosion
 - 7.2. Effects of Tidal Marsh Habitat Restoration
 - 7.2.1. Recognition That Any Agreed Upon Management Is Commensurate With Effects
 - 7.2.2. Threshold Effects Where Management May Be Appropriate
 - 7.2.3. Potential Management Practices
 - 7.2.3.1. Translocation of Decodon to Unoccupied Habitat
 - 7.2.3.2. Habitat Enhancement in Areas Outside Herring River Project Area
 - 7.2.3.3. Support for Increased Habitat Protection (i.e. **working with CYCC on voluntary land conservation**)
 - 7.2.3.4. Support for Species-focused Public Education and Outreach
 - 7.2.3.5. Support for Targeted Research, Long-term Monitoring

8.F Project Chronology

(See following pages)

Project Chronology

2005

August 2005

Cape Cod National Seashore (CCNS) and Town of Wellfleet Board of Selectmen entered into an MOU (MOU I) to review and summarize the scientific and technical information on the Herring River systems and study whether restoration of Herring River is feasible.

Pursuant to MOU I, the Wellfleet Board of Selectmen appointed the Herring River Technical Committee (HRTC) to carry out the feasibility study. HRTC included representatives of CCNS, MA Coastal Zone Management's (CZM) Wetlands Restoration Program, the Wellfleet Conservation/Health Agent, Wellfleet Open Space Committee, Wellfleet Shellfish Advisory Committee, Wellfleet Shellfish Constable, Wellfleet Herring Warden, Wellfleet Natural Resources Advisory Committee, the Chequessett Yacht and Country Club, the Truro Board of Selectmen, the US Fish & Wildlife Service (USFWS), the Natural Resources Conservation Service (NRCS), the Cape Cod Cooperative Extension Service, the National Oceanic and Atmospheric Administration's (NOAA) Restoration Center, the Barnstable County Health and Human Services Department, and the Chair of the Herring River Stakeholders Group.

A Herring River Stakeholders Group was appointed and charged with conveying public input about the restoration to the HRTC. The Group met separately and consisted of representatives of the towns, CCNS, potentially affected landowners, the shellfish/fishing community, the Cape Cod Mosquito Control Project, the MA Division of Marine Fisheries, the National Oceanic and Atmospheric Administration (NOAA) Restoration Center, and the Natural Resources Conservation Service (NRCS).

October 2005

The first HRTC and Stakeholders Group meetings were held on October 12, 2005. The HRTC held five additional meetings in 2005, including a joint meeting with the Stakeholders Group. The Stakeholders Group met three more times in 2005.

2006

January 2006

A Full Report of the HRTC was submitted to the Wellfleet Selectmen, finding that tidal restoration of the Herring River salt marsh is feasible and would provide substantial public benefits.

The HRTC met thirteen times throughout 2006 to continue work in developing the plan, including meetings with consultants, local stakeholders, property owners and local boards.

August 2006

A public informational meeting was held with landowners in or near the 100-year flood plain on August 21, 2006.

Members of the HRTC provided updates to the Wellfleet Non-resident Taxpayers Association and Wellfleet Conservation Trust.

September 2006

Members of HRTC provided an update to the Wellfleet Conservation Commission.

October 2006

Representatives of The Nature Conservancy were given a tour of the site by HRTC, MA Coastal Zone Management, NOAA, and local officials.

Senator Kennedy and Congressman Delahunt addressed restoration partners at the Herring River Dike on their efforts to obtain funding.

2007

HRTC met eight times in 2007 to continue technical work, including meetings with staff from NOAA, Cape Cod National Seashore, USFWS, Mass Natural Heritage and Endangered Species Program, local Departments of Public Works and project consultants.

March 5, 2007

Members of HRTC provided an update to the Cape Cod National Seashore Advisory Commission.

July 2007

The National Park Service committed funding to prepare the draft and final Environmental Impact Statement/Report (EIS/EIR).

Woods Hole Group was selected to undertake two-dimensional modeling with a grant from NOAA to the Town of Wellfleet.

August 13, 2007

HRTC met with Mill Creek abutters to discuss sensitivity of water supply wells.

October 2007

The HRTC completed the Herring River Conceptual Restoration Plan (CRP), which describes several possible ways to restore the estuary.

November 2007

MOU II was signed by CCNS, Truro and Wellfleet to accept the CRP and move forward with a detailed restoration plan. HRTC, having fulfilled its charge, was dissolved and the Herring River Restoration Committee (HRRC) was formed to develop the detailed restoration plan and oversee the environmental review process under the National and Massachusetts Environmental Policy Acts (NEPA and MEPA). Members include representatives of the Towns of Wellfleet and Truro, CCNS, USFWS, the MA Division of Ecological Restoration (MA DER), NOAA's Restoration Center and NRCS.

From 2008-2016 HRRC conducted monthly 1-2 daylong meetings to review technical studies and develop project plans for the environmental assessments.

2008

2008 – 2016

Representatives of the Project participated in and placed informational displays at Annual *State of Wellfleet Harbor* conferences.

June 2008

The MA Secretary of Environmental Affairs approved a Special Review Procedure to allow a coordinated environmental review process between federal and state agencies.

July 2008

On behalf of project partners, HRRC submitted an Environmental Notification Form (ENF) to the MA Secretary of Energy and Environmental Affairs pursuant to the MA Environmental Policy Act, to determine whether the Project requires preparation of an Environmental Impact Report and, if so, specify the scope. A public comment session was opened until October 2008.

August and September 2008

Two public scoping sessions were held to explain the planning process and solicit public comments on the Project. Additional written comments (43 letters containing 288 separate comments) were submitted following the scoping sessions.

November 2008

MA Secretary of Environmental Affairs issued a Certificate on the ENF outlining the required scope for the Draft Environmental Impact Report, requiring evaluation of four different restoration alternatives, including no action.

November 2008

Friends of Herring River (FHR) was formed as a 501 (c)(3) non-profit organization dedicated to restoring the ecological integrity of the Herring River watershed.

2008-2012

Project partners contracted with the Woods Hole Group to develop a detailed hydrodynamic model of the Herring River estuary. The Final Woods Hole Group Modeling Report was delivered to HRRC in 2012 and its findings incorporated into the Draft EIS/EIR.

2009 - 2013

August 18, 2009

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a presentation by members of the HRRC on the progress of the joint state/federal Environmental Review Process. Each member explained their agency's role and presented information on the National Environmental Policy Act (NEPA) and the Massachusetts Environmental Policy Act (MEPA) processes. A demonstration was provided on the hydrodynamic model showing sample tidal effects in the estuary.

August 18, 2010

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a presentation by a HRRC member on alternatives to return a tidal flow to the river.

August 16, 2011

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a presentation detailing the benefits of the Herring River restoration to the community, water quality, and health of Wellfleet Harbor and Cape Cod Bay. A panel of HRRC members participated in a question and answer session.

August 21, 2012

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a presentation of the historical, environmental, and cultural impact of the Herring River on Bound Brook Island and the vibrant community that once existed there.

October 2012

The Draft EIS/EIR was released; a 60-day public comment period commenced. HRRC sent a letter to all private landowners who abut the Herring River estuary prior to the hearing, describing the Project and potential impacts to private properties, and inviting landowners to contact the HRRC for further information.

November 2012

MEPA and the Cape Cod Commission held a public hearing in Wellfleet on the DEIS/EIR. Over 100 people attended and 43 pieces of correspondence with 161 separate comments were received following the hearing.

2013

NOAA awarded a three-year grant of \$3 million to FHR to prepare design/engineering plans and conduct scientific analyses for the Herring River Restoration Project.

2012-2016

HRRC and FHR contracted with Woods Hole Group for additional hydrodynamic and sediment modeling, and contracted with the Louis Berger Group to develop survey plans and engineering designs for structurally affected private properties.

HRRC and FHR contacted, and in many instances met directly with, over 100 property owners to discuss their questions and concerns about the project and to seek permission for survey work on specific properties. This work is on-going.

August 2013

The FHR Annual Meeting at Wellfleet Council of Aging included a presentation on project plans and a presentation by Bill Burke, the Cape Cod National Seashore Historian about the history of the Herring River Estuary and nearby uplands based on a recently compiled park service archeological report.

2014

2014-2017

The Consensus Building Institute facilitated discussions between HRRC and Chequessett Yacht and Country Club (CYCC) to enable restoration of the Herring River ecosystem, including Mill Creek, while providing necessary flood protection for CYCC's golf facilities. The Project funded surveys, engineering, land planning and appraisals needed to develop a golf course protection plan for CYCC.

August 2014

The FHR Annual Meeting at Wellfleet Council of Aging featured a presentation on the Conceptual Design for Chequessett Neck Road Dike.

October 2014

MA Executive Office of Energy and Environmental Affairs awarded the first of a series of grants to FHR for Project design and engineering and environmental assessments.

October 2014 and November 2015

The U.S. Geological Survey (USGS) Adaptive Management Team held two stakeholders meetings to explain the adaptive management process for the Restoration Project and engage stakeholders in developing the adaptive management plan.

2015

February 4, 12 and 25, 2015

Public forums on roadway alternation for the Herring River Restoration Project were held in Wellfleet (Low roads and High Toss Road).

June 2 and 24, 2015

Public forums on Low-lying roadway alterations for the Herring River Restoration Project were held in Wellfleet (Low roads and High Toss Road).

August 18, 2015

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a presentation by the Association to Preserve Cape Cod; a look at river herring experience in the estuary by the Wellfleet Herring warden; a report on changes to Chequessett Neck Road Bridge Plans, including kayak portage access provisions in response to public comments solicited during public meetings; and planned funding.

October 22, 29 and November 5, 2015

The Herring River – a journey through history from our past to the present seminar series was presented at the Wellfleet Public Library.

2016

February 11, 2016

A public meeting on High Toss Road marsh crossing was held in Wellfleet.

March 2016

The Wellfleet Board of Selectmen received additional comments on High Toss Road marsh crossing.

April 14, 2016

FHR held a public informational meeting in Wellfleet prior to the Annual Town Meeting. The plan for removing High Toss Road was overwhelmingly approved by a vote of the Town Meeting.

June 2016

The Final EIS/EIR was published in the Federal Register and the Massachusetts Environmental Monitor.

The Cape Cod Commission held a Joint Review hearing with the Massachusetts Environmental Policy Act Unit to review the Final EIS/EIR. More than 100 people attended the hearing and 12 comment letters were submitted following the hearing.

July 2016

The MA Secretary of Energy and Environmental Affairs issued a Certificate on the Final Environmental Report (FEIR) finding that it adequately and properly complies with MEPA, and establishing a new Regulatory Oversight Group (ROG) for the Project.

July – August 2016

FHR hosted a summer program series at Wellfleet Public Library to explore facets of the restoration project including: Herring River Tidal Restoration Effects: Current and planned monitoring projects; Salt Meets Fresh: Tidal seawater, fresh groundwater, and the Herring River restoration; Tidal Water: A History of Wellfleet's Herring River; horseshoe crab research; and marsh birds of Herring River.

August 2016

Cape Cod Commission opened a public hearing (procedural only) on the Herring River Restoration Project as a Development of Regional Impact. This public hearing was continued.

August 16, 2016

The FHR Annual Meeting at Wellfleet Council on Aging facility featured a project update, announcement of the publication of a book on the history of Herring River, a summary of current conditions and rationale for restoration including social, economic and ecological benefits.

September 2016

The Record of Decision on the Final EIS/EIR was signed by the National Park Service Northeast Regional Director.

September 2016

MOU III was executed by Wellfleet and Truro Boards of Selectmen and the NPS Northeast Regional Director, setting forth the management structure for the next phase of the Restoration Project. MOU III called for the creation of the Herring River Executive Council (HREC) to provide Project policy direction and coordinate Project implementation.

2017

The HREC met four times in 2017 (January 9, March 9, June 7 and September 25). During this time the HREC appointed the Herring River Stakeholder Group. (HRSG) to provide advisory input on key implementation issues. The HRSG consists of nineteen members representing broad interests in the community: shellfish/fisheries, conservation/environmental protection, flood plain property owners, businesses, navigation, recreation, mosquito control, and the Cape Cod National Seashore Advisory Commission.

The HRRC continued monthly meetings to advance project design and permitting activities.

The ROG will meet in January to review permitting issues.

February 2017

A briefing for Senator Cyr and Representative Peake was held at the Friends of Herring River office.

March 2017

The Friends of Herring River and Wellfleet Shellfish Advisory Board hosted a forum on the science behind the benefits of tidal restoration for shellfish resources.

The Herring River Restoration Committee (HRRC) made a recommendation to the Herring River Executive Council (HREC) that the permit applications seeking authorization to implement the Restoration Project not include the use of any herbicides in the Herring River Restoration Project area. These permit applications will specify other non-chemical methods of *Phragmites* control. The HREC unanimously supported this recommendation.

The newly designed Friends of Herring River website was launched, including up to date information about meetings held by the HRRC, HREC and HRSG, and also new reports and public informational materials.

April 2017

Wellfleet Town Meeting rejected one petitioned warrant article which sought to stop permit applications for improving Herring River, and indefinitely postponed another article with a similar purpose.

Truro Town Meeting rejected a petitioned warrant article which sought to stop permit applications for improving Herring River.

A public presentation on the Herring River Restoration Project was held in the Truro Town Hall.

A new project brochure was mailed to all households in Truro and Wellfleet.

May 2017

The HRRC and Chequessett Yacht & Country Club (CYCC) executed a memorandum of understanding (MOU) to advance the Herring River Restoration Project. The MOU spells out the flood protection measures the project will provide to CYCC before tidal flow is partially restored in the Mill Creek sub-basin.

June – August

The Friends of Herring River sponsored monthly summer field trips to explain the effects of tidal restoration and restriction.

In August, the Friends of Herring River Annual Meeting featured a presentation on “Blue Carbon” the carbon storage benefits of salt marsh restoration.

November - December

Friends of Herring River published a newsletter explaining Phase 1 of the project, which was mailed to all households and businesses in Truro and Wellfleet. Individual letters were sent with the newsletter to all 300+ property owners in the Herring River flood plain.

2018

The HRRC continued monthly meetings to advance project design and permitting activities.

March 2018

The Friends of Herring River co-sponsored a forum on monitoring to protect shellfish resources with the Wellfleet Shellfish Advisory Board.

The Friends of Herring River co-sponsored a forum on Blue Carbon, the carbon storage benefits of salt marsh restoration with Climate Mobilization Outer Cape Mobilization.

A new video entitled *Herring River Estuary: Restoring and Ecological Treasure* was released and premiered at the Cape Cod Natural History Conference.

May 2018

The Friends of Herring River co-sponsored a forum on wildlife in Herring River and habitat changes resulting from restoration with the Wellfleet Conservation Trust, Wellfleet Natural Resources Advisory Board, Wellfleet Bay Wildlife Sanctuary.

The HREC met on May 16 to launch the HRSG.

The HRSG held its first meeting on June 21st. The HRSG met again on July 25th, and October 11th.

July – August 2018

The Friends of Herring River sponsored monthly summer field trips to explain the effects of tidal restoration and restriction.

September 2018

Friends of Herring River celebrates 10th anniversary annual meeting. Guest speakers include Senator Julian Cyr, Superintendent Brian Carlstrom, and Massachusetts Division of Ecological Restoration Assistant Director Hunt Durey.

December 2018

Truro Board of Selectmen vote to remove Truro as project partner.

2018

January 2019

Town of Wellfleet files an application with the Cape Cod Commission for a Limited Scope Decision.

March 2019

March 7, 2019, public hearing on Limited Scope application before the Cape Cod Commission Regulatory Subcommittee. Following the public hearing the subcommittee voted unanimously to ratify the proposed Limited Scope Decision. The decision was issued March 7, 2019.

June 2019

Herring River Stakeholder Group meets.

A fourth Memorandum of Understanding (MOU IV) is signed by the Town of Wellfleet and Cape Cod National Seashore. MOU IV becomes the new governing document for project implementation.

July-August 2019

A newsletter containing updated project information is mailed to all households and homeowners in Wellfleet and Truro.

Friends of Herring River Board members meet with various neighborhood associations and civic groups to update them about the project.

September 2019

Town of Wellfleet submits Development of Regional Impact application to the Cape Cod Commission.

8.G Support Letters

(See following pages)

Hon. Julian Cyr, Senator and Hon. Sarah Peake, Representative

Wellfleet Shellfish Advisory Board

Wellfleet Open Space Committee

Wellfleet Natural Resources Advisory Board

Dennis O'Connell, Wellfleet Conservation Trust

Andrew Gottlieb, Association to Preserve Cape Cod

John J. Clarke, Massachusetts Audubon

Richard Delaney, Center for Coastal Studies

Wayne Klockner, The Nature Conservancy

Great Pastures Homeowners Association, Wellfleet

Gail Ferguson, Wellfleet

The Cumblers, Wellfleet



THE GENERAL COURT OF MASSACHUSETTS
STATE HOUSE, BOSTON 02133-1053

Superintendent Brian Carlstrom
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Wellfleet Select Board
300 Main Street
Wellfleet, MA 02667

September 16, 2019

Re: Support of the Herring River Restoration Project

Dear Superintendent and Select Board Members,

Over the past decade, the Herring River restoration has grown from a visionary idea, to a carefully planned and rigorously designed project. It embodies the goals of resiliency, stewardship, and partnership that are vital to our region's – and the Commonwealth's future.

We are pleased to reaffirm our strong support for this regionally significant project as it embarks on a new phase of permitting and fundraising necessary for implementation.

The return of tidal flow to Herring River would restore approximately 1,000 acres of tidal marsh and numerous ecosystem services these resources provide. Healthy salt marshes and other forms of estuarine wetlands provide critical habitat for a wide variety of birds and wildlife; and serve as nurseries for fish and shellfish. Estuarine habitats are more resilient to coastal flooding; and they help to filter nutrients and other pollutants from run-off and rainfall before they enter the estuary.

Healthy tidal marshes also play a key role in combating climate change. Preliminary estimates based on current science indicate that restoration of salt marsh in the Herring River would result in a substantial reduction in the net volume of greenhouse gases released into the atmosphere.

A collaboration of local state and federal partners has been central to the project's success. This partnership has enabled the project to benefit from vast technical knowledge and experience while ensuring that decisions about project design and implementation remain local and responsive to community needs.

As residents of the Outer Cape, we have a deep appreciation of the link between the health of our coastal environment to the economic opportunities and quality of life in our communities.

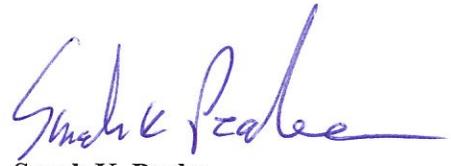
The Herring River Restoration stands out as one of the most significant projects of its time in the Northeast. It exemplifies the exciting potential of the emerging Blue Economy on Cape Cod, by utilizing modeling and management techniques that are at the leading edge of coastal restoration science. The example set by and the lessons learned from the successful Herring River coastal restoration project will benefit other estuaries on Cape Cod and beyond.

For all of these reasons we believe that the Herring River Restoration is a rare and significant opportunity to restore a native ecosystem and the many environmental and economic benefits it provides to our communities, the region and the Commonwealth.

Sincerely,



Julian Cyr
State Senator
Cape and Islands District



Sarah K. Peake
State Representative
4th Barnstable District

Cc:
Congressman William Keating
Senator Elizabeth Warren
Senator Edward Markey
Friends of Herring River



TOWN OF WELLFLEET

300 MAIN STREET WELLFLEET MASSACHUSETTS 02667

Tel (508) 349-0300 Fax (508) 349-0305

www.wellfleet-ma.gov

To: The Wellfleet Selectboard
Brian Carlstrom, Superintendent, Cape Cod National Seashore

October 10, 2019

Cc: Congressman William Keating
Senator Julian Cyr
Senator Elizabeth Warren
Senator Edward Markey
Representative Sarah Peake
Friends of Herring River

From: The Wellfleet Shellfish Advisory Board

Dear Superintendent Carlstrom, and members of the Wellfleet Selectboard:

The Wellfleet shellfish Advisory Board at its October 9, 2019 meeting voted unanimously to convey our continued support for the Herring River restoration project as originally conveyed in a letter dated June 19, 2017. Since that time, the makeup of our board has undergone some changes, and we felt it was time to restate our strong support for the project. All in all, there have been over 100 meetings regarding this project including public meetings, and one-on-one individual meetings with private landowners, as well as in other public venues in Wellfleet and Truro. We still believe that restoring controlled tidal flow in line with current science, and closer to a flow rate that existed before installation of the Chequessett Neck Road tide gate will benefit those in the shellfishing community, the residents of Wellfleet, and those species of anadromous fish that use the Herring River estuary to spawn each year. Ever since the original structure was installed over 100 years ago, shellfishing has suffered in the area adjacent to the tide gate due to high levels of fecal coliform present resulting from restricted tidal flushing. Improving the amount of water flowing upstream and downstream of the new dike will surely be of great service towards improving water quality to provide for the needs of the shellfish, anadromous fish and wildlife native to the area.

In an era when going GREEN has become all the rage, and climate change is an increasingly apparent threat, it is of particular concern to our board - for the obvious reasons associated with changes in sea level, ocean temperature and acidification, to do anything that would help slow the effects of a changing climate to maintain our robust shellfishing resource. One of the ancillary benefits of salt marsh restoration is in reducing methane emissions (a major contributor in climate change) as outlined in a University of Chicago [Marine Biological Laboratory](#) report. In it is a detailed [scientific report](#) which considers "The benefits of Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention". That report could have been written with the Herring River in mind. The Herring River estuary could indeed become a shining example of a successful salt marsh restoration by reversing the negative consequences of blocking tidal flow all those years ago.

Please move forward as previously requested in obtaining the necessary permits for the timely construction of a new dike at Chequessett Neck Road. Our board looks forward to seeing a new and improved structure completed within the next 5 years.

Sincerely,



John Duane - on behalf of:

The Wellfleet Shellfish Advisory Board

Dave Seitler - Chair, Chip Benton, Zack Dixon, John Duane
Jacob Puffer, Tom Siggia, Rebecca Taylor

Town of Wellfleet Selectboard

Brian Carlstrom, Superintendent, Cape Cod National Seashore

The Wellfleet Open Space Committee is a town committee dedicated to land protection for the benefit of conservation, recreation, and natural resource protection. At our meeting on October 8, 2019 the Committee voted to send this letter of support for the Herring River Restoration Project. The timing of this is to ensure ongoing support for the project as it moves forward with permit applications and fundraising.

The Herring River Restoration Project is an unmatched opportunity to restore 1,000 acres of estuarine marsh, and the many ecosystem services that marshes provide to the environment and greater community. These services include enhancements to habitat for a wide range of animals, birds and aquatic life. A healthy marsh also helps to mitigate flooding from storms, and filter pollutants from run-off before they reach estuarine waters. We are also impressed with the potential for a healthy Herring River marsh system to absorb carbon and reduce existing methane emissions, which in combination will help to combat the effects of climate change.

As a committee dedicated to preserving the natural environment for the benefit of the Wellfleet community, we see tremendous benefit in the enhanced recreational opportunities afforded by restoring six miles of river way for canoeing, kayaking and fishing. Improvements to water quality from restoration of tidal flushing will reduce fecal coliform concentrations in the river, which are now contaminating shellfish beds downstream of the Chequessett Neck Road Dike. Improved water quality resulting from the restoration is expected to lead to the re-opening of shellfish beds downstream of Herring River which have been closed for decades, and could help to revitalize local river herring populations.

Restoring Herring River will bring significant benefits to our community and environment, and will serve as a model for coastal restoration elsewhere on Cape Cod, and beyond. The Wellfleet Open Space Committee strongly supports the Herring River Restoration Project.

Sincerely,

Bruce Hurter, Chairman Wellfleet Open Space Committee

cc: Senator Elizabeth Warren
Senator Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River

NATURAL RESOURCES ADVISORY BOARD

Wellfleet, Massachusetts

300 Main Street
Wellfleet, MA, 02667

Wellfleet Board of Selectmen
Wellfleet Town Hall
300 Main Street
Wellfleet, MA, 02667

October 14 2019

Brian Carlstrom, Superintendent
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA, 02667

Representing the Wellfleet Natural Resources Advisory Board (NRAB), I am writing to express our continued strong support for the Herring River Restoration Project.

NRAB has long been an advocate for restoration of the Herring River estuary. Salt marsh protection was a priority in both Harbor Management Plans (HMP) submitted to the Board of Selectmen/Wellfleet in 1995 and 2006. Both reports are on the Town website, under NRAB. The recommendation to restore the Herring River was a top priority in the 2006 HMP.

The Herring River today is in poor health due to more than a century of tidal restriction caused by the construction of the Chequessett Neck Road dike. Tidal restriction has caused poor water quality, loss of salt marsh, degradation of habitat, and contamination of shellfish beds downstream of the dike in Wellfleet Harbor. These conditions will continue as long as the existing Chequessett Neck Road dike remains in place.

The Towns of Wellfleet and Truro with the Cape Cod National Seashore had the foresight to develop a restoration plan to reverse these degraded conditions.

The Herring River Restoration Project will result in significant improvements in water quality, fisheries and wildlife habitat, and the overwhelming benefits these resources provide to the community and the region.

- Roughly 1,000 acres of salt marsh and other estuarine wetlands—and the habitat and food sources they provide—will be restored;
- Expanded habitat for many species of birds, mammals and reptiles—including rare species—that thrive in salt/brackish marsh;
- 11+ river miles for fish passage will be restored, along with access to 160 pond acres

- for spawning.
- Water quality will improve in Herring River and Wellfleet Harbor, to the benefit of residents, shellfishermen, and visitors;
 - Restored salt marsh will enhance the ability to adapt to sea level rise;
 - Recreational access to 6 miles of waterways will be restored;
 - Restoration of healthy salt marsh will capture carbon and reduce methane, resulting in a substantial reduction of the net volume of greenhouse gases released to the atmosphere.
 - The existing Chequessett Neck Road dike, which is no longer functioning to control tidal flow, will be replaced with a state-of-the-art tide control structure, which can be used to limit any storm surge in the estuary.

The Herring River Restoration Project is the result of scientific study and extensive community discussions. Changes in tide levels will be made incrementally, while carefully modeling and monitoring of system responses will allow the project to adjust the rate of change and take other management actions to achieve the benefits of restoration while avoiding or minimizing unintended outcomes.

In particular, as Wellfleet is a shellfishing town the project managers have made an especial effort to keep the shellfish community informed on the project and the planned restoration process.

The Herring River Restoration Project will restore the health of a unique and environmentally significant resource for the benefit of the community today and for years to come.

Sincerely,

John Riehl

John Riehl,
Chair, Natural Resources Advisory Board

Cc:

Senators Elizabeth Warren and Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River

NATURAL RESOURCES ADVISORY BOARD

Wellfleet, Massachusetts

300 Main Street
Wellfleet, MA, 02667

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Wellfleet Town Hall
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99 Marconi Site Road
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Sincerely,

John Riehl

John Riehl,
Chair, Natural Resources Advisory Board

Cc:

Senators Elizabeth Warren and Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River



September 4, 2019

Town of Wellfleet Selectboard
Superintendent, Cape Cod National Seashore
- by electronic delivery-

Dear Selectboard Members and Superintendent:

The Board of Trustees of the Wellfleet Conservation Trust (WCT) wishes to demonstrate our support for the progress made by the **Herring River Restoration Project** and to support the plans to continue to evaluate and proceed as the project goes into the permitting and funding phases.

This Board has been continuously aware of the progress of the HR Restoration Project for more than 10 years. In fact, WCT funded the first widely distributed information sheet during the early evaluation period, before the Friends of Herring River was formed and funded. Also, we own several parcels of land within the anticipated flood zone of the project.

We have been impressed with the efforts for transparency, for public awareness, and, especially for the degree of scientific research that has gone into the development of restoration plans. Also, we are impressed by the opportunities to improve the environmental conditions and water quality of the estuary and of the Harbor. We have great confidence in the leadership structure that has evolved. We believe that the leadership team will continue its practice of understanding all aspects of the project and will do what is best for the citizens of the Towns of Wellfleet and the interests of the Cape Cod National Seashore, taking into consideration all those who are impacted by the project.

We urge continuing efforts to progress this project through the permitting and funding stages.

Sincerely,



THE GENERAL COURT OF MASSACHUSETTS
STATE HOUSE, BOSTON 02133-1053

Superintendent Brian Carlstrom
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Wellfleet Select Board
300 Main Street
Wellfleet, MA 02667

September 16, 2019

Re: Support of the Herring River Restoration Project

Dear Superintendent and Select Board Members,

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We are pleased to reaffirm our strong support for this regionally significant project as it embarks on a new phase of permitting and fundraising necessary for implementation.

The return of tidal flow to Herring River would restore approximately 1,000 acres of tidal marsh and numerous ecosystem services these resources provide. Healthy salt marshes and other forms of estuarine wetlands provide critical habitat for a wide variety of birds and wildlife; and serve as nurseries for fish and shellfish. Estuarine habitats are more resilient to coastal flooding; and they help to filter nutrients and other pollutants from run-off and rainfall before they enter the estuary.

Healthy tidal marshes also play a key role in combating climate change. Preliminary estimates based on current science indicate that restoration of salt marsh in the Herring River would result in a substantial reduction in the net volume of greenhouse gases released into the atmosphere.

A collaboration of local state and federal partners has been central to the project's success. This partnership has enabled the project to benefit from vast technical knowledge and experience while ensuring that decisions about project design and implementation remain local and responsive to community needs.

As residents of the Outer Cape, we have a deep appreciation of the link between the health of our coastal environment to the economic opportunities and quality of life in our communities.

R. Dennis O'Connell

R. Dennis O'Connell, President

cc: Senator Edward Markey,
Senator Elizabeth Warren,
Congressman William Keating,
Senator Julian Cyr,
Representative Sarah Peake, and
The Friends of Herring River



October 1, 2019

Andrew Gottlieb
Executive Director

Town of Wellfleet Board of Selectmen
Brian Carlstrom, Superintendent, Cape Cod National Seashore

BOARD OF DIRECTORS

RE: Herring River Restoration Letter of Support

Margo Fenn
President

The Association to Preserve Cape Cod (APCC) writes to express our strong support for the Herring River Restoration Project in Wellfleet.

Charles Sumner
Vice President

Bob Ciolek
Treasurer

Founded in 1968, APCC is the Cape Cod region’s leading nonprofit environmental advocacy and education organization. Representing thousands of members across Cape Cod, APCC’s mission is to promote policies and programs that foster the preservation of the Cape’s natural resources. APCC focuses its efforts on the protection of groundwater, surface water, and wetland resources, preservation of open space, the promotion of responsible, planned growth and the achievement of an environmental ethic.

Maureen O’Shea
Clerk

Michael Corrigan

DeeDee Holt

Thomas Huettner

One of APCC’s major program areas involves promoting and assisting in salt marsh restoration efforts on Cape Cod, and with good reason. Cape Cod has experienced a critical loss of salt marsh habitat. More than 7,000 acres—or 38 percent—of our salt marshes on Cape Cod have been lost or destroyed due to damming, dredging, filling, ditching and other human development activities.

Pat Hughes

Cheryl Lubin

Elysse Magnotto-Cleary

The loss of salt marshes also means the loss of the many valuable ecosystem functions they provide. For example:

Blue Magruder

Eliza McClennen

Stephen Mealy

- It is estimated that 75 percent of our commercially important fish and shellfish species depend on salt marsh habitat at some point in their life cycles for nurseries and as a source of food.
- Salt marshes attenuate storm flooding and provide a buffer against storm surges.
- Salt marshes filter pollutants from runoff and groundwater before they enter our estuaries.

Kris Ramsay

Robert Summersgill

Taryn Wilson

In addition, we are beginning to understand the significant role salt marshes play in mitigating the effects of climate change. Research shows that salt marshes are able to store more carbon per acre than tropical rain forests.

The Herring River Restoration Project has the potential to restore nearly 1,000 acres of salt marsh, reclaiming a substantial percentage of salt marsh habitat previously lost on

Cape Cod. It is a high priority restoration project for the Cape Cod National Seashore, the town of Wellfleet and many partner agencies and organizations. It has also been a priority project for APCC for many decades; APCC was one of the first voices calling for restoration of the Herring River in the 1970s.

The restoration project will significantly improve habitat for a wide variety of wildlife species that thrive in salt and brackish marsh environments. Salt marshes are among the most productive ecosystems on the planet and provide food, shelter, nesting sites and migratory habitat for many species of birds, mammals and reptiles. Restoring tides to the Herring River will enhance the quality and quantity of these resources and improve their resiliency in the face of increased threats by sea level rise and land-based pollution and encroachment.

By restoring twice-daily flushing with clean, high-salinity Cape Cod Bay water, the project will improve water quality, especially near the Herring River mouth, resulting in the likely re-opening and expansion of more than 100 acres of harvestable oyster beds.

The restoration will also restore several miles of river for fish passage as well as access to 160 pond acres for spawning. By providing improved fish passage, improved water quality and expanded habitat, the project will benefit all species of anadromous and catadromous fish, including river herring (alewife and blueback herring), hickory shad, white perch and American eel.

Technical direction for the project has come from a partnership of local, state and federal agencies in consultation with leading estuarine scientists from public, private and university sectors to ensure that the work is founded on a current and peer-reviewed knowledge base. Thanks to an ongoing commitment to public outreach and education on the part of project partners, the project has gained strong local and regional support, and is poised for successful permitting, funding and implementation.

For all the reasons cited above, APCC pledges its continued support of this critically important project to ensure that the full potential of the Herring River restoration is achieved.

Sincerely,



Andrew Gottlieb
Executive Director

cc: Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River



Six Beacon Street, Suite 1025, Boston, MA 02108
617-523-8448 jclarke@massaudubon.org

October 7, 2019

Brian Carlstrom
Superintendent
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Wellfleet Selectboard
300 Main Street
Wellfleet, MA 02667

Re: Herring River Restoration project

Dear Mr. Carlstrom and Wellfleet Selectboard,

On behalf of Mass Audubon, I submit the following letter of support for the Herring River Restoration project. Mass Audubon has a long-held interest in the restoration of the Herring River and has commented numerous times during the project review process. We continue to be strongly supportive of this project because of the important local benefits it will generate, and because it serves as a model for restoring other estuaries along Massachusetts' and America's coast.

The project will return tidal flow to the 1,000-acre Herring River estuary by replacing the Chequessett Neck Road dike with a new bridge with tide gates. This will reverse the loss of hundreds of acres of salt marsh habitat that has occurred over the past 100 years. Salt marshes provide food, shelter, nesting sites, and migratory habitat for many species of birds, including wintering Black Ducks, state-listed Clapper Rail, and Least Bittern. They restore foraging habitat and open new nesting areas for the state-listed diamondback terrapin at the north edge of its range. The project will also restore nursery habitat for the greatly reduced populations of horseshoe crabs in the Wellfleet harbor system and that spawn on nearby Great Island

Restoring tides to the Herring River will enhance the quality and quantity of these resources and improve their resiliency in the face of sea level rise and projected increased storm activity along the coast.

This project will restore natural tidal flow to the Herring River, reversing the damage that has occurred since 1909 when the installation of the dike blocked tides that had carried oxygen-rich ocean waters into the Herring River system.

By restoring twice-daily flushing with clean, high-salinity Cape Cod Bay water, the Project will improve water quality and increase the flow of nutrients into Wellfleet Harbor, fueling shellfish growth and an increase in harvestable oyster beds. The restoration will allow for fish passage and improvements to habitat for species including Osprey and Common and Roseate Terns, and increase forage fish plankton which will improve striped bass and bluefish feeding opportunities. By restoring healthy coastal wetlands, the project will also enhance climate change resiliency against impacts like sea level rise by acting as a natural floodplain.

Restoration of tidal flow will improve water quality and benefit shellfish habitat. A century of tidal restriction has resulted in high concentrations of fecal coliform bacteria in the River, which has led to shellfish closures in Wellfleet Harbor downstream of the Chequessett Neck Road dike. Restoration will reduce bacterial concentrations by flushing cleaner ocean water into Herring River twice daily and by increasing salinity levels in the River that reduce survival time of bacteria. The reduction in fecal coliform concentrations is expected to lead to the reopening of once-productive shellfish beds in Wellfleet Harbor.

Sincerely,



John J. Clarke
Director of Public Policy & Government Relations

cc: Senator Elizabeth Warren
Senator Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River



Center for Coastal Studies Provincetown

ADMINISTRATIVE OFFICES AND HIEBERT MARINE LABORATORY

5 Holway Avenue, Provincetown, MA 02657

tel (508) 487-3622/3623 fax (508) 487-4695

November 7, 2019

Board of Selectmen, Wellfleet
Superintendent Brian Carlstrom Cape Cod
National Seashore

Dear Mr. Murphy and Mr. Carlstrom:

The Center for Coastal Studies is dedicated to promoting stewardship of coastal and marine ecosystems in the Gulf of Maine, and to encouraging responsible use and conservation of these ecosystems. We carry out our work through scientific research, education, and collaboration with other institutions and individuals.

The Center's Seafloor Mapping Program worked closely with many partners both public and private (Cape Cod National Seashore, The Town of Wellfleet, Friends of Herring River and SPAT, Inc.), in funded and pro bono efforts, to better understand the current conditions of Herring River and the surrounding Harbor to improve estimates and/or projections of the potential impacts of tidal restoration on the entire system.

The Herring River Restoration Project is a model for restoring other estuaries in Massachusetts and America's coast. Reconnecting the Herring River to the Gulf of Maine will let it once again support the natural coastal food web that numerous fish, birds and other wildlife depend on for their survival. Restoring the estuary is an important step to help increase finfish and shellfish populations, revive the region's commercial and recreational fisheries and increase access for boaters.

The Project will use state-of-the art adaptive management techniques to introduce changes to the natural system carefully, while on-going modeling and monitoring of system responses takes place. This will provide opportunities to adjust the rate of change to achieve maximum restoration benefits while avoiding or minimizing any unintended changes.

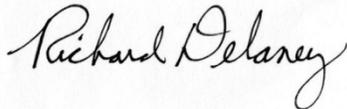
We are also encouraged by the Project's potential to expand the benefits of Blue Carbon on Cape Cod. The Center for Coastal Studies is a founding member of the Cape Cod Climate Change Collaborative, an organization formed to unite the varied expertise and experience of Cape Cod organizations to address the impacts of climate change. Tidal restoration of

Herring River will reduce methane emissions from the system as saltwater wetlands are re-established in place of freshwater wetlands.

Avoidance of methane emissions is particularly significant since it is known to be approximately 20 times more potent as a heat trapping gas in the atmosphere than carbon dioxide.

As scientists focused on the health of ocean resources, we often see degradation of marine resource go unaddressed, with devastating long-term consequences. The Herring River Restoration is a rare and important opportunity to reclaim the extensive ecosystem services provided by a healthy 1,000-acre estuary. It will be a living laboratory for future monitoring and research on estuarine restoration. We strongly support the project and offer our assistance to help in facilitating its implementation.

Sincerely

A handwritten signature in black ink that reads "Richard Delaney". The signature is written in a cursive style with a large, prominent 'R' and 'D'.

Richard F. Delaney, President and CEO
Center for Coastal Studies

cc:

Senator Elizabeth Warren
Senator Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sara Peake
Friends of Herring River

Wellfleet Board of Selectmen
Brian Carlstrom, Superintendent, Cape Cod National Seashore

October 11, 2019

Dear Selectmen of Wellfleet, and Superintendent Carlstrom,

I am writing to express The Nature Conservancy's strong support for the Herring River Restoration Project.

The Nature Conservancy is a global non-profit conservation organization whose mission is to "conserve the lands and waters on which all life depends." In Massachusetts, the Conservancy has protected some 23,000 acres of crucial natural resources, and TNC leads many science-based projects to keep nature healthy throughout the state. TNC proudly represents the ideals of 28,000 members in Massachusetts and more than one million members globally. We work using the best available science and in collaboration with individuals, local communities, businesses, public agencies, and other nonprofit groups.

Herring River today is in poor health due to more than a century of tidal restriction caused by the construction of the Chequessett Neck Road dike. Tidal restriction has resulted in poor water quality, loss of salt marsh, degradation of habitat, and contamination of shellfish beds downstream of the dike in Wellfleet Harbor. These conditions will continue as long as the existing Chequessett Neck Road dike remains in place.

Fortunately, the Town of Wellfleet and the Cape Cod National Seashore had the foresight to develop a restoration plan to reverse these degraded conditions. The Herring River Restoration Project will result in significant improvements in water quality, fisheries and wildlife habitat, and the overwhelming benefits these resources provide to the community and the region. These benefits for nature and people include:

- Roughly 1,000 acres of salt marsh and other estuarine wetlands—and the habitat and food sources they provide—will be restored;
- Expanded habitat for many species of birds, mammals and reptiles—including rare species—that thrive in salt/brackish marsh;
- 11+ river miles for fish passage will be restored, along with access to 160 acres of ponds for spawning;
- Water quality will improve in the Herring River and in Wellfleet Harbor, to the benefit of residents, shellfishermen, and visitors;
- Restored salt marsh will enhance coastal storm resiliency and the ability to adapt to sea level rise;
- Recreational access to 6 miles of waterways will be restored; and,

- Restoration of healthy salt marsh will capture carbon and reduce methane, resulting in a substantial reduction of the net volume of greenhouse gases released to the atmosphere.

The Herring River Restoration Project is the result of scientific study and extensive community discussions. Changes in tide levels will be made incrementally, while careful modeling and monitoring of system responses will allow the project's executors to adjust the rate of change and take other management actions to achieve the benefits of restoration while avoiding or minimizing unintended outcomes.

The Herring River Restoration Project will restore the health of a unique and environmentally significant resource for the benefit of the community today and for years to come.

Sincerely,



Wayne Klockner
State Director
Massachusetts Program
The Nature Conservancy

Cc:

Senator Elizabeth Warren
Senator Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River

Wellfleet Selectboard
Superintendent, Cape Cod National Seashore

September 9, 2019

As officers of the Great Pastures Property Owners Association we wish to express support for the Herring River Restoration Project.

Our organization is made up of several (50+) homeowners located in what is referred to in Wellfleet as Great Pastures. Some of our member's property abut the restoration estuary and all live in close proximity to it.

The Herring River today is in poor health due to more than a century of tidal restriction caused by the construction of the Chequessett Neck Road dike. Tidal restriction has caused poor water quality, loss of salt marsh, degradation of habitat, and contamination of shellfish beds up and downstream of the dike in Wellfleet Harbor. These conditions will continue and get worse as long as the existing Chequessett Neck Road dike remains in place.

Fortunately, the Town of Wellfleet and the Cape Cod National Seashore had the foresight to develop a restoration plan to reverse these degraded conditions.

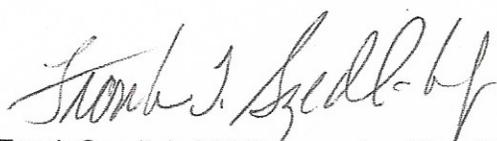
The Herring River Restoration Project will result in significant improvements in water quality, fisheries and wildlife habitat, and the overwhelming benefits these resources provide to the community including commercial entities and the region as a whole; some, but not all include:

- Restored salt marsh will enhance coastal storm resiliency and the ability to adapt to sea level rise;
- Expanded habitat for many species of birds, mammals and reptiles including rare species—that thrive in salt/brackish marsh;
- Water quality will improve in Herring River and Wellfleet Harbor, to the benefit of residents, shell fishermen, and visitors;
- 11+ river miles for fish passage will be restored, along with access to 160 pond acres for spawning;
- Roughly 1,000 acres of salt marsh and other estuarine wetlands-and the habitat and food sources they provide-will be restored;
- Restoration of healthy salt marsh will capture carbon and reduce methane, resulting in a substantial reduction of the net volume of greenhouse gases released to the atmosphere;
- Recreational access to 6 miles of waterways will be restored;
- The existing Chequessett Neck Road dike, which is no longer functioning to control tidal flow, will be replaced with a state-of-the-art tide control structure.

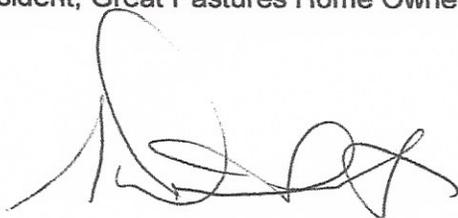
The Herring River Restoration Project is the result of years of scientific study and extensive community discussions. As part of this process changes in tide levels will be made incrementally, while carefully modeling and monitoring of system responses will allow the project to adjust the rate of change. This approach allows management actions to achieve the benefits of restoration while avoiding or minimizing unintended outcomes. The results of this action ensures that no property owners or others will be adversely effected.

The Herring River Restoration Project will restore the health of a unique and environmentally significant resource for the benefit of the community today and for years to come.

Sincerely,



Frank Szedlak 85 Highmeadow Road Wellfleet, Ma. 02667
President, Great Pastures Home Owners' Association



S. David Koonce Jr. 30 Highmeadow Road Wellfleet, Ma. 02667
Treasurer, Great Pastures Home Owners' Association

Cc: Senator Elizabeth Warren
Senator Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River

October 2, 2019

Wellfleet Selectboard; Superintendent, Cape Cod National Seashore

Subject: Letter of Support for the Herring River Restoration Project

Greetings,

I am writing to express my support for the Herring River Restoration Project. I am a resident of Wellfleet who owns real property at 112 West Main Street that is located in the southern most part of the Upper Pole Dike Basin, and within the historic Herring River flood plain.

In late 2012 I received a letter from the Town of Wellfleet notifying me that my property would experience increased water levels and increased regulation as a result of a proposed restoration of the Herring River. From that time until the present time, I have attended most, if not all, of the public hearings and informational meetings that have been held in Wellfleet concerning the restoration and its expected effects.

While I had long been a supporter of salt marsh restoration generally, I nevertheless had concerns about the impact of this particular project on my own property. My concerns, however, faded as I began to gain a sense of the high level of professional attention and expertise upon which the Herring River Project plans rested. As I followed the public hearings I came to understand that a very slow re-introduction of salt water would be carefully monitored throughout the restoration process, thereby enabling a quick response to any deviation from what earlier modeling had predicted. This adaptive approach, together with the mitigation actions that will be taken to protect private structures, eased my initial concerns about unexpected impacts to my own property.

As I am sure you know, it has been a long and complex journey for the proposed restoration. Following the publication of the Herring River Technical Committee's final report in 2007 (their, "Conceptual Restoration Plan") the Herring River project has slowly, but steadily, progressed to the point where the restoration is now poised to become a project in fact once the permitting process is finished and funding is in hand. When it is completed the Herring River Restoration project will be the largest restoration of a salt marsh in the Northeast region.

People who had been paying attention to local environmental matters have known for some time that Wellfleet erred when the town decided to restrict tidal flow into the Herring River in the early 1900's. Eventually the consequences of this tidal restriction became obvious to others, like myself, who live in, or close to, the historic flood plain.

During the approximately 30 years that I have owned my home on West Main Street I have observed a dead and dying landscape along the side of Pole Dike road (a continuation of West Main Street) in an area that was once a beautiful expanse of salt hay and a healthy spawning ground for several species of marine life. Now when I pass by this area I think of the day when oxygen rich tides are re-introduced, and the journey back to a healthy marsh has begun.

(And, as I have learned more about our changing climate I have come to understand that a healthy salt marsh will provide better protection from the higher tides and stronger storms that we now know we should expect.)

I once described the Herring River Restoration Project as our gift to future generations. More recently I have begun to think of it as an act of stepping up to the plate and doing the right thing. When it is completed I believe that it will be a model, as well as an inspiration, for other coastal communities.

Sincerely,

A handwritten signature in black ink that reads "Gail Ferguson". The signature is written in a cursive, flowing style.

Gail Ferguson
130 West Main Street
Wellfleet, MA 02667
gfergusonwellfleet@comcast.net

CC: Sen. Elizabeth Warren
Sen. Edward Markey
Congressman William Keating
Senator Julian Cyr
Representative Sarah Peake
Friends of Herring River

To: Wellfleet Select Board

From: The Cumblers

Concerning: The Herring River Restoration

As an environmentalist-a professor of environmental studies- and an abutter to the Herring River project, I have carefully looked at the science around the studies of the Herring River as it is now and am greatly concerned. The Herring River is in an advanced state of decline, acidification is increasing, the marsh is sinking, and the drainage from a degraded marsh is compromising shellfish beds. The restoration of the Herring River will dramatically reduce these negative impacts on the eco-system.

The restoration will also increase the herring run and limit the stress on the herring of dealing with highly acidic and polluted water as well as opening up more space for the herring to run thus reducing predation particularly in narrow culverts. The flushing of the Herring River will definitely support greater diversity of marine life, expand the nursery for juvenile fish and perhaps even become a spawning area for striped bass. Sand eels, a significant food source for striped bass and blue fish, will most likely recolonize the mouth of the river.

With restoration, the Herring River will become a significant destination for fishers from around the region. It will also provide an important destination for canoeists and kayakers. With the increasing concern over sharks at our beaches, a restored Herring River will provide an important alternative tourist attraction to town beaches.

We are full-time residents of Wellfleet who strongly support the restoration of the Herring River. We are also abutters on Mill Creek, which will, soon we hope, eventually be part of the restoration. We strongly urge the town to take whatever steps necessary to move this project forward. We have watched the Herring River degrade over the 30 years we have owned abutting property. As a recreational fisherman I have long advocated the opening up of the Herring River if for no other reason than to dramatically increase fishing potential in town.

This project is long overdue. As conservationists argued at the time (and the courts agreed), the dyke should never have been rebuilt 50 years ago. It is well past time we rectified that mistake. Please continue your support for the restoration project. Future generation of Wellfleetians will thank you.

The Cumblers

380 Old Chequessett Neck Rd

Wellfleet, MA 02667

8.H Design Plans

8.H.1 Project Elements

Chequessett Neck Road Bridge:

Herring River Restoration Project Chequessett Neck Road Bridge and Water Access Facility Construction. Permitting Drawing Set. June 2018; Revised November 12, 2019. Prepared by Fuss & O'Neill, Inc.

Pole Dike Road and other low-lying roads:

Herring River Restoration Project. Engineering Design to Elevate Low-Lying Roadways and Replace Associated Culverts. Permit Plans – Not for Construction. May 2019. Prepared by Louis Berger U.S. Inc.

High Toss Road Removal:

Herring River Restoration Project. High Toss Road Permit-Level Design Plans. June 30, 2017; Revised June 28, 2018. Prepared by ESS Group, Inc.

8.H.2 Mitigation

Herring River Restoration Project. Permit Plans for Low-Lying Property Impact Prevention. Miller-Frederiksen Property (695 Bound Brook Island Road). Permit Plans – Not For Construction. April 2018. Prepared by Louis Berger U.S. Inc.

Herring River Restoration Project. Chequessett Yacht and Country Club Reconfiguration Permit-Level Design Plans. DRAFT. September 13, 2019. Prepared by ESS Group, Inc.
(Note: An updated stamped plan set will be provided shortly to reflect a new haul road location)

8.H.3 Federal Structures on Federal Land

Mill Creek Water Control Structure:

Herring River Restoration Project Mill Creek Water Control Structure. Construction Project Permitting Drawing Set. June 2018. Prepared by Fuss & O'Neill, Inc.

Way 672 Tide Barrier:

Herring River Restoration Project. Way #672 Tidal Barrier Alternatives Assessment. Existing and Proposed Conditions. June 2019. Prepared by Fuss & O'Neill, Inc.
(Note: An updated plan set will be provided shortly for informational purposes)