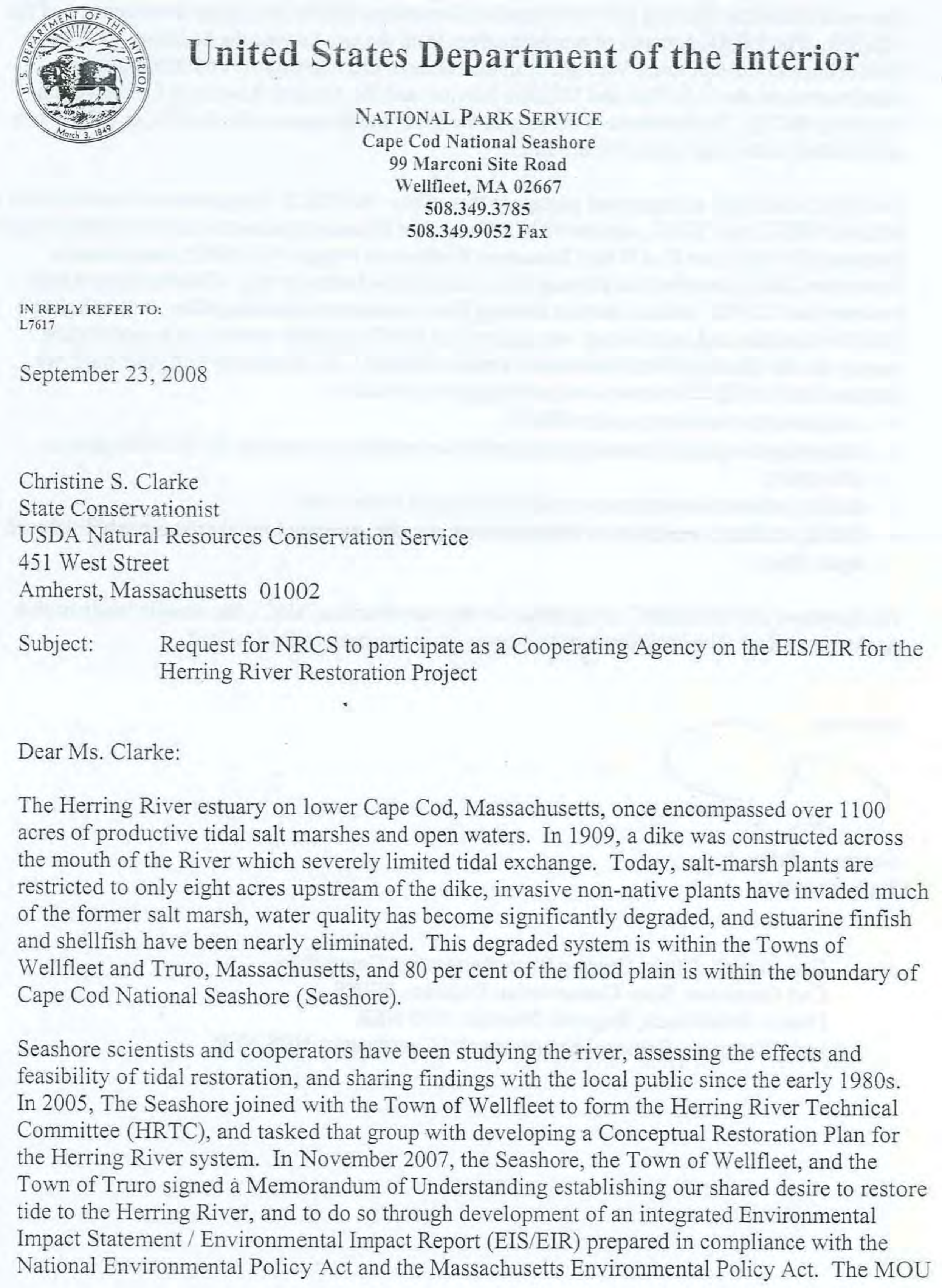
Appendices

APPENDIX A: SCOPING LETTERS AND RESPONSES

COOPERATING AGENCY CORRESPONDENCE



United States Department of the Interior

NATIONAL PARK SERVICE
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
508.349.3785
508.349.9052 Fax

IN REPLY REFER TO:
L7617

September 23, 2008

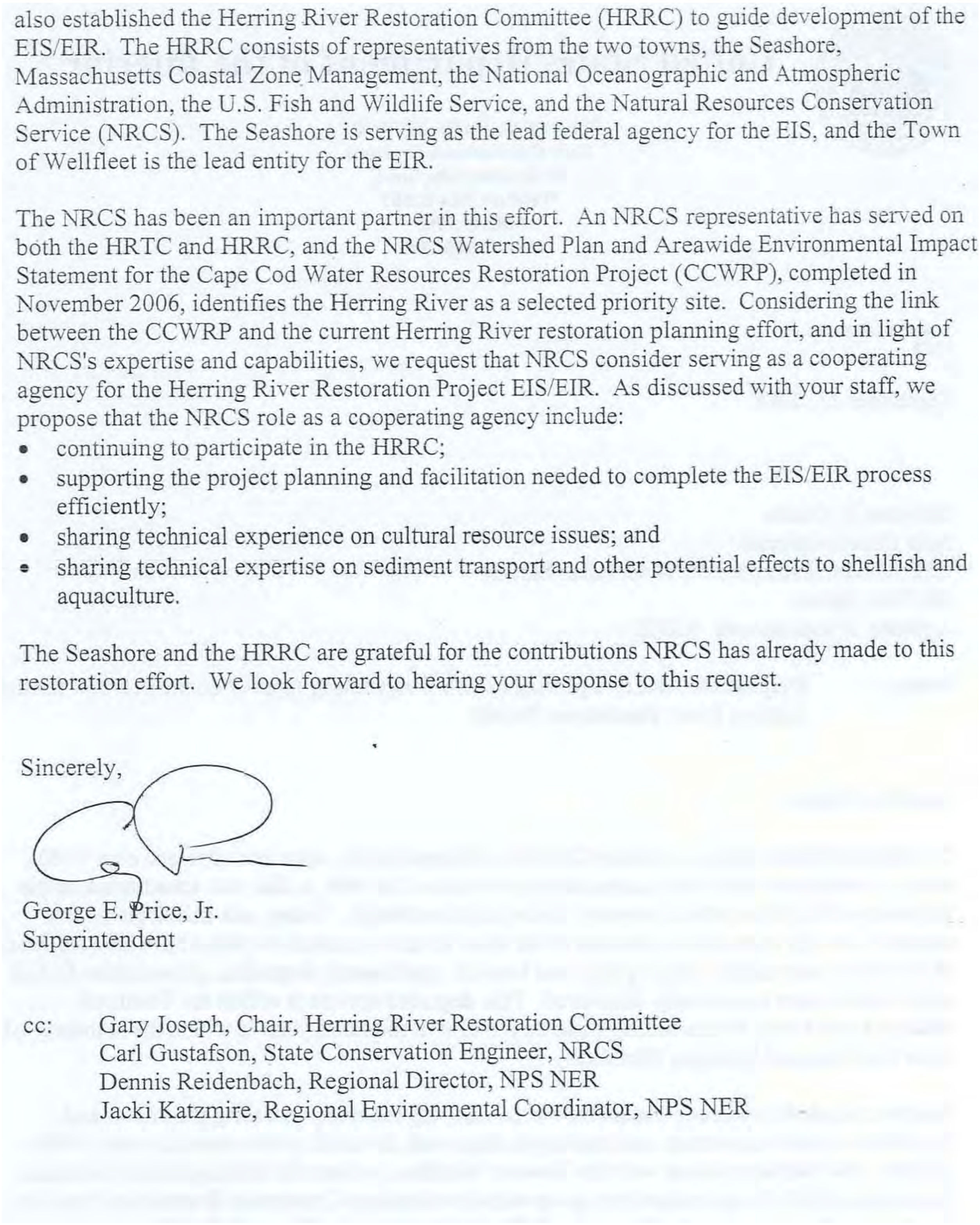
Christine S. Clarke
State Conservationist
USDA Natural Resources Conservation Service
451 West Street
Amherst, Massachusetts 01002

Subject: Request for NRCS to participate as a Cooperating Agency on the EIS/EIR for the Herring River Restoration Project

Dear Ms. Clarke:

The Herring River estuary on lower Cape Cod, Massachusetts, once encompassed over 1100 acres of productive tidal salt marshes and open waters. In 1909, a dike was constructed across the mouth of the River which severely limited tidal exchange. Today, salt-marsh plants are restricted to only eight acres upstream of the dike, invasive non-native plants have invaded much of the former salt marsh, water quality has become significantly degraded, and estuarine finfish and shellfish have been nearly eliminated. This degraded system is within the Towns of Wellfleet and Truro, Massachusetts, and 80 per cent of the flood plain is within the boundary of Cape Cod National Seashore (Seashore).

Seashore scientists and cooperators have been studying the river, assessing the effects and feasibility of tidal restoration, and sharing findings with the local public since the early 1980s. In 2005, The Seashore joined with the Town of Wellfleet to form the Herring River Technical Committee (HRTC), and tasked that group with developing a Conceptual Restoration Plan for the Herring River system. In November 2007, the Seashore, the Town of Wellfleet, and the Town of Truro signed a Memorandum of Understanding establishing our shared desire to restore tide to the Herring River, and to do so through development of an integrated Environmental Impact Statement / Environmental Impact Report (EIS/EIR) prepared in compliance with the National Environmental Policy Act and the Massachusetts Environmental Policy Act. The MOU



also established the Herring River Restoration Committee (HRRC) to guide development of the EIS/EIR. The HRRC consists of representatives from the two towns, the Seashore, Massachusetts Coastal Zone Management, the National Oceanographic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and the Natural Resources Conservation Service (NRCS). The Seashore is serving as the lead federal agency for the EIS, and the Town of Wellfleet is the lead entity for the EIR.

The NRCS has been an important partner in this effort. An NRCS representative has served on both the HRTC and HRRC, and the NRCS Watershed Plan and Areawide Environmental Impact Statement for the Cape Cod Water Resources Restoration Project (CCWRP), completed in November 2006, identifies the Herring River as a selected priority site. Considering the link between the CCWRP and the current Herring River restoration planning effort, and in light of NRCS's expertise and capabilities, we request that NRCS consider serving as a cooperating agency for the Herring River Restoration Project EIS/EIR. As discussed with your staff, we propose that the NRCS role as a cooperating agency include:

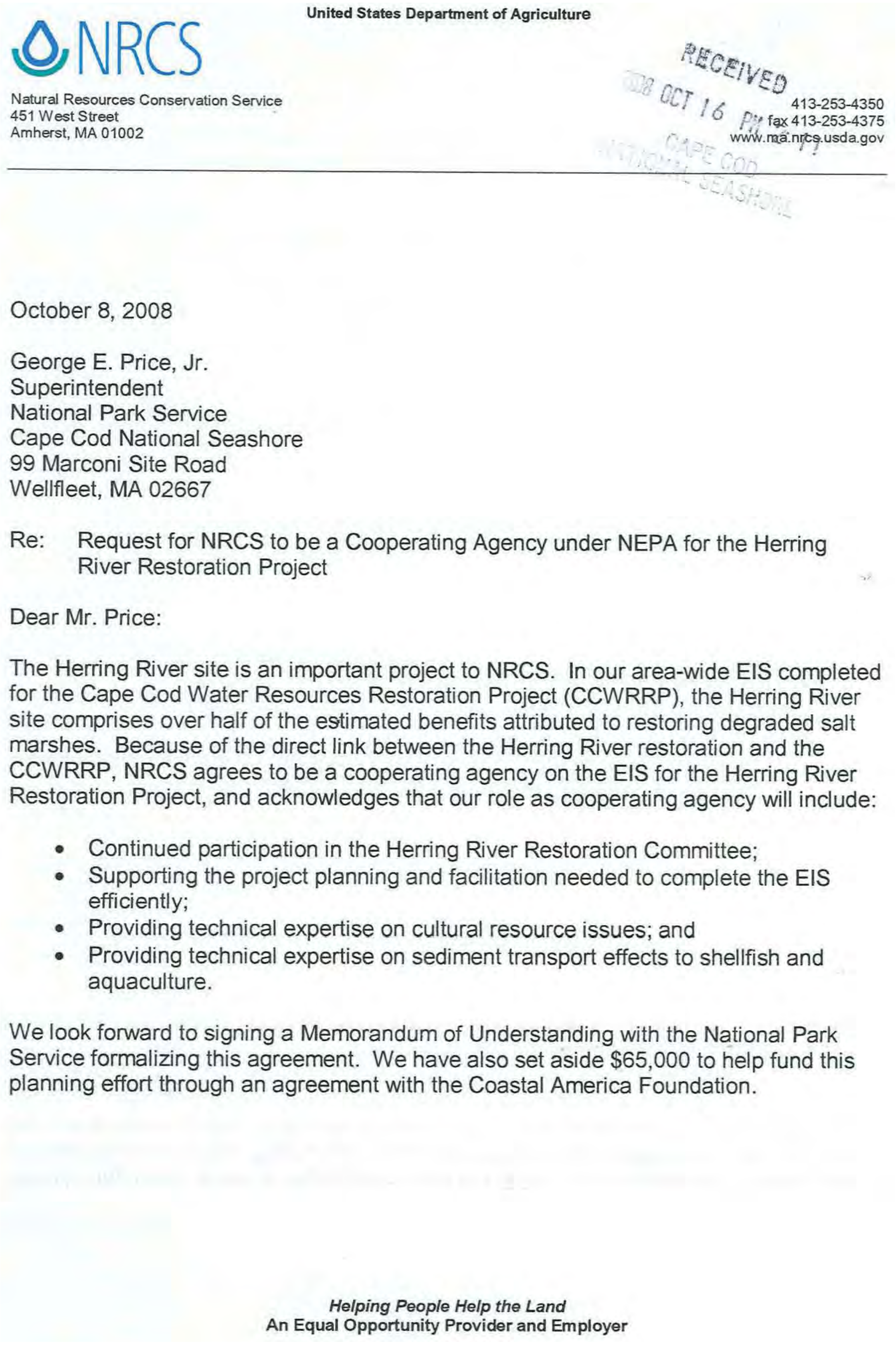
- continuing to participate in the HRRC;
- supporting the project planning and facilitation needed to complete the EIS/EIR process efficiently;
- sharing technical experience on cultural resource issues; and
- sharing technical expertise on sediment transport and other potential effects to shellfish and aquaculture.

The Seashore and the HRRC are grateful for the contributions NRCS has already made to this restoration effort. We look forward to hearing your response to this request.

Sincerely,

George E. Price, Jr.
Superintendent

cc: Gary Joseph, Chair, Herring River Restoration Committee
Carl Gustafson, State Conservation Engineer, NRCS
Dennis Reidenbach, Regional Director, NPS NER
Jacki Katzmire, Regional Environmental Coordinator, NPS NER



United States Department of Agriculture

NRCS

Natural Resources Conservation Service
451 West Street
Amherst, MA 01002

413-253-4350
fax 413-253-4375
www.ma.nrcs.usda.gov

RECEIVED
2008 OCT 16 PM [illegible]
CAPE COD
NATIONAL SEASHORE

October 8, 2008

George E. Price, Jr.
Superintendent
National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Re: Request for NRCS to be a Cooperating Agency under NEPA for the Herring River Restoration Project

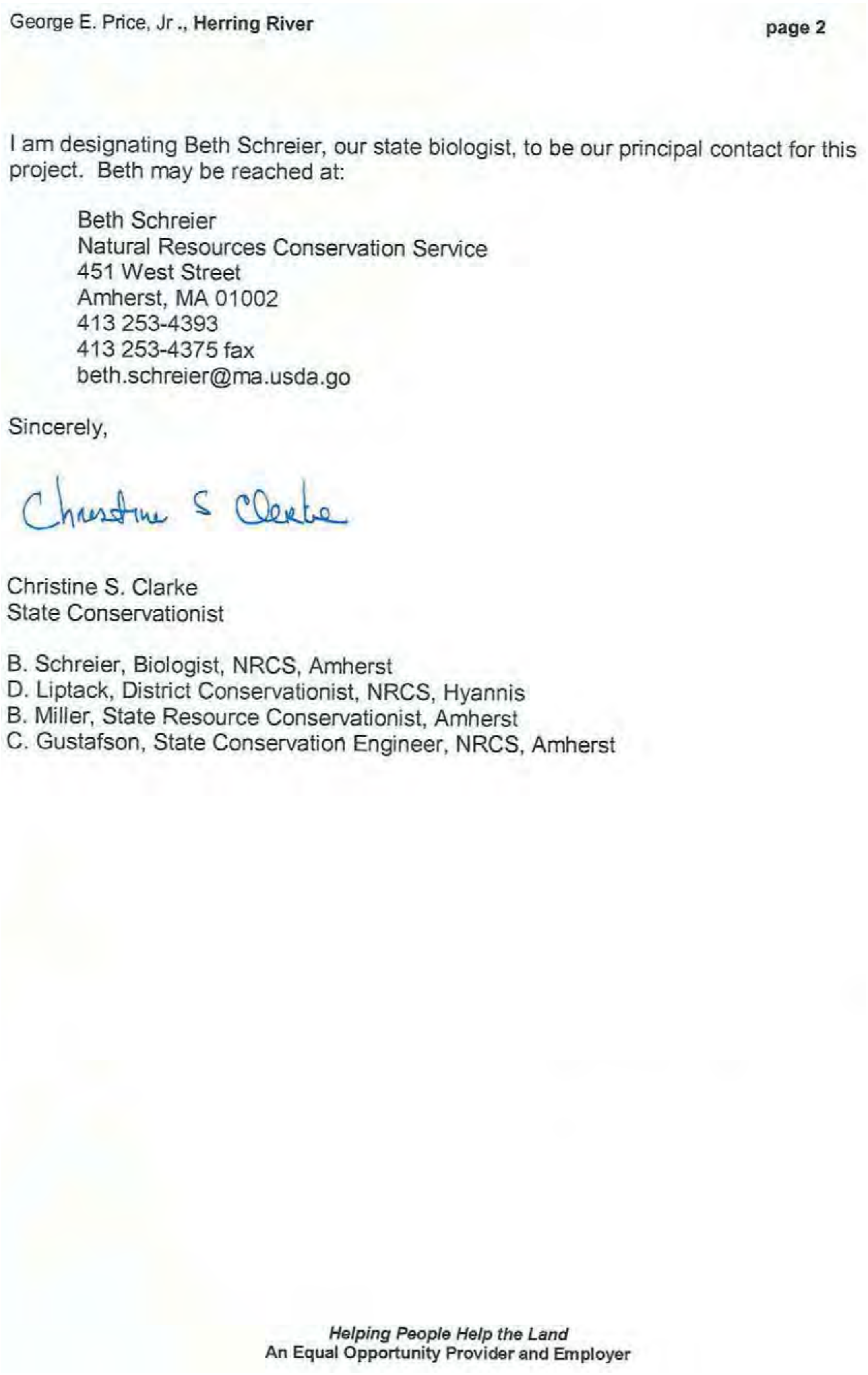
Dear Mr. Price:

The Herring River site is an important project to NRCS. In our area-wide EIS completed for the Cape Cod Water Resources Restoration Project (CCWRRP), the Herring River site comprises over half of the estimated benefits attributed to restoring degraded salt marshes. Because of the direct link between the Herring River restoration and the CCWRRP, NRCS agrees to be a cooperating agency on the EIS for the Herring River Restoration Project, and acknowledges that our role as cooperating agency will include:

- Continued participation in the Herring River Restoration Committee;
- Supporting the project planning and facilitation needed to complete the EIS efficiently;
- Providing technical expertise on cultural resource issues; and
- Providing technical expertise on sediment transport effects to shellfish and aquaculture.

We look forward to signing a Memorandum of Understanding with the National Park Service formalizing this agreement. We have also set aside $65,000 to help fund this planning effort through an agreement with the Coastal America Foundation.

Helping People Help the Land
An Equal Opportunity Provider and Employer



I am designating Beth Schreier, our state biologist, to be our principal contact for this project. Beth may be reached at:

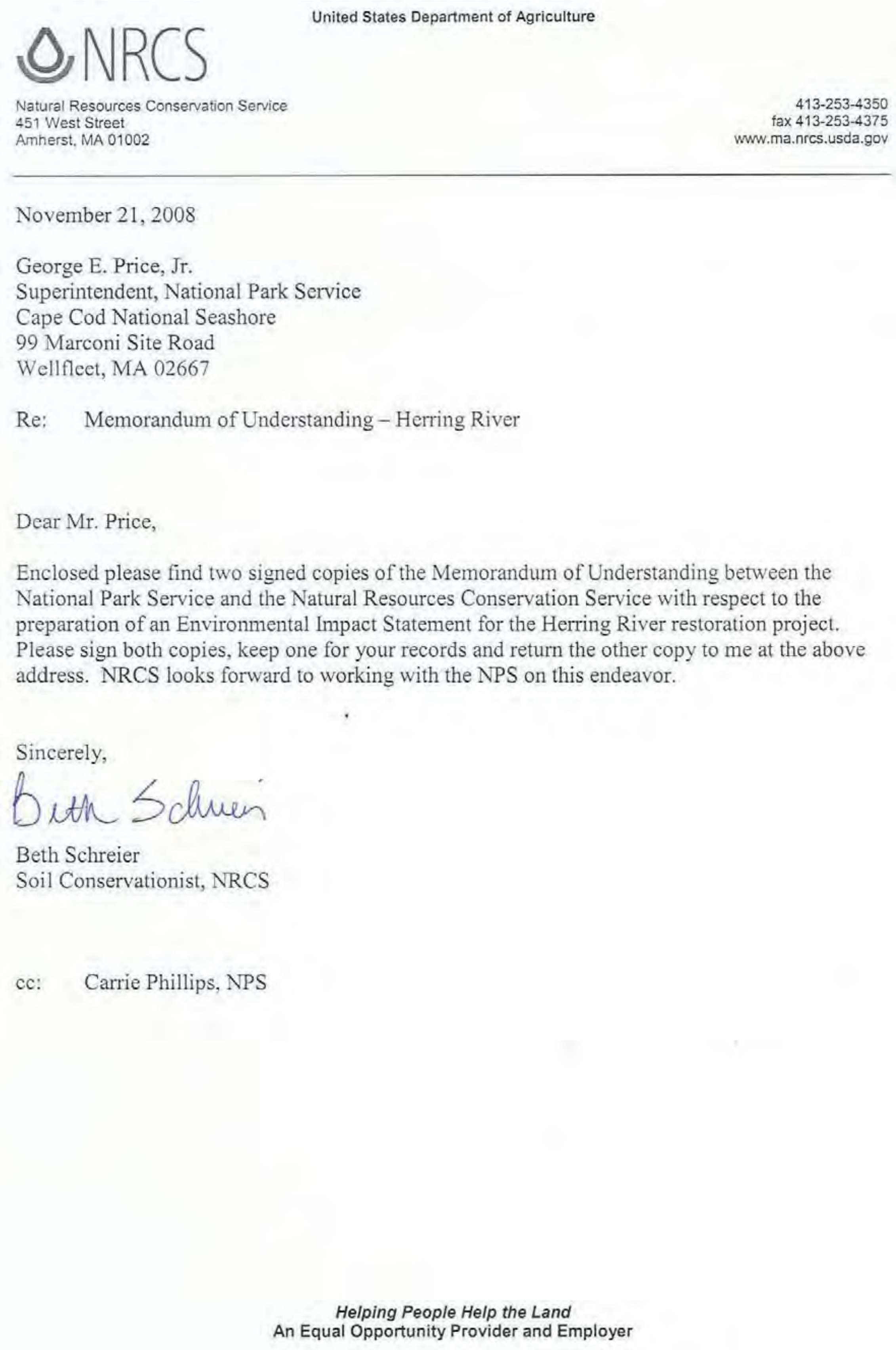
Beth Schreier
Natural Resources Conservation Service
451 West Street
Amherst, MA 01002
413 253-4393
413 253-4375 fax
beth.schreier@ma.usda.go

Sincerely,

Christine S Clarke

Christine S. Clarke
State Conservationist

B. Schreier, Biologist, NRCS, Amherst
D. Liptack, District Conservationist, NRCS, Hyannis
B. Miller, State Resource Conservationist, Amherst
C. Gustafson, State Conservation Engineer, NRCS, Amherst



United States Department of Agriculture

NRCS

Natural Resources Conservation Service
451 West Street
Amherst, MA 01002

413-253-4350
fax 413-253-4375
www.ma.nrcs.usda.gov

November 21, 2008

George E. Price, Jr.
Superintendent, National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Re: Memorandum of Understanding – Herring River

Dear Mr. Price,

Enclosed please find two signed copies of the Memorandum of Understanding between the National Park Service and the Natural Resources Conservation Service with respect to the preparation of an Environmental Impact Statement for the Herring River restoration project. Please sign both copies, keep one for your records and return the other copy to me at the above address. NRCS looks forward to working with the NPS on this endeavor.

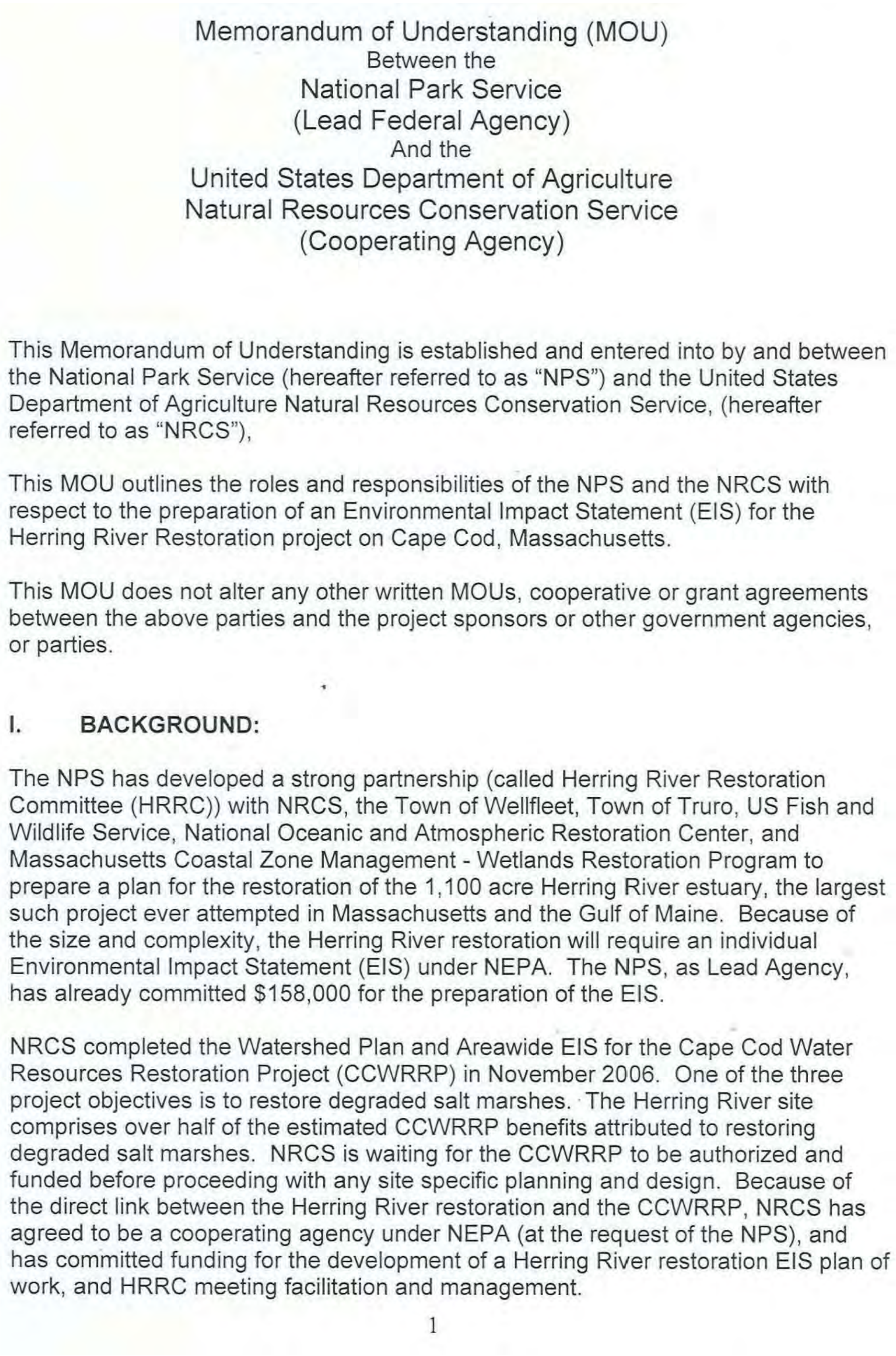
Sincerely,

Beth Schreier

Beth Schreier
Soil Conservationist, NRCS

cc: Carrie Phillips, NPS

Helping People Help the Land
An Equal Opportunity Provider and Employer



Memorandum of Understanding (MOU)
Between the
National Park Service
(Lead Federal Agency)
And the
United States Department of Agriculture
Natural Resources Conservation Service
(Cooperating Agency)

This Memorandum of Understanding is established and entered into by and between the National Park Service (hereafter referred to as "NPS") and the United States Department of Agriculture Natural Resources Conservation Service, (hereafter referred to as "NRCS"),

This MOU outlines the roles and responsibilities of the NPS and the NRCS with respect to the preparation of an Environmental Impact Statement (EIS) for the Herring River Restoration project on Cape Cod, Massachusetts.

This MOU does not alter any other written MOUs, cooperative or grant agreements between the above parties and the project sponsors or other government agencies, or parties.

I. BACKGROUND:

The NPS has developed a strong partnership (called Herring River Restoration Committee (HRRC)) with NRCS, the Town of Wellfleet, Town of Truro, US Fish and Wildlife Service, National Oceanic and Atmospheric Restoration Center, and Massachusetts Coastal Zone Management - Wetlands Restoration Program to prepare a plan for the restoration of the 1,100 acre Herring River estuary, the largest such project ever attempted in Massachusetts and the Gulf of Maine. Because of the size and complexity, the Herring River restoration will require an individual Environmental Impact Statement (EIS) under NEPA. The NPS, as Lead Agency, has already committed $158,000 for the preparation of the EIS.

NRCS completed the Watershed Plan and Areawide EIS for the Cape Cod Water Resources Restoration Project (CCWRRP) in November 2006. One of the three project objectives is to restore degraded salt marshes. The Herring River site comprises over half of the estimated CCWRRP benefits attributed to restoring degraded salt marshes. NRCS is waiting for the CCWRRP to be authorized and funded before proceeding with any site specific planning and design. Because of the direct link between the Herring River restoration and the CCWRRP, NRCS has agreed to be a cooperating agency under NEPA (at the request of the NPS), and has committed funding for the development of a Herring River restoration EIS plan of work, and HRRC meeting facilitation and management.

II. PURPOSE AND BENEFITS:

NPS and NRCS worked together in the development of the CCWRRP. By combining resource efforts for the Herring River EIS, implementation of USDA programs will be improved, interagency coordination and cooperation will be strengthened, and both agencies will improve efficiencies. Therefore, the NPS and the NRCS deem it mutually advantageous to cooperate in the undertaking, and hereby agree as follows:

III. NPS (Lead Federal Agency) RESPONSIBILITIES:

A. As the lead agency, the NPS has primary responsibility for meeting the requirements of the National Environmental Policy Act (NEPA), including the preparation of the Draft EIS (DEIS) and Final EIS (FEIS) for the Herring River Restoration project.

B. The NPS will consult with the NRCS regarding the EIS issues of concern, range of EIS alternatives considered, and associated mitigation measures to be analyzed in the EIS.

C. The NPS will identify NRCS as a cooperating agency in the EIS, and will include in the EIS written material which would allow the NRCS to meet its NEPA compliance requirements.

D. The NPS will provide NRCS with copies of the preliminary draft(s) of the DEIS and FEIS in a timely manner.

IV. NRCS (Cooperating Agency) RESPONSIBILITIES:

A. As a cooperating agency, NRCS will participate in the HRRC.

B. NRCS will provide technical assistance on the cultural resource issues associated with the preparation of the Herring River EIS.

C. NRCS will provide technical assistance on sediment transport and other potential effects to shellfish and aquaculture associated with the Herring River restoration.

D. NRCS will review the preliminary draft of the DEIS and provide comments to the NPS within 30 working days (unless a different mutually agreed upon time frame is established) of receipt of the DEIS.

E. NRCS will review the preliminary draft of the FEIS and provide comments to the NPS within 30 working days (unless a different mutually agreed upon time frame is established) of receipt of the draft FEIS.

V. IT IS MUTUALLY AGREED THAT:

A. The principle contacts for this MOU are:

NPS:
Carrie Phillips
Chief, Natural Resource Management
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
508 349-3785 x216

NRCS:
Beth Schreier
Soil Conservationist
451 West Street
Amherst, MA 01002
413 253-4393

B. This MOU may be modified by the parties hereto by mutual agreement only. Any modification will be in writing.

C. This MOU is terminated when either the Record of Decision (ROD) is signed or when written notice is given by a respective agency.

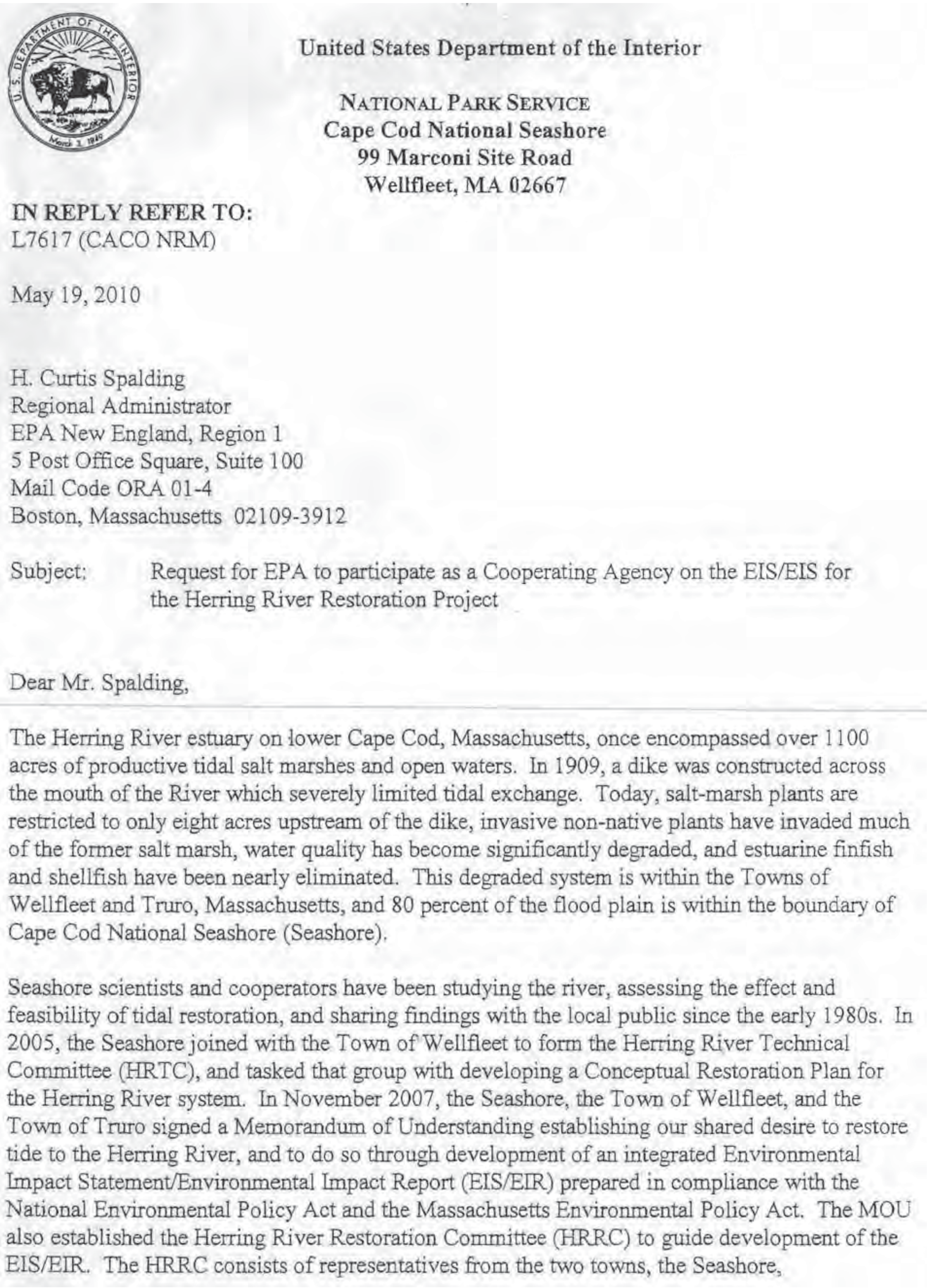
THE NPS AND THE NRCS AGREE TO THIS MOU AS OF THE LAST DATE WRITTEN BELOW:

Date: 12/1/08 By: ______________________

George E. Price, Jr.
Superintendent, National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Date: 11/20/08 By: Christine S. Clarke

Christine S. Clarke
State Conservationist
USDA Natural Resources Conservation Service
451 West Street
Amherst, MA 01002



United States Department of the Interior

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

IN REPLY REFER TO:
L7617 (CACO NRM)

May 19, 2010

H. Curtis Spalding
Regional Administrator
EPA New England, Region 1
5 Post Office Square, Suite 100
Mail Code ORA 01-4
Boston, Massachusetts 02109-3912

Subject: Request for EPA to participate as a Cooperating Agency on the EIS/EIS for the Herring River Restoration Project

Dear Mr. Spalding,

The Herring River estuary on lower Cape Cod, Massachusetts, once encompassed over 1100 acres of productive tidal salt marshes and open waters. In 1909, a dike was constructed across the mouth of the River which severely limited tidal exchange. Today, salt-marsh plants are restricted to only eight acres upstream of the dike, invasive non-native plants have invaded much of the former salt marsh, water quality has become significantly degraded, and estuarine finfish and shellfish have been nearly eliminated. This degraded system is within the Towns of Wellfleet and Truro, Massachusetts, and 80 percent of the flood plain is within the boundary of Cape Cod National Seashore (Seashore).

Seashore scientists and cooperators have been studying the river, assessing the effect and feasibility of tidal restoration, and sharing findings with the local public since the early 1980s. In 2005, the Seashore joined with the Town of Wellfleet to form the Herring River Technical Committee (HRTC), and tasked that group with developing a Conceptual Restoration Plan for the Herring River system. In November 2007, the Seashore, the Town of Wellfleet, and the Town of Truro signed a Memorandum of Understanding establishing our shared desire to restore tide to the Herring River, and to do so through development of an integrated Environmental Impact Statement/Environmental Impact Report (EIS/EIR) prepared in compliance with the National Environmental Policy Act and the Massachusetts Environmental Policy Act. The MOU also established the Herring River Restoration Committee (HRRC) to guide development of the EIS/EIR. The HRRC consists of representatives from the two towns, the Seashore, Massachusetts Division of Ecological Restoration, National Oceanographic and Atmospheric Administration, U.S. Fish and Wildlife Service, and Natural Resources Conservation Service. The Seashore is serving as the lead federal agency for the EIS, and the Town of Wellfleet is the lead entity for the EIR. In his Certificate date November 7, 2007, Ian Bowles, Secretary of the MA Executive Office of Energy and the Environment, established a Technical Working Group (TWG) to help guide compliance and permitting processes for the project.

The Environmental Protection Agency (EPA) has been an important partner in this effort. An EPA representative has served on the TWG and EPA is a leading proponent and sponsor of salt marsh restoration projects throughout Cape Cod and other parts of Massachusetts. In light of EPA's expertise and capabilities, we request that EPA consider serving as a cooperating agency for the Herring River Restoration Project EIS/EIR. As discussed with your staff, we anticipate that the EPA role as a cooperating agency will include:

- Continuing to participate in the TWG;
- Supporting the project planning and facilitation needed for compliance and permitting processes;
- Sharing technical experience on natural and cultural resource issues; and
- Sharing technical expertise on design of salt marsh restoration projects, wetland permitting, monitoring, and adaptive management.

The Seashore and the HRRC are grateful for the contributions EPA has already made to this restoration effort. We look forward to hearing your response to this request. If you have questions regarding this topic, please contact Tim Smith, Restoration Ecologist, at (508) 487-3262.

Sincerely,

George E. Price, Jr.
Superintendent

cc: Gary Joseph, Chair, Herring River Restoration Committee
Ed Reiner, EPA
Tim Timmerman, EPA
John Sargent, Army Corps
Dennis Reidenbach, Regional Director, NPS NER
Jacki Katzmire, Regional Environmental Coordinator, NPS NER
CACO central files

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 1
5 POST OFFICE SQUARE, SUITE 100
BOSTON, MA 02109-3912

June 8, 2010

George E. Price, Superintendent
National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

RE: Request to be a Cooperating Agency for the preparation of an Environmental Impact Statement for the Herring River Restoration Project in Wellfleet and Truro, Massachusetts

Dear Superintendent Price:

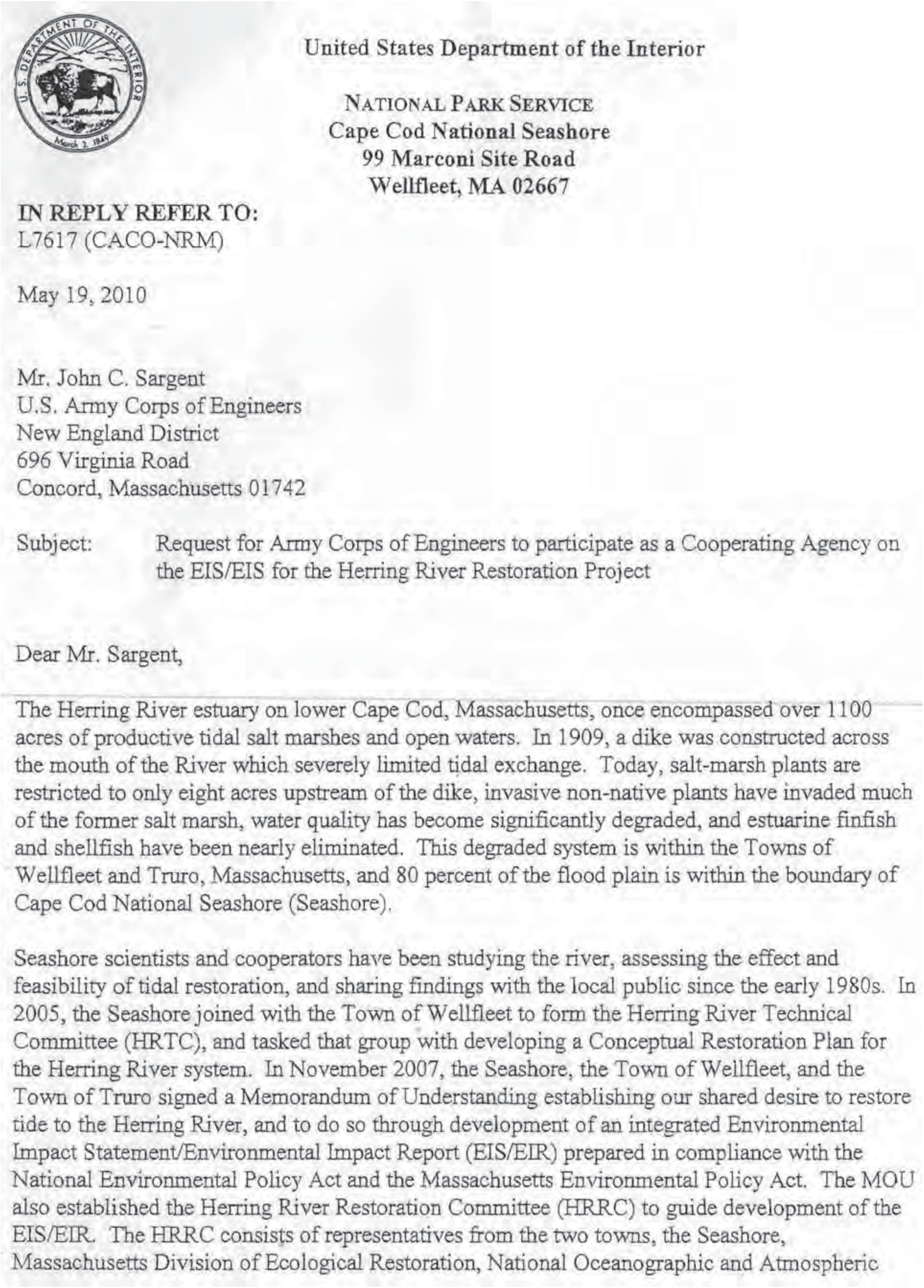
Thank you for your recent letter requesting the Environmental Protection Agency (EPA) participation as a cooperating agency during the preparation of the Environmental Impact Statement (EIS) for the Herring River Restoration project. EPA New England looks forward to participation as a cooperating agency during the preparation of the EIS for this important ecological restoration effort.

EPA intends to work as a cooperating agency within the limit of our resources to help define the scope of analysis, identify sources of information and to offer input on how specific issues should be addressed in the EIS. We appreciate the leadership provided to date by Tim Smith of your office during interagency meetings to discuss the EIS and look forward to continued close coordination with the National Park Service and other interested local, state and federal agency representatives as the NEPA process continues.

If you have any questions about this letter or EPA's involvement in the EIS process, please contact Timothy Timmermann at 617-918-1025.

Sincerely,

H. Curtis Spalding
Regional Administrator



United States Department of the Interior

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

IN REPLY REFER TO:
L7617 (CACO-NRM)

May 19, 2010

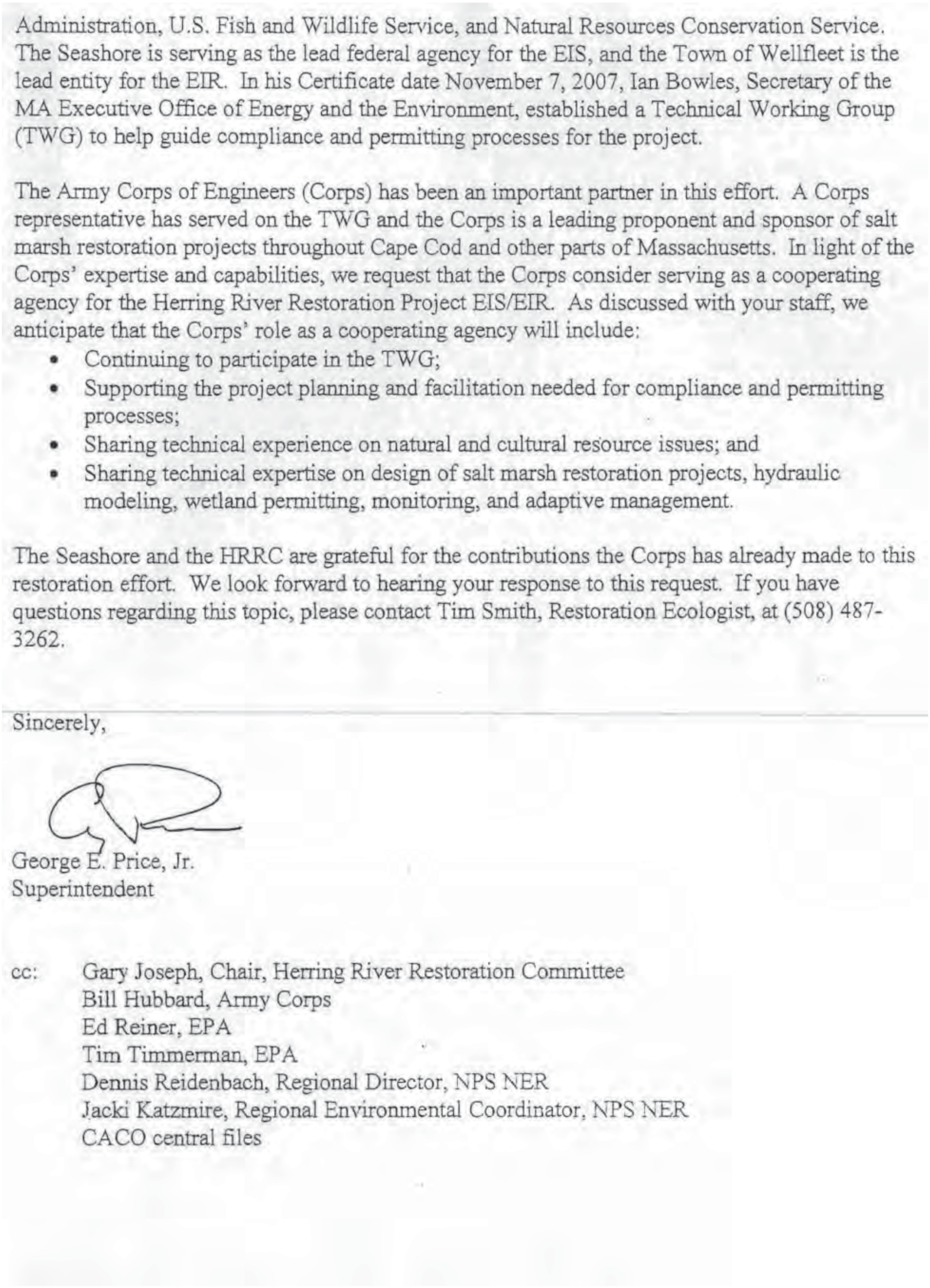
Mr. John C. Sargent
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, Massachusetts 01742

Subject: Request for Army Corps of Engineers to participate as a Cooperating Agency on the EIS/EIS for the Herring River Restoration Project

Dear Mr. Sargent,

The Herring River estuary on lower Cape Cod, Massachusetts, once encompassed over 1100 acres of productive tidal salt marshes and open waters. In 1909, a dike was constructed across the mouth of the River which severely limited tidal exchange. Today, salt-marsh plants are restricted to only eight acres upstream of the dike, invasive non-native plants have invaded much of the former salt marsh, water quality has become significantly degraded, and estuarine finfish and shellfish have been nearly eliminated. This degraded system is within the Towns of Wellfleet and Truro, Massachusetts, and 80 percent of the flood plain is within the boundary of Cape Cod National Seashore (Seashore).

Seashore scientists and cooperators have been studying the river, assessing the effect and feasibility of tidal restoration, and sharing findings with the local public since the early 1980s. In 2005, the Seashore joined with the Town of Wellfleet to form the Herring River Technical Committee (HRTC), and tasked that group with developing a Conceptual Restoration Plan for the Herring River system. In November 2007, the Seashore, the Town of Wellfleet, and the Town of Truro signed a Memorandum of Understanding establishing our shared desire to restore tide to the Herring River, and to do so through development of an integrated Environmental Impact Statement/Environmental Impact Report (EIS/EIR) prepared in compliance with the National Environmental Policy Act and the Massachusetts Environmental Policy Act. The MOU also established the Herring River Restoration Committee (HRRC) to guide development of the EIS/EIR. The HRRC consists of representatives from the two towns, the Seashore, Massachusetts Division of Ecological Restoration, National Oceanographic and Atmospheric



Administration, U.S. Fish and Wildlife Service, and Natural Resources Conservation Service. The Seashore is serving as the lead federal agency for the EIS, and the Town of Wellfleet is the lead entity for the EIR. In his Certificate date November 7, 2007, Ian Bowles, Secretary of the MA Executive Office of Energy and the Environment, established a Technical Working Group (TWG) to help guide compliance and permitting processes for the project.

The Army Corps of Engineers (Corps) has been an important partner in this effort. A Corps representative has served on the TWG and the Corps is a leading proponent and sponsor of salt marsh restoration projects throughout Cape Cod and other parts of Massachusetts. In light of the Corps' expertise and capabilities, we request that the Corps consider serving as a cooperating agency for the Herring River Restoration Project EIS/EIR. As discussed with your staff, we anticipate that the Corps' role as a cooperating agency will include:

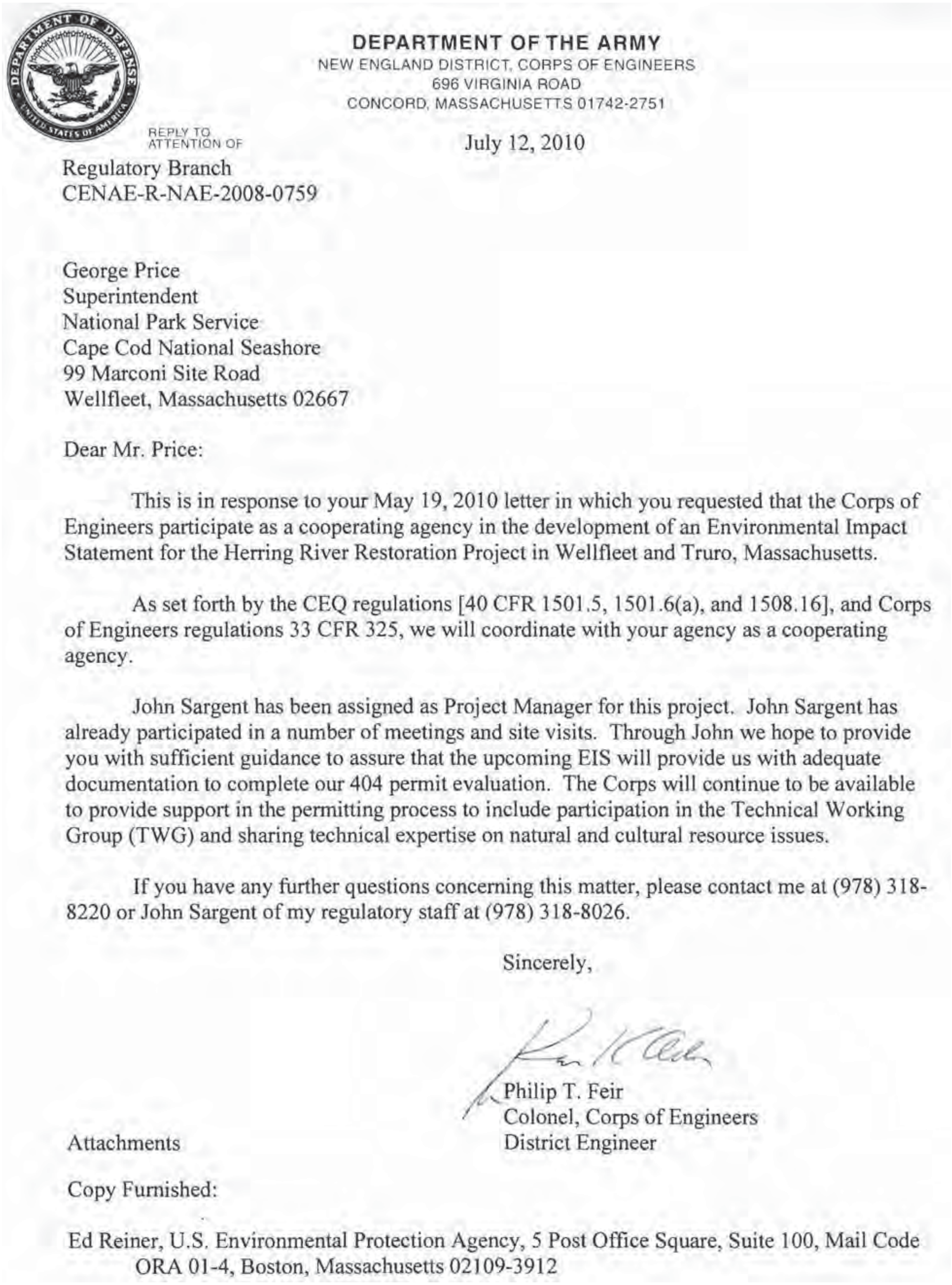
- Continuing to participate in the TWG;
- Supporting the project planning and facilitation needed for compliance and permitting processes;
- Sharing technical experience on natural and cultural resource issues; and
- Sharing technical expertise on design of salt marsh restoration projects, hydraulic modeling, wetland permitting, monitoring, and adaptive management.

The Seashore and the HRRC are grateful for the contributions the Corps has already made to this restoration effort. We look forward to hearing your response to this request. If you have questions regarding this topic, please contact Tim Smith, Restoration Ecologist, at (508) 487-3262.

Sincerely,

George E. Price, Jr.
Superintendent

cc:
Gary Joseph, Chair, Herring River Restoration Committee
Bill Hubbard, Army Corps
Ed Reiner, EPA
Tim Timmerman, EPA
Dennis Reidenbach, Regional Director, NPS NER
Jacki Katzmire, Regional Environmental Coordinator, NPS NER
CACO central files



DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
696 VIRGINIA ROAD
CONCORD, MASSACHUSETTS 01742-2751

REPLY TO
ATTENTION OF

July 12, 2010

Regulatory Branch
CENAE-R-NAE-2008-0759

George Price
Superintendent
National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, Massachusetts 02667

Dear Mr. Price:

This is in response to your May 19, 2010 letter in which you requested that the Corps of Engineers participate as a cooperating agency in the development of an Environmental Impact Statement for the Herring River Restoration Project in Wellfleet and Truro, Massachusetts.

As set forth by the CEQ regulations [40 CFR 1501.5, 1501.6(a), and 1508.16], and Corps of Engineers regulations 33 CFR 325, we will coordinate with your agency as a cooperating agency.

John Sargent has been assigned as Project Manager for this project. John Sargent has already participated in a number of meetings and site visits. Through John we hope to provide you with sufficient guidance to assure that the upcoming EIS will provide us with adequate documentation to complete our 404 permit evaluation. The Corps will continue to be available to provide support in the permitting process to include participation in the Technical Working Group (TWG) and sharing technical expertise on natural and cultural resource issues.

If you have any further questions concerning this matter, please contact me at (978) 318-8220 or John Sargent of my regulatory staff at (978) 318-8026.

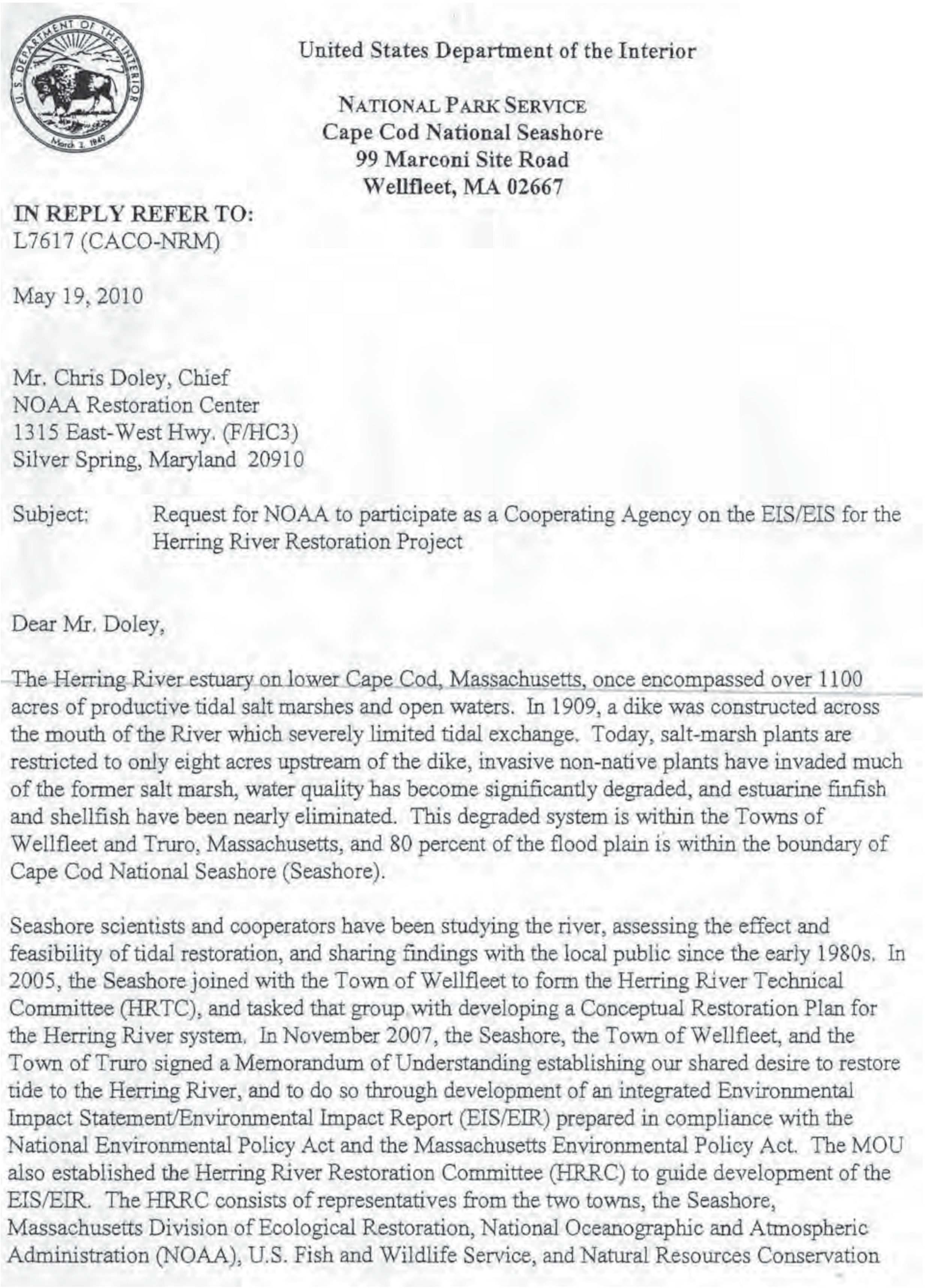
Sincerely,

Philip T. Feir
Colonel, Corps of Engineers
District Engineer

Attachments

Copy Furnished:

Ed Reiner, U.S. Environmental Protection Agency, 5 Post Office Square, Suite 100, Mail Code ORA 01-4, Boston, Massachusetts 02109-3912



March 3, 1849

United States Department of the Interior

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

IN REPLY REFER TO:
L7617 (CACO-NRM)

May 19, 2010

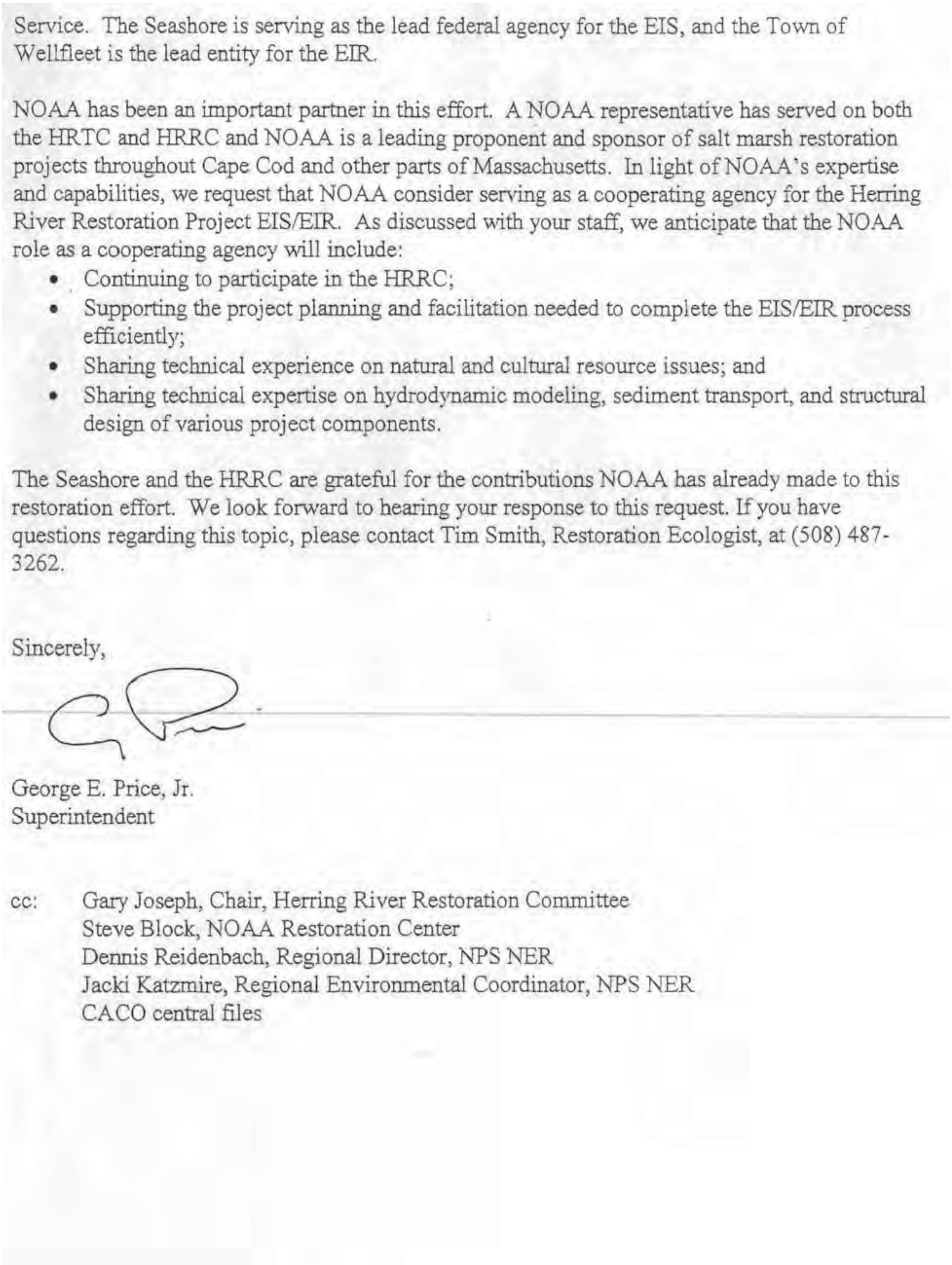
Mr. Chris Doley, Chief
NOAA Restoration Center
1315 East-West Hwy. (F/HC3)
Silver Spring, Maryland 20910

Subject: Request for NOAA to participate as a Cooperating Agency on the EIS/EIS for the Herring River Restoration Project

Dear Mr. Doley,

The Herring River estuary on lower Cape Cod, Massachusetts, once encompassed over 1100 acres of productive tidal salt marshes and open waters. In 1909, a dike was constructed across the mouth of the River which severely limited tidal exchange. Today, salt-marsh plants are restricted to only eight acres upstream of the dike, invasive non-native plants have invaded much of the former salt marsh, water quality has become significantly degraded, and estuarine finfish and shellfish have been nearly eliminated. This degraded system is within the Towns of Wellfleet and Truro, Massachusetts, and 80 percent of the flood plain is within the boundary of Cape Cod National Seashore (Seashore).

Seashore scientists and cooperators have been studying the river, assessing the effect and feasibility of tidal restoration, and sharing findings with the local public since the early 1980s. In 2005, the Seashore joined with the Town of Wellfleet to form the Herring River Technical Committee (HRTC), and tasked that group with developing a Conceptual Restoration Plan for the Herring River system. In November 2007, the Seashore, the Town of Wellfleet, and the Town of Truro signed a Memorandum of Understanding establishing our shared desire to restore tide to the Herring River, and to do so through development of an integrated Environmental Impact Statement/Environmental Impact Report (EIS/EIR) prepared in compliance with the National Environmental Policy Act and the Massachusetts Environmental Policy Act. The MOU also established the Herring River Restoration Committee (HRRC) to guide development of the EIS/EIR. The HRRC consists of representatives from the two towns, the Seashore, Massachusetts Division of Ecological Restoration, National Oceanographic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service, and Natural Resources Conservation



Service. The Seashore is serving as the lead federal agency for the EIS, and the Town of Wellfleet is the lead entity for the EIR.

NOAA has been an important partner in this effort. A NOAA representative has served on both the HRTC and HRRC and NOAA is a leading proponent and sponsor of salt marsh restoration projects throughout Cape Cod and other parts of Massachusetts. In light of NOAA's expertise and capabilities, we request that NOAA consider serving as a cooperating agency for the Herring River Restoration Project EIS/EIR. As discussed with your staff, we anticipate that the NOAA role as a cooperating agency will include:

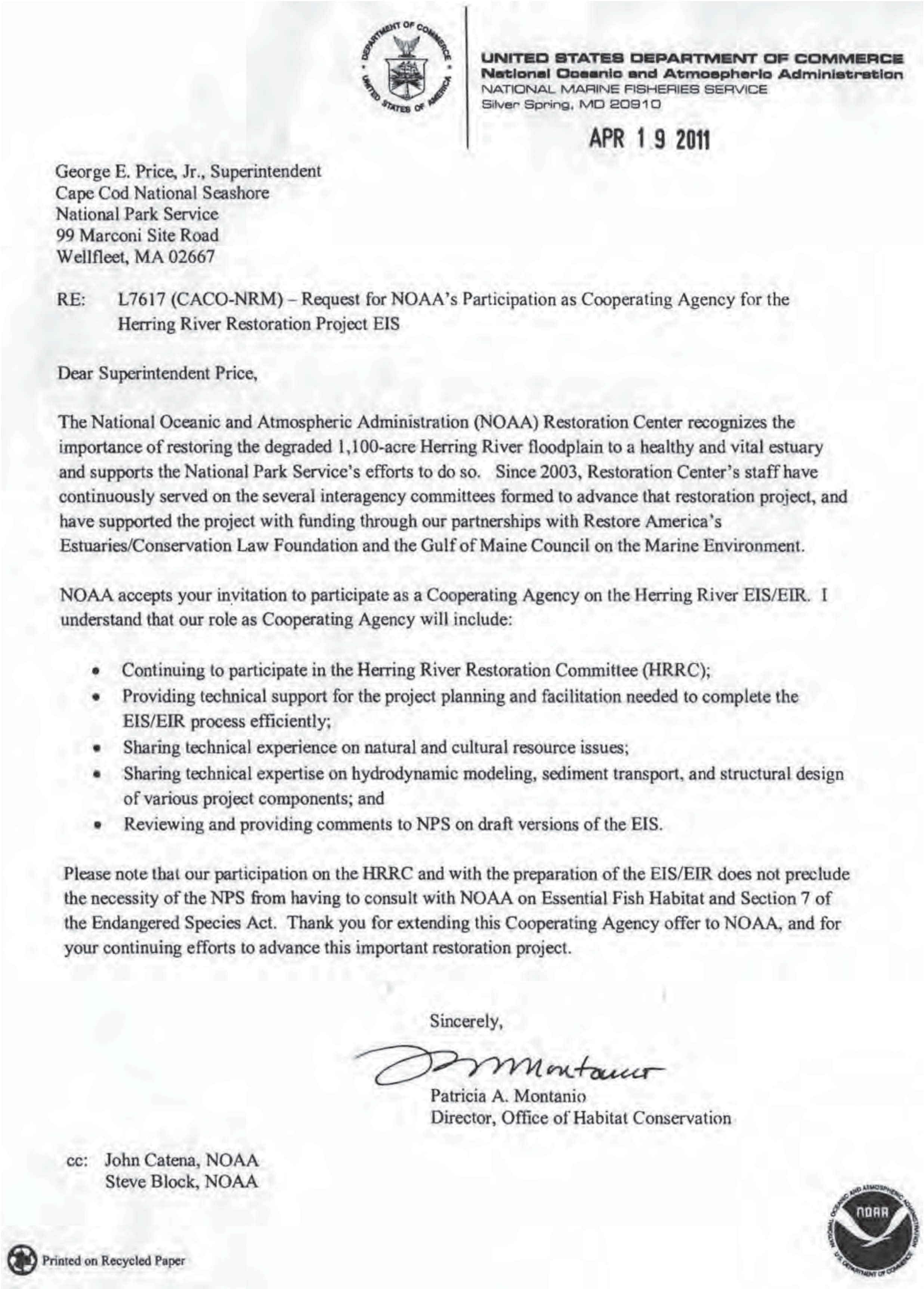
- Continuing to participate in the HRRC;
- Supporting the project planning and facilitation needed to complete the EIS/EIR process efficiently;
- Sharing technical experience on natural and cultural resource issues; and
- Sharing technical expertise on hydrodynamic modeling, sediment transport, and structural design of various project components.

The Seashore and the HRRC are grateful for the contributions NOAA has already made to this restoration effort. We look forward to hearing your response to this request. If you have questions regarding this topic, please contact Tim Smith, Restoration Ecologist, at (508) 487-3262.

Sincerely,

George E. Price, Jr.
Superintendent

cc: Gary Joseph, Chair, Herring River Restoration Committee
Steve Block, NOAA Restoration Center
Dennis Reidenbach, Regional Director, NPS NER
Jacki Katzmire, Regional Environmental Coordinator, NPS NER
CACO central files



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

APR 19 2011

George E. Price, Jr., Superintendent
Cape Cod National Seashore
National Park Service
99 Marconi Site Road
Wellfleet, MA 02667

RE: L7617 (CACO-NRM) – Request for NOAA's Participation as Cooperating Agency for the Herring River Restoration Project EIS

Dear Superintendent Price,

The National Oceanic and Atmospheric Administration (NOAA) Restoration Center recognizes the importance of restoring the degraded 1,100-acre Herring River floodplain to a healthy and vital estuary and supports the National Park Service's efforts to do so. Since 2003, Restoration Center's staff have continuously served on the several interagency committees formed to advance that restoration project, and have supported the project with funding through our partnerships with Restore America's Estuaries/Conservation Law Foundation and the Gulf of Maine Council on the Marine Environment.

NOAA accepts your invitation to participate as a Cooperating Agency on the Herring River EIS/EIR. I understand that our role as Cooperating Agency will include:

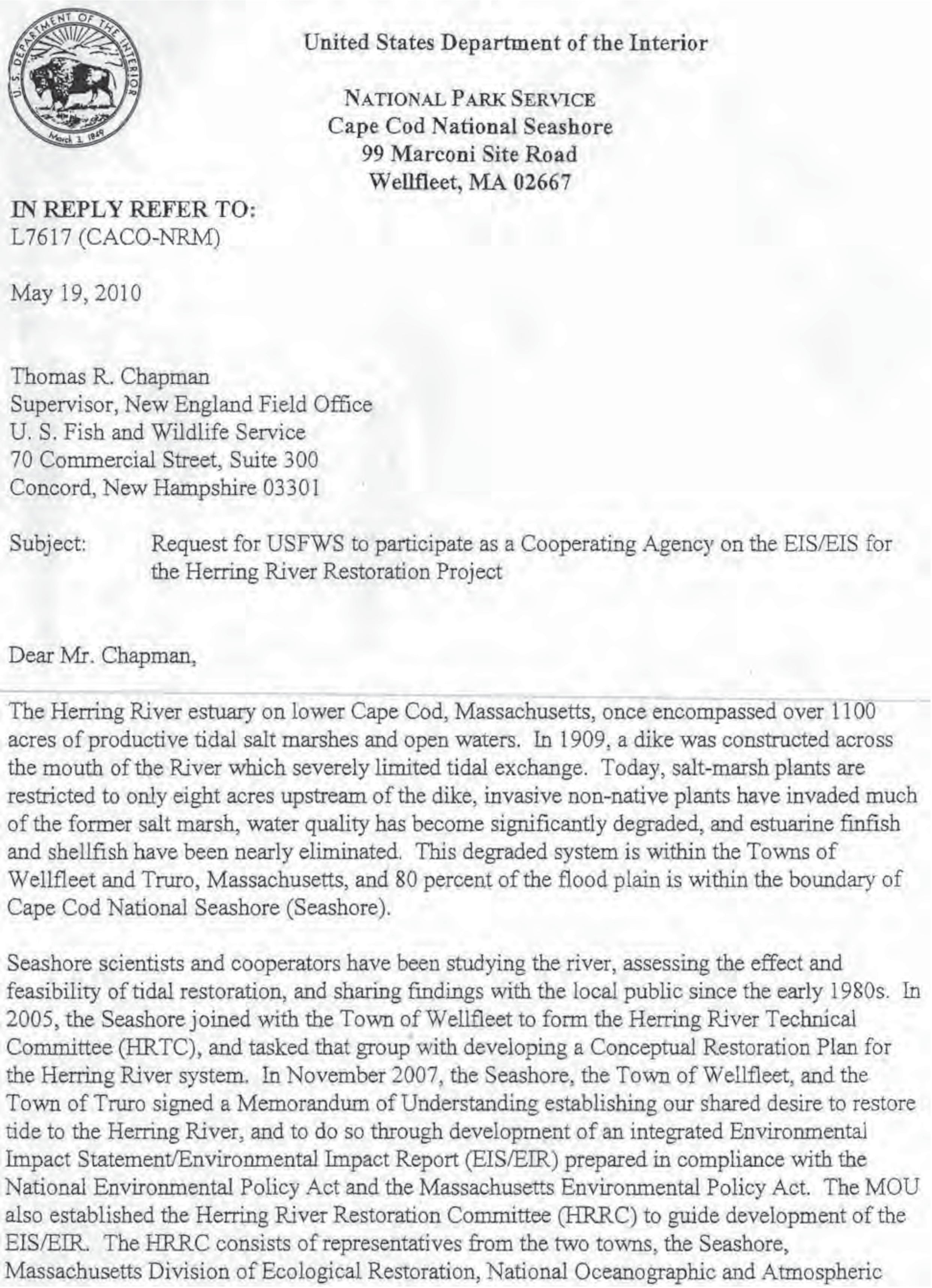
- Continuing to participate in the Herring River Restoration Committee (HRRC);
- Providing technical support for the project planning and facilitation needed to complete the EIS/EIR process efficiently;
- Sharing technical experience on natural and cultural resource issues;
- Sharing technical expertise on hydrodynamic modeling, sediment transport, and structural design of various project components; and
- Reviewing and providing comments to NPS on draft versions of the EIS.

Please note that our participation on the HRRC and with the preparation of the EIS/EIR does not preclude the necessity of the NPS from having to consult with NOAA on Essential Fish Habitat and Section 7 of the Endangered Species Act. Thank you for extending this Cooperating Agency offer to NOAA, and for your continuing efforts to advance this important restoration project.

Sincerely,

Patricia A. Montanio
Director, Office of Habitat Conservation

cc: John Catena, NOAA
Steve Block, NOAA



March 3, 1849

United States Department of the Interior

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

IN REPLY REFER TO:
L7617 (CACO-NRM)

May 19, 2010

Thomas R. Chapman
Supervisor, New England Field Office
U. S. Fish and Wildlife Service
70 Commercial Street, Suite 300
Concord, New Hampshire 03301

Subject: Request for USFWS to participate as a Cooperating Agency on the EIS/EIS for the Herring River Restoration Project

Dear Mr. Chapman,

The Herring River estuary on lower Cape Cod, Massachusetts, once encompassed over 1100 acres of productive tidal salt marshes and open waters. In 1909, a dike was constructed across the mouth of the River which severely limited tidal exchange. Today, salt-marsh plants are restricted to only eight acres upstream of the dike, invasive non-native plants have invaded much of the former salt marsh, water quality has become significantly degraded, and estuarine finfish and shellfish have been nearly eliminated. This degraded system is within the Towns of Wellfleet and Truro, Massachusetts, and 80 percent of the flood plain is within the boundary of Cape Cod National Seashore (Seashore).

Seashore scientists and cooperators have been studying the river, assessing the effect and feasibility of tidal restoration, and sharing findings with the local public since the early 1980s. In 2005, the Seashore joined with the Town of Wellfleet to form the Herring River Technical Committee (HRTC), and tasked that group with developing a Conceptual Restoration Plan for the Herring River system. In November 2007, the Seashore, the Town of Wellfleet, and the Town of Truro signed a Memorandum of Understanding establishing our shared desire to restore tide to the Herring River, and to do so through development of an integrated Environmental Impact Statement/Environmental Impact Report (EIS/EIR) prepared in compliance with the National Environmental Policy Act and the Massachusetts Environmental Policy Act. The MOU also established the Herring River Restoration Committee (HRRC) to guide development of the EIS/EIR. The HRRC consists of representatives from the two towns, the Seashore, Massachusetts Division of Ecological Restoration, National Oceanographic and Atmospheric

Administration, U.S. Fish and Wildlife Service (FWS), and Natural Resources Conservation Service. The Seashore is serving as the lead federal agency for the EIS, and the Town of Wellfleet is the lead entity for the EIR.

FWS has been an important partner in this effort. A FWS representative has served on both the HRTC and HRRC and FWS is a leading proponent and sponsor of salt marsh restoration projects throughout Cape Cod and other parts of Massachusetts. In light of FWS's expertise and capabilities, we request that FWS consider serving as a cooperating agency for the Herring River Restoration Project EIS/EIR. As discussed with your staff, we anticipate that the FWS role as a cooperating agency will include:

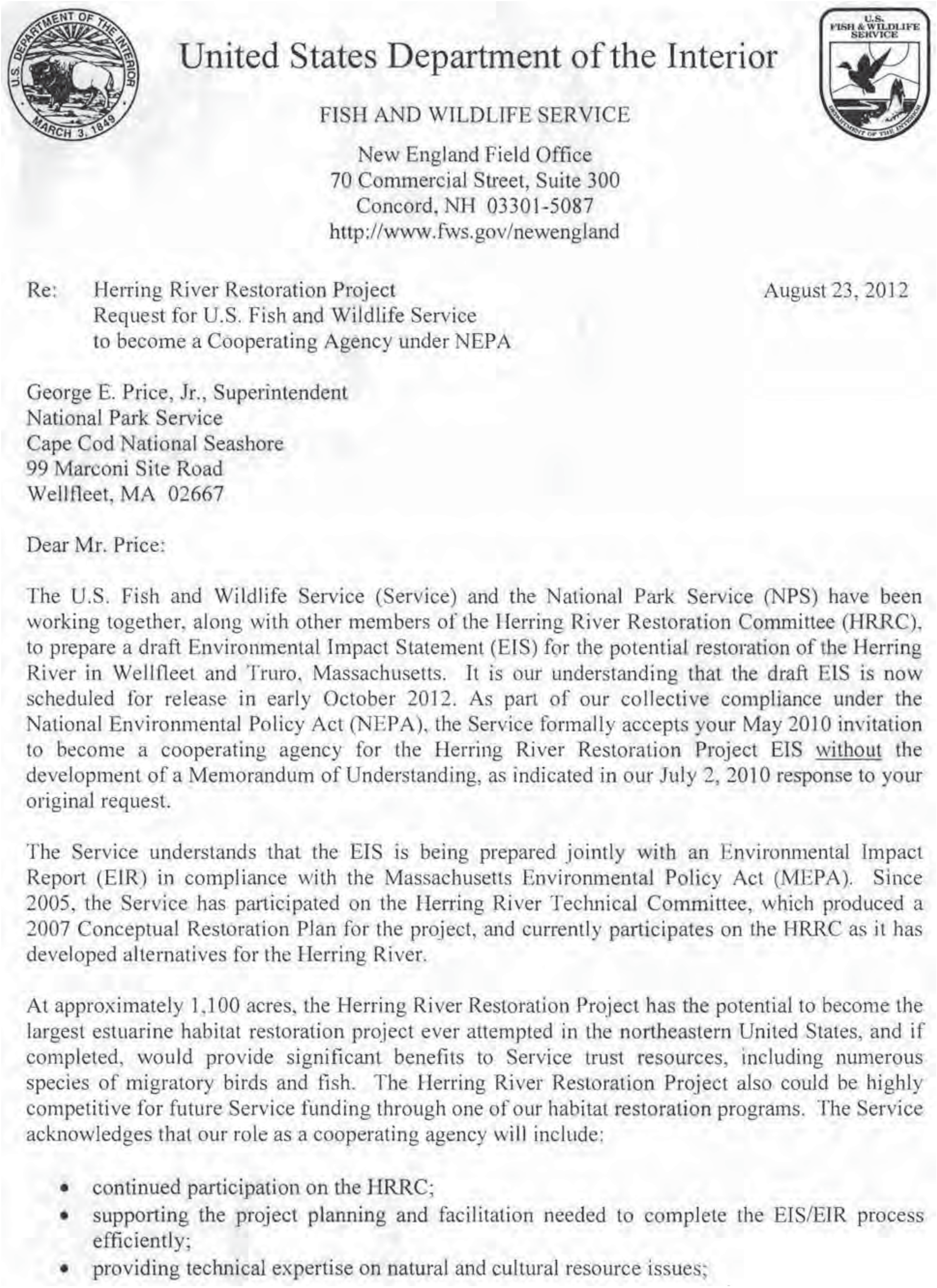
- Continuing to participate in the HRRC;
- Supporting the project planning and facilitation needed to complete the EIS/EIR process efficiently;
- Sharing technical experience on natural and cultural resource issues; and
- Sharing technical expertise on hydrodynamic modeling, sediment transport, monitoring, and adaptive management.

The Seashore and the HRRC are grateful for the contributions FWS has already made to this restoration effort. We look forward to hearing your response to this request. If you have questions regarding this topic, please contact Tim Smith, Restoration Ecologist, at (508) 487-3262.

Sincerely,

George E. Price, Jr.
Superintendent

cc: Gary Joseph, Chair, Herring River Restoration Committee
Eric Derleth, USFWS
Dennis Reidenbach, Regional Director, NPS NER
Jacki Katzmire, Regional Environmental Coordinator, NPS NER
CACO central files



United States Department of the Interior

FISH AND WILDLIFE SERVICE

New England Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5087
http://www.fws.gov/newengland

Re: Herring River Restoration Project
Request for U.S. Fish and Wildlife Service
to become a Cooperating Agency under NEPA

August 23, 2012

George E. Price, Jr., Superintendent
National Park Service
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

Dear Mr. Price:

The U.S. Fish and Wildlife Service (Service) and the National Park Service (NPS) have been working together, along with other members of the Herring River Restoration Committee (HRRC), to prepare a draft Environmental Impact Statement (EIS) for the potential restoration of the Herring River in Wellfleet and Truro, Massachusetts. It is our understanding that the draft EIS is now scheduled for release in early October 2012. As part of our collective compliance under the National Environmental Policy Act (NEPA), the Service formally accepts your May 2010 invitation to become a cooperating agency for the Herring River Restoration Project EIS without the development of a Memorandum of Understanding, as indicated in our July 2, 2010 response to your original request.

The Service understands that the EIS is being prepared jointly with an Environmental Impact Report (EIR) in compliance with the Massachusetts Environmental Policy Act (MEPA). Since 2005, the Service has participated on the Herring River Technical Committee, which produced a 2007 Conceptual Restoration Plan for the project, and currently participates on the HRRC as it has developed alternatives for the Herring River.

At approximately 1,100 acres, the Herring River Restoration Project has the potential to become the largest estuarine habitat restoration project ever attempted in the northeastern United States, and if completed, would provide significant benefits to Service trust resources, including numerous species of migratory birds and fish. The Herring River Restoration Project also could be highly competitive for future Service funding through one of our habitat restoration programs. The Service acknowledges that our role as a cooperating agency will include:

- continued participation on the HRRC;
- supporting the project planning and facilitation needed to complete the EIS/EIR process efficiently;
- providing technical expertise on natural and cultural resource issues;

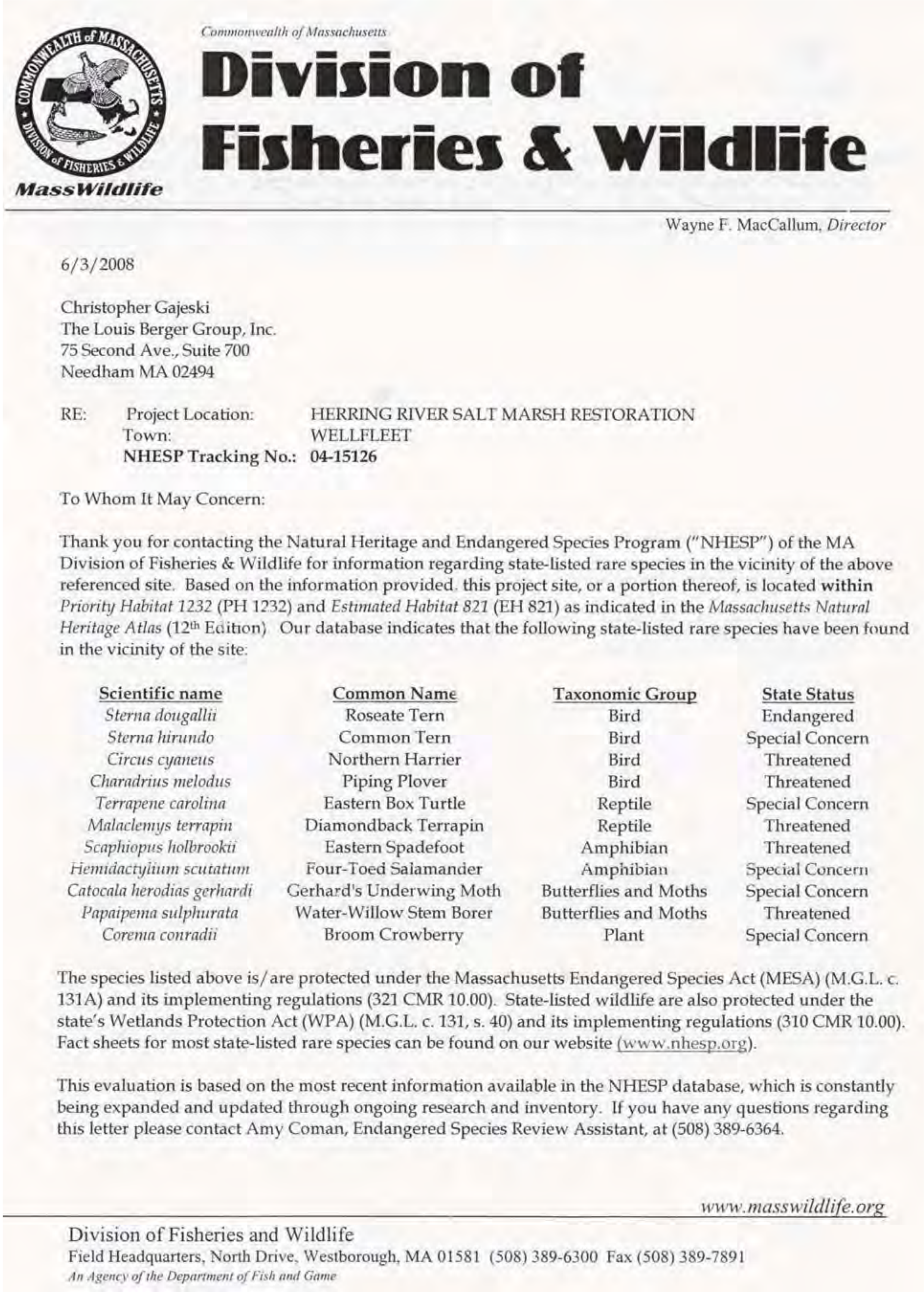
- providing technical expertise on hydrodynamic modeling, sediment transport, monitoring and adaptive management; and
- reviewing and providing comments to the NPS on draft versions of the EIS and assisting with responses to public comments during the development of the final EIS.

The Service looks forward to continuing our collaboration with the NPS as we complete our collective responsibilities during the NEPA process. Eric Derleth, the New England Field Office's Partners for Fish and Wildlife Program Coordinator, will continue to represent the Service on the HRRC and will be the principal contact for the project. Mr. Derleth can be reached at the above address, or by phone at (603) 223-2541, and email at eric_derleth@fws.gov.

Sincerely yours,

Thomas R. Chapman
Supervisor
New England Field Office

AGENCY CONSULTATION



Commonwealth of Massachusetts
Division of Fisheries & Wildlife
MassWildlife

Wayne F. MacCallum, *Director*

6/3/2008

Christopher Gajeski
The Louis Berger Group, Inc.
75 Second Ave., Suite 700
Needham MA 02494

RE: Project Location: HERRING RIVER SALT MARSH RESTORATION
Town: WELLFLEET
NHESP Tracking No.: 04-15126

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program ("NHESP") of the MA Division of Fisheries & Wildlife for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided. this project site, or a portion thereof, is located **within** *Priority Habitat 1232* (PH 1232) and *Estimated Habitat 821* (EH 821) as indicated in the *Massachusetts Natural Heritage Atlas* (12th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

Scientific name	Common Name	Taxonomic Group	State Status
Sterna dougallii	Roseate Tern	Bird	Endangered
Sterna hirundo	Common Tern	Bird	Special Concern
Circus cyaneus	Northern Harrier	Bird	Threatened
Charadrius melodus	Piping Plover	Bird	Threatened
Terrapene carolina	Eastern Box Turtle	Reptile	Special Concern
Malaclemys terrapin	Diamondback Terrapin	Reptile	Threatened
Scaphiopus holbrookii	Eastern Spadefoot	Amphibian	Threatened
Hemidactylium scutatum	Four-Toed Salamander	Amphibian	Special Concern
Catocala herodias gerhardi	Gerhard's Underwing Moth	Butterflies and Moths	Special Concern
Papaipema sulphurata	Water-Willow Stem Borer	Butterflies and Moths	Threatened
Corema conradii	Broom Crowberry	Plant	Special Concern

The species listed above is/are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.nhesp.org).

This evaluation is based on the most recent information available in the NHESP database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Amy Coman, Endangered Species Review Assistant, at (508) 389-6364.

www.masswildlife.org

Division of Fisheries and Wildlife
Field Headquarters, North Drive, Westborough, MA 01581 (508) 389-6300 Fax (508) 389-7891
An Agency of the Department of Fish and Game

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Deval L. Patrick
GOVERNOR

Timothy P. Murray
LIEUTENANT
GOVERNOR

Ian A. Bowles
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1181
http://www.mass.gov/
envir

June 20, 2008

CERTIFICATE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS ESTABLISHING A SPECIAL REVIEW PROCEDURE

PROJECT NAME	: Herring River Restoration Project
PROJECT MUNICIPALITY	: Wellfleet and Truro
PROJECT WATERSHED	: Cape Cod
EEA NUMBER	: 14272
PROJECT PROPONENTS	: Town of Wellfleet, Town of Truro, and Cape Cod National Seashore
DATE NOTICED IN MONITOR	: N/A

Pursuant to the Massachusetts Environmental Policy Act (M.G. L. c. 30, ss. 61-62H) and Section 11.09 of the MEPA regulations, I hereby establish a Special Review Procedure to guide the MEPA review of the project.

Project Background and Description

As described in a letter submitted by the proponent, the Herring River Restoration Committee, to the Secretary of Energy and Environmental Affairs on May 29, 2008, the proposed project entails the restoration of ecosystem functions and values to a degraded 1,100-acre tidally restricted estuary. Prior to the 1908 construction of a dike at the mouth of the Herring River, the estuary was dominated by healthy and highly productive salt marsh plant communities. The prime objective of the project is to eventually restore tidal exchange to an extent closely approximating the normal, natural tidal range that occurred prior to diking. Tides will be restored gradually, over a period of several years, with small, incremental opening of adjustable tide gates.

The Herring River Restoration Committee (HRRC), a multi-agency group appointed by the two Towns and the National Seashore, is currently engaged in development of a comprehensive restoration plan for the estuary, building upon work completed by the preceding Town-appointed Herring River Technical Committee (HRTC). With input from the Herring River Stakeholder Group (also appointed by the Wellfleet Selectmen), the HRTC's work culminated with release of the Herring River Conceptual Restoration Plan in November 2007. As described in the Conceptual Restoration Plan, the Herring River Project comprises the following elements:

- Reconstruction of the existing 1908 dike and tide control structure at Chequessett Neck Road with a new structure, incorporating enlarged culverts and adjustable tide gates designed to allow gradual increases to tidal range.
- Replacement of at least seven additional culverts at road crossings upstream of Chequessett Neck Road to allow increased tidal exchange and better fish passage.
- Raising, relocating, or abandoning up to 22,000 linear feet of low-lying roadway occurring within the Herring River floodplain that are vulnerable to flooding from restored tidal range.
- Removal of approximately 600 acres of woody vegetation that has become established within the Herring River floodplain in order to promote recolonization of salt marsh vegetation and support fish passage coincident with restored tidal range.
- Restoration of natural channel sinuosity in the channelized portions of the Herring River system to enhance wetland habitat functions and abate mosquito production.
- Prevention and/or mitigation of flooding impacts to several private properties within the Herring River floodplain, including structures, developed lands, and domestic water wells.

MEPA Jurisdiction and Required Permits

At a minimum, it is expected that the Herring River project will alter at least one acre of salt marsh or bordering vegetated wetlands, triggering the mandatory EIR threshold described at 310 CMR 11.03(3)(a). Although the exact nature and extent of wetland alteration is unknown at this time, it is likely this threshold will be exceeded to a significant extent. In addition, the project area is known to contain both estimated and priority rare species habitat, is adjacent to significant cultural and historic resources, and is located with the Wellfleet Harbor Area of Critical Environmental Concern. The project will require numerous state permits (Chapter 91 Licenses, 401 Water Quality Certification, etc.) and has already received funding from the Massachusetts Office of Coastal Zone Management's Wetlands Restoration Program. Because the project requires a Chapter 91 License, MEPA jurisdiction is broad in scope and extends all aspects of the project with the potential to cause Damage to the Environment.

SPECIAL REVIEW PROCEDURE

The proponent has requested that I establish of a Special Review Procedure (SRP) for the review of the project under MEPA. The MEPA regulations provide that a Special Review Procedure may be established to provide for "coordination or consolidation of MEPA review with other environmental or development review and permitting processes". In addition, 301 CMR 11.09 states that "A Special Review Procedure may be appropriate, for example, for reviewing a proposed program, regulations, policy, or other Project in which there is more than one Proponent or more than one Participating Agency with a significant role, or a Project that is undefined or is expected to evolve during MEPA review, or a Project that may benefit the environment if there is early Commencement of a portion of the Project."

A SRP will enable the MEPA process to build on, rather than duplicate, the extensive analysis that has been and will be conducted by the HRRC. After considering the factors cited in Section 11.09 of the MEPA regulations, I hereby find that the review of the project would benefit from the establishment of a SRP.

Coordination with Other Review Processes

The SRP is largely for administrative convenience, designed to provide an opportunity for coordinated review and to consolidate the MEPA review with other environmental or development review and permitting processes.1

The Herring River Restoration Project is deemed a Development of Regional Impact (DRI) under the enabling regulations of the Cape Cod Commission and is, therefore, subject to DRI review. Additionally, approximately 80 percent of the project area is located within the Cape Cod National Seashore and, therefore, subject to compliance with the National Environmental Policy Act (NEPA). Because of the complexity, and long-term duration of the project, National Seashore staff and other cooperating federal agencies, have determined that a full Environmental Impact Statement (EIS) is appropriate.

This consolidation and coordination allows these regulatory and public review processes to be conducted in such a way that the public will be able to provide both written and oral comments, within a single timeframe, under the various regional, state and federal regulatory processes.

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1 The term "coordinated review" as used in this Certificate and in the MEPA regulations refers to the practice of allowing a single set of documents to serve simultaneously for more than one environmental review process, concurrent with that conducted under MEPA. In common usage, the practice is sometimes referred to as "joint review," although this term is misleading since federal and state agencies retain independent authority to judge the adequacy of the information submitted pursuant to their respective statutory and regulatory responsibilities.

Citizens Advisory Committee

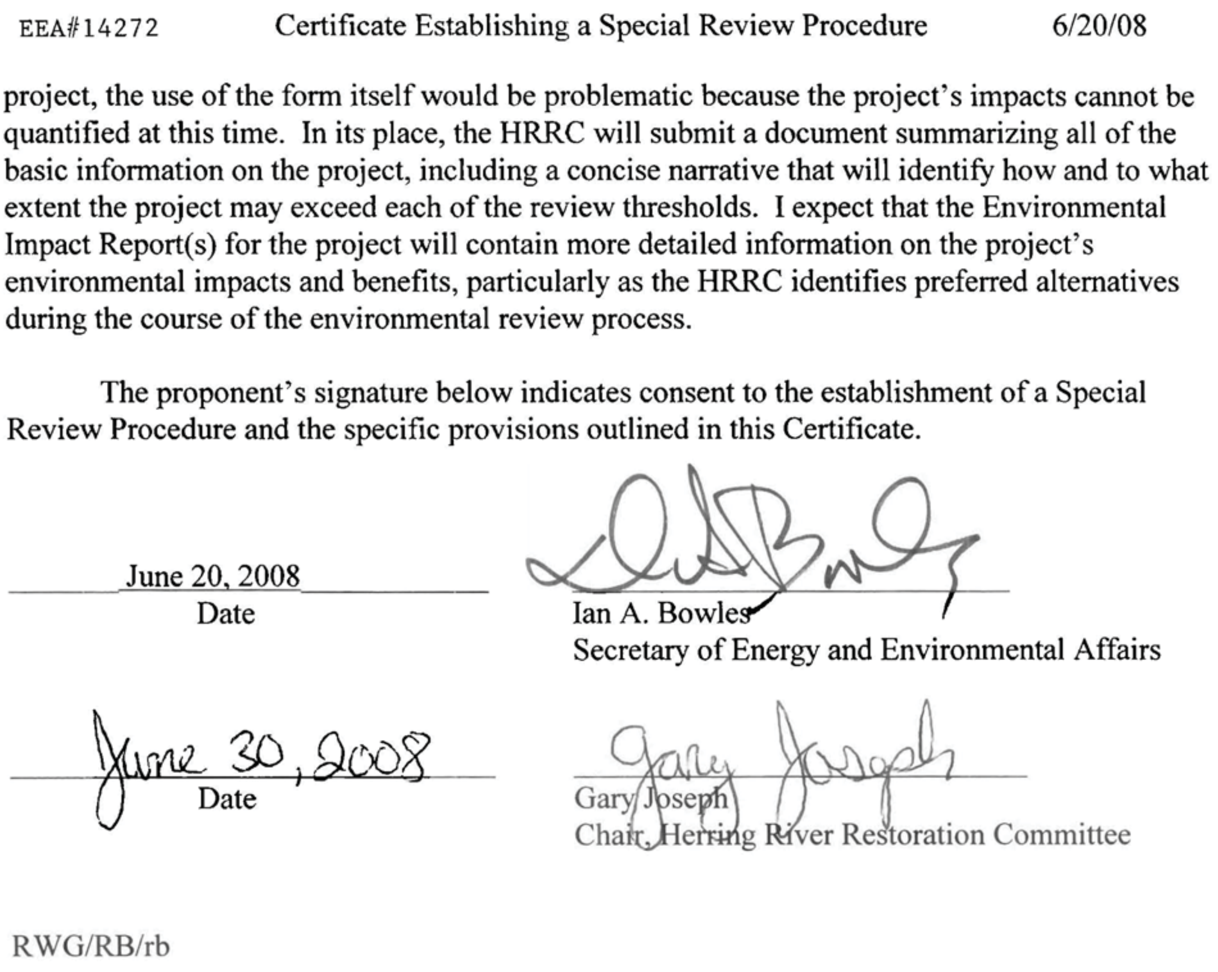
The MEPA regulations at 310 CMR 11.09(3) allow for the establishment of a Citizen's Advisory Committee (CAC) to assist with public and agency review and comment. For the Herring River Restoration Project, I hereby designate the Herring River Restoration Committee as the CAC. In addition to the Towns of Wellfleet and Truro and the Cape Cod National Seashore, the HRRC includes representatives from Office of Coastal Zone Management's Wetlands Restoration Program; the National Oceanic and Atmospheric Administration Restoration Center; the U.S. Fish and Wildlife Service; and the Natural Resources Conservation Service. All of these agencies were also represented on the former Herring River Technical Committee (HRTC) and have been meeting at least monthly, either as the HRTC or HRRC, since September 2005. As directed by a Memorandum of Understanding (signed in November 2007) between the two Towns and the National Seashore, the HRRC will prepare a detailed, comprehensive restoration plan, pursue funding, and obtain permits. Though actual implementation and oversight of the restoration activities may be directed by a successor committee, it is expected that any future committee will be similarly comprised.

As the CAC, the HRRC, or its successor, would continue to meet regularly as the project advances. At a yet-to-be determined frequency, the HRRC would hold meetings with regulatory agencies including, but not limited to, the MEPA Office; the Department of Environmental Protection (MassDEP); the Natural Heritage and Endangered Species Program (NHESP); the Department of Conservation and Recreation (DCR); the U.S. Army Corps of Engineers (ACOE); the Cape Cod Commission (CCC); and the local Conservation Commissions, to review project plans and designs. As the project advances to the implementation stages, these meetings also would include review of monitoring data; outcomes of prior restoration actions; and consensus-driven decision-making regarding future actions. As a publicly-appointed body, the HRRC meetings are open to the public and this will continue under the SRP. It is anticipated that additional meetings focused more directly on specific public stakeholder concerns will be held on a regular basis. The HRRC will also conduct a wide-ranging outreach campaign, including regular updates via a newsletter, a dedicated project web-site, educational programs, site walks, and other events.

Under this proposed SRP, these agency consultations and public meetings would meet the compliance and reporting requirements of MEPA and allow the Herring River Restoration Project to proceed under Adaptive Management guidelines, which acknowledge uncertainty and rely on iterative, science-based, and incremental management decisions. However, it is expected that individual restoration activities, e.g. culvert replacements and road relocations, will most likely require separate permits.

Environmental Notification Form (ENF)

As requested by the HRRC, I hereby waive the specific requirement to submit the form usually required as part of the Environmental Notification Form (ENF) submission. While the HRRC intends to submit a document that would serve as the ENF for the MEPA review of the



project, the use of the form itself would be problematic because the project's impacts cannot be quantified at this time. In its place, the HRRC will submit a document summarizing all of the basic information on the project, including a concise narrative that will identify how and to what extent the project may exceed each of the review thresholds. I expect that the Environmental Impact Report(s) for the project will contain more detailed information on the project's environmental impacts and benefits, particularly as the HRRC identifies preferred alternatives during the course of the environmental review process.

The proponent's signature below indicates consent to the establishment of a Special Review Procedure and the specific provisions outlined in this Certificate.

June 20, 2008
Date

Ian A. Bowles
Secretary of Energy and Environmental Affairs

June 30, 2008
Date

Gary Joseph
Gary Joseph
Chair, Herring River Restoration Committee

RWG/RB/rb

CAPE COD COMMISSION STAFF REPORT

Date: **August 8, 2008**

To: **DRI Subcommittee**
Frank Hogan, Chair, Joy Brookshire, Roslyn Garfield, Peter Graham, Roger Putnam, Elizabeth Taylor (alt.), Royden Richardson (alt.)

Proposed Project: **Herring River Tidal Restoration Project**
DRI—MEPA Joint Review
(#ENF08009)

Commission Staff: Stacey Justus, Project Planner, Gabriel Belfit, Glenn Cannon, Sarah Korjeff, Heather McElroy and Scott Michaud

---

INTRODUCTION

The above referenced project comes before the Commission as a joint review with MEPA. The Herring River Restoration Committee (HRRC), chaired by Gary Joseph, is the project applicant.

The first public hearing on this project is to be held next Thursday, 8/14/08, 2:00 pm at the Wellfleet Senior Center. This hearing will serve as the joint scoping meeting with MEPA intended to allow public comment on the project to inform your letter to MEPA on the Environmental Notification Form (ENF). Next week will also serve the National Park Service as required public outreach under the NEPA process. Similarly, it will serve MEPA as their public scoping meeting. The format will accommodate all three processes.

Two documents were sent to you previously, including the ENF and the Conceptual Restoration Plan. Also being sent to you is the Joint DRI/MEPA Review Application filed with the Commission on July 25, 2008.

ENVIRONMENTAL NOTIFICATION FORM (ENF)

An ENF was prepared and noticed in the Environmental Monitor on July 9, 2008. Comments on the ENF are due to MEPA by October 31, 2008. As a mandatory EIR is required, this project will be a DRI as well.

I anticipate that after this hearing the Subcommittee will need to hold meeting(s) in order to develop and finalize your comments on the EIR/DRI scoping, and to discuss how to review this project under the RPP. The applicant seeks specific comments on the information needed to complete a DRI application and facilitate your DRI review.

Attached to this report is a section from the Commission's Joint Review Application that nicely explains the CCC/MEPA joint review process (see **Attachment A** below).

MEPA / NEPA Review

Prior to the ENF filing, the applicant applied to MEPA for a Special Review Procedure (SRP), which was granted by the Secretary on 6/20/08. This SRP is primarily to facilitate the NEPA/CCC/MEPA process and to identify the Herring River Restoration Committee as a Citizens Advisory Committee that is responsible for assisting with public and agency review and comment. According to the National Park Service, they do anticipate a joint EIR/EIS/DRI filing. The SRP may also enable the regular MEPA timeframes to be adjusted.

PROJECT DESCRIPTION

The proposed project entails the restoration of ecosystem functions and values to a degraded 1,100-acre tidally restricted estuary. The project area is located within the Wellfleet Harbor Area of Critical Environmental Concern. Most of the project area is located within the town of Wellfleet and the boundary of the Cape Cod National Seashore. Should full tidal restoration ultimately be achieved, lands within the town of Truro will be affected as well.

The prime objective of this project is to eventually restore tidal exchange to an extent closely approximating the normal, natural tidal range that occurred prior to diking at Chequessett Neck Road in 1908. Tides will be restored gradually, over a period of several years, with small, incremental opening of adjustable tide gates.

As described in the Conceptual Restoration Plan, the Herring River project comprises the following elements:

- Reconstruction of the existing 1908 dike and tide control structure at Chequessett Neck Road with a new structure, incorporating enlarged culverts and adjustable tide gates designed to allow gradual increases to tidal range.
- Replacement of at least seven additional culverts at road crossings upstream of Chequessett Neck Road to allow increased tidal exchange and better fish passage.

Page 2 of 6

- Raising, relocating, or abandoning up to 22,000 linear feet of low-lying roadway occurring within the Herring River floodplain that are vulnerable to flooding from restored tidal range.
- Removal of approximately 600 acres of woody vegetation that has become established within the Herring River floodplain in order to promote recolonization of salt marsh vegetation and support fish passage coincident with restored tidal range.
- Restoration of natural channel sinuosity in the channelized portions of the Herring River system to enhance wetland habitat functions and abate mosquito production.
- Prevention and/or mitigation of flooding impacts to several private properties within the Herring River floodplain, including structures, developed lands, and domestic water wells.

Four preliminary project alternatives are described in the ENF, including:

1. No action alternative
2. Modified tidegate control at Chequessett Neck Road dike
3. Open bridge with upstream tidegate controls
4. Complete opening of the existing culverts

Ultimately, the Commission should provide comments to MEPA and the Applicant on each of these alternatives in terms of their relative consistency with the RPP.

RPP MINIMUM PERFORMANCE STANDARD CONSISTENCY REVIEW

Staff has considered the project as proposed in the ENF and Conceptual Restoration Plan in the context of the issue areas of the 2002 Regional Policy Plan. **Attachment B (RPP Minimum Performance Standards Relevant for DRI Review, Preliminary Staff Analysis – August 8, 2008)** presents tables that begin to identify the standards that will be relevant to this project review. Based on the information provided to date, staff believes that the issues areas of Water Resources, Coastal Resources, Wetlands, Wildlife and Plant Habitat, and Heritage Preservation are relevant to the project as proposed.

Attachment B provides a list of applicable MPSs, the project's consistency with them, questions/comments to focus analysis, and information requested for DRI review. We expect that as the project alternatives analysis develops this chart will be revised.

CONCLUSION

Commission staff supports the HRRC goal of addressing the tidal restriction in the Herring River system. As the project develops we look forward to reviewing it in the context of the 2002 Barnstable County Regional Policy Plan and working with the Subcommittee throughout the DRI review.

Cc: Gary Joseph, HRRC Chair
c/o Hillary Greenberg
220 West Main St.
Wellfleet, MA 02667

Craig Woods, PWS
The Louis Berger Group
75 Second Ave., Suite 700
Needham, MA 02494

Charlene Greenhalgh, Truro DRI Liaison

Rex Peterson, Wellfleet DRI Liaison

Carrie Phillips
Chief, Natural Resource Management
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

ATTACHMENT A

(Excerpt from Attachment 6: Request of Joint Review/DRI Review from the DRI application)

STEP THREE: JOINT REVIEW OF ACCEPTED APPLICATIONS

ENF Process
Once a Joint Review application has been submitted and accepted, a public hearing/scoping session will be scheduled within 20 days of the publication of the ENF in the *Environmental Monitor* (published by MEPA). The public hearing/scoping session is intended to allow interested persons to comment on the project and is held during the required ENF comment period for the project. Commission staff will prepare a Staff Report in advance of the public hearing/scoping session to provide comment on the project information submitted and contained in the ENF.

Following the public hearing/scoping session, and prior to the ENF comment period ending, the subcommittee will meet to decide on its comments to MEPA. The subcommittee then sends a comment letter to MEPA that includes a recommended scope for the Joint Review process. It should be noted that the Commission's scope of review may be broader than the MEPA jurisdiction.

Following the close of the ENF comment period, the Secretary of Environmental Affairs (Secretary) will issue a certificate for the project. If the Secretary does not require an EIR, the joint Commission/MEPA process concludes. However, the Commission DRI process continues if a mandatory threshold is exceeded and a town referral is received (see Attachment 1 for the applicable DRI review process). If the Secretary requires an EIR, the scope is detailed in the Secretary's certificate and the Joint Review process continues with the preparation of a Draft EIR.

Draft EIR Process
A Draft EIR is prepared and submitted to MEPA that responds to the scope of the Secretary's ENF certificate. The preparer should also submit 12 copies of the Draft EIR to the Commission. The preparer of the Draft EIR should ensure that all materials required for the Commission's DRI review be included in the document based on the ENF scoping letter submitted by the Commission subcommittee. During the public comment period on the Draft EIR, the Commission may hold a public hearing to receive input from the public on the document. Prior to the closing of the public comment period, a Commission subcommittee submits a letter to MEPA commenting on whether the Draft EIR adequately responds to the EIR scope. Following the close of the Draft EIR comment period, the Secretary issues a certificate on the adequacy of the Draft EIR and either requires the preparation of a supplemental Draft EIR or a Final EIR.

Final EIR Process
The proponent prepares a Final EIR that may be limited to aspects of the project or issues that require further description or analysis. The Final EIR also contains a response to comments raised by the Commission and others. The preparer submits the Final EIR to MEPA and 12 copies of the Final EIR to the Commission. During the public comment period for the Final EIR, the Commission may hold a public hearing to receive input from the public on the document. Prior to the closing of the public comment period, a Commission subcommittee will submit a letter to MEPA commenting on whether the Final EIR is adequate. Following the close of the Final EIR

comment period, the Secretary issues a certificate on the adequacy of the Final EIR and either requires the preparation of a supplemental Final EIR or determines the Final EIR to be adequate. Once the Secretary issues a certificate that determines the Final EIR to be adequate, the state environmental review process concludes and the Commission's statutory timeframes begin.

Commission DRI Review Process

The Commission must open a public hearing within 45 days of the date of the certificate issued by the Secretary indicating that the Final EIR is adequate. Additional hearings may be held as necessary throughout the Commission's review process.

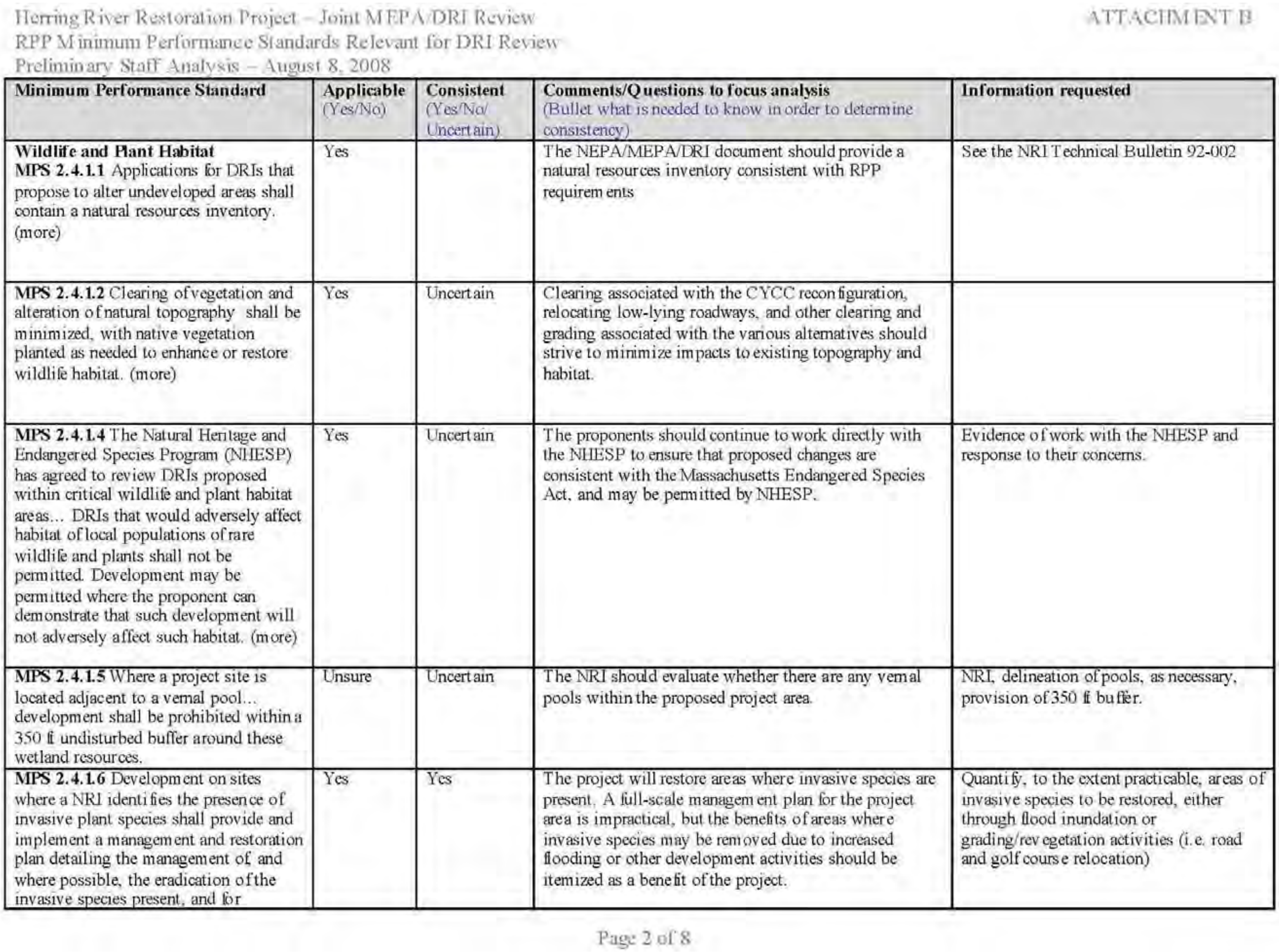
Before a substantive public hearing can be held, all information required for a complete DRI application must be submitted, included in the EIR or waived by the Executive Director. If the DRI application is incomplete at the conclusion of the environmental review process, a hearing officer may be required to open the public hearing for procedural purposes. The required submittals and required number of plans for a DRI application are itemized in "*Attachment 1: DRI Application Filing Procedures & Requirements*" that may be obtained from Commission staff or the Commission's web site (www.capecodcommission.org). Additional information may be required by the Commission to address any remaining issues. The Commission reviews a proposed project for its consistency with the Cape Cod Commission Act, the Regional Policy Plan, Districts of Critical Planning Concern, local regulations, and certified Local Comprehensive Plans.

Herring River Restoration Project – Joint MEPA/DRI Review
RPP Minimum Performance Standards Relevant for DRI Review
Preliminary Staff Analysis – August 8, 2008

ATTACHMENT B

RPP Issue Areas: Wetlands and Wildlife and Plant Habitat

Minimum Performance Standard	Applicable (Yes/No)	Consistent (Yes/No/ Uncertain)	Comments/Questions to focus analysis (Bullet what is needed to know in order to determine consistency)	Information requested
Wetlands **Goal 2.3.1** To preserve and restore the quality and quantity of inland and coastal wetlands	Yes	Yes	While the project will restore various wetland and habitat values, some values will be lost or changed.	Quantify the nature of the changes, positive and negative, by wetland resource area, to the extent possible.
MPS 2.3.1.1 Wetland alteration shall not be permitted except as provided herein and in MPS 2.3.1.3. As an exception, where there is no feasible alternative, water-dependent projects involving wetland alteration with appropriate mitigation may be permitted subject to the approval of all permitting authorities. (more)	Yes	Yes	As a water dependent wetland restoration, this project may likely be found to comply with the standard. But the Commission will have to find that the alteration is the minimum necessary to accomplish the goals of the project, and presumably that the benefits of the restoration outweigh the impacts to the existing functions of the wetlands involved.	Quantify the nature of the changes, positive and negative, by wetland resource area, to the extent possible.
MPS 2.3.1.2 Vegetated, undisturbed buffer areas of at least 100 ft in width shall be maintained and/or provided from the edge of coastal and inland wetlands including isolated wetlands, to protect their natural functions. (more)	Yes	No	While a literal interpretation of this standard will result in noncompliance due to the possible alteration of buffers to wetlands, compliance with the standard may be waived through use of the Flexibility Clause, and/or demonstration that the habitat values have been improved. Mitigation could be required if there is a finding of adverse impacts to buffers.	Quantify the nature of the changes, positive and negative, by wetland resource area, to the extent possible.
ODRP 2.3.1.5 measures to restore altered or degraded inland and coastal wetlands, including… restoration of tidal flushing should be encouraged; however, such areas should not be used as mitigation banking for wetland alteration projects.	Yes	Yes	This standard is not a minimum performance standard, but more of a best management practice. It is included in the RPP as a demonstration of the RPP's support of wetland restoration projects. However, it should be noted that compliance with the MPSs is primary.	Catalogue, consistent with much of the research that has been completed to date, the multiple benefits to ecology, economy, etc. known or expected from the project. To the extent these benefits may be quantified, provide quantities.



Herring River Restoration Project – Joint MEPA/DRI Review
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Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ Uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
Wildlife and Plant Habitat **MPS 2.4.1.1** Applications for DRIs that propose to alter undeveloped areas shall contain a natural resources inventory. (more)	Yes		The NEPA/MEPA/DRI document should provide a natural resources inventory consistent with RPP requirements	See the NRI Technical Bulletin 92-002
MPS 2.4.1.2 Clearing of vegetation and alteration of natural topography shall be minimized, with native vegetation planted as needed to enhance or restore wildlife habitat. (more)	Yes	Uncertain	Clearing associated with the CYCC reconfiguration, relocating low-lying roadways, and other clearing and grading associated with the various alternatives should strive to minimize impacts to existing topography and habitat.	
MPS 2.4.1.4 The Natural Heritage and Endangered Species Program (NHESP) has agreed to review DRIs proposed within critical wildlife and plant habitat areas… DRIs that would adversely affect habitat of local populations of rare wildlife and plants shall not be permitted. Development may be permitted where the proponent can demonstrate that such development will not adversely affect such habitat. (more)	Yes	Uncertain	The proponents should continue to work directly with the NHESP to ensure that proposed changes are consistent with the Massachusetts Endangered Species Act, and may be permitted by NHESP.	Evidence of work with the NHESP and response to their concerns.
MPS 2.4.1.5 Where a project site is located adjacent to a vernal pool… development shall be prohibited within a 350 ft undisturbed buffer around these wetland resources.	Unsure	Uncertain	The NRI should evaluate whether there are any vernal pools within the proposed project area.	NRI, delineation of pools, as necessary, provision of 350 ft buffer.
MPS 2.4.1.6 Development on sites where a NRI identifies the presence of invasive plant species shall provide and implement a management and restoration plan detailing the management of, and where possible, the eradication of the invasive species present, and for	Yes	Yes	The project will restore areas where invasive species are present. A full-scale management plan for the project area is impractical, but the benefits of areas where invasive species may be removed due to increased flooding or other development activities should be itemized as a benefit of the project.	Quantify, to the extent practicable, areas of invasive species to be restored, either through flood inundation or grading/revegetation activities (i.e. road and golf course relocation)

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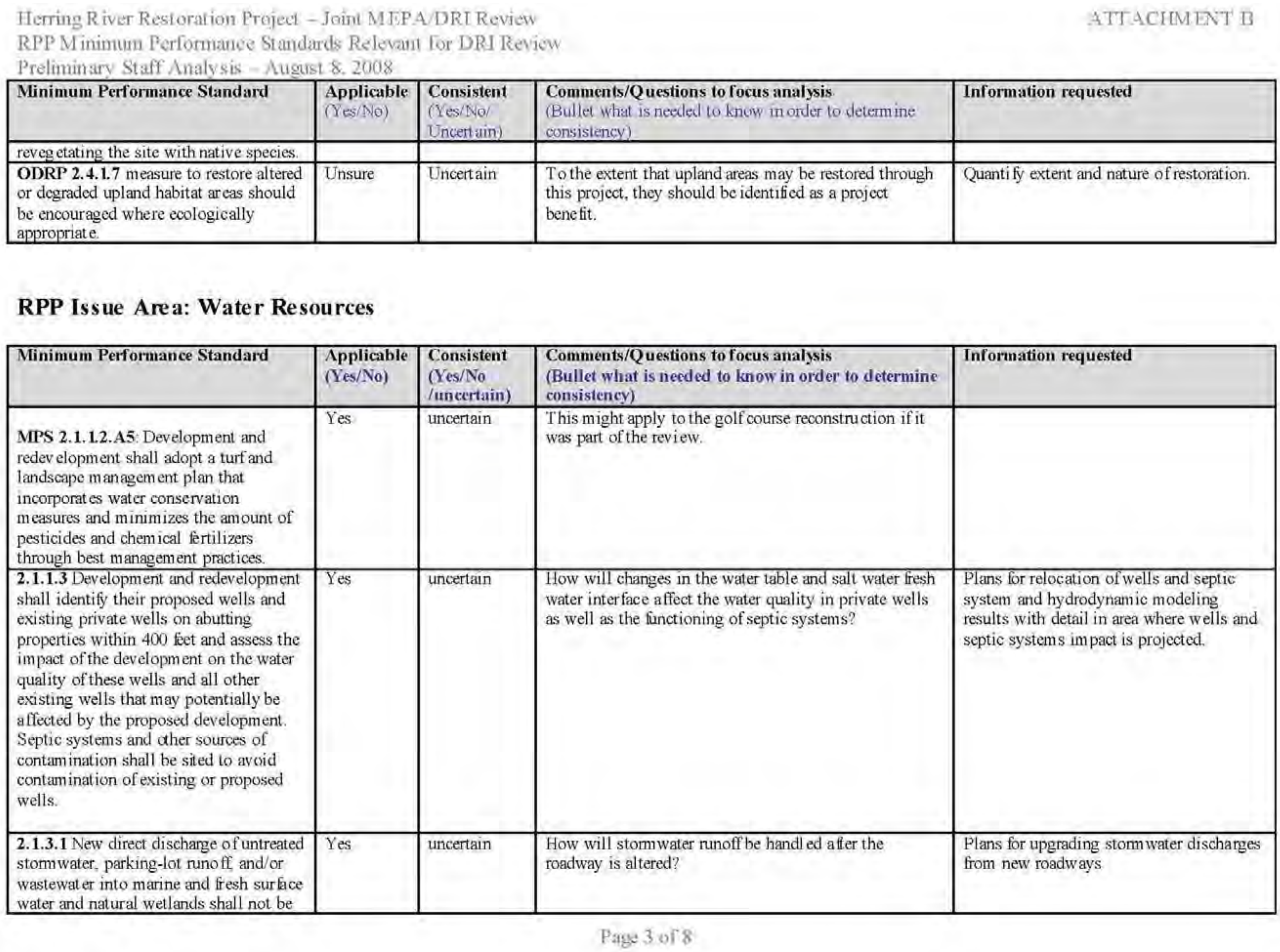

Herring River Restoration Project – Joint MEPA/DRI Review
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Minimum Performance Standard	Applicable (Yes/No)	Consistent (Yes/No/ Uncertain)	Comments/Questions to focus analysis (Bullet what is needed to know in order to determine consistency)	Information requested
revegetating the site with native species.				
ODRP 2.4.1.7 measure to restore altered or degraded upland habitat areas should be encouraged where ecologically appropriate.	Unsure	Uncertain	To the extent that upland areas may be restored through this project, they should be identified as a project benefit.	Quantify extent and nature of restoration.

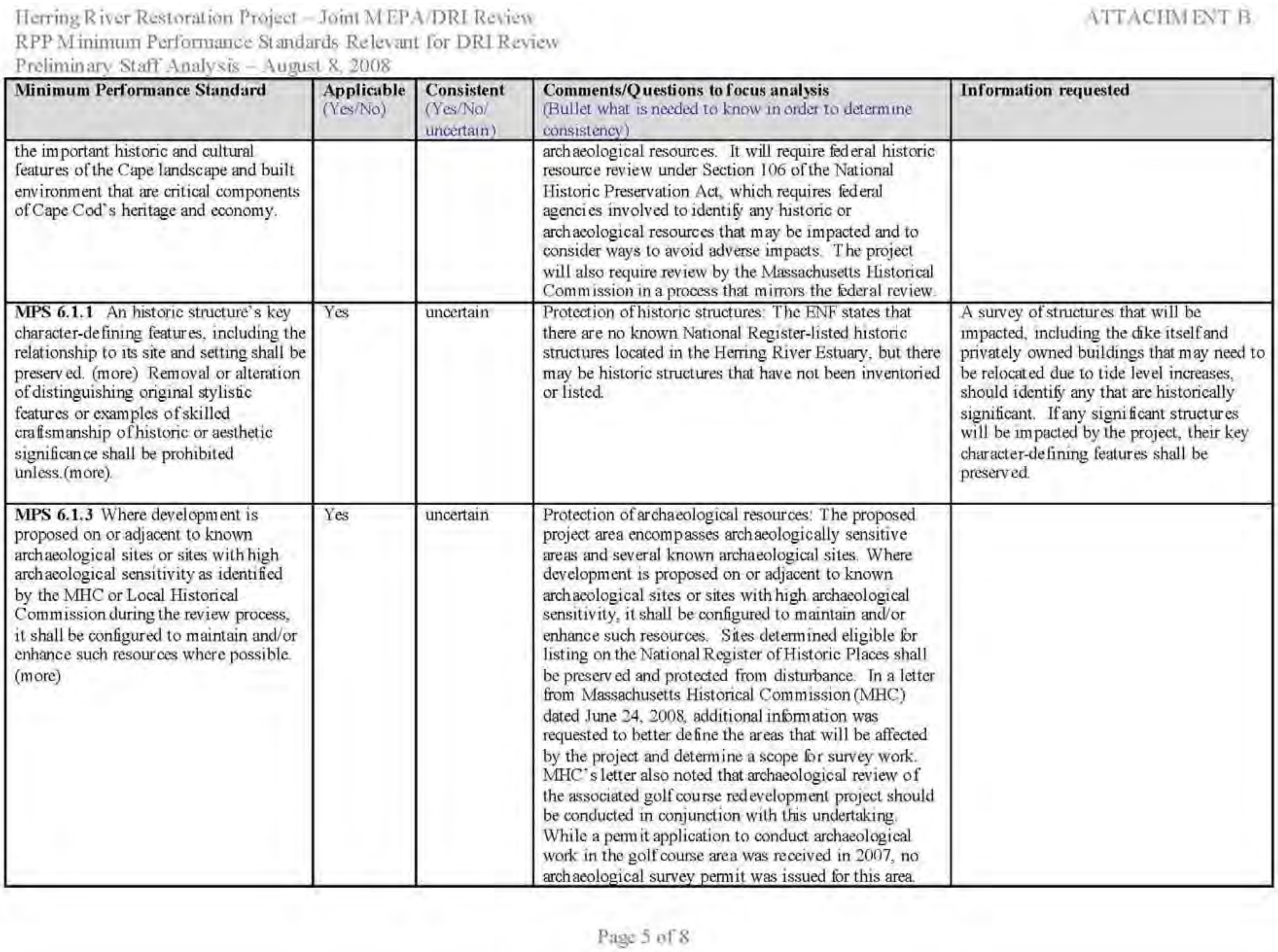
RPP Issue Area: Water Resources

Minimum Performance Standard	Applicable (Yes/No)	Consistent (Yes/No /uncertain)	Comments/Questions to focus analysis (Bullet what is needed to know in order to determine consistency)	Information requested
MPS 2.1.1.2.A5: Development and redevelopment shall adopt a turf and landscape management plan that incorporates water conservation measures and minimizes the amount of pesticides and chemical fertilizers through best management practices.	Yes	uncertain	This might apply to the golf course reconstruction if it was part of the review.	
2.1.1.3 Development and redevelopment shall identify their proposed wells and existing private wells on abutting properties within 400 feet and assess the impact of the development on the water quality of these wells and all other existing wells that may potentially be affected by the proposed development. Septic systems and other sources of contamination shall be sited to avoid contamination of existing or proposed wells.	Yes	uncertain	How will changes in the water table and salt water fresh water interface affect the water quality in private wells as well as the functioning of septic systems?	Plans for relocation of wells and septic system and hydrodynamic modeling results with detail in area where wells and septic systems impact is projected.
2.1.3.1 New direct discharge of untreated stormwater, parking-lot runoff, and/or wastewater into marine and fresh surface water and natural wetlands shall not be	Yes	uncertain	How will stormwater runoff be handled after the roadway is altered?	Plans for upgrading stormwater discharges from new roadways

Minimum Performance Standard	**Applicable (Yes/No)**	**Consistent (Yes/No /uncertain)**	**Comments/Questions to focus analysis (Bullet what is needed to know in order to determine consistency)**	**Information requested**
permitted.				
2.1.3.2 Stormwater shall be managed and infiltrated on site to minimize runoff and maximize water quality treatment. Stormwater treatment designs shall be based upon a 25-year 24-hour storm and attain 80% total suspended solids removal and at a minimum be consistent with Massachusetts Stormwater Policy Guidelines.	Yes	uncertain	What are the specific stormwater disposal designs for the new roadways?	Plans for upgrading stormwater discharges from new roadways
2.1.3.3 Development and redevelopment shall use best management practices such as vegetated swales and non-structured wetland detention basins for treatment prior to infiltration. Non-structured wetland detention basins and vegetated swales may be counted as open space within Wellhead Protection Areas.	Yes	uncertain	What are the specific stormwater disposal designs for the new roadways?	Plans for upgrading stormwater discharges from new roadways
2.1.3.5 Infiltration basins or other stormwater leaching structures shall maintain a two-foot separation between maximum high water table and point of infiltration.	Yes	uncertain	What are the specific stormwater disposal designs for the new roadways? How will the alteration of the water table affect the separation distance from existing stormwater discharge locations.	Plans for upgrading stormwater discharges from new roadways. Results of hydrodynamic modeling in relation to existing and proposed stormwater discharge locations.

RPP Issue Area: Heritage Preservation

Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
RPP Goal 6.1 To protect and preserve	Yes	uncertain	This project may have impacts on historic and	



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Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
the important historic and cultural features of the Cape landscape and built environment that are critical components of Cape Cod's heritage and economy.			archaeological resources. It will require federal historic resource review under Section 106 of the National Historic Preservation Act, which requires federal agencies involved to identify any historic or archaeological resources that may be impacted and to consider ways to avoid adverse impacts. The project will also require review by the Massachusetts Historical Commission in a process that mirrors the federal review.	
MPS 6.1.1 An historic structure's key character-defining features, including the relationship to its site and setting shall be preserved. (more) Removal or alteration of distinguishing original stylistic features or examples of skilled craftsmanship of historic or aesthetic significance shall be prohibited unless.(more).	Yes	uncertain	Protection of historic structures: The ENF states that there are no known National Register-listed historic structures located in the Herring River Estuary, but there may be historic structures that have not been inventoried or listed.	A survey of structures that will be impacted, including the dike itself and privately owned buildings that may need to be relocated due to tide level increases, should identify any that are historically significant. If any significant structures will be impacted by the project, their key character-defining features shall be preserved.
MPS 6.1.3 Where development is proposed on or adjacent to known archaeological sites or sites with high archaeological sensitivity as identified by the MHC or Local Historical Commission during the review process, it shall be configured to maintain and/or enhance such resources where possible. (more)	Yes	uncertain	Protection of archaeological resources: The proposed project area encompasses archaeologically sensitive areas and several known archaeological sites. Where development is proposed on or adjacent to known archaeological sites or sites with high archaeological sensitivity, it shall be configured to maintain and/or enhance such resources. Sites determined eligible for listing on the National Register of Historic Places shall be preserved and protected from disturbance. In a letter from Massachusetts Historical Commission (MHC) dated June 24, 2008, additional information was requested to better define the areas that will be affected by the project and determine a scope for survey work. MHC's letter also noted that archaeological review of the associated golf course redevelopment project should be conducted in conjunction with this undertaking. While a permit application to conduct archaeological work in the golf course area was received in 2007, no archaeological survey permit was issued for this area.	

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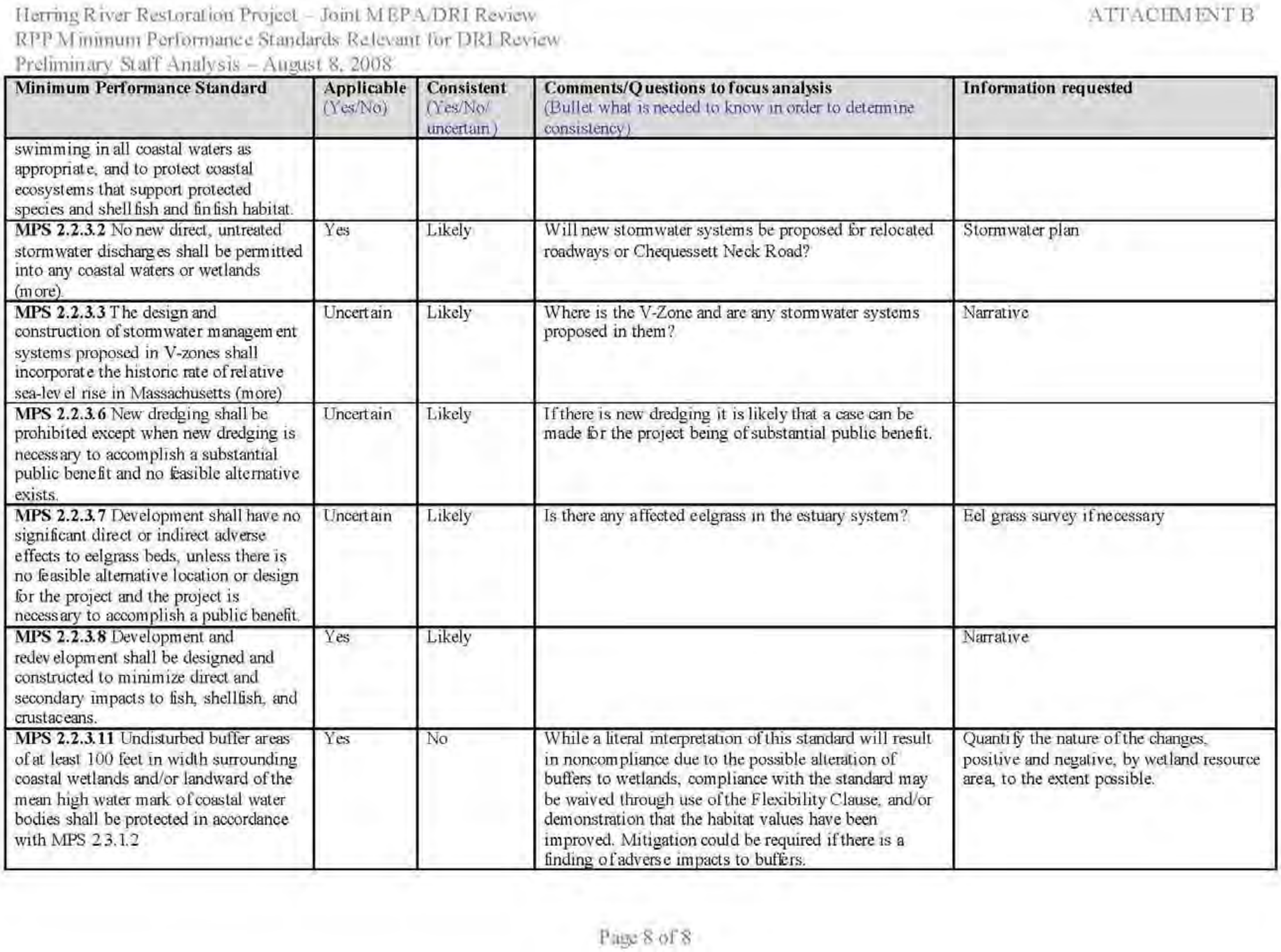
RPP Issue Area: Coastal Resources

Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
Public Access **Coastal Resources Goal 2.2.1:** To protect public and traditional maritime interests in the coast and rights for fishing, fowling, and navigation, to preserve and manage coastal areas so as to safeguard and perpetuate their biological, economic, historic, maritime, and aesthetic values, and to preserve, enhance and where appropriate expand public access to the shoreline.	Yes	Yes	The ENF p.18 discusses public access improvements that will result from this project	
MPS 2.2.1.1 Development and redevelopment along the coastline shall not interfere with existing public access and traditional public rights of way to and environmentally appropriate use of the shoreline.	Yes	Uncertain	Materials indicate that these interests will be expanded. (Conceptual Restoration Plan p. 72-47)	Project plans
ODRPs 2.2.1.5 and 2.2.1.8	Yes	Uncertain	There may be opportunity to enhance public access that should be part of the preferred alternative and project design	Construction design details of dike and Chequessett Neck Road or other locations as appropriate to these ODRPs
Hazard Mitigation **Coastal Resources Goal 2.2.2**: To limit development in areas subject to coastal storm flow, particularly high-hazard areas, in order to minimize human casualties and property or environmental damage resulting from storms, flooding, erosion, and relative sea level rise.	Yes	Uncertain	Restoring the natural floodplain would likely minimize storm-induced damage. However, over time development has occurred in the floodplain upstream of the dike. How will the restoration change flood heights and what development will be affected?	Project plans showing existing and projected flood elevations for each alternative.
MPS 2.2.2.1 – 2.2.2.3 (see text regarding development in flood zones)	Maybe	Uncertain	Depending on where development (Chequessett Neck golf course redevelopment, road relocations, etc) is ultimately proposed, these standards may become relevant	Project plans with resource delineations
MPS 2.2.2.4 No new non-water dependent development shall be	Maybe	Uncertain	Is the CYCC proposed reconfiguration area on coastal bank?	Project plans with resource delineations

Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
permitted within 100 feet of the top of a coastal bank, dune crest, or beach.				
MPS 2.2.2.6 No new public infrastructure or expansion of existing infrastructure shall be made in flood hazard zones unless it is shown that there is an overriding public benefit provided, and provided that such infrastructure will no promote new growth and development in flood hazard areas.	Yes	Likely		
MPS 2.2.2.7 Where land subject to coastal storm flow serves to control floods and prevent storm damage, no activity shall increase the existing site elevations or the velocity of flood waters (more)	Yes	Uncertain	Will fill be needed for any component?	Narrative
MPS 2.2.2.8 New development or redevelopment shall not impede the landward migration of resources areas within the 100-year floodplain (more)	Yes	Likely		
MPS 2.2.2.9 New structures…new or proposed expansions of coastal engineering structures, and new septic systems shall be prohibited within the V zone of a beach, dune, barrier beach, or coastal bank.	Yes	Likely	Would this be considered an expansion of a coastal engineering structure?	Flood zone mapping (existing and projected changes due to increased tidal range) and resource delineation overlay
MPS 2.2.2.11 Monitoring and maintenance plans shall be required of all projects proposing to place dredged material on public or private beaches for nourishment of eroding features. (more)	Maybe	Uncertain	Is there dredging and disposal as part of this proposal? Will there be dredging done that will be considered new/improvement dredging?	Narrative
MPS 2.2.2.12 Wherever feasible dredge materials shall be used for nourishment on public beaches subject to erosion. (more)	Maybe	Uncertain	Is there dredging and disposal as part of this proposal? Will there be dredging done that will be considered new/improvement dredging?	Narrative
Coastal Resources Goal 2.2.3 To maintain and improve coastal water quality to allow shell fishing and/or	Yes	Likely		



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Minimum Performance Standard	**Applicable** (Yes/No)	**Consistent** (Yes/No/ uncertain)	**Comments/Questions to focus analysis** (Bullet what is needed to know in order to determine consistency)	**Information requested**
swimming in all coastal waters as appropriate, and to protect coastal ecosystems that support protected species and shellfish and finfish habitat.				
MPS 2.2.3.2 No new direct, untreated stormwater discharges shall be permitted into any coastal waters or wetlands (more).	Yes	Likely	Will new stormwater systems be proposed for relocated roadways or Chequessett Neck Road?	Stormwater plan
MPS 2.2.3.3 The design and construction of stormwater management systems proposed in V-zones shall incorporate the historic rate of relative sea-level rise in Massachusetts (more)	Uncertain	Likely	Where is the V-Zone and are any stormwater systems proposed in them?	Narrative
MPS 2.2.3.6 New dredging shall be prohibited except when new dredging is necessary to accomplish a substantial public benefit and no feasible alternative exists.	Uncertain	Likely	If there is new dredging it is likely that a case can be made for the project being of substantial public benefit.	
MPS 2.2.3.7 Development shall have no significant direct or indirect adverse effects to eelgrass beds, unless there is no feasible alternative location or design for the project and the project is necessary to accomplish a public benefit.	Uncertain	Likely	Is there any affected eelgrass in the estuary system?	Eel grass survey if necessary
MPS 2.2.3.8 Development and redevelopment shall be designed and constructed to minimize direct and secondary impacts to fish, shellfish, and crustaceans.	Yes	Likely		Narrative
MPS 2.2.3.11 Undisturbed buffer areas of at least 100 feet in width surrounding coastal wetlands and/or landward of the mean high water mark of coastal water bodies shall be protected in accordance with MPS 2.3.1.2	Yes	No	While a literal interpretation of this standard will result in noncompliance due to the possible alteration of buffers to wetlands, compliance with the standard may be waived through use of the Flexibility Clause, and/or demonstration that the habitat values have been improved. Mitigation could be required if there is a finding of adverse impacts to buffers.	Quantify the nature of the changes, positive and negative, by wetland resource area, to the extent possible.

MEMORANDUM

TO: Deirdre Buckley, Environmental Reviewer, MEPA Unit

THROUGH: Jonathan Hobill, Acting Deputy Regional Director,
Bureau of Resource Protection
Brenda Chabot, Deputy Regional Director, ADMIN
David Johnston, Acting Regional Director
Millie Garcia-Serrano, Deputy Regional Director, BWSC

CC: Elizabeth Kouloheras, Chief, Wetlands and
Team Leader, Cape Cod Watershed
Patti Kellogg, Wetlands Cape Cod Watershed Coordinator
Richard Keith, Chief, Municipal Services

FROM: Sharon Stone, SERO MEPA Coordinator

DATE: October 31, 2008

RE: ENF EOEEA #14272 – TRURO/WELLFLEET – Herring River Tidal
Restoration Plan

****

"For Use in Intra-Agency Policy Deliberations"

The Southeast Regional Office of the Department of Environmental Protection (MassDEP) has reviewed the Environmental Notification Form (ENF) for the proposed Herring River Tidal Restoration Plan, to be located in the Towns of Truro and Wellfleet, Massachusetts (EOEEA #14272). The project proponent provides the following information for the project:

"The project consists of the re-establishment of tidal flow to the 1,100-acre Herring River estuary and floodplain. The project is being proposed by the Herring River Restoration Committee (HRRC), a multi-agency group appointed by the Towns of Wellfleet and Truro and the National Seashore. Proposed restoration activities include reconfiguration of the Chequessett Neck Road Dike, replacement of additional upstream culverts, additional upstream tidal control structures and mitigation for low-lying roadways, structures and private properties. Tides will be restored gradually with small, incremental opening of adjustable tide gates.

At a minimum, it is expected that the Herring River project will alter at least one acre of salt marsh or bordering vegetated wetlands, triggering the mandatory EIR threshold described at 310 CMR 11.03(3)(a). Although the exact nature and extent of wetland alteration is unknown at this time, it is likely this threshold will be exceeded to a significant extent. In addition, the project area is known to contain both estimated and priority rare species habitat, is adjacent to significant cultural and historic resources, and is located with the Wellfleet Harbor Area of Critical

Environmental Concern (ACEC). The project will require numerous state permits (Chapter 91 Licenses, 401 Water Quality Certification, etc.) and has already received funding from the Massachusetts Office of Coastal Zone Management's Wetlands Restoration Program. Because the project requires a Chapter 91 License, MEPA jurisdiction is broad in scope and extends all aspects of the project with the potential to cause Damage to the Environment.

The project is also subject to review under the National Environmental Policy Act (NEPA) and the Cape Cod Commission Act. A Certificate Establishing a Special Review Procedure (SRP) was issued on June 20, 2008 to provide for coordination of MEPA review with other environmental and developmental review and permitting processes. The Scoping Session will also serve as a scoping session for the NEPA process and a Cape Cod Commission hearing."

The Cape Cod Watershed Team/Wetlands and Waterways Program has reviewed the document and indicates the following comments.

The project consists of the re-establishment of tidal flow to the 1,100-acre Herring River estuary and floodplain. The project is being proposed by the Herring River Restoration Committee (HRRC), a multi-agency group appointed by the Towns of Wellfleet and Truro and the National Seashore.

Proposed restoration activities include reconfiguration of the Chequessett Neck Road dike, replacement of additional upstream culverts, additional upstream tidal control structures and mitigation for low-lying roadways, structures and private properties. The project area is known to contain both estimated and priority rare species habitat, is adjacent to significant cultural and historic resources, and is located with the Wellfleet Harbor Area of Critical Environmental Concern (ACEC).

The Herring River Conceptual Restoration Plan includes several preliminary alternatives for restoring tidal flow to the Herring River. Therefore, the exact nature and extent of the impacts are not known at this time. However, it is expected that the project will alter at least 1 acre of salt marsh or bordering vegetated wetlands. The alteration of one or more acres of salt marsh or BVW or any alteration requiring a variance in accordance with the Wetlands Protection Act requires a mandatory EIR. Greater detail of the impacts of the alternatives will be required in the EIR.

Several potential plan components could alter coastal and inland wetlands. The project will require numerous state permits including authorization under the WPA, Chapter 91, 401 Water Quality Certification, and compliance with the Town of Wellfleet's Coastal Wetlands Restriction Order [310 CMR 12.00 and MGL c 130 s. 105]. Since the project is located within the Wellfleet Harbor Area of Critical Environmental Concern, the project must meet the standards relative to ACEC in 310 CMR 10.00 and 314 CMR 9.00 and 4.00.

The waters in and adjacent to the Cape Cod National Seashore within 1,000 feet seaward of mean low water are considered outstanding resource waters (ORW) pursuant to 314 CMR 4.06. Should the project result in a discharge to an ORW, a Major 401 Quality Certification will be required. A 401 WQC will require an alternatives analysis demonstrating avoidance, minimization and mitigation of any adverse impacts. Portions of the project are located on lands subject to the Department's Order of Restriction adopted April 19, 1982. This Order contains specific prohibitions, including substantially altering existing patterns of tidal flow. The proponent is advised to contact the Department to conduct a review of the land restricted pursuant to the Order to determine if an amendment or modification to the Order of Restriction is required.

There are known design concerns particularly for low lying roads and properties. Culvert replacements will need to be reviewed and permitted either by the local conservation commission, the Massachusetts Department of Environmental Protection (§401 Water Quality Certification), the US Army Corp of Engineers, or a combination of the three. Additional separate permits may be required for culvert replacements and road relocations. Culverts shall meet the MA Rivers and Stream Crossing Standards and stormwater management standards shall apply to any culvert replacements or road repairs that will result in a stormwater discharge. Higher standards apply to discharges to ORW. A redevelopment project must meet the stormwater standards to the maximum extent practicable.

For work effecting the Riverfront Area (the mouth of the Herring River for Riverfront Area designation is the dike at Chequessett Neck Road), the applicant shall prove by a preponderance of the evidence that there are no practicable and substantially equivalent economic alternatives to the proposed project with less adverse effects on the interests identified in M.G.L. c.131 §40 and that the work, including proposed mitigation, will have no significant adverse impact on the riverfront area to protect the interests identified in M.G.L. c. 131 §40.

As part of the EIR, the proponent should identify the specific resource areas, referenced in 310 CMR 10.25 to 10.35 and 310 CMR 10.54 to 10.57, to be impacted by the project. Evaluation of resource impacts should include the development of a map at an appropriate scale which identifies the square footage and/or linear footage of impacts to each resource area. For each resource area to be impacted by the project, the applicant should identify how the performance standards for each resource area will be achieved. Emphasis should be placed on evaluating the impacts to the flood plain and effects on the interests of the Act, particularly storm damage prevention and flood control. At a minimum, any activity in a resource area or buffer zone shall be designed and constructed using best practical measures so that adverse effects are minimized.

Although projects that restore or rehabilitate a salt marsh or bordering vegetated wetlands may be permitted pursuant to 310 CMR 10.32 (5) and 310 CMR 10.53 (4), projects located within an ACEC are subject to the provisions of 310 CMR 10.24 (5), requiring no adverse effect on the interests of the Act.

If a variance is sought for the application of any regulation, the applicant should be requested to develop the appropriate information necessary to evaluate the criteria to be considered in the issuance of a variance. (See: 310 CMR 10.36 or 310 CMR 10.58.) In order to receive a variance the applicant is required to show that there is an overriding public interest in the project, that no other reasonable alternative exists, and that mitigation efforts will be undertaken to minimize the project impacts.

The applicant should also be required to identify and discuss all reasonable alternatives which have been considered for the present project in order to avoid wetland impacts. The Applicant should be required to state why those alternatives which meet performance standards have been found to be unreasonable or why the alternatives which do not meet performance standards are less desirable for wetlands protection than the proposed alternative.

Finally, the Applicant should be required to provide a full description of the mitigation measures which are proposed for this project. The discussion of mitigation measures should detail the extent of wetlands resource impacts, the functions associated with those resources, and the mitigation measures which will minimize resource impacts and/or restore resource functions.

The applicant should be advised that if the above information is not thoroughly presented as part of the EIR process, the request for this information will be required as part of the variance review process by the Department of Environmental Protection. Since the issuance of variance decisions has, in the past, taken considerable time, it is critical that the applicant consider the standards for a variance and address informational requirements during the project planning process. The incorporation of the above information in the EIR process will save the applicant considerable time and may save the cost of the variance filing fee if a variance does not appear likely following the full assessment of the project as part of the EIR.

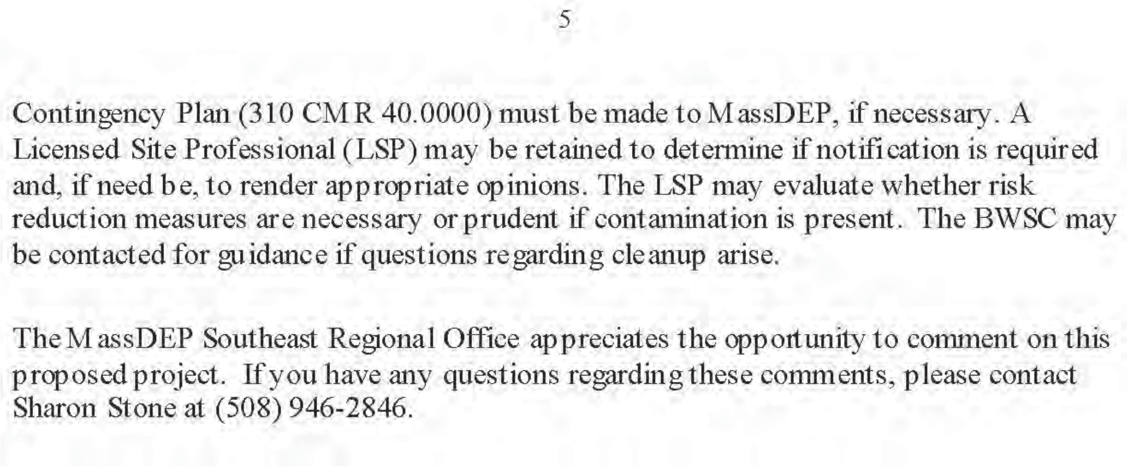
Construction Activities - EPA

The project construction activities may disturb one or more acres of land and therefore, may require a NPDES Stormwater Permit for Construction Activities. The proponent can access information regarding the NPDES Stormwater requirements and an application for the Construction General Permit at the EPA website: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm

BWSC Comments

Based on the information provided in the ENF, the Bureau of Waste Site Cleanup (BWSC) searched its database for disposal sites and release notifications. There is one former disposal site located in the vicinity of the project. Release Tracking Number (RTN) 4-16352, located at the Chequessett Brush Dump Area, submitted a Class A2 RAO on November 14, 2001.

The Project Proponent is advised that, if oil and/or hazardous material is identified during the implementation of this project, notification pursuant to the Massachusetts



Contingency Plan (310 CMR 40.0000) must be made to MassDEP, if necessary. A Licensed Site Professional (LSP) may be retained to determine if notification is required and, if need be, to render appropriate opinions. The LSP may evaluate whether risk reduction measures are necessary or prudent if contamination is present. The BWSC may be contacted for guidance if questions regarding cleanup arise.

The MassDEP Southeast Regional Office appreciates the opportunity to comment on this proposed project. If you have any questions regarding these comments, please contact Sharon Stone at (508) 946-2846.

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
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November 7, 2008

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS ON THE ENVIRONMENTAL NOTIFICATION FORM

PROJECT NAME : Herring River Restoration Project
PROJECT MUNICIPALITY : Wellfleet and Truro
PROJECT WATERSHED : Cape Cod
EOEA NUMBER : 14272
PROJECT PROPONENT : Town of Wellfleet, Town of Truro and Cape Cod National Seashore
DATE NOTICED IN MONITOR : July 23, 2008

Pursuant to the Massachusetts Environmental Policy Act (G. L. c. 30, ss. 61-62I) and Section 11.06 of the MEPA regulations (301 CMR 11.00), I hereby determine that this project **requires** the preparation of an Environmental Impact Report (EIR).

This project has the potential to re-introduce up to 1,000 acres of salt marsh to the Herring River floodplain and estuary. This is the largest salt marsh restoration project in Massachusetts and represents an ambitious undertaking by the Cape Cod National Seashore (CCNS), the Town of Wellfleet and the Town of Truro. The Nature Conservancy and Mass Audubon have expressed their strong support for the project. Comments on the project, including comments from the US Environmental Protection Agency (EPA), the Natural Heritage and Endangered Species Program (NHESP) and the Areas of Critical Environmental Concern (ACEC) Program and other state resource agencies, identify support for the goals of the project. Comments from residents that could be affected by the project stress the importance of planning the project carefully to avoid unintended consequences and to minimize impacts of the project on private property.

Project Description

The project consists of the re-establishment of tidal flow to the 1,100-acre Herring River estuary and floodplain to an extent closely approximating the natural tidal range that occurred prior to diking at the Chequesset Neck Road. The ecological goal of the project is to restore the full natural tidal range throughout as much of the Herring River floodplain as practicable, including up to the 100-year flood level (9.1 feet NAVD88). In certain areas where tidal flooding must be limited to protect existing land uses, the goal is to restore the maximum high tide up to the mean spring high-tide level (9.1 feet NAVD88). The project proponents plan to use an adaptive management strategy to restore tides gradually with small, incremental openings of adjustable tide gates over a period of several years allowing floodplain characteristics to be monitored and adjusted in response to these actions.

Project planning has been guided by the Herring River Restoration Committee (HRRC), a multi-agency group appointed by the towns of Wellfleet and Truro and the CCNS. The HRRC, with input from stakeholders, prepared the Herring River Conceptual Restoration Plan (November 2007) which was provided to the MEPA Office as a supplement to the ENF.

Proposed restoration activities include reconfiguration of the Chequessett Neck Road dike, replacement of additional upstream culverts, additional upstream tidal control structures and mitigation for low-lying roadways, structures and private properties.

The ENF indicates that the project will include some or all of the following activities:

- Reconstruction of the existing dike and tide control structure at Chequessett Neck Road.
- Construction of several tidegate control structures upstream of Chequessett Neck Road to protect existing land uses.
- Replacement of several culverts upstream of Chequessett Neck Road to allow increased tidal exchange and better fish passage.
- Reconfiguration of the CYCC golf course to maintain a playable layout given increased tide heights.
- Raising, relocating, or removing up to 22,000 linear feet of low-lying roadway occurring within the Herring River floodplain which would be vulnerable to flooding from a restored tidal range.
- Removal of approximately 600 acres of woody vegetation that has become established within the Herring River floodplain in order to promote recolonization of salt marsh vegetation and support fish passage coincident with restored tidal range.
- Restoration of natural channel sinuosity to enhance wetland habitat functions and abate mosquito production.
- Prevention and/or mitigation of flooding impacts to several private properties within the Herring River floodplain, including structures and domestic water wells.
- Public access improvements including additional canoe/kayak put-in locations and fishing piers.

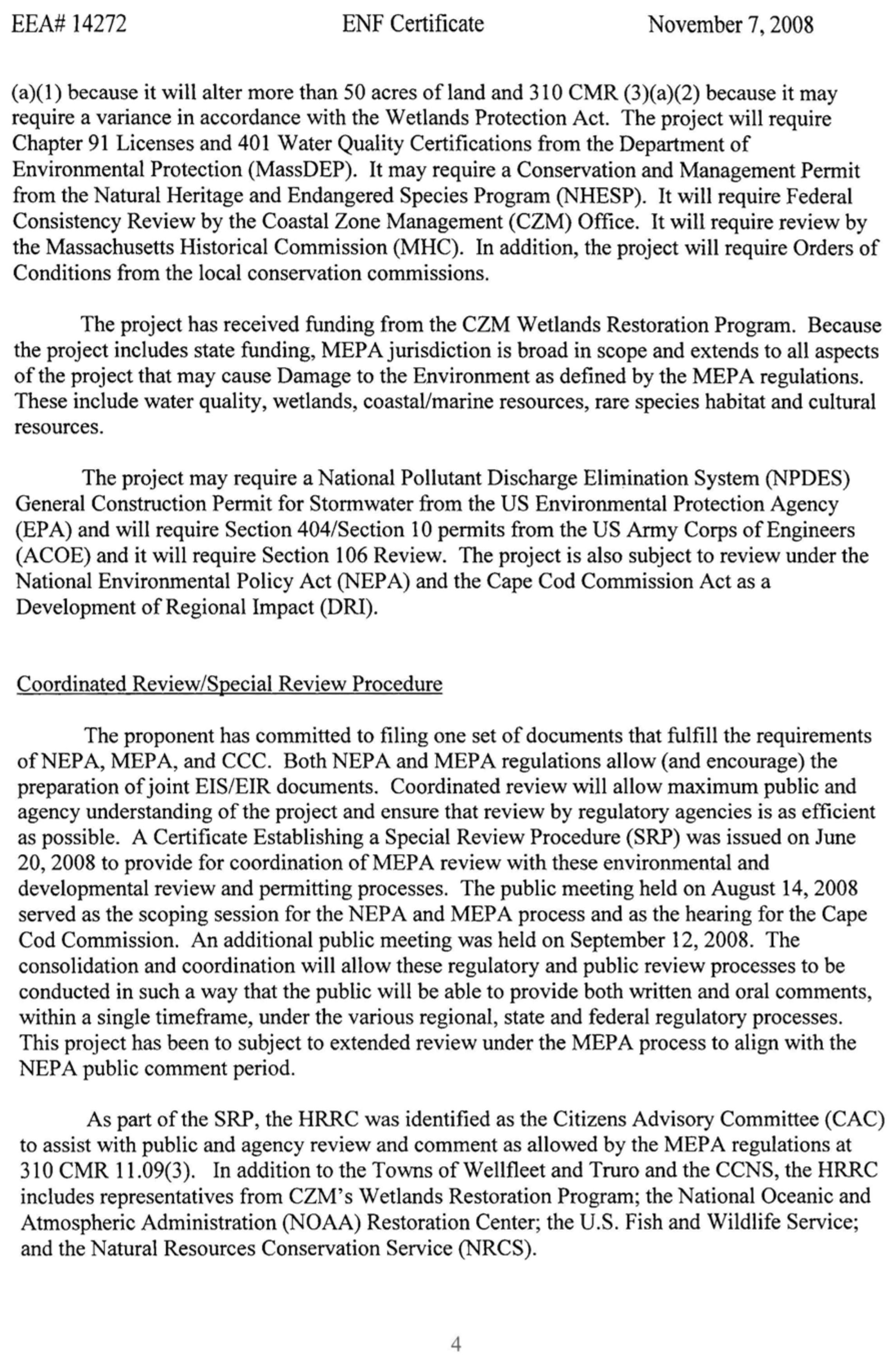
Project Site

The project site includes the Herring River floodplain within Wellfleet and Truro. The Herring River extends from Wellfleet Harbor at the Chequesset Neck Road dike northeast about four miles to Herring Pond in Wellfleet, and to the northwest a similar distance to Ryder Beach in south Truro. Approximately 80% of the floodplain is within and is managed by the CCNS. The Chequesset Neck Dike, which was constructed in 1908, consists of three 6-foot wide culverts, two of which allow river outflow into Wellfleet Harbor, but block the inflow of seawater, while the third has a partially open sluice gate that allows some inflow of seawater. According to the ENF, the estuary was dominated by healthy and highly productive salt marsh plant communities prior to the construction of the dike. The result of the diking and subsequent drainage of the estuary has led to the conversion of hundreds of acres of intertidal salt marsh to upland vegetation, eliminating habitat for estuarine animals, including shellfish and finfish. Approximately 13.6 acres of saltmarsh remain upstream of the dike. In addition, surface waters have been acidified, toxic metals have been leached from native clays, and dissolved oxygen depletions are common, which have contributed to fish kills in the river. The dike has restricted the normal tidal range of 10 feet (ranging from 5 below to 5 feet above NAVD88) within Wellfleet Harbor just seaward of the dike to approximately 2 feet (ranging from 1.1 feet below to .9 feet above NAVD88) above the dike. Drainage has caused the wetlands upstream of the dike to subside by nearly 3 feet.

The project area contains both estimated and priority rare species habitat, contains important fisheries and shellfishery resources, is adjacent to significant cultural and historic resources, and is located with the Wellfleet Harbor Area of Critical Environmental Concern (ACEC). According to the NHESP 13th Edition of the MA Natural Heritage Atlas, the project will occur within or in the vicinity of the habitat of the following state-listed species: Roseate Tern (*Sterna dougallii),* Common Tern (*Sterna hirundo*), Northern Harrier (*Circus cyaneus*), Piping Plover (*Charadrius melodus*), Eastern Box Turtle (*Terrapene carolina*), Diamond-backed Terrapin (*Malaclemys terrapin*), EasternSpadefoot (*Scaphiopus holbrookii*), Gerhard's Underwing Moth (*Catocala herodias gerhardi*), Water-Willow Stem Borer (*Papaipema sulphurata*) and Broom Crowberry (*Corema conradii*). Diadromous fish species (Alewife and Blueback herring) use all or part of the river for passage, spawning, nursery and forage habitat. Various life stages of numerous other finfish species transit and/or inhabit the river during the year including American eel, white perch and lamprey. Oyster beds are located within the Herring River and seaward of the Chequesset Neck Road Dike. The ENF indicates that the project area is adjacent to and includes significant cultural resources. In addition, the project area includes private property including the CYCC and private residences.

Permits and Jurisdiction

At a minimum, it is expected that the Herring River project will alter at least one acre of salt marsh or bordering vegetated wetlands (BVW), triggering the mandatory EIR threshold described at 310 CMR 11.03(3)(a). The exact nature and extent of wetland alteration is unknown at this time; however, it is likely this threshold will be exceeded to a significant extent. In addition, the project may exceed other mandatory EIR thresholds including 310 CMR 11.03



(a)(1) because it will alter more than 50 acres of land and 310 CMR (3)(a)(2) because it may require a variance in accordance with the Wetlands Protection Act. The project will require Chapter 91 Licenses and 401 Water Quality Certifications from the Department of Environmental Protection (MassDEP). It may require a Conservation and Management Permit from the Natural Heritage and Endangered Species Program (NHESP). It will require Federal Consistency Review by the Coastal Zone Management (CZM) Office. It will require review by the Massachusetts Historical Commission (MHC). In addition, the project will require Orders of Conditions from the local conservation commissions.

The project has received funding from the CZM Wetlands Restoration Program. Because the project includes state funding, MEPA jurisdiction is broad in scope and extends to all aspects of the project that may cause Damage to the Environment as defined by the MEPA regulations. These include water quality, wetlands, coastal/marine resources, rare species habitat and cultural resources.

The project may require a National Pollutant Discharge Elimination System (NPDES) General Construction Permit for Stormwater from the US Environmental Protection Agency (EPA) and will require Section 404/Section 10 permits from the US Army Corps of Engineers (ACOE) and it will require Section 106 Review. The project is also subject to review under the National Environmental Policy Act (NEPA) and the Cape Cod Commission Act as a Development of Regional Impact (DRI).

Coordinated Review/Special Review Procedure

The proponent has committed to filing one set of documents that fulfill the requirements of NEPA, MEPA, and CCC. Both NEPA and MEPA regulations allow (and encourage) the preparation of joint EIS/EIR documents. Coordinated review will allow maximum public and agency understanding of the project and ensure that review by regulatory agencies is as efficient as possible. A Certificate Establishing a Special Review Procedure (SRP) was issued on June 20, 2008 to provide for coordination of MEPA review with these environmental and developmental review and permitting processes. The public meeting held on August 14, 2008 served as the scoping session for the NEPA and MEPA process and as the hearing for the Cape Cod Commission. An additional public meeting was held on September 12, 2008. The consolidation and coordination will allow these regulatory and public review processes to be conducted in such a way that the public will be able to provide both written and oral comments, within a single timeframe, under the various regional, state and federal regulatory processes. This project has been to subject to extended review under the MEPA process to align with the NEPA public comment period.

As part of the SRP, the HRRC was identified as the Citizens Advisory Committee (CAC) to assist with public and agency review and comment as allowed by the MEPA regulations at 310 CMR 11.09(3). In addition to the Towns of Wellfleet and Truro and the CCNS, the HRRC includes representatives from CZM's Wetlands Restoration Program; the National Oceanic and Atmospheric Administration (NOAA) Restoration Center; the U.S. Fish and Wildlife Service; and the Natural Resources Conservation Service (NRCS).

In addition, the SRP waived the specific requirement to submit the form usually required as part of the Environmental Notification Form (ENF) submission. The ENF submitted on this project summarizes basic information regarding the project, including a narrative that identifies how and to what extent the project may exceed each of the review thresholds.

SCOPE

The EIR should follow the general guidance for outline and content contained in section 11.07 of the MEPA regulations, as modified by this Certificate. The Cape Cod Commission provided a comment letter on this project identifying information that will be relevant to this project's review as a DRI. Because the proponent will file a Draft EIR/EIS/DRI, I am incorporating the comment letter from the CCC into the Scope by reference.

Project Description

The Draft EIR should include a thorough description of the project and all project elements and construction phases. The Draft EIR should include an existing conditions plan illustrating resources, including the existing floodplain, structures and abutting land uses for the entire project area and a proposed conditions plan (or plans) illustrating proposed floodplain elevations, structures and access roads. The Draft EIR should include sufficient baseline data to allow a full characterization of existing conditions and natural resources and support a meaningful analysis of feasible alternatives. The Draft EIR should identify all project related activities including structural modifications, dredging, fill and removal of vegetation. The Draft EIR should identify where and how public access will be improved or introduced.

Project Permitting and Consistency

The Draft EIR should briefly describe state permits required for the project and should describe how the project will meet applicable performance standards or where regulatory flexibility will be requested based on the stated public purpose of the project. In accordance with section 11.01 (3)(a) of the MEPA regulations, the Draft EIR should discuss the consistency of the project with any applicable local or regional land use plans. The Draft EIR should also address the requirements of Executive Order 385 (Planning for Growth).

I am recommending the formation of a Technical Working Group (TWG), comprised of state and federal agency representatives, to support effective and coordinated consultation throughout the review of this project. The TWG will assist the proponent in developing appropriate study methodologies and protocols and should review interim studies, plans and analysis prior to inclusion in the Draft EIR to ensure that the proponent's efforts adequately address the analysis and data requirements of required permits and approvals. In addition, the TWG should assist in the development of benchmarks and criteria for environmental monitoring. Representatives from CZM, Division of Marine Fisheries (DMF), NHESP, ACEC Program, MassDEP, MHC and representatives from EPA and US ACOE will be asked to participate in the TWG.

Adaptive Management/Environmental Monitoring

The ENF indicates that tidal restoration will be restored gradually over time using an adaptive management approach that relies on iterative, science-based and incremental management decisions. The nature and timing of specific activities will be implemented based on the results of environmental monitoring and the response of the ecosystem to tidal flow as well as technical and public review of project progress. This project will include major project elements such as redesign of the Chequesset Neck Road opening to the Herring River and many discrete elements that will include installation of new tidal controls, replacement or maintenance of existing culverts and tidal controls, reconstruction, or realignment of roadways and management of vegetation. The environmental review of this project may result in phasing of the project into a number of coordinated but discrete actions that will be implemented based on adaptive management as well as funding availability and other factors.

The Draft EIR should identify how adaptive management will be employed throughout the project and include a comprehensive Environmental Management Plan that incorporates a monitoring program for pre-construction, construction and post-constructions phases that will provide sufficient information to adequately assess progress towards project goals, identify impacts and inform the development of adaptive management strategies. The Plan should identify what will be monitored, how monitoring will be conducted and the proposed duration of monitoring. At a minimum, monitoring should include water quality, rare species, fisheries, shellfish, sediment transport and vegetation.

At this conceptual stage of the project while several distinct alternatives are under consideration, it would be premature to establish phasing; however, once a Preferred Alternative is identified and phasing can be considered in more detail, the SRP may be amended to establish a process for subsequent review within an adaptive management framework under the aegis of the CAC/HRRC.

Alternatives Analysis

As noted previously, this project has the potential to restore up to 1,100 acres of salt marsh. It is a large and ambitious undertaking. Although this is an environmental restoration project and its clear intention is to improve and strengthen the ecosystem of the Herring River, MEPA imposes a requirement on project proponents to understand and fully disclose the potential impacts of a project, both positive and negative; to study feasible alternatives to a project; and to avoid, reduce, or mitigate environmental impacts to the maximum extent feasible. The environmental review process should create a strong foundation for planning and implementation of this project. The review will include consideration of alternatives to achieve the project goals and will require a straightforward analysis of environmental impacts and benefits.

The primary emphasis of the Draft EIR will be to evaluate potential alternatives. The alternatives analysis should identify benefits, impacts and mitigation associated with each alternative and provide information, data and analysis necessary for state resource agencies to evaluate the alternatives. Various regulatory programs may require the submission of an alternatives analysis as part of permitting or as a requirement for regulatory flexibility. I encourage the proponent to prepare the alternatives analysis so that it will address the needs of these regulatory processes. If a Preferred Alternative is identified in the Draft EIR, the Draft EIR should provide adequate information to support this selection and discuss mitigation approaches.

The Draft EIR should evaluate the following four alternatives:

No Action Alternative: Existing tidegates would remain in place and tide levels would be managed under existing conditions.

Modified Tidegate Control at Chequesset Neck Road: Existing dike would be replaced with a new structure with an opening 100 – 130 feet wide consisting of culverts arch spans or a bridge. The structure would be fitted with sluice gates to allow full tidal control and management.

Open Bridge with Upstream Tidegate Controls: An open bridge span would be constructed at the site of the Chequesset Neck Road dike. The bridge would not have any tidal control. Tidal control would be established at upstream locations with several smaller structures to regulate the limit of tidal flooding.

Hybrid of Modified Tidegate Control at Chequesset Neck Road with Upstream Tidegate Controls: A combination of controlling tides at the neck of the river and at upstream locations.

The Draft EIR should investigate all feasible methods of restoring salt marsh while avoiding, reducing or minimizing negative impacts, in particular impacts to private properties. The alternative analysis should include a clear comparison (quantified to the extent feasible) of the impacts of each alternative and its project components. For each alternative, the Draft EIR should quantify the amount of land altered, quantify the amount of impervious surfaces created, quantify wetlands impacts, identify impacts to rare species, identify associated dredging and identify impacts to cultural resources. The Draft EIR indicates that two-dimensional hydraulic/hydrologic modeling will be used to analyze alternatives. The results of the modeling should be included in the Draft EIR including the tidal ranges, expansion of the floodplain, salinities and velocities at road crossings and other impediments to tidal exchange. The Draft EIR should identify criteria that will be used to select a Preferred Alternative and the Draft EIR should clearly explain why certain alternatives are selected and others ruled out for further consideration. The Draft EIR should fully explain any trade-offs inherent in the alternatives analysis, such as increased impacts on some resources to avoid impacts to other resources.

The alternatives analysis should identify alternatives for avoiding impacts to private properties within each sub-basin. In particular, it should include a detailed discussion of alternatives for addressing the Chequessett Yacht and Country Club (CYCC) golf course which is located in Mill Creek adjacent to the Chequessett Neck Road dike. Portions of five holes within this nine-hole golf course were constructed in the floodplain. The majority of comments made during public meetings identify concerns with the impact of this project on the CYCC. Commentors have requested that these impacts be carefully evaluated and that the proponent work cooperatively with the CYCC to identify alternatives. In addition, some comments identify efforts the CYCC has made to address this problem and identify alternatives. The ENF indicates that the proponent and CYCC have discussed several potential alternatives including filling of this area to raise it above the floodplain or re-location of holes within land owned by the CYCC. The alternatives must consider and balance the private property concerns of the CYCC with potential impacts to wetlands, historic resources and rare species habitat.

The ENF indicates that several structures, wells and septic systems are located on private property and are at elevations low enough to be directly affected by tidal restoration up to the spring high tide elevation of 5.1 feet (NAVD88). The Draft EIR should address alternatives that will protect structures, public and private water supplies and septic systems from flooding and/or saltwater intrusion.

Land Alteration

The Draft EIR should quantify the amount of land alteration associated with the project. The Draft EIR should clearly identify how land will be altered, where vegetation will require removal and identify objectives and measures that will be included in the vegetation management program to minimize impacts and maximize the effectiveness of the project.

Wetlands

Wetlands impacts will include alterations to wetland resources associated with construction, reconstruction or maintenance of structural elements of the project and impacts associated with the introduction of tidal flow. The re-introduction of tidal flow will convert some wetland resource areas such as upland wetlands to salt marsh and introduce wetland resources to areas that are currently non-jurisdictional.

The Draft EIR should characterize wetland resources throughout the site, identify and quantify wetland alterations associated with each alternative and identify how negative impacts will be minimized consistent with the Performance Standards of the Wetlands Regulations (310 CMR 10.00). The Draft EIR should include plans at an appropriate scale that illustrate impacts to resource areas. The analysis should demonstrate how the project will support the interests of the Wetlands Protection Act and how it may impact those interests, particularly storm damage prevention and flood control. In addition, the Draft EIR should illustrate where new resource areas will be created and identify associated buffer zones. The proponent should consult with the

TWG and the Wellfleet and the Truro Conservation Commissions regarding the preparation of wetlands information for the Draft EIR.

MassDEP comments indicate that portions of the project are located on lands subject to the Town of Wellfleet's Coastal Wetlands Restriction Order (310 CMR 12.00 and MGL c 130 s. 105) adopted April 19, 1982. This Order contains specific prohibitions, including substantially altering existing patterns of tidal flow. The proponent should consult with MassDEP to conduct a review of the land restricted pursuant to the Order and to determine if an amendment or modification to the Order of Restriction is required.

If MassDEP determines that the project requires a variance in accordance with the Wetlands Protection Act or the proponent chooses to seek a variance, the Draft EIR should provide the information required as part of a variance request. This includes:

1. a description of alternatives explored that would allow the project to proceed in compliance with 310 CMR 10.21 through 10.60 and an explanation of why each is unreasonable;
2. a description of the mitigating measures to be used to contribute to the protection of the interests identified in M.G.L. c. 131, § 40; and
3. evidence that an overriding public interest is associated with the project which justifies waiver of 310 CMR 10.21 through 10.60.

MassDEP comments identify additional regulatory requirements the project may be subject to. The proponent should carefully review the MassDEP comment letter and take note of the requirements and standards identified within it.

Tidelands/Chapter 91

The reconstruction of the existing dike and upstream culvert crossing will likely require Chapter 91 licenses. The Draft EIR should identify project elements associated with each alternative that would require Chapter 91 licensing. The Draft EIR should include an analysis of the project's compliance with the Waterways Regulations. The Draft EIR should assess the project's impacts, positive and negative, on the public's right to access, use and enjoy tidelands that are protected by Chapter 91 and identify measures to avoid, minimize or mitigate any adverse impact on these rights.

Pursuant to Chapter 168 of the Acts of 2007, I am required to conduct a public benefit review for this project because it requires a license under Section 18 of Chapter 91 and is required to file an EIR. The Draft EIR should include detailed information concerning benefits to the public trust rights in tidelands or other associated rights, including but not limited to, benefits provided though community activities on site, environmental protection and preservation, public health and safety and the general welfare. In weighing the benefit to the public trust rights in tidelands, I will apply a preference for a benefit on-site that promotes access to, and use and enjoyment of, the waterfront.

Dredging

The Draft EIR should identify any dredging associated with project alternatives, estimate the amount of material to be dredged and describe the soils to be dredged. Potential impacts associated with dredging and fill activities include increased turbidity, mobilization of pollutants and downstream sediment deposition. It should identify measures that can be employed to avoid release of sediments into the river environment and to protect downstream shellfish beds.

Rare Species/Wildlife Habitat

As noted previously, the site includes habitat for many rare species. Restoration of salt marsh will alter habitats for some of these species and expand habitat for others. Comments from NHESP indicate that portions of the proposed project may qualify for a Habitat Management Exemption in accordance with the Massachusetts Endangered Species Act (MESA) (321 CMR 10.14 (11)), while other portions may require a Conservation & Management Permit. The Draft EIR should include detailed hydrologic/hydraulic models and impact analyses for all proposed alternatives to assist the NHESP in making a determination regarding the appropriate approach to permitting. Analyses should address impacts to state-listed species for both the proposed restoration efforts, as well as for any associated upland projects such as the relocation of roads or relocation of the CYCC holes. The Draft EIR should address how each alternative could be designed to avoid, minimize, and mitigate impacts to state-listed species. The proponent should consult with NHESP through the TWG regarding permitting approaches and the development of additional rare species surveys.

The Draft EIR should identify how overall habitat within the floodplain will be monitored and evaluated consistent with adaptive management goals.

Fisheries

This section should summarize the benefits of the project to fisheries and shellfish and provide projections regarding growth. It should identify temporary impacts to fish and shellfish during construction and identify measures to avoid, minimize and mitigate these impacts, including consideration of time-of-year (TOY) restrictions identified by the Division of Marine Fisheries (DMF). It should identify how restoration of tidal flow to the Herring River at Chequesset Neck Road will be designed to optimize fish passage.

Water Quality

The Draft EIR should identify baseline water quality data that measures salinity, pH and metals, dissolved oxygen and fecal coliform, identify how project alternatives will affect water quality and identify how water quality will be monitored. The Draft EIR should identify impacts on public and private water supplies and septic systems associated with each alternative. It should provide a more detailed discussion of the relationship between the restoration of tidal flow and groundwater. The Draft EIR should identify how the project will be conducted consistent with water quality standards associated with the 401 Water Quality Certification. In addition, the Draft EIR should discuss short- and long-term changes in rates and volumes of sediment transport associated with each alternative and related impacts on the river and the harbor.

Historic/Archaeological Impacts

The Draft EIR should identify historic properties and archaeological sites within the project area and its vicinity and identify potential impacts to these sites. MHC comments indicate that it will consult with the National Park Service (NPS) under Section 106 of the National Historic Preservation Act of 1966 during their review of the project under NEPA regarding the scope of work for the cultural resources survey and development of the area of potential effect (APE) for this project. Also, MHC comments indicate that it previously reviewed a portion of this project in 2006 and 2007 including a Project Notification Form (PNF) for the CYCC redevelopment and indicate that any redevelopment of the CYCC will be reviewed as part of the Herring River Restoration Project.

Greenhouse Gas Emissions

The project is subject to the EEA Greenhouse Gas Policy and Protocol because it requires an EIR and MEPA has full scope jurisdiction. This is an environmental restoration project that will not result in the emissions of Greenhouse Gases (GHG) and therefore falls within the de minimis exception of the policy. The proponent is not required to prepare an analysis of GHG emissions or identify measures to mitigate GHG emissions. The ENF indicates that the project will serve to minimize the impacts of climate change by providing additional protection from flooding and storm surges and expanding habitat for wildlife. In addition, the structure at Chequesset Neck could be designed to incorporate tidal power. The Draft EIR should identify how the impacts of climate change, including sea level rise, are being incorporated into the analysis of this project, how the project will provide protection from the impacts of climate change and whether the Chequesset Neck Dike could be designed to incorporate tidal power while balancing other project goals including improved habitat for fisheries and recreational access.

Construction Period Impacts

The Draft EIR should include a discussion of construction phasing, evaluate potential impacts associated with construction activities and propose feasible measures to avoid or eliminate these impacts. The proponent should implement measures to alleviate dust, noise, and odor nuisance conditions, which may occur during the construction activities.

Mitigation

The Draft EIR should include a separate chapter on mitigation measures. This section should form the basis of the proposed Section 61 Findings that will be presented in the Final EIR. Draft Section 61 Findings for all state permits should include a clear commitment to mitigation, an estimate of the individual costs of the proposed mitigation, the identification of the parties responsible for implementing the mitigation and a schedule for the implementation of mitigation, based on the construction phasing of the project.

Comments

To ensure that the issues raised by commenters are addressed, the Draft EIR should include a response to comments section. This directive is not intended to, and shall not be construed to, enlarge the scope of the Draft EIR beyond what has been expressly identified in this Certificate. A copy of each comment letter should be included in the Draft EIR. I defer to the proponent as it develops the format for this section, but the Response to Comments section should provide clear answers to questions raised.

Circulation

The Draft EIR should be circulated in compliance with Section 11.16 of the MEPA regulations and copies should also be sent to the list of "comments received" below and to local officials in Wellfleet and Truro. A copy of the Draft EIR should be made available for public review at the Wellfleet and Truro public libraries. The proponent should provide a hard copy of the Draft EIR to each state agency and town department from which the proponent will seek permits or approvals.

November 7, 2008
Date

Ian A. Bowles

Comments Received[1]:

10/31/08	Massachusetts Department of Environmental Protection/Southeast Regional Office (MassDEP/SERO)
10/31/08	Department of Conservation and Recreation/Areas of Critical Environmental Concern Program (DCR/ACEC)
10/14/08	Division of Marine Fisheries (DMF)
10/28/08	Division of Fisheries and Wildlife/Natural Heritage Endangered Species Program (DFW/NHESP)
7/29/08	Massachusetts Historical Commission (MHC)
10/31/08	US Environmenta1 Protection Agency (EPA)
10/23/08	Cape Cod Commission (CCC)
10/31/08	Mass Audubon
8/14/08	Chequesset Yacht and Country Club
10/15/08	Chequesset Yacht and Country Club (second letter)
10/23/08	The Nature Conservancy (TNC)
8/14/08	Nancy Deppen
10/21/08	Dale and Lee Ann Fanning
9/10/08	P. Faxon
8/20/08	Doug Franklin
9/240/8	Bill Dahl
9/26/08	Douglas E. Franklin
8/26/08	Katherine Gilmour
8/14/08	Kathryn Hubby
8/15/08	David Kew
10/1/08	Sarah Nickerson
8/16/08	John & Linda Riehl
9/24/08	Elliot Paul Rothman
9/6/08	Laura Runkel
10/21/08	Nancy N. Ryder
8/28/08	Harvey F. Schwallie
9/24/08	Marc Stahl
8/14/08	Paula Tasha
8/14/08	Jack Whalen
11/3/08	Wellfleet resident

IAB/CDB/cdb

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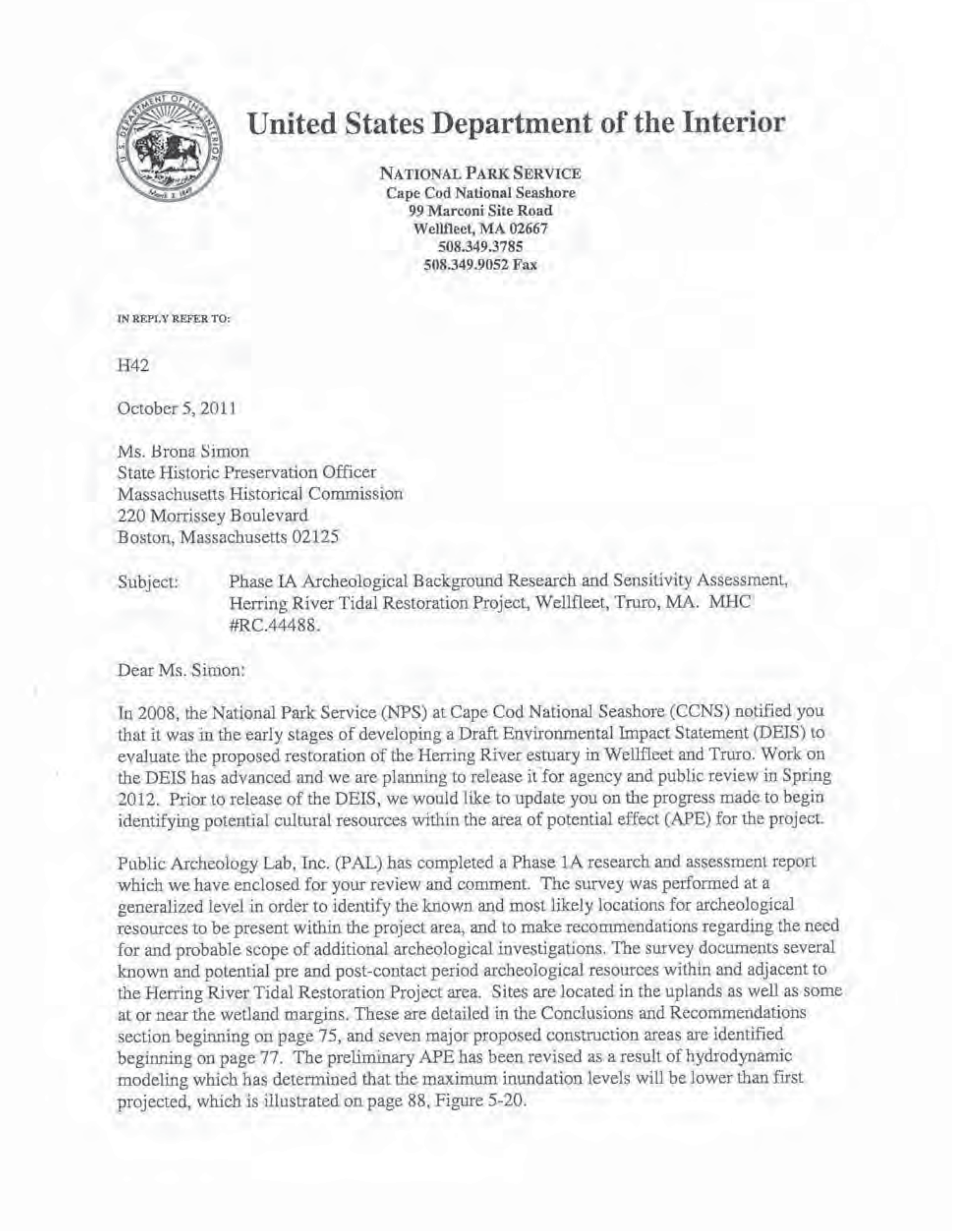
[1] MEPA, NPS and CCC agreed that any letter submitted to one of the agencies/organizations would be accepted by each as a comment letter. I have reviewed all comment letters submitted including the transcripts from the August 14 scoping session and the September 24, 2008 public meeting, as I am authorized under 301 CMR 11.06 (2), and they have factored into this decision to the extent that the issues raised fall within MEPA jurisdiction.



United States Department of the Interior

NATIONAL PARK SERVICE
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
508.349.3785
508.349.9052 Fax

IN REPLY REFER TO:

H42

October 5, 2011

Ms. Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morrissey Boulevard
Boston, Massachusetts 02125

Subject: Phase IA Archeological Background Research and Sensitivity Assessment, Herring River Tidal Restoration Project, Wellfleet, Truro, MA. MHC #RC.44488.

Dear Ms. Simon:

In 2008, the National Park Service (NPS) at Cape Cod National Seashore (CCNS) notified you that it was in the early stages of developing a Draft Environmental Impact Statement (DEIS) to evaluate the proposed restoration of the Herring River estuary in Wellfleet and Truro. Work on the DEIS has advanced and we are planning to release it for agency and public review in Spring 2012. Prior to release of the DEIS, we would like to update you on the progress made to begin identifying potential cultural resources within the area of potential effect (APE) for the project.

Public Archeology Lab, Inc. (PAL) has completed a Phase 1A research and assessment report which we have enclosed for your review and comment. The survey was performed at a generalized level in order to identify the known and most likely locations for archeological resources to be present within the project area, and to make recommendations regarding the need for and probable scope of additional archeological investigations. The survey documents several known and potential pre and post-contact period archeological resources within and adjacent to the Herring River Tidal Restoration Project area. Sites are located in the uplands as well as some at or near the wetland margins. These are detailed in the Conclusions and Recommendations section beginning on page 75, and seven major proposed construction areas are identified beginning on page 77. The preliminary APE has been revised as a result of hydrodynamic modeling which has determined that the maximum inundation levels will be lower than first projected, which is illustrated on page 88, Figure 5-20.

Given the complexity of the project and the ongoing refinement of the APE, the NPS suggests that a programmatic agreement executed pursuant to 36CFR 800.14 be developed in order to allow for a phased process to conduct identification and evaluation efforts as we move forward. In developing the agreement, several specific issues should be addressed, such as the level of archeological investigation necessary when project impacts in specific areas of the APE are limited to changes in water level and where potential historic features have already been identified. Please notify us if this approach is acceptable, and if so, we will prepare a draft programmatic agreement for your office to review and comment on.

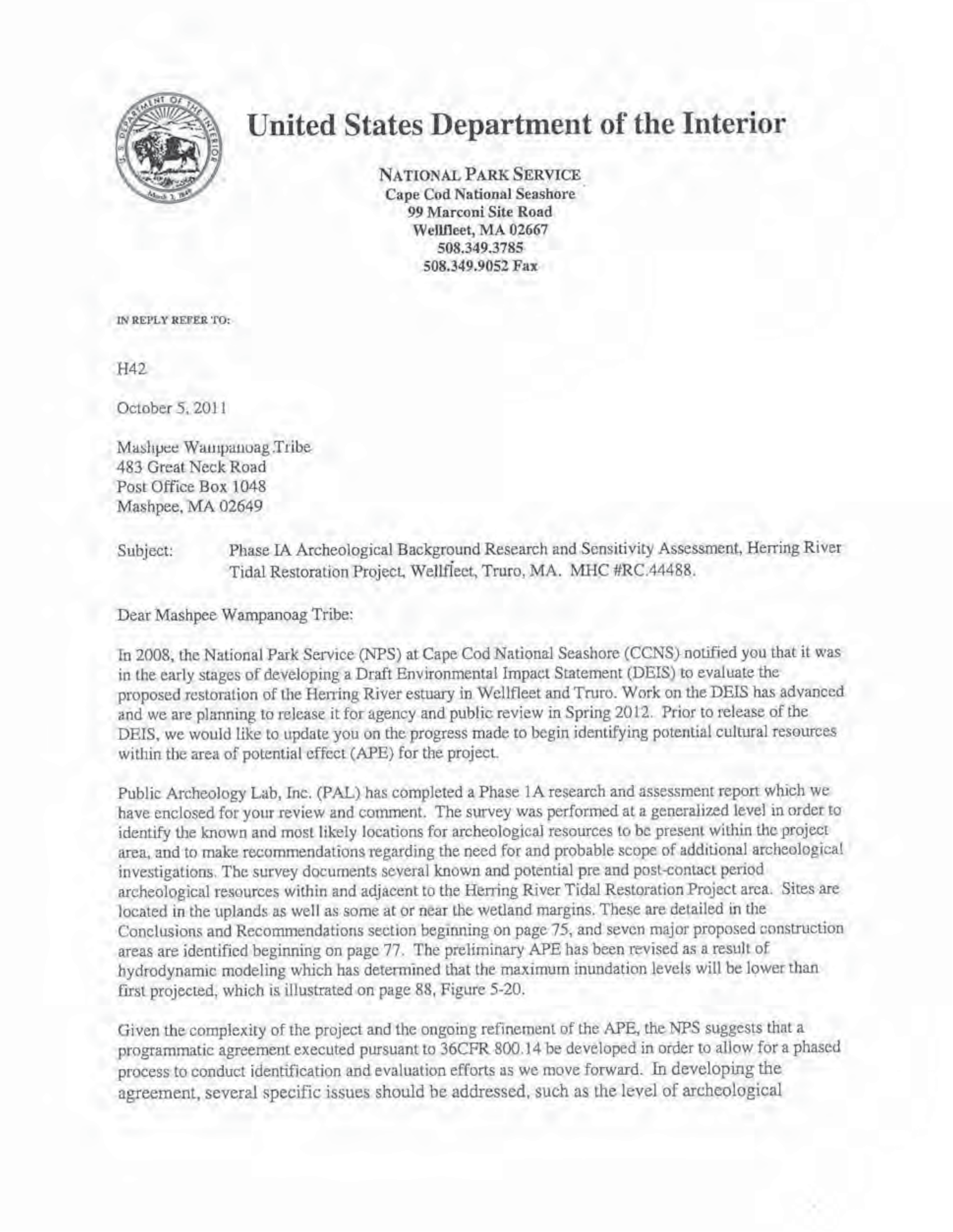
If you have any questions, please contact William Burke, Section 106 Coordinator, at (508) 255-3421, ext 14.

Sincerely,

George E. Price, Jr.
Superintendent

Enclosure

cc:
Wampanoag Tribe of Gay Head-Aquinnah
Mashpee Wampanoag Tribe
Advisory Council for Historic Preservation
Wellfleet Historical Commission
Wellfleet Historical Society
Truro Historical Commission
Truro Historical Society
Secretary Ian A. Bowles, EEA, Attn: Holly Johnson, MEPA Unit
Hunt Durey, MA Division of Ecological Restoration
Bob Boeri, MA Coastal Zone Management
Vic Mastone, MA Board of Underwater Archaeological Resources
Liz Koulaheras, DEP-SERO, Wetlands
John Sargent, US Army Corps of Engineers
Tim Timmerman, US Environmental Protection Agency
Steve Block, NOAA
Charleen Greenhalgh, Town of Truro
Hillary Greenberg, Town of Wellfleet
Eric Derleth, USFWS
Jacklyn Bryant, Louis Berger Group
Mark Husbands, NPS Environmental Quality Division



United States Department of the Interior

NATIONAL PARK SERVICE
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
508.349.3785
508.349.9052 Fax

IN REPLY REFER TO:

H42

October 5, 2011

Mashpee Wampanoag Tribe
483 Great Neck Road
Post Office Box 1048
Mashpee, MA 02649

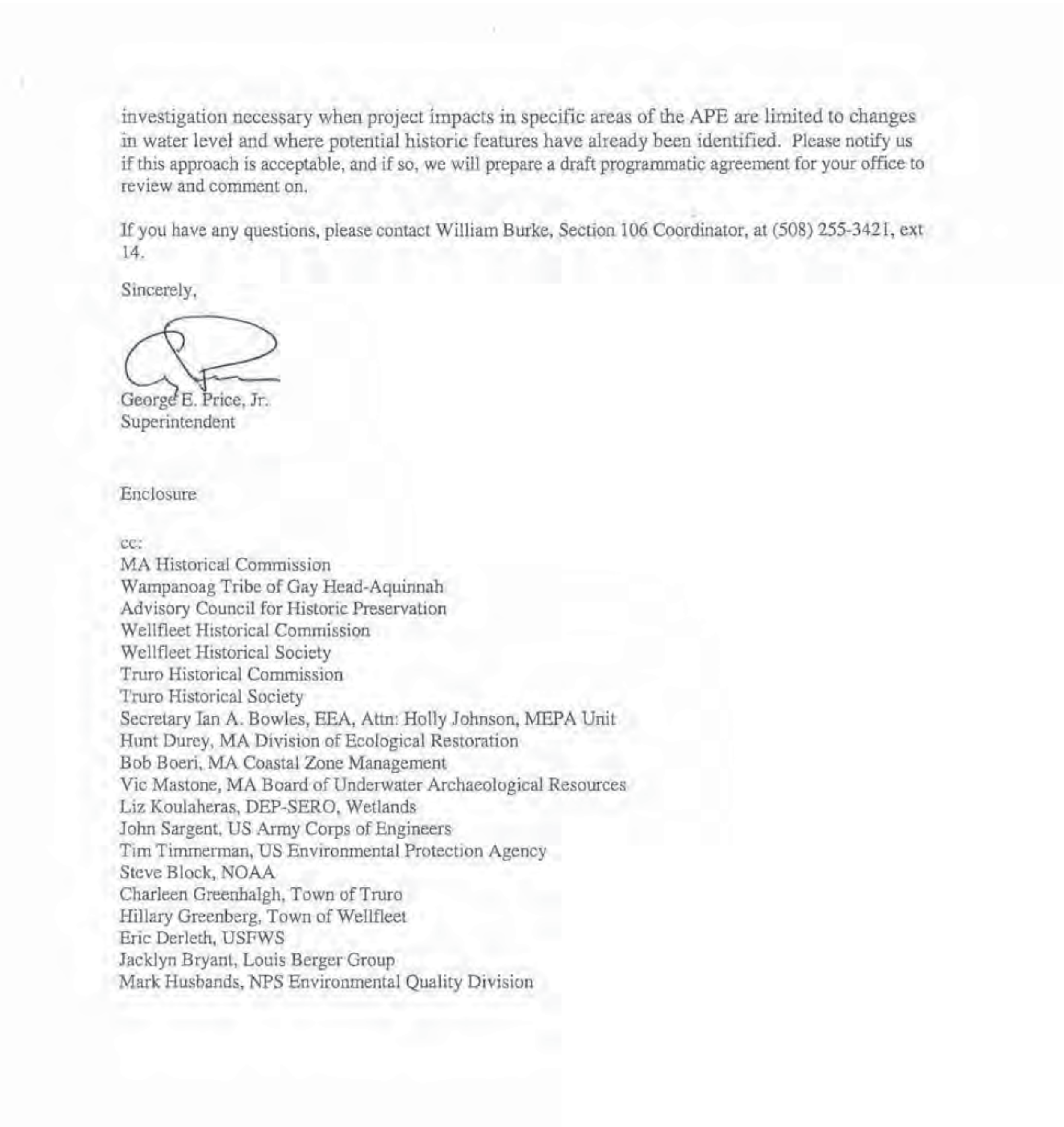
Subject: Phase IA Archeological Background Research and Sensitivity Assessment, Herring River Tidal Restoration Project, Wellfleet, Truro, MA. MHC #RC.44488.

Dear Mashpee Wampanoag Tribe:

In 2008, the National Park Service (NPS) at Cape Cod National Seashore (CCNS) notified you that it was in the early stages of developing a Draft Environmental Impact Statement (DEIS) to evaluate the proposed restoration of the Herring River estuary in Wellfleet and Truro. Work on the DEIS has advanced and we are planning to release it for agency and public review in Spring 2012. Prior to release of the DEIS, we would like to update you on the progress made to begin identifying potential cultural resources within the area of potential effect (APE) for the project.

Public Archeology Lab, Inc. (PAL) has completed a Phase 1A research and assessment report which we have enclosed for your review and comment. The survey was performed at a generalized level in order to identify the known and most likely locations for archeological resources to be present within the project area, and to make recommendations regarding the need for and probable scope of additional archeological investigations. The survey documents several known and potential pre and post-contact period archeological resources within and adjacent to the Herring River Tidal Restoration Project area. Sites are located in the uplands as well as some at or near the wetland margins. These are detailed in the Conclusions and Recommendations section beginning on page 75, and seven major proposed construction areas are identified beginning on page 77. The preliminary APE has been revised as a result of hydrodynamic modeling which has determined that the maximum inundation levels will be lower than first projected, which is illustrated on page 88, Figure 5-20.

Given the complexity of the project and the ongoing refinement of the APE, the NPS suggests that a programmatic agreement executed pursuant to 36CFR 800.14 be developed in order to allow for a phased process to conduct identification and evaluation efforts as we move forward. In developing the agreement, several specific issues should be addressed, such as the level of archeological



investigation necessary when project impacts in specific areas of the APE are limited to changes in water level and where potential historic features have already been identified. Please notify us if this approach is acceptable, and if so, we will prepare a draft programmatic agreement for your office to review and comment on.

If you have any questions, please contact William Burke, Section 106 Coordinator, at (508) 255-3421, ext 14.

Sincerely,

George E. Price, Jr.
Superintendent

Enclosure

cc:
MA Historical Commission
Wampanoag Tribe of Gay Head-Aquinnah
Advisory Council for Historic Preservation
Wellfleet Historical Commission
Wellfleet Historical Society
Truro Historical Commission
Truro Historical Society
Secretary Ian A. Bowles, EEA, Attn: Holly Johnson, MEPA Unit
Hunt Durey, MA Division of Ecological Restoration
Bob Boeri, MA Coastal Zone Management
Vic Mastone, MA Board of Underwater Archaeological Resources
Liz Koulaheras, DEP-SERO, Wetlands
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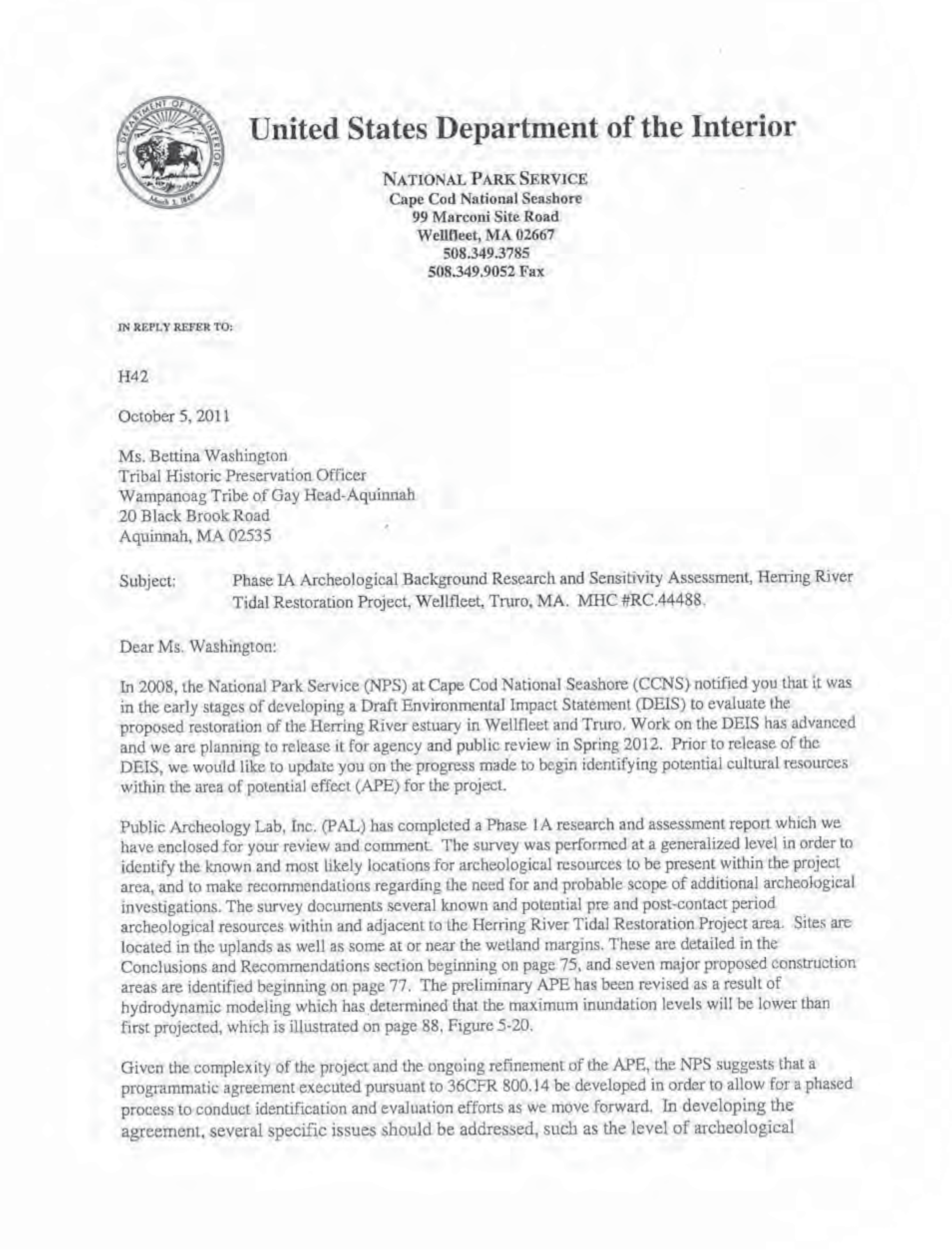

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IN REPLY REFER TO:

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October 5, 2011

Ms. Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head-Aquinnah
20 Black Brook Road
Aquinnah, MA 02535

Subject: Phase IA Archeological Background Research and Sensitivity Assessment, Herring River Tidal Restoration Project, Wellfleet, Truro, MA. MHC #RC.44488.

Dear Ms. Washington:

In 2008, the National Park Service (NPS) at Cape Cod National Seashore (CCNS) notified you that it was in the early stages of developing a Draft Environmental Impact Statement (DEIS) to evaluate the proposed restoration of the Herring River estuary in Wellfleet and Truro. Work on the DEIS has advanced and we are planning to release it for agency and public review in Spring 2012. Prior to release of the DEIS, we would like to update you on the progress made to begin identifying potential cultural resources within the area of potential effect (APE) for the project.

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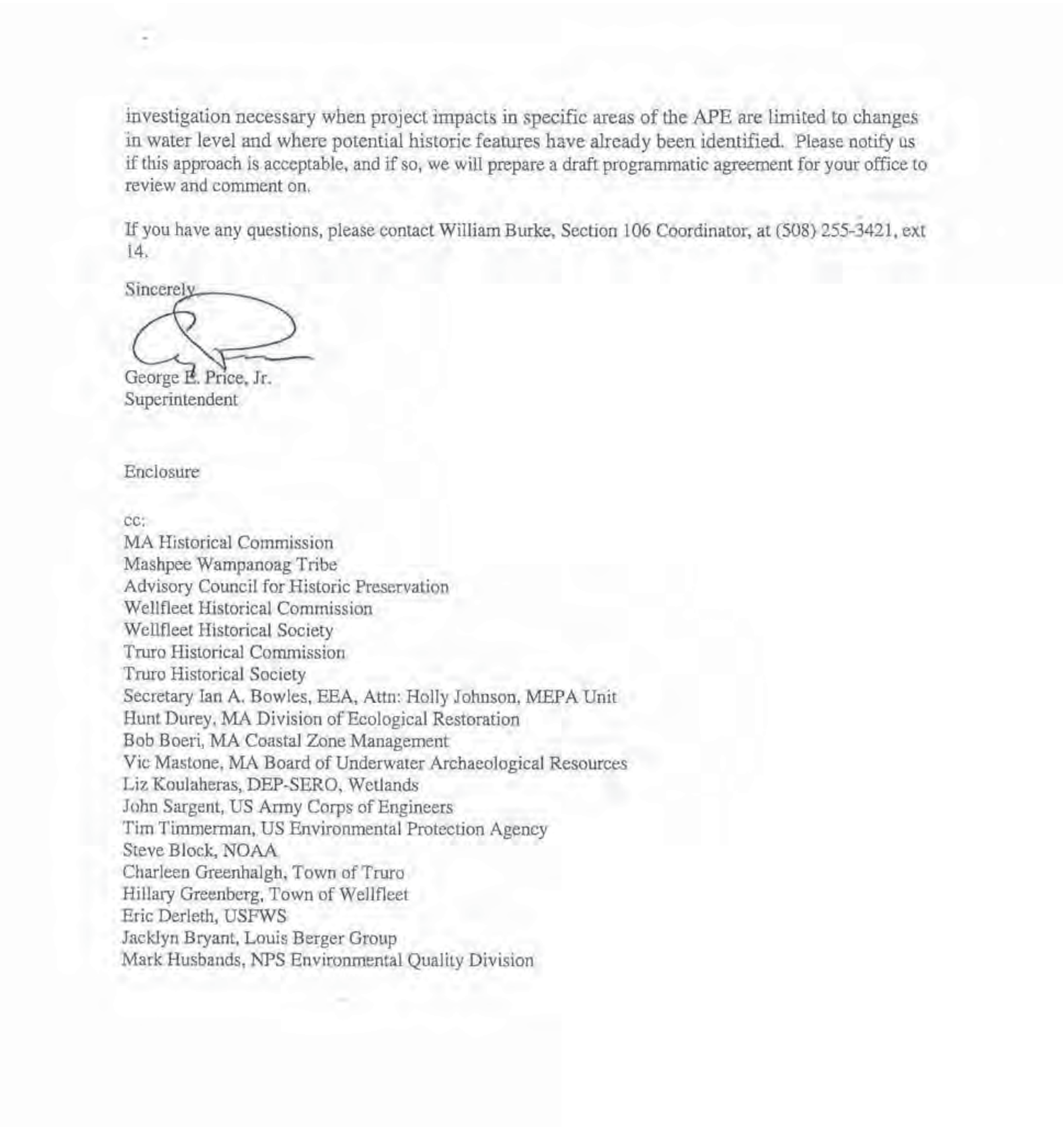

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George E. Price, Jr.
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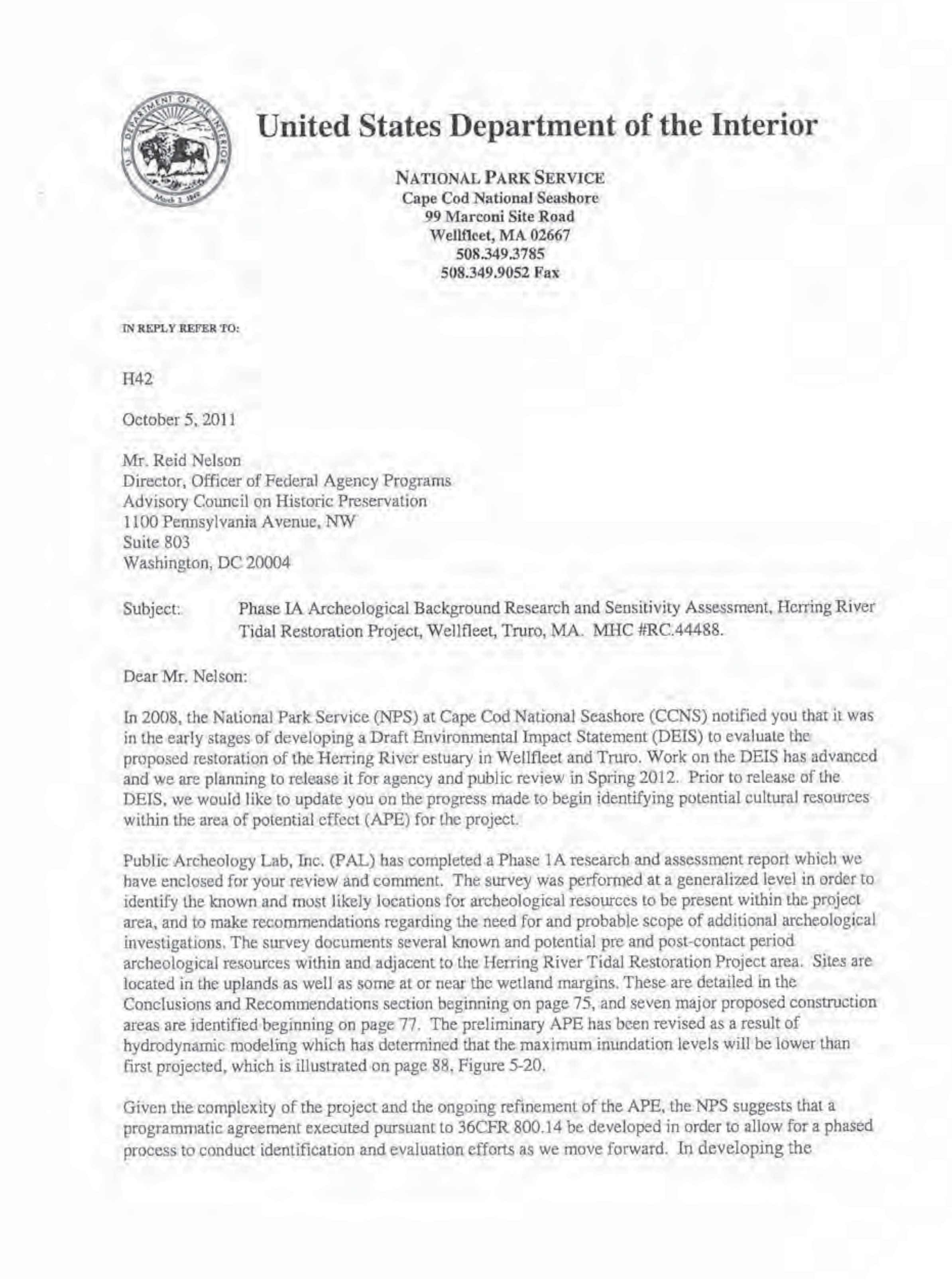

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IN REPLY REFER TO:

H42

October 5, 2011

Mr. Reid Nelson
Director, Officer of Federal Agency Programs
Advisory Council on Historic Preservation
1100 Pennsylvania Avenue, NW
Suite 803
Washington, DC 20004

Subject: Phase IA Archeological Background Research and Sensitivity Assessment, Herring River Tidal Restoration Project, Wellfleet, Truro, MA. MHC #RC.44488.

Dear Mr. Nelson:

In 2008, the National Park Service (NPS) at Cape Cod National Seashore (CCNS) notified you that it was in the early stages of developing a Draft Environmental Impact Statement (DEIS) to evaluate the proposed restoration of the Herring River estuary in Wellfleet and Truro. Work on the DEIS has advanced and we are planning to release it for agency and public review in Spring 2012. Prior to release of the DEIS, we would like to update you on the progress made to begin identifying potential cultural resources within the area of potential effect (APE) for the project.

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If you have any questions, please contact William Burke, Section 106 Coordinator, at (508) 255-3421, ext 14.

Sincerely,

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Jacklyn Bryant, Louis Berger Group
Mark Husbands, NPS Environmental Quality Division

APPENDIX B: HERRING RIVER HYDRODYNAMIC MODELING FINAL COMPREHENSIVE REPORT

Herring River Hydrodynamic Modeling

Final Comprehensive Report

EXECUTIVE SUMMARY

ES.1 - INTRODUCTION

The Herring River is a 1000+ acre estuary system located on Outer Cape Cod. A majority of the system is located in Wellfleet, Massachusetts and is physically separated from Wellfleet Harbor by a compound dike system at the Chequessett Neck Road crossing. The system is hydraulically connected to Wellfleet Harbor through the dike by three 6-foot wide box culverts, each with a flow control structure (Figure ES-1). One culvert has an adjustable sluice gate, which is currently set to be partially open two (2) feet and allows bi-directional tidal flow. The remaining two culverts have tidal flap gates, which are designed to permit flow only during an ebbing (outgoing) tide. Tidal exchange between the tidal marsh and harbor is severely restricted by the dike and culvert system. Herring River has been tidally restricted for over a century, which has resulted in significant degradation of the ecological functions and values of the marsh.

Figure ES-1. Dike structure at the Chequessett Neck Road crossing.

Prior to the dike construction in 1909, Herring River was connected to Wellfleet Harbor through a natural inlet at Chequessett Neck. The marsh system consisted of nearly 1,100 acres of thriving coastal wetlands, including a productive herring run, shellfishery, and tidal marsh habitats. The dike construction, intended to control mosquitoes and create additional developable land area, significantly degraded the natural marsh ecosystem. Today, after 100 years of influence, as well as numerous other anthropogenic impacts (e.g., upstream culverts, railroad crossings, ditch creation, etc.), hundreds of acres of intertidal tidal marsh have been degraded. This transition has eliminated habitat for estuarine flora and fauna. On-site monitoring has documented reduced tidal amplitudes, minimal salinity levels, loss of marsh vegetation, degraded fish and wildlife habitat, decomposition and subsidence of soils/sediments, and colonization by invasive species.

The Herring River Restoration Committee (HRRC), a multi-agency group appointed by the Cape Cod National Seashore and the Towns of Wellfleet and Truro, has recognized the environmental and socioeconomic benefits of restoring this tidally restricted and degraded wetland system, and is currently developing a comprehensive restoration project/plan that is geared towards identification of restoration actions and adaptive management strategies that will improve the system through a monitored and adjustable approach. As part of the restoration effort, the HRRC requested the development of a comprehensive hydrodynamic model that could be used to assess existing conditions within the estuarine system, as well as evaluate a range of alternatives and their potential impacts. The model was required to be sufficiently flexible to integrate with the adaptive management approach, capable of simulating the complexities of the Herring River system (e.g., marsh surface wetting and drying, salinity levels, a range of flow control structures, etc.). Working with the Towns of Wellfleet and Truro, the HRRC contracted with the Woods Hole Group (WHG) to identify and develop the hydrodynamic model for the Herring River system.

The hydrodynamic modeling effort is a major component of the restoration plan that will address numerous concerns associated with re-establishing increased tidal exchange, as well as provide the necessary information to design an appropriate system of dikes, culverts, and road crossings. The purpose of this report is to provide details on the development and implementation of the hydrodynamic model for the Herring River System. It is expected that as the restoration plan continues to progress, the model could also be used to assess final design alternatives, refine the adaptive management approach, address additional physical mechanisms as needed, provide visualizations of the proposed alternatives, and provide an adaptive tool for integration of monitoring results.

ES.2 – MODEL SCOPING AND SELECTION

The overall goal of the Herring River Restoration Project is to create a productive, natural environment that will sustain itself with improved water quality and a strengthened ecosystem by restoring tidal flow to the estuary. While it would be desirable to allow the Herring River estuary to simply resume its previous natural state of unimpeded tidal flow, human and environmental constraints pose limitations on the extent to which the natural tidal flow can be restored. The success of the project will largely depend on the successful implementation of a comprehensive restoration plan, which addresses all the important issues related to those limitations. Hydrodynamic modeling is a central piece in developing this plan as it allows for the evaluation of specific questions about potential changes to surface water flow, velocities, water surface elevation, and salinity levels within the estuary.

Following an eel kill in the fall of 1980, which drew attention to the poor and declining water quality in the Herring River upstream of the dike, a significant amount of literature was generated documenting studies conducted within the area. These studies indicated the detrimental impact caused by the diking of the system and called for tidal restoration in order to revitalize the ecosystem. This led to the development of some hydrodynamic model efforts to assess the Herring River System. Overall and not surprisingly, the previous modeling efforts demonstrated that larger openings in the dike would cause increases to the mean tidal elevation and the tidal range. Increasing the opening would also increase the saltwater penetration distance. These modeling efforts provided a good initial evaluation of potential restoration options for Herring River.

The model developed by the WHG as part of this scope of work further advances the hydrodynamic understanding throughout the entire Herring River estuarine system. The model more precisely represents the geometry of the estuary (including its plan form); it considers variable frictional effects throughout the estuary; it allows for flooding, drying, and ponding of water; it produces accurate current velocities and water surface elevations throughout the estuary; and it properly represents the physics of mixing for a wide range of forcing conditions.

The Herring River restoration project requires a model that incorporates the physics necessary to analyze water surface elevation, current velocities, salinity, sediment transport, and water quality. The model has to be dynamic, capable of handling bi-directional flow, high resolution to identify important processes, and flexible enough to link with other potential modeling tools (e.g., biological models) in an adaptive management setting. After evaluation of over 10 of the most capable hydrodynamic models in conjunction with the goals of the restoration project, the Environmental Fluid Dynamics Code (EFDC) model was selected to simulate the Herring River estuarine system. The model has been applied to studies of circulation, discharge dilution, water quality, Total Maximum Daily Load (TMDL), and sediment transport. EFDC is capable of predicting hydrodynamics and water quality in multiple dimensions and is a widely accepted Environmental Protection Agency (EPA) approved model.

ES.3 – MODEL APPROACH

The overall model approach that was applied to develop the hydrodynamic model for the Herring River system consisted of a phased approach that allowed for key stopping points to evaluate model performance and progress. This allowed for a flexible approach that included the incorporation of new data, and/or a re-direction of the effort based on the results of the current modeling phase. The primary steps in the modeling approach include:

1. Model Calibration - Model calibration is the process by which adjustments are made to the model parameters to ensure the model appropriately simulates measured water surface elevation, salinity, and other observed parameters.

2. Model Validation - Model validation is achieved by applying the calibrated model, with its fixed parameters, to one or more sets of observed data that are independent from the calibration data. Typically, sets of data for validation are collected at a different time and under conditions that differ from the calibration period.

3. Existing Conditions Simulations - Once the model has been calibrated and validated, additional simulations are conducted to provide a better understanding of the behavior of the system over a broader range of forcing conditions. These existing conditions simulations also provide a baseline for comparison to proposed restoration alternatives in order to gauge the potential benefits and/or risks associated with different restoration alternatives. Various conditions simulated include the spring/neap tidal conditions, storm scenarios, and sea level rise cases.

4. Chequessett Neck Road Dike Alternative Simulations – Several alternatives were simulated to evaluate the response of the Herring River system to modifications of the Chequessett Neck Road dike. These simulations included, but were not limited to, the removal of all anthropogenic structures (to provide an estimate of maximum restoration potential and assess historic conditions), optimization of a new dike opening width, and

various opening heights with flow control structures to provide potential adaptive management openings.

5. Upstream Feature Evaluations and Alternative Simulations - Alternative simulations focused on the culverts located in the upstream portions of the system. Specifically, this included evaluation of the crossing at High Toss Road, removal of the large flood tidal shoal existing just upstream of the dike, and assessment of the various road/culverts upstream throughout the system.

6. Mill Creek Sub-Basin Alternative Simulations - Alternative simulations were focused on evaluation of the Mill Creek sub-basin, including the potential implementation of a new dike restricting tidal exchange into this portion of the system. Evaluation of these simulations included construction of a Mill Creek Dike, optimization of a Mill Creek dike culvert (height and width), a re-graded Chequessett Yacht & Country Club (CYCC) golf course, and a preliminary assessment of potential groundwater impacts.

ES.4 – MODEL DEVELOPMENT

The development of the Herring River hydrodynamic model required configuration so the model would represent the form and function of the real system (i.e., the Herring River Estuary). Model configuration involves compiling observed data from the actual estuarine system into the format required for the execution of the model. The Herring River estuary model was developed using various data observed throughout the Herring River system. Data were provided by various agencies and were assumed to be correct and appropriate for model development of the Herring River system. Evaluation of the accuracy of the data observations was not a component of this modeling study.

ES.4.1 Existing Data

The data required for the development of a more robust and detailed hydrodynamic model, are of two distinct types, topographic and hydrographic. The topographic data are required to construct the model geometry, while the hydrologic data are required for model forcing and proper calibration and verification to ensure the model will provide accurate predictions. Additional data types are also required to further utilize the model to assess other

Figure ES-2. Elevation data from photogrammetric survey collected in 2007. Each red dot represents a data point.

physical processes. For example, sediment information is required for sediment transport modeling, salinity observations to assess salt levels in the system, etc.

High-resolution photogrammetry data (approximately 200,000 points within the estuary above the mean low water elevation) collected in 2007 were used to accurately develop the model elevations throughout the marsh system (Figure ES-2). Bathymetric data (at elevations below the lower limit of the photogrammetry data) were used to provide depths within the creeks and streams of the Herring River estuary system, as well as for the area just downstream of the dike.

Water surface elevation data were collected by the National Park Service at various locations throughout the estuary. Data were collected in 2007 and 2010. Figure ES-3 shows the water surface elevation data collected in 2010 from locations just upstream and downstream of the dike. Salinity and temperature data were also collected at two (2) locations. Subsets of these data were used for both model calibration and verification. Other hydrologic data that was also used in model verification includes the data collected for the earlier modeling studies from 1999-2000. Water surface elevation, salinity, temperature, and other data records continue to be collected throughout the Herring River estuary system by National Park Service.

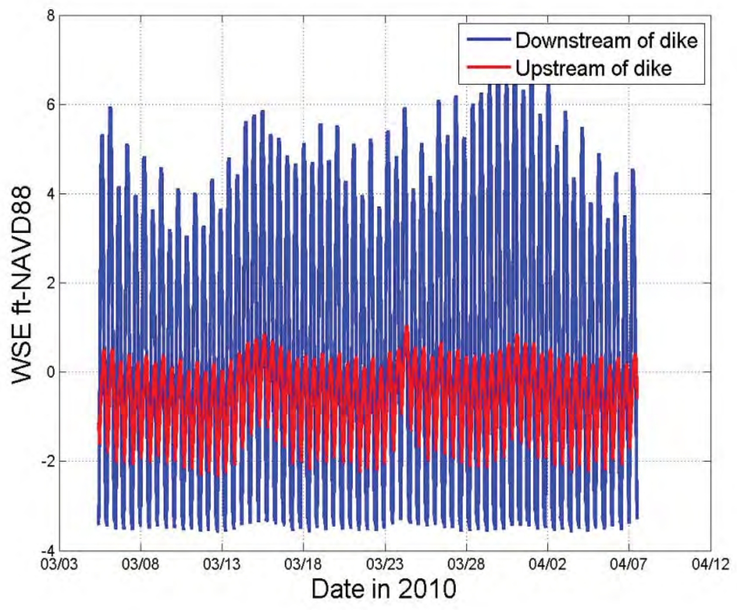


Figure ES-3. Water surface elevation data collected in 2010 from locations just upstream (red) and downstream (blue) of the dike.

Various types of sediment data were also used to analyze and model sediment mobilization and transport. These data included sediment samples and associated grain size analysis, sediment cores, synoptic measurements of total suspended solids, and continuous measurements of turbidity.

ES.4.2 Model Grid Generation

The development of a model grid defines the spatial domain on which the model performs its calculations. The model grid is a digital abstraction of the real life geometry of the Herring River system. The grid building process involves using geo-referenced digital maps or aerial photos to define the model domain, generating a grid within this domain providing the desired degree of spatial resolution, and assigning elevation values to the grid using the topographic and bathymetric data sets. The accuracy of the model is highly dependent on accurate representation of the form of the real system expressed through the model grid. For this system, a curvilinear orthogonal grid was developed because of its increased flexibility, allowing grid boundaries to better follow natural irregular boundaries. The curvilinear orthogonal grid also allows gradual variation in horizontal resolutions, such that higher resolution areas can be defined in areas where greater detail is required. The resulting Herring River grid has over 85,000 cells with resolution of less than 10 feet in critical areas. The grid has satisfactory orthogonality and aspect ratio, as well as smooth boundary point distribution and resolution change. Figure ES-4 shows a portion of the modeling grid near the Chequessett Neck Road dike. The black boxes show the resolution of the grid, while the color scale shows the elevation of the topography in the model domain.

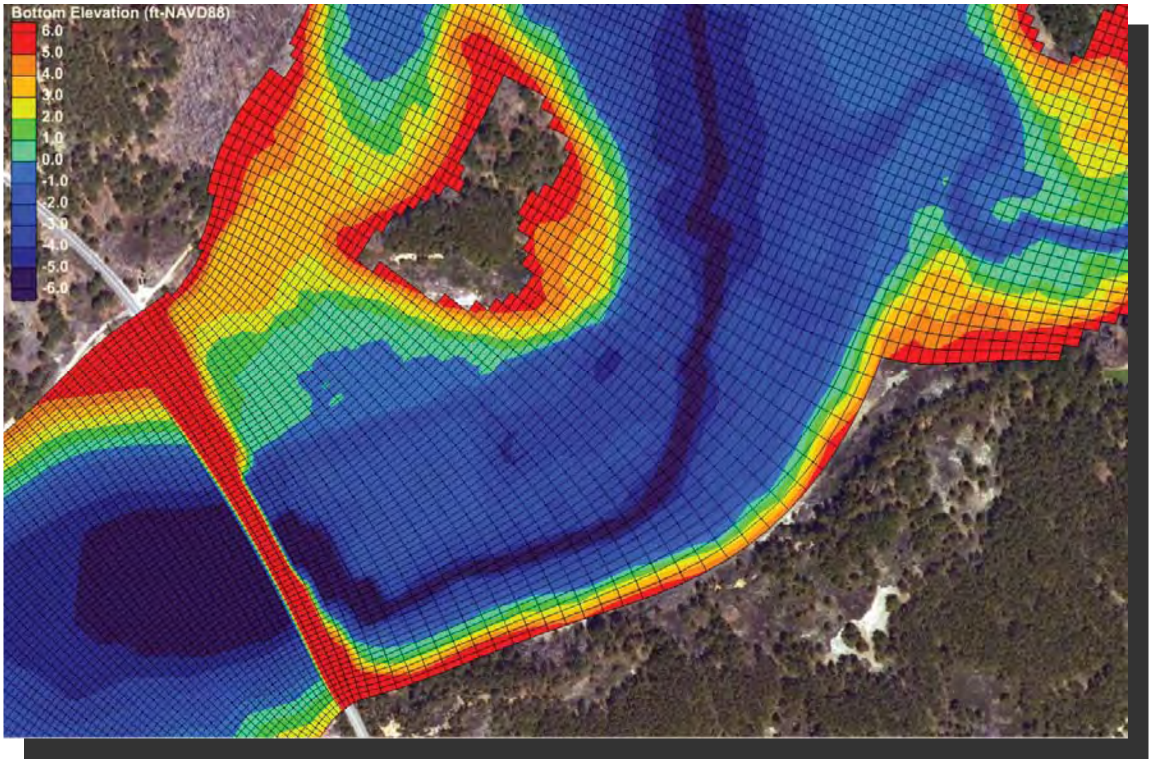


Figure ES-4. Detail of model grid showing bottom elevation contours and individual grid cells near the Chequessett Neck Road dike.

ES.4.3 Boundary Conditions and Model Parameters

In order for the Herring River model to compute a hydrodynamic solution it is necessary to specify the model variables on the domain boundaries. The Herring River model consisted of the following:

- Most of the model's boundary is considered to be a "land" boundary, which for the Herring River model was specified at an elevation of 12 feet NAVD88. This elevation provides the upper limit of expected water surface elevation during extreme storm events (100-year return period). At these land boundaries, water is constrained to flow only parallel to the boundary.

- The primary forcing for the model is provided by an open boundary at the southern end of the model domain in Wellfleet Harbor. At this location, time dependent water surface elevation and salt concentration is specified, as observed by gauge data from Wellfleet Harbor.

- Freshwater inflow volumetric flux is also specified in the model at three separate locations (Bound Brook, upper Herring River, and Pole Dike Creek) to simulate freshwater inflow into the estuary.

- Bihourly precipitation data collected at the National Atmospheric Deposition Program (NADP) station MA01 was used to provide rainfall input to the model.

- Bottom friction (or roughness length) throughout the model domain was assigned to individual cells to represent the characteristics of the flow through the system. Physically, bottom drag forces depend on a number of phenomena that are difficult to characterize. These include bottom material type, growth of biota, and the amount of channel meander, which all contribute to the overall energy loss that are accounted for by the bottom friction. Bottom friction parameters are typically used for “tuning” hydrodynamic model to reproduce the data observations. For the Herring River model, local adjustments were made to the roughness length values in order to improve the model results to match observed data. For example, observed data at the Pole Dike Creek gauge locations show the complete dampening of the tidal signal at this point in the estuary. This is likely due to the dense submerged aquatic vegetation (SAV) that exists in this creek and other vegetative influences in this relatively narrow channel. Observations conducted in 2008 indicated the creek to be almost impenetrable by canoe. Therefore, there are significant frictional and/or constriction influences in this portion of the estuarine system and a higher frictional parameter was assigned to replicate the real world conditions. All final assigned values are considered within the range of normal bottom friction values determined through empirical laboratory testing.

- Various types of flow control structures were also modeled throughout the systems. This included developing hydraulic routines embedded in the model to simulate culverts, slide (sluice) gates, and flap gates.

ES.4.4 Model Calibration and Validation

Model calibration is the process in which model parameters are systematically adjusted through a range of acceptable values and results are examined using standard measures of error. The Herring River model was calibrated to water surface elevation observations collected between September 5, 2007 and October 3, 2007 at seven locations throughout the estuary and calibrated to salinity at a station in the Lower Herring River. The model performance is evaluated by comparing time series output from the model to the observed time series at specific locations. The results are presented visually as time series plots and scatter plots, and absolute error of the model is quantified by calculating the bias and Root Mean Square Error (RMSE). For example, Figure ES-5 shows a visual comparison of the modeled (red) and measured (blue) water surface elevations at the tide station just upstream of High Toss Road for data collected in 2007. Figure ES-6 shows the associated scatter plot and calibration errors for the same location. Additionally, the five most dominant modeled and measured tidal constituents are compared using both amplitude and phase.

The magnitudes of the water surface elevation errors were well within bounds of standard calibration limits for hydrodynamic models. The model bias was less than 0.1 feet for all locations meaning that the calibration simulation reproduced average water levels that were within an inch or two of observed levels. The root mean square error was less than 0.4 feet for all locations indicating that on average the modeled water level is within a few inches of the observed level at any given time. Relative errors were approximately 1-2% at all locations.

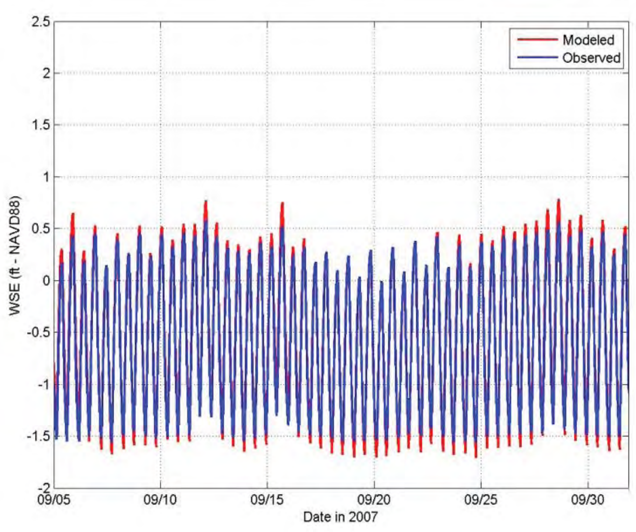


Figure ES-5. Water surface elevation data comparison for modeled (red) and measured (blue) time series just upstream of High Toss Road.

Salt penetration in the Herring River in its current restricted state is not normally observed above High Toss Road. As such, verifying that the model could accurately simulate salinity throughout the entire system was not feasible since currently salt only penetrates into the lower portion of the Herring River system. In the Lower Herring River where salinity data are available, the model is well calibrated with a relative error of 11%, which is well below the EPA recommended value.

Following calibration, the model was also validated to two additional data sets collected in 1999 and 2010. Validation involves applying the calibrated model to set of observed data that are independent from the calibration data set without changing the model configuration or parameterization. The water surface elevation relative errors were 1.7% and 2.8% for the 1999 and 2010 data sets, respectively.

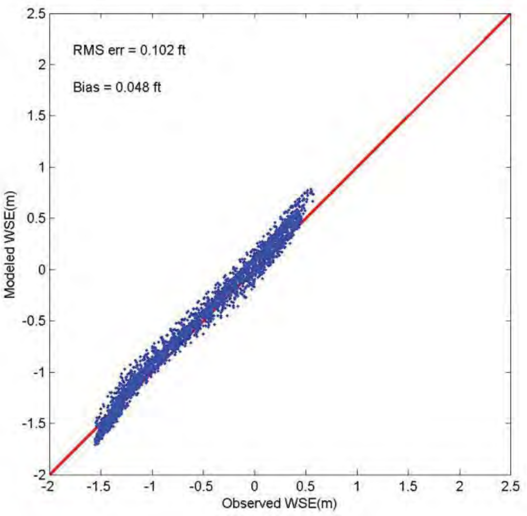


Figure ES-6. Scatter plot comparing modeled and measured water surface elevation just upstream of High Toss Road.

ES.5 – EXISTING CONDITIONS

The calibrated and validated model was further applied to simulate a number of scenarios to aid in understanding the behavior of the Herring River estuary in its current restricted state. In addition to providing better understanding of the current system, these simulations also provided a baseline for comparison to alternative simulations. For example, the impact of opening the Chequessett Neck Road dike on the potential storm surge signal throughout the estuary system can be evaluated compared to existing conditions.

The existing conditions simulations consisted of normal tidal conditions, storm scenarios, and sea level rise cases. Normal tidal conditions were simulated by using the same water surface elevation data used during calibration and validation without the inclusion of temporally specific atmospheric forcing (wind, rainfall, etc.). Storm events and forecasted sea level rise (SLR) scenarios were simulated by modifying the water surface elevation boundary conditions to represent storm surge and/or long-term sea level rise increases.

The return-period tidal flood simulations demonstrate the effectiveness of the existing Chequessett Neck Dike in reducing storm surge. For example, during the 100-year flood event, the greatest increase in peak elevation is only 0.7 feet above the normal high water conditions in Lower Herring River, a 63% reduction in storm surge height between Wellfleet Harbor and High Toss Road. Sea level rise simulations were also conducted to provide an estimate of future projected water levels in the Herring River over the next half century. Three (3) projected rates of sea level rise (high, intermediate, and low) were used based on federal guidelines for incorporating sea level change considerations in civil works programs.

ES.6 – ALTERNATIVE EVALUATION AND SCREENING

A series of alternatives were simulated that were geared towards gaining a better understanding of system response to potential modifications, while determining potential adaptive management steps and restoration endpoints. The results of alternative evaluation and screening were used to assist in defining specific restoration alternatives that were further analyzed, detailed, and selected for design consideration.

First a simulation of the "natural" Herring River system through the removal of all anthropogenic features (e.g., culverts, dikes, railroad beds, etc.) was conducted. In this scenario, the system was allowed to be fully open to tidal flow and allow relatively uninhibited exchange throughout the entire estuarine system. This simulation could be considered a reasonable representation of the greatest restoration level that may be expected for a natural system (excluding natural and/or anthropogenic changes to the bathymetry/topography) and a reasonable facsimile of the historic (a century ago) conditions of the system. Although the fully open alternative is not likely a reasonable final solution given the upland infrastructure that has been developed over the last century, this alternative does provide a reasonable estimate of the maximum restoration potential for the Herring River system and is used for comparison purposes. Figure ES-7 shows a comparison of the maximum water surface elevation for existing conditions (left panel) and for the simulation that removed all anthropogenic structures (right panel), under normal tidal conditions. Tidal water is shown in yellow in both the upper and lower panels.

Figure ES-7. Maximum water levels in the Herring River system for existing conditions (left panel) and for the no anthropogenic structures simulation (right panel).

Next, a range of potential opening widths at Chequessett Neck Road was simulated to determine the water surface elevations, tidal ranges, and salinity levels throughout the Herring River system. The results indicated that a 100 foot (30 meter) opening would optimize the water surface elevations and tidal range within the Herring River system, while a 165 foot (50 meter) opening would optimize the salinity penetration into the system.

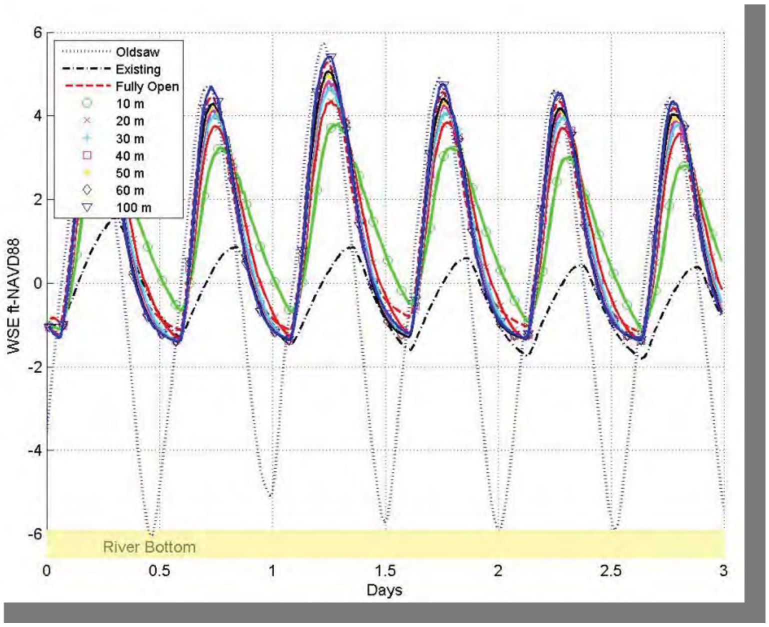


Figure ES-8. Water surface elevation (WSE) results in the lower Herring River sub-basin for a range of opening widths at Chequessett Neck Road.

Figure ES-8 shows water surface elevation time series results for opening sizes ranging between approximately 30 feet (10 meters) and 325 feet (100 meters), while Figure ES-9 shows the levels of Mean High Water (MHW) and Mean Low Water (MLW) in the lower Herring River sub-basin for increasing opening widths at Chequessett Neck Road. While a 100 foot (30 meter) opening optimized the water surface elevation levels, salinity levels were optimized with a 165 foot (50 meter) opening. Figure ES-10 shows the increased salinity penetration resulting from a 165 foot (50 meter) opening (right panel) compared to a 100 foot (30 meter) opening (left panel). Although wider openings (greater than 165 feet) continued to let more tidal water and salt into the system, the changes were minimal and therefore produced diminishing restoration value. A 165 foot opening at Chequessett Neck Road was determined to be the largest width required to optimize restoration.

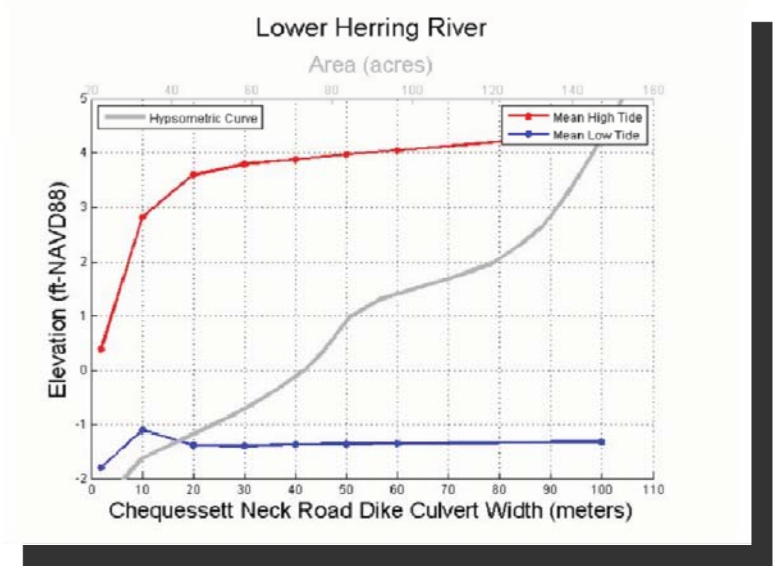


Figure ES-9. Mean High Water (red) and Mean Low Water (blue) levels in the lower Herring River sub-basin for a range of opening widths at Chequessett Neck Road.

Following the selection of the optimal Chequessett Neck Road dike opening width, simulations for various opening heights (assumed to be controlled by slide/sluice gate structures in the new dike opening) were conducted. These simulations evaluated targeted endpoints for restoration (based on limiting water surface elevations that could be accepted during storm conditions throughout the system) and provided opening sizes that could be used as initial set points in the adaptive management process. Results indicated that:

- A uniform 3’ slide (sluice) gate opening across the entire 165’ dike opening would limit the 100-year storm event water surface elevation to less than 6.0 feet NAVD88 throughout the system.
- A uniform 10’ slide (sluice) gate opening, which is fully vertically open, limits the 100-year storm event water surface elevation to less than 7.5 feet NAVD88 throughout the system.

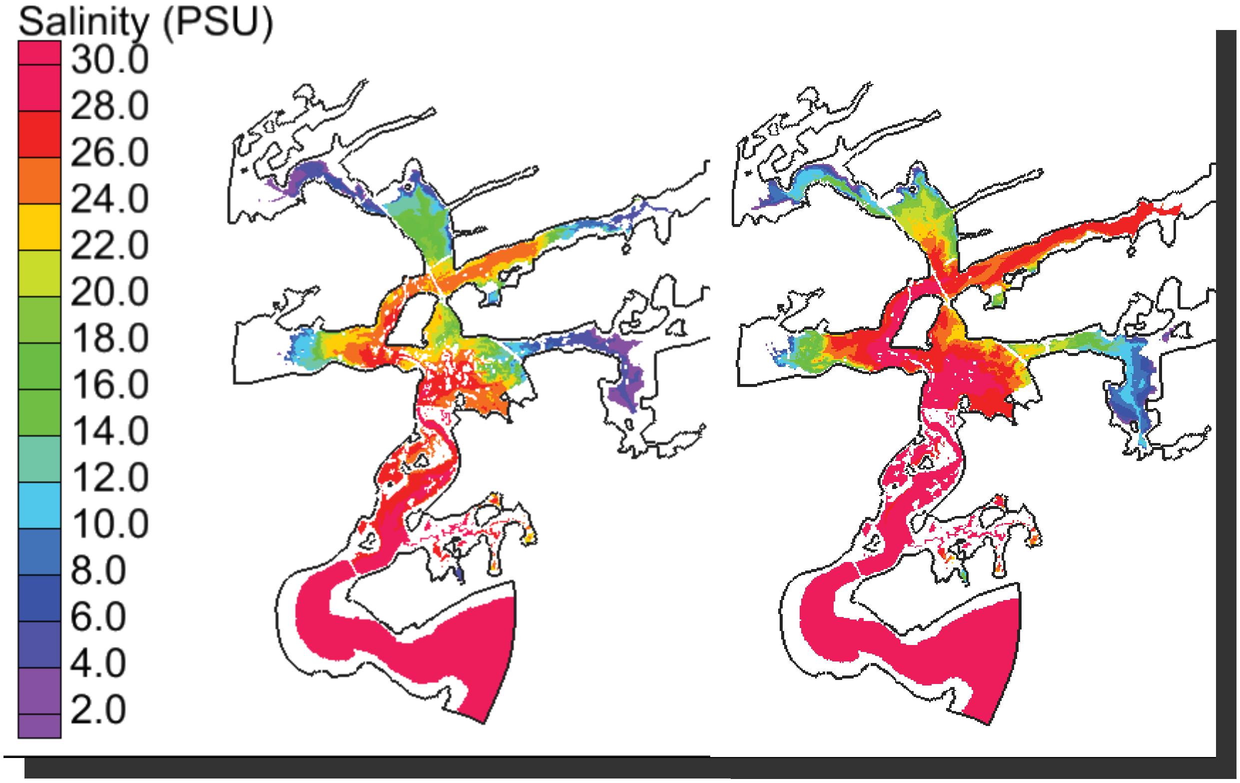


Figure ES-10. Salinity concentration throughout the Herring River system with an opening width at Chequessett Neck Road of 100 feet (30 meters) and 165 feet (50 meters). Color scale show salinity levels in practical salinity units (psu).

Based on the width and height variants simulated, recommended alternatives were selected for the new dike opening at Chequessett Neck Road that represented specific restoration endpoints. These restoration endpoints were intended to be eventually achieved through an adaptive management approach that would allow for controlled advancement towards the endpoints. Specifically, the following three alternatives were defined for the Chequessett Neck Road dike:

- A new Chequessett Neck Road dike with a 165’ wide opening and a future targeted maximum 100-year storm water surface elevation of 6.0 feet NAVD88 in the Lower Herring River (achieved with an approximate 3’ slide [sluice] gate opening). Golf course re-grading and other flood proofing would be required in the Mill Creek sub-basin for this alternative. Several segments of low-lying roads would also require elevation increases and re-grading. Restoration would be significant through most of the system, but would not be maximized since the lower infrastructure elevations in the Mill Creek sub-basin would limit the maximum water surface elevation allowed in the system as a whole.

- A new Chequessett Neck Road dike with a 165’ wide opening and a future targeted maximum 100-year storm water surface elevation of 7.5 feet NAVD88 in the Lower Herring River (achieved with an approximate 10’ slide [sluice] gate opening) with a new dike at Mill Creek to ***eliminate*** tidal exchange. A new proposed dike at the entrance to

Mill Creek with a one-way flap gate flow control structure would be installed to eliminate the tidal exchange into Mill Creek. This would allow freshwater flow out of the Mill Creek basin, but would not allow tidal water into the Mill Creek basin. As such, this alternative would maximize restoration throughout the Herring River system, but the Mill Creek sub-basin would remain a non-tidal system. No re-grading or flood proofing in the Mill Creek sub-basin would be proposed, but flood mitigation would be required in other sub-basins, including elevating and re-grading low lying roads.

- A new Chequessett Neck Road dike with a 165' wide opening and a future targeted maximum 100-year storm water surface elevation of 7.5 feet NAVD88 in the Lower Herring River (achieved with an approximate 10' slide [sluice] gate opening) with a new dike at Mill Creek to ***limit*** tidal exchange. This alternative would maximize restoration throughout the entire system; however, the new dike at the entrance to Mill Creek with appropriate flow control structure(s) would limit the tidal exchange into Mill Creek. This new Mill Creek dike would produce similar water levels as the 3' slide/sluice gate opening alternative within the Mill Creek sub-basin. Flood proofing and mitigation would be needed in select locations within the Herring River flood plain.

Since the Mill Creek sub-basin was a critical element of each of these defined alternatives, these three (3) final alternatives were further detailed through detailed assessment of the Mill Creek sub-basin. Therefore, simulation of potential tidal control at the entrance to the Mill Creek sub-basin, which followed a similar approach to the modeling and assessment of an opening at the Chequessett Neck Road dike, were conducted. This includes (1) optimization of an opening width at a new Mill Creek dike; (2) potential opening heights of a flow control structure to allow limited water into Mill Creek sub-basin; (3) simulations of a re-graded golf course region; (4) evaluation of the Mill Creek sub-basin completely blocked from tidal exchange and the effect on freshwater outflow, and (5) a preliminary assessment of potential groundwater impacts in the Mill Creek sub-basin relative to both sea level rise and the restoration effort. These results indicated that:

- A 25 foot opening in a new dike at the entrance to Mill Creek would optimize restoration in the Mill Creek sub-basin with the optimized opening at the Chequessett Neck Road dike.

- Alternatives that could be considered for managing water levels within Mill Creek include a maximum 3 foot sluice opening at Chequessett Neck Road with no dike at Mill Creek, or a dike at Mill Creek that would allow for managed water levels when the sluice opening at the Chequessett Neck Road dike is increased to opening sizes greater than 3 feet. The Mill Creek sluice/slide gate could also be closed completely and only allow flow out of the system.

- A re-graded golf course would remove some flood storage capacity from the Mill Creek sub-basin. For example, under the alternative with a 10 foot sluice opening at Chequessett Neck Road and a 3 foot sluice opening at Mill Creek, a peak water surface elevation of approximately 6.4 feet would occur during a 100-year storm surge event in the re-graded Mill Creek sub-basin, while a peak water surface elevation of 6.0 feet would occur with the existing topography. Therefore, for a re-graded golf course area, an adaptive management approach would need to be implemented that would be able to adequately anticipate and manage water surface elevations in the Mill Creek sub-basin.

- Simulations of freshwater storm events (heavy rainfall) in the Mill Creek sub-basin indicated that proposed alternatives would decrease the ability of the additional water to drain from the system, but would not increase the water surface elevation level above the normal mean high water level within Mill Creek. For the alternative that would completely eliminate tides from the Mill Creek sub-basin, the water surface elevation would not exceed 2 feet NAVD88 during any of the storm cases considered.

- Using the results of a preliminary evaluation, the impacts of sea level rise on the groundwater levels in the Mill Creek sub-basin indicate that under all three sea level rise scenarios (low, intermediate, high), the greatest increase in water table elevation would be 1.12 feet in 50 years in areas closest to Wellfleet Harbor. In general, a larger increase in water table elevation is expected at locations closer to Wellfleet Harbor, while a smaller increase is expected at locations near Mill Creek.

Additional findings and recommendations, corresponding to the overall restoration effort, include:

- Lowering the culvert inverts at the Chequessett Neck Road dike does allow a greater volume of flow (slightly higher tides); however, without a significant adjustment to the local bathymetry upstream and downstream of the dike, the low water level does not decrease. It may be feasible that a lower culvert invert, combined with the increased volumetric flow, would cause scour and an eventual lowering of the river bed and thereby a more significant change to the mean low water elevation. However, this lowering would have to occur over a significant distance both upstream and downstream of the dike and it is more likely that the actual scour would occur in a localized area at the dike only.

- Assessment of High Toss Road indicates that under restored conditions (Chequessett Neck Road dike openings of 65 feet or greater), the roadway will be overtopped. As such, the road would require mitigation to remain useable, or be abandoned. The existing High Toss Road and culvert also negatively impact restoration potential in the upper portions of the Herring River estuary. Specifically, the restrictive culvert and causeway impede the draining of the upper system during an ebbing tide, resulting in a reduced tidal range, excessive ponding, and higher MLW. The removal of the High Toss Road culvert and creation of an open channel at this location is recommended.

- As the restoration process advances, several upstream culverts, specifically the culverts at Pole Dike Road and Old County Road, may need to be replaced with larger culverts. However, since the effect on water surface elevation is relatively small, especially in the early stages of the restoration, these culverts do not need to be replaced during the initial restoration effort. Monitoring of water surface elevations and salinities during the adaptive management process should be conducted to determine the potential influence of these anthropogenic structures.

ES.7 – FINAL ALTERNATIVE ASSESSMENT AND MODEL OUTPUT

Modeling results of the recommended alternatives were summarized to analyze potential changes to the Herring River system and to provide more easily digestible modeling output. The detailed results of the hydrodynamic model were also used to complete a preliminary sediment transport assessment. This assessment does not determine actual sediment movement but rather areas where there is potential for erosion or deposition. However, the analysis does provide reasonable results that can be utilized to help guide the adaptive management restoration approach.

ES.7.1 Tidal Benchmarks and Salinity

Water surface elevations and salinity throughout the Herring River system were evaluated using the results of the hydrodynamic model. Water surface elevation results from the alternative simulations were presented in three specific ways:

1) Tables that present relevant tidal benchmarks (Mean Low Water, Mean High Water, Mean High Water Spring, Annual High Water), the 100- year storm water level, and potential future sea level rise scenarios for restoration endpoint alternatives. These water surface elevation values were provided for each sub-basin.

2) Graphical aerial overviews and geo-rectified bounds of the water surface elevation level for each specific tidal benchmark. An example showing mean high water spring (MHWS) for existing conditions and for a 165 foot wide and 3 foot high opening at Chequessett Neck Road is presented in Figure ES-11. Graphical aerial overviews of salinity penetration are also provided.

3) Interactive Google© Earth files that provide both the tabular and spatial data files for each of the simulated water levels.

Results are provided within each sub-basin and include data for existing conditions, fully open, and a range of sluice/slide gate openings associated with the proposed opening sizes both at Chequessett Neck Road and Mill Creek. Water surface elevation results show the limited tidal range under existing conditions, as a vast majority of the system is non-tidal, and the overall intertidal area is minimal, even just upstream of the dike. From a salinity perspective, under existing conditions, the salt water does not propagate beyond High Toss Road, while for the proposed 3 foot sluice opening and greater, salt water advances into a significant portion of the upper sub-basins. Modeling results for all the various adaptive management cases can be used to determine changes to intertidal areas, expected high water locations, and assess potential marsh vegetation areas.

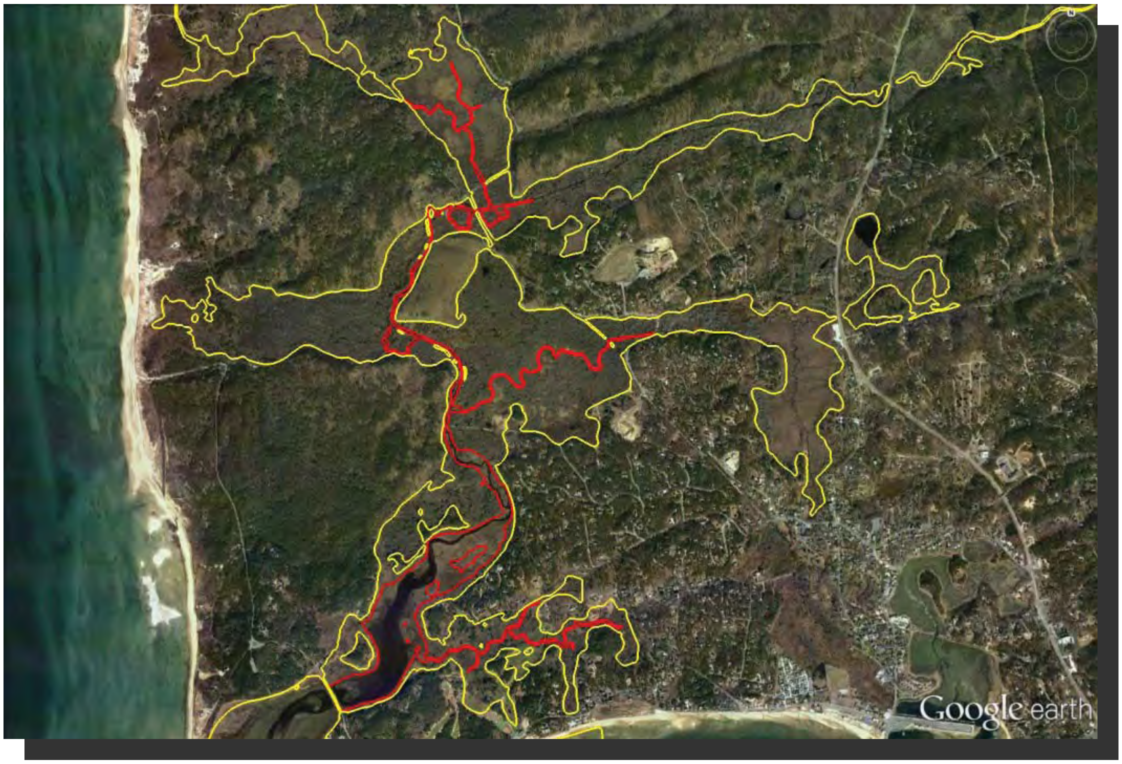


Figure ES-11. Mean High Water Spring for existing conditions (red) and 165 foot wide, 3 foot high opening at Chequessett Neck Road (yellow).

ES.7.2 Tidal Flushing

The proposed opening at Chequessett Neck Road would result in substantially improved flushing within the system. The improved opening size is particularly effective at flushing the extents of the system beyond High Toss Road. Under existing conditions, the sub-basins of the system do not exchange water efficiently with Wellfleet Harbor. For example, the Herring River System above High Toss Road takes approximately 200 days to fully flush with Wellfleet Harbor under existing conditions, while under the alternative opening scenarios the flushing time is reduced to 6-8 days.

ES.7.3 Sensitive Receptors

Sensitive receptors include specific low-lying infrastructure (e.g., roadways, etc.), as well as other critical locations (e.g., golf course areas), that may potentially be influenced by the restoration and changes to the water surface elevations. Model results were evaluated to determine the water surface elevation at critical locations. Water surface elevation results from the alternative simulations were presented at the sensitive receptor locations as:

- Tables that present relevant tidal benchmarks (Mean Low Water, Mean High Water, Mean High Water Spring, Annual High Water), the 100- year storm water level, and potential future sea level rise scenarios for restoration endpoint alternatives. These water surface elevation values are provided for each sensitive receptor (e.g., roadway).

- Interactive Google© Earth files that provide the tabular results at each sensitive receptor location.

ES.7.4 Marsh Receptors

Similar to the sensitive receptors, water surface elevations and salinity values were evaluated at specific locations throughout the marsh plain. Additional metrics, hydroperiod, percent of tides wetting, and a classification values were also determined at each marsh receptor location. These locations can be used to assess the relative changes, and potential ecological changes that may occur throughout the Herring River system. The model results for the marsh receptor locations are presented as:

- Tables that present relevant tidal benchmarks (Mean High Water and Mean High Water Spring) critical for marsh vegetation delineation, mean and maximum salinity levels, hydroperiod (the length of time [in hours] a point stays wet once it has gotten wet), and percent wetting (the percentage of high tides that wet that point). The tables also provide classification values.

- Interactive Google© Earth files that provide the tabular results at each marsh receptor location.

ES.7.5 Ponding

Simulations of the adaptive management steps and restoration endpoints revealed there were certain areas within the system that were prone to ponding of water with the introduction of the increased tidal exchange. These areas are generally due to subsidence that has occurred over the century of marsh degradation, or caused due to poor drainage pathways. Although these potential ponding areas appear in the hydrodynamic model for restoration endpoint simulations (3 foot and 10 foot height openings), this does not indicated that these will occur during the restoration process. The hydrodynamic model is using the existing bathymetry to simulate future restoration endpoints. However, due to the adaptive management approach that is intended to be applied to the system (smaller incremental openings over time); it is likely that this topography will change as the system responds to increased tidal exchange. For example, it is expected that additional sediment will be transported into the system and be deposited in the lower velocity zones of the subsided areas. Additionally, existing channels leading to limited drainage areas will be naturally widened and deepened due to the increased tidal flux during the restoration process. Therefore, widespread ponding during the restoration effort is not expected as long as monitoring is conducted and the appropriate adaptive management actions are applied.

ES.7.6 Sediment Mobilization and Transport

In order to assess the potential impact of the proposed dike openings, a preliminary sediment transport assessment was conducted using the results of the hydrodynamic model. The analytical sediment transport model employed was based on the established concept that sediments begin to move when sufficient stress is applied to the grains on the estuary seabed. The sediment transport potential was determined for normal tidal conditions and for a 100 year extreme storm surge event. Each scenario was simulated for existing conditions, and for the restoration alternative with a 165 feet wide span at Chequessett Neck Road with sluice openings of 3 feet.

- Under existing conditions with normal tides, increased tidal asymmetry imposed by Chequessett Neck Road dike reduces the total volume of water and suspended sediment that can physically be transported into the lower Herring River. Any suspended sediment that does pass through the sluice gate quickly settles out because flood tide currents in the lower Herring River are severely reduced by the dike (this is supported by existence of the flood tidal shoal in that is present in the existing system). The dike also causes a significant reduction in the flood tide current velocity in the area downstream of the dike. This reduction in current velocity likely deposits a portion of suspended sediment in the upper region of the area downstream of the dike during slack flood tide.

- When compared to existing conditions, the 3 foot opening shows similar pathways for sediment transport in the areas downstream of the dike. Generally, bed load is expected to move slightly seaward or remain in the same location, while a majority of the suspended sediment would ultimately be transported farther upstream into the estuary. For the 3 foot opening, this general process is expected to increase, with potential bed load transport extending from the lower Herring River to the area downstream of the dike, while an increased suspended load would be transported upstream of Chequessett Neck Road during flood tides. Over time, these processes would likely lead to a coarsening of the sediment, particularly in the area downstream of the Chequessett Neck Road dike. With the new dike opening, potential sediment transport in the lower Herring River during both the flood and ebb tides would begin to occur. Initially, this is likely to lead to some transport of fine-grained material out of the lower Herring River. This fine-grained material would not easily settle and would be transported into Cape Cod Bay and possibly dispersed within Wellfleet Harbor. In addition, a significant portion of this material would be transported into the subsided, upper portions of the estuary due to asymmetry in the tidal current and trapping by vegetation. The upper Herring River would remain primarily a depositional environment with the exception of the area near High Toss Road. Considering the greater volume of sediment that is able to enter the upper Herring River, it is likely that 3 foot opening will lead to significant deposition of suspended sediment and fines in the upper estuary, specifically in lower lying areas that have historically subsided.

- During the 100-year storm under existing conditions, there is a large area of potential transport just downstream of the dike and sediment would be mobilized and transported upstream towards and potentially beyond Chequessett Neck Road (if the material can make it past the existing dike). Overall, the storm surge is not expected to cause significant mobilization of sediment in the lower or upper Herring River, although more suspended sediment mobilized from downstream of the dike would be carried above Chequessett Neck Road than during normal tidal conditions. The model results show a larger area of potential mobilization during the rising surge suggesting a net upstream transport of bed load and coarser suspended sediment. Fines entrained during the surge would likely make their way out of the system and ultimately become dispersed in Cape Cod Bay.

- Qualitatively, sediment transport pathways in the area downstream of the dike are similar for both existing conditions and the restoration alternatives. However, because the

Chequessett Neck Road dike severely restricts flow in the upstream reaches under existing conditions, a significantly smaller volume of water enters the estuary during the 100-year storm surge when comparing current conditions to proposed conditions. For existing conditions, there is practically no sediment mobilization above Chequessett Neck Road even during the 100-year storm surge. However, there will be a moderate increase of suspended sediment entering the lower Herring River and being deposited during a storm event when compared to normal tidal conditions. For the 3 foot opening, storm surge simulations indicate a significant mobilization of sediment in both the lower Herring River, as well as in the lower portion of the upper Herring River near High Toss Road. Significantly greater mobilization and erosion exists at the area near High Toss Road as the storm surge floods into the upper estuary and transports sediment upstream into depositional areas (primarily subsided regions). Downstream of High Toss Road, it is likely that bed load will be moved in both directions resulting in little net movement. Some sediment suspended during the flooding storm tide will likely deposit in areas of the estuary that are not typically flooded during normal conditions. As the surge recedes fines that are not deposited in the upper estuary will proceed toward the dike. Some of this sediment may make it into Wellfleet Harbor and become dispersed before the following tide brings it back into the estuary or it is carried into Cape Cod Bay.

Sediment transport processes are expected to change when the Herring River system is restored. Since the restoration project will use an adaptive management approach, it is expected that the changes to the sediment transport regime will occur over smaller incremental steps (via incremental opening of the sluice gates). As such, the sediment transport changes and amount of sediment transported will be less than is indicated in the modeling, which represents a significant opening size immediately after construction of a new dike.

Significant and valuable shellfish aquaculture exist in Wellfleet Harbor and there are concerns that the proposed restoration may result in smothering of these resources areas with sediment discharged from the Herring River system due to the increased tidal exchange. It is expected that when the system is initially opened, some fine-grain material would be likely transported downstream into the Wellfleet Harbor area. Over the long-term however, sediment would be transported upstream into the Herring River system. Figure ES-12 shows an illustration of the net upstream sediment transport process by tracking a suspended sediment particle through a complete tidal cycle. The suspended particle was initially mobilized in the High Toss Road region. The color of each dot represents the age of the suspended particle, progressing from blue (start of tracking) to red (end of tracking and a complete tidal cycle). The suspended particle is transported downstream during the ebb tide, but then returns upstream during the flood tide and settles in a position further upstream than where it originally started. If mobilized on the subsequent tide, it would be transported further upstream over the next full tidal cycle until it deposits in a depositional area and can no longer be easily mobilized.

In addition, the amount of sediment deposited in the Wellfleet Harbor area is not expected to be significant. The adaptive management approach will limit the total amount of material mobilized and a significant portion of the fine grained material will stay in suspension to areas seaward of Wellfleet Harbor. Additionally, the total volume of sediment mobilized from within the Herring River system is small compared to the area of Wellfleet Harbor. For example, if it is assumed that (1) all sluices are immediately opened to 3 feet (e.g., no adaptive management), (2) all sediment mobilized is transported downstream and deposited in Wellfleet Harbor, and (3) the depth of erosion for all mobilized areas is 1 foot, then the total thickness of sediment deposited in Wellfleet Harbor would be less than 1 cm (approximately 0.76 cm). As such, even using conservative assumptions, the potential sediment deposition thickness is minimal.

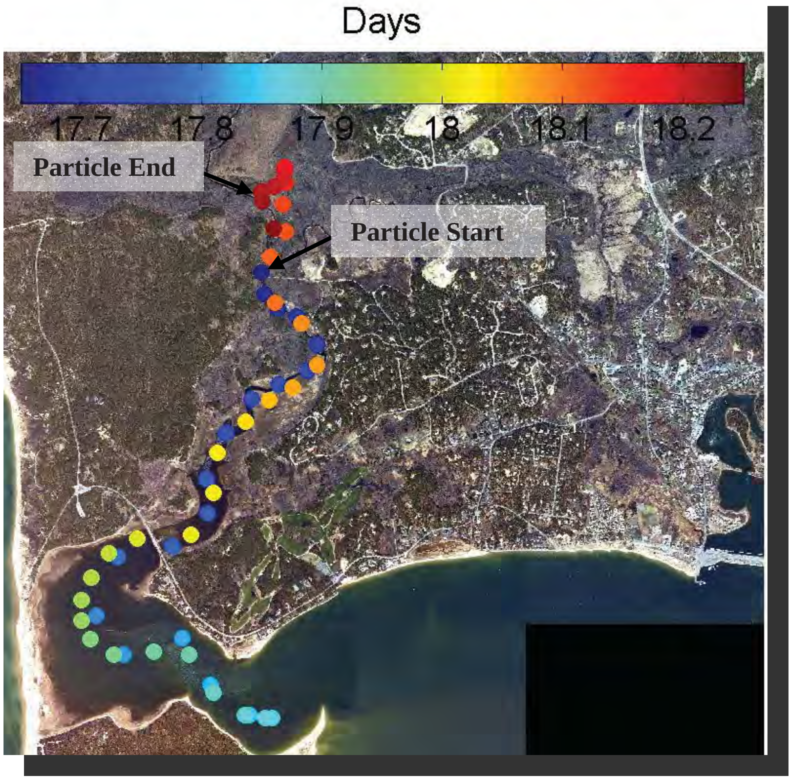
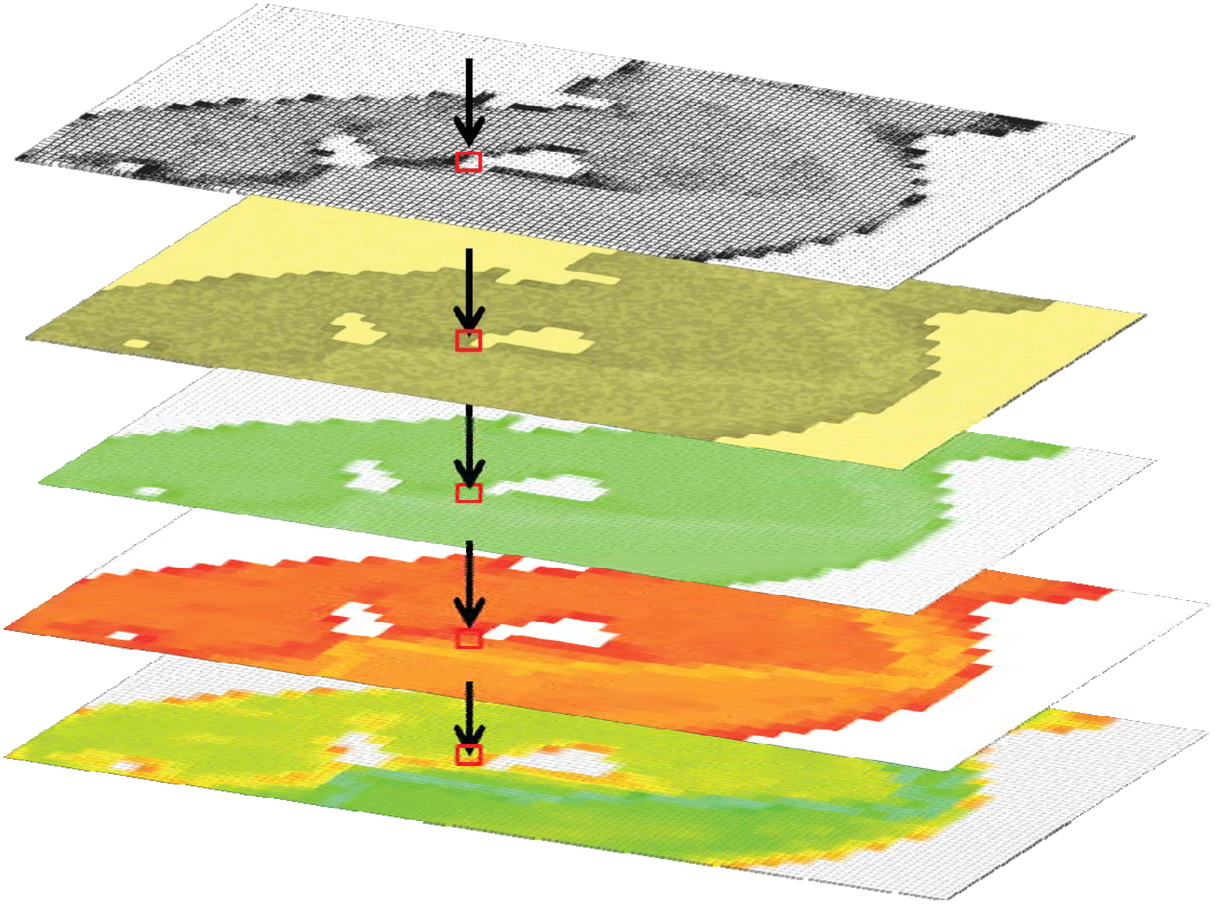


Figure ES-12. Suspended sediment particle tracking through a complete tidal cycle.

APPENDIX C: OVERVIEW OF THE ADAPTIVE MANAGEMENT PROCESS FOR THE HERRING RIVER RESTORATION PROJECT



Herring River Restoration Committee

March 2016

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Acronyms

CYCC	Chequessett Yacht and Country Club
EIS/EIR	Herring River Restoration Project Draft Environmental Impact Statement / Environmental Impact Report
EFDC	Environmental Fluid Dynamics Code
FHR	Friends of Herring River
GHG	greenhouse gas(es)
HREC	Herring River Executive Council
HRRC	Herring River Restoration Committee
MEPA	Massachusetts Environmental Policy Act
MOU	memorandum of understanding
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
ROG	regulatory oversight group
SDM	structured decision making
UNH	University of New Hampshire
USGS	United States Geological Survey
WHG	Woods Hole Group

INTRODUCTION

WHAT IS ADAPTIVE MANAGEMENT?

Adaptive management, in the context of natural resources, is a formal process intended to aid decision making in situations where the outcomes of natural resource management actions are uncertain. It is an approach applied to decisions that are repeated over time; the approach makes it possible to simultaneously manage and learn about the resources under management. Learning, and thereby reducing uncertainty about the outcomes, is achieved through an 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 this comparison to formally update our understanding of the system response to our actions. Information is obtained to specifically address the uncertainties that make decision making difficult, thus improving our ability to predict future outcomes and make better decisions regarding 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 iterative decision making, with a focus on reducing the specific uncertainties that hinder our ability to make the best management decisions (Williams and Johnson 1995). It has been applied to natural resource management since the 1970s (Walters and Hilborn 1978); however, formal usage of adaptive management is not common. SDM is a logical framework for making decisions that distinguishes those components of a decision that are subjective and values-oriented from those that are objective and science-based. An SDM framework guides a transparent decision-making process by explicitly linking the anticipated outcomes of management alternatives to well-defined objectives. The process balances competing objectives and the varied perspectives of multiple stakeholders, and incorporates quantitative measures of uncertainty, to identify management actions that are most likely to achieve the stated objectives.

Adaptive management requires careful planning, which can be described as a two-step process: a setup phase and an iterative phase. In the setup phase, components of the decision or problem being faced are identified and developed. These components include (1) a clear definition of the problem being addressed; (2) specific objectives to be achieved; (3) potential 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) the method for assessing trade-offs among competing objectives and identifying the decision, or alternative, or action that is most likely to achieve the objectives; and (6) a monitoring program that describes how the resource will be measured and monitored. The iterative phase involves implementing management actions, monitoring outcomes, and comparing the predicted outcomes of the action taken with the actual observed outcomes. As the iterative phase progresses, knowledge of the resource and the effectiveness of management intervention are 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 management strategy as the best approach to achieving the stated 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.

RATIONALE FOR ADAPTIVE MANAGEMENT AT HERRING RIVER

The 1,100-acre Herring River estuary within Cape Cod National Seashore has undergone more than 100 years of ecological degradation due to diking and drainage that began in 1909 and has resulted in almost complete exclusion of tidal exchange to the estuary. Over the past few decades, National Park Service (NPS) scientists and cooperators have conducted ecological and hydrologic research to identify impacts of the tidal exclusion to the ecosystem and develop options for restoration. Completion and subsequent support of a conceptual plan for the restoration of the Herring River (Herring River Technical Committee 2007) was the impetus to develop a hydrodynamic model (WHG 2012) and prepare the *Herring River Restoration Project Draft Environmental Impact Statement / Environmental Impact Report* (EIS/EIR, NPS 2012). The EIS/EIR, developed by the NPS and the Herring River Restoration Committee (HRRC; which includes the US Fish and Wildlife Service, National Oceanic and Atmospheric Administration (NOAA), Natural Resources Conservation Service, Commonwealth of Massachusetts, and the towns of Wellfleet and Truro), proposes construction of new dikes and water control structures to facilitate a gradual increase in tidal exchange to the estuary. The Herring River restoration project is the largest proposed tidal restoration project in the northeast, and there is a high degree of stakeholder involvement from both government agencies and the public due to the potential benefits and risks associated with large-scale management interventions (NPS 2012). Given that several decisions related to restoration need to be made prior to the restoration of tidal influence, some uncertainties can only be resolved once actions are taken, and the restoration is expected to be a long-term process, the EIS/EIR describes commitment to using an adaptive approach to guide decisions regarding implementation and evaluation of the Herring River restoration project. Collaboration and support of the US Geological Survey (USGS) was initiated in 2013 to begin development of a formal adaptive management decision structure that will help guide management decisions and measure progress toward specific restoration objectives for restoration of the Herring River.

The comprehensive adaptive management plan currently under development will

- identify ecological and socio-economic objectives of the restoration;
- define quantifiable metrics for all objectives to facilitate predictions and to measure progress towards management goals;
- determine a discrete set of management alternatives available to meet restoration objectives;
- work with subject matter experts to integrate existing models that predict how proposed management actions (model input) may affect the performance across all management objectives (model output);
- pinpoint critical areas of uncertainty and develop approaches to explicitly incorporate uncertainty into the decision framework;
- translate the range of objective outcomes into measures of value to decision makers and stakeholders (i.e., utility);
- develop an approach to evaluate trade-offs among the multiple objectives to identify the management strategy that is most likely to achieve the best (i.e., most desirable) outcome across all objectives;
- describe a monitoring protocol to collect data necessary as feedback under the adaptive management process; and
- establish a process to formally incorporate learning into future predictions.

PURPOSE AND STRUCTURE OF THIS DOCUMENT

The purpose of this document is to review development of the adaptive management framework for the Herring River project. It provides an overview of the forthcoming adaptive management plan and how these concepts will be applied as the project is implemented and evaluated. It is intended to provide greater understanding of how adaptive management and SDM will be used for the Herring River project and how this framework will integrate with project administration, oversight, permitting, stakeholder input and public outreach. It is expected that this document will provide the basis for preparation of a comprehensive adaptive management plan, to be developed in 2014–2016 through a collaboration of the HRRC, USGS, and other local, state, federal, and non-government stakeholders.

The document is structured according to the two-phase process often applied to adaptive management planning (Williams, Szaro, and Shapiro 2009; Williams and Brown 2012): a setup phase and an iterative phase. The setup phase is structured according to the SDM "PrOACT" model (Keeney, Hammond, and Raiffa 1999), where

- Pr = problem
- O = objectives
- A = alternatives (or actions)
- C = consequences, and
- T = trade-offs.

The iterative phase covers the steps that are specific to repeated decision-making aspect of adaptive management. These include making and implementing a decision, monitoring the response of the system related to the action taken, assessing how well predictions of the expected responses compare with the actual observed responses, and adapting the next decisions or management actions based on what was learned. These aspects of the setup and iterative phases are discussed separately in the following sections.

SECTION 1: SETUP PHASE

PROBLEM: DEFINING AND FRAMING THE DECISIONS TO BE MADE

The first step of SDM requires a clear definition of the problem to be addressed, which identifies why a decision needs to be made, the type of decisions that need to be made, and the individuals who will make the decision (i.e., "decision makers"). The 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 also be identified. The following are also included:

- a brief description of the potential actions that can be taken;
- the spatial and temporal scale of the problem;
- the frequency and timing of the decisions;
- the complexity of the problem;
- uncertainties that make decision making difficult; and
- legal, financial, or political constraints.

Cape Cod National Seashore and the towns of Wellfleet and Truro formally agreed to pursue the Herring River project by accepting the findings of a conceptual restoration plan (Herring River Technical Committee 2007) and signing a memorandum of understanding (MOU II) in 2007. The conceptual restoration plan laid out a strategy for restoration of the river, its tributaries, and floodplain by reintroducing natural tidal exchange, managing vegetation, and reestablishing estuarine marsh elevations and hydrology. As directed by the MOU, implementation of the project will be guided by the final EIS/EIR, under the policies of the National Environmental Policy Act (NEPA) and Massachusetts Environmental Policy Act (MEPA), and a newly developed MOU (MOU-III). MOU-III, developed concurrently with the final EIS/EIR, outlines a structure for administering the project which recognizes the authority of the Cape Cod National Seashore superintendent and Wellfleet and Truro Boards of Selectmen as the primary authorities for making decisions about project-related infrastructure under their respective ownership and management control (i.e., tide gates, as well as affected roads and public properties). MOU-III also describes the organizational structure and role of science, technical, outreach, and regulatory groups to provide support and management recommendations to Cape Cod National Seashore and the towns. As described in MOU-III, a non-governmental organization is envisioned to provide overall project management and to implement the decisions made by Cape Cod National Seashore and the towns according to guidelines of the MOU, the final EIS/EIS Record of Decision, and final adaptive management plan. As the adaptive management plan is developed and the project is eventually implemented, Cape Cod National Seashore, the towns, and other proponents will work closely with stakeholders (such as the Wellfleet and Truro Conservation Commissions, Public Works Department, Shellfish Committee, Natural Resources Advisory Committee, private landowners, and others) to ensure their concerns are considered in the decision-making process and to promote public understanding and support for the project.

The primary action requiring decisions includes the reestablishment of natural tidal flow and salinity levels throughout the approximate 1,000-acre Herring River floodplain by managing a series of adjustable tide gates at a rebuilt Chequessett Neck Road dike, a new dike along Mill Creek, and a new tide gate installed at Pole Dike Creek Road. Tide gate adjustments could be made zero to several times per year and would take into consideration the need to avoid adverse impacts to structures and roads, water quality, and vegetation as a result of changes in tidal flow, as well as the time needed to collect data that describes effects on state- and federally-listed rare species and system changes. The project will require permits and approvals from several municipal, regional, state, and federal agencies, including the U.S. Army Corps of Engineers, Massachusetts Department of Environmental Protection, Massachusetts Natural Heritage Program, and the local conservation commissions, which will likely impose conditions and constraints on several project elements. Availability of construction funding could also influence the timing and sequencing of implementing elements of the project.

In addition to incremental tidal restoration through the management of tide gates, secondary actions are likely to be needed to achieve the desired conditions. These secondary actions include the removal of trees and shrubs from the floodplain, management of non-native common reed (*Phragmites australis*), management of sediment to restore the elevation of subsided marshes, removal of anthropogenic fill (i.e., spoil piles from past mosquito ditch maintenance) from the floodplain, and reestablishment of appropriate channel dimensions and sinuosity of the Herring River and its tributaries. Decisions about implementing anticipated primary and secondary management actions are complicated by the difficulty of collecting data and observing changes throughout a large and complex system and an incomplete understanding of the effects of tidal restoration on tidal hydraulics, sediment transport, and water quality dynamics within the Herring River system. Some examples of questions about tidal restoration related to the Herring River restoration include the following:

- How will salt water circulate throughout the system as tidal range is increased incrementally?
- How much sediment will flow onto the floodplain and deposit on subsided marshes upstream of Chequessett Neck Road dike?
- To what extent will particles (i.e., sediment, bacteria, and nutrients) flow out of the river and into Wellfleet Harbor?
- How will vegetation change along a dynamically changing salinity gradient?

Decisions will also be complicated by the overlapping, integrated nature of anticipated management actions; that is, how incremental tidal restoration will be coordinated with other work elements, such was tree/shrub clearing, sediment management, and others.

Models and other predictive tools are needed to anticipate how these and other questions may be resolved. Monitoring data will be collected to compare predictions with actual results which will then be factored into future management decisions.

OBJECTIVES: WHAT WE WANT TO ACHIEVE

Clearly defined and measurable objectives are the foundation of any adaptive management program. Objectives are needed to identify the desired future conditions of the resource being managed and what the project is trying to achieve. Careful deliberation of objectives at the beginning of the setup phase permits a clearer understanding of the consequences and trade-offs involved with any decision, as well as a transparent means for evaluating progress toward success.

In the context of an adaptive management framework, objectives are intended to be more specific than the broader, more general objectives commonly cited for many natural resource undertakings. Adaptive management objectives must link to actions that can be realistically implemented or modified. Objectives for adaptive management also need to be tied to measurable parameters which can be predicted and monitored.

Fundamental objectives state the overarching reasons for management of the resource. In natural resource management settings fundamental objectives are often derived from an agency's or organization's mission to protect or manage for particular resources based on the general recognition by society-at-large that certain conditions are desirable. Sub-objectives articulate the means for achieving a fundamental objective. For example, there is a consensus that modern society requires clean drinking water. Thus, water resource agencies have a fundamental objective to protect public water supplies. Regulating development within watersheds is one of many sub-objectives, or the means, of achieving this over-arching fundamental objective.

Objectives must be measurable, with assigned performance measures or metrics. Performance measures serve two purposes: (1) to quantify and compare projections of how well alternative actions are expected to meet each of the objectives; and (2) to determine, via monitoring, the system response to implementation of a management action (i.e., a measure of progress towards achieving stated objectives). Comparison of the projected and observed performance measure is the basis for learning in adaptive management.

For the Herring River restoration project, the fundamental objectives are derived, in part, from NPS management policies as articulated in the current General Management Plan for Cape Cod National Seashore, 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 can be applied to the Herring River project more explicitly with a set of over-arching fundamental objectives (table 1) to restore the ecosystem by

- Restoring natural hydrography, including tide range and topography/ bathymetry;
- Restoring ecological function and integrity;
- Minimizing adverse impacts to ecological, cultural, and socioeconomic resources;
- Maximizing ecosystem services (i.e., benefits people receive from the estuary); and
- Minimizing the costs of restoration.

These fundamental objectives can be generically categorized as benefits (ecosystem restoration and services) and costs (adverse impacts and monetary costs of restoration). Each fundamental objective has sub-objectives, and each sub-objective has a performance measure, which will be used to measure how well an alternative action meets the restoration objectives. Sub-objectives and matching performance measures identified to date, and their hierarchical relationship to each fundamental objective, are depicted in table 1 and described in more detail in the following sections.

As part of the adaptive management planning process, the HRRC has discussed and reviewed sub-objectives and performance measures internally and at several forums involving regulatory agencies, technical advisors, and other subject matter experts. In addition, workshops for local stakeholders have been conducted to ensure that individual and group concerns are included in the objective framework and, ultimately, the adaptive management decision-making process. Comments from agencies and individuals received during review of the draft EIS/EIR were also incorporated into the objectives development process.

Table 1: Objectives and Performance Measures for Herring River Adaptive Management Plan

Sub-Objectives	Performance Measures	Predictions	Monitoring
Fundamental Objective #1: Restore Hydrography			
Restore tidal range			
Restore low tide	Maximum/minimum water surface elevations averaged for sub-basins and at key locations	Environmental Fluid Dynamics Code (EFDC)[1] hydrodynamic model	Electronic water level data loggers for sub-basins and at key locations
Restore high tide			
Restore hydroperiod			
Frequency of flooding	Wetting/drying of marsh surface averaged at key locations	EFDC hydrodynamic model	Electronic water level data loggers for sub-basins and at key locations
Duration of flooding	Duration of inundation of marsh surface at key locations		
Maximize marsh surface drainage	Extent of ponded water at low tide	EFDC hydrodynamic model	Electronic water level data loggers in areas of predicted ponding
Maximize marsh surface elevation			
Marsh surface sediment deposition	Accumulation of sediment at key marsh surface locations	EFDC hydrodynamic model with sediment module, coupled with MEM[2]	Deposition/elevation at surface elevation tables and markers
Below ground organic matter and pore space volume	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			
Maximize area restored			
Appropriate salinity gradient	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
Coverage of New England halophytes	Coverage of native estuarine vegetation types	SMART[3] and SLAMM[4] informed by EFDC model output	Transect/plot cover estimates; habitat mapping
Maximize habitat quality for native estuarine animals			
Water quality	Dissolved oxygen, pH, residence time (flushing), ammonium	USGS nutrient flux model[5]; expert judgment/elicitation informed by EFDC model	Synoptic surface water quality monitoring at key locations
Nekton	Species composition of nekton community	Published values; expert judgment/elicitation	Nekton sampling at key locations

Sub-Objectives	Performance Measures	Predictions	Monitoring
Benthic community	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			
Prevent impacts to structures and roads	Number of structures or roads impacts	EFDC hydrodynamic model	Groundwater wells near receptors
Minimize risk to public safety			
Minimizing risk to public at water control structures	Number of water-related incidents	Velocity output from EFDC model	Observations of activity during peak-use periods
Minimize risk to public elsewhere	Number of boating, transportation, recreation incidents in project area	Expert judgment/elicitation	Observations of activity during peak-use periods
Maximize access to emergency response	Size of area remaining fully accessible to emergency response	Expert judgment/elicitation	Document change in response time for incidents
Minimize adverse impacts to shellfish beds in harbor			
Minimize excess nitrogen export	Ammonium concentration near aquaculture areas	USGS nutrient model	Surface water quality monitoring near aquaculture areas
Minimize fecal coliform levels	Fecal coliform counts near aquaculture areas	Expert judgment/elicitation	Surface water quality monitoring near aquaculture areas
Minimize sediment deposition onto shellfish beds	Suspended sediment and deposition near aquaculture areas	EFDC hydrodynamic model with sediment module, coupled with MEM	TSS downstream of dike; particle size and deposition near aquaculture areas
Minimize loss of privacy for abutting property owners	Number of complaints	Water surface elevations and vegetation change from models	Documentation of incidents
Maximize aesthetics			
Maximize viewscapes from public vantage points	Horizontal viewing distance from key locations	Vegetation change from SMART/SLAMM models	Time series photo stations
Minimize negative appearance of dead woody vegetation	Number of complaints	Vegetation change from SMART/SLAMM models	Time series photo stations
Minimize hydrogen sulfide smell	Number of complaints	Expert judgment/elicitation	Documentation of complaints
Minimize noise	Number of complaints	Expert judgment/elicitation	Documentation of complaints

Sub-Objectives	Performance Measures	Predictions	Monitoring
Minimize turbidity	Turbidly, TSS	EFDC hydrodynamic model with sediment module, coupled with MEM	Continuous turbidity data logger; synoptic TSS grab samples
Minimize community conflict	Number of issues lacking community consensus	Expert judgment/elicitation	Documentation of conflicts and resolutions
Fundamental Objective #4: Maximize Ecosystem Services			
Maximize natural mosquito control	Species composition and abundance	EFDC output for ponding and salinity; mosquito prediction model	Larvae counts in breeding areas
Maximize greenhouse gas (GHG) sequestration	Rate of horizontal and vertical GHG fluxes	BWN GHG model[6] informed by EFDC hydro model output	Atmosphere carbon exchange; soil carbon accumulation
Maximize shellfishing opportunities (above and below dike)	Acres of open shellfishing areas	EFDC hydrodynamic model	Fecal coliform counts
Maximize recreational opportunities			
Minimize loss of existing recreational opportunities	Number of access points, parking areas	Expert judgment/elicitation	Documentation of lost/gain of access points
Maximize newly created recreational opportunities	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			
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

Notes:

Objectives hierarchy relating fundamental and sub-objectives for Herring River adaptive management to anticipated predictive models/tools and monitoring variables.

BWN Bringing Wetlands to Market; TSS = total suspended solids

1 Environmental Fluid Dynamics Code (Hamrick and Wu 1997)

2 Marsh Equilibrium Model (Morris 2010)

3 Salt Marsh Assessment and Restoration Tool (Rogers, Korisky, and Mustard 2007)

4 Sea Level Affecting Marshes Model (Warren Pinacle Consulting, Inc. 2012)

5 USGS Nutrient Model (Colman in prep.)

6 BWM Wetland GHG Model (Abdul-Aziz and Ishtiaq 2015)

Fundamental Objective 1: Restore Hydrography

In the context of the Herring River project, hydrography refers to the combined effect of tidal exchange, channel bathymetry, and marsh surface elevation. It is the prime factor determining the overall health and function of the estuary. After more than 100 years of tidal restriction, drastic loss of marsh elevation due to subsidence, and extensive direct and indirect modification to the tidal channel network, the hydrography of Herring River is significantly impaired.

The primary management actions under consideration to implement the project are all intended to reverse these conditions and restore natural hydrographic conditions to the greatest extent possible. This includes restoration of tidal range, including achieving the approximate levels of low and high tides occurring prior to diking, and promoting sediment deposition and marsh surface accretion to the extent that marsh elevations are restored within the appropriate inter-tidal range to support native estuarine vegetation.

To track progress toward meeting these objectives, extensive monitoring data throughout the project area will be collected (see table 1). This will include tidal water surface elevations, suspended sediment concentrations, sediment deposition, and other metrics intended to characterize the extent of tidal flow and sediment dynamics. Monitoring data will be compared with output from the hydrodynamic model and other predictive tools, in order to evaluate and improve their predictive capability.

Fundamental Objective 2: Restore Ecosystem Function and Integrity

While restoration of natural tide range and marsh surface elevations are the primary physical drivers of change within the Herring River system, the ecological responses of the system to tidal restoration are the primary outcomes sought by the project. These include the following:

- recovery of native estuarine habitats (i.e., sub-tidal benthic and aquatic habitats and inter-tidal salt, brackish, and freshwater habitats);
- improvements to water quality resulting from increased tidal flushing; and
- restoration of habitat and connectivity for diadromous and estuarine fish species.

Tidal restoration and the reestablishment of natural salinity levels would provide significant improvements when compared to existing conditions. However additional actions are likely to be necessary, and are being considered, in order to maximize these ecological outcomes and ensure that they are realized within a reasonable time frame. These actions, collectively referred to as secondary management actions, are described in more detail in the “Alternatives/Management Actions” section.

As both primary (i.e., incremental tidal restoration) and secondary actions are implemented, data will be collected to track the ecosystem responses to management. Monitoring efforts will focus on vegetation changes, water quality, and utilization of restored habitats by fish and other estuarine animals. Several predictive tools, including quantitative ecosystem models, expert elicitation, and professional judgment, will be used to predict ecosystem responses to management. More details about ecosystem modeling and management are described in more detail in the section “Consequences: Predicting Outcomes of Management Alternatives.”

Fundamental Objective 3: Minimize Adverse Impacts (to Ecological and Socioeconomic Resources)

Despite the dramatic and overwhelming benefits of restoring tidal exchange and functional native habitats to the Herring River, the current degraded state of the system and human development within the floodplain provide the potential for several adverse outcomes if the project is not carried out in a careful and well-monitored manner. Potential adverse impacts identified by project stakeholders are described and analyzed in detail in the final EIS/EIR and include the following concerns:

- Restored tidal flow effects to low lying structures (e.g., buildings, wells, driveways, etc.) and roads;
- Possible increased risk to public safety stemming from limitations to emergency response access during road and dike construction and increased recreational canoe/kayak activity near newly constructed culverts and tide control structures;
- Possible shellfish bed impacts in Wellfleet Harbor from excess nutrient export, transport of fecal coliform bacteria, algal blooms, and sediment deposition;
- Indirect impacts to residential property owners caused by vegetation changes (i.e., loss of woody vegetation), changing viewscapes, odors, and changes to recreational use of the river and floodplain, and;
- Potential conflicts among project proponents, town officials, local residents, and other stakeholders over management of the project and changes in recreational access and uses within the project area.

Avoiding and mitigating these potential impacts is one of the primary reasons why an incremental and adaptive approach is proposed for project implementation. Performance measures and monitoring procedures are being developed to track these impacts. A set of preliminary performance measures is included in table 1.

Fundamental Objective 4: Maximize Ecosystem Services

Coastal wetlands provide critical ecosystem services. Ecosystem services are the direct and indirect benefits accrued to people by the natural environment. Widespread examples are clean air, clean drinking water, and the harvest of fish and wildlife for food and recreation.

Along with the dramatic ecological improvements (described previously as part of objectives 1 and 2, and extensively in the EIS/EIR), objectives for the Herring River project include many improvements that would benefit people. Some of these, such as improvements to shellfishing and enhanced access for boating, link back to the historic uses of the Herring River prior to diking, when humans were first attracted to the area by the abundant resources and convenient water access to Wellfleet Harbor and Cape Cod Bay.

Other improvements to ecosystem services address long-standing issues associated with the tidal restriction and the degraded condition of the Herring River. For example, although the primary purpose for building the Chequessett Neck Road dike was to control mosquitoes, this goal was never achieved and high mosquito populations are a periodic concern. The restoration project is not expected to completely eliminate this issue; however, increased tidal flushing and higher salinity levels throughout the floodplain will reduce the area of breeding habitat for freshwater mosquitos. Reduced breeding habitat, combined with better access and habitat for fish that eat mosquito larvae (e.g., mummichog, *Fundulus heteroclitis*), is expected to result in an overall reduction of mosquito species that typically constitute a public nuisance.

An ecosystem service that has newly been recognized is the ability of coastal wetlands to absorb and store tremendous amounts of carbon. Until recently, carbon storage in coastal ecosystems—referred to as "blue carbon"—was largely a theoretical concept, but end users are now exploring its practical application to ameliorate rising levels of GHG in the atmosphere. The Herring River project presents a first of its kind opportunity to achieve GHG benefits, particularly methane emission reductions, from a large-scale tidal wetland restoration. Anticipated changes in tides and salinity suggest the Herring River provides one of the best and largest opportunities in the northeast United States to tie GHG carbon market benefits to tidal marsh restoration.

Fundamental Objective 5: Minimize Costs

The Herring River Restoration Project is a large and complex undertaking, with a preliminary cost estimate in the $40–60 million range and a requirement, borne in part by the commitment to the adaptive approach described in this document, to long-term monitoring and stewardship and a commensurate commitment of public funds. As such, project planners are obligated to minimize costs to the extent possible, while also ensuring satisfactory quality of all project elements including adequate resources for planning, oversight, and long-term operations and maintenance. For purposes of this evaluation, the idea of cost is broadly interpreted to include all of the direct construction costs as well as the human, administrative, and logistical resources required to manage and implement the project.

One primary factor that influences the overall cost of the project is the time required to fully implement the project and achieve some end-point. As stated in Herring River project documents, this is a long-term project, however the exact length of time implied by this cannot be specified. One way to minimize costs is to implement the project at faster rate (i.e., more frequent and/or larger tide gate openings) and thereby shorten this "long-term" timeframe, while concurrently minimizing the time required for intensive monitoring and oversight of project infrastructure. Other costs could be reduced by minimizing the need to implement secondary management (i.e., letting nature take its course versus proactively implementing targeted actions for specific purposes), designing tide control structures that are simple to operate and easy to maintain, and focusing monitoring and modeling efforts on the key processes and interactions that directly influence the outcomes of restoration actions and inform decision making. Along with the objectives previously described, these are factored into the SDM process described in the remainder of this document.

Process and Strategic Objectives

In addition to fundamental and sub-objectives, process and strategic objectives have been identified to help guide how the adaptive management plan is developed and ultimately implemented. These are useful for expressing important elements needed to support the adaptive management process, but would not be used for distinguishing among different strategies for tide gate operation or other management actions or for guiding decisions. Process and strategic objectives include the following:

- Maximizing the long-term collaboration of the towns of Wellfleet and Truro / Cape Cod National Seashore partnership and supporting technical and outreach groups;
- Maximizing access to funding opportunities;
- Maximizing responsiveness to community concerns;
- Maximizing public awareness and support for the project; and
- Maximizing learning about tidal restoration.

Objectives Hierarchy

Adaptive management objectives for the Herring River project are summarized in table 1, which contains the current list of fundamental objectives and sub-objectives. The objectives are listed within a hierarchy, with related sub-objectives grouped below each fundamental objective; the sub-objectives specify the components of the fundamental objective. As noted previously, these objectives have been developed by the HRRC over several meetings with technical experts, resource agency staff, and community stakeholders. As the adaptive management plan is developed and refined, the list of objectives may change, but this list is currently reflective of the project's important goals and concerns.

Performance measures associated with the lowest levels of the objective hierarchy are also included in table 1. Ultimately, these measureable attributes will be used to assess the consequences of the decision alternatives; that is, they will be the evaluation criteria used to compare the performance of each of the alternative actions with regard to the objectives. The attribute/performance measure is the content that must be predicted and monitored. In order of preference from a decision analysis perspective, measureable attributes can be (1) natural (i.e., a direct measurement of the objective), (2) a constructed scale or index, or (3) a proxy (a natural measurement that this highly correlated with the objective, though not a direct measure of it).

Table 1 identifies methods and means for predicting and monitoring the responses of the system as the project is implemented. Predictions and monitoring will serve several purposes:

1) to understand the current state of the system and thus be able to make state-based decisions,
2) to reduce uncertainty in how the system responds to management by comparing the predicted outcomes of decision alternatives with the actual observed outcomes, and
3) to track progress with regard to objectives.

Predictive tools (i.e., models) and monitoring are discussed in more detail in the "Consequences" section and "Section 2: Iterative Phase."

Influence Diagrams

Influence diagrams are conceptual models of how the system behaves regarding the influences that actions have on the system and, ultimately, the objectives (see figures 1a-1e). They help develop, communicate, and improve understanding about how the system functions. They identify where there are existing models to predict outcomes of actions and where such models are lacking; thus, they identify where other predictive methods are needed, such as new predictive models or expert opinion. The influence diagrams can also serve as the basis for developing a Bayesian Belief Network (a graphical probabilistic model that explicitly defines conditional relationships among key variables). The diagrams can also help us think creatively about alternative courses of action, or strategies, to compare with each other in terms of their predicted outcomes with respect to the objectives. Although the diagrams may appear complicated, they include only as much detail as is necessary to understand the key components of the system and make predictions of outcomes with respect to the objectives.

Influence diagrams developed for the Herring River, which are shown in figures 1a through 1e, are provided as examples and should be regarded as preliminary. They are expected to be modified as the adaptive management process develops; more refined diagrams will be included in the final adaptive management plan.

Figures 1a-1e should be read from right to left, starting with a fundamental objective (green hexagon). Sub-objectives (green rectangles) that are nested under each fundamental objective (see table 1) are shown to the left of the fundamental objectives in the influence diagrams. There may be multiple sub-objectives nested under each fundamental objective. Influences (purple rectangles) are shown to the left of the lowest level sub-objectives. Stochastic (i.e., random) events (red circles) are shown with linkages to the influence it affects. Management actions/decisions (gray rectangles) that are part of the adaptive decision making process, (i.e., tide gate manipulations and secondary actions) are shown on the far left of the influence diagrams. Models (yellow diamonds) require management actions as input and provide predictions of management outcomes.

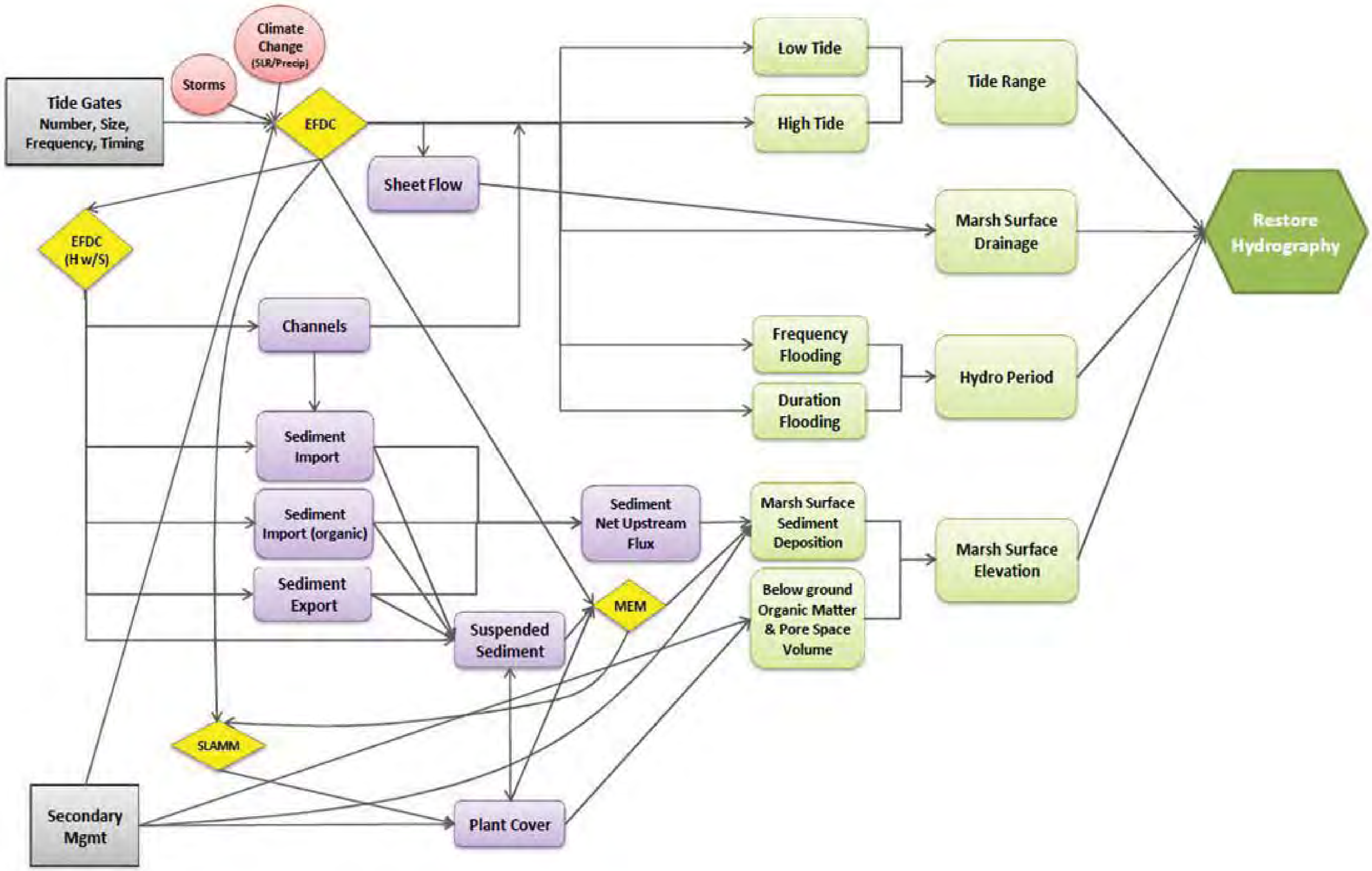


FIGURE 1A: INFLUENCE DIAGRAM FOR RESTORING HYDROGRAPHY

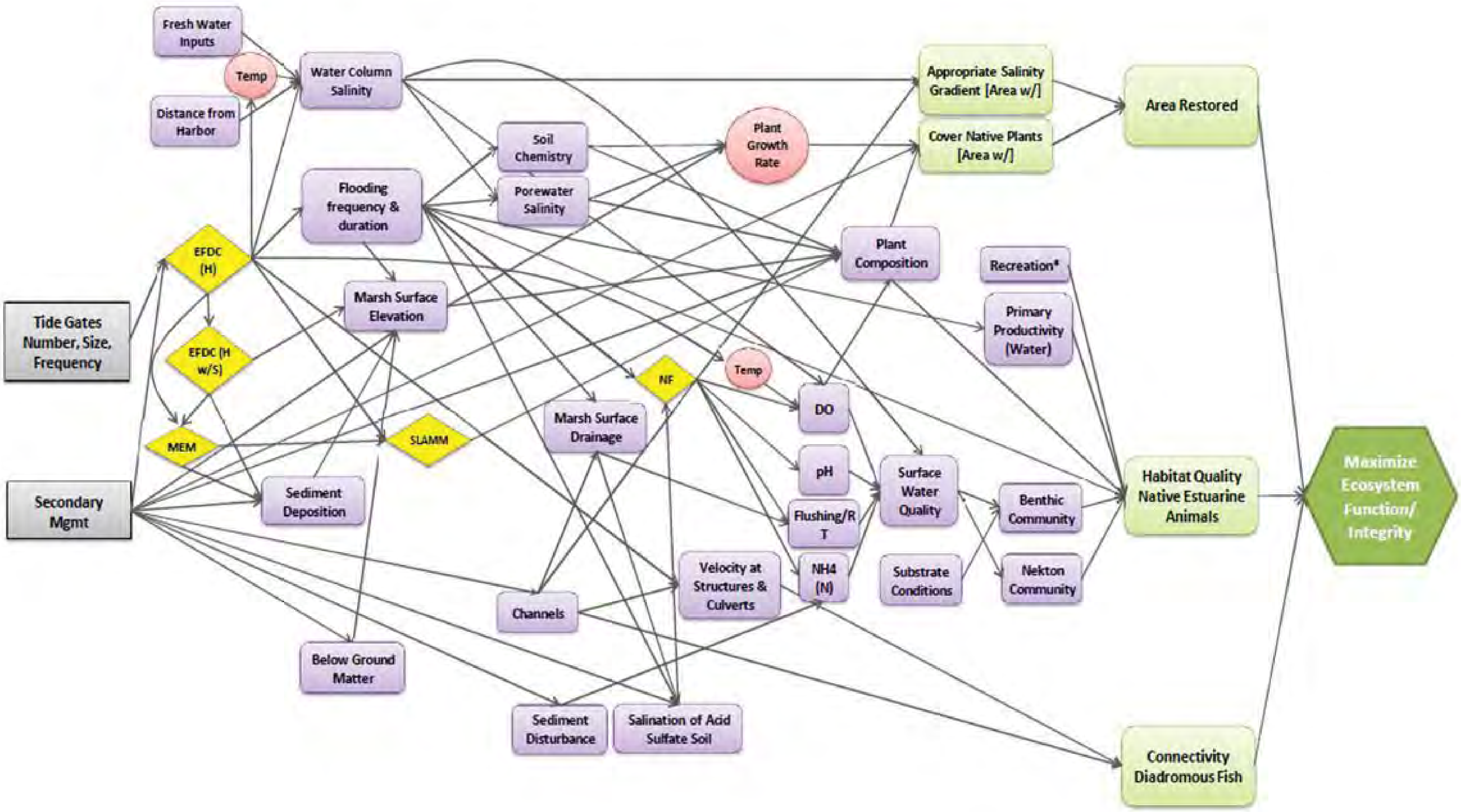


FIGURE 1B: INFLUENCE DIAGRAM FOR MAXIMIZING ECOSYSTEM FUNCTIONS AND INTEGRITY

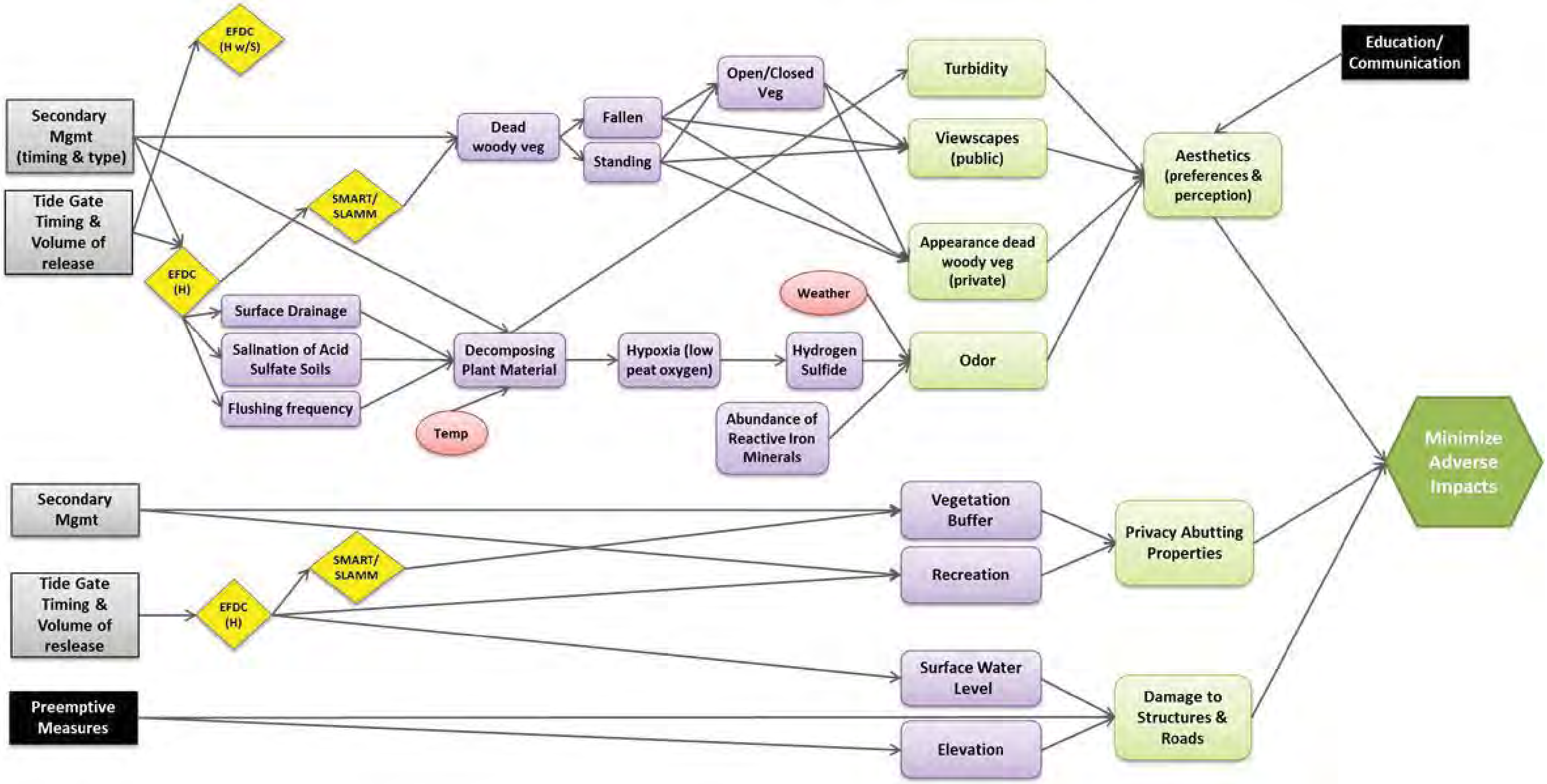


FIGURE 1C: INFLUENCE DIAGRAM FOR MINIMIZE ADVERSE IMPACTS (1 OF 2)

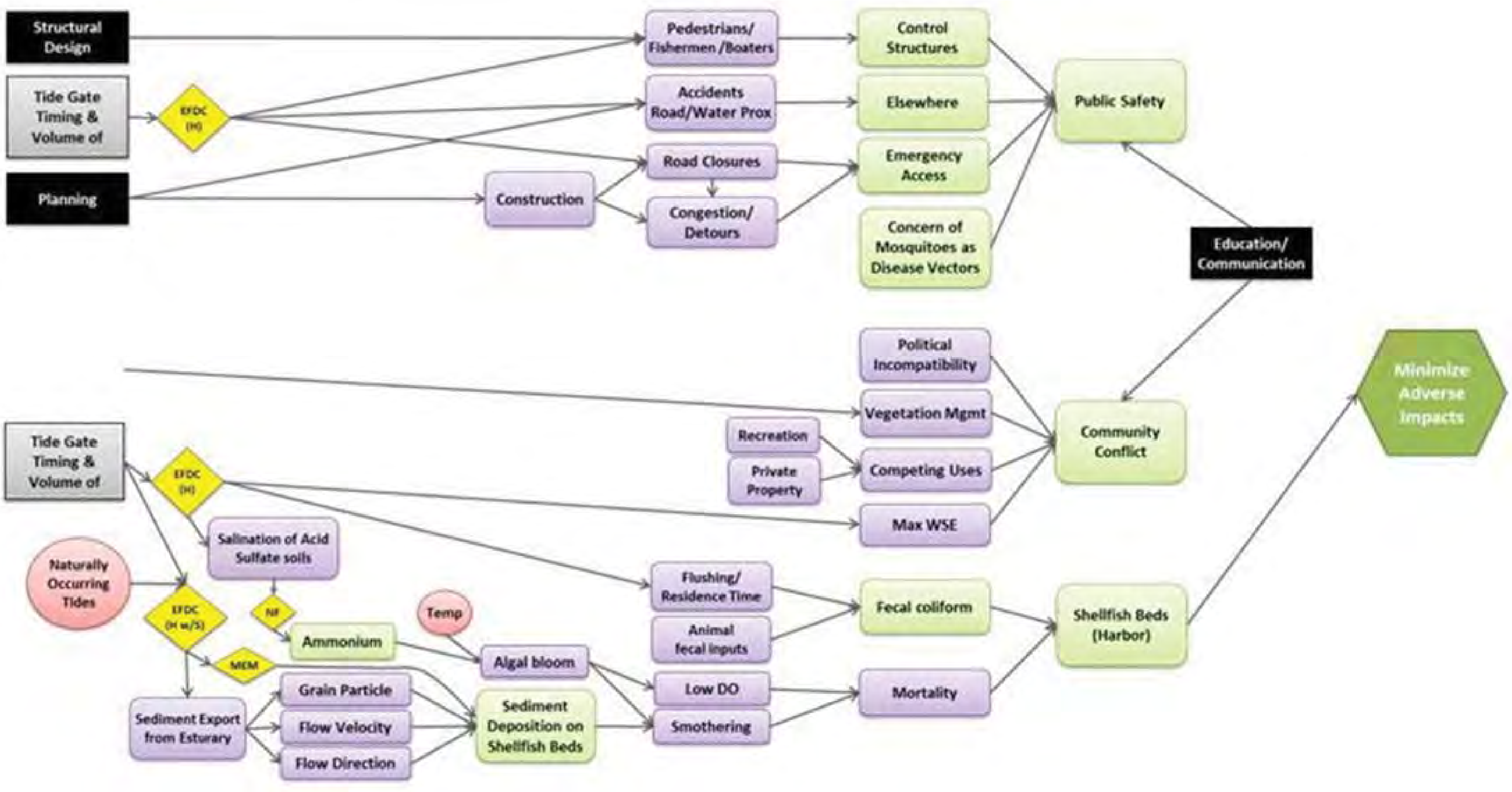


FIGURE 1C: INFLUENCE DIAGRAM FOR MINIMIZE ADVERSE IMPACTS (2 OF 2)

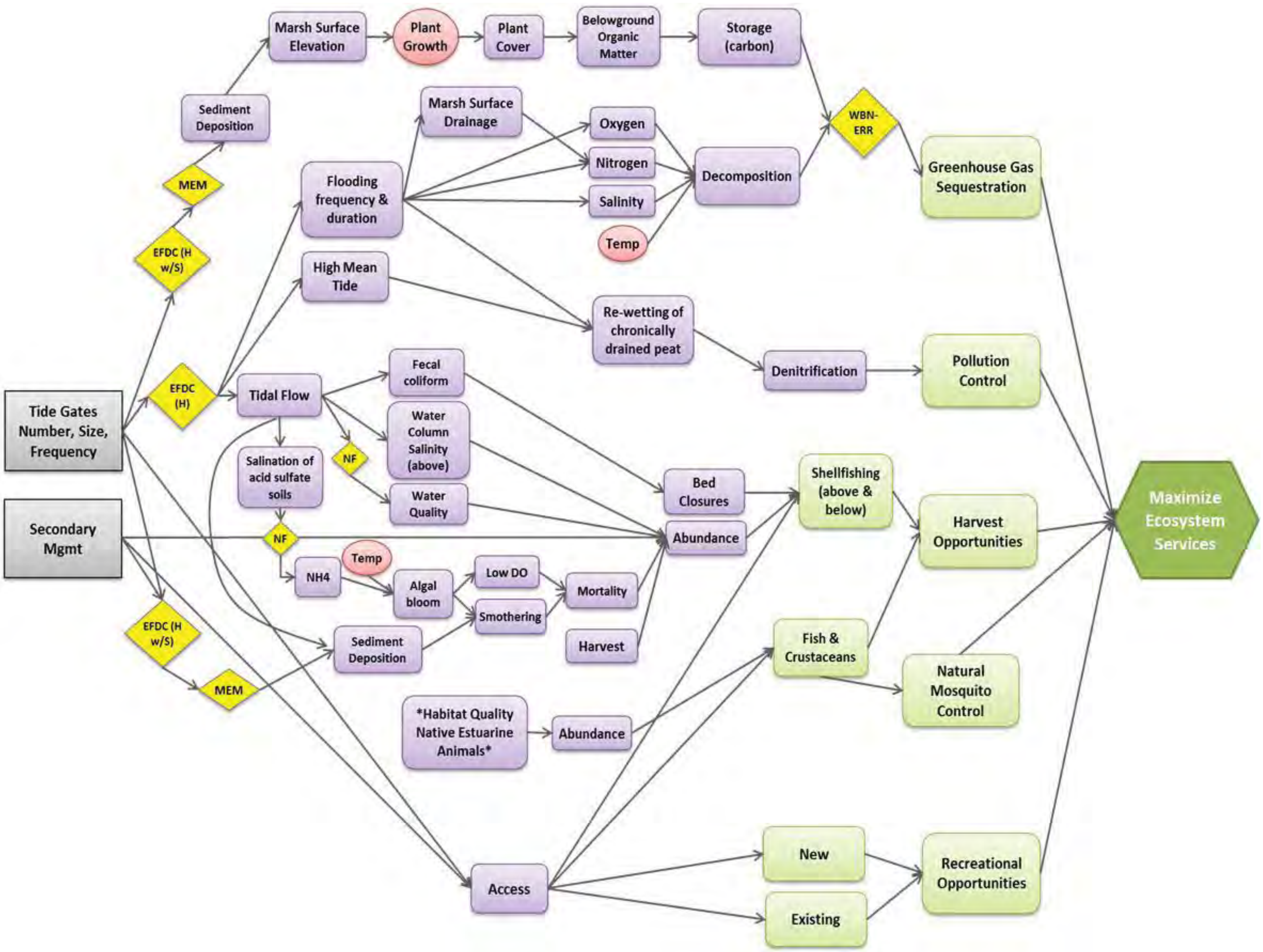


FIGURE 1D: INFLUENCE DIAGRAM FOR MAXIMIZE ECOSYSTEM SERVICES

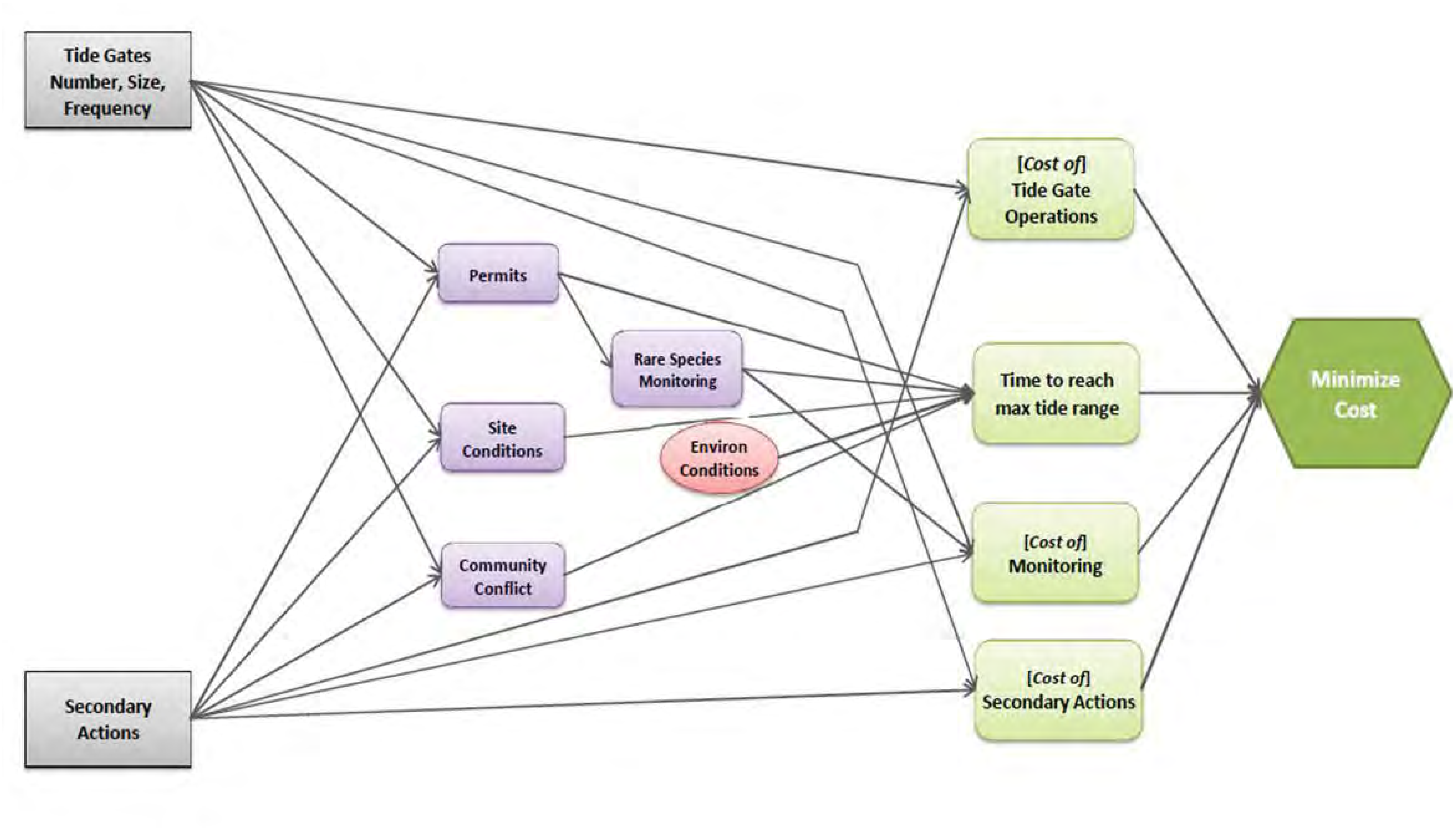


FIGURE 1E: INFLUENCE DIAGRAM FOR MINIMIZING COSTS

ALTERNATIVES/MANAGEMENT ACTIONS: WHAT WE CAN DO TO ACHIEVE OUR OBJECTIVES

In the SDM/adaptive management framework, alternatives are the actions or policies that are available to implement in our attempt to best achieve the project objectives. A set of potential management actions, or combinations of actions, from which to select is identified. Alternatives considered should span all reasonable actions available to managers. They should also have distinct measurable differences in their predicted outcomes, such that the differences amongst them can be discerned to distinguish the performance of one alternative over another across the range of objectives.

The Herring River project is comprised of a series of inter-related actions deemed necessary to meet the project objectives. Herring River restoration actions can be grouped into two categories:

1) primary actions needed to incrementally restore tidal range and salinity to the floodplain by managing a series of adjustable tide gate structures at Chequessett Neck Road, Mill Creek, and Pole Dike Creek Road;
2) secondary actions implemented in coordination with tide gate management that are intended to augment and maximize the effects of restored tidal exchange – generally these can be categorized as vegetation management, sediment management, and enhancements to tidal circulation.

A summary of potential actions contemplated as part of the Herring River project is included in table 2.

Primary Management Action: Incremental Tide Gate Openings

For the Herring River project, the primary action for tidal restoration, the opening of tide gates, appears to involve a relatively simple decision, repeated over time. However tide gate management is likely to be more complicated as there can be competing ecological and socioeconomic objectives. Although the core of each decision involves a simple "yes-or-no" answer about whether to manipulate tide gates, managers will be faced with making decisions under varying conditions as the project is implemented and objectives are reassessed. Complexity is also added by the configuration of the proposed tide control structures, which will be constructed at three distinct locations (Chequessett Neck Road, Mill Creek, and Pole Dike Creek Road) and the diversity of tide gate types (i.e., adjustable slide gates, conventional flap gates, combination slide-flap gates). These actions will require decisions about which gates to open, how large the openings should be, and how frequently adjustments should be made.

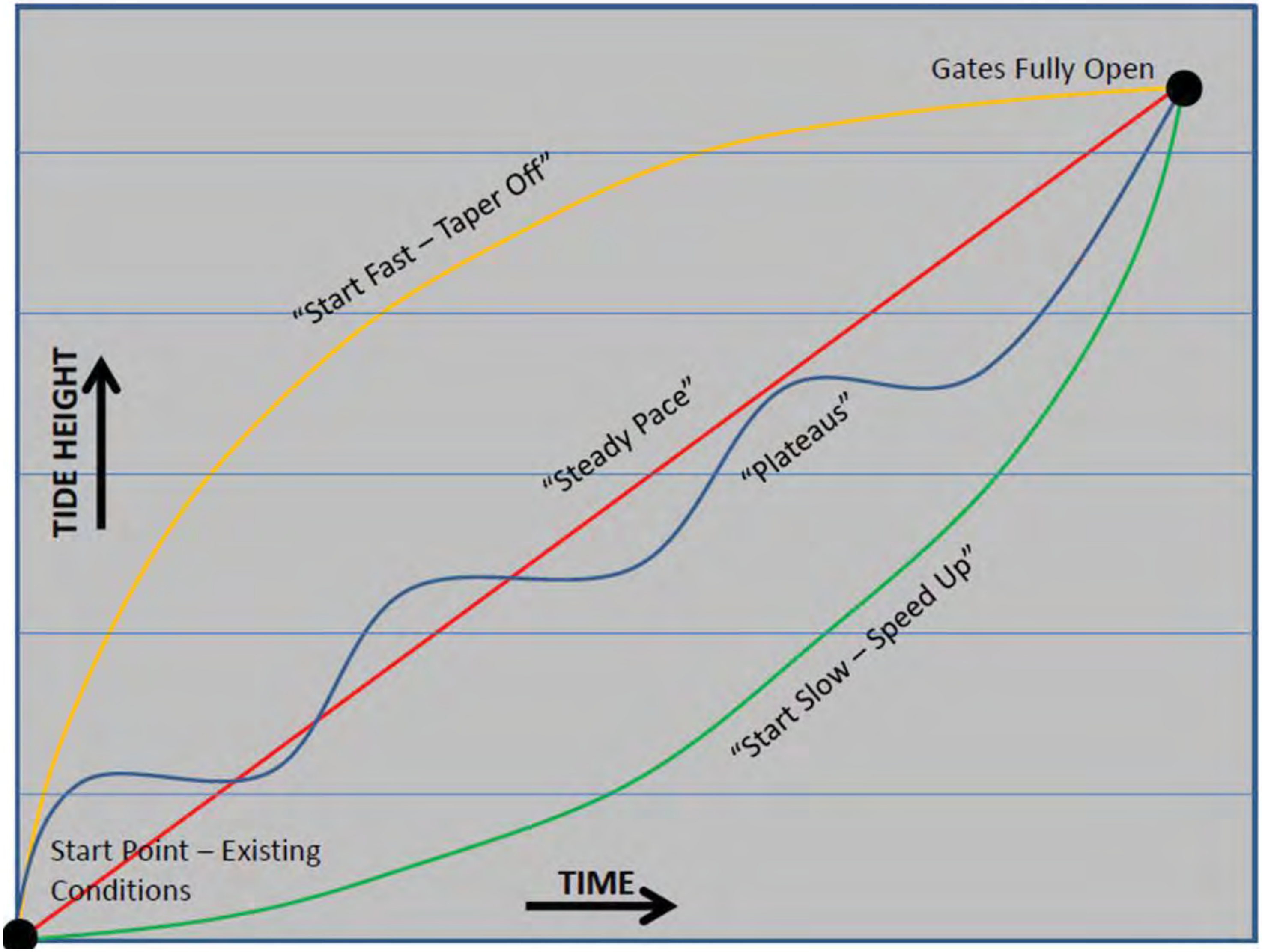
Table 2: Menu of Possible Management Actions

Tide Gate Management	
Less frequent gate openings	Relatively long time period between tide gate adjustments
More frequent gate opening	Relatively short time period between tide gate adjustments
Smaller gate openings	Relatively smaller incremental openings
Larger gate openings	Relatively larger incremental openings
Gate closure	Reduction in tide gate opening size in response to unforeseen adverse impacts
Sediment driven	Tide gate manipulation dictated by high tide events in order to promote sediment deposition in Herring River flood plain
Vegetation driven	Tide gate manipulation dictated by progressive colonization of inter-tidal areas as tide range increases
Vegetation Management	
Herbicide application	Treatment of common reed with herbicide
Mechanical – cut and leave	Woody vegetation cut in place and left to decompose on marsh surface
Mechanical – cut and burn	Woody vegetation cut in place, slash burned after dry
Mechanical – chipped in place	Woody vegetation cut in place and chipped, chips remain on marsh surface
Mechanical – whole tree chipping	Woody vegetation cleared with heavy duty forestry equipment (e.g., "brontosaurus" mulching cutter)
Mechanical – remove large wood, chip remainder	Larger trees removed by conventional forestry practices; other woody vegetation cut and chipped
Prescribed fire	Use of fire to clear selected areas
Remove vegetation and dead material from channel	Non-native submerged vegetation (e.g., watercress) and fallen woody material removed from stream channels
Planting/seeding	Use of seeds, potted, and bare root stock to enhance revegetation of natural plant communities
Wrack dispersal	Dispersal of dead, floating salt marsh vegetation over marshes to introduce seed source
No action	No direct actions for vegetation management
Sediment Management	
Mechanical dredging of channels and redistribution	Sediment trapped in ditches and channels dredged and distributed over subsided marsh surfaces
Mechanical excavation of spoil piles and redistribution	Removal of anthropogenic spoil piles and distribution of material over subside marsh surfaces
Off-site importation and deposition	Deposition of sediment derived from off-site upland sources on subsided marsh surfaces
"Thin layer" deposition (hydraulic dredging and pumping)	Beneficial use of dredged material from Wellfleet Harbor and elsewhere and deposition on subsided marsh surfaces
Re-use of Chequessett Neck Road dike and High Toss Road materials	Deposition of excavated material from Chequessett Neck Road dike, High Toss Road, and elsewhere on subsided marsh surfaces

Channel/Pool Management	
Breach and remove ditch spoil berms	Full or partial removal of anthropogenic spoil and fill on marsh to improve tidal flow
Dig connector and radial ditches	Creation of new ditches to improve tidal flow and habitat connectivity
Ditch plugging	Full or partial plugging or blocking of anthropogenic ditches to promote sheet flow over marsh and revegetation
Scrape out salt pools and pannes	Creation of shallow salt pools and pannes for estuarine fish habitat and mosquito control
No action	No direct actions taken channel/pool management
Wildlife/Fish/Shellfish	
Supplement shellfish stocks	Introduce shellfish spat in appropriate habitats
Substrate enhancement	Introduce cultch in appropriate habitats
Remove obstacles from channels; improve passage	Remove impediments to fish passage from tidal creeks and at culverts/crossings
Maintain tree roosting/nesting habitat	Allow dead/dying trees to persist as roosting and/or nesting sites for birds and bats
Relocation of state-listed rare species	Move populations/individuals from affected habitats to appropriate refugia
Turtle "Gardens"	Create/restore sandy nesting habitat for diamond-back terrapin
No action	No direct actions for fish/wildlife management

Note: Potential actions being considered to achieve the objective of the Herring River adaptive management plan involve management of tide gates, vegetation, sedimentation, marsh channels and pools, and fish, shellfish, and wildlife.

As part of the evaluation of alternative management strategies, the HRRC is undertaking an in-depth analysis of the range of options, or policies, available for managing tide gates. As shown in table 2, there are several approaches to how quickly and how often tide gates could be opened and how they could be manipulated to favor discrete objectives or outcomes. This concept is demonstrated graphically in figure 2, where four alternative approaches to tide gate management are depicted by hypothetical hydrographs. In this figure, the x-axis represents time and the y-axis represents the elevation of high tide in the Herring River. The red line, labeled "steady pace" shows a tide gate opening policy where water levels are increased at an even rate from the beginning to the end of the process. Each incremental change to the tide gate structure would result in an equal increase in high tide level. Alternately, the policy depicted by the orange line ("start fast – taper off") is one where tide levels would increase relatively rapidly early in the project and then be scaled back. The green line ("start slow – speed up") shows the opposite approach, where early tide height changes occur slowly but are ramped up later in the process. Finally, the blue line ("plateaus") describes a process where high tide is quickly increased to a certain elevation and then held there for a period of time before being increased further. These representations illustrate approaches to managing tide gates at the new Chequessett Neck Road dike, however the approaches could be applied equally to both the Mill Creek dike and Pole Dike Creek Road tide gates. No matter where it is applied, this is a simplified example of several tide gate management policies; other polices will also be identified and considered. In reality it is likely that multiple polices will be used and modified as the project is implemented and circumstances evolve.



Note: Each line represents a potential pattern for increasing tide range over time: even, steady changes (red line); changes that start quickly and slow down (orange line); start slow and speed up (green line); and changes that reach certain threshold elevations for periods of time (blue line).

FIGURE 2: HYPOTHETICAL HYDROGRAPHS FOR FOUR POTENTIAL TIDE GATE MANAGEMENT POLICIES

Although the targeted end point (i.e., tide gates fully open) and long-term effects (described in detail in the final EIS/EIR) are the same in every case, each of the tide gate management policies depicted in figure 2 would have varied shorter-term impacts during the time period when tide gates are being actively managed and other project actions are being implemented. Each policy would likely result in faster or more complete attainment of some objectives while slowing down or limiting the attainment of others. For example, opening the tide gates faster during early periods of implementation may promote greater sediment transport and deposition throughout the floodplain, but could also result in adverse but temporary water quality effects. The analysis and evaluation of these and other impacts relative to alternative management strategies are discussed further in the following sections.

Secondary Management Actions

Although incremental openings of new and reconfigured tide control structures are the central actions for implementation of the Herring River project, it is likely that additional actions, primarily occurring directly on the former tidal marsh surface, will be needed to fully achieve and maximize the project's objectives. The basic intent of these actions is to restore and maximize ecological function in order to reverse direct and indirect damage to the floodplain from more than 100 years of tidal restriction and wetland drainage. Damage to the system includes subsidence of the former estuarine floodplain, colonization of freshwater and upland plant species (including non-native vegetation) within former salt and brackish habitats, loss of tidal creek and salt panne microhabitats, and deposition of dredge and ditch spoil on marsh surfaces and in former tidal creeks. Actions needed to address these problems are summarized in table 2 and include

- **Vegetation Management.** Intended primarily to (1) remove woody trees and shrubs, including both upland and freshwater wetland dependent species, which if left in place would likely impede the recovery of native salt and brackish marsh plants, and (2) control the expansion of non-native common reed throughout the floodplain. Options for treatment methods and management of cut material need to be assessed to determine how each affects water quality, sediment transport, vegetation recovery, and other project objectives.
- **Sediment Management**. Substantial sediment deposition throughout the Herring River floodplain is needed to counteract historical subsidence and restore the marsh plain surface to elevations where salt and brackish marsh vegetation will flourish within the inter-tidal range. Though tidal restoration is the primary driver for importation of sediment and marsh accretion, it is possible that additional management actions will be necessary in order for marsh surfaces to reach the appropriate elevations within a reasonable timeframe (in some locations, 2–3 feet of accretion is needed and this could take decades without additional interventions beyond the restoration of tidal flow).
- **Restoration of Salt Pannes, Pools, and Tidal Creeks**. A number of additional management actions likely will be necessary to enhance and maximize the effects of tidal restoration to address past channelization and marsh ditching alterations made directly to the floodplain.

Alternate Action Strategies

As described previously, implementation of the Herring River project will primarily involve a series of tide gate adjustments at three locations (Chequessett Neck Road, Mill Creek, and Pole Dike Creek Road) to increase the extent of tidal influence and salinity levels throughout the estuary. A series of secondary actions are also assumed to be necessary to maximize the effects of tidal restoration and avoid several potential adverse impacts. These actions have been presented as separate activities, but actual implementation of the project will require coordinated integration of management actions in order to achieve multiple objectives. Some actions could favor one project objective while impeding or conflicting with others. Thus, as part of the adaptive management framework, it is useful to consider how each discrete action may affect each Herring River objective and how actions could be integrated to form strategies aimed at specific objectives or outcomes.

Table 2 lists specific actions being considered under the broad management categories of tide gates, vegetation, sediment, channel/pool restoration, and fish and wildlife habitat. For example, varying approaches to managing new tide control structures are listed and briefly described and vegetation management includes varied methods of removal and disposal of material. These items could be viewed as a "menu" from which to select one or more actions from each of these broad categories. Collectively, a set of selected items would comprise a strategy or policy intended to favor specific and distinct outcomes.

To illustrate this concept, the HRRC has initiated an analysis of several sets of separate actions that could be considered as discrete strategies. As a planning exercise, project strategies that would prioritize one objective above others were identified. Strategies were developed to favor, for example, water quality improvement, marsh surface accretion, vegetation recovery, anadromous fish passage, and minimization of costs. Actions listed in table 2 were selected and combined to determine a strategy that would be most advantageous for each prioritized objective. The combined sets of actions, summarized in table 3, constitute coordinated strategies, where specific alternative actions for managing tide gates, sediment, vegetation, and other elements of the project would be taken to promote specific objectives.

CONSEQUENCES: PREDICTING OUTCOMES OF MANAGEMENT ALTERNATIVES

Predicting the expected consequences or outcomes of an action is an essential part of any decision-making process. In a SDM/adaptive management framework, models are necessary to predict the consequences (in terms of both costs and benefits) of alternative actions and to anticipate how management decisions affect project objectives. In this context, the term "model" is considered broadly, encompassing any type of predictive tool, ranging from simple narrative statements and conceptual diagrams, to informed judgments elicited from subject matter experts, to complex computer simulations. No matter what type of model is used, the important thing is that it represents a particular hypothesis about how the system functions and it links the alternatives (model input) to the objectives (model output).

TABLE 3: EXAMPLES OF COMPILED MANAGEMENT STRATEGIES FOR SPECIFIC OBJECTIVES

Objectives	Available Actions				
	Tide Gates	Vegetation Mgmt	Sediment Mgmt	Marsh Restoration	Wildlife/Fish/Shellfish
Improve Water Quality	Chequessett Neck Road: Open fast (winter only)	Apply herbicide to phragmites prior to flooding	No action	Breach and remove ditch spoil berms and other anthropogenic fill	Supplement shellfish stocks
	Mill Creek and Pole Dike Creek Road: Open slow (winter only)	Avoid mechanical work that will disturb substrate or result in sedimentation		Re-establish flow to historic reaches	Substrate enhancement
		Seed and plant ASAP to stabilize marsh surface and prevent erosion and sedimentation		Enhance circulation while minimizing soil disturbance	Oyster reef development (build/restore)
Improve Fish Passage	Chequessett Neck Road: Open fast	Remove vegetation and dead material from channels and banks	Time of year restrictions on all in-water activities	Ensure there is a well-defined channel	Time of year restrictions on all in-water activities
	Adequate depth at all crossings, not just at tide gates	Remove submerged aquatic vegetation			
Facilitate Sediment Accretion	Phase I: Open on incoming tide, close tide gate at top of tide, hold for x amount of time to allow sediment to settle. Repeat as necessary	Mechanically clear trees, but not shrubs; focus on areas impacted by tides	Push spoil piles adjacent to channelized reaches into adjacent marsh by bulldozer	Breach and remove ditch spoil berms and other anthropogenic fill	No action
	Phase II: Fast, larger opening on moon tide – once or twice a month – or on storm tide		"Thin layer" deposition (hydraulic dredging and pumping)	Restore connectivity of tidal creeks (construct channels) to all sub-basins	
	Phase III: Revert to routine tide management		Re-use of Chequessett Neck Road dike and High Toss Road materials		
			Importation of materials from Wellfleet Harbor dredging		

Objectives	Available Actions				
	Tide Gates	Vegetation Mgmt	Sediment Mgmt	Marsh Restoration	Wildlife/Fish/Shellfish
Enhance Recreation	Open fast – maximize access by kayak/canoe	Mechanical – whole tree chipping	No action	Remove blockages and berms from tidal creeks	No action
		Place wrack in floodplain		Increase Connectivity	
		Seed and plant			
Promote Estuarine Vegetation	Phase I: Open quickly to restore 18+ ppt to lower basin to kill phragmites	Phase II, III: Herbicide phragmites	No action	Dredge to maximize circulation and drainage within basin appropriate to the phase	No action
	Phase II: Open on incoming tide, close on outgoing tide, and hold	Phase II, III: Remove all woody vegetation			
	Phase III: Repeat (same as phase II) for mid-basin when mid-basin is not subject to marsh drowning.	Phase I, II, III: Seed and plant as necessary in each basin			
	Phase IV: Repeat (same as phase III) to fully open when upper-basin is not subject to marsh drowning.				
Minimize Time to Natural Hydrography	Open gates as quickly as possible (according to EFDC model). Get to fully open and accept resulting subtidal areas (open water and inter-tidal mud flats).	Manage as necessary to support connectivity and circulate flow	Use dredged material to raise fringe areas of subsided areas in mid-basin	Manage channels as necessary to support connectivity and circulate flow	No action
Minimize Cost	Open gates as quickly as possible (according to EFDC model). Get to fully Open and Accept Resulting subtidal areas (open water and inter-tidal mud flats).	Manage as necessary to support connectivity and circulate flow	Use dredged material to raise fringe areas of subsided areas in mid-basin	Manage channels as necessary to support connectivity and circulate flow	No action

Note: Available management alternatives are combined into "portfolios" of actions that best achieve specific project objectives.

The primary predictive tool for the Herring River project is the two-dimensional hydrodynamic model developed by the Woods Hole Group (WHG) derived from the EFDC (Hamrick 1996), which has been used to simulate the hydraulic and hydrologic conditions resulting from a wide range of restoration scenarios (WHG 2012, 2013). The hydrodynamic model has been used for determining the optimal dimensions for the reconstructed Chequessett Neck Road dike and tide gates as well as other tide control structures and culverts throughout the project area. It is the primary tool for estimating the extent of tidal and storm-driven flows under a range of restoration scenarios, including the impacts of the project alternatives described in the final EIS/EIR, and for determining where flood prevention measures are likely necessary to avoid adverse impacts to roads and structures. Along with predicted water surface elevations, the hydrodynamic model also provides predictions of future salinity levels, which have been used to make overall long-term habitat change estimates included in the final EIS/EIR. The hydrodynamic model will continue to be used as part of the adaptive management plan, to predict outcomes of potential tide gate changes; it will also be linked with other models and predictive tools (see the next section on developing a conceptual framework for ecosystem modeling). The hydrodynamic model will also be refined as the adaptive management plan is implemented and we are able to compared model predictions of actions with actual observed outcomes after action implementation.

Developing a Conceptual Framework for Ecosystem Modeling

During 2013, the HRRC partnered with the Center for Coastal Studies, WHG, and Jackson Lab at the University of New Hampshire (UNH) to develop a framework for a comprehensive ecosystem model, or set of models, capable of simulating a broad range of ecosystem functions and services and predicting responses to multiple project objectives that result from tidal restoration and other management activities. The endeavor included two workshops where coastal ecology, modeling, wetland restoration, and decision-analysis experts reviewed and discussed applicable models and monitoring plans with respect to project objectives, anticipated management actions, stakeholder concerns, and uncertainties. With this input and feedback, the WHG/UNH team investigated existing models and evaluated their functionality and suitability for application to the Herring River system and potential compatibility with the EFDC hydrodynamic model. A summary of models reviewed during this effort, as well as their data input requirements, simulated output, typical scenarios, and complexity are included in table 4.

TABLE 4: SUMMARY OF ECOSYSTEM MODELS EVALUATED FOR HERRING RIVER

Model Type	Model	Parameters Simulated/Output	Input Data Requirements	Typical Scenarios	Level of Complexity
Hydrodynamic/Water Quality/Sediment Transport	EFDC	Water level, current speed and direction, salinity, temperature, suspended sediment, water quality concentrations (e.g., nutrients, contaminants)	Topography/bathymetry; boundary conditions (water level, inflow rate, salinity, atmospheric, flux rates, etc.)	Existing/baseline conditions; storm and sea level rise conditions; modified flow restrictions/structures/grading/dredging; changing water quality loads/fluxes	Numerical, time stepping
	Integrated Compartment Model (CE-QUAL-ICM)	Water level, velocity, algae growth, water quality (21 parameters), DO/nutrient dynamics	Topography/bathymetry; boundary conditions (water level, inflow rate, salinity, atmospheric, flux rates, etc.)	Water quality simulations in vertically-stratified systems	Numerical
	Estuarine Loading Model (ELM)	Limited to transformations, availability, and export of nitrogen (inorganic and organic species)	Watershed nitrogen loads (from models such as NLM), water residence time, areas of open water, salt marsh eelgrass meadows within the estuaries of interest. In addition, average depth and tidal range will be needed for a calculation of flushing time by ELM if not provided by hydrodynamic model or other means	Predicting labile and refractory nitrogen in marsh/estuarine systems; understanding production rates of organic matter and rates of total system metabolism	Analytical
Landscape/Vegetative Cover	Salt Marsh Restoration Assessment Toolbox (SMART)	Habitat: Low/high/invasive species by salinity category	Potential flood level (mean high water, 4th largest, max); sea level rise, accretion/subroutine; salinity; plant composition; elevations (e.g., LIDAR)	Predict habitat changes in marsh based on restoration alternatives, including no action; influence of sea level rise; identify monitoring gaps	Prescriptive
	Polygon Based Spatial (PBS) Model	Water level; suspended sediment concentration; elevation; habitat/vegetation succession	Runoff; water level; elevation; habitat type; sediment information	Forecast habitat/vegetation succession in response to different water level/runoff conditions	Analytical / numerical

Model Type	Model	Parameters Simulated/Output	Input Data Requirements	Typical Scenarios	Level of Complexity
	Everglades Landscape Model (ELM v2.8.4)	• Hydrology: Overland, groundwater, canal flows • Nutrients: Phosphorus cycling and transport • Periphyton: Response to nutrients and water • Macrophytes: Response to nutrients and water • Soils: Response to nutrients and water	Maps: Surface water, elevation, bathymetry, soil moisture, bulk density, organic matter, and phosphorus; habitat type, plant biomass, hydrological routing Time Series: Weather data, P deposition, total atmospheric P deposition	Changes in hydrology, changes in phosphorus loading, climate change scenarios	Numerical / analytical
	Marsh Equilibrium Model (MEM v. 3.4; DCERPI Module)	Plant growth; sediment trapping; marsh plain elevation change	Plant biomass as a function of Elevation; Root:Shoot Quotient; Turnover Rate of BG biomass; refractory BG biomass; relative marsh elevation; tidal range; rate of sea level rise; suspended sediment concentration and trapping coefficients	Long-term forecasts of marsh productivity and relative elevation	Analytical
	Sea Level Affecting Marsh Model (SLAMM) 6	Habitat: saline to fresh marshes	Existing habitat, sea level rise, accretion by habitat, fetch or erosion rates	Predict habitat changes for sea level rise, storm surge, restoration alternatives	Prescriptive

Model Type	Model	Parameters Simulated/Output	Input Data Requirements	Typical Scenarios	Level of Complexity
Estuary Fauna	Shiraz	Fisheries (e.g., different species and life stages of salmonids)	Land cover characteristics	Impacts of Introducing alternative land use/covers	Analytical
	Dynamic hydrology model to predict mosquito abundances	Surface wetness as proxy (statistical predictor) for mosquito abundance (species-specific)	Input from a hydrology model; species characteristics; meteorological; topographic; soil; vegetation	Real-time forecasting of surface wetness as basis for control measures for floodwater and non-Floodwater Mosquito Species	Numerical / statistical
	Coastal CAPS	N/A	Counts of individuals within species by location	An assessment model (i.e., not predictive)	Empirical
	Massachusetts Marine MIMES	Food webs (pelagic and benthic)	Species look-up table, bathymetry, soil characteristics	Development of adaptive strategies; regulations	Integrated toolbox
	Estuarine Simulation Model (ESM)	Water quality, eelgrass, bivalves	Watershed loads (nutrients, TSS, CDOM, labile OM), freshwater contributions, wind, salinity, temperature, PAR, and physics	Chlorophyll, DIN, DO, phytoplankton and benthic microalgal primary production, water column and sediment respiration, sediment denitrification scenarios	Numerical
Statistical	Bayesian networks/models	Unlike conventional simulation models. Utilize data to describe probabilistic dependencies among system variables (i.e., rather than substance mass balances). Full networks are decomposable into smaller sub models, with structure and quantification that reflect relevant theory, judgment, and/or observation.	System data and output (various complexities) from other models.	Various ecological attribute desired for which data exist/are being developed (e.g., consideration of probabilistic or frequency-based water quality standards)	Statistical

Note: A number of existing estuarine and landscape models were evaluated for their potential application to the Herring River adaptive management plan. Along with the previously developed EFDC hydrodynamic model, SLAMM, SMART, and MEM are being considered in more detail.

The primary outcome of the ecosystem model study (WHG/UNH 2014) was a conceptual framework for a "modeling toolkit" comprised of individual sedimentation, vegetation change, and water quality models integrated and linked to the EFDC hydrodynamic model. The modeling framework provides models to predict the outcomes of potential management actions/strategies in terms of the performance measures of the project objectives. As described in the model framework final report:

> "Such a toolkit preferably includes the means to estimate the responses of the biophysical system to restoration efforts, and consequently weigh these responses against socially defined preferences on the state of the system. The recommended models allow for simulation of restoration alternatives and phases to provide a basis for selecting restoration actions based upon best available information and data to date. The models also can be refined over time to incorporate new data and to simulate subsequent restoration phases as the basis for incremental restoration of the system as part of the overall adaptive management process. The models in the toolkit can vary in scope and level of complexity. For example, some of the recommended models are detailed numerical models, while others are basic analytical modeling approaches or assessment of field data."

The specific numerical models recommended for use with the Herring River EFDC model include the following:

- Marsh Equilibrium Model (Morris et. at. 2002) – a marsh accretion model which would be used for predicting long-term changes in marsh surface elevation as tidal range and salinity are restored.
- Salt Marsh Assessment and Restoration Tool (Rogers, Konisky, and Mustard 2007) – a vegetation model intended to predict long-term changes in fresh and saltwater dependent plant communities.
- Sea Level Affecting Marshes Model (Warren Pinacle Consulting, Inc. 2012) – a landscape model used for assessment of rising sea level impacts on coastal resource areas.

WHG/UNH (2014) provides a detailed summary of the model framework development process. Recommendations from the WHG/UNH model framework investigation include a series of pilot studies to test and compare models and assess methods for coupling and integrating model outputs with model inputs. These investigations are being conducted and will be part of the full adaptive management plan.

Consequence Tables

The use of consequence tables is a common technique for evaluating and comparing consequences of alternative management actions with regard to their performance across all project objectives. They are used in an SDM framework to conduct side-by-side comparisons of different management strategies, or policies, and evaluate how they affect objectives. Output from models, other predictive tools, and expert elicitations are the means by which the estimated performance of alternate strategies or policies are evaluated in a consequence table. Consequence tables are useful for understanding and building consensus about how each strategy affects the objectives, while concurrently identifying uncertainty in the predicted outcomes and recognizing potential trade-offs among competing objectives.

Table 5a is an excerpt of a consequence table that shows four example project objectives developed as part of the adaptive management planning process for the Herring River project. This simplified, preliminary example is shown here for illustrative purposes only. The objectives are listed in the first column, whereas the second column indicates the desired direction of each objective; that is, whether each objective is intended to be minimized or maximized (in this simple example, the objectives are all to be maximized). The following four columns are populated with hypothetical predictions under the status quo condition and for each of three unspecified management strategies. Each strategy represents a distinct approach to management, such as those described previously in the "Alternatives/Management Actions" section. The last column includes the units of the predicted outcomes for each objective entered under each strategy.

In this hypothetical example, table 5a indicates that the tide range of the river is 2.0 feet (relative to NAVD88) in its current state ("status quo") and would rise to 2.2 feet under strategies A and B and 3.0 feet under strategy C. In the final adaptive management plan, actual predictions for this objective under each specified alternative strategy would be extracted from the hydrodynamic model. In this hypothetical example, other predictions are proposed in table 5a for sediment deposition (millimeters per year), the number of acres with saltwater influence, and impacts to water quality (as measured by a water quality index). In actuality, predictions for these objectives (and others) will be populated using output of appropriate ecosystem models and professional judgments of subject matter experts.

Finalizing similar consequence tables and populating them with predictions for each objective, under each alternative strategy, is one of the major steps for developing the full adaptive management plan. How these tables will be used and applied to decision making is described further in the following section on trade-offs and in "Section 2: Iterative Phase." The method for populating the consequence table with predictions (table 5a) is an objective, science-driven process. It relies on subject matter experts and technical specialists to provide predicted outcomes by way of modeling, use of existing data, review of the literature, and expert elicitation. The next steps, described in the "Trade-offs" section are value-based, subjective processes based on input from decision makers and stakeholders.

TRADE-OFFS: IDENTIFYING THE "BEST" DECISION

Assessing Performance of Alternatives Across all Objectives

As discussed in the previous section, we expect to use consequence tables as a formal method to assess the expected performance of each alternative decision or management strategy under consideration across all project objectives. The goal of the assessment is to identify the decision or management strategy that performs the best (given the identified objectives, considered alternatives, and predicted consequences). Consequence tables allow the user to identify trade-offs; that is, situations where undertaking a management action clearly advances some objectives while delaying or impairing others. Trade-offs become apparent when the predicted outcomes of a complete consequence table reveal clear distinctions about the effects of management strategies. Recognizing these distinctions, and the trade-offs implied by carrying out any of the actions, is critical so that clear differences can be discerned among the management options under consideration.

The Need for a Common Scale: A Couple of Methods

To begin the process of identifying trade-offs, the predicted outcomes initially entered into the consequence table must be converted to the same scale to allow comparisons of the performance of the competing alternatives to be made among the different objectives. For example, in table 5a, the four objectives have four different units: tide range is in feet, sediment deposition is in mm/year, salt water influence is in acres, and water quality is an index. In their raw format, the performance of each alternative on these objectives cannot be compared with one another because it would be like comparing apples and oranges. To make comparisons, we need the objectives to be on a common scale. Different methods exist to put objectives on a common scale; we mention two such methods, normalized scores and utility, below.

Normalized Scores. One method to put objectives on a common scale is to convert the predicted outcomes of each objective to a unit-less scale between 0 and 1 by way of normalization. The process of normalization is demonstrated in table 5b and described here. The maximum and minimum predicted outcomes are identified for each objective across all alternatives. If the goal is to maximize the objective, the largest predicted outcome is assumed to be the best and is assigned the value of "1," whereas the smallest predicted outcome is assumed to be the worst and is assigned a value of "0." The outcomes predicted for the remaining alternatives on the same objective are then normalized between the best (1) and the worst (0). To obtain a normalized score between 0 and 1, for each raw prediction to be normalized, use the following equation: ([value to be normalized] – [smallest value])/([largest value] – [smallest value]). See the "Normalized Scores" in table 5b for an example. Alternatively, if the goal is to minimize the objective, the smallest prediction is assumed best and assigned the value of "1," the largest prediction is assumed worst and assigned the value of "0," and the other predictions are normalized by subtracting the equation noted above from 1. It is important to note that use of the normalization method assumes a linear relationship of the predicted outcomes; that is, every unit increase in the predicted outcome, regardless of whether it occurs at the low-end, middle, or high-end of the range, is considered an equal increase.

Utility. Another method to put objectives on a common scale is to convert the raw predictions of each objective to a unit-less scale between 0 and 1 by way of utility. "Utility" is the value or level of satisfaction decision makers feel regarding the predicted outcome. Unlike normalization, utility is not calculated from the raw predictions; rather, it is elicited from decision makers. As with normalization, the outcome that is valued the most is assigned a value of "1," and the outcome that is valued the least is assigned a value of "0." The remaining outcomes are assigned a value between the worst (0) and the best (1), according to the value system of the decision makers. Utility is used rather than normalization when a non-linear relationship is suspected in the valuation of the outcome across its full range. By converting the raw predicted outcomes to utility, the consequence table captures two aspects: (1) the prediction, which is based on the best available science and (2) values, which are based on how decision makers feel about the predicted outcomes. Preliminary elicitation of utility, mainly as a training exercise, has been conducted with the HRRC to investigate levels of satisfaction with different amounts of restoration at different time frames.

Weight: The Relative Importance of Competing Objectives

After converting the objectives to a common scale, the next step in a consequence-table type trade-off analysis is to assign weights to the multiple objectives. Weights reflect the relative importance of each objective, and are determined by elicitation of the decision makers. We continue to build on the hypothetical example proposed in tables 5a (Raw Predictions) and 5b (Normalized Scores) and carry the trade-off analysis through the weighting step to demonstrate how the process identifies the alternative that best meets the objectives. For the purposes of demonstration, we assume equal weight of 0.25 on all objectives (table 5c; Weighted Scores). We multiply the normalized scores of each objective by the weights assigned to each objective. We then sum the scores for each alternative across the objectives for a final sum of weighted scores. The alternative with the highest score is the alternative that performs best. We see that under a scenario of equal weights on all four objectives, Strategy C has the highest final score and is identified as the “best” alternative. Stated another way, Strategy C is determined to produce the greatest overall benefit when compared with the three other alternative strategies. It is important to note that although Strategy C is shown to be most favorable when we look at all objectives as a whole, it is not the best at achieving each of the four objectives when they are considered individually; for example, Strategy A would provide a better result for water quality and Strategy B would promote the highest rate of sediment deposition. This is a multiple objective situation; thus, we must take into account all objectives, weighted according to their determined importance, and identify the alternative strategy (from amongst those considered) that performs the best across all objectives when taken as a whole.

It is essential to understand and remain cognizant that the culmination of an identified best alternative is explicitly and transparently based on the combination of many distinct components: the list of objectives; the menu of alternative strategies considered; the predicted outcomes of each strategy for each objective (which are based on the best available science and understanding of the system at the time); the choice to normalize the predictions (which assumes a linear relationship); and the weights assigned to each objective. This fact is critical for several reasons. First, it provides the ability to transparently explain to stakeholders how the decision regarding which management strategy to implement was determined. This ability is crucial in projects that have high community engagement and potential impacts, involve regulatory implications, or have potential for litigation. Second, if there is disagreement about the management strategy that is identified as best, the explicit components and the transparent method of synthesis provide a clear basis for communication and discussion about the appropriate point(s) of disagreement; that is, rather than argue about the identified decision itself, discussion can be proactively focused on the components where the disagreement originates. For example, the disagreement might be about the science used to predict outcomes, the assumption of linearity in the normalization calculation, the value-system used to assign the weights on the objectives, or another component. The explicit and transparent nature of the SDM approach fosters effective communication and offers potential avenues to resolve disagreements. Lastly, the SDM decision framework we have described provides a basis to investigate if the decision that has been identified as best is sensitive to uncertainty or disagreements in different components of the framework. This last topic of sensitivity is discussed in the next section.

Sensitivity Analysis: Does the Identified “Best” Decision Change with Variations in Predicted Outcomes, Utility, and/or Weights?

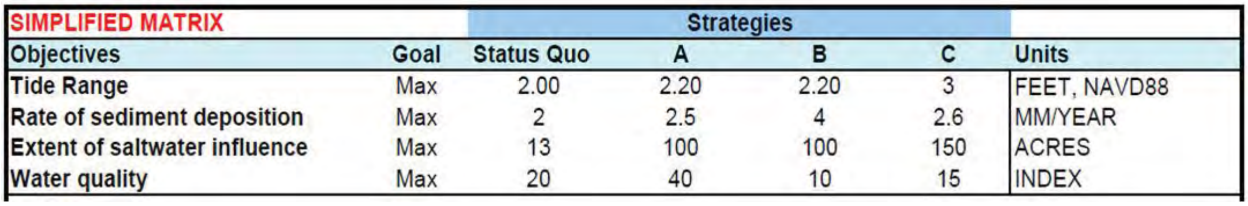
Decision makers and stakeholders want to be confident in the decision that is identified by the decision framework as “best.” Confidence in the decision comes from understanding and agreeing on the different components of the decision framework, as well as from demonstrating that the identified decision is robust to uncertainty and/or disagreements regarding the components that go into the decision framework. That said, an important aspect of analyzing the decision, is testing the robustness (or, conversely, sensitivity) of the identified “best” decision; this process is known as sensitivity analysis. Sensitivity analysis can, and should, be conducted for any component where there is uncertainty or disagreement. Below, we mention three potential components where sensitivity analysis is often applied: predicted outcomes (uncertainty or disagreement about the science), utility (disagreement about level of satisfaction or preferences), and the relative importance or weights on objectives (disagreement about values).

If there is uncertainty regarding the predicted outcome of an objective, we capture this scientific uncertainty in a range for the prediction. We then run the full trade-off analysis under different scenarios using the extreme low- and high-end predictions for the objective and determine if the decision that is identified as best changes under the different predictions for the outcome. If the same decision is identified, then the decision is considered to be robust to the uncertainty in the predicted outcome of that objective. If, however, the management strategy that is identified as best changes under the different scenarios, then the decision is said to be sensitive to that uncertainty.

The same type of process can be used to assess the robustness/sensitivity of the decision to an assumption of linearity in the predicted outcomes (i.e., the normalization approach) as opposed to using utility to represent a non-linear relationship. Or, if a utility approach is used, but there is disagreement among decision makers regarding the shape of the non-linear relationship, the resulting decision can be determined given the full range of possibilities for the utility. If the decision does not vary with the different approaches or utilities, then the decision is robust to the range of variability of those inputs. If, however, the decision changes given the range of variability in those inputs, then the decision is deemed sensitive to the possible scenarios.

The relative importance of the different objectives is another potential area for disagreements among decision makers and a key framework component for which to conduct a sensitivity analysis. In our hypothetical example, we demonstrated that an equal weighting of all objectives resulted in the identification of Strategy C as best (table 5c). However, if the decision makers ascribed higher importance (i.e., weight) to the objective of sediment deposition (e.g., double the weight than that of the other objectives), this would produce different weighted scores than those shown in table 5c, and would result in Strategy B being identified as the best management decision (table 5d). Table 5e, shows another different weighting scheme where water quality is deemed twice as important as the other three objectives; given this weighting scheme, Strategy A is identified as the best course of action. The fact that three different weighting schemes resulted in three different decisions demonstrates that this hypothetical decision is sensitive to these potential disagreements in how to weight the different competing objectives.

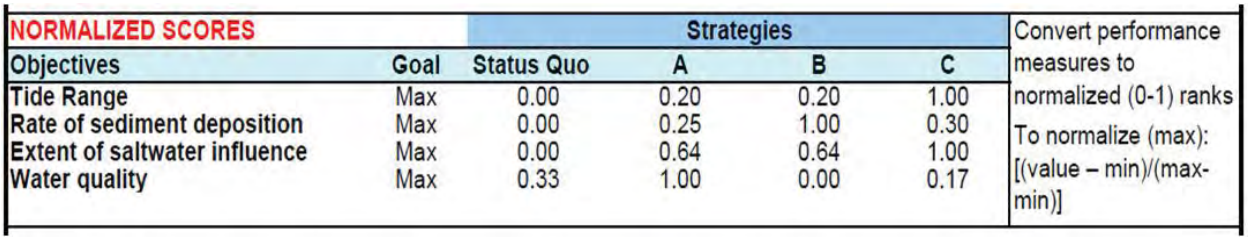
TABLE 5A: EXAMPLE OF CONSEQUENCE TABLE WITH RAW PREDICTED VALUES



SIMPLIFIED MATRIX		Strategies				
Objectives	Goal	Status Quo	A	B	C	Units
Tide Range	Max	2.00	2.20	2.20	3	FEET, NAVD88
Rate of sediment deposition	Max	2	2.5	4	2.6	MM/YEAR
Extent of saltwater influence	Max	13	100	100	150	ACRES
Water quality	Max	20	40	10	15	INDEX

Note: A basic consequence table is populated with direct output from models and other predictive tools to compare how undertaking varied management strategies affects objectives.

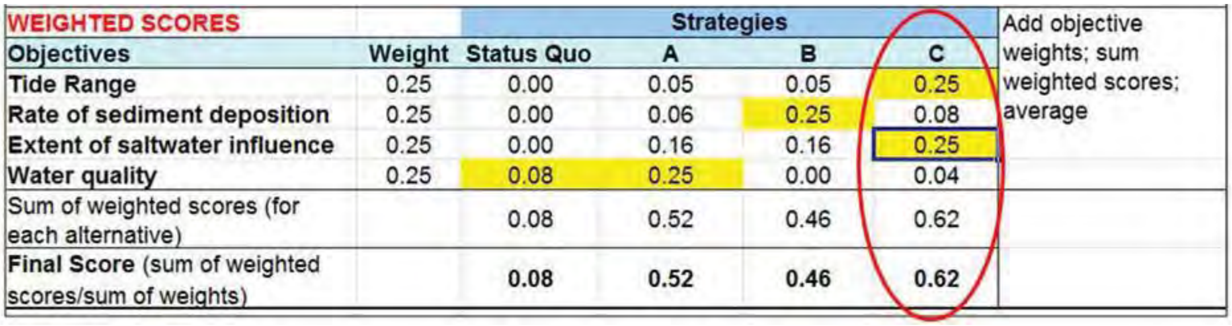
TABLE 5B: EXAMPLE OF CONSEQUENCE TABLE, NORMALIZED TABLE, AND EQUAL WEIGHTING



NORMALIZED SCORES		Strategies				Convert performance measures to normalized (0-1) ranks To normalize (max): [(value – min)/(max-min)]
Objectives	Goal	Status Quo	A	B	C	
Tide Range	Max	0.00	0.20	0.20	1.00	
Rate of sediment deposition	Max	0.00	0.25	1.00	0.30	
Extent of saltwater influence	Max	0.00	0.64	0.64	1.00	
Water quality	Max	0.33	1.00	0.00	0.17	

Note: In order to make meaningful comparisons, original data can be mathematically transformed, or “normalized,” to resolve issues with different measurement units and scales.

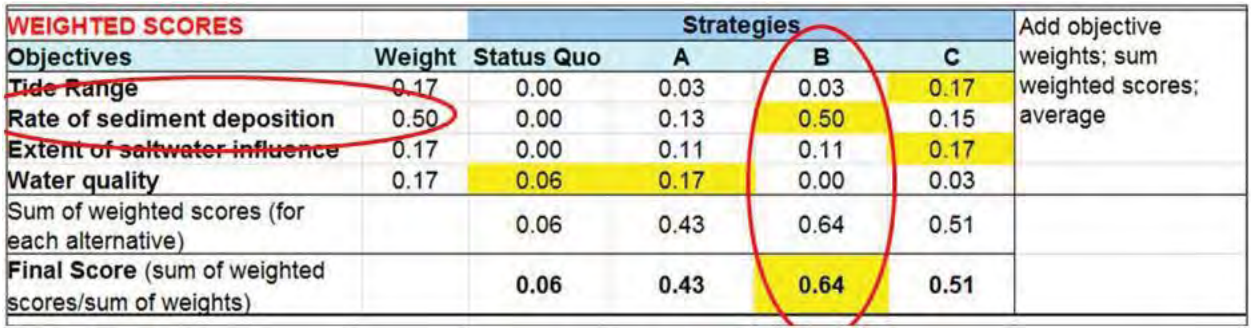
TABLE 5C: EXAMPLE OF CONSEQUENCE TABLE WITH EQUAL WEIGHTING



WEIGHTED SCORES		Strategies				Add objective weights; sum weighted scores; average
Objectives	**Weight**	**Status Quo**	**A**	**B**	**C**	
Tide Range	0.25	0.00	0.05	0.05	0.25	
Rate of sediment deposition	0.25	0.00	0.06	0.25	0.08	
Extent of saltwater influence	0.25	0.00	0.16	0.16	0.25	
Water quality	0.25	0.08	0.25	0.00	0.04	
Sum of weighted scores (for each alternative)		0.08	0.52	0.46	0.62	
Final Score (sum of weighted scores/sum of weights)		**0.08**	**0.52**	**0.46**	**0.62**	

Note: In this example, where all objectives are regarded equally, strategy C scores highest and would be the best choice for meeting all objectives.

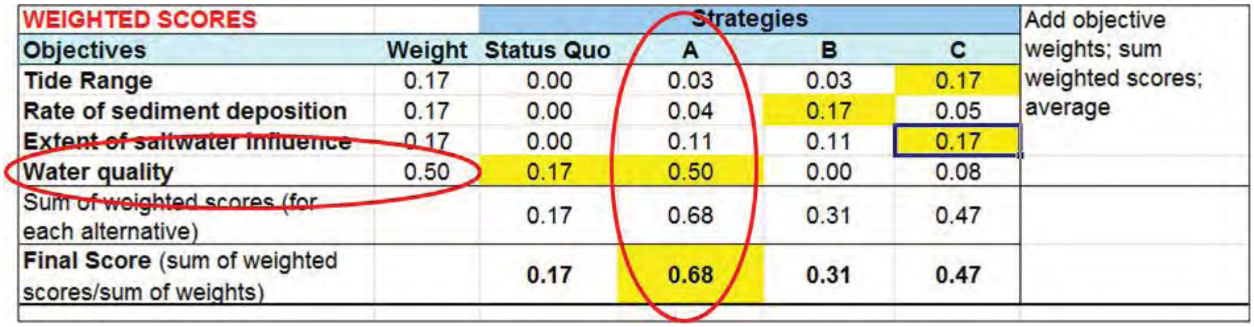
TABLE 5D: EXAMPLE OF CONSEQUENCE TABLE, WEIGHTED FOR SEDIMENTATION



WEIGHTED SCORES		Strategies				Add objective weights; sum weighted scores; average
Objectives	**Weight**	**Status Quo**	**A**	**B**	**C**	
Tide Range	0.17	0.00	0.03	0.03	0.17	
Rate of sediment deposition	0.50	0.00	0.13	0.50	0.15	
Extent of saltwater influence	0.17	0.00	0.11	0.11	0.17	
Water quality	0.17	0.06	0.17	0.00	0.03	
Sum of weighted scores (for each alternative)		0.06	0.43	0.64	0.51	
Final Score (sum of weighted scores/sum of weights)		**0.06**	**0.43**	**0.64**	**0.51**	

Note: In the case of sedimentation rising in priority, that objective is given a greater weight, doubled in this example. Strategy B would produce the best result in this circumstance.

TABLE 5E: EXAMPLE OF CONSEQUENCE TABLE, WEIGHTED FOR WATER QUALITY



WEIGHTED SCORES		Strategies				Add objective weights; sum weighted scores; average
Objectives	**Weight**	**Status Quo**	**A**	**B**	**C**	
Tide Range	0.17	0.00	0.03	0.03	0.17	
Rate of sediment deposition	0.17	0.00	0.04	0.17	0.05	
Extent of saltwater influence	0.17	0.00	0.11	0.11	0.17	
Water quality	0.50	0.17	0.50	0.00	0.08	
Sum of weighted scores (for each alternative)		0.17	0.68	0.31	0.47	
Final Score (sum of weighted scores/sum of weights)		**0.17**	**0.68**	**0.31**	**0.47**	

Note: In contrast, if water quality was a priority, that objective is given a greater weight and strategy A would produce the best result.

If, after a sensitivity analysis is completed, a decision is found to be sensitive to real uncertainty or disagreement in one or more of the key framework components, the path forward depends on whether the uncertainty/disagreement is one of science (e.g., predicted outcomes) or one of values (e.g., utility or weights). If there is an uncertainty in the science that results in decision makers receiving conflicting guidance regarding the best decision, then this is a key uncertainty that can be targeted to learn about through the adaptive management process. One approach is to create competing models that reflect the range of uncertainty in the prediction. A relative weight of belief is assigned to each competing model, and the confidence in each model is updated with each subsequent decision cycle by comparing the model-specific predicted outcomes to the actual observed outcomes; the model with greater agreement between the predicted and actual outcomes gains weight at the expense of the model with lesser agreement. Using this approach allows both models to influence the identified decision according to their assigned weight of confidence. If, alternatively, the disagreement is not one of science but one of values (i.e., utility or relative importance of objectives), the path forward is one of identifying the set of potential best decisions and finding a negotiated solution among the decision makers. Throughout this process, it is essential to remember that the decision framework is a decision-support tool; the tool provides guidance to identify the decision that is best given the various inputs, but the final decision belongs to the decision makers.

Tables 5a-5e show a very simplified example of how consequences and trade-offs would be recognized and evaluated; the actual execution of this process, however, is likely to be complex and will constitute a significant element of the adaptive management planning process and written documentation. A summary of how technical specialists and decision makers will use these tools and methods is described further in “Section 2: Iterative Phase.”

SECTION 2: ITERATIVE PHASE

The preceding description of the setup phase describes the elements of SDM that are being considered and discussed extensively by project proponents and stakeholders as part of the process for developing a formal, written adaptive management plan. When complete, the setup phase and adaptive management plan will result in a recommendation by the HRRC for a newly formed Herring River Executive Council (HREC, discussed in more detail below) for the initial step of tide gate management, based on the modeling results and trade-off analysis described previously. The iterative phase of the adaptive management process will constitute the execution of the plan and implementation of the restoration project. As implied, the iterative phase will also include continuing updates to and modification of the adaptive management plan as the restoration project advances and new information generated through the monitoring program is incorporated into models, predictions, and decision making.

This description of the iterative phase provides information on the following:

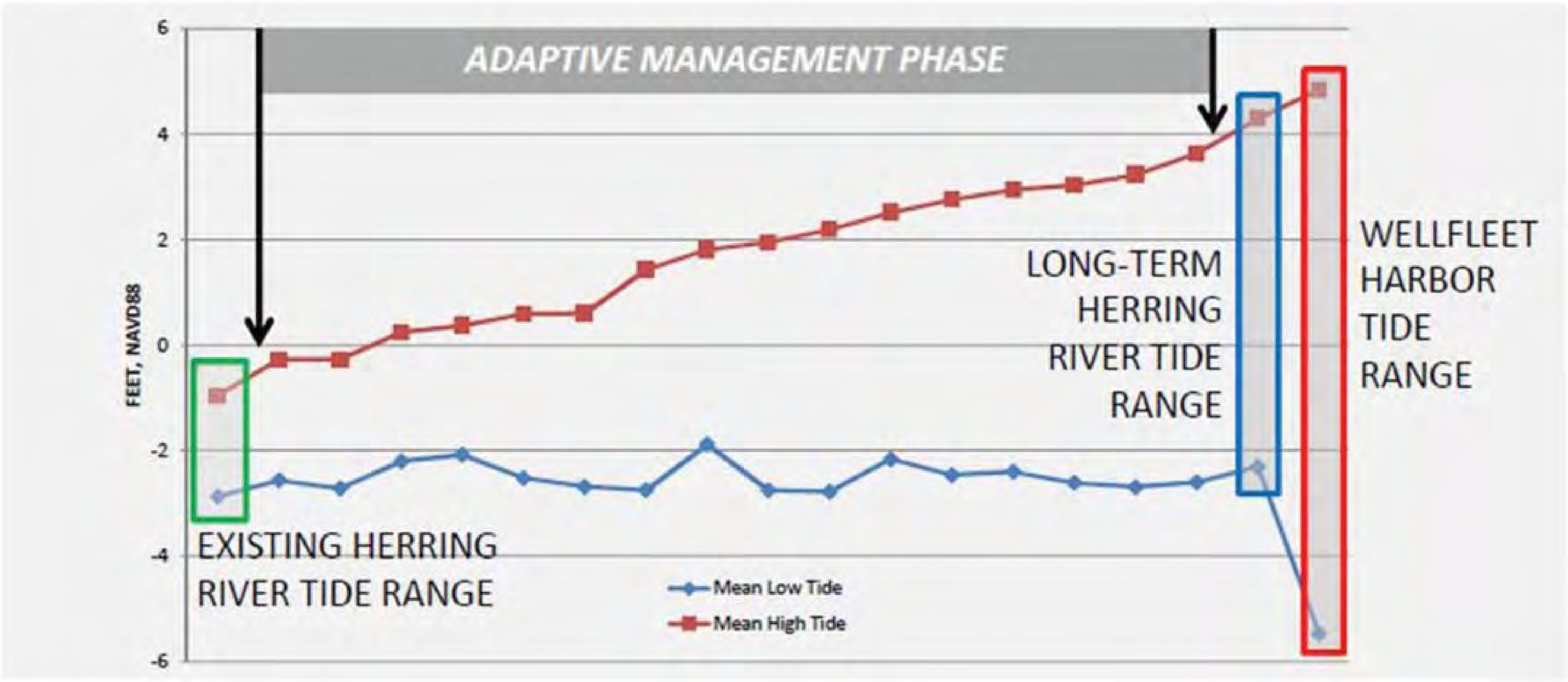
- General implementation of the project
- How decisions are made during implementation
- Permitting: How the adaptive management plan is integrated with permitting guidelines and conditions
- Public/stakeholder involvement during implementation
- Modeling and monitoring to support the adaptive management plan
- Iterative steps during implementation of the adaptive management plan

OVERVIEW OF IMPLEMENTING THE PROJECT

The SDM trade-off analysis discussed at the end of “Section 1: Setup Phase” is based on multiple objectives and the predicted outcomes of alternative management actions. To begin the iterative phase, the initial trade-off analysis (described at the end of “Section 1: Setup Phase”) will be used to identify the first recommended management strategy for opening the Chequessett Neck Road tide gates (see figure 3). The first iteration will include the following general steps (discussed in more detail in the following sections):

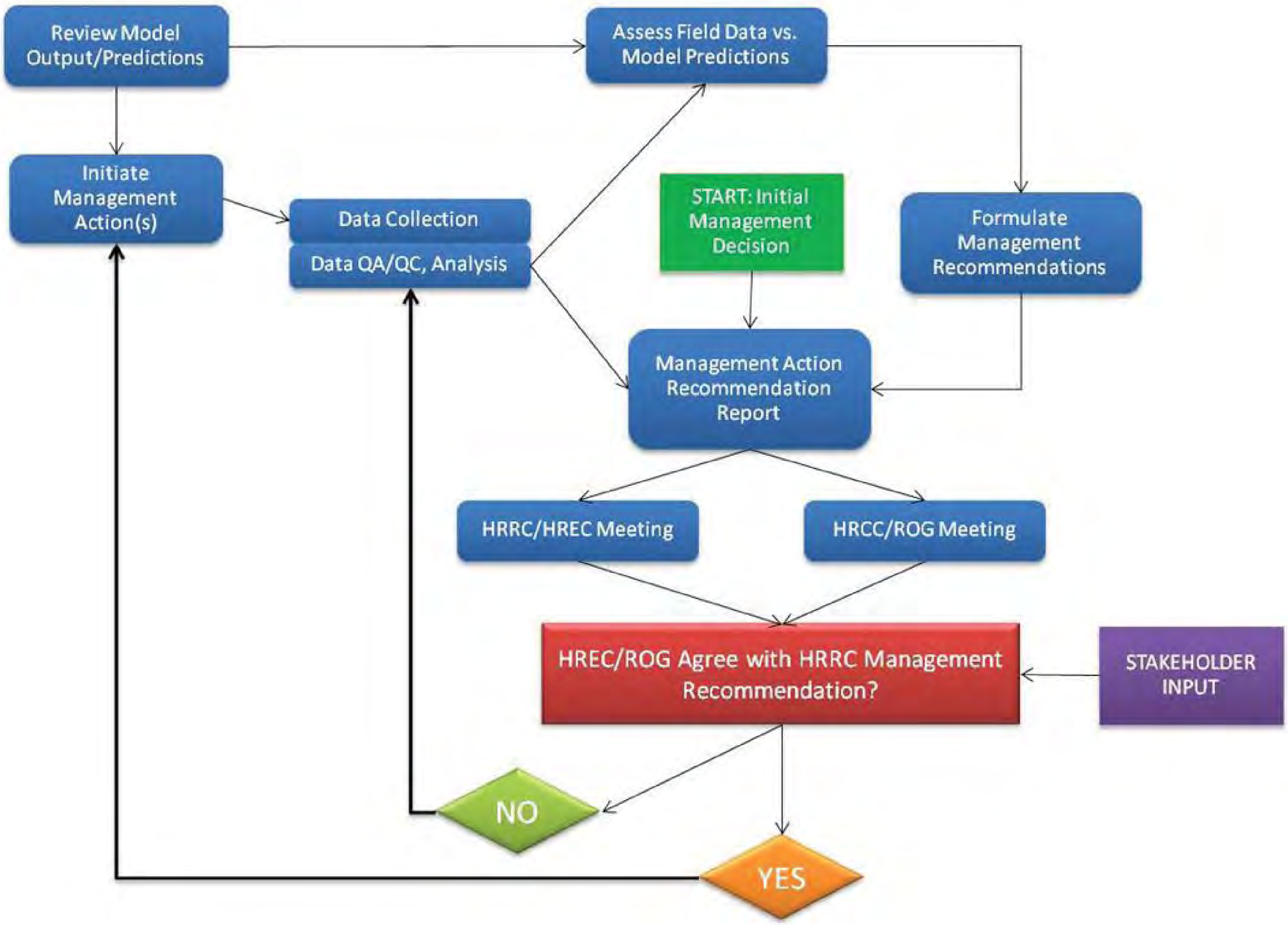
1) Provide the recommendation (based on the initial trade-off analysis)
2) Make the decision (based on the recommendation, input from stakeholders, and other factors specific to when the decision is made)
3) Implement the action
4) Monitor the response
5) Assess the decision (i.e., compare the predicted outcomes to the actual observed outcomes for the project objectives).

After the assessment step (step 5), one of two pathways can be taken depending on the response (see figure 4). If monitoring data indicate that a pre-determined threshold value has been met, then it is warranted to update the predicted outcomes of the consequence table (step 6) and update the trade-off analysis (step 7). The trade-off analysis will then lead to the next recommendation, which is the identified best alternative management strategy given the updated knowledge regarding the system.



Note: Hydrodynamic modeling output showing mean high tide (red line) and mean low water (blue line) with increasing Chequessett Neck Road tide gate openings.

FIGURE 3: TIDE RANGES IN THE LOWER HERRING RIVER WITH INCREASED OPENING OF CHEQUESSETT NECK DIKE TIDE GATES



Note: Conceptual diagram for proposed data review and decision-making sequence for Herring River adaptive management plan.
HRRC: Herring River Restoration Committee; HREC: Herring River Executive Council; ROG: Regulatory Oversight Group

FIGURE 4: DECISION MAKING SEQUENCE

The recommendation may or may not change with the updated information. Then the iterative decision cycle repeats. If, however, as a result of the assessment step (step 5), a threshold value is not met, the alternate pathway is to continue with the previous information and recommendation, and continue implementing the same management strategy. These threshold values, or triggers, will be identified for each objective in the final adaptive management plan.

Updating the predictions and trade-off analysis with new information is the iterative/learning part of the process that makes adaptive management decision making truly adaptive. This approach is a modified version of adaptive management where the predicted consequences will be passively updated when a specific, pre-outlined trigger is met. The key is formally updating predictions based on learning from the iterative cycle (i.e., predicting, decision making, monitoring, assessing). Updated predictions may lead to changing the recommendation (i.e., adapting management based on what has been learned). It is important to note, however, that the updated predictions may not cause a change in the recommendation; that is, the result of the updated trade-off analysis may point to the same recommendation as the best management strategy among those considered. The following sections provide additional information on how this approach will be applied to the project and how decisions will be made and evaluated.

DECISION MAKING DURING IMPLEMENTATION

The governance and administrative structure for implementing the Herring River adaptive management plan is described in the third memorandum of understanding (MOU-III) between Cape Cod National Seashore and the towns of Wellfleet and Truro (see Appendix J of the final EIS/EIR). The executed MOU-III is incorporated into the Record of Decision of the EIS/EIR. The management structure is similar to the administrative framework described in MOU-II, executed in 2008, which established the HRRC and authorized preparation of the joint federal/state EIS/EIR and the adaptive management plan. MOU-III also explicitly acknowledges the responsibility of the two towns and Cape Cod National Seashore by establishing the HREC as the formal, decision-making authority for the project. The HREC is comprised of select board members and town managers from both towns, and the Cape Cod National Seashore superintendent, or their designees. MOU-III formally retains the HRRC to serve in an advisory and technical support capacity similar to its present function. As described in MOU-III, both the HREC and HRRC can consult with or convene formal and informal groups to provide technical or advisory support on specific topics.

The HREC and HRRC are the entities primarily responsible for executing the adaptive management plan. Simply stated, the HREC will be responsible for authorizing actions at each major decision point, while the HRRC will provide management recommendations to the HREC and be responsible for carrying out authorized actions in accordance with the guidelines outlined in the adaptive management plan (summarized in this document) and regulatory permit requirements. The HRRC would also have the role of analyzing, compiling, and summarizing monitoring data, modeling output, field observations, and other information for the HREC. As indicated in MOU-III, the HREC and HRRC may work with a third-party organization to implement agreed upon management actions, field monitoring, data analysis, and public outreach activities.

After the initial management decision is made and applied, the future cyclical, iterative decision-making process, illustrated in figure 4, is grounded on the collection and analysis of monitoring data intended to measure performance of the specific objectives formulated for the adaptive management plan (see table 1). The general approach for monitoring and data collection is discussed in the "Monitoring and Modeling for Adaptive Management" section below. Although not likely to be directly involved in data collection, the HRRC will be the primary user of the monitoring data, thereby establishing the link between monitoring and decision making. As management actions are implemented and the response of the system is monitored, the HRRC 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 HRRC 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 HRRC recommendations or request additional data collection and/or analysis for further review and possible reconsideration of recommended management actions.

The HRRC will also consider the trade-offs of various management alternatives. Consequence tables, in particular, help illustrate trade-offs by organizing the relationships between alternate management strategies, objectives, and predicted outcomes indicted by model output. They are described in the "PrOACT" planning process in Section 1 of this document. Consequence tables will identify which alternative actions would be most advantageous for achieving certain objectives based on weighted stakeholder preferences and attitudes toward risk taking. The tables would result in a numeric scoring of "preferred" management strategies, but it would be up to the HREC and HRRC to evaluate these results, along with input from stakeholders and other factors germane to the decision, to make informed and transparent decisions about the most appropriate actions at any given point of 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-off analyses, while reviewing monitoring data and formulating management options available for to advancing the objectives of the Herring River project, the HRRC 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 to 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., change in tide gate configuration; methods of required 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., water surface elevations, salinity changes, water quality changes, sediment movement, vegetation/habitat changes)
  - 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, 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

ADAPTIVE MANAGEMENT AND PERMITTING

The adaptive approach for implementing and managing the Herring River project presents several challenges in obtaining the regulatory approvals required from local, regional, state, and federal agencies. Traditionally, proponents are expected to describe the environmental impacts of their project, how the design and alternative analysis process was used to minimize and avoid adverse impacts, and what mitigation methods would be used to offset unavoidable adverse impacts.

The final EIS/EIR for the Herring River identifies the long-term environmental and socioeconomic effects of restoring natural tidal range and salinity levels to the floodplain. The immediate direct impacts resulting from construction elements of the project are also described. These construction elements are relatively straightforward, with clear, predictable impacts which can be described in detail in permitting applications in a manner similar to traditional project permitting. Two examples of these construction elements are the reconstruction of the Chequessett Neck Road dike and associated tide gates and the increase of elevation of low lying roads.

In contrast, the impacts of adaptive elements of the project including many of the secondary management actions (e.g., management of sediment, vegetation management, restoration of marsh channels and pools, etc.) by their nature cannot be analyzed in detail in the final EIS/EIR or presented in the traditional manner as part of a permit application package. These and other elements share varying degrees of uncertainty about how, when, or where they would be implemented; whether they will need to be implemented at all; and what the resulting effects would be. Questions surrounding these actions cannot be addressed in any quantifiable way until implementation of the project is initiated. Formally and explicitly characterizing the uncertainties that affect and hinder decision making is a core component of the iterative process. In the adaptive management plan uncertainties will be thoroughly specified and will be captured in the decision-making framework, either through competing models or parameter distributions in a single model.

This will result in improved predictions and future decision making by reducing the specified uncertainties through targeted monitoring.

As an example of a project component that requires this adaptive approach, deposition of large volumes of sediment is needed on the existing subsided portions of the Herring River floodplain in order to restore conditions suitable for the recolonization of salt marsh vegetation. However, sediment transport models for predicting whether or to what extent this will occur by natural means are expensive to develop and the estimates from those models have large variances. When restoration of tidal influence is underway, monitoring data and observed outcomes can be used to determine whether natural deposition is occurring and if so, whether the location and rate of deposition is sufficient to promote vegetation recovery or if secondary management actions might need to be implemented. Similar uncertainty exists for knowing if, when, how, and where tidal channels may need to be constructed or enhanced to promote circulation of tidal waters, or the location and frequency of actions required to manage undesirable vegetation.

Within this context, the final EIS/EIR the HRRC describes a permitting process that would meet all local, regional, state, and federal agency regulatory requirements while also allowing flexibility to implement the project according the adaptive management guidelines described in this document. This approach to permitting acknowledges that some elements of the project – such as those cited in the previous paragraph – are uncertain and difficult to predict and are therefore not conducive to a traditional permitting approach.

This approach to permitting is based on a multi-tiered process where project proponents would initially apply for a comprehensive set of permits and approvals. [Note that this permit application package refers to the Massachusetts 401 Water Quality Certification, Clean Water Act Section 404 permit application, town of Wellfleet and town of Truro Notices of Intent (under the Massachusetts Wetlands Protection Act and town bylaws), and Massachusetts-Department of Environmental Protection Chapter 91 License applications; related approvals from other agencies (e.g., Massachusetts National Heritage and Endangered Species Program, Massachusetts Division of Marine Fisheries, NOAA, Cape Cod Commission will also be included)]. Permit applications would address project elements grouped into classes associated with each phase of project implementation. This recommended approach is more fully described in chapter 5 of the final EIS/EIR.

A core element of the permitting approach is the proposed formation of a regulatory work group. This group would be comprised of local, regional, state, and federal agency staff/representatives that would meet with the HRRC on a regular basis. The regulatory oversight group (ROG) would be analogous to the current Technical Working Group that was established by the MEPA office as part of MOU-II. The purpose of the group would be to review monitoring data, reports, and proposed plans for additional work and provide regulatory guidelines for the submission and approval of proposed management actions.

In concert with the HRRC and HREC (see figure 4), the ROG would be part of the decision-making process for implementing the adaptive management plan. Similar to the HREC, the HRRC would provide the ROG written reports and participate in meetings to review monitoring data and discuss management recommendations. The ROG would evaluate prior and proposed actions for adherence to established permit conditions and stated project objectives and provide guidance for necessary permit modifications, amendments, and extensions. Agency participation in the ROG will be requested from the Wellfleet and Truro Conservation Commissions, Cape Cod Commission, Massachusetts Department of Environmental Protection, Massachusetts Natural Heritage and Endangered Species Program, Massachusetts Division of Marine Fisheries, Massachusetts Coastal Zone Management, MEPA Office, U.S. Environmental Protection Administration, NOAA Fisheries, US Fish and Wildlife Service, and the Army Corps of Engineers. Formation and organization of the proposed ROG will be pursued during 2016 and 2017 as agencies are requested to actively participate in development and review of the adaptive management plan and initial permit applications are prepared.

PUBLIC AND STAKEHOLDER INVOLVEMENT DURING IMPLEMENTATION

One of the key tenets of adaptive management is providing a transparent, objective, and logical basis for making decisions in the public realm. Early identification and involvement of stakeholders – those groups and individuals with an interest in the resource and a willingness to contribute to discussion on how it is managed – is a critical step for developing an effective adaptive management program. Stakeholder outreach has been informally conducted for the Herring River project since the idea of restoring tidal flow to the river was raised in the 1970s. More recently, coordination with stakeholders was formally recognized in the original MOU (referred to as MOU I)signed by the Cape Cod National Seashore and town of Wellfleet in 2005, which designated a Stakeholder Committee to consult with and provide feedback to the Herring River Technical Committee as the Conceptual Restoration Plan was prepared. Although this group was not explicitly cited in MOU II (2007), the HRRC and USGS adaptive management planning team has met several times with ad hoc groups representing the same interest groups (in some cases the same individuals) included in the Stakeholder Committee. The objectives discussed previously and summarized in table 1 reflect comments, concerns, and feedback from these meetings.

A new stakeholder group is proposed to be established by the HREC when MOU III is formally executed. Similar to the prior groups, the stakeholder group is intended to represent the broad interests of the community including, but not limited to, potentially affected landowners and business owners, recreational users of the Herring River flood plain, shellfishermen, and conservation and environmental advocates. Once established, the stakeholder group will work with the HRRC, HREC, and ROG to ensure that community interests and concerns are represented in the adaptive management plan as it is further developed and implemented.

In addition to a standing stakeholder group, public involvement with the Herring River project will occur as part of the permitting and decision approval processes. All permitting processes (see previous section) require extensive public input and review periods that provide ample opportunities for individuals, private organizations, and public agencies to provide input. Because the adaptive management plan will be included as part of the permitting process, direct feedback about the general approach and specific details of the plan can be provided on multiple occasions. After the permitting process is concluded, HREC and ROG meetings will be open to the public and any information provided to those groups will also be made publicly available. It is expected that before any monitoring data are analyzed in formal summaries, some data will be available to the public on the internet on a real-time, on demand basis.

Public involvement will also extend to numerous recreational, educational, stewardship, and volunteer opportunities provided by the restoration project. The Friends of Herring River (FHR), established in 2009 with the mission of promoting education, research, and public awareness of the Herring River Estuary, will continue to initiate and engage in public education activities to ensure community-wide involvement in the project. Cape Cod National Seashore also provides numerous recreational programs focusing on the Herring River. Utilizing volunteers for a variety of stewardship and monitoring activities will be a focus of FHR and the Cape Cod National Seashore and will be extremely beneficial given the diversity and magnitude of required activities and limited budgets.

MONITORING AND MODELING FOR ADAPTIVE MANAGEMENT

The collection, analysis, and application of sound, 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 SDM and adaptive management output data from models are used to populate consequence tables 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. Table 1 provides an overview of available monitoring methods and predictive tools for each objective of the adaptive management plan. These are described in more detail in the following sections.

Fundamental Objective 1: Restore Hydrography

As described previously, "hydrography" in this context refers to the interaction between tidal hydrology and marsh surface elevation. Hydrography represents the interrelated physical processes that ultimately support the ecological function of an estuary. Restoring hydrography to the Herring River involves reestablishing the natural tidal range and other hydraulic functions, as well as the sediment transport dynamics that occurred prior to construction of the Chequessett Neck Road dike in 1909.

Tide Monitoring and Hydrodynamic Modeling

Historic, current, and proposed tidal conditions of the Herring River are well documented by both robust long-term data sets (i.e., 2004–present) developed and maintained by Cape Cod National Seashore and the hydrodynamic model developed by WHG in 2012. Cape Cod National Seashore tidal monitoring has included water surface elevations collected at several locations within the Herring River flood plain and Wellfleet Harbor as both stand-alone efforts starting in 2004 and as part of other studies (NPS unpub.). Groundwater elevations were also recorded by Cape Cod National Seashore from 2006 through 2014 in shallow wells installed throughout the flood plain (Martin and Medeiros 2014).

Some of these data were used for calibration and validation of the Herring River hydrodynamic model (WHG 2012) and are described in detail in several reports and memos prepared by the WHG (WHG 2013, 2016). In addition to projected water surface elevations expected under a range of future restoration management scenarios, the hydrodynamic model also provides data on flow velocities, salinity change and degree of penetration within the Herring River (discussed in the next section), and derived metrics describing the frequency and duration of tidal inundation (i.e., wetting/drying and hydroperiod).

Cape Cod National Seashore monitoring of water surface elevations at currently established locations is expected to continue for the duration of the project. In order to more fully describe current baseline conditions, the Cape Cod National Seashore and the HRRC are working with FHR to expand the network of tide monitoring locations as the project advances toward the construction phase. Additional stations will be installed on a pilot basis in 2016 which will use electronic water level sensors similar to those used by Cape Cod National Seashore since 2004, but will also include radio telemetry systems to enable real-time data availability to the public via the internet. Full coverage of tide monitoring stations will be in place throughout the floodplain so that future changes in tidal hydrology will be maintained by the project on a long-term basis. In 2015, one of these stations was established by USGS just downstream of the Chequessett Neck Road dike and is currently streaming tide level and other data that can be viewed at: http://waterdata.usgs.gov/ma/nwis/uv/?site_no=011058798&PARAmeter_cd=00065,00060.

When the project is underway and tide monitoring is implemented, new data will be used to recalibrate and revalidate the hydrodynamic model and refine predictions about how manipulation of the tide gates influence tidal hydrology. These refined predictions will improve the ability to make subsequent management decisions and track how the project is meeting the stated objectives.

Sediment Transport Monitoring and Modeling

Sediment transport is a critical component of the hydrography objective because, combined with tidal dynamics, it is a key determinant of a marsh surface elevation that is in equilibrium with tidal conditions. The elevation of the marsh surface affects the distribution of inter-tidal habitats and associated vegetation and faunal assemblages. This relationship is particularly important in the Herring River flood plain because extensive subsidence has occurred, resulting in areas that are up to 3 feet lower when compared with their historic elevation relative to mean sea level. The ability to predict the locations and rates of sediment deposition throughout the flood plain, and to monitor this as the project is implemented, is necessary in order to develop reasonable projections of the recovery of vegetated inter-tidal habitats and their associated ecological functions. In addition, many potential secondary management actions, such as channel clearing, ditch plugging, and the restoration of salt panne and pool habitat are dependent on sediment transport processes. If these secondary actions are implemented, data will be collected in order to plan, design, and evaluate the actions. Sediment transport is also a key element of several other ecological and socioeconomic objectives, and is discussed in more detail in the subsequent sections.

In contrast to tidal dynamics, sediment transport dynamics relating to the Herring River project are less well understood and as such predictions of sediment transport from modeling poses higher levels of uncertainty. The size of the project area and difficult access make collecting sediment data challenging. Additionally, sediment transport models are notoriously complex to develop and predictions are subject to relatively high variability. Nonetheless, limited sediment data have been collected from the Herring River flood plain and Wellfleet Harbor as part of several studies. Existing sediment-related data sets and investigations include:

- grain-size analyses of sediment cores (NPS unpub.) and surficial grab samples (Harvey 2010; Gorczynski 2010)
- bulk density and carbon dating of sediment cores (Gonneea unpub.)
- marsh accretion data from sediment elevation tables and associated marker horizons (NPS unpub.), and
- qualitative assessment of historical geomorphic processes (Dougherty 2004)

Combined with output from the hydrodynamic model, these data have been used by the WHG to develop an analytical sediment model which provides a generalized qualitative assessment of how sediment would move under a range of restoration scenarios, that is predicted areas of deposition and erosion (described in detail in WHG 2012).

To supplement existing data, in 2016 HRRC is initiating a combined approach for enhanced modeling and the monitoring of baseline bathymetric and topographic conditions to improve predictions of sediment transport. This includes exploring methods for measuring shallow water and fine scale bedform change within the system. The multi-task approach is focused on the following tasks:

- identifying and selecting appropriate sediment measurement technologies
- exploring the sensitivity of implementing the sediment transport and morphological change module of the existing EFDC hydrodynamic model for the Herring River system
- developing an appropriate sediment characterization and monitoring program and
- initiating a long term marsh surface and bathymetric survey and monitoring program.

Fundamental Objective 2: Restore Ecosystem Function and Integrity

Ecological integrity refers to the combined chemical and biological processes that constitute the ecological function of the estuary. As shown on table 1, the ecological function of the Herring River is indicated by the following sub-objectives:

- the area influenced by estuarine salinity;
- the area supporting estuarine vegetation communities appropriate for New England;
- the quality of habitat for estuarine fish, shellfish, and invertebrates; and
- accessibility of river and pond spawning habitat for diadromous fish (i.e., river herring and American eels).

As the basis for determining baseline conditions for the proposed restoration project, Cape Cod National Seashore natural resource staff and other scientists have been monitoring ecological functions within the Herring River for more than 20 years, with continuous data collection occurring for some variables since 2004. Salinity values (as determined through electrical conductivity) have been recorded simultaneously with the tidal water surface elevations described in the previous section. Other water quality variables, including dissolved oxygen and temperature, are measured and recorded by electronic sensors and data loggers. Synoptic grab samples are also collected monthly at locations throughout the flood plain for field and laboratory analysis of pH, alkalinity, total suspended solids, iron, color, chlorophyll-A, sulfate, nitrogen, and phosphorus.

The pre-restoration ecological function of the Herring River estuary is also being assessed by Cape Cod National Seashore through bioindicator studies designed to assess movement of nutrients, carbon, and sediment through the ecosystem and baseline inventories of benthic invertebrates. Recent work completed during the 2015 field season included:

1) benthic invertebrate surveys in areas upstream and downstream of the Chequessett Neck Road dike, and
2) a bioassay where macroalgae and oysters were deployed in the water column along a downstream to upstream gradient to measure carbon, nitrogen, and sulfur stable isotopes as method to determine nutrient and carbon sources and evaluate water quality.

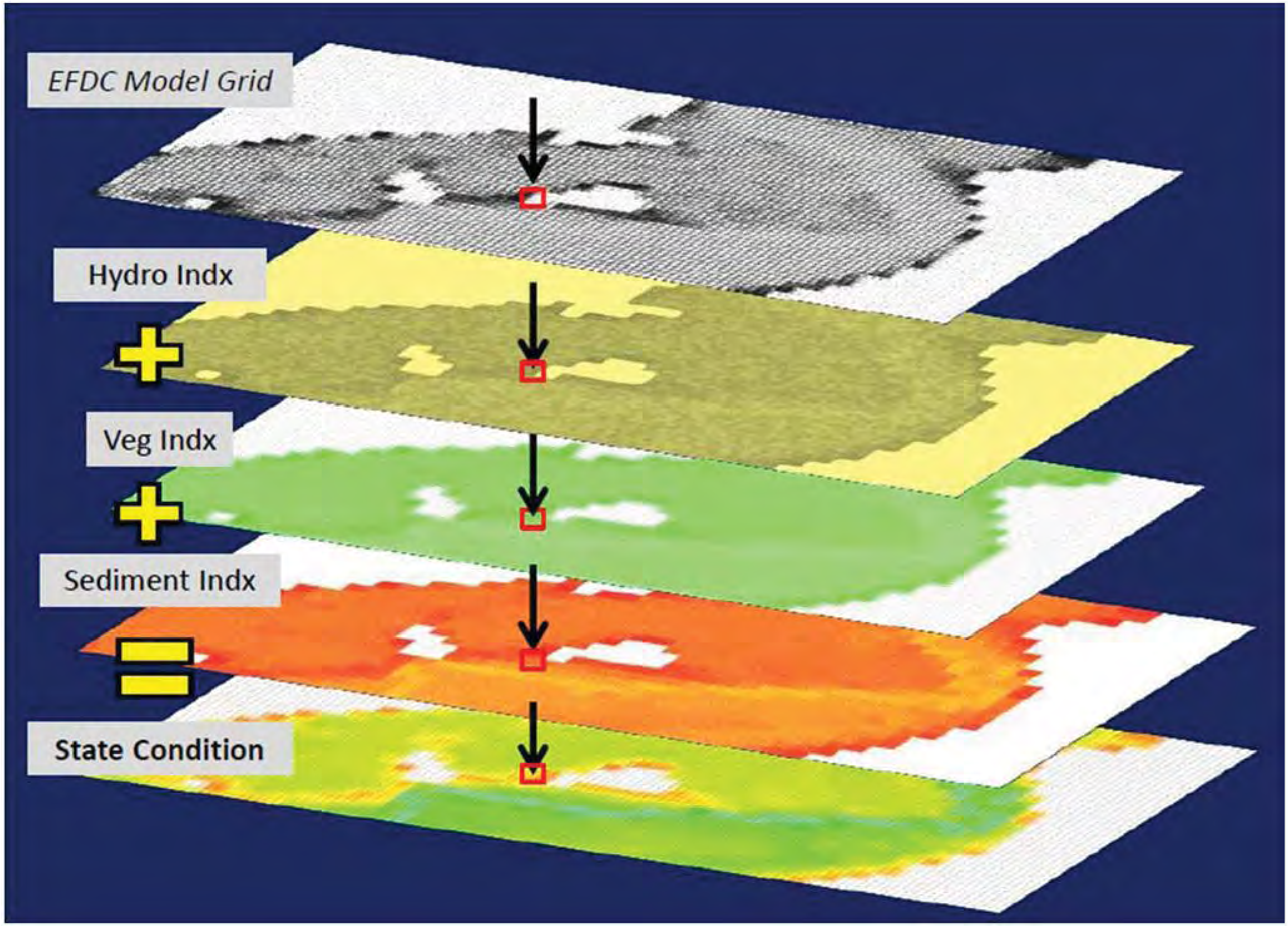
Preliminary data received from these studies are currently being analyzed. Funding requests for repetition of these studies during the restoration process are pending approval.

Baseline plant community composition within the Herring River system has been characterized by Cape Cod National Seashore with data collected from monitoring plots distributed throughout the flood plain. Plots have been resampled every 3 to 5 years since 2004, as part of the Cape Cod National Seashore regular vegetation monitoring program. This sampling and analysis will continue with increased frequency when the project is implemented. Estimation of plant community composition is also being supplemented with updated vegetation cover type mapping. In 2013, the Cape Cod National Seashore acquired two Digital Globe satellite data sets in panchromatic and multispectral formats. Data processing and field work at randomly selected training sites was conducted to support unsupervised classification. Several raster data sets and draft mapping products have been prepared to date and are currently being reviewed by Cape Cod National Seashore staff and the HRRC. Pending future funding, the methodology for processing and analyzing these data will be used with new satellite and other airborne data acquired as the project is implemented.

As described previously in the "Consequences" section, the development of a framework that links hydrodynamic, sediment transport, water quality, and vegetation models for the Herring River ecosystem is in the early conceptual development stage (see influence diagram, figure 1b). The scoping process for evaluating existing ecosystem models and exploring their utility for the Herring River project is described in detail the Conceptual Model Framework Report prepared by WHG and the Jackson Lab at Univ. of New Hampshire in 2014 (WHG/UNH 2014). This investigation recommended exploring three existing models in greater detail; the Sea Level Affecting Marshes Model (SLAMM, Warren Pinacel Consulting, Inc. 2012) and Salt Marsh Assessment and Restoration Toolbox (SMART, Rogers, Konisky, and Mustard 2007) (both of which are currently being evaluated as vegetation change models) and the Marsh Equilibrium Model (MEM, Morris 2002) (which is being considered to predict marsh accretion and sediment changes, as a complement to other sediment related tools described in the previous section). Additional ecosystem models for the Herring River include a tool currently being developed by USGS for estimating fluxes of nitrogen and other constituents between the water column and rewetted peat soils and a simple empirical model to predict GHG fluxes (carbon dioxide and methane) from the system.

An Ecological Landscape Model

Efforts are also underway to synthesize the array of physical, chemical, and biological monitoring data with output from the hydrodynamic and ecosystem models by developing a spatially explicit, raster-based landscape model of the Herring River flood plain. This is in the early planning stages. The approach is based on creating a series of summary indices to represent state conditions such as hydrology, sediment/marsh accretion, and vegetation cover types. These could be mathematically combined to produce an assessment score of the overall ecological condition. The landscape model domain and boundary conditions would be adapted from the two-dimensional, curvilinear grid developed for the hydrodynamic model. Model cells would be populated with index values representing existing state conditions and predicted future conditions would be derived by the hydrodynamics of various restoration scenarios. This would facilitate assessment of actual conditions across a range of indicators compared with model-derived predictions at discrete locations. The landscape model would also provide a convenient organizational and data management framework for the project. A schematic concept for the landscape model is shown in figure 5.



Note: Conceptual diagram for Herring River landscape model, depicting raster layers representing three ecosystem function indices (hydrology, vegetation, and sedimentation) used to formulate an overall state condition variable for model raster cells.

FIGURE 5: LANDSCAPE MODEL SCHEMATIC DIAGRAM

Fundamental Objective 3: Minimize Adverse Impacts

In contrast to the two objectives discussed previously, which are wholly ecological, minimizing adverse impacts involves both ecological and socioeconomic issues. Therefore, predicting and monitoring potentially adverse impacts requires some of the ecological modeling and data collection discussed in the previous sections plus additional work to assess and evaluate socioeconomic issues. As discussed in detail in the final EIS/EIR, changes in tidal hydrology, vegetation, water quality, and sediment transport patterns all have the potential to cause some adverse effects. Socioeconomic impacts, such as public safety and aesthetics, will require additional assessment beyond the ecological monitoring already discussed.

Predicting and Monitoring Adverse Impacts to Ecological Resources

Detecting adverse ecological impacts before they cause substantial, adverse effects is one of the major tenets of the Herring River project and a primary reason for initiating the adaptive management process described in this document. Potential adverse effects are discussed in detail in the final EIS/EIR and generally include, but are not limited to:

- releases of sediment, nutrients, and coliform bacteria into the Herring River and Wellfleet Harbor;
- poor circulation of tidal flows and ponding of salt and freshwater throughout the Herring River flood plain;
- impacts of dead and dying trees and shrubs on marsh habitat;
- potential spread of non-native common reed (*Phragmites australis*)
- slow recovery of native salt and brackish vegetation due to lack of marsh accretion; and
- potential impacts to freshwater and upland dependent state-listed wildlife species and the state- and federally-listed Northern long-eared bat.

The ecological modeling output and monitoring data described previously under "Objective 2: Restore Ecosystem Functions and Integrity" would be used to track, detect, and characterize these, and other potential adverse ecological and socioeconomic impacts. Hydraulic and hydrologic data (i.e., tidal elevation, flow velocity, residence time, etc.) will be used to recalibrate and revalidate the EFDC hydrodynamic model and to estimate sediment and other particle transport processes which could affect shellfish and other resources in Wellfleet Harbor. These physical data would be used in concert with chemical and biological data developed through the previously described water quality monitoring and bioindicator studies to both predict expected changes and confirm actual changes. As the adaptive management and monitoring program is further developed, threshold values, indicating a trend toward conditions which could adversely impact specific resources, will be identified in collaboration with stakeholders, technical experts, and decision makers. As stated at the beginning of Section 2 of this document, reaching or exceeding a threshold could trigger a change in management strategy (e.g., slowing or reversing increases to tidal exchange), a reanalysis of data and/or modeling output to confirm results, or other actions to mitigate the unintended effects.

Restoration of tidal influence to the Herring River will initiate changes to existing vegetation and habitats that could potentially cause adverse impacts. In order to reduce adverse impacts, and with landowner concurrence, non-native common reed could be treated with herbicide and trees could be removed from areas of the flood plain prior to being affected by tidal flow. However, some woody material from dead and dying shrubs and trees that cannot be cut down is anticipated and the resulting woody debris has the potential to impede flow of tidal waters, thereby creating stagnant pools, odors, and possible mosquito breeding habitat. Active management of tidal flow within the Herring River and its tributaries during the restoration process will be an important component in minimizing adverse impacts. Predicting and monitoring vegetation change will be an important means for detecting potential problems. The adaptive management plan will specify several management responses to address any issues identified through vegetation and habitat monitoring.

Vegetation and habitat change are also critical factors for estimating and tracking potential impacts to state-listed rare, threatened, and endangered species and the state- and federally-listed Northern long-eared bat. The changes, and their general effects to these species, are more fully described in chapter 4 of the final EIS/EIR. As previously discussed, because of the uncertainty of future salinity levels in the mid- and upper reaches of the Herring River flood plain, the changes in habitat and its subsequent effects to the listed species are difficult to quantify. In general, much of the anticipated impacts to the state-listed species (includes American bittern, least bittern, Northern harrier, Eastern box turtle, and water willow stem borer) will be caused by the restoration of current freshwater wetland habitats to tidally influenced salt and brackish marsh habitats. Baseline studies for of the species are underway and, as part of a habitat management plan to be submitted for approval under the Massachusetts Endangered Species Act by the National Heritage and Endangered Species Program, changes to these habitats and how these regulated species respond will be monitored as the projected is implemented.

Predicting and Monitoring Potential Adverse Impacts to Socioeconomic Resources

Despite the substantial benefits of the Herring River project, there is the risk that adverse impacts could occur to private properties, roads, shellfish beds, and other natural and socioeconomic resources. Eliminating and minimizing these risks, however small, is a fundamental objective of the project and is a driving force for undertaking a transparent, adaptive, and rigorously monitored approach in determining impacts to these resources. Socioeconomic objectives include eliminating impacts to roads and privately-owned structures (including the Chequessett Yacht and Country Club (CYCC) golf course), minimizing adverse aesthetics (viewscapes) within the flood plain, and minimizing risks to public safety. Eliminating the risk of adverse impacts to water quality within the river and Wellfleet Harbor is an objective that spans both ecological (e.g., estuarine habitat quality) and socioeconomic topics (e.g., shellfishing, water-based recreation, aesthetics, etc.).

Potential impacts to roads and privately-owned structures from incremental increases to tidal influence have been modeled using the hydrodynamic model. After an initial screening that incorporated model data with desktop GIS resources to locate potentially vulnerable sites, additional site-specific information is currently being collected to refine impacts and inform mitigation design plans that will be completed before project activities have impacts on these properties.

Although mitigation plans will be implemented for affected properties before restored tidal influence reaches them, monitoring during project implementation will still occur in order to confirm that the mitigation measures are performing as designed, model predictions are accurate, and that no other mitigation is needed. Similar to other potential adverse impacts, the goal of monitoring low roads and structures is to detect trajectories which could harm these resources before any actual harm occurs. The primary means for doing this will be surface water monitoring instrumentation and groundwater monitoring wells placed downgradient from areas of concern. Changes detected in these areas attributable to restored tidal flow would signal that refinements to the hydrodynamic model may be necessary and that additional measures need to be in place to mitigate impacts before any additional increases are made to tidal range.

Rigorous monitoring of surface water and groundwater is anticipated at the CYCC golf course located in the Mill Creek sub-basin. As part of the preferred alternative described in the final EIS/EIR, the intent of the project is to fully implement the mitigation plan for the golf course, including filling and regrading the low portions of the golf course vulnerable to restored tidal flow. However, it is uncertain whether funding, permits, and other approvals, including mitigation agreements with the CYCC and other Mill Creek landowners, will be in place to complete this concurrently with construction of Mill Creek and Chequessett Neck Road dikes. If the project advances to the point where restoration of tidal influence in the Herring River is ready to begin before the Mill Creek sub-basin, tide gates at the Mill Creek dike will remain closed (maintained in a drainage only condition) as Chequessett Neck Road tide gates are opened. The Mill Creek dike tide gates would only be opened to initiate tidal restoration in that sub-basin after all necessary mitigation measures have been implemented to prevent adverse impacts to low-lying properties.

Groundwater studies undertaken by the NPS, HRRC, and FHR (WHG 2012, 2016) have demonstrated that restoration of tidal exchange in the Herring River main basin, with the Mill Creek dike tide gates closed (allows drainage only), would not cause adverse groundwater impacts to the golf course. However, given the inherent uncertainty of groundwater models and low risk tolerance for groundwater impacts to the golf course, a robust monitoring program will be put in place before any changes to tide range in the Herring River are implemented. This monitoring program would include establishing baseline groundwater conditions and collecting data in order to detect future project-related groundwater elevation changes on the golf course. Groundwater monitoring wells would be located at key locations within the Mill Creek sub-basin and other parts of the flood plain. If analysis of monitoring data indicates that increasing tide range in the Herring River results in groundwater increases approaching predetermined threshold elevations in Mill Creek, measures will be employed to prevent project-related changes to groundwater from exceeding the predetermined elevation thresholds. If necessary, Chequessett Neck Road tide gates could be adjusted to reduce Herring River water levels and maintain Mill Creek groundwater below threshold elevations. Monitoring data, model parameters, and model output would be reevaluated to determine whether additional actions could allow resumption of increases to Herring River tide range while preventing adverse effects on the CYCC golf course. Project modifications may require investigation of alternate means of impact mitigation for the golf course and possibly other Mill Creek structures. These measures could include cleaning out trapped sediment from the sub-basin channel network to increase drainage, adjusting Chequessett Neck Road tide gate operation to limit increases in mean water levels, on-site mitigation measures on affected properties, and installation of a pump system at the Mill Creek dike.

Other potentially adverse socioeconomic impacts cited as adaptive management objectives include increased risks to public safety and aesthetic concerns associated with impacts to vegetation, odors, water quality, and construction noise. Predictions and monitoring for some of these will be partly based on the ecological monitoring parameters discussed previously. These include, but are not limited to:

- water quality variables that assess the visual appearance of water;
- marsh odors associated with hydrogen sulfide gas production;
- salinity-driven habitat changes that affect the visual appearance of the project area; and,
- changes to viewscapes from residential areas and public vantage points.

Socioeconomic data will be required to establish the baseline conditions, make predictions, and track changes for some of these objectives. These will include pre- and post-construction photo documentation of visual impacts, surveys of abutters and other stakeholders to solicit opinions about project changes, and tracking stakeholder input from the public and officials (town, NPS, and other) regarding these project impacts.

Fundamental Objective 4: Maximize Ecosystem Services

Ecosystem services are the ecological and socioeconomic benefits of the Herring River project that are accrued to people. Similar to the previous discussion of potential adverse impacts (refer to the “Fundamental Objective 3: Minimize Adverse Impacts” in “Section 1: Setup Phase”) modeling and monitoring for ecosystem services spans both ecological and socioeconomic variables.

Hydrologic/hydraulic and water quality modeling information will be integrated with real time monitoring data to predict expected changes, and document actual changes to the quality and quantity of recreational shellfish habitat. Predictions and observations of salinity, aquatic habitat changes, and occurrences of estuarine fish species, will be used to assess the condition of mosquito breeding habitat in addition to hydrologic/hydraulic modeling and data collection. Emissions and sequestration of GHG (i.e., carbon dioxide and methane) are being quantified to assess the extent to which salt marsh restoration (known as Blue Carbon) could reduce the emission of GHG. GHG are being monitored directly and modeled by a team of investigators affiliated with the Bringing Wetlands to Market project sponsored by the Waquoit Bay National Estuarine Research Reserve (http://www.waquoitbayreserve.org/research-monitoring/salt-marsh-carbon-project/resources/).

Changes to ecosystem services related to recreational use of the Herring River project area, including canoeing and kayaking, fishing, and hiking, will be projected and monitored using pre- and post-construction user surveys and observations of usage at key access points.

Fundamental Objective 5: Minimize Costs

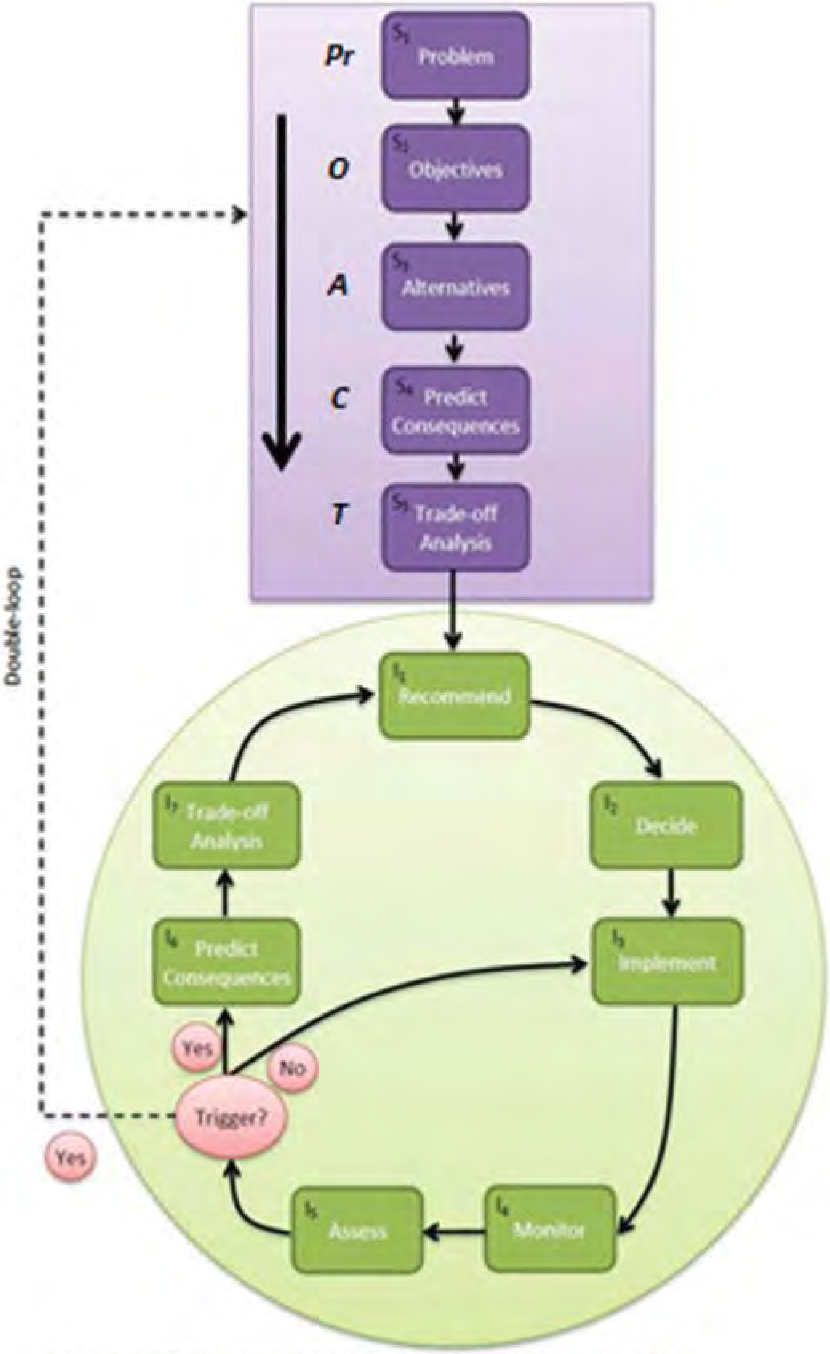
As a project funded primarily by public sources, minimizing the costs of the Herring River project is a critical objective. Costs include direct construction costs and the financial, human, and administrative resources required for monitoring, project oversight, maintenance, and implementation of the adaptive management plan. Consideration of the costs may affect the timing and pace of restoring tidal flow to the estuary and the governmental and non-governmental commitments necessary to provide long-term oversight and mitigation for unavoidable impacts. Cost of secondary actions will also affect the ability to increase the rate of restoration by more active means than simply waiting for it to occur naturally by restoring the tidal exchange.

A “model” for predicting costs is currently being developed as cost estimates for construction elements and budget projections for future personnel and other project needs are being prepared by HRRC and FHR. Anticipated costs will be a consideration and will be assessed with all of the other objectives as alternative actions are evaluated. As with the other ecological and socioeconomic models previously discussed, preliminary cost estimates and projections will be refined and improved as budget requests are submitted and actual work programs are funded, contracted, and completed.

ITERATING THE ADAPTIVE MANAGEMENT PLAN

Adaptive management is frequently characterized as a two-phase learning process (see figure 6). This sequence was partially described in the “Introduction” section. The setup phase comprises the top of the illustration, including the steps described here by the PrOACT model. The iterative phase is represented in the bottom part of the diagram, where models predict results, actions are recommended and taken, results are monitored, monitoring data is integrated to improve models, improved models are used inform future actions, with the process being repeated as needed. The “double-loop” involves exiting the iterative phase and revisiting some or all elements of the setup phase by seeking new input from stakeholders, restating the problem, and potentially modifying objectives, available actions, predicted consequences, and/or trade-offs based on learning gained from the initial set of actions and outcomes. There may also be other triggers that prompt the “double-loop,” where components of the setup phase are revisited. As discussed previously, these triggers will be explicitly specified in the final adaptive management plan.

The Herring River project is in the early stages of adaptive management planning, and is currently working through the setup phase and is still developing models and monitoring plans for many objectives. Thus it is difficult to anticipate how the iteration within adaptive management plan or double loop learning would occur. It is likely, however, that the initial steps of tidal restoration will provide extensive new data which would allow for recalibration and validation of existing models, refinement of models, and development of new models. These recalibrated and/or new models will be used to make updated predictions regarding the consequences of the alternative actions, which in turn will prompt an updated trade-off analysis, and which could potentially lead to the recommendation of a different alternative management strategy. In addition to recalibrated or updated predictive models, working through the early steps of implementing tidal restoration will result in a much clearer understanding of the interactions and relationships between tide gate configuration, tidal hydrology and hydraulics, response of the ecosystem, and impacts to sensitive areas and structures. This new information can also be used to update the initial predicted consequences. Information that results from project implementation will generate new input from stakeholders and may bring about the need to reexamine objectives, actions, and other components identified in the setup phase (this is the double-loop learning process). As the adaptive management plan is developed and the administrative and management protocols are established for the project, communication, flexibility, responsiveness, acceptance to modifying ideas and assumptions, will be a critical to the success of the Herring River Restoration Project.



S=Setup Phase; I=Iterative Phase; Subscript = Step of the respective phase

Note: Two-phase learning in adaptive management. Technical learning involves an iterative sequence of decision making, monitoring, and assessment. Process and institutional learning involves periodic reconsideration of the adaptive management set-up elements.

FIGURE 6: DOUBLE-LOOP MODEL FOR ADAPTIVE MANAGEMENT

CONCLUSION

This summary of the Herring River adaptive management planning process is intended to provide a broad overview of how the project intends to use the ideas and methods of SDM and adaptive management as the project advances from the NEPA/MEPA compliance phase, through final design, permitting, fund-raising, construction, and, ultimately, restoration and monitoring the consequences of tidal exchange throughout the flood plain. The information used to develop the adaptive management strategy represents work undertaken by the HRRC, FHR, environmental and engineering advisors and consultants, and a team of SDM and decision-analysis experts from USGS from 2012 through 2015. The viewpoints and concerns of local and regional stakeholders, project team members, and municipal, state, and federal resource agencies were solicited through formal means -- including public forums, agency committee meetings, written comments submitted to the towns and NPS, through the NEPA/MEPA process -- and informally through ad hoc group discussions, personal communications, and general outreach for the project conducted primarily by FHR. This feedback is reflected in the objectives described here and will be carried forward, and modified as needed, through the adaptive management process as the setup and iterative phases move forward.

During 2016, the USGS will continue to work closely with the HRRC to further develop the elements discussed in the setup phase, including a suite of alternative management strategies which can be assessed and evaluated against all of the objectives through the use of consequence tables and the trade-off analyses. This work will include additional collaboration with technical experts to generate and extract the information from models and other predictive tools that are needed for analyzing and comparing outcomes. Budgets and funding requests are currently being prepared to support additional hydrodynamic and ecosystem modeling and to develop and implement the monitoring plan discussed in the section “Fundamental Objective 5: Minimize Costs.”

With completion of the NEPA/MEPA process and issuance of a Record of Decision from the NPS and a Certificate from the Massachusetts Secretary of Energy and Environment, Cape Cod National Seashore and towns will establish the HREC and a new HRRC. A key next step will be to request the establishment of the proposed ROG (described further in the “Adaptive Management and Permitting” section), which will be needed in order to provide guidance and feedback on how the adaptive management plan is integrated with the various regulatory processes as the plan is formulated. Prompt establishment of the proposed science team and stakeholder group is similarly important in order for all technical perspectives and viewpoints of the public to be represented in the adaptive management plan.

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2014 Model Framework for the Herring River Ecosystem Final Comprehensive Report to HRRC and NPS, Cape Cod National Seashore, Wellfleet, MA. 81 pp.

APPENDIX D: APPLICABLE LAWS, POLICIES, AND REGULATIONS

NPS ORGANIC ACT

The 1916 NPS Organic Act (16 USC § 1) commits the NPS to making informed decisions that perpetuate the conservation and protection of park resources unimpaired for the benefit and enjoyment of future generations. In the Organic Act, Congress directed the U.S. Department of the Interior and the NPS to manage units of the national park system "to conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such a manner and by such a means as will leave them unimpaired for the enjoyment of future generations" (16 USC § 1). Congress reiterated this mandate in the Redwood National Park Expansion Act of 1978 by stating that NPS must conduct its actions in a manner that will ensure no "derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress" (16 USC § 1a-1).

While some actions and activities cause impacts, the NPS cannot allow an adverse impact that constitutes resource impairment (NPS 2006, sec. 1.4.3). The Organic Act prohibits actions that permanently impair park resources unless a law directly and specifically allows for the action (16 USC § 1a-1). An action constitutes an impairment when its impacts "harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values" (NPS 2006, sec. 1.4.5). To determine impairment, the NPS must evaluate "the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts" (NPS 2006, sec. 1.4.5). Therefore, this EIS/EIR analyzes the context, duration, and intensity of impacts related to restoration activities within the Herring River estuary and the Seashore as well as the potential for resource impairment as required by Director's Order 12 (NPS 2001).

NPS MANAGEMENT POLICIES 2006

The introduction to "Chapter 4, Natural Resources Management" of NPS *Management Policies 2006* states that parks "will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks" and that the NPS "manages the natural resources of parks to maintain them in an unimpaired condition for present and future generations" (NPS 2006).

The *NPS Management Policies 2006* acknowledge that park units are parts of much larger ecosystems and that parks can contribute to the conservation of regional biodiversity (NPS 2006). Conversely, many parks cannot meet their natural resource preservation goals without the assistance and collaboration of neighboring landowners and resources to achieve ecosystem stability and other resource management objectives. Therefore, section 4.1.4 of the NPS *Management Policies 2006* states that the agency will pursue cooperative conservation with other agencies, Indian tribes, other traditionally associated people, and private landowners in accordance with Executive Order 13352 (Facilitation of Cooperative Conservation).

Section 4.1.5 (Restoration of Natural Systems) of the NPS *Management Policies 2006* states that the NPS will seek to return areas impacted by human disturbances "to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated" and that impacts on natural systems resulting from human disturbances include among other things "changes to hydrologic patterns and sediment transport…and the disruption of natural processes" (NPS 2006).

Other sections of the NPS *Management Policies 2006* most relevant to this restoration plan/EIS/EIR include Section 4.4.1, General Principles for Managing Biological Resources; Section 4.4.2, Management of Native Plants and Animals; Section 4.4.2.2, Restoration of Native plant and Animal Species; Section 4.4.2.3, Management of Threatened and Endangered Plants and Animals; Section 4.4.2.4, Management of Natural Landscapes; Section 4.4.4, Management of Exotic Species; Section 4.6.3, Water Quality; Section 4.6.4, Floodplains; Section 4.6.5, Wetlands; Section 4.6.6, Watershed and Stream Processes; and Section 8.2, Visitor Use.

DIRECTOR'S ORDER 12: CONSERVATION PLANNING, ENVIRONMENTAL IMPACT ANALYSIS, AND DECISION MAKING AND HANDBOOK

NPS Director's Order 12 and its accompanying handbook (NPS 2001) lay the groundwork for how the NPS complies with NEPA. Director's Order 12 and the handbook set forth a planning process for incorporating scientific and technical information and establishing a solid administrative record for NPS projects.

NPS Director's Order 12 requires that impacts to park resources be analyzed in terms of their context, duration, and intensity. It is crucial for the public and decision-makers to understand the implications of those impacts in the short term and long term, cumulatively, and within context, based on an understanding and interpretation by resource professionals and specialists. Director's Order 12 also requires an analysis of impairment to park resources and values as part of the NEPA document.

DIRECTOR'S ORDER 77: NATURAL RESOURCE PROTECTION

Director's Order 77 addresses natural resource protection with specific guidance provided in Reference Manual 77: Natural Resource management. This director's order includes Director's Order 77-1: Wetland Protection and Director's Order 77-2: Floodplain Management, both of which were considered during the development of this draft EIS/EIR.

DIRECTOR'S ORDER 28: CULTURAL RESOURCE MANAGEMENT

This director's order sets forth the guidelines for management of cultural resources, including cultural landscapes, archeological resources, historic and prehistoric structures, museum objects, and ethnographic resources. This order calls for the NPS to protect and manage cultural resources in its custody through effective research, planning, and stewardship in accordance with the policies and principals contained in the NPS *Management Policies 2006*.

OTHER FEDERAL LEGISLATION, EXECUTIVE ORDERS, COMPLIANCE, AND NPS POLICY

National Environmental Policy Act, 1969, as Amended (NEPA)

NEPA is implemented through regulations of the Council on Environmental Quality (40 CFR 1500-1508) (CEQ). The NPS has in turn adopted procedures to comply with the act and the CEQ regulations, as found in Director's Order 12: Conservation Planning, Environmental Impact Analysis, and Decision Making and its accompanying handbook (NPS 2001). Section 102(2) (c) of this act requires an EIS for proposed major federal actions that may significantly affect the quality of the human environment.

National Parks Omnibus Management Act of 1998

The National Parks Omnibus Management Act of 1998 (16 USC 5901 et seq.) underscores NEPA in that both are fundamental to NPS park management decisions. Both acts provide direction for articulating and connecting the ultimate resource management decision to the analysis of impacts using appropriate technical and scientific information. Both also recognize that such data may not be readily available and provide options for resource impact analysis in this case.

National Parks Omnibus Management Act of 1998 directs the NPS to obtain scientific and technical information for analysis. The NPS handbook for Director's Order 12 states that if "such information cannot be obtained due to excessive cost or technical impossibility, the proposed alternative for decision will be modified to eliminate the action causing the unknown or uncertain impact or other alternatives will be selected" (NPS 2001).

Redwood National Park Act of 1978, as Amended

Reasserting the system-wide standard of protection Congress established in the original *Organic Act*, the Redwood Amendment states:

> The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress (P.L. 95-250, USC Sec 1a-1).

Congress intended the language of the Redwood Amendment to the General Authorities Act to reiterate the provisions of the Organic Act, not to create a substantively different management standard. The House committee report described the Redwood Amendment as a "declaration by Congress" and that the promotion and regulation of the national park system is to be consistent with the Organic Act. The Senate committee report stated that under the Redwood Amendment, "[t]he Secretary has an absolute duty, which is not to be compromised, to fulfill the mandate of the 1916 Act to take whatever actions and seek whatever relief as will safeguard the units of the national park system." Although the Organic Act and the General Authorities Act, as amended by the Redwood Amendment, use different wording ("unimpaired" and "derogation") to describe what the NPS must avoid, both acts define a single standard for the management of the national park system, not two different standards. For simplicity, NPS *Management Policies 2006* uses "impairment," not both statutory phrases, to refer to that single standard.

Endangered Species Act of 1973, as Amended

This act requires all federal agencies to consult with the Secretary of the Interior on all projects and proposals with the potential to impact federally endangered or threatened plants and animals. It also requires federal agencies to use their authorities in furtherance of the purposes of the Endangered Species Act by carrying out programs for the conservation of endangered and threatened species. Federal agencies are also responsible for ensuring that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat.

Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act implements various treaties and conventions between the United States and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under this act, it is prohibited, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export at any time or in any manner, any migratory bird included in the terms of this Convention…for the protection of migratory birds…or any part, nest, or egg of any such bird" (16 USC 703). Subject to limitations in the Act, the Secretary of the Interior may adopt regulations determining the extent to which, if at all, hunting, taking, capturing, killing, possessing, selling, purchasing, shipping, transporting, or exporting of any migratory bird, part, nest, or egg will be allowed, having regard for temperature zones, distribution, abundance, economic value, breeding habits, and migratory flight patterns.

Code of Federal Regulations, Title 36 (1992)

Title 36, Chapter 1, provides the regulations "for the proper use, management, government, and protection of persons, property, and natural and cultural resources within areas under the jurisdiction of the National Park Service" (16 USC 3).

National Historic Preservation Act of 1966, as Amended

The National Historic Preservation Act (NHPA), as amended, is the principal legislative authority for managing cultural resources associated with NPS projects. Generally, Section 106 of the NHPA, as amended, and as implemented in 36 CFR 800, requires all federal agencies to consider the effects of their actions on cultural resources listed and/or determined eligible for listing in the National Register. Such resources are also termed "historic properties."

Moreover, the federal agency must afford the Advisory Council on Historic Preservation (ACHP) the opportunity to comment in the event that an undertaking will have an adverse effect on a cultural resource that is eligible for or listed in the National Register, and must consult with the State Historic Preservation Officer (SHPO) and other interested parties in an effort to avoid, minimize, or mitigate adverse effects.

Eligibility for the National Register is established according to the official Criteria of Evaluation (36 CFR 60.4) issued by the Department of the Interior. The criteria relate to the following:

> The quality of significance in American history, architecture, archeology, engineering, and culture present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and:
>
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) That are associated with the lives of persons significant in our past; or
>
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic

values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

(d) That has yielded, or may be likely to yield, information important in prehistory or history.

A historic property can be considered significant under one or more of the criteria.

Other important laws and regulations designed to protect cultural resources are listed below:

- Native American Graves Protection and Repatriation Act, 1990
- American Indian Religious Freedom Act, 1978
- National Environmental Policy Act, 1969
- Archeological Resources Protection Act, 1979
- Protection of Historic Properties (36 CFR 800), as amended 2004
- Executive Order 11593: Protection and Enhancement of the Cultural Environment, 1971
- Executive Order 13007: Indian Sacred Sites, 1996

Historic Sites Act of 1935

This act declares as national policy the preservation for public use of historic sites, buildings, objects, and properties of national significance. It authorizes the Secretary of the Interior and the NPS to restore, reconstruct, rehabilitate, preserve, and maintain historic or prehistoric sites, buildings, objects, and properties of national historical or archaeological significance.

Marine Mammal Protection Act, 1972

The Marine Mammal Protection Act prohibits, with certain exceptions, the taking of marine mammals in United States waters and by United States citizens on the high seas and the importation of marine mammals and marine mammal products into the United States. The act defines "take" as "to harass, capture, kill, or attempt to harass, hunt, capture, or kill any marine mammal." It defines harassment as "any act or pursuits, torment or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild; or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." This act recognizes that some marine mammal species or stocks may be in danger of extinction or depletion as a result of human activities and that these species or stocks must not be permitted to be depleted. The act, as amended in 1994, provides for certain exceptions to the take prohibitions, such as for Alaska Native subsistence and permits and authorizations for scientific research; a program to authorize and control the taking of marine mammals incidental to commercial fishing operations; preparation of stock assessments for all marine mammal stocks in waters under United States jurisdiction; and studies of pinniped (fin-footed mammals)-fishery interactions.

Magnuson-Stevens Fishery Management and Conservation Act of 1976

The Magnuson-Stevens Fishery Management and Conservation Act was established to promote conservation of marine fishery (shellfish and finfish) resources and included the establishment of eight regional fishery management councils that develop fishery management plans to properly manage fishery resources within their jurisdictional waters. The 1986 and 1996 amendments to the Act recognized that many fisheries depend on nearshore and estuarine habitats for at least part of their lifecycles and included evaluation of habitat loss and protection of critical habitat. The marine environments important to marine fisheries, referred to as essential fish habitats (EFH), are defined to include "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity." The Act further mandates that National Marine Fisheries Service (NMFS) coordinate with other federal agencies to avoid, minimize, or otherwise offset adverse effects on EFH that could result from proposed activities. To delineate EFH, regional fishery management councils mapped coastal waters and superimposed ten minute by ten minute (10′ × 10′) square coordinate grids. The Cape Cod Bay grid contains Wellfleet Harbor and the Herring River within.

Coastal Zone Management Act 1972, as Amended

The Coastal Zone Management Act (CZMA) (16 USC 1451 et seq.) seeks to preserve and protect coastal resources. Through the CZMA, states are encouraged to develop coastal zone management programs (CZMPs) to allow economic growth that is compatible with the protection of natural resources, the reduction of coastal hazards, the improvement of water quality, and sensible coastal development. The CZMA provides financial and technical incentives for coastal states to manage their coastal zones in a manner consistent with CZMA standards and goals. CZMA Section 307 requires that federal agency activities that affect any land or water use or natural resource of the coastal zone must be consistent to the maximum extent practicable with the enforceable policies of the state CZMP. Federal agencies and applicants for federal approvals must consult with state CZMPs and must provide the CZMP with a determination or certification that the activity is consistent with the CZMP's enforceable policies, where those policies will have a possible effect on state coastal resources, as the CZMP and local land use plans define them.

Clean Water Act of 1972, as Amended

The Clean Water Act (CWA) is a comprehensive statute aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The U.S. Army Corps of Engineers (USACE) administers section 404 of this Act and regulates discharge of dredged and fill material to waters of the United States, including wetlands under federal jurisdiction. The CWA also requires the establishment of state water quality standards for surface waters, as well as federal water quality standards, and the development of guidelines to identify and evaluate the extent of nonpoint source pollution. Section 401 of the Act – Water Quality Certification – gives states the authority to review projects that must obtain federal licenses or permits and that result in a discharge to state waters. The purpose of the Water Quality Certification is to ensure that a project will comply with state water quality standards and other appropriate requirements of state law, and it is required for any project that also requires a USACE Section 404 wetland permit.

Section 10 of the Rivers and Harbors Act of 1899

The USACE New England District administers Section 10, which is required for all work including work seaward of the mean high water line in navigable waters of the United States. Given the nature and extent of the restoration project, it is most likely that the general permit, a consolidation of all USACE permits, would not suffice, and applications for individual permits would be necessary. Under this latter review process, applications are submitted to the USACE, which in turn issues a Public Notice and initiates a comment period. The USACE evaluates comments, public interest criteria, and compliance with the federal CWA, and issues a permit, as deemed appropriate.

Executive Order 11990: Protection of Wetlands

This executive order directs federal agencies to avoid, to the extent possible, the long-term and short-term adverse impacts associated with the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.

Executive Order 11988: Floodplain Management

This executive order directs federal agencies to avoid, to the extent possible, the long-term and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct or indirect support of flood plain development wherever there is a practicable alternative.

Executive Order 13112: Invasive Species

This executive order defines an invasive species as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.” and is intended to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. By this executive order, federal agencies are directed to expand and coordinate their efforts to combat the introduction and spread of plants and animals not native to the United States.

Executive Order 11593: Protection and Enhancement of the Cultural Environment

This executive order directs federal agencies to support the preservation of cultural properties and to identify and nominate to the NRHP cultural properties in the park and to “exercise caution… to assure that any NPS-owned property that might qualify for nomination is not inadvertently transferred, sold, demolished, or substantially altered.”

Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds

Migratory birds are of great ecological and economic value to this country and to other countries. They contribute to biological diversity and bring tremendous enjoyment to millions of people who study, watch, feed, or hunt these birds throughout the United States and other countries. The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. Such conventions include the Convention for the Protection of Migratory Birds with Great Britain on behalf of Canada 1916, the Convention for the Protection of Migratory Birds and Game Mammals-Mexico 1936, the Convention for the Protection of Birds and Their Environment-Japan 1972, and the Convention for the Conservation of Migratory Birds and Their Environment-Union of Soviet Socialist Republics 1978. These migratory bird conventions impose substantive obligations on the United States for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the United States has implemented these migratory bird conventions with respect to the United States. This executive order directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act.

STATE AND LOCAL LAWS, POLICIES, REGULATIONS, AND PLANS

Massachusetts Environmental Policy Act

The Massachusetts Environmental Policy Act (MEPA) is the state equivalent of NEPA. MEPA provides meaningful opportunities for public review of the potential environmental impacts of projects for which state agency action is required and assists each agency in using—in addition to applying any other applicable statutory and regulatory standards and requirements—all feasible means to avoid damage to the environment or, to the extent damage to the environment cannot be avoided, to minimize and mitigate damage to the environment to the maximum extent practicable.

MEPA considers projects that may meet or exceed review thresholds for various resource categories found in 301 CMR 11.00. For this project, those categories include land, rare species, wetlands, waterways, and tidelands, water supply, transportation, and historic and archaeological resources.

The project area is located in the Wellfleet Harbor Area of Critical Environmental Concern (ACEC). While restoration of the Herring River would help to achieve the goal of preserving, restoring, and enhancing the resources in the ACEC (301 CMR 12.12), it will have to be carried out in a manner that minimizes adverse effects on marine and aquatic productivity, surface and groundwater quality, habitat values, storm damage prevention or flood control, historic and archaeological resources, scenic and recreational resources, and other natural resource values of the area.

Because the restoration plan also includes state funding and other state permits, it is subject to MEPA.

Massachusetts Waterways Licensing Program (M.G.L. c.91)

The Massachusetts Waterways Licensing Program (Chapter 91) is the Commonwealth's primary tool for protection and promotion of public use of its tidelands and other waterways. The Commonwealth formally established the program in 1866, but the philosophy behind Chapter 91 dates back to the earliest days of the Massachusetts Bay Colony, most notably in the Colonial Ordinances of 1641–1647. The Colonial Ordinances codified the "public trust doctrine," a legal principle that dates back nearly 2000 years which holds that the air, the sea, and the shore belong not to any one person, but rather to the public at large. The oldest program of its kind in the nation, Chapter 91 regulates activities on both coastal and inland waterways, including construction, dredging, and filling in tidelands, great ponds, and certain rivers and streams. The restoration plan would undergo a Chapter 91 review due to new structures (culverts) over tidelands and modifications to previously licensed or unlicensed structures.

Massachusetts Endangered Species Act (M.G.L. c. 131A)

The Massachusetts Endangered Species Act (M.G.L c.131A and regulations 321 CMR 10.00) (MESA) protect rare species and their habitats by prohibiting the "taking" of any plant or animal species listed as endangered, threatened, or species of concern by the Massachusetts Division of Fisheries and Wildlife. Taking includes the harassing, killing, trapping, collecting of species as well as the disruption of nesting, breeding, feeding, or migratory activity, including habitat modification or destruction. Three types of filings under MESA are coordinated through the Natural Heritage and Endangered Species Program at the Division of Fisheries and Wildlife: (1) MESA Information Request for rare species information; (2) MESA Project Review; and (3) the Conservation and Management Permit Application. Projects resulting in a "take" of state-listed rare species may be eligible for a Conservation and Management Permit (321 CMR 10.23). A Rare Species Habitat assessment or survey may be required as part of the Conservation and Management Permit process.

Cape Cod Commission – Development of Regional Impact

An Act of the Massachusetts General Court in 1990 created the Cape Cod Commission (CCC). The Commission reviews projects that present regional issues identified in the Act, including water quality, traffic flow, historic values, affordable housing, open space, natural resources, and economic development.

The law requires a Development of Regional Impact (DRI) review if a project exceeds a specific threshold. Examples of projects that need to go through mandatory DRI review by the CCC are those involving:

- subdivisions of 30 acres or more
- development of 30 or more residential lots or dwelling units
- development of 10 or more business, office, or industrial lots
- commercial development or change of use for buildings greater than 10,000 square feet
- transportation facilities for passage to or from Barnstable County
- demolition or major changes to some national- or state-recognized historic structures
- bridge, ramp, or road construction providing access to several types of water bodies and wetlands
- new construction or change of use involving outdoor commercial space greater than 40,000 square feet
- construction of any wireless communication tower exceeding 35 feet in height
- site alterations or site disturbance greater than 2 acres without a valid local permit
- mixed use residential and non-residential developments with a floor area greater than 20,000 square feet

Projects that do not meet a threshold but are forwarded to the CCC from the town in which they are located also require a DRI review. The Commission must first vote to accept this type of referral as a development that has regional impacts. The Herring River Restoration Project would meet the threshold for a DRI review because an EIR is required by MEPA.

Massachusetts Historical Commission

The Massachusetts Historical Commission (MHC) must review any projects that require funding, licenses, or permits from any state agency in compliance with Massachusetts General Laws (MGL) Chapter 9, sections 26–27C. This law creates the MHC, the office of the State Archaeologist, and the State Register of Historic Places among other historic preservation programs. It provides for MHC review of state projects, State Archaeologist’s Permits, the protection of archaeological sites on public land from unauthorized digging, and the protection of unmarked burials. These regulations set up a process that mirrors the federal Section 106 regulations, which include identification of historic properties; assessment of effect; and consultation among interested parties to avoid, minimize, or mitigate any adverse effects.

Massachusetts Wetland Protection Act and Rivers Protection Act

The Wetlands Protection Act (MGL Chapter 131, Section 40) protects wetlands and the public interests they serve, including flood control, prevention of pollution and storm damage, and protection of public and private water supplies, groundwater supply, fisheries, land containing shellfish, and wildlife habitat. These public interests are protected by requiring a careful review of proposed work that may alter wetlands. The law protects not only wetlands, but other resource areas, such as land subject to flooding (100-year flood plains), the riverfront area (added by the Rivers Protection Act), and land under water bodies, waterways, salt ponds, fish runs, and the ocean.

These regulations set forth a public review and decision-making process by which activities affecting areas subject to protection under the law are to be regulated in order to contribute to the following public interests and values:

- protection of public and private water supply
- protection of ground water quality and supply
- flood control
- erosion and sedimentation control
- storm damage prevention
- prevention of pollution
- protection of land containing shellfish
- protection of fisheries
- protection of wildlife habitat

Wellfleet Environmental Protection Bylaw

At the local level, the community's conservation commission administers the Wetlands Protection Act. The Wellfleet Conservation Commission promulgated the Wellfleet Environmental Protection Regulations pursuant to the authority granted under the Wellfleet Environmental Protection Bylaw as approved on April 28, 1986 at a town meeting. In addition to the regulations required by the Wetlands Protection Act, these regulations set forth a public review and decision-making process by which activities affecting areas subject to protection under the bylaw are to be regulated in order to contribute to public interests and values.

The bylaw and regulations subject the following Wetland Resource Areas to protection under:

- any freshwater wetland, inland bank, coastal wetland, coastal bank, beach, dune, flat, marsh, wet meadow, bog, or swamp
- any estuary, creek, river, stream, pond, lake, and lands under these bodies of water; land under the ocean
- land subject to tidal action, land subject to coastal storm flowage, bordering land subject to flooding, and isolated land subject to flooding
- all land within 100 feet (200 feet for rivers, streams, and fresh creeks) of any freshwater wetland, inland bank, coastal wetland, coastal bank, beach, dune, flat, marsh, wet meadow,

bog, swamp, estuary, creek, river, stream, pond, lake, lands under these bodies of water, and land under the ocean

Massachusetts Water Quality Certification

The MassDEP's Division of Wetlands and Waterways is responsible for ensuring clean air and water within the Commonwealth of Massachusetts. MassDEP administers regulations relating to the discharge of dredged or fill material, dredging, and dredged material disposal activities in waters of the United States within the state that require federal licenses or permits and that are subject to state water quality certification under 33 USC 1251, et seq. For work in USACE jurisdiction involving a discharge to waters of the United States, MassDEP must provide or waive certification before work can proceed. This permit represents the state's assurance that land disturbing activities will not adversely affect water quality. The Section 401 review ensures that a proposed dredge and/or fill project that can result in the discharge of pollutants complies with Massachusetts Surface Water Quality Standards, the Massachusetts Wetlands Protection Act, and otherwise avoids or minimizes individual and cumulative impacts to Massachusetts waters and wetlands.

Coastal Zone Management Act Consistency Review

Massachusetts CZMP administers the Federal Consistency Review under the federal CZM Act of 1972, which ensures that any federal activities in or affecting Massachusetts coastal resources are consistent with state coastal policies. CZM's mission is to balance the impacts of human activity with the protection of coastal and marine resources. Massachusetts CZM was specifically established to work with other state agencies, federal agencies, local governments, and the general public to promote sound management of the Massachusetts coast. The Massachusetts CZM is not a permitting agency; however, it does have the authority to review federal activities in the Massachusetts coastal zone to ensure that they are consistent with CZM program policies. Because this restoration project is a federal undertaking, CZM must approve the action before the action can take place.

APPENDIX E: BIRDS OF THE HERRING RIVER AREA

Common Name	Scientific Name
American Black Duck	*Anas rubripes*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Green-Winged Teal	*Anas c. carolinensis*
American Redstart	*Setophaga ruticilla*
American Robin	*Turdus migratorius*
American Wigeon	*Anas americana*
American Woodcock	*Scolopax minor*
Atlantic Brant	*Branta b. bernicla*
Baltimore Oriole	*Icterus galbula*
Bank Swallow	*Riparia riparia*
Barn Swallow	*Hirundo rustica*
Belted Kingfisher	*Megaceryle alcyon*
Black-And-White Warbler	*Mniotilta varia*
Black-Bellied Plover	*Pluvialis squatarola*
Black-Billed Cuckoo	*Coccyzus erythropthalmus*
Black-Capped Chickadee	*Poecile atricapillus*
Black-Cheeked Warbler	*Basileuterus melanogenys*
Black-Crowned Night-Heron	*Nycticorax nycticorax*
Black-Throated Blue Warbler	*Dendroica caerulescens*
Blue Jay	*Cyanocitta cristata*
Blue-Gray Gnatcatcher	*Polioptila caerulea*
Blue-Headed Vireo	*Vireo solitarius*
Bonaparte's Gull	*Chroicocephalus philadelphia*
Bronzed Cowbird	*Molothrus aeneus*
Brown Creeper	*Certhia americana*
Brown Thrasher	*Toxostoma rufum*
Brown-Headed Cowbird	*Molothrus ater*
Bufflehead	*Bucephala albeola*
Cackling Goose	*Branta hutchinsii*
Carolina Wren	*Thryothorus ludovicianus*
Cedar Waxwing	*Bombycilla cedrorum*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow	*Spizella passerina*

Common Name	Scientific Name
Common Eider	*Somateria mollissima*
Common Goldeneye	*Bucephala clangula*
Common Grackle	*Quiscalus quiscula*
Common Loon	*Gavia immer*
Common Merganser	*Mergus merganser*
Common Tern	*Sterna hirundo*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Double-Crested Cormorant	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern Phoebe	*Sayornis phoebe*
Eastern Towhee	*Pipilo erythrophthalmus*
Eastern Wood-Pewee	*Contopus virens*
European Starling	*Sturnus vulgaris*
Field Sparrow	*Spizella pusilla*
Forster's Tern	*Sterna forsteri*
Golden-Crowned Kinglet	*Regulus satrapa*
Great Black-Backed Gull	*Larus marinus*
Great Blue Heron	*Ardea herodias*
Great Crested Flycatcher	*Myiarchus crinitus*
Greater Yellowlegs	*Tringa melanoleuca*
Green Heron	*Butorides virescens*
Grey Catbird	*Dumetella carolinensis*
Hairy Woodpecker	*Picoides villosus*
Hermit Thrush	*Catharus guttatus*
Herring Gull	*Larus argentatus*
Hooded Merganser	*Lophodytes cucullatus*
House Finch	*Carpodacus mexicanus*
Killdeer	*Charadrius vociferus*
Laughing Gull	*Leucophaeus atricilla*
Least Sandpiper	*Calidris minutilla*
Lesser Yellowlegs	*Tringa flavipes*
Little Blue Heron	*Egretta caerulea*
Mallard	*Anas platyrhynchos*
Merlin	*Falco columbarius*

Common Name	Scientific Name
Mourning Dove	*Zenaida macroura*
Mute Swan	*Cygnus olor*
Myrtle Warbler	*Dendroica c. coronata DENCCO*
Nashville Warbler	*Oreothlypis ruficapilla*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Gannet	*Morus bassanus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Northern Parula	*Parula americana*
Northern Waterthrush	*Parkesia noveboracensis*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Palm Warbler	*Dendroica palmarum*
Pied-Billed Grebe	*Podilymbus podiceps*
Pine Warbler	*Dendroica pinus*
Prairie Warbler	*Dendroica discolor*
Red-Bellied Woodpecker	*Melanerpes carolinus*
Red-Breasted Merganser	*Mergus serrator*
Red-Breasted Nuthatch	*Sitta canadensis*
Red-Tailed Hawk	*Buteo jamaicensis*
Red-Throated Loon	*Gavia stellata*
Red-Winged Blackbird	*Agelaius phoeniceus*
Ring-Billed Gull	*Larus delawarensis*
Ruby-Crowned Kinglet	*Regulus calendula*
Ruby-Throated Hummingbird	*Archilochus colubris*
Ruddy Turnstone	*Arenaria interpres*
Ruff	*Philomachus pugnax*
Sanderling	*Calidris alba*
Semipalmated Plover	*Charadrius semipalmatus*
Semipalmated Sandpiper	*Calidris pusilla*
Sharp-Shinned Hawk	*Accipiter striatus*
Slate-Colored Junco	*Junco h. hyemalis*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularius*
Swamp Sparrow	*Melospiza georgiana*

Common Name	Scientific Name
Tree Swallow	*Tachycineta bicolor*
Tufted Titmouse	*Baeolophus bicolor*
Turkey Vulture	*Cathartes aura*
Vesper Sparrow	*Pooecetes gramineus*
Wedge-Rumped Storm-Petrel	*Oceanodroma tethys*
Whimbrel	*Numenius phaeopus*
White-Breasted Nuthatch	*Sitta carolinensis*
White-Throated Sparrow	*Zonotrichia albicollis*
Willet	*Tringa semipalmata*
Wood Thrush	*Hylocichla mustelina*
Yellow Warbler	*Dendroica petechia*
Yellow-Billed Cuckoo	*Coccyzus americanus*
Yellow-Shafted Flicker	*Colaptes a. auratus*

Kearney and Cook 2001; MassAudubon 2006; Veit and Peterson 1993.

APPENDIX F: ESSENTIAL FISH HABITAT ASSESSMENT FOR THE HERRING RIVER RESTORATION PROJECT

INTRODUCTION

Many aquatic habitats are critical to the productivity and sustainability of marine fisheries. The Magnuson-Stevens Fishery Conservation and Management Act, amended by the Sustainable Fisheries Act in 1996 (the Act), requires the National Oceanic and Atmospheric Administration National Marine Fisheries Services (NMFS) and eight regional fishery management councils (Councils) to protect and conserve the habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. Essential Fish Habitat (EFH) is defined to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The Act requires the Councils to describe and identify the essential habitat for the managed species, minimize to the extent practicable adverse effects on EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of EFH. As required by the Act, federal agencies must consult with NMFS on all actions or proposed actions authorized, funded, or undertaken that may adversely affect EFH. In return, NMFS must provide recommendations including measures to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH resulting from the proposed actions. The New England Fishery Management Council (NEFMC) identifies and protects EFH for all species within the federal 200-mile limit off the coasts of Maine, New Hampshire, Massachusetts (including the project area), Rhode Island and Connecticut.

In compliance with Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (1996 amendments), the Herring River Restoration Committee (HRRC) and the National Park Service (NPS) is providing this assessment of the potential effects of restoring native tidal wetland habitat to large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore) on essential fish habitats.

PROJECT BACKGROUND

The Herring River estuary is located in the towns of Wellfleet and Truro on Cape Cod, Massachusetts. The river, along with its flood plain, tributary streams, and associated estuarine habitats encompasses approximately 1,100 acres, with approximately 80 percent of the river’s flood plain located within the boundary of the Seashore (Figure 1). The river itself extends from Wellfleet Harbor northeast for nearly 4 miles to Herring Pond in north Wellfleet. The dike at Chequessett Neck Road separates Wellfleet Harbor from the majority of the river. The dike consists of three 6-foot wide box culverts, each with an attached flow control structure. One culvert has an adjustable sluice gate that is currently set partially open at 2 feet and allows limited bi-directional tidal flow. The remaining two culverts have tidal flap gates, designed to permit flow only during the outgoing (ebbing) tide. In addition to the Herring River’s upper, middle, and lower basins, the estuary is composed of other important sub-basins including Mill Creek, Duck Harbor, Lower and Upper Pole Dike Creek, and Lower and Upper Bound Brook (Figure 2).

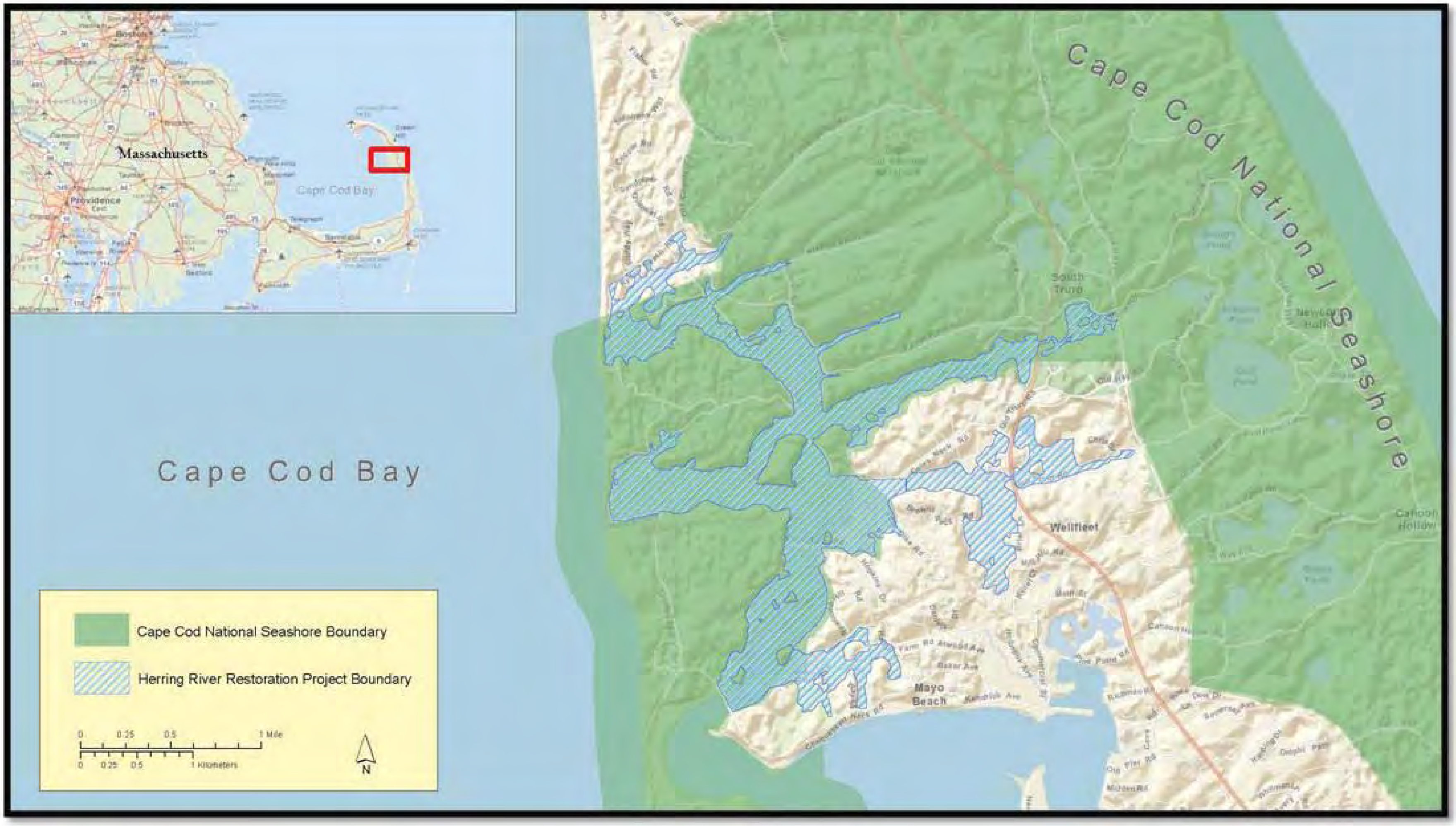

FIGURE 1. HERRING RIVER RESTORATION PROJECT AREA

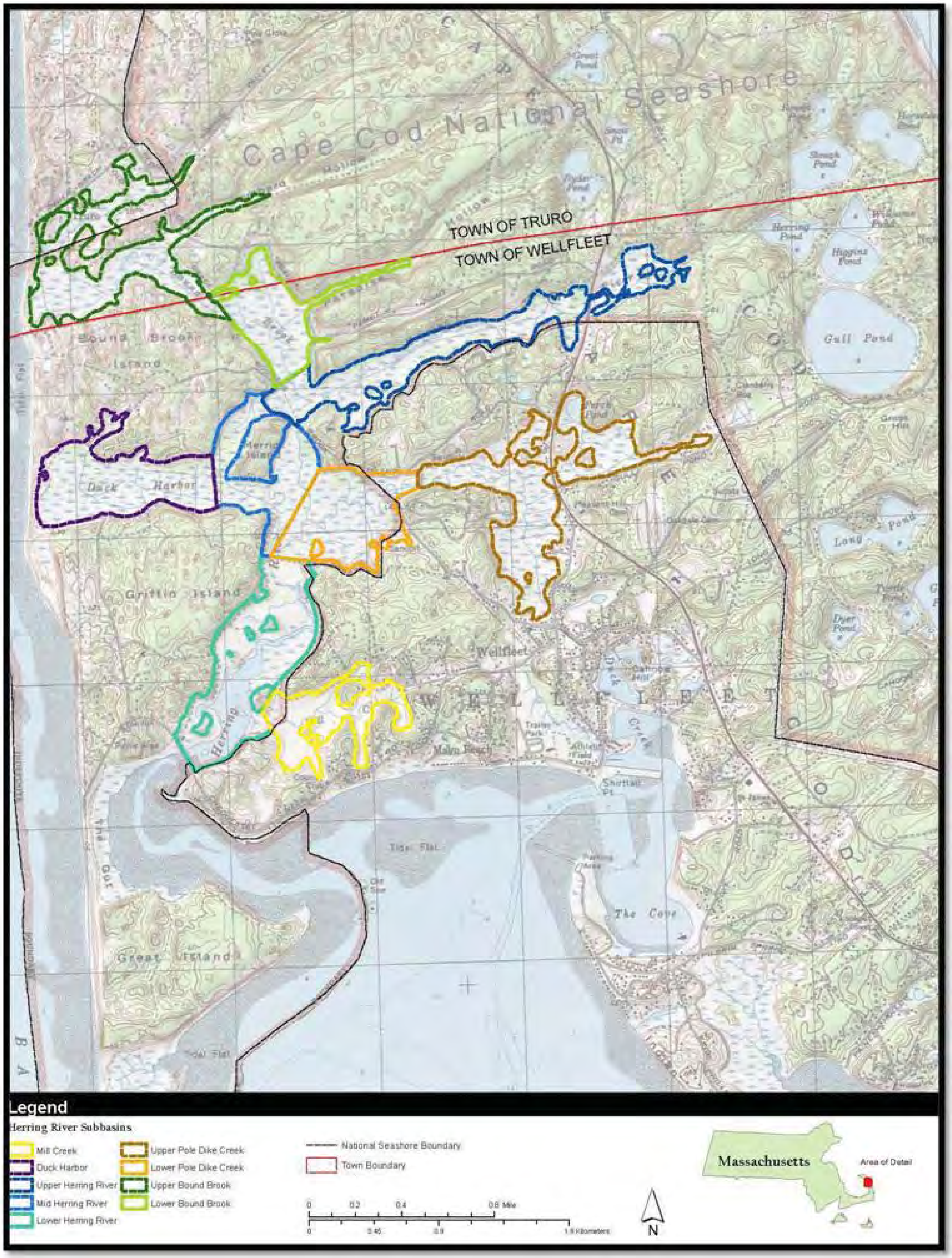

FIGURE 2. HERRING RIVER SUB-BASINS

Since the dike at Chequessett Neck Road was constructed in 1909, the river's wetland resources and natural ecosystem functions have been severely altered and damaged by 100 years of tidal restriction and salt marsh drainage. Adverse ecological effects include but are not limited to:

- Lack of tidal inflow and outflow – tidal range restriction. The Chequessett Neck Road Dike restricts the tidal range in the Herring River from more than 10 feet on the downstream, harbor side, to about 2 feet upstream of the dike. With the tidal restriction, seawater only reaches approximately 3,000 feet upstream of the dike. Under the original natural conditions, seawater reached upstream beyond present-day Route 6 and supported estuarine plants and animals throughout the flood plain.
- Loss of estuarine habitat. The original Herring River estuary included about 1,100 acres of salt marsh, intertidal flats, and open water habitats. The total estuarine habitat (sub-tidal and intertidal habitat) now totals about 70 acres and is confined to the Lower Herring River immediately upstream of the Chequessett Neck Road Dike.
- Degradation of water quality. The elimination of salt water input to the estuary and marsh dewatering has resulted in highly acidic waters which in the past has caused fish kills and causes the leaching of toxic metals, further degrading the water quality. The lack of tidal flushing has also resulted in low summertime dissolved oxygen levels.
- Impediments to fish passage and river herring migration. The Chequessett Neck Road Dike physically impedes fish passage and creates an artificially abrupt transition from seawater to fresh river water.
- Plant community changes, including loss of salt marsh vegetation and increase in non-native invasive species. Only about seven acres of salt marsh remain in the Herring River system. Much of the original Herring River wetlands have been converted from salt marsh to forest and shrublands dominated by opportunistic upland species. Large portions of the original sub-tidal and intertidal substrates between the dike and High Toss Road have been converted to monotypic stands of common reed (*Phragmites australis*).
- Elimination of natural sediment processes and salt marsh surface subsidence. Diking of the river has effectively blocked the transport of inorganic sediment from reaching the salt marshes in the Herring River basin, which along with other processes, has contributed to the severe historic and continuing subsidence in the Herring River's diked wetlands.

PROJECT DESCRIPTION

The proposed project is to develop and implement actions for the restoration of self-sustaining coastal habitats in a large portion of the 1,100-acre Herring River estuary in the towns of Wellfleet and Truro, Massachusetts. Besides the dike, there are more than five miles of roadway, an abandoned railroad embankment, several tidally restrictive culverts and berms, channelized stream reaches, and acres of invasive, non-native vegetation that impact the Herring River flood plain. There are multiple options for addressing each of these issues. As a result of having multiple options to select from, the specific impacts of the project are unknown, so impacts are addressed in more general terms in this assessment. The major components and focus areas of the Herring River project include:

Chequessett Neck Road Dike: Reconstruction of the dike to allow greater tidal exchange is the primary element of the restoration project. Reconstruction of the dike would involve installing a 165-foot-wide series of culverts to allow passage of Wellfleet Harbor tides. The objective of the project, depending on the alternative selected through the National Environmental Policy Act

(NEPA) process, is to ultimately reach either a mean high spring tide of 4.8 feet and a 100-year storm driven tide of 6.0 feet in the Lower Herring River or alternatively a mean high spring tide of 5.6 feet and a 100-year storm driven tide of up to 7.5 feet. To achieve the desired tidal ranges the tide gates would be opened gradually and according to guidelines set forth in an adaptive management plan (see appendix A).

- Mill Creek Sub-basin: This sub-basin has a number of private properties that could be subject to flooding without protective measures. If the selected goal for the Lower Herring River through the NEPA process is achieving a mean high spring tide of 4.8 feet, then no dike construction at the mouth of Mill Creek would be needed, or would occur. However, if a mean high spring tide of 5.6 feet in Lower Herring River is the goal selected, then a dike would be constructed across the mouth of Mill Creek. The dike would either completely eliminate tidal influence to the sub-basin, or it would allow partially restored tidal flow to the sub-basin by using a combination tide gate at this location. In this instance, mean high water spring tides would be limited to a maximum of 4.7 feet and 100-year storm driven events would be limited to a maximum of 5.9 feet in Mill Creek.
- High Toss Road: Complete removal of the tidal restriction at High Toss Road is another major component of the project. The five-foot diameter circular culvert at High Toss Road would need to be removed or enlarged to maximize tidal circulation upstream. The roadway itself would be impacted by restored tidal exchange and could either be elevated or removed.
- Upper Pole Dike Creek Sub-basin: Under certain restoration scenarios and tidal conditions, flood protection measures might be required in Upper Pole Dike Creek sub-basin to protect low lying properties. Any significant flood impacts will be addressed on a property-specific basis or by restricting tide flow at Pole Dike Road with either the existing road culvert or a tide control gate.
- Pole Dike Creek, Old County, and Bound Brook Island Roads: Culverts under these low-lying roads could need to be enlarged if future monitoring shows the existing culverts are impeding tidal flows or altering other ecological processes. Preliminary engineering analyses show that approximately 8,000 linear feet of road surfaces would need to be elevated or relocated to remain passable during high tides.
- Management of Flood Plain Vegetation: Measures would be taken to remove woody shrubs and trees that die during transition to a more saline and/or wetter environment. Potential techniques include cutting, chipping, and burning.
- Restoration of Tidal Channel Structure and Marsh Surface Elevation: Measures would be taken to restore the natural configuration of tidal channels to maximize water circulation and promote elevation of subsided marsh surfaces. Potential actions to be taken include, but are not limited to, the following:
  - Dredging of accumulated sediment to establish a natural bottom of the Herring River channel at the appropriate depth to maximize ebb tide drainage.
  - Creation of small channels and ditches to improve tidal circulation.
  - Restoring natural channel sinuosity.
  - Removing lateral ditch dredge spoil berms and other anthropogenic material on the marsh surface to facilitate drainage of ponded water.
  - Applying thin layers of dredged material to build up subsided marsh surfaces.

- Chequessett Yacht and Country Club (CYCC): Any action that allows tidal influence to be restored to Mill Creek under the Herring River project would allow salt water to inundate low portions of the CYCC golf course during most high tides unless action is taken to protect it from tidal flooding. Two options for addressing the impacts to the CYCC include elevating affected portions of the facility by providing necessary quantities of fill, regrading, and replanting the areas. Approximately 150,000 cubic yards of fill and 32 acres of disturbance for grading and site preparation would be required. The other option is to relocate the affected portions of the facility to upland locations currently owned by the CYCC. This would involve clearing, grading, and planting of new golf holes and a practice area.

ADAPTIVE MANAGEMENT

Reintroduction of tidal influence to the Herring River estuary would be adaptively managed over a long-term, phased process that would take several years. Gradual opening of adjustable tide gates at the Chequessett Neck Road Dike would incrementally increase the tidal range in the river. This would allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate response actions taken. An Operations and Maintenance Plan will also be developed to ensure that the project's habitat restoration and flood protection goals are achieved.

CONSTRUCTION METHODS AND TIMEFRAME

Standard construction methods and equipment would be used to construct the infrastructure needed to implement the components of the restoration project and would include additional activities such as bank excavation/stabilization, culvert replacement, vegetation clearing, dredging, and the use of temporary fill. Earth-moving equipment, graders, cranes, dump trucks, cement trucks, and other equipment would be operated and staged in project areas. Fill, armor stones, and other construction materials would also be staged in preparation for use. To the extent possible, previously disturbed areas would be used to stage equipment and materials; however, clearing of vegetation will be needed for some of the actual construction activities. For dike construction, the sites (Chequessett Neck Road Dike and/or Mill Creek) would be de-watered using coffer dams and pumps, or other common methods for dike construction, though provisions would be made to ensure that the existing level of fish passage would continue to occur during construction activities.

Preliminary engineering guidance suggests construction of the new dike at Chequessett Neck Road Dike would be expected to take approximately 12-18 months to complete. Elevation or changes to low-lying roads would take approximately 6-12 months to complete. At Mill Creek, if construction of a dike is required it would take approximately 6-12 months. It is likely that individual construction elements would be phased in over time and would not occur concurrently. Elevation construction of some of the roads that are in the more upstream reaches of the flood plain could be delayed or phased with the later incremental dike openings. All low-lying roads do not need to be elevated at the start of the incremental tidal restoration.

ASSESSMENT OF IMPACTS TO ESSENTIAL FISH HABITATS

PHYSICAL ENVIRONMENT

Water Quality—Long term, the proposed action would have beneficial impacts to water quality within the Herring River estuary. Restored tidal flushing would be expected to reduce acidification within the mid-portion of the Herring River where salt water would again saturate drained peat and increase the pH of porewater and surfaces waters (Portnoy and Giblin 1997). With restored salinities, aluminum and iron would no longer be leached from the soils to receiving waters in concentrations that stress aquatic life. Modeling also indicates that the project would reduce the system resident times upstream of High Toss Road by at least a factor of 25 (4,801 hours vs. 191 hours) (Woods Hole Group 2011). Regular tidal flushing of the Herring River estuary with well-oxygenated water from Wellfleet Harbor is expected to maintain dissolved oxygen (DO) concentrations above state water quality standards at all times, benefitting resident fish, diadromous fish and invertebrates.

During the restoration process some short-term adverse impacts on water quality would be expected to occur. Portnoy and Giblin (1997) demonstrated that renewed tidal flushing of acid sulfate soils would allow ammonium-nitrogen to be released into receiving waters, at least in the short term. While this would benefit growth of salt marsh vegetation in the restored marsh, if large volumes of sea water were introduced suddenly, abundant nutrient release and sulfide production could promote algal blooms both in the river and downstream into Wellfleet Harbor that could temporarily reduce DO levels. The gradual reintroduction of tidal exchange through the adaptive management process should allow ammonium-nitrogen to be slowly released; avoiding nitrogen loading that could contribute to algal blooms in receiving waters in Herring River. Increased concentrations of released nutrients would likely be short-lived (probably months) and not persist beyond an initial adjustment period. Wellfleet Harbor is open to Cape Cod Bay and well flushed. With small incremental increases in tidal exchange, informed by appropriate water quality monitoring under adaptive management, the release of nutrients from the estuary would likely be small and would not result in persistent algae blooms in Wellfleet Harbor.

There has likely been historical use of pesticides throughout the Herring River watershed. During restoration, sediment is expected to be mobilized within the estuary in response to increased volume of tidal exchange. Mobilized sediment is expected to mostly be transported upgradient onto the marsh surface and partially downgradient toward Wellfleet Harbor. Potential impacts on the aquatic ecosystem from chemicals bound to mobilized sediments will be assessed once background levels of pesticides have been determined by ongoing efforts of the Seashore.

Sediment—Over 100 years of diking on the Herring River likely has resulted in extensive siltation with the river channel. Restoring the estuary and allowing more tidal flow through the dike would mobile these sediments within the system as suspended load and suspended fines. Modeling indicates that coarser-grained sediment would be transported primarily as bedload along the bottom of the tidal channels. Some of the bedload transport from areas just upstream and downstream of the dike would be slightly seaward toward Wellfleet Harbor, whereas finer-grained suspended sediments would be transported upstream to settle out in the upper sub-basins of the Herring River. Very fine particles would remain in suspension and may be transported upstream into the Herring River or downstream toward the harbor, and eventually out into Cape Cod Bay. The degree and rate of sediment mobilization would largely be determined by the amount of tidal influence and rate of incremental opening of the tide gates that would occur under the adaptive management process. The tide gates would be used to manage water levels and flows minimize the potential of mobilizing and resuspending large volumes of sediment at once and to promote deposition of sediment upstream of the dike. An adaptive management process would be informed by appropriate monitoring, evaluating both upstream and downstream transport and deposition of sediment during the incremental dike opening process.

Sediment and soil could also be mobilized during the reconstruction of the Chequessett Neck Road Dike and other construction activities (e.g., roads, construction of Mill Creek Dike, etc.), potentially resulting in local increases in turbidity in the adjacent water bodies, causing short-term adverse impacts on water quality. However, construction related impacts are expected to be minimal as Best

Management Practices (BMPs) would be employed to minimize the amount of stormwater runoff, as well as control in-water sediment disturbance. Stormwater management plans would be employed to reduce runoff carrying sediment to the receiving waters during construction activities. BMPs would also be put into place to minimize potential fuel or hydraulic fluid leaks from equipment. Coffer dams would be used for in-water activities during the reconstruction of the Chequessett Neck Road Dike as well as construction of a new Mill Creek Dike, if that alternative is selected. During the construction of the coffer dams there would be some temporary increases in turbidity from disturbed sediments; however, this would have a relatively short duration. Once the coffer dams are in place, construction activities would then be conducted in "dry" conditions and would not impact turbidity levels in the surrounding waters.

Bathymetry/Water Depth—Other impacts expected from the proposed project include changes to the bathymetry and morphology of the Herring River. Long term, as tidal flows are restored to the estuary and water velocities increase, erosion of the river banks and bed would be expected to occur, increasing both the width and depth of the restored tidal channels from just below the Chequessett Neck Road Dike upstream to the Middle Herring River and Lower Pole Dike Creek sub-basins.

Estuarine Habitat—Opening the tide gate structure at Chequessett Neck Road Dike to allow increases in the mean spring tide would provide long-term benefits by changing the Herring River estuary from a largely freshwater system to a largely tide-influenced system with saline water extending much farther upstream than under current conditions. Salinity values would range from approximately 15 to 30 parts per thousand (ppt) in the lower sub-basins (Lower Herring River, Mill Creek under alternatives where tidal flow is restored to this sub-basin, Middle Herring River, and Lower Pole Dike Creek), increasing the amount of estuarine habitat (sub-tidal and intertidal habitat) from the existing 70 acres confined to the Lower Herring River basin below High Toss Road to somewhere between approximately 790 acres to 885 acres, depending on the alternative selected through the NEPA process. Restored habitat would also include approximately 10.6 miles to 11.5 miles, depending on the alternative, of mainstem tidal creek. This is an increase from the existing 1.4 miles of estuarine tidal creek habitat currently confined to the Lower Herring River basin below High Toss Road.

Restored tidal flow and improved water quality would also beneficially impact three other important habitat types: salt marsh, submerged aquatic vegetation (SAV), and intertidal mudflats. Restored inter-tidal habitat subjected to higher salinity waters, generally 18 ppt and higher, would be expected to transition to salt marsh, greatly increasing the amount of this habitat type within the system from the 13 acres that currently exists in the Lower Herring River sub-basin. With the reintroduction of tides into the Herring River estuary, the occurrence and distribution of wideon grass (*Ruppia maritime*), an SAV which is currently found in the open waters of the Lower Herring River sub-basin, would likely increase in coverage and biomass in high salinity areas and experience a general migration towards brackish areas. Eelgrass (*Zostera marina*), another SAV, is currently not found in the Herring River upstream of the dike, but is found in small isolated patches downstream of the dike just north of Great Island. With the introduction of higher salinities and improved water quality, *Zostera* could become re-established in the Lower Herring River sub-basin. In addition to higher high tides, restoration would also result in lower low tides upstream of the dike, greatly increasing the amount of intertidal mudflat habitat.

BIOLOGICAL ENVIRONMENT

Prey species—The abundance and/or distribution of prey species for fish for which EFH has been designated may be impacted by restoration of the Herring River estuary. As estuarine habitat increases upstream of the Chequessett Neck Road Dike so would the amount of spawning and nursery habitat for finfish prey species such as the mummichog (*Fundulus heteroclitus*), striped killifish (*Fundulus majalis*), Atlantic silversides (*Menidia menidia*) and other common tidal salt marsh species, as well as for macroinvertebrate species; greatly increasing their populations throughout the Herring River estuary. Movement of finfish prey species from downstream of the dike to upstream of the dike, and vice versa, would also be enhanced. During construction activities for the new dike(s) (Chequessett Neck Road and/or Mill Creek) and any other infrastructure improvements such as upstream culverts or road relocations, some short-term adverse impacts on prey species could occur in the vicinity of the construction. Finfish and macroinvertebrate prey species could be temporarily displaced from habitat due to construction noise and vibrations, and some mortality of sedentary and less mobile species through burial could occur. However, most fish species are highly mobile and would just avoid the areas. Once construction was completed, species would be expected to readily recolonize and use the affected area. Overall, the project would have long-term benefits to prey species and subsequently to EFH species that forage on them.

Anadromous species including alewife (*Alos pseudoharengus*), blueback herring (*Alosa aestivalis*), hickory shad (*Notemigonus chrysoleucas*), and white perch (*Morone Americana*), along with one catadromous species American eel (*Anguilla rostrata*) are found in the Herring River during spring and fall adult and juvenile migrations. Design of the new Chequessett Neck Road Dike would benefit all species of anadromous and catadromous fish through better fish passage. In addition to allowing more fish to move upstream, the new tide gates would reduce the direct mortality of emigrating juveniles and post-spawning adults. Improved water quality upstream of the High Toss Road would decrease the mortality of juvenile and post-spawning adult river herring as well as American eels. With increased salinity during spring high tides expanding into the upper reaches of Upper Herring River, the creek channels leading to the headwater ponds where river herring spawn would likely become free of the emergent and submergent freshwater aquatic plants that often choke and block the waterway. This would benefit juvenile river herring as they emigrate from the ponds and move down stream. The increased amount of estuarine habitat and tidal creeks would also increase the amount of nursery habitat for juvenile fish. Increased fish passage and estuarine nursery habitat would also increase the utilization of the Herring River estuary by white perch and hickory shad. Though total suspended sediments (TSS) from sediment mobilized during the initial increased flushing of the system could temporarily adversely impact adult and juvenile anadromous and catadromous species, small, incremental openings of the tides gates under adaptive management would help mitigate these temporary impacts. Construction of the coffer dam for construction of the dike(s) could temporarily increase TSS, adversely impacting anadromous and catadromous species; however, these impacts would be short-lived and coordinating with the Massachusetts Division of Marine Fisheries (MA DMF) and NMFS to appropriately time in-water construction activities would help to minimize any impacts. Additionally, measures would be taken to ensure the existing level of fish passage would continue to occur during all construction activities at the dike as well as at culverts upstream of the dike. Therefore, impacts to EFH species that prey on anadromous and catadromous species would not be significantly adversely impacted during the short-term and overall would experience long-term benefits from the likely increases in anadromous and catadromous species populations resulting from the restoration of the Herring River estuary.

Shellfish also serve as prey items for EFH species. Shellfish populations upstream of the Chequessett Neck Road Dike are very limited due to low salinity and the availability of suitable substrate. With increased salinity ranges upstream of the Chequessett Neck Road Dike resulting from the proposed project, oysters (*Crassostrea virginica*), which are rare upstream of the dike, could potentially recolonize areas where salinity values fall within their preferred range of 10 ppt to 30 ppt, especially if cultch is laid down. Hard clams (*Mercenaria mercenaria*), which are absent upstream of the dike, would likely be able to reestablish populations in tidal creek habitat upstream of the dike within its preferred salinity range of 15 ppt to 35 ppt. During the period in 1973 when increased salinity occurred upstream of the dike due to the disrepair of the dike, soft shelled clams (*Mya arenaria*) occurred along an approximately 0.5-acre area of sub-tidal sandy shoreline in the Lower Herring River sub-basin (Gaskell 1978), indicating that with restoration, the soft shelled clam would also likely be able to expand its population upstream of the dike. Other prey species such as blue mussels (*Mytilus edulis*) would also benefit and increase in population from restoration of the estuary.

With restoration, increased tidal flows would erode sediments in the existing tidal creeks upstream and downstream of the dike, both deepening and widening them. While a large portion of these sediments would likely be moved upstream in this flood-dominated system, some sediment would be transported and deposited downstream of the dike and in Wellfleet Harbor. Species such as hard clams and softshelled clams can move up and down in the sediment column and would not likely be adversely impacted by sedimentation or erosion. While they may become temporarily buried deeper than preferred, or exposed by erosion, they would move up or down in the sediment column to adjust to the new substrate. Oysters, however, are sedentary and would be susceptible to burial by excessive sedimentation. However, because of the generally finer grain size of the mobilized sediment in Herring River as compared to the current sediment in Wellfleet Harbor, these sediment accumulations would likely be temporary in nature. The accumulated sediment would be expected to eventually be redistributed by currents and waves in the harbor with the finest particles either flushed out into Cape Cod Bay, or transported into tidal estuaries surrounding the harbor. Small, incremental openings in the tide gates through adaptive management would also minimize the amount of sediment mobilized at once, reducing the likelihood that large amounts of sediment would be mobilized and deposited on shellfish downstream of the dike all at once.

Shellfish would be adversely impacted by construction activities as well, though most impacts would occur below the dike as currently few species occur upstream of the dike. During construction, direct mortality of shellfish (oysters and hardclams) in the vicinity of the dike would occur through burial or other in-water construction activities. However, using a coffer dam during construction, as well as employing BMPs as part of a stormwater management plan, would reduce the amount of sedimentation and result in only short-term adverse impacts. Consequently, no significant adverse impacts are expected to occur within shellfish populations in the Herring River estuary or Wellfleet Harbor, and overall, shellfish populations would see long-term benefits from the restoration of the estuary.

ESSENTIAL FISH HABITAT SPECIES

EFH-designated species and life history stages in the proposed project area were identified based on a list in the NOAA Guide to Essential Fish Habitat Designations in the Northeastern United States (NOAA 2011). The guide identifies the managed species and their life stages that have EFH in selected 10-minute by 10-minute squares of latitude and longitude (referred to as “blocks”). These designations were completed by the NEFMC and the Mid-Atlantic Fishery Management Council. The project area falls within Block 41507000 (Table 1 and Figure 3) and species with EFH designated in this block are presented in Table 2. Because this block encompasses both offshore and nearshore estuarine waters, specific habitat conditions may indicate that EFH does not exist for some of these species or life stages within the proposed project area.

TABLE 1. TEN MINUTE SQUARE COORDINATE DESIGNATION ENCOMPASSING THE PROJECT AREA

Block Number	North	East	South	West
41507000	42° 00.0’N	70° 00.0’W	41° 50.0’N	70° 10.0’W

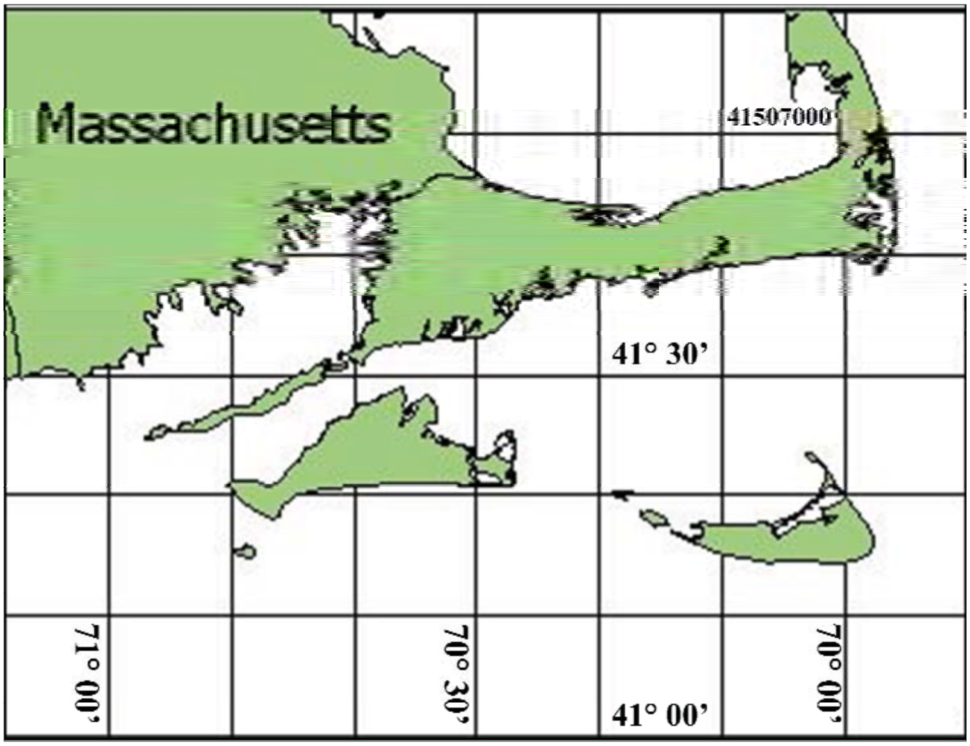

Figure 3. NMFS 10 × 10 minute blocks for EFH designation

Table 2. Species With Identified EFH in Block Number 4150700

Species	Scientific Name	Eggs	Larvae	Juveniles	Adults
Atlantic cod	*Gadus morhua*	X	X	X	X
Haddock	*Melanogrammus aeglefinus*	X	X		
Pollock	*Pollachiius virens*		⊗	⊗	⊗
Whiting	*Merluccius bilinearis*	X	X	X	X
Red hake	*Urophycis chuss*	X	⊗	⊗	⊗
White hake	*Urophycis tenuis*	X	X	△⊗	△⊗
Winter flounder	*Pleuronectes americanus*	△⊗	△⊗	△⊗	△⊗
Yellowtail flounder	*Pleuronectes ferruginea*	X	X	X	X
Windowpane flounder	*Scopthalmus aquosus*	⊗	⊗	⊗	⊗
American plaice	*Hippoglossoides platessoides*	X	X	X	X
Ocean pout	*Macrozoarces americanus*	X	X	⊗	⊗
Atlantic halibut	*Hippoglossus hippoglossus*	X	X	X	X
Atlantic sea scallop	*Placopecten magellanicus*	X	X	X	X
Atlantic sea herring	*Clupea harengus*	X	X	X	X
Monkfish	*Lophius americanus*	X	X	X	

Species	Scientific Name	Eggs	Larvae	Juveniles	Adults
Bluefish	*Pomatomus saltatrix*			△⊗	△⊗
Long finned squid	*Loligo pealei*	n/a	n/a	X	X
Short finned squid	*Ilex illecebrosus*	n/a	n/a	X	X
Atlantic butterfish	*Peprilus triacanthus*	⊗	X	⊗	X
Atlantic mackerel	*Scombrer scombrus*	⊗	⊗	⊗	⊗
Summer flounder	*Paralicthys dentatus*				△⊗
Scup	*Stenotomus chrysops*	n/a	n/a	⊗	⊗
Black sea bass	*Centropristus striata*	n/a			X
Surf clam	*Spisula solidissima*	n/a	n/a	⊗	⊗
Ocean quahog	*Artica islandica*	n/a	n/a		
Spiny dogfish	*Squalus acanthias*	n/a	n/a	⊗	⊗
Blue shark	*Prionace glauca*				X
Bluefin tuna	*Thunnus thynnus*			X	X

n/a This notation in the tables indicates some of the species either have no data available on the designated life stages, or those life stages are not present in the species' reproductive cycle.

X – indicates EFH for this life stage exists in Block Number 4150700

○ - indicates EFH for this life stage exists in Wellfleet Harbor

△ - indicates EFH for this life stage exists in Herring River

Unless otherwise cited, all of the EFH information below is from the Guide to Essential Fish Habitat Designations in the Northeastern United States (NOAA 2011).

Atlantic Cod

Eggs—EFH for Atlantic cod eggs include waters around the perimeter of the Gulf of Maine, Georges Bank, and the eastern portion of the continental shelf off southern New England. Generally, Atlantic cod eggs can be found in water temperatures below 54 degrees (°) Fahrenheit (F), water depths less than 361 feet, and within a salinity range between 32 ppt and 33 ppt. Within the project area, eggs would only be found in Wellfleet Harbor in areas within the salinity range; however, based on best professional judgment, the MA DMF concludes that they are not present (Evans et al. 2011). Therefore, there would be no impact.

Adults—EFH for adult Atlantic cod include bottom habitats with a substrate of rocks, pebbles, or gravel in the Gulf of Maine, Georges Bank, southern New England, and the middle Atlantic south to Delaware Bay. They are also found across a wide range of oceanic salinities and in areas where generally water temperatures are below 50° F and depths range from 33 feet to 492 feet. Given the depths where cod are found, they would generally only be found in the deeper portions of Wellfleet Harbor; however, based on best professional judgment, the MA DMF concludes that they are not present (Evans et al. 2011). Therefore, there would be no impact.

Though EFH has been designated for both larvae and juvenile Atlantic cod, they are generally found in depths (minimum depth 98 feet and 82 feet respectively) that are greater than what is found in the project area; therefore, there would be no adverse impacts associated with the proposed projects.

Haddock

Water depths for which EFH is designated for eggs and larvae exceeds those which occur in the project area (eggs: 164 feet to 295 feet; larvae: 98 feet to 295 feet; juveniles: 115 feet to 328 feet; adults: 131 feet to 492 feet). Therefore, no EFH exists in the project area.

Pollock

Larvae—EFH for the larvae of pollock has been designated for the waters of the Gulf of Maine and Georges Bank. Generally the larvae are found in areas where the sea surface temperatures are less than 63° F and water depths range between 33 feet and 820 feet. Pollock larvae are often observed from September to July with peaks from December to February. Within the project area, larvae could be found in Wellfleet Harbor near the mouth where depths are deep enough. This area would not be impacted by restoration activities and would therefore not impact EFH for larvae.

Juveniles—For juvenile pollock, EFH has been designated for bottom habitats with aquatic vegetation or a substrate of sand, mud or rocks in the Gulf of Maine and Georges Bank. They are also generally found where water temperatures are less than 64° F, salinities range from 29 ppt to 32 ppt, and depths range from 0 feet to 820 feet. Within the project area, those areas in Wellfleet Harbor with salinities in the above range are designated as EFH. No impacts to Wellfleet Harbor would occur from restoration activities other than some small amount of sedimentation in areas close to the mouth of Herring River. While juvenile pollock are daytime sight feeders, turbidity levels in Wellfleet Harbor are not expected to increase much as a result of sediment mobilized during restoration. Small incremental openings of the tide gate structures would further reduce the impacts of turbidity reaching Wellfleet Harbor. Therefore, adverse impacts, if any, to EFH for juvenile pollock is anticipated to be minimal and short-term.

Adults—Bottom habitats in the Gulf of Maine and Georges Bank and hard bottom habitats (including artificial reefs) off southern New England and the middle Atlantic south to New Jersey are designed as EFH for adult pollock. Water temperatures below 57° F, salinities between 31 ppt and 34 ppt, and depths between 49 feet and 1,197 feet are also found in the EFH designations. Given the depth designations, only the deeper portions or Wellfleet Harbor are classified as EFH. For reasons described above for juveniles, impacts, if any, to EFH for adult pollock are anticipated to be minimal and short-term.

Whiting

Water depths for which EFH is designated for all life stages of whiting exceeds those which occur in the project area (eggs: 164 feet to 492 feet; larvae: 164 feet to 427 feet; juveniles: 66 feet to 886 feet; adults: 98 feet to 1,066 feet). Therefore, no EFH exists in the project area.

Red hake

Eggs—EFH for red hake eggs includes surface waters of the Gulf of Maine, Georges Bank, the continental shelf off southern New England, and the middle Atlantic south to Cape Hatteras and are most frequently seen during the months from May to November. Preferred conditions for red hake eggs include sea surface temperatures below 50° F along the inner continental shelf with salinities less than 25 ppt. Red Hake eggs are not likely to be found in Herring River or Wellfleet Harbor.

Larvae—EFH for red hake larvae includes surface waters of the Gulf of Maine, Georges Bank, the continental shelf off southern New England, and the middle Atlantic south to Cape Hatteras where water temperatures are below 66° F, depths are less than 656 feet, and salinities are greater than 0.5 ppt. They are most often observed during the months from May through December with peaks in September and October. Although EFH may encompass part of the project area, red hake likely do not occur in Herring River or Wellfleet Harbor. Therefore, no more than minimal impact on EFH for red hake larvae is anticipated as a result of the proposed project.

Juveniles—Red hake juveniles are found in bottom habitats with a substrate of shell fragments, including areas with an abundance of live scallops. Water temperatures below 61° F, depths less than 328 feet and a salinity range from 31 ppt to 33 ppt are preferred by red hake juveniles. Although EFH may encompass part of the project area in Wellfleet Harbor, red hake juveniles likely do not occur in the harbor and none were collected during the 1968-1969 survey by Curley et al. (1972). Therefore, no more than minimal impact on EFH for red hake juveniles is anticipated as a result of the proposed project.

Adults—Adult red hake are generally found in bottom habitats in depressions with a substrate of sand and mud; water temperatures below 54° F, and depths from 33 feet to 427 feet. They also have a preference for salinities in the range of 33 ppt to 34 ppt. Although EFH may encompass part of the project area in Wellfleet Harbor, adult red hake likely do not occur in the harbor and none were collected during the 1968-1969 survey by Curley et al. (1972). Therefore, no more than minimal impact on EFH for adult red hake is anticipated as a result of the proposed project.

White hake

Eggs—EFH for white hake eggs includes surface waters of the Gulf of Maine, Georges Bank and southern New England, and are most often observed in August and September. During trawl surveys eggs were most often collected in water depths between 33 feet and 820 feet (Chang et al. 1999). Eggs are unlikely to be found in Herring River and Wellfleet Harbor.

Larvae—EFH for larvae is pelagic waters where temperatures are between 50° F and 64° F in water depths between 33 feet and 492 feet. They are unlikely to be found in inshore or nearshore waters (Chang et al. 1999), and therefore would not be found in Herring River or Wellfleet Harbor.

Juveniles—EFH is designated for two life stages of juveniles: the pelagic stage and the demersal stage. White hake juveniles in the pelagic stage are most often observed from May through September within pelagic waters. Demersal stage juveniles tend to occupy bottom habitats with seagrass beds or a substrate of mud or fine-grained sand. These juvenile stages are found in waters with temperatures between 46° F to 66° F and depths from 16 feet to 738 feet. Although EFH may encompass part of the project area, white hake juveniles were not collected in any surveys (Curley et al. 1972, Roman 1987, Raposa 1999 unpublished data, Gwilliam 2005 unpublished data) and likely do not occur in the harbor or Herring River. Therefore, no more than minimal impact on EFH for red hake juveniles is anticipated as a result of the proposed project.

Adults—EFH for white hake adults includes bottom habitats with a substrate of mud or fine-grained sand, as well as water temperatures of 41° F to 57° F and depths from 16 feet to 1,066 feet. Although EFH may encompass part of the project area, white hake adults were not collected in any surveys (Curley et al. 1972, Roman 1987, Raposa 1999 unpublished data, Gwilliam 2005 unpublished data) and likely do not occur in the harbor or Herring River. Therefore, no more than minimal impact on EFH for red hake juveniles is anticipated as a result of the proposed project.

Winter flounder

Eggs—Winter flounder eggs are found in bottom habitats with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to Delaware Bay. They generally tend to occur in waters with temperatures less than 50° F, water depths less than 16 feet, and salinities between 10 ppt and 30 ppt. Eggs are often observed from February to June. Herring River and Wellfleet Harbor likely provide EFH for this species. Winter flounder are rare upstream of the Chequessett Neck Road Dike, so any impact from construction activities or sedimentation to EFH for winter flounder eggs would be minimal upstream of the dike. Downstream of the dike and in Wellfleet Harbor, eggs could be impacted through burial during construction of the dike and through sedimentation processes. However, much of the sedimentation in Wellfleet Harbor would likely occur in proximity to the mouth of Herring River and would be minimized by small incremental openings in the tide gates through adaptive management. Coordination with MA DMF and NMFS for appropriate in-water construction time periods and periods when the tide gates would be incrementally opened would also help to mitigate impacts to EFH for winter flounder eggs. With these measures, any impact to EFH for eggs is anticipated to be minimal and temporary. Over the long-term, restoration of Herring River estuary would provide better fish passage and dramatically increase the amount of estuarine habitat upstream of the dike, providing better access to areas upstream of the dike, as well as more spawning habitat and EFH for eggs.

Larvae—Winter flounder larvae are found in pelagic and bottom waters of Georges Bank and the inshore areas of the Gulf of Maine, where sea surface temperatures are less than 59° F, depths are less than 20 feet, and salinities are between 4 ppt and 30 ppt. Winter flounder larvae are often observed from March to July. EFH for the larvae of this species is likely found in Herring River and Wellfleet Harbor, though currently the occurrence of winter flounder upstream of the dike is rare. While increased turbidity during construction activities could impact EFH for larvae, impacts would be temporary in nature and localized, with areas of impact mostly just downstream of the Chequessett Neck Road Dike. Turbidity is not expected to increase very much in Wellfleet Harbor as a result of the project and would be minimized by the small incremental openings of the tide gates under adaptive management. Coordination with MA DMF and NMFS for appropriate in-water construction timeframes and periods when the tide gates would be incrementally opened would also help to minimize any potential impacts to EFH. In the long-term, the project would increase the amount of estuarine habitat upstream of the dike, providing beneficial impacts to EFH for larvae.

Juveniles—EFH is designated for two stages of winter flounder juveniles have been identified. Winter flounder young-of-the-year occupy bottom habitats with a substrate of mud or fine grained sand, within waters where the temperature is below 82° F, depths are from 0.3 feet to 33 feet, and salinities ranging between 5 ppt and 33 ppt. The second juvenile stage of winter flounder is the Age 1-plus juvenile found in inshore areas in waters with temperatures below 77° F, depths from 3 feet to 164 feet, and salinities between 10 ppt to 30 ppt. Winter flounder were collected during the surveys in 1968-1969 and 1984 and 2005, with the majority of them being juveniles and found downstream of the Chequessett Neck Road Dike (Curley et al. 1972, Roman 1987, Gwilliam 2005 unpublished data); therefore, Herring River and Wellfleet Harbor likely provide EFH for juvenile winter flounder. Juvenile winter flounder are mobile and would likely be temporarily displaced from construction activity, avoiding direct impacts such as mortality. During construction of the Chequessett Neck Road Dike measures will be taken to ensure that existing levels of fish passage continue, allowing winter flounder to access suitable habitat upstream of the dike. Localized increases in turbidity from in-water construction activities and sediment mobilization during restoration may affect feeding success. It may also restrict habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality. However individuals are mobile and would likely flee the area to neighboring waters where feeding and other impacts will be less problematic. Therefore, no more than minimal impact to juvenile flounder EFH is anticipated. During restoration, increased fish passage at the dike would allow greater access to areas upstream of the dike, and estuarine habitat upstream of the dike would expand and increase the quality of EFH for juveniles, providing long-term beneficial impacts.

Adults—Adult winter flounder occur in bottom habitats including estuaries with a substrate of mud, sand, and gravel, with water temperatures below 77° F depths, from 3 feet to 328 feet, and salinities between 15 ppt and 33 ppt. Spawning winter flounder adults are found in waters with temperatures below 59° F, depths less than 20 feet (except on Georges Bank where they spawn as deep as 262 feet), and salinities between 5.5 ppt and 36 ppt. Spawning occurs in January through May, with an optimal temperature being 38° F to 42° F and optimal salinity 11 ppt to 33 ppt. Adults have been collected in the project area, and the Herring River and Wellfleet Harbor likely provide EFH for adult and spawning adult winter flounder. Impacts would be similar to those described above for juveniles, resulting in minimal short-term adverse impacts and long-term beneficial impacts to EFH for adult winter flounder.

Yellowtail flounder

Yellowtail flounder are rare in most estuaries and rivers in the North Atlantic, although they are common in the Sheepscot River and Casco Bay and abundant in Boston Harbor (Johnson et al. 1999). Given the depth preferences for eggs (98 feet to 295 feet), larvae (33 feet to 295 feet), juveniles (66 feet to 164 feet) and adults (66 feet to 164 feet), Herring River and Wellfleet Harbor do not provide EFH for any life stage of yellowtail flounder.

Windowpane flounder

Eggs—EFH designated for windowpane flounder eggs includes surface waters around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras with temperatures ranging between 43° F and 68° F and water depths less than 230 feet. Although EFH may encompass part of the project area windowpane flounder eggs likely do not occur in Wellfleet Harbor or Herring River. Therefore, no more than minimal impact on EFH for windowpane flounder eggs is anticipated as a result of the proposed project.

Larvae—EFH for windowpane flounder larvae includes pelagic waters around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras with temperatures less than 68° F and water depths less than 230 feet. Although EFH may encompass part of the project area in Wellfleet Harbor, windowpane flounder larvae likely do not occur in harbor. Therefore, no more than minimal impact on EFH for windowpane flounder larvae is anticipated as a result of the proposed project.

Juveniles—EFH for juveniles includes bottom habitats around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras with substrates consisting of mud or fine-grained sand. Juveniles are common from June through October at temperatures below 77° F, depths from 3 feet to 328 feet, and salinities between 5.5 ppt to 36 ppt. Juvenile windowpane flounder were sampled at all stations except in Herring River downstream of the dike by Curley et al. (1972). They were also not sampled in Herring River in 1984, 1999, or 2005 (Roman 1987, Raposa 1999 unpublished data, Gwilliam 2005 unpublished data); therefore it is likely that only Wellfleet Harbor provides EFH for juveniles. Turbidity levels in Wellfleet Harbor are not expected to increase much as a result of in-water construction or sediment mobilization processes associated with restoration of Herring River; therefore, adverse impacts to feeding habits/success in juveniles is expected to be minimal and temporary. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. With the project resulting in increased fish passage at Chequessett Neck Road dike and increased estuarine habitat upstream of the dike, EFH for juvenile window pane flounder would likely expand to areas upstream of the dike, resulting in long-term benefits.

Adults—For adult windowpane flounder EFH is designated as bottom habitats with a substrate of mud or fine-grained sand in the Gulf of Maine, Georges Bank, southern New England, and the middle Atlantic south to the Virginia-North Carolina border. Water temperatures are generally below 80° F, water depths generally range from 3 feet to 246 feet, and salinities range from 5.5 ppt to 36 ppt. Wellfleet Harbor likely provides EFH for adult windowpane flounder. Impacts to EFH for adult windowpane flounder would be similar to those for juvenile window pane flounder discussed above and result in long-term benefits by expanding potential EFH upstream of the Chequessett Neck Road dike.

American plaice

Water depths designated as EFH for American plaice eggs (98 feet to 295 feet), larvae (98 feet to 427 feet), juveniles (148 feet to 492 feet) and adults (148 feet to 574) are greater than what exist in Herring River and Wellfleet Harbor. Therefore, EFH for this species does not exist within the project area.

Ocean pout

Eggs—EFH consists of bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay. Due to low fecundity, relatively few eggs (< 4200) are laid in gelatinous masses, generally in hard bottom sheltered nests, holes, or crevices where they are guarded by either female or both parents. Additionally, water temperatures are generally below 50° F, depths are generally less than 164 feet, and salinities range from 32 ppt to 34 ppt. Given the habitat requirements, it is not expected that eggs would occur in the project area.

Larvae—For larvae, EFH consists of bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay that remains in close proximity to the hard bottom nesting areas. Where larvae are found, water temperatures are generally below 50° F, depths are less than 164 feet, and salinities are greater than 25 ppt. Given the bottom habitats, no EFH is found within the project area.

Juveniles—EFH for juveniles consists of bottom habitats, often smooth bottom near rocks or algae in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay where water temperatures are below 57° F, depths less than 262 feet, and salinities are greater than 25 ppt. Although EFH may encompass part of the project area in Wellfleet Harbor, ocean pout juveniles likely do not occur in the harbor and none were collected in the surveys conducted in the harbor in 1968-1969 or 1984 (Curley et al. 1972, Roman 1987). Therefore, no more than minimal impact on EFH for ocean pout juveniles is anticipated as a result of the proposed project.

Adults—Bottom habitats for adult EFH occur in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay where the substrate is sand, gravel, or a rough bottom, but are rarely found over mud (Steimle et al. 1999). Additionally, the following conditions exist where ocean pout adults are found: water temperatures below 59° F, depths less than 361 feet, and a salinity range from 32 ppt to 34 ppt. Although EFH may encompass part of the project area in Wellfleet Harbor, ocean pout adults likely do not occur in the harbor and none were collected in the surveys conducted in the harbor in 1968-1969 or 1984 (Curley et al. 1972, Roman 1987). Therefore, no more than minimal impact on EFH for ocean pout adults is anticipated as a result of the proposed project.

Atlantic halibut

Eggs and Larvae—Atlantic halibut spawn offshore (Cargnelli et al. 1999) Atlantic halibut eggs are generally observed between late fall and early spring, in waters with temperatures between 39° F and 45° F, depths less than 2,297 feet, and salinities less than 35 ppt. EFH for larvae is the surface water of the gulf of Main and Georges Bank where salinities are between 30 ppt and 35 ppt. Because Atlantic halibut spawn offshore, it is unlikely that eggs or larvae would be found within the project area.

Juveniles—Juvenile halibut tend to emigrate from nursery areas between 3 and 4 years of age. They prefer sand and coarse sediment in the Gulf of Main and Georges Bank where depths range from 66 feet to 197 feet and water temperatures are above 36° F. There is no EFH for juveniles in the project area as preferred depths are greater than found in Wellfleet Harbor.

Adults—Adult Atlantic halibut, as well as spawning adults tend to occupy waters with temperatures below 56° F, depths from 328 feet to 2,296 feet, and salinities between 30.4 ppt and 35.3 ppt. Due to preferred depths, no EFH exists within the project area.

Atlantic sea scallops

Sea scallops are an offshore species inhabiting water depths typically ranging from 59 feet to 361 feet, but may also occur in waters as shallow as seven feet in estuaries and embayments along the Maine coast and in Canada. In southern areas, scallops are primarily found at depths between 148 feet to 246 feet, and are less common in shallower water (82 feet to 148 feet) due to high temperature (Hart and Chute 2004). Because they are an offshore species, there is no EFH for them in the project area.

Atlantic sea herring

Although juvenile Atlantic herring were sampled during the 1968-1969 survey in Wellfleet Harbor (Curley et al. 1972), water depths for which EFH is designated for all life stages exceeds those which occur in the project area (eggs: 66 feet to 262 feet; larvae: 164 feet to 295 feet; juveniles: 49 feet to 443 feet; adults: 66 feet to 427 feet). Therefore, no EFH exists in the project area.

Monkfish

Water depths for which EFH is designated for all life stages of monkfish exceeds those which occur in the project area (eggs: 49 feet to 3,281 feet; larvae: 82 feet to 3,281 feet; juveniles: 82 feet to 656 feet; adults: 82 feet to 656 feet). Therefore, no EFH exists in the project area.

Bluefish

Eggs and Larvae—Eggs and larvae are generally not collected in estuarine waters, thus there is no EFH designation inshore for these life stages.

Juveniles and Adults—EFH for juveniles and adults is all major estuaries between Penobscot Bay, Maine and St. Johns River, Florida. In North Atlantic estuaries, juvenile and adult bluefish generally occur from June through October in the "mixing" (0.5 ppt to 25 ppt) and "seawater" (> 25 ppt) zones. Therefore, Herring River and Wellfleet Harbor serve as EFH for juvenile and adult bluefish. They were sampled downstream of the dike in 1984 (Roman 1987) and in Wellfleet Harbor in 1968-1969 (Curley et al. 1972). Localized increases in turbidity associated with in-water construction activities and sediment mobilization processes during restoration could affect feeding success. It may also restrict habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality. However, these impacts would be localized and temporary. Juveniles and adults would are highly mobile and also likely flee impacted areas to surrounding waters where feeding and other impacts are less problematic. Therefore, any short-term adverse impact is anticipated to be minimal. However, the restoration project would have long-term beneficial impacts on EFH for juvenile and adult bluefish as the project would result increased fish passage at Chequessett Neck Road Dike, providing greater access to the increased amount of estuarine habitat and prey species populations resulting from the project.

Long finned squid

There is no EFH for long finned squid in the project area as EFH for pre-recruits and recruits is pelagic waters found over the continental shelf (from the coast out to the limits of the Exclusion Economic Zone (EEZ)), for the Gulf of Maine through Cape Hatteras, North Carolina.

Short finned squid

There is no EFH for short finned squid in the project area as EFH for pre-recruits and recruits is pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ), for the Gulf of Maine through Cape Hatteras, North.

Atlantic butterfish

Eggs—Inshore, EFH for eggs is the "mixing" (0.5 ppt to 25 ppt) and/or "seawater" (25 ppt) portions of all the estuaries where butterfish eggs are "common," "abundant," or "highly abundant" on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the Estuarine Living Marine Resources (ELMR) database (NOAA 2010). Butterfish eggs pelagic and are generally collected from shore to 6,000 ft and temperatures between 52° F and 63° F, though they have been collected from temperatures up to 73° F (Cross et al. 1999). For the seawater portions of Cape Cod Bay, eggs are common during the months of July to September (NOAA 2010); therefore, they could potentially be present in the seawater portions of Wellfleet Harbor. However, the harbor is on the upper end of the temperature range during those months. Butterfish eggs are not present in the mixing portion of Cape Cod Bay estuaries (NOAA 2010). Turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Therefore, any impact to EFH for eggs is expected to be minimal and short-term.

Larvae—Inshore, EFH is designated as the "mixing" (0.5 ppt to 25 ppt) and/or "seawater" (> 25 ppt) portion of all the estuaries where Atlantic mackerel eggs are "common," "abundant," or "highly abundant” on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Larvae are generally found from 33 feet to 6,000 feet in areas where water temperatures range from 48° F to 66° F. For the seawater portions of Cape Cod Bay, butterfish larvae are rare, and they are not present in the mixing portion of the estuaries; therefore there is no EFH in the project area (NOAA 2010).

Juveniles—Inshore, EFH is designated as the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portion of all the estuaries where Atlantic mackerel eggs are “common,” “abundant,” or “highly abundant” on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Juvenile fish are generally found in depths between 33 feet and 1,200 feet in areas where water temperatures range from 37° F to 82° F. For Cape Cod Bay, juveniles are common in both the seawater and mixing portions of its estuaries (NOAA 2010); therefore, while butterfish juveniles were not collected during the surveys conducted in 1968-1969 (Curley et al. 1972) or 1984 (Roman 1987), they could potentially occur in Wellfleet Harbor. Depths are too shallow for Herring River. Feeding success in juveniles could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Juveniles are highly mobile and would also likely flee any impacted areas to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for juvenile butterfish is expected to be minimal and short-term.

Adults—Inshore, EFH is designated as the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portion of all the estuaries where Atlantic mackerel eggs are “common,” “abundant,” or “highly abundant” on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Adult butterfish are generally found in depths between 33 feet and 1,200 feet in areas where water temperatures range from 37° F to 82° F. For Cape Cod Bay, adults are common in both the seawater and mixing portions of its estuaries (NOAA 2010). Therefore, while adult butterfish were not collected during the surveys conducted in 1968-1969 (Curley et al. 1972) or 1984 (Roman 1987), they could potentially occur in Wellfleet Harbor. The depths are too shallow in Herring River for EFH. Impacts to EFH for adult butterfish would be the same as described above for juveniles and are expected to be minimal and short-term.

Atlantic mackerel

Eggs—Inshore, EFH is designated as the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portions of all the estuaries where Atlantic mackerel eggs are “common,” “abundant,” or “highly abundant” on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Generally, Atlantic mackerel eggs are collected from shore to 50 ft and temperatures between 41° F and 73° F. Eggs are common in the mixing portion of the estuaries and abundant to highly abundant in the seawater portion of the estuaries May through August (NOAA 2010). Therefore, they could be present in Wellfleet Harbor. Turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Therefore, any impact to EFH for eggs is expected to be minimal and short-term.

Larvae—Inshore, EFH is designated as the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portions of all the estuaries where Atlantic mackerel larvae are "common," "abundant," or "highly abundant" on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Generally, Atlantic mackerel larvae are collected in depths between 33 feet and 425 feet and temperatures between 43° F and 72° F. In Cape Cod Bay, larvae are common in the mixing portion of estuaries and common to highly abundant in the seawater portion May through August (NOAA 2010); therefore, larvae could be found in the deeper portions of Wellfleet Harbor. Turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Therefore, any impact to EFH for eggs is expected to be minimal and short-term.

Juveniles—Inshore, EFH is designated as the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portions of all the estuaries where juvenile Atlantic mackerel are "common," "abundant," or "highly abundant" on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Generally, juvenile Atlantic mackerel are collected from shore to 1,050 feet and temperatures between 39° F and 72° F. In Cape Cod Bay, juveniles are common in the mixing portion of estuaries May through October and common to abundant in the seawater portion May through November (NOAA 2010). Juvenile mackerel were collected in Wellfleet Harbor in the 1968-1969 survey (Curley et al. 1972) and one was collected in Herring River downstream of the dike during the 1984 survey (Roman 1987). EFH exists in the project area. Feeding success in juveniles could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Juveniles are highly mobile and would also likely flee any impacted areas downstream of the dike and in Wellfleet Harbor to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for juvenile Atlantic mackerel is expected to be minimal and short-term. Long-term benefits to EFH for juvenile Atlantic mackerel are expected from the increased populations of prey species resulting from the restoration of Herring River estuary.

Adults—Inshore, EFH is designated for the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portions of all the estuaries where adult Atlantic mackerel are "common," "abundant," or "highly abundant" on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia according to the ELMR database. Generally, adult Atlantic mackerel are collected from shore to 1,250 feet and temperatures between 39° F and 61° F. In Cape Cod Bay, adult mackerel are common in the mixing portion of estuaries during May through August and common to abundant in the seawater portion of estuaries from May through November (NOAA 2010). Adult mackerel could potentially occur in Wellfleet Harbor during the fall when temperatures fall below 60° F, otherwise water temperatures are too warm in the harbor and Herring River for adult mackerel. Feeding success in adults could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Adults are highly mobile and would also likely flee any impacted areas downstream of the dike and in Wellfleet Harbor to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for adult Atlantic mackerel is expected to be minimal and short-term. Long-term benefits to EFH for adult Atlantic mackerel are expected from the increased populations of prey species resulting from the restoration of the Herring River estuary.

Summer flounder

No EFH is designated for eggs, larvae or juveniles in Cape Cod Bay and its estuaries.

Adults—Inshore, EFH for adult summer flounder is designated for the "mixing" (0.5 ppt to 25 ppt) and/or "seawater" (> 25 ppt) portions of all the estuaries where adult summer flounder are "common," "abundant," or "highly abundant" according to the ELMR database. Generally, summer flounder inhabit shallow coastal and estuarine waters during warmer months and move offshore on the outer continental shelf at depths of 500 feet in colder month. The ELMR database does not provide any data for summer flounder in Cape Cod Bay (NOAA 2011). Though no summer flounder were collected during the 1968-1969 and 1984 surveys (Curley et al. 1972, Roman 1987), given the species preference for shallow coastal and estuarine habitats during the warmer months, and the fact that MA DMF considers the shoal waters of Cape Cod Bay and the region east and south of Cape Cod, including all estuaries, bays and harbors thereof, as critically important habitat (Packer et al. 1999) summer flounder could potentially be found in Wellfleet Harbor and possibly Herring River; therefore these areas should be considered as EFH for this species. Feeding success in adults could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Turbidity in Herring River would be localized and temporary in nature as well. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Adults are highly mobile and would also likely flee any impacted areas to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for adult summer flounder is expected to be minimal and short-term. Long-term benefits to EFH for adult summer flounder are expected from the increased populations of prey species resulting from the restoration of Herring River estuary. Increased fish passage at Chequessett Neck Road Dike and increased estuarine habitat upstream of the dike would also increase the amount of EFH available to adult summer flounder.

Scup

Juveniles—Inshore, EFH is designated as the estuaries where scup are identified as being common, abundant, or highly abundant in the ELMR database for the "mixing"(0.5 ppt to 25 ppt) and "seawater"(>25 ppt) salinity zones. In general during the summer and spring, juvenile scup are found in estuaries and bays between Virginia and Massachusetts, in association with various sands, mud, mussel and eelgrass bed type substrates, in water temperatures greater than 45° F and salinities greater than 15 ppt. In Cape Cod Bay, juvenile scup are common in the mixing and seawater portion of estuaries during July through September (NOAA 2010) and scup were collected in Wellfleet Harbor by Curley et al. (1972). Feeding success in juveniles could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Juveniles are highly mobile and would also likely flee any impacted areas to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for juvenile scup is expected to be minimal and short-term. Long-term benefits to EFH for juvenile scup are expected to occur. Restoration of Herring River would increase salinity levels upstream of the Chequessett Neck Road Dike and would increase fish passage at the dike as well. This would potentially expand suitable habitat for scup to access. Restoration of Herring River estuary would also increase populations of prey species for scup, providing long-term benefits to EFH for juvenile scup.

Adults—Inshore, EFH is designated as the estuaries where scup were identified as being common, abundant, or highly abundant in the ELMR database for the "mixing"(0.5 ppt to 25 ppt) and "seawater"(>25 ppt) salinity zones. Generally, wintering adults (November through April) are usually offshore, south of New York to North Carolina, in waters above 45° F. In Cape Cod Bay, adult scup are common in the seawater portion of estuaries from June through September (NOAA 2010) and scup were collected in Wellfleet Harbor by Curley et al. (1972). Impacts to EFH for adult scup from the proposed project would be the same as those described above for juvenile scup.

Black sea bass

Adults—Inshore, EFH is designated for the estuaries where adult black sea bass were identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” (0.5 ppt to 25 ppt) and/or “seawater” (> 25 ppt) portions. Black sea bass are generally found in estuaries from May through October. Wintering adults (November through April) are generally offshore, south of New York to North Carolina. Temperatures above 43° F appear to be the minimum requirements. Structured habitats (natural and man-made), sand and shell are usually the substrate preference. Black sea bass are uncommon in the cooler waters north of Cape Cod (Drohan et al. 2007) and the ELMR database does not provide distribution information for areas of Cape Cod Bay. Therefore, there is no EFH for this species in the project area.

Surf clam

Juveniles/adults—EFH for surf clam juveniles and adults is designated throughout the substrate, to a depth of three feet below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ. Surf clams generally occur from the beach zone to a depth of about 200 feet, but beyond about 125 feet abundance is low. They also only occur in salinities greater than 28 ppt (Cargnelli et al. 1999). The higher salinity areas of Wellfleet Harbor could serve as EFH for this species. Though some sedimentation is expected to occur in Wellfleet Harbor in the vicinity of the mouth of Herring River, it would be minimized by small incremental openings in the tide gates under adaptive management. Surf clams are able to move up and down in the substrate; therefore, it is not anticipated that they would be affected by any sedimentation that would occur. Thus, any impact to surf clams is anticipated to be minimal and short-term.

Ocean quahog

No EFH is designated for any life stage of ocean quahog in Cape Cod Bay and its estuaries.

Spiny dogfish

Juveniles—Inshore, EFH is the "seawater" (>25 ppt) portions of the estuaries where dogfish are common or abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to Cape Cod Bay, Massachusetts. Generally, juvenile dogfish are found at depths of 33 feet to 1,280 feet in water temperatures ranging between 37° F and 82° F. Though no spiny dogfish have been collected in the project area (Curley et al. 1972, Roman 1987), they could potentially be found in the deeper portions of Wellfleet Harbor. Feeding success in juveniles could be impacted by increased turbidity. However, turbidity in Wellfleet Harbor resulting from the restoration of Herring River is not expected to increase much, and would only be temporary in nature. Other impacts that can be caused by increased turbidity such as restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality would also be expected to be minimal and temporary. Juveniles are highly mobile and would also likely flee any impacted areas to surrounding waters where feeding and other impacts would be less problematic. Therefore, any impact to EFH for juvenile spiny dogfish is expected to be minimal and short-term.

Adults—Inshore, EFH is the "seawater" (.25 ppt) portions of the estuaries where dogfish are common or abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to Cape Cod Bay, Massachusetts. Generally, adult dogfish are found at depths of 33 feet to 1,476 feet in water temperatures ranging between 37° F and 82° F. Though no spiny dogfish have been collected in the project area (Curley et al. 1972, Roman 1987), they could potentially be found in the deeper portions of Wellfleet Harbor. Impacts to EFH for adult spiny dogfish would be similar to those for juvenile spiny dogfish discussed above and are expected to be minimal and short-term.

Blue shark

Adults—The blue shark is a pelagic species that inhabits clear, deep, blue waters, usually in temperatures of 50° F to 68° F, at depths greater than 590 feet. EFH is designated in localized areas in the Atlantic off Florida and Georgia, and from South Carolina to the Gulf of Maine. Based on the mapping for this species, there is no EFH for adult blue sharks in the project area (NOAA 2009).

Bluefin tuna

Juveniles/Subadults—EFH juvenile/subadult bluefin tuna consists of all inshore and pelagic waters warmer than 53.6° F off the Gulf of Maine and Cape Cod Bay, from Cape Ann, MA (~42.75 N) east to 69.75 W (including waters of the Great South Channel west of 69.75 W), continuing south to and including Nantucket Shoals at 70.5 W to off Cape Hatteras, NC (approximately 35.5 N), in pelagic surface waters warmer than 53.6° F, between the 82 and 328 foot isobaths. No EFH exists in the estuarine waters of Wellfleet Harbor and Herring River.

Adults—Adult bluefin tuna are found from Newfoundland to Brazil, but have EFH for adults in pelagic waters of the Gulf of Maine from the 164 foot isobath to the EEZ boundary, including the Great South Channel, then south of Georges Bank to 39 N from the 164 foot isobath to the EEZ boundary. No EFH exists in the estuarine waters of Wellfleet Harbor and Herring River.

CUMULATIVE EFFECTS

Cumulative impacts are those resulting from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. Other projects and plans in the area with the potential to beneficially affect EFH include the Town of Wellfleet Comprehensive Wastewater Management Plan, the Mayo Creek and East Harbor salt marsh restoration projects, and oyster spawning experiments in Wellfleet Harbor. Wellfleet’s wastewater management plan would improve water quality in the project area waters by reducing the potential for nutrient loading and domestic sewage contamination of local surface waters, improving the habitat for estuarine fish and macroinvertebrate species as well as shellfish. The May Creek and East Harbor restoration projects, similar to the Herring River restoration project, would improve and increase the amount of habitat available for all aquatic species. The oyster spawning experiments in Wellfleet Harbor could directly enhance the local population of oysters and provide additional spat that could settle in restored areas of Herring River. The oysters used in the experiments could also potentially improve the overall local water quality by filtering nitrogen out of the water; improving habitat conditions for all aquatic species.

Recurrent dredging of the federal navigation channel between the Town Pier and Wellfleet Harbor, which has occurred four times since 1971, has the potential to adversely affect EFH through temporary disturbance, decreases in local water quality, sedimentation and direct mortality. Although these effects are temporary, they recur with each dredging event, resulting in long-term, intermittent impacts. Mobile species, both fish and macroinvertebrates, would temporarily move out of the area while the dredging occurs; returning once the activities are over. This would temporarily impact both prey species as well as EFH species, but once the dredging is over, species would readily return. Dredging delivers sediment to the water column and increases turbidity. Fine sediments would likely be transported out of Wellfleet Harbor on ebbing tides while coarser sediments could settle to the bottom within the harbor. Increased turbidity can adversely impact aquatic species, including shellfish, and sedimentation can adversely affect shellfish through burial. While feeding for species with designated EFH would be impacted, these species would likely flee the impacted areas to surrounding waters where feeding is less problematic, resulting in minimal adverse impacts that would be temporary in nature. Dredging would also result in the direct mortality of some benthic species that are not mobile enough to move out of the area; again impacting feeding resources for species with designated EFH. However, once dredging activities cease, species would quickly recolonize the affected area.

Overall, the proposed action when combined with the projects in the vicinity of the proposed action would have long-term beneficial impacts on EFH, as any adverse impacts would be temporary and localized in nature and would not result in a cumulative impact that was significant.

CONCLUSIONS

Long-term, the proposed restoration of the Herring River estuary is expected to provide numerous benefits to EFH for species occurring in the area, including improved quality and quantity of EFH. Through increased tidal flow and flushing rates water quality upstream of the Chequessett Neck Road Dike as well as upstream of High Toss Road would improve. Salinity values would increase throughout much of the system with values ranging from 15 ppt to 30 ppt in most of the lower sub-basins, increasing the amount of estuarine habitat (sub-tidal and intertidal habitat) by approximately 790 acres to 885 acres, depending on the alternative selected through the NEPA process. This new estuarine habitat in turn would result in an increase in the population of prey species, including finfish, macroinvertebrates and shellfish, which species with EFH feed on. Fish passage at the Chequessett Neck Road dike would also increase, decreasing potential mortality rates for anadromous and catadromous species and increasing access to estuarine habitat upstream of the dike for both prey species and species for which EFH is designated.

Although some adverse impacts to species with designated EFH would occur, they are expected to be minimal and short-term in nature. During construction activities less mobile prey species would likely be buried or directly killed during in-water construction activities. Sediment disturbance would increase turbidity in the surrounding waters, adversely impacting the feeding behaviors of species with EFH, as well as other species. It may also restrict habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and mortality. However, this would be temporary and localized and species would likely flee to neighboring waters where feeding and other impacts are less problematic. As tidal flows increase with restoration, sediments would be mobilized, and though most would be transported upstream onto the marsh system, some would be transported downstream of the dike and into Wellfleet Harbor, with coarser sediments settling out and finer sediments likely flushing out to Cape Cod Bay. However, with small incremental openings in the tide gates under adaptive management, impacts would be minimized and benthic species would be expected to recolonize areas readily.

ACRONYMS

BMPs	Best Management Practices
CYCC	Chequessett Yacht and Country Club
DO	dissolved oxygen
EFH	Essential Fish Habitat
MA DMF	Massachusetts Division of Marine Fisheries
NEPA	National Environmental Policy Act
NEFMC	New England Fishery Management Council
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service
ppt	parts per thousand
TSS	total suspended solids

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APPENDIX G: STATEMENT OF FINDINGS FOR WETLANDS AND FLOODPLAINS

STATEMENT OF FINDINGS FOR WETLANDS AND FLOODPLAINS

HERRING RIVER RESTORATION PROJECT

STATEMENT OF FINDINGS
WETLANDS and FLOODPLAINS

For the Herring River Restoration Project
Cape Cod National Seashore, Massachusetts

February 2016

Recommended: ____________________________ _____________

Superintendent Date

Cape Cod National Seashore

Certification of

Technical Adequacy and

Servicewide Consistency: ____________________________ _____________

Chief Date

NPS Water Resources Division

Approved: ____________________________ _____________

Regional Director Date

Northeast Region

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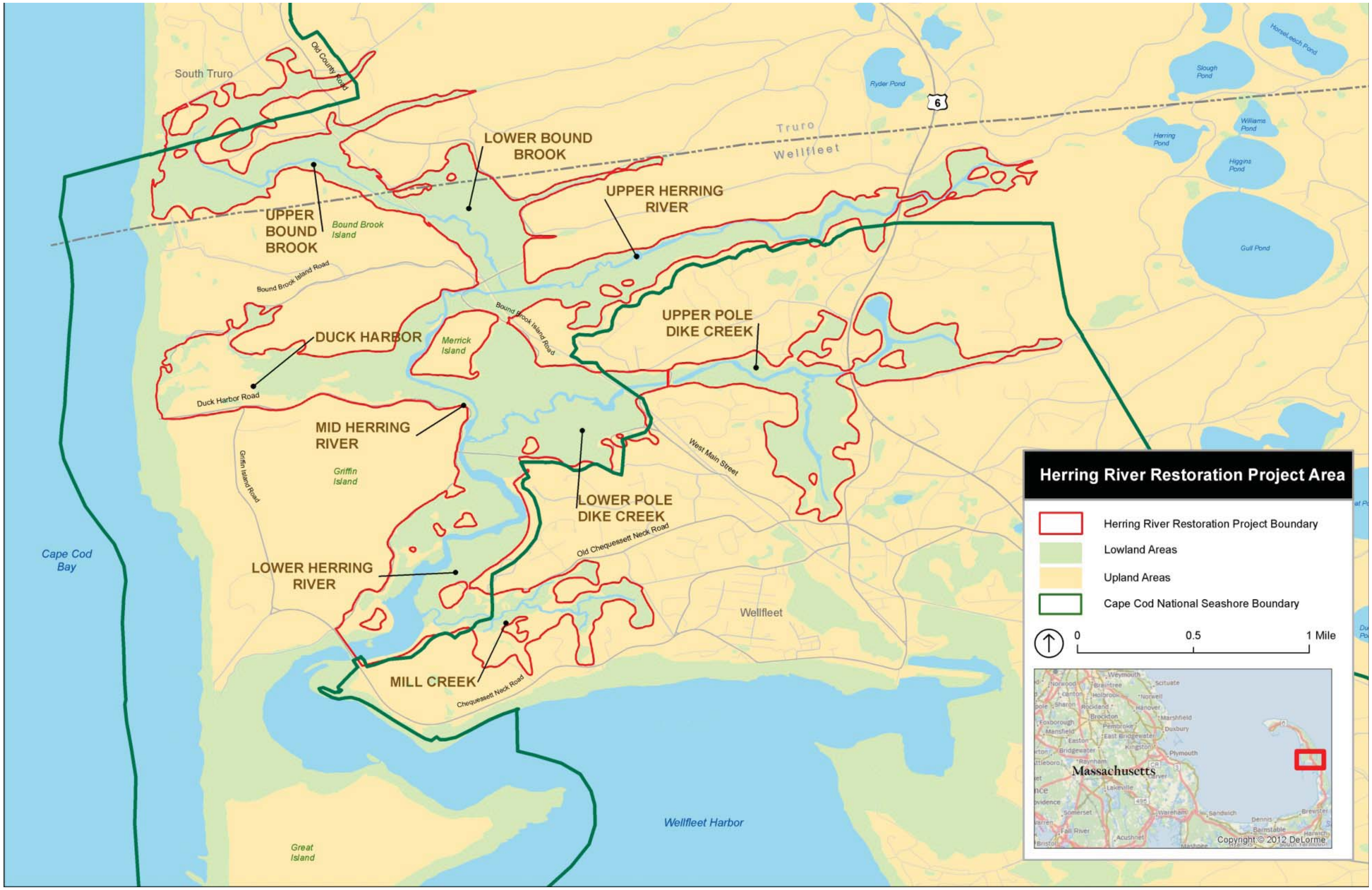
1. INTRODUCTION

This Wetlands and Floodplains Statement of Findings (SOF) describes the alternatives that were evaluated in the EIS, characterizes the wetland and floodplain resources that may be adversely impacted as a result of implementing the preferred alternative, describes adverse impacts that the project would likely have on these resources, and documents the steps that would be taken to avoid, minimize, and offset these impacts.

NPS Director's Order 77-1 and Procedural Manual 77-1 provide guidance regarding NPS policies and procedures for wetland protection. The purpose of this Director's Order is to establish NPS policies, requirements, and standards for implementing Executive Order (EO) 11990: Protection of Wetlands (42 Fed. Reg. 26961), which was issued by President Carter in 1977 "…to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative...."

Consistent with this order, the NPS has adopted a goal of "no net loss of wetlands." Additionally, the NPS will strive to achieve a longer-term goal of a net gain of wetlands Servicewide. When proposing new development or other new activities, plans, or programs that have the potential to result in adverse impacts on wetlands, the NPS will avoid adverse wetland impacts to the extent practicable, minimize impacts that cannot be avoided, and compensate for remaining unavoidable adverse wetland impacts via restoration of degraded wetlands.

EO 11988: Floodplain Management, also enacted by then President Jimmy Carter in 1977, requires the NPS and other federal agencies to avoid to the extent possible the short- and long-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Under the EO, each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains (EO 11988). NPS Director's Order 77-2 Floodplain Management and Procedural Manual 77-2 provide NPS policies and procedures for complying with EO 11988.



Source: The Louis Berger Group, Inc., 2012.

FIGURE 1: PARK VICINITY MAP AND HERRING RIVER RESTORATION AREA

2. PROJECT BACKGROUND

The proposed project will restore native tidal wetland habitat to large portions of the Herring River estuary (figure 1) by re-establishing tidal exchange in the main river basin and its connected sub-basins. Increased tidal exchange will be achieved by reconstructing the Chequessett Neck Road Dike (figure 2), which separates the Herring River estuary from Wellfleet Harbor and Cape Cod Bay, and by building a new dike to control tides in the Mill Creek sub-basin . Tidal exchange would be increased incrementally, over time, using an adaptive management approach. While the ecological goal is to restore the natural tidal range in as much of the Herring River floodplain as possible, flooding in certain areas must be controlled to protect existing land uses.

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). In 1909, the Town of Wellfleet constructed the Chequessett Neck Road Dike (figure 2) at the mouth of the Herring River to reduce the presence of salt marsh mosquitoes. The dike restricted tides in the Herring River from approximately 10 feet on the downstream harbor side to about 2 feet upstream of the dike (figure 3).

By the mid-1930s, the Herring River, now flowing with freshwater, was channelized and straightened. Between 1929 and 1933, developers associated with 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 floodplain.

By the 1960s, the dike tide gates had rusted open, increasing tidal range and salinity in the lower Herring River. This caused periodic flooding of the 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 showed that the new tide gate opening was too small to achieve the required tide heights. In 1977, control of the dike was transferred to the Massachusetts Department of Environmental Protection (MassDEP) so that increased tidal flow could be attained in the interest of restoration (HRTC 2007).

In 1980, a large die-off of American eel (Anguilla rostrata) and other fish drew attention to the poor water quality in the Herring River. The Massachusetts Division of Marine Fisheries 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 tide gate opening was increased to 20 inches in 1983. That year, Seashore 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, Aedes cantator and Ae. 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).

Source: NPS, 2011.

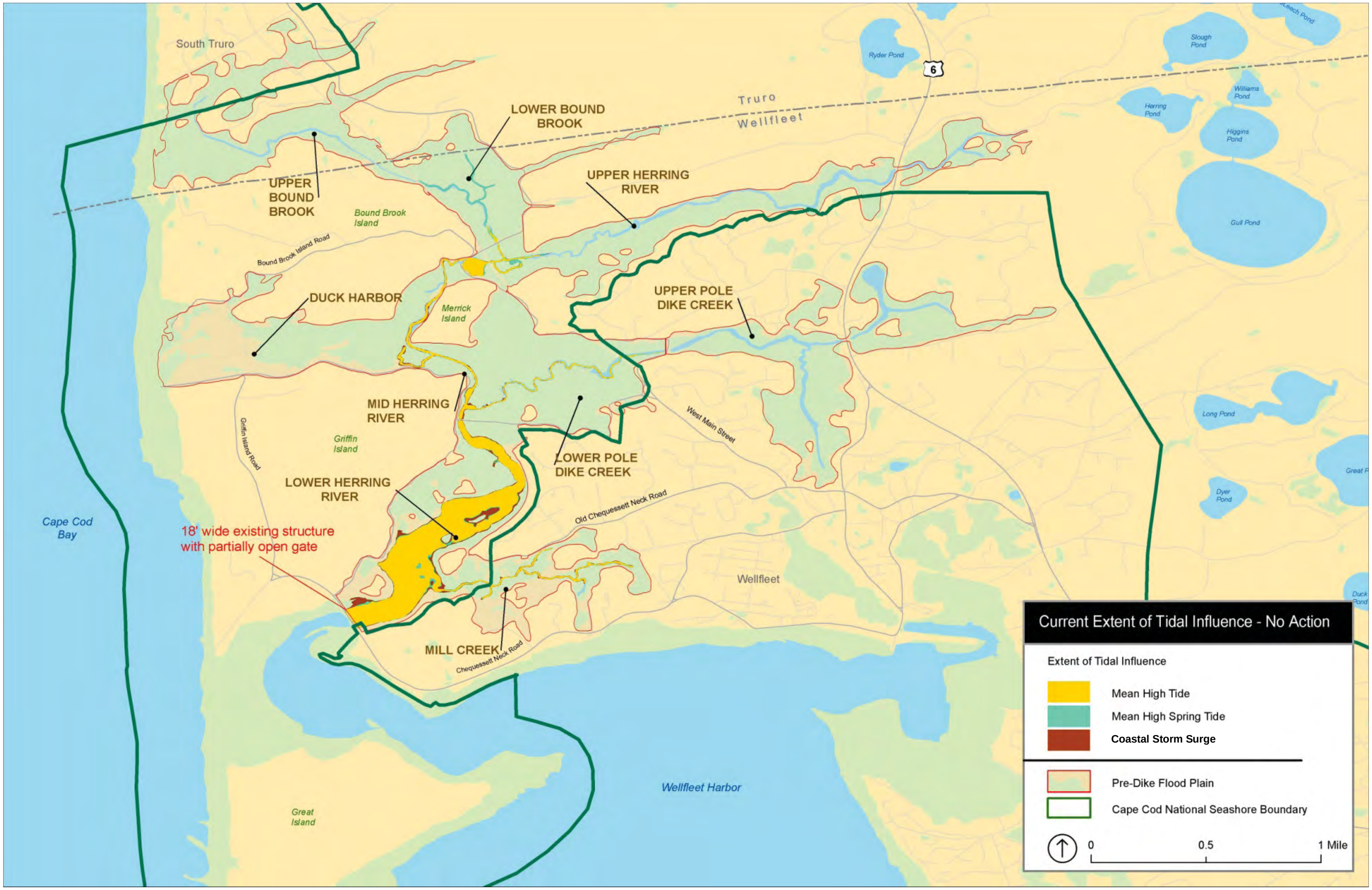
FIGURE 2: CHEQUESSETT NECK ROAD DIKE

In 1985, the Massachusetts Division of Marine Fisheries 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 and high metal concentrations. More recently, NPS researchers identified bacterial contamination as another result of restricted tidal flow and reduced salinity (Portnoy and Allen 2006).

Concentrations of nitrogen and phosphorus in the sediments of Herring River have remained high. Although there is no documentation of specific anthropogenic or natural inputs, potential sources of excessive nutrients in the watershed include agriculture, fertilized lawns, CYCC golf course, the nearby Coles Neck landfill, leaking septic systems, animal waste, and atmospheric deposition. The lack of tidal flushing has allowed nutrients to accumulate in the Herring River. In a normally functioning estuary, nutrients would be diluted and flushed out of the system with each tide cycle.

In addition, pesticides have likely been used throughout the Herring River watershed, including long-term use for mosquito control. Pesticide concentrations (dichloro-diphenyl-trichloroethane (DDT) and dieldrin) measured in the Herring River sediments downstream of the dike in 1969 (Curley et al. 1972) were found to be elevated, exceeding National Oceanic and Atmospheric Administration (NOAA) guideline values (Buchman 2008). However, samples analyzed for organics (including pesticides) from the Wellfleet Harbor by Hyland and Costa (1995) did not exceed NOAA guideline values. Quinn et al. (2001) analyzed the upper 2 cm of the marsh sediments at four stations upstream and downstream of the Chequessett Neck Road Dike for polychlorinated biphenyls (PCBs), DDT, total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAHs). PAHs were found to be below NOAA's effects range low (ERL) guideline values while PCBs and DDT were found to be above NOAA's ERL guidelines.

Because tidal restrictions radically affect the process of sedimentation on the salt marsh, much of the diked Herring River floodplain has subsided up to three feet (Portnoy and Giblin 1997a). Coastal marshes must increase in elevation at a rate equal to or greater than the rate of sea-level rise in order to persist. This increase in elevation (accretion) depends on several processes, including transport of sediment and its deposition onto the marsh surface during high tides. This sediment transport must occur to promote the growth of salt marsh vegetation and gradually increase the elevation of the marsh surface. Diking has



Source: The Louis Berger Group, Inc., 2012.

FIGURE 3. CURRENT LEVEL OF TIDAL INUNDATION IN THE HERRING RIVER FLOODPLAIN

effectively blocked sediment from reaching the Herring River floodplain. 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 severe historic and continuing subsidence in the Herring River's diked wetlands.

3. STUDY AREA AND METHODS

The geographic study area for this Statement of Findings is the Herring River estuary on Massachusetts' Cape Cod. The majority of the river's floodplain (approximately 80 percent) is within the boundary of Cape Cod National Seashore. The river itself extends from Wellfleet Harbor northeast for just under four miles to Herring Pond in north Wellfleet. The river system, generally defined by the landward limit of the historic floodplain of the river and its tributaries, encompasses approximately 1,100 acres.

In addition to the Herring River's upper, middle, and lower basins, the restoration project area is composed of important stream sub-basins (table 1 and figure 4). Each basin is distinct physically, chemically, and biologically, because of its elevation and distance from the Herring River and Wellfleet Harbor. Therefore, tidal restoration will influence each basin to a different degree.

TABLE 1. DESCRIPTION OF SUB-BASINS WITHIN HERRING RIVER RESTORATION AREA

Sub-Basin Name	Location and Acreage	Current Vegetation Type(s)
Herring River Basin	Approximately 396 acres are divided into three separate hydrologic units: Lower Herring River, Mid Herring River, and Upper Herring River.	The only remaining salt marsh in the Herring River system, approximately seven acres in size, is located just upstream of the dike in the Lower Herring River. The remaining sub-basin is dominated by non-native common reed (*Phragmites australis*) and freshwater wetland and upland species.
Mill Creek	This 80-acre sub-basin forms the southeastern portion of the project area, lying just upstream and east of the Chequessett Neck Road Dike.	*Phragmites* marsh and disturbed wooded wetland habitat cover much of the Mill Creek sub-basin. In the 100 years since the Herring River Dike was constructed, the CYCC and several private residences have been developed in the Mill Creek floodplain.
Pole Dike Creek	This sub-basin forms the east central portion of the project area, encompasses approximately 288 acres, and consists of two hydrologic units: Lower Pole Dike Creek and Upper Pole Dike Creek.	The sub-basin is dominated by mixed freshwater marsh. Private properties have been more intensely developed around the Upper Pole Dike Creek wetlands than in other Herring River sub-basins.
Duck Harbor	This 131-acre sub-basin basin extends west from the main stem of the Herring River to the Duck Harbor barrier beach. Today, Duck Harbor is separated from Cape Cod Bay by a vegetated duneline. Historic maps show a tidal channel connecting it to the bay as recently as 1848 (Tyler 1922).	Dry deciduous woodlands are typical in the eastern portion, while freshwater wetland shrubs dominate in the lower, wetter, western portion, except where the basin rises up to the barrier beach.

Sub-Basin Name	Location and Acreage	Current Vegetation Type(s)
Bound Brook	This 234-acre wetland extends to the north and west of Herring River above Old County Road. Consists of two hydrologic units: Lower Bound Brook and Upper Bound Brook. Today, Bound Brook is separated from Cape Cod Bay by a vegetated duneline. In the past, Bound Brook Basin was likely an estuary with a tidal connection to Cape Cod Bay.	Due to generally low elevations, the peat has remained saturated, albeit fresh, and the dominant vegetation is wetland shrubs and cattail.

Use of Hydrodynamic Modeling to Describe Existing Conditions and Expected Changes

The Woods Hole Group developed a hydrodynamic model simulating the complexities of the Herring River system (WHG 2012). The model allows for the evaluation of specific questions regarding potential change to surface water elevations, flow velocities, salinity changes, and sediment processes in the estuary. Specifically, the numerical modeling has been used to evaluate the goals of the proposed project. Some of the modeling objectives include:

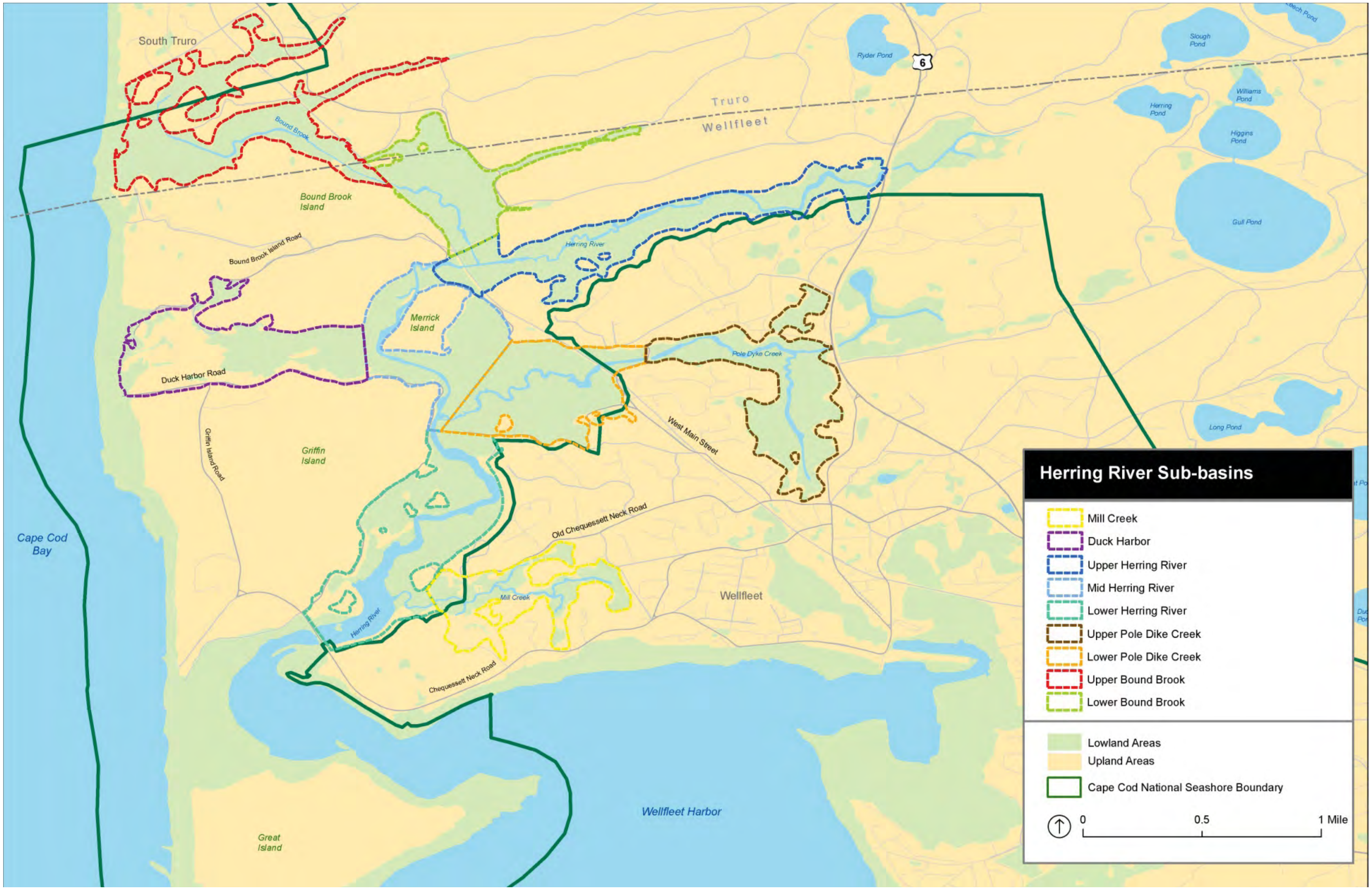
- Prediction of restored water surface elevations and salinities;
- Estimation of hydroperiod and wetting/drying of marsh surfaces;
- Assessment of potential change in the velocities and sedimentation patterns in the project area; and
- Assessment of impacts to low-lying properties and infrastructure.

Information regarding and results of the modeling process can be found in appendix B to the final EIS/EIR (WHG 2012).

4. DESCRIPTION OF WETLANDS IN THE PROJECT AREA

In order to achieve compliance with EO 11990, parks are directed to use the "Classification of Wetlands and Deepwater Habitats of the United States" (FWS/OBS-79/31; Cowardin et al. 1979) as the standard for defining, classifying, and inventorying wetlands. As a former extensive tidal marsh, the project area is currently comprised primarily of Palustrine (freshwater) wetlands with a smaller amount of remnant Estuarine (saltwater) in the lower sub-basins. Estuarine systems are those in which salinities during the period of average annual low flow exceeds 0.5 ppt (Cowardin et al. 1979). The project area also includes smaller areas of natural dune overwash onto former wetlands and developed areas (primarily golf course fairways on hydric soil).

Reduced salinity and marsh drainage have had a gradual but dramatic impact on the species composition of the Herring River salt marsh plant communities. Salt marsh plants, including salt marsh cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*S. patens*), and salt meadow rush (*Juncus gerardii*) were denied their competitive edge over freshwater wetland species, such as cattail (*Typha* spp.). Cattail-dominated plant communities gradually replaced salt marsh vegetation. By the 1960s, continued drainage allowed upland grasses, forbs, and trees to replace cattails (Portnoy and Soukup 1982). Black cherry



Source: The Louis Berger Group, Inc., 2012.

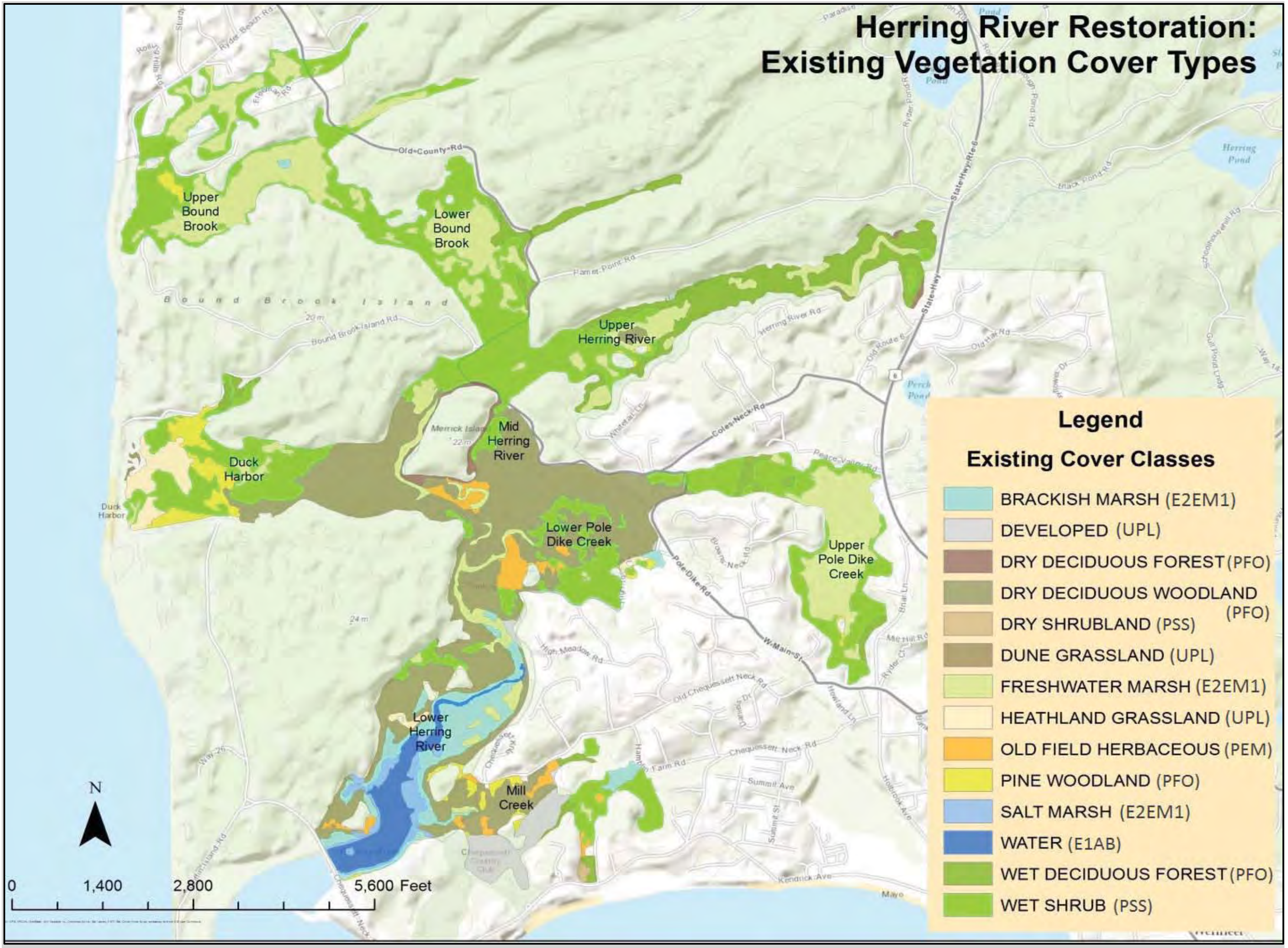
FIGURE 4: HERRING RIVER SUB-BASIN MAP

(*Prunus serotina*) and pitch pine (*Pinus rigida*) are now dominant in areas that were once naturally occurring salt marsh habitats. By the 1970s, much of the original Herring River had developed into forest and shrublands dominated by opportunistic upland species (Portnoy and Soukup 1982). At the same time, large portions of the original sub-tidal and intertidal substrates between the dike and High Toss Road had converted to monotypic stands of common reed (*Phragmites australis*).

No formal wetland delineation has been undertaken for the project area. However, the Seashore has vegetation cover type mapping for the project area. Table 2 and figure 5 summarize existing vegetation types and classifications in the Herring River restoration area.

TABLE 2: EXISTING VEGETATION COVER TYPES WITHIN THE HERRING RIVER ESTUARY

FEIS Vegetation Analysis Cover Types	NWI Cover Types	Existing Acreage
Wet deciduous forest	**PFO**	75
Dry deciduous forest		7
Pine woodland		26
Dry deciduous woodland		231
Total PFO		**339**
Wet shrubland	**PSS**	288
Dry shrubland		1
Total PSS		**289**
Old field herbaceous mix	**PEM**	18
Freshwater marsh (non-tidal)		172
Freshwater marsh (tidal)		0
Total PEM		**190**
Brackish marsh (tidal)	**E2EM1**	36
Salt marsh (tidal)		13
Total E2EM1		**49**
Total All Wetland Classes		**867**
Water (tidal)	**E1AB**	94
Total E1AB		**94**
Heathland	**UPL**	20
Dune grassland		1
Developed		24
Total UPL		**45**
Total All Non-Wetland Classes		**139**
Project Area Total Acres		**1006**



Source: The Louis Berger Group, Inc., 2012.

FIGURE 5: EXISTING VEGETATION COVER TYPES USING 2007 NPS VEGETATION MAPPING DATA

5. DESCRIPTION OF FLOODPLAINS IN THE PROJECT AREA

The presence of the Chequessett Neck Road Dike has dramatically reduced floodplain functions in the 1,100 acre estuary. While the normal tidal range in Wellfleet Harbor just seaward of the dike is nine feet, the existing tidal range in the Herring River above the dike is only about two feet. As a result, seawater only reaches approximately 3,000 feet upstream of the dike. For many years, therefore, the estuary has not been exposed to extreme high water caused by Nor'easters or other major storms coinciding with high tide. By eliminating flooding, the diking and drainage of the Herring River floodplain allowed land uses and development of the former salt marsh and adjacent areas.

A total of 368 properties lie partially or fully within Herring River floodplain. These properties include private and municipal parcels; parcels owned by non-profit organizations; non-federal conservation land parcels; residential and commercial parcels (Town of Wellfleet 2009). In total, these parcels cover approximately 354 acres of land within the Herring River floodplain. Several dozen of these properties could potentially be affected by restored tidal exchange to some degree. The largest of these is the CYCC. Most of the other potentially affected properties are residential parcels within the Mill Creek and Upper Pole Dike Creek sub-basins. See page 32, Impacts to Floodplains for a complete discussion.

Figure 6 identifies both NPS and non-NPS parcels within the floodplain.

6. ALTERNATIVES ANALYZED

Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck

Under alternative A, no action means that the existing 18-foot-wide structure composed of two flap gates and an adjustable tide gate would remain in place (shown in figure 3), and no tidal restoration would occur. Although no physical changes would be made, it is important to emphasize that "no action" is not a steady state from an environmental perspective. Physical factors acting on the dike will continue and the tide gates will entail maintenance costs during the next several years. Additionally, ecological conditions with the Herring River would continue to be affected by tidal restriction.

Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek

Under Alternative B, a box beam bridge/dike structure with a total opening width of 165 feet spanned by a series of adjustable and removable tide gates would be installed in the Chequessett Neck Road Dike to allow passage of Wellfleet Harbor tides (common to all action alternatives). The tide gates would be opened gradually and according to guidelines set forth in the Adaptive Management Plan with an objective to ultimately reach a mean high spring tide of 4.8[1] feet and a coastal storm driven tide of 6.0 feet in the Lower Herring River. These elevations reflect the maximum restoration possible without installing a secondary tidal control structure at Mill Creek and are based on the feasibility of addressing flood impacts within the Mill Creek sub-basin. Hydrodynamic modeling has demonstrated that a vertical tide gate opening of approximately three feet across the 165-foot culvert structure would result in this tidal regime. Tides in the upstream sub-basins would be lower because of natural tide attenuation.

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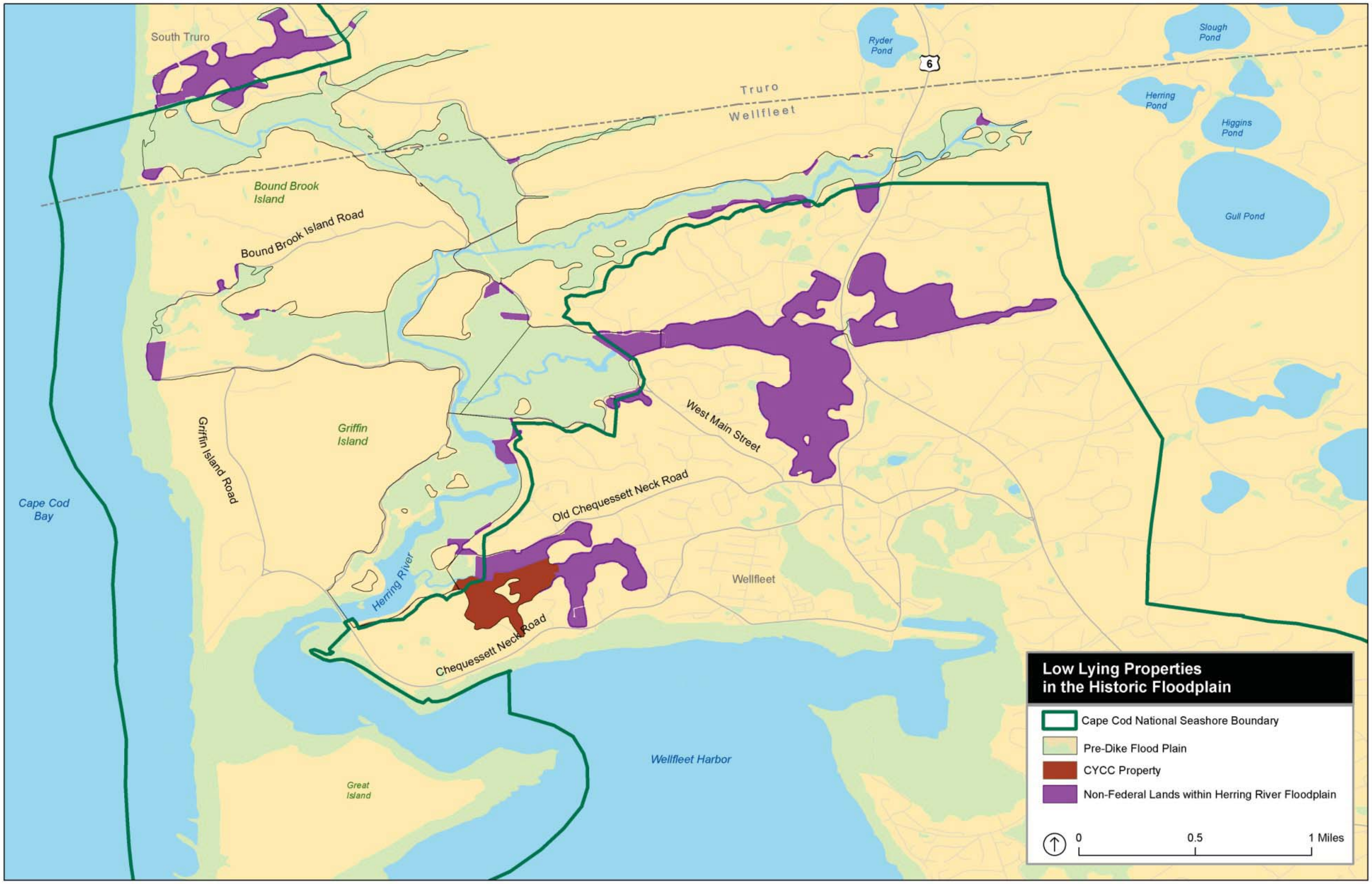
[1] All tidal elevations cited are referenced to the North American Vertical Datum of 1988 (NAVD88), which in Wellfleet Harbor is approximately 0.3 feet above mean sea level and 5.2 feet above mean low water.



Source: The Louis Berger Group, Inc., 2012.

Figure 6: Low-Lying Properties in the Historic Herring River Floodplain

This alternative would not require the construction of a dike at Mill Creek. Flood-proofing actions undertaken for the CYCC golf course and other low-lying properties would be designed to accommodate coastal storm driven tidal flooding up to 5.9 feet within the Mill Creek sub-basin and 5.3 feet in the Upper Pole Dike Creek sub-basin. The exact final maximum high tide elevations would be determined through the adaptive management process, but would not exceed these elevations.

Alternative B would also forego the ability to pursue higher inundation levels in the estuary as part of an adaptive management process. This would limit both horizontal effects (restored acreage) and vertical effects (restored elevation of the salt marsh surface) of tidal restoration.

Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow

Similar to the other action alternatives, tide gates at a rebuilt Chequessett Neck Road Dike would be opened gradually and in accordance to guidelines set forth in the Adaptive Management Plan. The objective for alternative C would be to fully open the gates to allow mean high water spring tides up to 5.6 feet and coastal storm driven tides up to 7.5 feet in the Lower Herring River. These elevations reflect the maximum restoration feasible for most of the Herring River floodplain; however, a tidal exclusion dike would need to be constructed at the mouth of Mill Creek in order to avoid flood impacts to low-lying private properties. Tides in the upstream sub-basins would be lower because of natural tide attenuation. Mitigation actions undertaken throughout the remainder of the Herring River estuary would be designed to accommodate flooding up to these maximum tidal elevations.

7. PREFERRED ALTERNATIVE

Alternative D, the Preferred Alternative: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow

Tide elevations in the project area would reflect the maximum restoration possible for the majority of the Herring River floodplain (see table 3 in section 9, *Impacts to Wetlands*). The Chequessett Neck Road Dike would be reconstructed with a 165-foot tide gate opening that would be opened gradually and according to guidelines set forth in the Adaptive Management Plan. The objective of alternative D is to fully open the gates to allow mean high water spring tides up to 5.6 feet and coastal storm driven tides up to 7.5 feet in the Lower Herring River (see figure 7). Tides in the upstream sub-basins would be lower because of natural tide attenuation. With the exception of Mill Creek, mitigation measures undertaken throughout the estuary would be designed to accommodate flooding up to these maximum tidal elevations. Two options are possible under alternative D; Mill Creek option 1 would relocate portions of multiple low-lying golf holes to upland areas currently owned by the CYCC or, Mill Creek option 2 which would elevate the affected areas in place by filling and regrading. A new dike at the mouth of Mill Creek would be constructed to partially restore tidal flow to the sub-basin. Tidal flows would be *controlled* at this location using a combination tide gate to ensure mean high water spring tides to a maximum of 4.7 feet and coastal storm driven events to a maximum of 5.9 feet in Mill Creek. Flood-proofing measures would be required for Mill Creek (e.g., golf course and private dwelling flood-proofing and well relocation). Alternative D, with Mill Creek option 2, which elevates the fairways and practice area at the CYCC, is the preferred alternative.

All of the action alternatives would require reconstruction of the Chequessett Neck Road dike to allow for flood control and incremental tide restoration. Alternatives C and D also require a new Mill Creek Dike. There is no practical alternative to these dikes if the predicted increase in wetland acreage and wetlands function is to be achieved. The Preferred Alternative in particular achieves the greatest wetland restoration benefits relative to the direct wetland losses from dike construction and reconstruction.

Incremental Tidal Restoration and Adaptive Management

Reintroduction of tidal exchange would occur in phases over several years. Gradual opening of adjustable sluice gates would incrementally increase the tidal range and allow for monitoring so that unexpected and/or undesirable responses could be detected and appropriate response actions taken. Details of this process are described in appendix C of the final EIS/EIR.

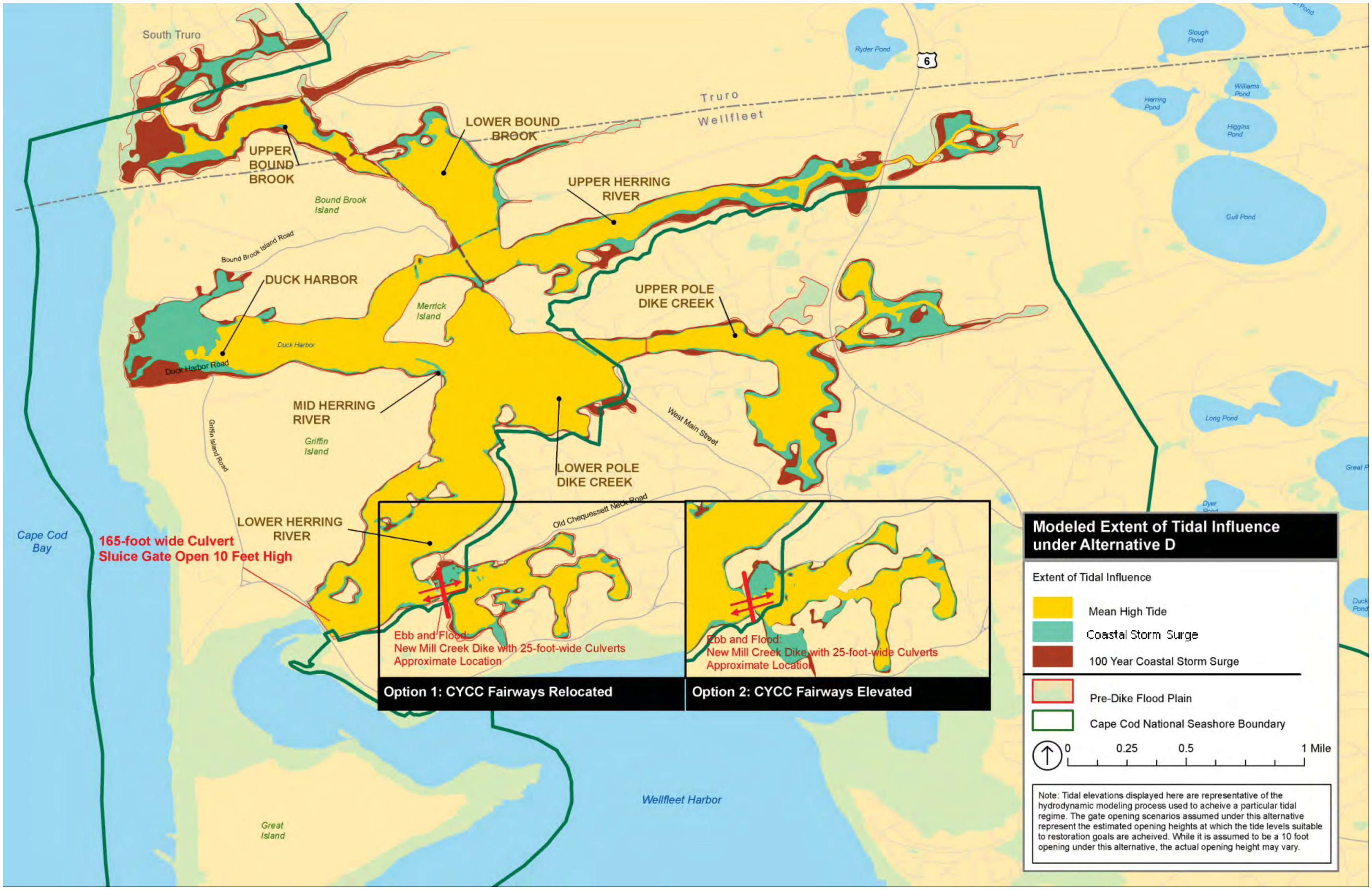
The increased tidal exchange between the Herring River estuary and Wellfleet Harbor would change many characteristics of the floodplain. One of the most noticeable and desirable changes would be to the composition of plant communities. There would be a transition from one set of plant community types to another as changes occur to environmental parameters, such as tidal inundation, tide frequency, soil saturation, and most notably salinity. Management of floodplain vegetation would have the following objectives:

- Encourage re-establishment of *Spartina*-dominant marsh;
- Remove woody debris that might impede fish passage; and
- Remove large trees that would otherwise die, topple, and leave holes on the wetland surface where mosquitoes might breed.

Vegetation management activities would consist of cutting of the vegetation and processing and removal of the biomass that has been cut. Cutting would be accomplished with tools such as hand-held loppers, chain saws, mowers, brush hogs, or larger, wheeled or treaded machines that cut and chip. Removal would be accomplished by the sale of cut hardwood, removal of wood chips, and burning brush and branches.

Low-lying Roads and Culverts

Several segments of Pole Dike, Bound Brook Island, and Old County Roads where they cross the main Herring River and tributary streams are vulnerable to high tide flooding under the proposed restoration (ENSR 2007). To prevent this, road surfaces and culverts would need to be elevated or relocated. An adjustable flap gate would also be installed at Pole Dike Creek Road to provide flood protection for low lying properties in that basin, if necessary. Preliminary engineering analysis shows that approximately 8,000 linear feet of road should be elevated to a minimum grade of 5.5 feet. Elevating these roads would also require widening the road bases and increasing culvert sizes, which would result in limited direct wetland losses (see Table 6). A second option for these road segments would be to relocate the alignment onto a nearby former railroad right-of-way. Preliminary engineering analysis shows this to be feasible with lower costs. Additional engineering studies and traffic analyses are needed to fully evaluate both of these options (CLE 2011) and how they impact wetlands.



Note: Tidal elevations displayed here are representative of the hydrodynamic modeling process used to acheive a particular tidal regime. The gate opening scenarios assumed under this alternative represent the estimated opening heights at which the tide levels suitable to restoration goals are acheived. While it is assumed to be a 10 foot opening under this alternative, the actual opening height may vary.

Source: The Louis Berger Group, Inc., 2012.

FIGURE 7. EXTENT OF TIDAL INUNDATION UNDER THE PREFERRED ALTERNATIVE

Restoration of Tidal Channel and Marsh Surface Elevation

Several actions would be necessary to reverse other alterations of the system's topography, bathymetry, and drainage capacity. Diking and drainage have caused subsidence of the former salt marsh by up to three feet, reaches of the river have been channelized and straightened, mosquito ditches have been created, and spoil berms have been left along creek banks (HRTC 2007). These factors could limit or delay progress toward meeting the project objectives by inhibiting circulation of salt water, preventing recolonization of salt marsh vegetation, ponding fresh water, and expanding nuisance mosquito breeding habitat.

Several supplementary habitat management actions would be considered to address these issues. These actions and the conditions under which they would be employed are described and analyzed in detail in appendix C of the final EIS/EIR. In summary, potential actions include but are not limited to:

- Dredging of accumulated sediment to establish a natural bottom of the Herring River channel at the appropriate depth to maximize ebb tide drainage;
- Creation of small channels and ditches to improve tidal circulation;
- Restoring natural channel sinuosity;
- Removing lateral ditch dredge spoil berms and other anthropogenic material on the marsh surface to facilitate drainage of ponded water; and
- Applying a thin layer of dredged material to build up subsided marsh surfaces.

8. IMPACTS TO WETLANDS

Long-Term Impacts to Wetland Habitat and Vegetation

Restoration of the Herring River floodplain would result in the widespread change from degraded primarily freshwater (Palustrine) wetlands to Estuarine sub-tidal and inter-tidal habitats. Restored inter-tidal habitat subjected to higher salinity waters, generally 18 parts per thousand and higher, is expected to transition to salt marsh (E2EM1). However, lower salinities would likely occur on the periphery of the project area and in the upper reaches of many sub-basins where brackish (also E2EM1) and freshwater plants (Palustrine marsh, shrub swamp and forested wetland) are expected to persist. While changes in higher salinity areas are relatively clear and predictable, vegetation changes in restored inter-tidal areas with lower salinity are less certain and difficult to quantify.

To evaluate the changes in vegetation resulting from each of the action alternatives, the modeled areal extent of the mean high water spring tide was used to estimate the total area of restored inter-tidal habitat. The area of existing vegetation cover types affected up to the mean high water spring tide line for each alternative are summarized in table 3. In addition, a relatively small area of wetland-to-upland transitional habitat along the periphery of the mean high water spring tide line would be affected by AHW (the highest tide within a given year). Some vegetation change would be expected in these areas depending on the species present and the exact frequency and duration of tidal influence. The area encompassing the predicted limits of the mean high water spring tide line is greatest for the preferred alternative (alternative D). Table 3: Area of Existing Wetland Habitat and Vegetation Cover Types Affected by Mean High Water Spring Tide (Preferred Alternative)

TABLE 3: AREA OF EXISTING COVER TYPES AND FUTURE COVER TYPES UNDER THE PREFERRED ALTERNATIVE

FEIS Vegetation Analysis Cover Types	NWI Cover Types	Existing Acreage	Alternative D* Acreage	Notes
Wet deciduous forest	**PFO**	75	0	Of 339 acres of PFO, 337 acres will be converted to E2EM1 and 2 acres will remain unchanged
Dry deciduous forest		7	0	
Pine woodland		26	2	
Dry deciduous woodland		231	0	
Total PFO		**339**	**2**	
Wet shrubland	**PSS**	288	67	Of 289 acres of PSS, 195 acres will be converted to E2EM1, 27 acres to PEM, and 67 acres will remain unchanged
Dry shrubland		1	0	
Total PSS		**289**	**67**	
Old field herbaceous mix	**PEM**	18	0	Of 190 acres of PEM, 61 acres will be converted to E2EM1, 30 acres will remain unchanged, and 27 acres of PSS will be converted to PEM.
Freshwater marsh (non-tidal)		172	57	
Freshwater marsh (tidal)		0	99	
Total PEM		**190**	**156**	
Brackish marsh (tidal)	**E2EM1**	36	98	E2EM1 will expand from 49 acres to 683 acres (salt and brackish tidal wetlands) through conversion from PFO (337 acres), PSS (195 acres), PEM (61 acres), E1AB (8 acres), and UPL (33 acres).
Salt marsh (tidal)		13	585	
Total E2EM1		**49**	**683**	
Total All Wetland Classes		**867**	**908**	**41 acre increase in all wetland classes**
Water (tidal)	**E1AB**	94	86	Of 94 acres of E1AB, 8 acres will be converted to E2EM1.
Total E1AB		**94**	**86**	
Heathland	**UPL**	20	0	Of 45 acres of UPL, including 12 acres now developed as golf course, 33 acres will be converted to E2EM1.
Dune grassland		1	0	
Developed		24	12	
Total UPL		**45**	**12**	
Total All Non-Wetland Classes		**139**	**98**	
Project Area Total Acres		**1006**	**1006**	
* Alt. D = "Preferred Alternative"				

Under all of the action alternatives, there would be extensive vegetation change within the Lower Herring River sub-basins. Over the long term, mean high spring tides with relatively high salinity levels would affect the existing freshwater and brackish marsh, woodland, and shrubland plant communities that have replaced the historic salt marsh habitats (see figure 7). This area would largely be restored to low and high salt marsh vegetative communities but would also include sub-tidal and inter-tidal channel habitats. The lowest of these areas would lie below mean low water if the current topography remains unchanged. However, sediment transport modeling indicates that these severely subsided areas are expected to receive large volumes of sediment as higher tides are incrementally restored. In the long term, these areas are anticipated to accrete and support salt marsh vegetation as the marsh surface reaches equilibrium with a restored tidal regime. A smaller portion of transitional habitat along the periphery of the sub-basins would be affected by annual high water. Some vegetation change would be expected in these areas depending on the species present and the exact frequency and duration of tidal influence.

Vegetation changes in the upper sub-basins would be limited in comparison to the lower sub-basins. Although most of these areas are thought to have been historically dominated by salt marsh vegetation, the relatively low mean high spring tidal elevations achieved by all the alternatives would not allow salt water to regularly propagate into these basins and salinity levels within both the channel and on the marsh surface are predicted to remain low (see figure 7). Although no salt marsh or brackish species likely would colonize the marsh surface under these conditions, pulses of tidally forced freshwater would favor the displacement of upland woodland species with vegetation more characteristic of a Palustrine wetland. The transitional habitat (extending up to annual high water) along the periphery of these upper basins would be expected to experience less habitat change as compared to the lower basins. Figure 8 illustrates the anticipated wetland changes based upon the predicted extent of Mean High Water Spring.

Potential Changes in the Distribution of Phragmites

Intermediate salinity levels, between approximately 5 ppt and 18 ppt, could make some areas suitable for non-native common reed (*Phragmites australis*), particularly in the Bound Brook and the Upper Herring River sub-basins. Herbicide application would likely be used to reduce coverage of Phragmites prior to tidal restoration. As tidal exchange is restored, monitoring would be conducted to track vegetation change throughout the system. If Phragmites is observed to be expanding its range or colonizing new areas, management actions, including herbicide application, mechanical control, or hydrological (increased inundation and salinity) alterations could be implemented to limit or control its spread.

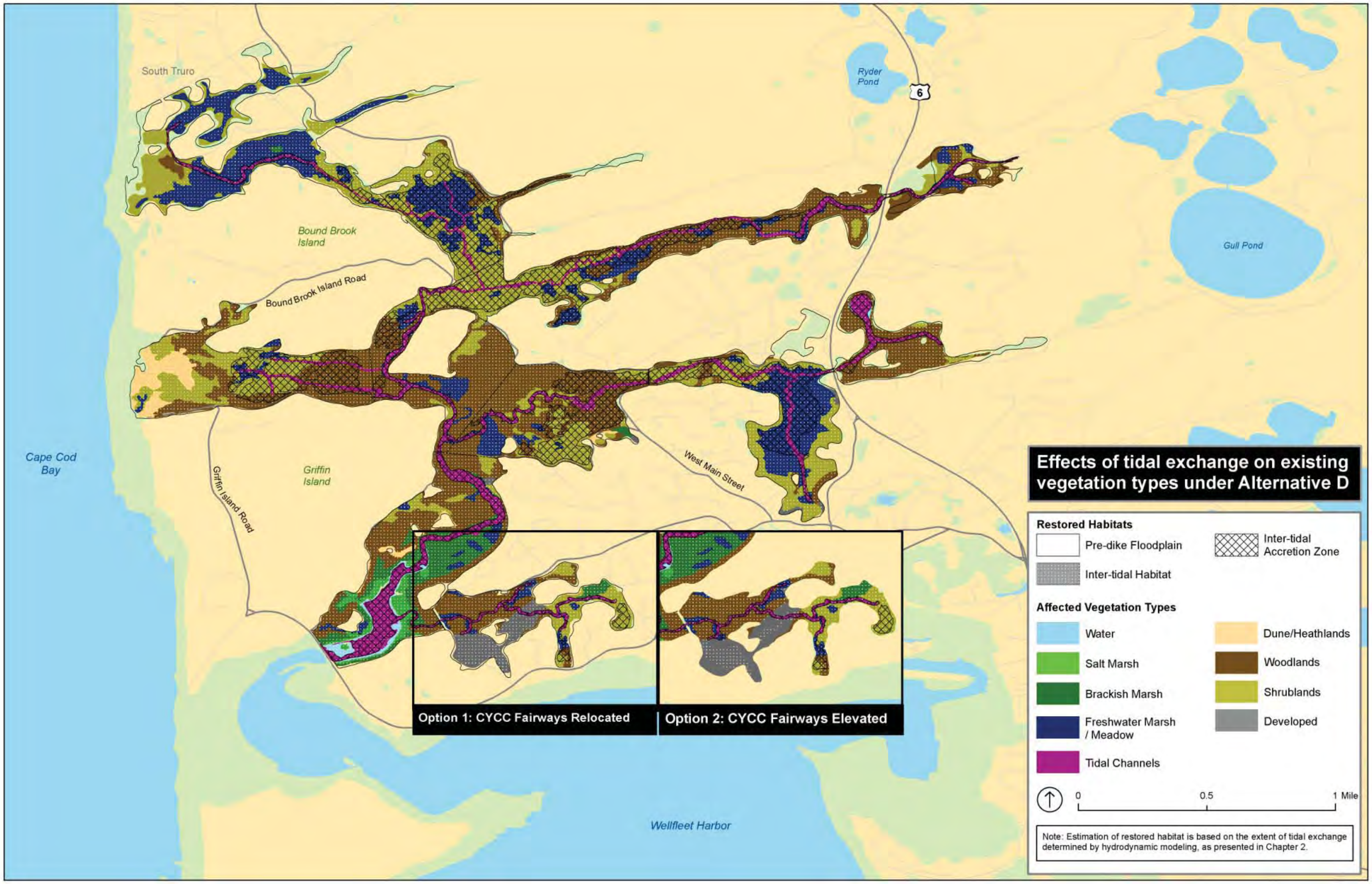
Woody Vegetation on the Floodplain

Mortality of approximately 559 acres of shrubland/woodland vegetation is anticipated. Large volumes of standing dead and fallen woody debris may be undesirable because it could obstruct formation of tidal channels and delay the establishment of marsh grasses by decreasing seed dispersal and germination. Options for woody vegetation management include removal through cutting, chipping, and/or burning as well as processing the cut biomass (harvest for firewood or wood chips and burning brush and branches). A future vegetation management program would require the concurrence of landowners (both private and public) as well as regulatory agencies. The types of mechanized equipment allowed in the project area and time-of-year restrictions will be defined based on early findings of the Adaptive Management Plan.

Impacts to Water and Sediment Quality

Restored tidal flushing is expected to reduce acidification, nutrient and fecal coliform concentrations and increase levels of dissolved oxygen in much of the project area. Tidal inundation would decrease the rate of aerobic decomposition and acid production within the soil while the pH of porewater and surface water would increase (Portnoy and Giblin 1997a). With restored salinities, aluminum and iron could no longer be leached from the soil in concentrations that stress aquatic life.

Tidewater residence times upstream of High Toss Road would be reduced by at least a factor of 25 (from 200 days under current conditions to 6 days after restoration flows are established) (see table 4). Regular tidal flushing of the Herring River estuary with well-oxygenated water from Wellfleet Harbor is expected to maintain dissolved oxygen concentrations above state water quality standards at all times. Adequate dissolved oxygen concentrations are expected to benefit migratory diadromous fish as well as resident fish and invertebrates**.**



Note: Estimation of restored habitat is based on the extent of tidal exchange determined by hydrodynamic modeling, as presented in Chapter 2.

Source: The Louis Berger Group, Inc., 2012.

FIGURE 8: RESTORED INTERTIDAL HABITAT COMPARED TO CURRENT VEGETATION COMMUNITIES

TABLE 4: MODEL CALCULATED SYSTEM RESIDENCE TIMES* OF THE HERRING RIVER ESTUARY

Basin /Sub-basin	Alternatives	Residence Time (days)	Improved Flushing over Existing Conditions
Mill Creek with Wellfleet Harbor	No Action	523	
	D**	17.7	97%
Sub-Basins above High Toss Road with Wellfleet Harbor	No Action	200	
	D**	6	97%

Source; Woods Hole Group, 2011.

* System residence time is a measure of tidal exchange from a given sub-basin with Wellfleet Harbor

** Residence Times are identical for alternatives C and D; however, alternative C does not include tidal flushing in Mill Creek which would result in change from existing conditions.

During restoration, a tidal channel system would likely be re-established. Sediment would be mobilized in response to the increased volume of tidal exchange. Mobilized sediment is expected to mostly be transported upgradient onto the marsh surface and partially downgradient toward Wellfleet Harbor. Potential impacts on the aquatic ecosystem from chemicals bound to mobilized sediments will be assessed once background levels of pesticide have been determined by ongoing efforts of the Seashore.

Fecal coliform concentrations would be substantially reduced by increased flushing rates (residence time would be decreased). Additionally, the survival time of fecal coliform bacteria would be reduced by higher salinity (e.g., Bordalo et al. 2002) as well as by higher dissolved oxygen and lower water temperature. Greatly reduced fecal coliform concentrations within Herring River and Wellfleet Harbor would likely allow for the removal of the river from the 303(d) list for impairment of pathogens increasing the potential for additional areas of shellfish beds to be reopened for harvesting.

Potential Short-Term Adverse Effects on Water and Sediment Quality

The long-term water and sediment quality changes resulting from tidal restoration in the Herring River would generally be positive and are integral to achieving the ecological objectives of the proposed project. However, several potentially adverse short-term effects to water and sediment quality may occur during restoration or may persist in spite of restoration. These potential adverse impacts will be subjects of long-term monitoring. These include:

- Continued low dissolved oxygen concentrations – Summertime dissolved oxygen levels could remain low in ponded areas until a tidal channel system becomes established. Targeted excavation of silted-in channels could be used to increase circulation and promote low-tide drainage.
- Temporary excessive release of nutrients – Renewed tidal flushing of acid sulfate soils would allow ammonium-nitrogen to be released into receiving waters in the short term (Portnoy and Giblin 1997a). Gradual reintroduction of tidal exchange should allow ammonium-nitrogen to be slowly released (Portnoy 1999). The increase in nutrient concentrations would likely be of relatively short duration. Wellfleet Harbor is open to Cape Cod Bay and is well-flushed, which limits the potential effects of temporary nutrient loading.
- Increased turbidity – Sediment and soil could be mobilized during the reconstruction of the dike and in other areas of construction, potentially resulting in short-term, local increases in turbidity in adjacent water bodies. BMPs would be required and would include erosion control measures as well as maintenance of the current rate of tidal exchange through the dike.

- Elevated fecal coliform concentrations – Elevated bacteria concentrations could persist in upstream reaches of the system, especially after rainstorms. Increasing salinity and flushing will reduce bacteria survival time and density prior to discharge into Wellfleet Harbor. Fecal coliform would continue to be monitored during the restoration process, particularly after rainstorms.
- Porewater sulfide concentrations depress salt marsh plant colonization and growth – Flooding of the lowest organic sediments with seawater could result in elevated porewater sulfide, especially in areas with poor low-tide drainage. Porewater sulfide levels and salt marsh plant colonization will be monitored in these low areas. As part of the Adaptive Management Plan, some channel excavation may be required to improve low-tide drainage and, consequently, peat aeration and sulfide oxidation.

9. IMPACTS TO WETLAND FUNCTIONS AND VALUES

The United States Army Corps of Engineers (USACE) New England Division method for assessing wetland functions and values (The Highway Methodology Workbook Supplement, Wetland Functions and Values - a Descriptive Approach, USACE NED, 1999) considers eight wetland functions and five wetland values as part of a Section 404 permit application. A functional assessment of the Herring River wetland complex up gradient of the Chequessett Neck Road Dike was conducted. A comparison of the functions and values provided by the Herring River wetland complex up gradient of the Chequessett Neck Road Dike is discussed below.

Floodflow Alteration (Storage/Desynchronization)

Wetlands can be important in the storage and desynchronization of floodwaters, protecting downstream resources from flood damage. Wetlands high in the watershed with constricted outlets or closed basins are generally important in capturing and detaining floodwaters. Other wetland characteristics that contribute to flood storage and desynchronization include broad floodplains and plant communities consisting of low, dense vegetation. Under existing conditions, broad, relatively flat local topography, large size, presence of ponded water, contiguous/branched channels, well vegetated floodplains, and numerous constricted outlets all contribute to the wetland complex’s ability to retain floodwaters higher in the watershed. These physical characteristics would remain relatively unchanged under the action alternatives.

During coastal flooding events, any newly constructed dikes would continue to provide flood protection by meeting the Federal Emergency Management Agency’s (FEMA) and other applicable agency requirements for construction and height (including necessary freeboard). As a result, the project area would be protected from extreme coastal floods. However with increased regular tidal exchange comes the opportunity to provide this function during some lesser storm events.

Fish and Shellfish Habitat (Aquatic Diversity / Abundance)

Large wetlands contiguous to a large, perennial stream or waterbody capable of supporting large fish and/or shellfish populations are important in providing Aquatic Diversity/Abundance. There are several factors that affect this function under existing conditions including water quality impairments and numerous barriers which limit fish movement. The restored estuarine waters and salt marsh would provide substantially more spawning and nursery habitat for both resident and transient fish species as well as for estuarine macroinvertebrates, greatly increasing their abundance and use of the estuary over existing conditions. The new dike at Chequessett Neck Road would provide improved fish passage for all fish including anadromous and catadromous species. Such changes coupled with improved water quality and access to the head waters of the river would likely enhance the river’s herring run size and allow for the possible reintroduction of sea-run brook trout into the Herring River estuary. With increased salinity upstream of the dike, habitat for shellfish would also be enhanced.

Sediment / Toxicant Retention (Pollutant Attenuation)

Typically wetland systems with permeable soils that detain storm and flood waters and promote percolation reduce runoff rates sufficiently to allow sediments and adsorbed toxicants to settle from the water column. Diffuse channels, deep pools, and dense low vegetation are wetland characteristics that may also contribute to this process by slowing water velocities. While these characteristics are generally present under existing conditions, the waters associated with the wetland system have a number of water quality impairments. As mentioned above, restored tidal flushing is expected to reduce acidification, reduce nutrient and fecal coliform concentrations, and increase levels of dissolved oxygen in much of the project area. Tidal inundation is also expected to decrease the rate of aerobic decomposition and acid production within the soil which in the past has led to fish kills attributed to high acidity and aluminum toxicity.

The long-term water and sediment quality changes resulting from tidal restoration in the Herring River are generally positive and integral to achieving the ecological objectives of the proposed project. However, several potentially adverse effects on water and sediment quality are possible and, as such, will be components of a long-term monitoring program. Components included in the long-term monitoring program include but are not limited to:

- Continued low dissolved oxygen concentrations – Summertime dissolved oxygen levels could remain low in ponded areas until a tidal channel system becomes established. Targeted excavation of silted-in channels could be used to increase circulation and promote low-tide drainage.
- Temporary excessive release of nutrients – Renewed tidal flushing of acid sulfate soils would allow ammonium-nitrogen to be released into receiving waters in the short term (Portnoy and Giblin 1997a). Gradual reintroduction of tidal exchange is expected to allow ammonium-nitrogen to be slowly released (Portnoy 1999). Increased nutrient concentrations would likely be short-lived. Wellfleet Harbor is open to Cape Cod Bay and well-flushed, limiting the potential effects of temporary increases in nutrient loading.
- Elevated fecal coliform concentrations – Elevated bacteria concentrations could persist in upstream reaches of the system, particularly after rainstorms. Increasing salinity and flushing will reduce bacteria survival time and density prior to discharge into Wellfleet Harbor. Fecal coliform will continue to be monitored during the restoration process, particularly after rainstorms.

Nutrient Removal / Retention / Transformation (Pollutant Attenuation)

Wetlands can serve as a filter for the removal or detention of nutrients carried in surface water flows. Many wetland plants respond to high nutrient concentrations with accelerated uptake rates. Some nutrients are assimilated in plant material while others are trapped in organic sediments in wetlands by chemical, physical, and biotic actions. Typically wetlands designated as having nutrient removal functions are identified by the presence of large areas of open or ponded water with dense emergent vegetation (primarily PEM), meandering streams with slow water velocities, and contiguous/branched channels. While these characteristics are generally present under existing conditions, the waters associated with the former Herring River estuary have a number of water quality impairments. Renewed tidal flushing of drained floodplain soils would allow nitrogen to be released into receiving waters in the short term. Over the long term, water and sediment quality changes resulting from tidal restoration in the Herring River are generally positive, integral to improving this wetland function, and the achievement of the ecological objectives of the proposed project.

Production Export (Nutrient)

Production export is the production of organic material and its subsequent transport out of a wetland to downstream areas or to deeper waters within the basin. This organic material is then added to the food chain where it is eaten by fish and other aquatic organisms. Wetlands with dense vegetation dominated by non-persistent emergent vegetation are important in supplying downstream wetlands with organic material. Wetlands dominated by shallow marshes with a perennial stream flowing from them are most important in providing production export. Wetlands designated as having production export functions are classified by the presence of high densities and diversity of hydrophytic vegetation, abundant fish and wildlife, and downstream/downgradient evidence of export. Under existing conditions, the function of production export is limited by the Chequessett Neck Road Dike configuration.

Wildlife Habitat

Factors that contribute to the provision of important wildlife habitat include large, undisturbed wetlands; the presence of shallow, permanent open water of good quality; proximity to undisturbed upland wildlife habitat; a high degree of interspersion of vegetation classes; a high degree of species and structural diversity within the vegetational community; high vegetation density; and the presence of wildlife food plants. Wetlands that are contiguous to other wetland areas may serve as travel or migratory corridors for wetland wildlife.

Even in its existing degraded state, the Herring River floodplain contains diverse habitats for a wide array of bird, mammal, reptile, and amphibian species. However, not undertaking the proposed project would result in the continued degradation of the Herring River estuary including continued encroachment of invasive plant species; loss of native plant communities and wildlife habitats; adverse impacts to water quality and associated effects to aquatic biota and associated water-dependent wildlife; and loss of natural wildlife habitat functions provided by the estuary.

Several high priority salt marsh- and tidal creek-dependent avian species are anticipated to benefit directly through restoration of nesting and/or foraging opportunities in the Herring River. Tidal restoration would also restore wetland and open-water habitats for resident and migratory waterfowl and shorebirds. Existing shrublands and woodlands dominated by upland vegetation, habitats widely used by generalist resident and migrating passerine species, would be reduced and replaced by tidally influenced brackish and freshwater marsh which would likely increase the amount and quality of habitat for wetland dependent avian species. Generalist populations would persist in the abundant uplands surrounding the project area and at the wetland/upland edge where some shrub thickets and relic tree stands would remain as suitable habitat after restoration.

Similarly, it is anticipated that adequate habitat elements (e.g., suitable food, cover, and den sites) would remain for most mammalian species as a result of tidal restoration. Initial restoration would result in gradual flooding of existing habitat and landward migration of many mammalian species. Affected species would likely readjust to the restored salt marsh system and shift their local range within and adjacent to the river and its floodplain. Eventual habitats for voles, mice, and other rodents would be expanded. As tidal restoration progresses, many mammals would continue to forage on the invertebrates, fish, and marsh vegetation and would continue to use surrounding wooded uplands for den sites and refugia. Increased tidal range and salinity coupled with restored marsh habitat may provide long-term benefits with improved water quality, more abundant and diverse prey species, and a more open, expansive habitat structure for mammals.

The Herring River floodplain also provides habitat for a variety of reptiles and amphibians such as snapping and spotted turtles and northern water snake. These species generally inhabit the freshwater areas upstream of High Toss Road but can also survive in brackish water and salt marsh habitats. Amphibians, such as green and wood frogs, Fowlers toad, and spotted salamander, generally are not present within high salinity portions of coastal environments and are more commonly found in the upper reaches of most sub-basins and in upland transitional habitats. Increases in tidal range and salinity associated with restoration may, in the short term, limit and disrupt reptile and amphibian breeding, foraging, and nesting in lower areas of the floodplain. However, these areas are less likely to be occupied initially and restoration will proceed at a gradual pace, allowing any affected populations to relocate to suitable habitat. In the long term, these populations are anticipated to shift and adjust their ranges with no significant declines in species diversity or abundance.

Uniqueness / Heritage / Listed Species

The Uniqueness/Heritage function includes the consideration of science, the endangerment of the wetland, and the importance of the wetland in the context of its local and regional environment. The wetland may contain areas of archaeological, historical, or social significance or it may represent the last fragment of its wetland type in an urbanized or agricultural environment. The presence of relatively scarce wetland habitats or wetland species contributes to the Uniqueness/Heritage function provided by the wetland. Areas containing Estimated Habitats of Rare Wildlife (Estimated Habitat) or Priority Habitats of Rare Species (Priority Habitat) mapped by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) and/or federally-protected species confer a higher value in this category.

The Herring River is the largest tidal river and estuary complex on the Outer Cape and for that reason alone it is considered to provide this function. The restoration project as a whole would substantially improve this function by returning this important coastal ecosystem to a self-sustaining estuarine floodplain. With regard to listed species habitat, the restoration of tidal flow would increase salinity and inundation, resulting in changes to vegetation and ultimately wildlife species and their habitats. Tidal marsh restoration would likely allow for the recolonization of the protected diamondback terrapin in the Herring River. Changes in vegetation types would reduce the value of the wetland system for species that rely on habitats that are less salt-tolerant protected species, such as the Northern harrier, eastern box turtle, and water willow stem borer.

Restoration of the Herring River estuary could impact pre-contact and post-contact archeological sites, primarily associated with construction activities, as well as any other ground-disturbing activities, including borrow or construction staging areas. Although there are no listed historic structures in the Herring River estuary, a dike was located across Mill Creek near the confluence with the Herring River likely as part of a historical gristmill. Some low-lying structures may need further evaluation for historic significance. The precise location and extent of effects to archaeological sites cannot be fully identified at this time, as the design process is still ongoing, and the locations of ground-disturbing activities are not yet finalized. As these locations and actions are identified, potential impacts to archaeological sites will be assessed and any effects would be resolved through implementation of the Programmatic Agreement under Section 106 of the National Historic Preservation Act of 1966.

Recreation (Consumptive / Non Consumptive)

Wetlands designated as having recreational value are classified based on the suitability of the wetland and associated watercourses to provide opportunities such as hiking, canoeing, boating, fishing, and hunting, among others. Consumptive opportunities, such as fishing and hunting, consume or diminish the plants, animals, and/or other resources that are intrinsic to the wetland. Non consumptive opportunities do not diminish these resources of the wetland.

Numerous opportunities for public recreational activities, such as boating, fishing, and wildlife viewing, currently exist in the Herring River estuary. There are many recreational access points within the estuary, including parking areas, viewing locations, boat landings, and trailheads. Under the restoration project, this value would be enhanced through better access accommodations and improved habitat conditions. Both shellfishing and finfishing are important recreational activities throughout Wellfleet and outer Cape Cod and are an integral component of the region's natural and cultural history. Removal of the tidal restriction caused by the dike would dramatically improve habitat for the full range of fish species formerly found in the estuary and provide a corresponding improvement to the recreational fishery. Additionally, improvements to estuarine habitat and connectivity within Wellfleet Harbor would also improve the near shore fishery in Cape Cod Bay. The proposed project is anticipated to provide long-term benefits to shellfish populations and potentially provide increased opportunities for the harvesting of shellfish.

10.SHORT AND LONG-TERM DIRECT ADVERSE IMPACTS TO WETLANDS

Implementation of the preferred alternative includes construction of two dikes to control tidal exchange in the Herring River floodplain, elevation or relocation of several road sections, installation of new culverts at road crossings in upstream project areas, and relocation or filling in place portions of the CYCC golf course. The various restoration actions would result in short-term impacts and, in some cases, include a direct and permanent adverse impact to wetlands occurring within or adjacent to construction areas.

Construction activities would result in soil disturbance and loss of vegetative cover in the construction area. Heavy equipment may also be used in management of large wood debris during the adaptive management phase of the plan. This disturbance could lead to temporary adverse effects to water quality during stormwater runoff events. However, best management practices (BMPs) would be implemented to limit sediment movement and protect water quality. Areas of temporary disturbance, such as access roads and equipment and material staging areas, would be returned to natural grade and seeded with native vegetation.

Areas of disturbance that would persist after completion of the adaptive management phase include the areas occupied by (footprint of) infrastructure. As demonstrated in table 6, the expected footprint of the Chequessett Neck Road Dike, Mill Creek Dike, and road realignment actions (under alternative D) would result in up to 12.1 acres of long-term vegetation/wetland disturbance. This represents approximately one percent of the total restoration project area.

Secondary restoration actions are those needed to maximize the effects of restoring tidal flood beyond rebuilding the Chequessett Neck Road Dike and increasing tidal range. They include but are not limited to direct vegetation management, sediment management, channel improvements, and planting vegetation. Specific impacts associated with any of these actions cannot be quantified but are expected to include work within wetland areas to remove trees and shrubs, dredge and/or deposit sediment, excavate or fill channels, and other actions to maximize tidal circulation and hasten the recovery of native estuarine habitats. Some actions would include access for heavy equipment and similar wetland impacts. These activities would be similar to those of many regional mosquito control programs implementing Open Marsh Water Management or Integrated Mosquito Management in New England salt marshes.

Table 6 summarizes the predicted acreage of short-term and long-term direct impacts. For a discussion of potential adverse effects on water and sediment quality, see page 22, Impacts to Water and Sediment Quality.

TABLE 5. SHORT AND LONG-TERM DIRECT WETLAND DISTURBANCE

Location	Short-term Disturbance	Long-term Disturbance	Note
Chequessett Neck Road Dike	**2.40 acres** Construction footprint for coffer dam, dewatering, etc.	**1.00 acre** Up to 800 linear feet of intertidal (E2UB/EM) and sub-tidal (E1UB) habitat loss (estimate up to one acre).	Final dike design will determine total acreage.
Mill Creek Dike	**2.40 acres** Construction footprint for coffer dam, dewatering, etc.	**0.29 acres** Up to 12,500 square feet of estuarine (E2EM1) and palustrine (PEM/ PSS) wetland loss.	Final dike design will determine total acreage..
High Toss Road	**0.50 acres** Approximately 20 feet width of disturbance along 1,000 foot length of causeway.	**0.30 acres** Up to 13,000 square feet (0.30 acres) palustrine wetland (PEM/ PSS) loss if elevated; Up to 12,000 square feet (0.28 acres) gain in estuarine wetland (E2EM1) if removed.	Option to elevate used for acreage estimate for all alternatives.
Pole Dike/Bound Brook Island Roads	**2.85 acres** Construction corridor of approximately 20 feet along 6,200 linear feet adjacent to vegetated wetlands.	**2.27 acres** Up to 99,000 square feet (2.27 acres) palustrine wetland (PEM/ PSS) loss to elevate above coastal storm surge; 2,300 square feet (just over 0.05 acre) lost to elevate to annual high water.	Independent of alternatives. Option to elevate above coastal storm surge used for estimate.
CYCC Golf Course		**8.25 acres** Up to 360,000 square feet wetland loss to elevate and flood proof golf course. Most of this loss is existing maintained golf course classed as Palustrine wet meadow.	Applies to alternatives B and D
Residential Flood Proofing		To be determined with input from landowners, but could include fill, berms, or walls. Assumed to be negligible in terms of acreage.	
Secondary Restoration Actions	Specific impacts cannot be identified or quantified at this time, but are expected to include work within wetland areas to remove trees and shrubs, dredge and/or deposit sediment, excavate or fill channels, and other actions to maximize tidal circulation and restoration; could include access by heavy equipment for some restoration actions.		
Total Disturbance Area	**8.2 acres** Predicted temporary vegetation/wetland disturbance. Limited additional impacts will result from vegetation removal, dredging, sediment deposition, and other secondary management actions during adaptive management phase.	**12.1 acres** Predicted long-term deep water and wetland disturbance for dike(s), road elevation, or realignment, and culvert installation.	Rounded to the tenth of an acre.

11. IMPACTS TO FLOODPLAINS

Although the proposed project would restore much of the natural tidal exchange water levels in the Herring River floodplain, any newly constructed dikes would continue to provide flood protection by meeting FEMA and other applicable agency requirements for construction and height, including freeboard. As a result, the project area would be protected from extreme floods. However, with increased regular tidal exchange comes an increase in inundation levels associated with unusual storms, which are desirable from a restoration standpoint. Under the preferred alternative, a coastal storm driven event would inundate up to an elevation of 7.5 feet in the Lower Herring River and 5.9 feet in the Mill Creek sub-basin. Water levels in the upstream sub-basins would be lower because of natural tide attenuation. Flood protection actions undertaken throughout the estuary would be designed to accommodate flooding up to these maximum tidal elevations.

Chequessett Yacht and Country Club

Five CYCC fairways and the practice area would be impacted by tidal waters and require flood proofing by elevating the low lying portions of the golf course. The current practice area would be restored to tidal wetland. This would result in filling 360,000 square feet (8.25 acres).

Low-lying Residential Properties

Hydrodynamic modeling results, aerial photography, topographic and ground survey data, and property records were used to compile a list of private properties within the project area potentially affected by restoration activities. Impacts to properties were categorized based on the frequency of tidal water reaching the property and the nature of the land or structures impacted, as summarized in table 5.

TABLE 6: LOW LYING PROPERTIES AFFECTED BY INCREASED TIDAL EXCHANGE

Impact Category	Number of Properties Affected	Description of Effect
No Effect	169	
Infrequent Effects on Natural Vegetation	54	Natural vegetation affected by tides, on average, one time per year or less frequently. Tidal influence would not be frequent enough to convert the vegetation type to salt or brackish marsh.
Frequent Effects on Natural Vegetation	8	Natural vegetation affected by daily high tides or monthly high spring tides. This would stress and kill salt-intolerant species and convert the area to salt or brackish marsh.
Both Frequent and Infrequent Effects on Natural Vegetation	83	Parcels contain areas both above and below mean high spring tide. This would either temporarily or permanently stress salt-intolerant species to some extent.
Infrequent Effects on Cultivated Vegetation	1	Cultivated, landscaped vegetation affected, on average, one time per year or less frequently. Some species could be temporarily stressed, but would likely recover and persist.
Frequent Effects on Cultivated Vegetation	0	Cultivated, landscaped vegetation (affected by daily high tides or monthly high spring tides. This would occur frequently enough to stress and kill salt-intolerant species and convert the area to salt or brackish marsh.
Both Frequent and Infrequent Effects on Cultivated Vegetation	1	Parcels contain areas both above and below mean high spring tide. This would either temporarily or permanently stress salt-intolerant species to some extent.
Infrequent Effects on Structures	9	Buildings, driveways, private lanes, wells, and septic systems affected, on average, one time per year or less frequently. The

Impact Category	Number of Properties Affected	Description of Effect
		potential for impacts would only occur during the highest predicted tide of the year or during coastal storm events.
Frequent Effects on Structures	11	Buildings, driveways, private lanes, wells, and septic systems affected, on average, by daily high tides or up to monthly high spring tides.

The NPS and HRRC are working with individual landowners to determine site-specific mitigation needs. Specific measures have not been identified at this time and cannot be quantified. It is anticipated that some of these actions would include the construction of small berms or walls, adding fill to a low area, and relocating a well or septic system to higher ground. Implementation of any of these measures would occur with close consultation of the landowners and would be subject to the regulatory review strategy and the Adaptive Management Plan.

12. COMPLIANCE

Compliance with Section 404 off the Clean Water Act and Section 10 of the Rivers and Harbors Act

Several components of the Herring River Restoration Project would include unavoidable impacts to wetlands under federal jurisdiction, primarily by the discharge of fill into waters of the United States. These actions include but are not limited to the reconstruction of the Chequessett Neck Road Dike, potential construction of a dike at Mill Creek, work to elevate or otherwise flood-proof low-lying roadways, and potentially fill low-lying areas of the CYCC golf course. Given the nature and extent of these impacts to wetlands under USACE jurisdiction, it is anticipated that compliance under Section 404 and Section 10 would require the filing of an Individual Permit verses being eligible for review under a Massachusetts General Permit. A permit application for the discharge of dredged and/or fill material in waters of the United States is evaluated using the Environmental Policy Act’s (EPA) Section 404(b) (1) guidelines. These guidelines are designed to avoid unnecessary filling of waters and wetlands. For the guidelines to be satisfied:

- There must be no practicable alternatives available which would have less adverse impact on the aquatic ecosystem and which do not have other significant adverse environmental consequences;
- The activity must not violate federal or state water quality standards or threaten a federally-listed endangered species;
- There must be no significant degradation of water and wetlands; and
- All reasonable steps must be taken to minimize adverse effects to the aquatic environment.

Action undertaken to restore the Herring River estuary will comply with the requirements of Section 404 of the Clean Water Act, Section 404(b) (1) guidelines, and Section 10 of the Rivers and Harbors Act.

Compliance with Section 401 off the Clean Water Act

Section 401 of the Federal Water Pollution Control Act of 1972 (Clean Water Act or CWA) requires that any applicant for a Section 404 (dredge and fill) permit also obtain a water quality certification from the state. The purpose of the certification is to confirm that the discharge of fill materials would comply with the state’s applicable water quality standards. Section 401 gives the authority to the states either to concur with USACE approval of a section 404 permit or to place special conditions on the approval, or deny the activity by not issuing a 401 certification. Compliance with Section 401 would be addressed through

Massachusetts 310 CMR Wetlands Protection Regulations and Consultation and Water Quality Certification prior to the implementation of project construction.

Compliance with the Coastal Zone Management Act of 1972, as amended

The Commonwealth of Massachusetts' Office of Coastal Zone Management implements the Coastal Zone Management Act (CZMA) through the Coastal Zone Management Policy Guide (October 2011) – the current official statement of the Massachusetts coastal program policies and legal authorities. Under the CZM program, all MEPA projects are reviewed for consistency with the management principles of CZM, which are intended as guidance for any activities proposed in the Coastal Zone. The overall goal of coastal zone management is to protect coastal resources from contamination or degradation, prevent the creation of coastal hazards, and maximize the public use and benefit of coastal areas. Compliance with the Massachusetts CZM will be achieved through review of this final EIS/EIR chapter 5 (see section 5.3.5).

13. CONCLUSION

Wetlands

The Preferred Alternative to restore the Herring River estuary is consistent with NPS policies to protect and improve wetland habitats in our nation's national park units, as expressed in NPS Procedural Manual 77-1: Wetland Protection and EO 11990: Protection of Wetlands. Specifically, the Preferred Alternative (D) for the Herring River Restoration project would 1) result in a net gain of wetland acreage, 2) improve wetland function within the project area, and 3) minimize adverse wetland impacts to those that are unavoidable.

Net Gain in Wetland Acreage

The Preferred Alternative would result in a transition in wetland types from non-tidal wetlands to intertidal wetlands (Table 3). Increasing the tidal range within the estuary would convert 8 acres of open water (E1AB) and 33 acres of upland (UPL) to intertidal marsh (E2EM1). In addition, increased tidal range would cause a shift in wetland types from woodlands (PFO), shrubland (PSS) and non-tidal marsh (PEM) to intertidal marsh (E2EM1). Together these conversions would increase intertidal wetlands (E2EM1) by 634 acres, which is the primary restoration objective. Of the 1006 acres in the project area, a total of 41 acres is predicted to shift from non-wetland NWI classes to wetland NWI classes.

However, some temporary and permanent disturbance would also occur (Table 5). In the short term, a total 8.2 wetland acres would be disturbed as a result of coffer dam construction, dewatering, and other construction activities. Following construction, all of these areas would be restored to functioning wetland. Approximately 12.1 wetland acres would be permanently lost in order to construct dikes, elevate roads, and elevate portions of the golf course. The net gain in wetlands is therefore approximately 28.9 acres when considering both the large scale restoration effects (Table 3) and the site-specific construction effects (Table 5). The NPS finds that this project meets the agency's "no net loss of wetlands" policy as well as its goal of long-term wetland gains across the national park system (NPS Management Policies Section 4.6.5).

Improved Wetland Function

The Preferred Alternative would result in improvement in seven out of eight wetland functional areas: 1) Fish and Shellfish Habitat, 2) Sediment/Toxicant Retention, 3) Nutrient Removal/Retention/Transformation, 4) Production Export, 5) Wildlife Habitat, 6)

Uniqueness/Heritage/Listed Species, and 7) Recreation. Improved fish passage would benefit fish species, including anadromous and catadromous species. Higher salinity upstream of the new Chequessett Neck Road dike would increase shellfish habitat. Water quality would generally be improved by increased flushing, nutrient flows would return to a more natural state, and monitoring would focus on potential limited adverse effects, such as continued low dissolved oxygen concentration, temporary nutrient releases from acid sulfate soils, and temporary elevated fecal coliform levels. Wildlife habitat for diverse wetland species would be improved, particularly for salt-marsh dependent species. The restored wetland as a whole would improve wetland function, since these types of estuaries were commonly diked and drained, and fully functioning systems of this kind are therefore rare. Finally, increased environmental quality and access to the restored estuary would improve function for recreation. The function in terms of floodflow alteration is primarily for protection of downstream conditions, and therefore is less relevant to the Herring River system than the other wetland functions. The project can be viewed as neutral in regards to this wetland function. Overall, the Preferred Alternative achieves these functional improvements across a larger number of wetland acres than the other alternatives that were evaluated. For a full discussion, see page 16, Impacts to Wetland Functions and Values.

Minimize Adverse Wetland Impacts

Dike construction at the mouths of the Herring River and Mill Creek and other flood mitigation measures in the estuary would result in long-term loss of up to 12.1 acres of wetland habitat (Table 6). In addition, construction activities would result in up to 8.2 acres of short-term wetland disturbance. However, there is no practical means to avoid these short and long- term impacts, since new dike construction is required if tide range is to be increased in the estuary, and flood proofing measures are necessary to mitigate adverse impacts to low-lying roads and properties. Compliance with Clean Water Act and other permit terms and the use of best management practices will avoid or mitigate adverse impacts to wetlands and water quality during and after construction. While the Preferred Alternative involves the construction of two dikes, and thus would result in a larger permanent infrastructure footprint than Alternative B (and the same as Alternative C), it also results in the largest increase in wetland acreage and the greatest improvement in wetland function, and is therefore best fulfills the purpose of EO 11990: Protection of Wetlands.

Floodplains

The project to restore the Herring River salt marsh habitats is consistent with the NPS policy to protect floodplain functions and avoid adverse impacts associated with floodplain occupancy and modification, as expressed in EO 11988: Floodplain Management and NPS Procedural Manual 77-2 Floodplain Management.

The project would increase regular tidal inundation across approximately 90 percent of the former Herring River tidal estuary. In addition, storm surges would reach higher elevations (7.5 feet in the Lower Herring River than under current conditions (2.1 feet in the Lower Herring River), restoring a portion of the high water events that are important for floodplain functions.

However, full inundation of the historic 100-year floodplain is not practicable because of existing development in the floodplain. Up to 336 properties may be contacted by elevated tidewaters (see table 5); 169 would experience no effects to structure or landscape; 145 would experience impacts to natural vegetation; 2 would experience impacts to cultivated landscapes; and 20 would experience structural impacts. Impacts to properties were categorized based on the frequency of tidal water reaching the property and the nature of the land or structures impacted. The NPS and HRRC are working with individual landowners on a case-by-case basis to determine site-specific flood mitigation measures. Flood risk from unusually high storm driven tides would be limited by new and reconstructed dikes.

REFERENCES

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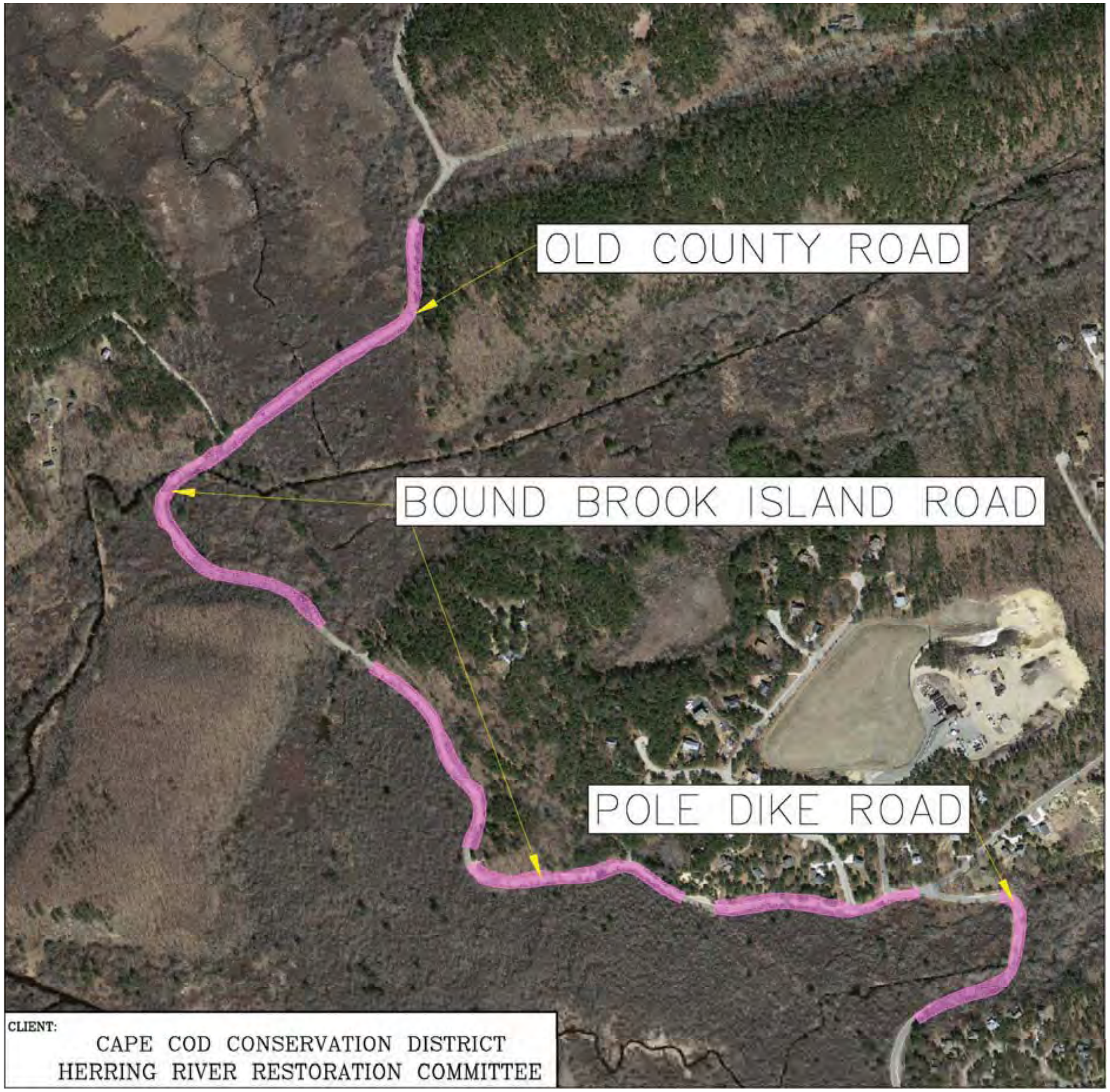
APPENDIX H: LOW LYING ROADS REPORTS

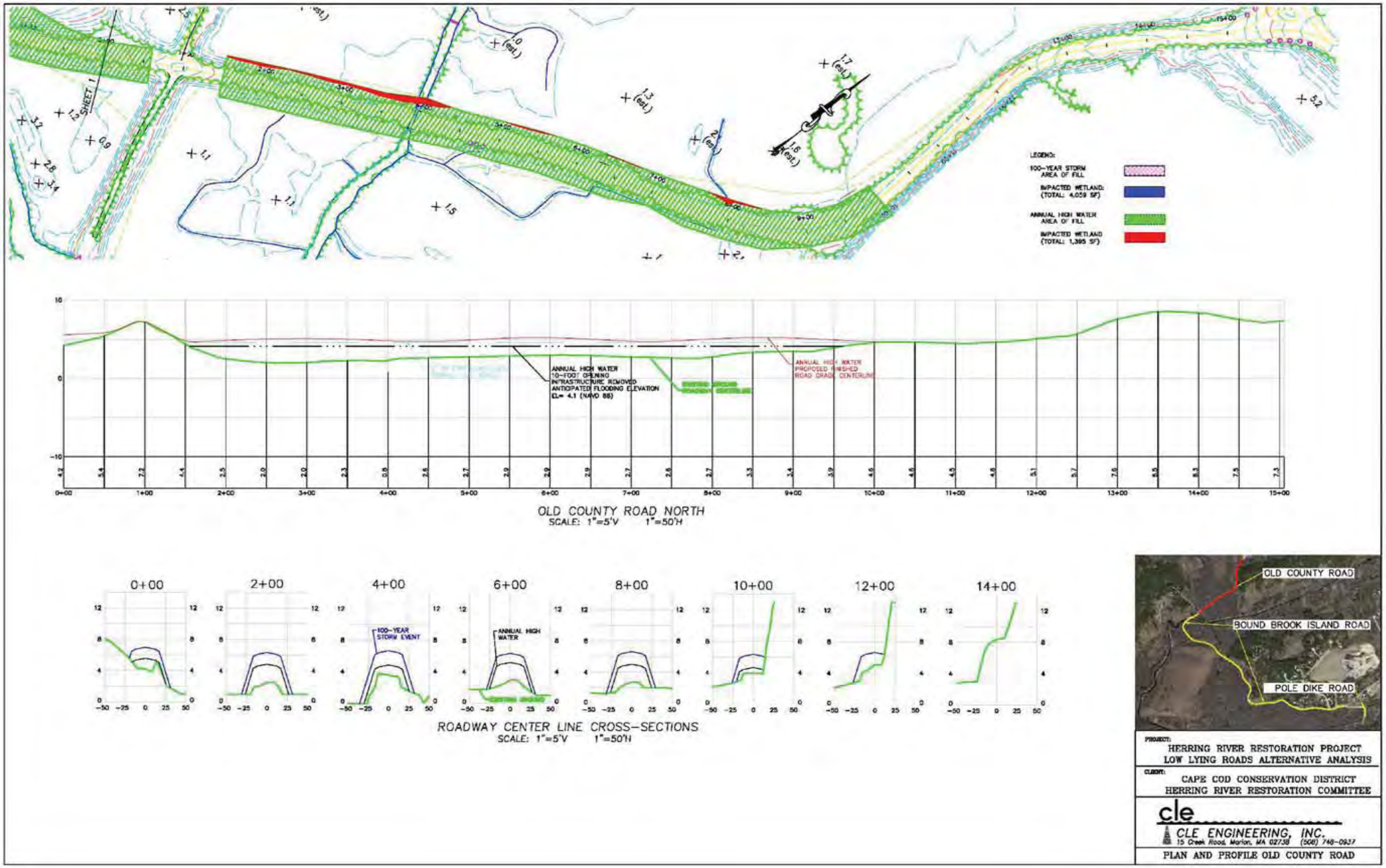
HERRING RIVER RESTORATION PROJECT
LOW LYING ROADS ALTERNATIVE ANALYSIS
ANNUAL HIGH WATER EVENT

HERRING RIVER RESTORATION PROJECT
LOW LYING ROADS ALTERNATIVE ANALYSIS
100 YEAR STORM EVENT

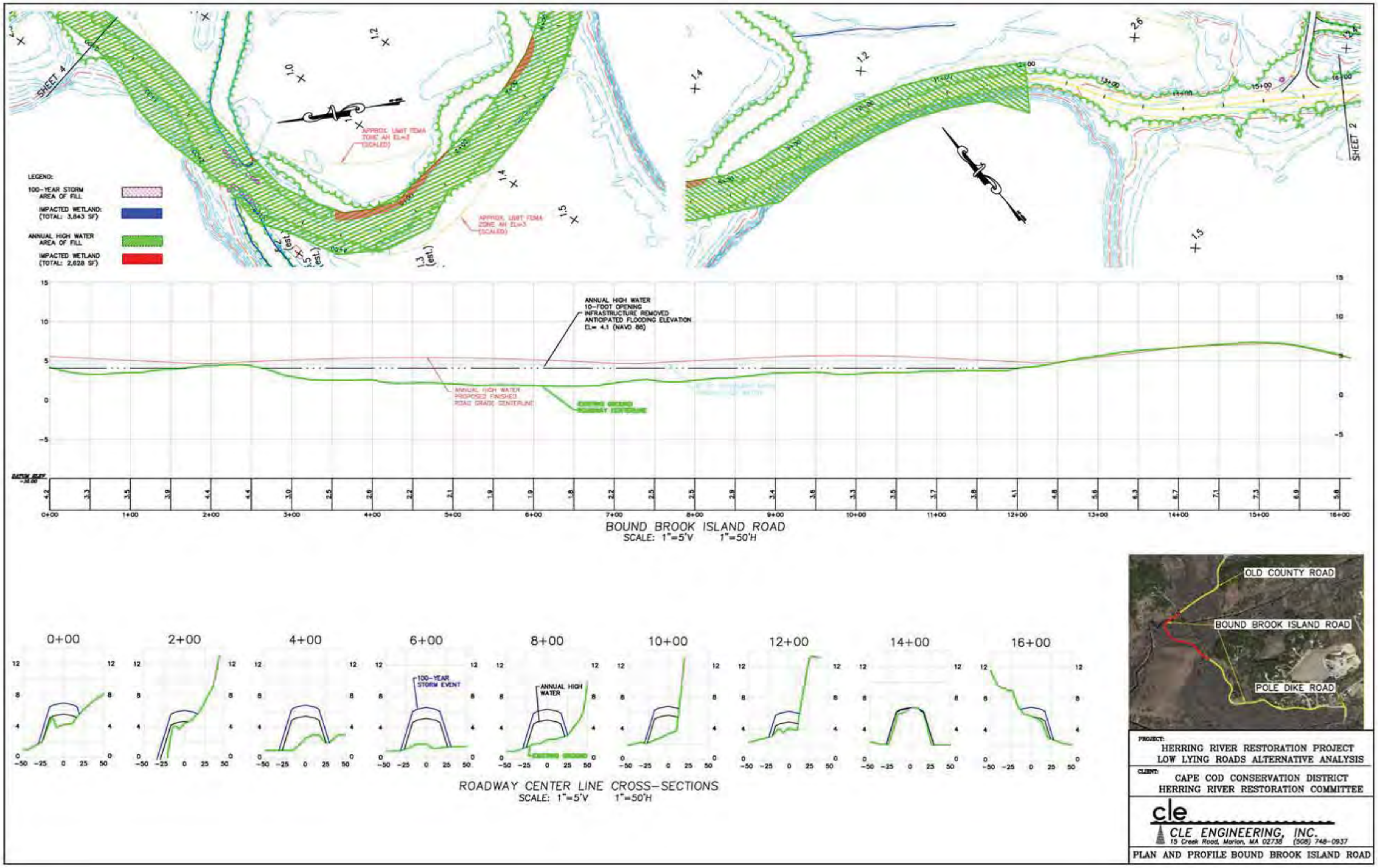


CLIENT:
CAPE COD CONSERVATION DISTRICT
HERRING RIVER RESTORATION COMMITTEE

Old County Road
Annual High Water Conditions



Bound Brook Island Road Annual High Water Conditions (1 of 3)



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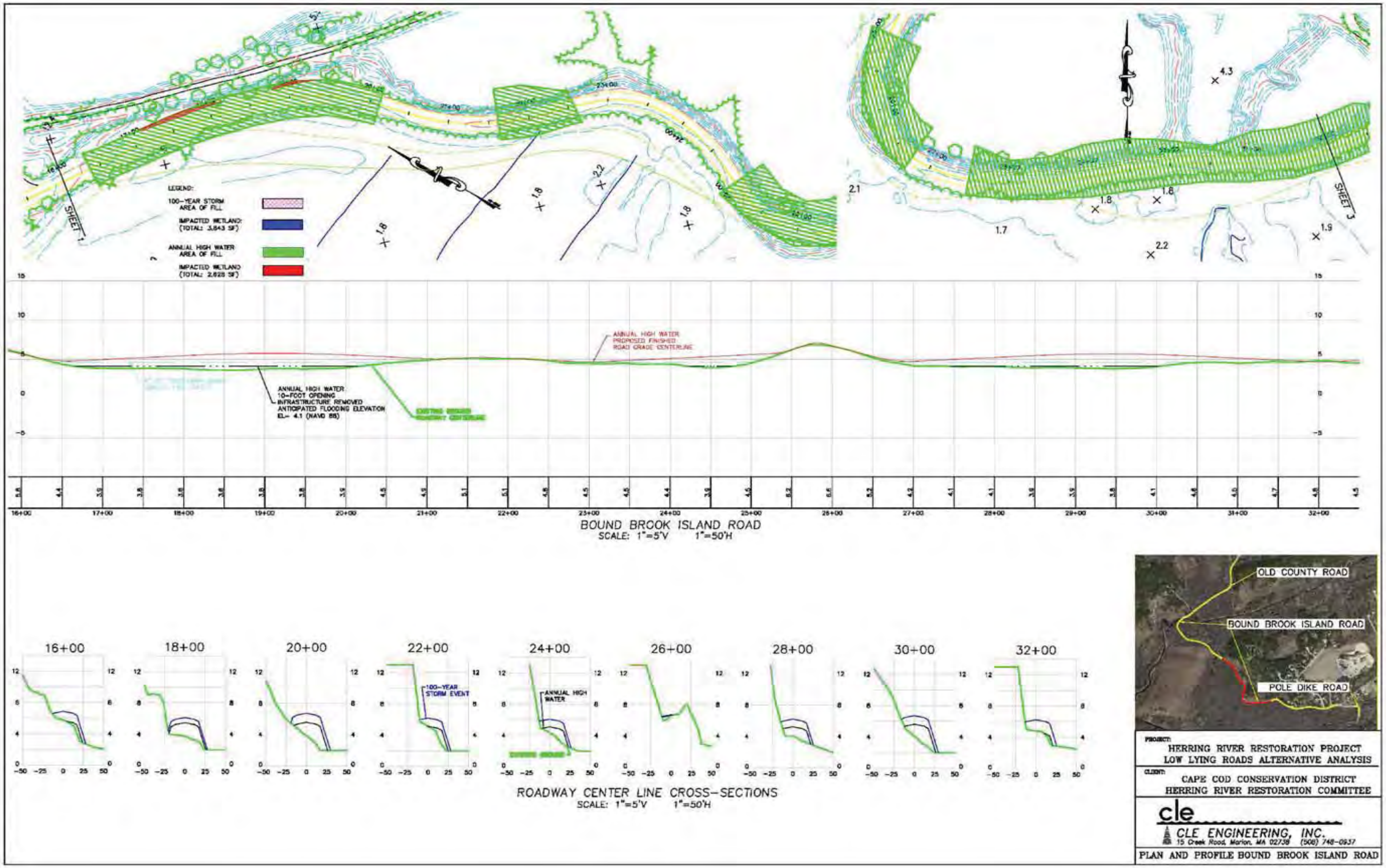
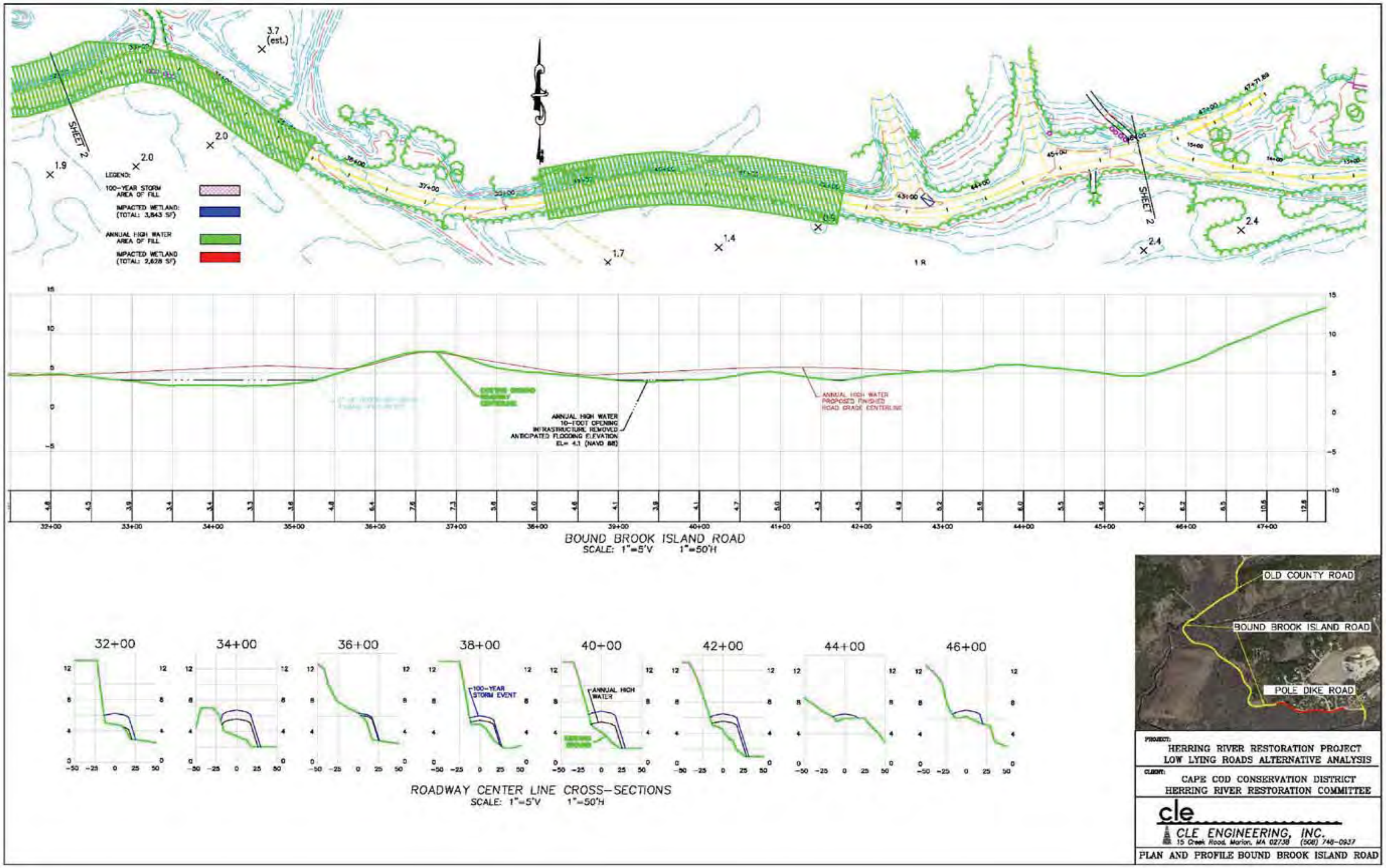
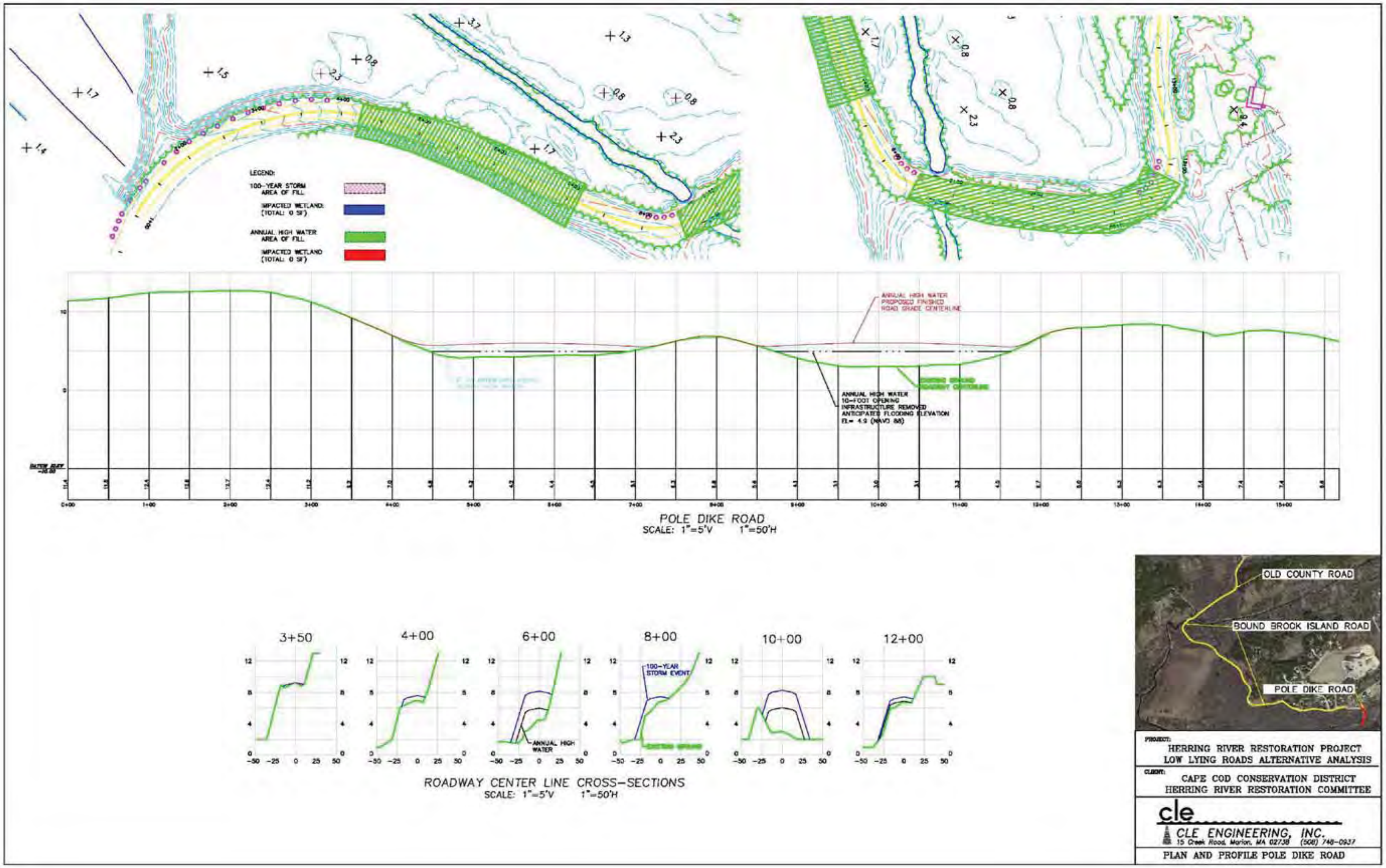
Annual High Water Conditions (2 of 3)



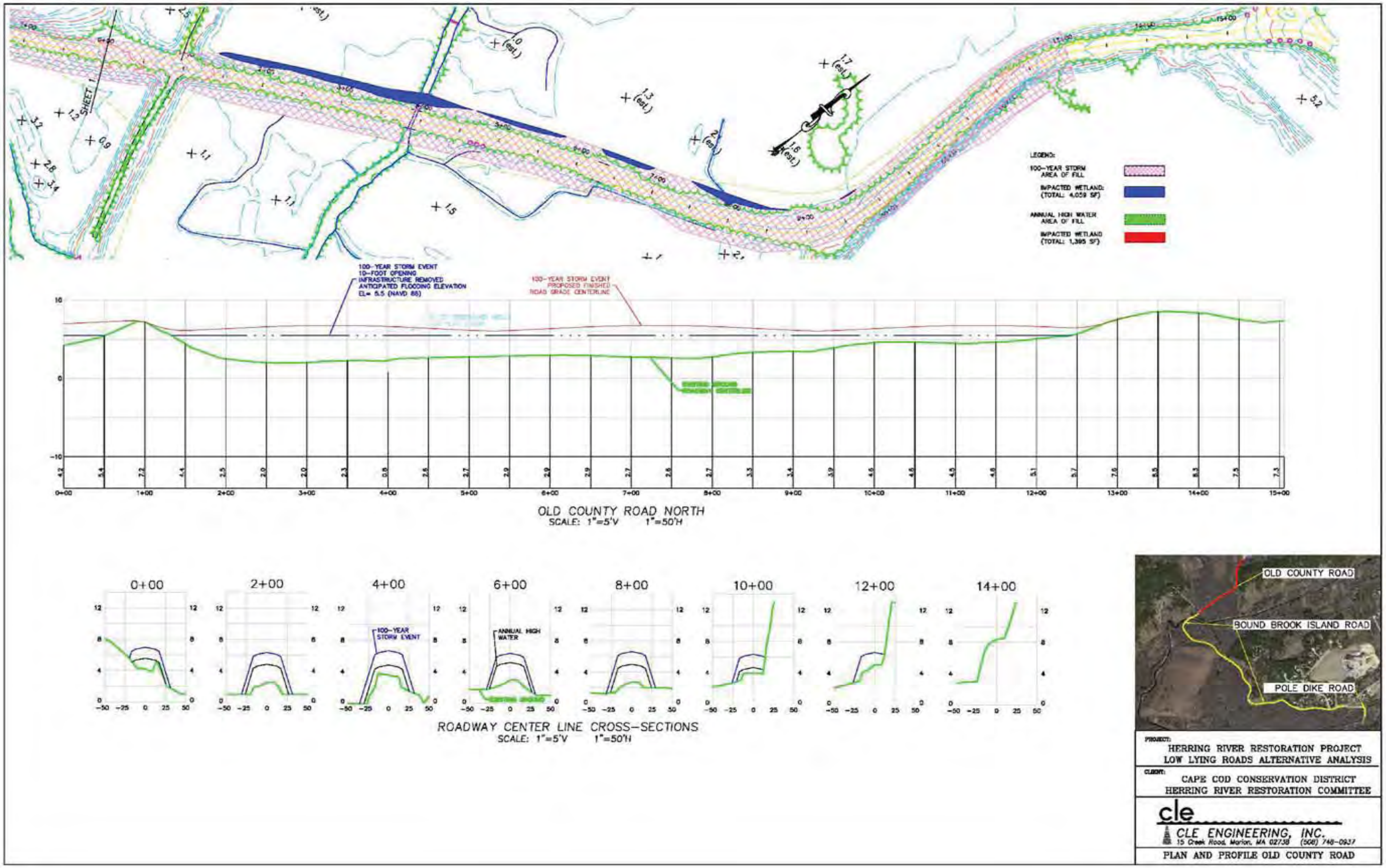
Bound Brook Island Road
Annual High Water Conditions (3 of 3)



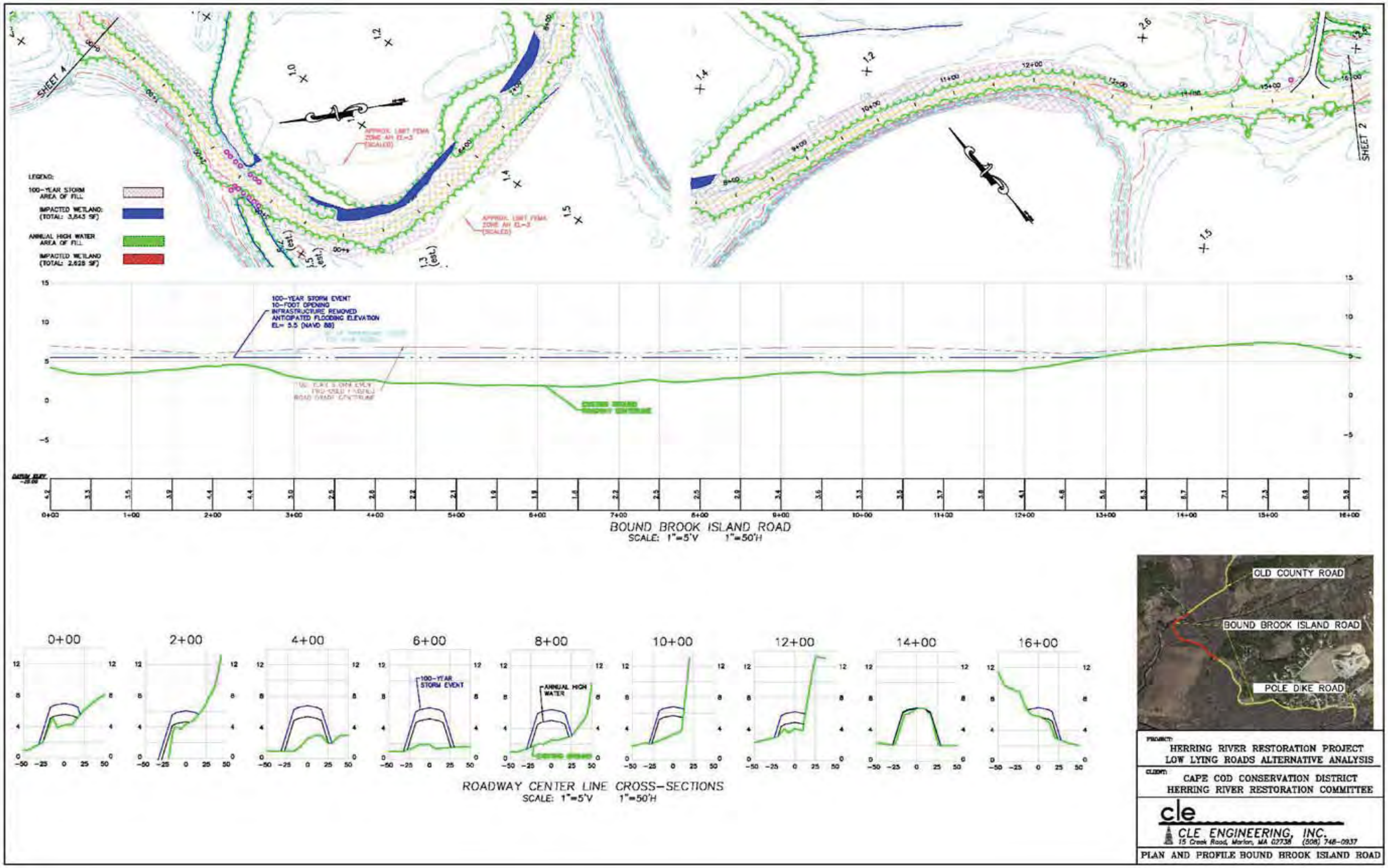
Pole Dike Road
Annual High Water Conditions



Old County Road
100-Year Storm Conditions



Bound Brook Island Road
100-Year Storm Conditions (1 of 3)



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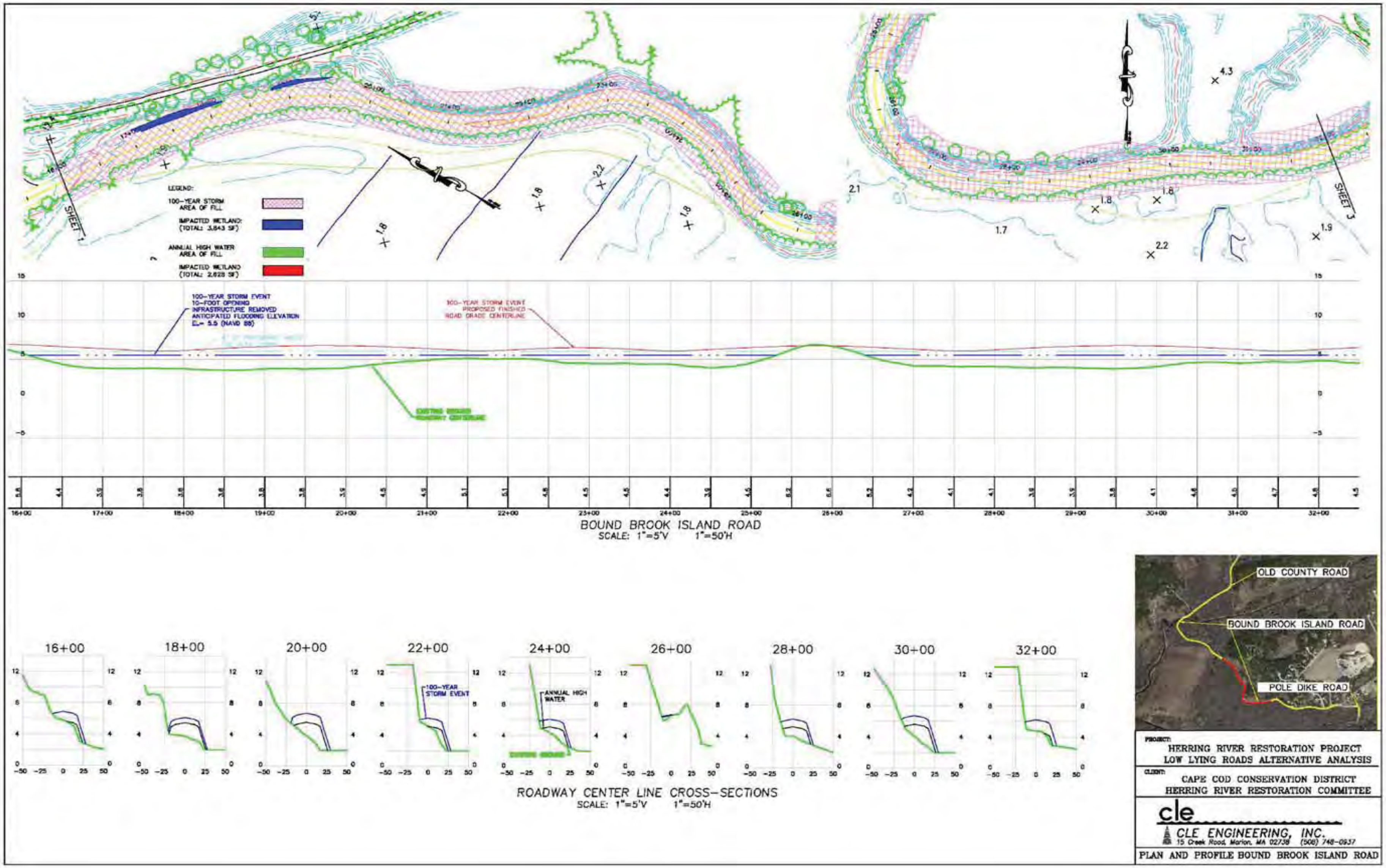
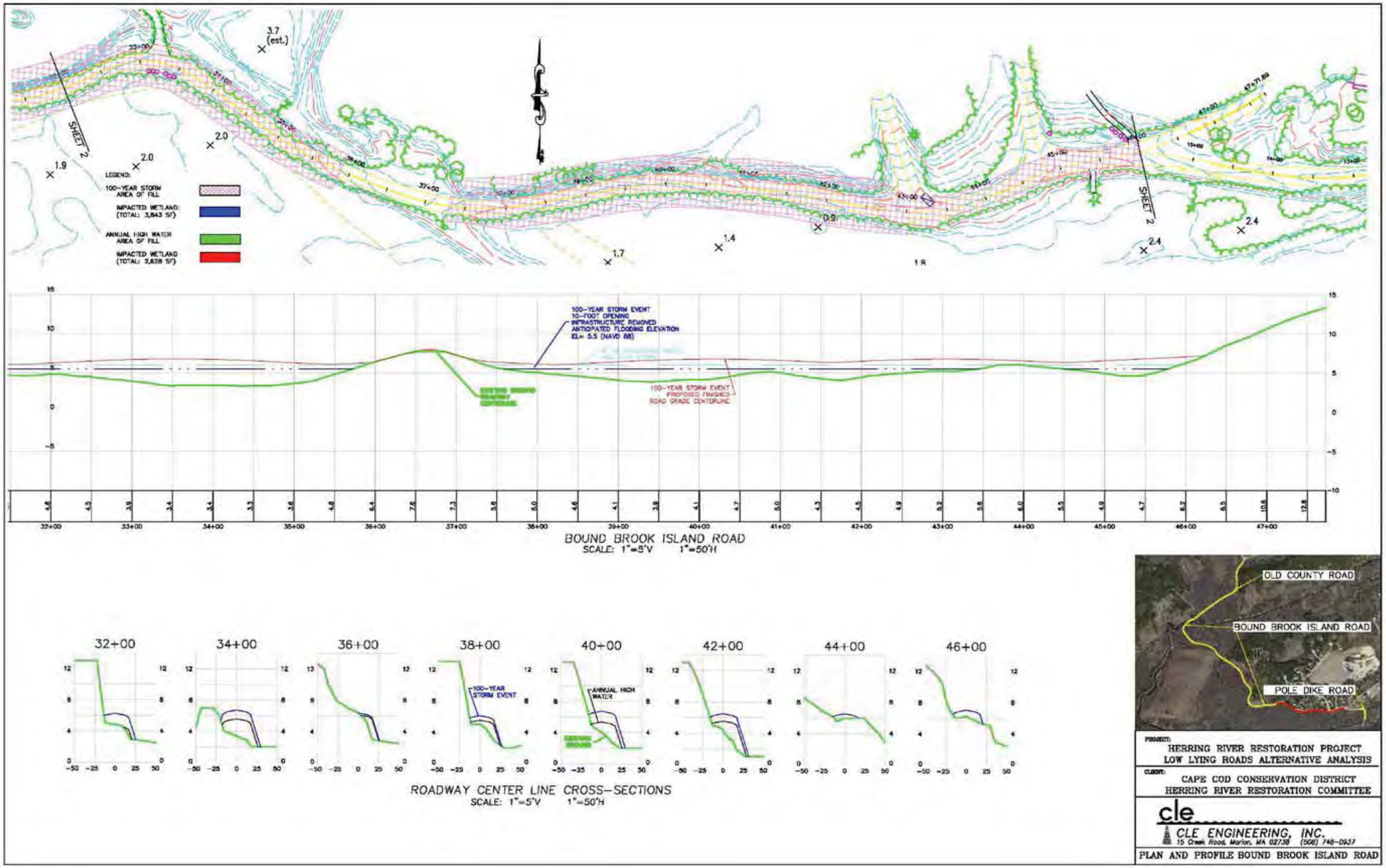
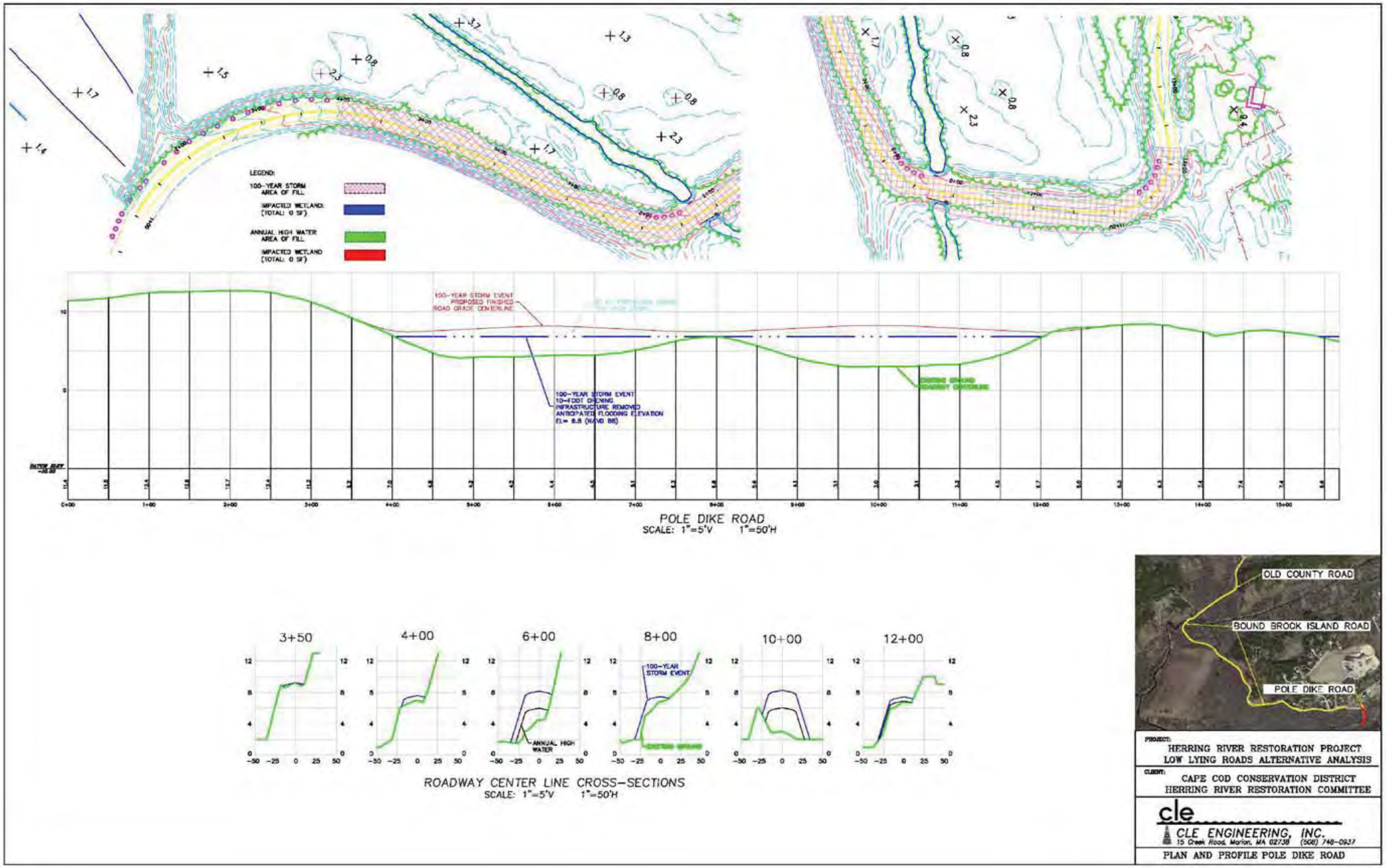
100-Year Storm Conditions (2 of 3)



Bound Brook Island Road
100-Year Storm Conditions (3 of 3)



Pole Dike Road
100-Year Storm Conditions



DRAFT COST COMPARISON

Roadway	**Annual 3' gate**	**Annual 10' gate**	**100 Year 3' gate**	**100 Year 10' gate**
Old County Rd.	$690,000	$730,000	$860,000	$965,000
Bound Brook Island Rd.	$2,030,000	$2,165,000	$2,310,000	$2,600,000
Pole Dike Rd.	$610,000	$620,000	$665,000	$730,000
TOTAL	$3,330,000	$3,515,000	$3,835,000	$4,295,000

Herring River Restoration Project Engineering Design to Elevate Low-Lying Roadways and Replace Associated Culverts Truro and Wellfleet, Massachusetts

PREPARED FOR: FRIENDS OF HERRING RIVER

PREPARED BY: THE LOUIS BERGER GROUP, INC.
166 VALLEY STREET, BUILDING 5
PROVIDENCE, RHODE ISLAND 02909

JUNE 2015

Volume I: Comprehensive Report

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Appendix A	Wetlands Information
Appendix B	Basis of Design Report
Appendix C	Geotechnical Report
Appendix D	Preliminary Opinion of Construction Cost
Appendix E	Meetings and Communications

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1.0 Introduction

Louis Berger was contracted by the Friends of Herring River (FHR) to complete the Engineering Design to Elevate Low-lying Roadways and Replace Associated Culverts Planning along several segments of roadway located in Wellfleet and Truro, Massachusetts. Louis Berger has completed the following tasks under this contract:

- Task 1: Review Existing Background Materials and Attend Kick-off Meeting
- Task 2: Develop Existing Conditions Plan
- Task 2A: Wetland Delineation
- Task 2B: Conduct Site Survey
- Task 3: Develop Preliminary (25%) Design for Replacement of Existing Culverts
- Task 4: Conduct Geotechnical Investigations
- Task 5: Prepare Preliminary (25%) Roadway Design Plans
- Task 6: Develop Traffic Management Analysis
- Task 7: Support Meetings and Communication

This report is part of Task 8 (Reporting), and provides the FHR a comprehensive document on the segments analyzed that includes all of the work completed to date as part of Tasks 1 through 7. This report describes the existing property conditions, including wetland delineation and site survey, preliminary design plans for culverts and roadways, geotechnical investigation, traffic management, and project meetings and communication. Survey work was performed by Outermost Land Survey (OLS) of Brewster, Massachusetts. Project Plans, including existing and proposed conditions, are contained in Volume II of this Report.

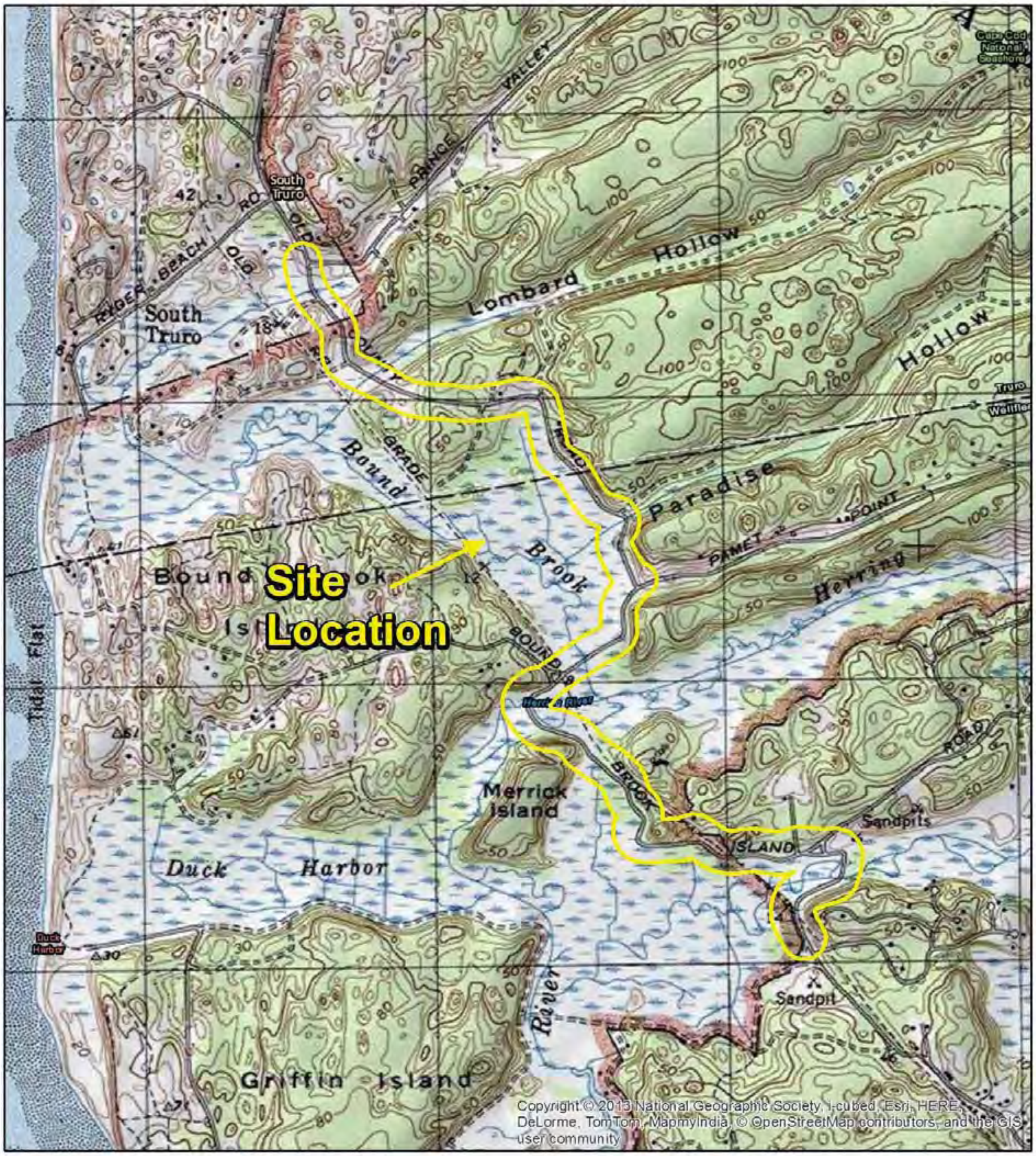
2.0 Background

The low-lying roadways investigated in this report are located in northwest Wellfleet, Massachusetts and southwest Truro, Massachusetts (see Figure 1 below). The five segments comprising the investigated roadway alignment, from south to north, are:

- Pole Dike Road (see Volume II, Sheet 7).
- Bound Brook Island Road (see Volume II, Sheets 8 – 13),
- Old County Road and Bound Brook Island Road (see Volume II, Sheet 14),
- Old County Road - Paradise Hollow (see Volume II, Sheets 15-16),
- Old County Road – Lombard Hollow (see Volume II, Sheets 16-20),

Prior to any investigations, the following documents and sources were consulted as part of the review of existing background materials:

- CLE Engineering, Inc.'s *Alternatives Analysis: Three Low-lying Roads Herring River Restoration Project Wellfleet and Truro, Massachusetts*, dated June 2011.
- National Park Service's Herring River Restoration Project *Draft Environmental Impact Statement/Environmental Impact Report*, dated October 2012.
- ENSR Corporation's Herring River Restoration Project – *Low-lying Roadways Review and Discussion*.
- Woods Hole Group's *Letter Regarding Herring River Restoration Project – Sizing of Low-lying Road Culverts*, dated January 2015.
- Woods Hole Group's *Herring River Hydrodynamic Modeling Model Report*, dated 2012.
- U.S. Department of Agriculture (USDA) Soil Conservation Service Soil Data Maps.
- Flood Insurance Rate Map, Barnstable County, Massachusetts, Map Number: 25001C0233J, dated July 16, 2014
- Flood Insurance Rate Map, Barnstable County, Massachusetts, Map Number: 25001C0231J, dated July 16, 2014
- U.S. Fish and Wildlife Service (US FWS) National Wetlands Inventory mapping.
- Massachusetts Natural Heritage and Endangered Species' *BioMap2 – Conserving the Biodiversity of Massachusetts in a Changing World – Truro*, dated 2012.
- Massachusetts Natural Heritage and Endangered Species' *BioMap2 – Conserving the Biodiversity of Massachusetts in a Changing World* – Wellfleet, dated 2012.
- Massachusetts Department of Transportation *Highway Division's Design Guide*, dated 2006.
- Massachusetts Division of Ecological Restoration's *Stream Crossings Handbook*, dated June 2012.



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Friends of Herring River

Louis Berger

Herrring River Restoration Project

Figure 1: Site Location

Source: ESRI, Berger

1 inch = 2,000 feet

May 2015

3.0 Wetland Delineation

Louis Berger conducted a wetland delineation on April 2 and 3, 2015, of the project area in Wellfleet and Truro, Massachusetts. During the field examination, Louis Berger assessed site topography, drainage patterns, soil characteristics, and hydrologic characteristics of the project area. Information provided in this report includes wetland delineation methodology, along with the hydrology, soils, wildlife, and vegetation found within the project area. Supporting documentation of the completed wetland delineation, including photographs of the project area, field data forms, and wetland delineation mapping, is included in Appendix A.

The Massachusetts Department of Environmental Protection (MassDEP) and the local Conservation Commissions implement the Massachusetts Wetlands Protection Act (WPA) (GL Ch. 131, sec. 40) and the associated Regulations (310 CMR 10.00) (the “Regulations”). Although the wetland areas adjacent to the roadways would have been regulated as coastal resource areas prior to the construction of the Chequessett Road Dike, as defined under the WPA and its Regulations, five types of inland resource areas are located in the project area, which include: Bank, Bordering Vegetated Wetland (BVW), Land Under Water Bodies and Waterways (LUW), Bordering Land Subject to Flooding (BLSF), and Riverfront Area (RF). Bank and BVW, were delineated in the field. In areas that contain a perennial stream or pond, LUW extends downgradient from Bank flags. The 200-foot Riverfront Area (RA, (310 CMR 10.58)) was not delineated in the field and is measured outward from each delineated Bank horizontally and parallel to the waterway.

3.1 Wetland Delineation Methodology

A wetland delineation to determine jurisdictional wetland boundaries of all wetlands identified within the project area was performed in accordance with the WPA and the Regulations. The project area is located adjacent to the Herring River and Bound Brook, along Pole Dike Road, Bound Brook Island Road, and Old County Road. Prior to conducting field delineation, Louis Berger reviewed U.S. Fish and Wildlife Service’s (US FWS) National Wetlands Inventory (NWI) maps for the area. Twelve NWI wetlands are mapped within the subject property.

Wetlands were delineated based on the presence of three parameters: hydrophytic vegetation, wetland hydrology, and hydric soils, as outlined in the U.S. Army Corps of Engineers (USACE) Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987), *the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region Version 2* (USACE 2012a), and the MassDEP (1995) *Delineating Bordering Vegetated Wetlands Manual* (Jackson 1995). The Routine On-site Inspection Methodology, as set forth in the 1987 USACE Manual, was employed. Wetland delineations were performed when the upper 18 inches of the soil were not frozen and there was sufficient vegetative cover to use the three-parameter approach detailed above.

The classification of wetlands and uplands was based on field observations and the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al., 1979) and Classification of the Natural Communities of Massachusetts (Swain and Kearsley, 2011).

The boundaries of the wetlands within 50 feet of the edge of the existing road were marked in the field with sequentially numbered flags, located by OLS, and plotted on a base map using North American Vertical Datum 1988 (NAVD88).[1] Project area photographs and field data sheets documenting the soil, vegetation, and hydrologic conditions are presented in Appendix A. The wetland boundaries are illustrated on the survey plans included Volume II of this report.

3.2 Project Area Ecology

3.2.1 Hydrology

The project is located within the Herring River Subwatershed (U.S. Geological Survey Cataloging Unit No. 010900020203), within the larger Cape Cod Watershed. Drainage within this subwatershed is to Wellfleet Harbor, which flows to Cape Cod Bay. Following the Cowardin system (Cowardin et al. 1979), the hydroperiods of the palustrine wetland systems delineated in the project area are classified as temporarily flooded, seasonally flooded/saturated, temporary tidal, and seasonal tidal.

3.2.2 Soils

The Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA) Web Soil Survey (Soil Survey Staff 2015) indicates that the soils within the subject property consist of five map units and three soil series. A soil series is a part of the soil taxonomy that includes order, great group, subgroup, family, and series. Soil phases are used for subdividing series into specific units that are significant for practical use and management (e.g., surface texture, slope, degree of erosion, stoniness). A mapping unit is a grouping of soils by their natural landscape and soil patterns. Most soil mapping units shown on detailed soil maps are phases of soil series. Each map unit is designated as all hydric, partially hydric, not hydric, or unknown hydric, depending on the rating of its respective components.

Of the five map units identified on the USDA maps, two types/units are classified as hydric – Freetown and Swansea mucks, and Maybid variant silty clay loam. Hydric soils are defined by the National Technical Committee for Hydric Soils as soils that are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil horizon (Federal Register 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. Therefore, hydric soils are typically found within wetlands. While hydric soils can be found within non-hydric listed soil map units, they typically comprise a smaller portion of the soil unit. The soil map units within the subject property are listed in Table 1 and described below. Soil descriptions are based on the text of the NRCS USDA Web Soil Survey.

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[1] All elevations are provided in NAVD 88 unless noted otherwise.

Table 1: Project Area Soil Characteristics

Map Unit Symbol	Soil Name	Percent Slope	Drainage Characteristics	Depth to WT (in.)	Hydric Soil
252B	Carver coarse sand	3 to 8	Excessively drained	>80	No
252C	Carver coarse sand	8 to 15	Excessively drained	>80	No
252D	Carver coarse sand	15 to 35	Excessively drained	>80	No
54A	Freetown and Swansea mucks	0 to 1	Very poorly drained	0-12	Yes
13A	Maybid variant silty clay Loam	0 to 1	Poorly drained	12-18	Yes

Source: Soil Survey Staff 2015

WT = seasonal water table

252B-Carver coarse sand, 8 to 15 percent slopes. This very deep, strongly sloping, excessively drained soil is found on small hills and ridges in areas of ice-contact deposits and on the side slopes of swales on outwash plains. Permeability is rapid in the subsoil and substratum of the Carver soil. Available water capacity is low. Depth to the seasonal high water table is more than 6 feet. This soil does not meet hydric criteria.

252C-Carver coarse sand, 8 to 15 percent slopes. This very deep, strongly sloping, excessively drained soil is found on small hills and ridges in areas of ice-contact deposits and on the side slopes of swales on outwash plains. Permeability is rapid in the subsoil and substratum of the Carver soil. Available water capacity is low. Depth to the seasonal high water table is more than 6 feet. This soil does not meet hydric criteria.

252D-Carver coarse sand, 15 to 35 percent slopes. This very deep, strongly sloping, excessively drained soil is found on small hills and ridges in areas of ice-contact deposits and on the side slopes of swales on outwash plains. Permeability is rapid in the subsoil and substratum of the Carver soil. Available water capacity is low. Depth to the seasonal high water table is more than 6 feet. This soil does not meet hydric criteria.

54A-Freetown and Swansea mucks, 0 to 1 percent slopes, ponded. This very deep, level, very poorly drained soil is found on outwash plains, moraines, and in areas of glacial lake deposits. It is in depressions and in areas adjacent to streams, ponds, and lakes. Most areas are wooded or support shrubby vegetation and are well suited to wetland wildlife habitat. The common native plant communities provide adequate food and cover for nesting areas. This soil meets hydric criteria.

13A-Maybid variant silty clay loam. This very deep, level, poorly drained soil is in low areas along the Herring River in the northwestern section of the town of Wellfleet. The soil formed in tidal marsh deposits that are no longer subject to tidal flooding and have been drained of salt water. This soil is well suited to wetland wildlife habitat and the common native plant communities provide adequate food and cover for nesting areas. Permeability is moderate to slow in the subsoil of the Maybid variant soil and slow or very slow in the substratum. Available water capacity is high. Depth to seasonal high water table is 1.0 to 1.5 feet. This soil meets hydric criteria.

3.3 Wildlife

Wildlife species observed during this field investigation were recorded based on direct sightings, calls heard, or the presence of scat, droppings, or tracks. All observed wildlife species during the wetland delineation are listed in Table 2.

Table 2: Wildlife Observed in Project Area

Common Name	Scientific Name
Birds	
American crow	*Corvus brachyrhynchos*
American tree sparrow	*Spizella arborea*
Baltimore oriole	*Icterus galbula*
Barn swallow	*Hirundo rustica*
Black-capped chickadee	*Poecile atricapilla*
Blackburnian warbler	*Setophaga fusca*
Blue jay	*Cyanocitta cristata*
Canada goose	*Branta canadensis*
Cedar waxwing	*Bombycilla cedrorum*
Common grackle	*Quiscalus quiscula*
Dark-eyed junco	*Junco hyemalis*
Downy woodpecker	*Picoides pubescens*
Gray catbird	*Dumetella carolinensis*
Herring gull	*Larus argentatus*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Northern cardinal	*Cardinalis cardinalis*
Northern mockingbird	*Mimus polyglottos*
Red-winged blackbird	*Agelaius phoeniceus*
Tree swallow	*Tachycineta bicolor*
Turkey vulture	*Cathartes aura*
White-throated sparrow	*Zonotrichia albicollis*
Herpetiles	
Eastern box turtle	*Terrapene carolina carolina*

Common Name	Scientific Name
Green frog	*Rana clamitans melanota*
Mammals	
Striped skunk	*Mephitis mephitis*
White-tailed deer	*Odocoileus virginianus*

3.4 Vegetative Communities

The project area consists of three wetland cover types, eight water regimes/special modifiers, and one upland cover type. The wetland cover types observed in the project area include palustrine forested wetland, palustrine scrub-shrub wetland, and palustrine emergent wetland. Water regimes and special modifiers identified in the project area include the following list:

- PFO1A - Palustrine forested wetland, broad-leaved deciduous, temporarily flooded
- PFO1E - Palustrine forested wetland, broad-leaved deciduous, seasonally flooded/saturated
- PFO1S - Palustrine forested wetland, broad-leaved deciduous, temporary-tidal
- PSS1E - Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonally flooded/saturated
- PSS1Ed - Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonally flooded/saturated, partially drained/ditched
- PSS1Rd - Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonal-tidal, partially drained/ditched
- PSS1S - Palustrine scrub-shrub wetland, broad-leaved deciduous, temporary-tidal
- PEM1E - Palustrine emergent persistent, seasonally flooded/saturated

Upland areas consist of coastal forest/woodland. The wetland and upland communities identified during the field delineation are described below. Vegetation observed within the project area is listed in Table 3.

Table 3: Vegetation Observed in Project Area

Common Name	Scientific Name	Wetland Indicator Status
Trees, Shrubs, Woody Vines		
Black cherry	*Prunus serotina*	FACU
Black gum	*Nyssa sylvatica*	FAC
Black locust	*Robinia pseudoacacia*	FACU
Black oak	*Quercus velutina*	NI
Beach plum	*Prunus maritima*	NI

Common Name	Scientific Name	Wetland Indicator Status
Coastal sweet pepperbush	*Clethra alnifolia*	FAC
Common green briar	*Smilax rotundifolia*	FAC
Common shadbush	*Amelanchier arborea*	FACU
Common winterberry	*Ilex verticillata*	FACW
Glossy buckthorn	*Frangula alnus*	FAC
Gray birch	*Betula populifolia*	FAC
Highbush blueberry	*Vaccinium corymbosum*	FACW
Huckleberry	*Gaylussacia baccata*	FACU
Lowbush blueberry	*Vaccinium angustifolium*	FACU
Maleberry	*Lyonia ligustrina*	FACW
Multiflora rose	*Rosa multiflora*	FACU
Northern bayberry	*Morella pensylvanica*	FAC
Pitch pine	*Pinus rigida*	FACU
Poison ivy	*Toxicodendron radicans*	FAC
Red maple	*Acer rubrum*	FAC
Red oak	*Quercus rubra*	FACU
Sheep laurel	*Kalmia angustifolia*	FAC
Southern arrowwood	*Viburnum dentatum*	FAC
Staghorn sumac	*Rhus typhina*	NI
Steeplebush	*Spiraea tomentosa*	FACW
Swamp azalea	*Rhododendron viscosum*	FACW
Swamp rose	*Rosa palustris*	OBL
Virginia creeper	*Parthenocissus quinquefolia*	FACU
White oak	*Quercus alba*	FACU
Winterberry	*Ilex verticillata*	FACW
Herbaceous Vegetation		
Blueflag	*Iris versicolor*	OBL
Broad-leaf cattail	*Typha latifolia*	OBL
Canada mayflower	*Maianthemum canadense*	FACU
Cinnamon fern	*Osmunda cinnamomea*	FACW
Lily-of-the-valley	*Convallaria majalis*	NI
Northern dewberry	*Rubus flagellaris*	FACU
Pennsylvania sedge	*Carex pensylvanica*	NI
Royal fern	*Osmunda spectabilis*	OBL
Sensitive fern	*Onoclea sensibilis*	FACW

Common Name	Scientific Name	Wetland Indicator Status
Soft rush	*Juncus effusus*	OBL
Starflower	*Trientalis borealis*	FAC
Tussock sedge	*Carex stricta*	OBL

Source: USACE 2012b; USDA, Natural Resources Conservation Service 2012

Key to Indicator Categories

OBL: Obligate Wetland, occur almost always (estimated probability >99 percent) under natural conditions in wetlands.

FACW: Facultative Wetland, usually occur in wetlands (estimated probability 67-99 percent), but occasionally found in non-wetlands.

FAC: Facultative, equally likely to occur in wetlands or non-wetlands (estimate probability 34-66 percent).

FACU: Facultative Upland, usually occur in non-wetlands (estimated probability 67-99 percent), but occasionally found in wetlands (estimate probability 1- 33%).

UPL: Obligate Uplands, occur almost always (estimated probability, >99 percent) under natural conditions in uplands

NI: No indicator.

The USACE and the United States Environmental Protection Agency (US EPA) define wetlands as areas inundated or saturated by surface water or groundwater 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 (33 Code of Federal Regulations (CFR), Part 328.3). The USACE regulates development in jurisdictional wetlands pursuant to section 404 of the Clean Water Act (CWA) (33 CFR, Parts 320–330). A jurisdictional determination is the process of identifying and locating jurisdictional waters of the United States (including wetlands). Identification and delineation of jurisdictional wetlands is based on the following three parameters:

- hydrophytic vegetation – the dominant vegetation consists of species capable of growing in water or on substrate that is at least periodically deficient in oxygen as a result of the presence of water;
- hydric soils – soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth of hydrophytic vegetation; and
- wetland hydrology – the area is inundated permanently or periodically, or the soil is saturated to the surface for sufficient duration during the growing season to support hydrophytic vegetation.

However, satisfying the three parameters does not necessarily qualify the wetland as a jurisdictional feature under USACE regulations. The 2001 U.S. Supreme Court case *Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers* reduced the regulatory power of the USACE. Prior to this decision, the USACE afforded federal protection to virtually all wetlands. The general result of the SWANCC decision was that the USACE could only take jurisdiction over navigable waters, their tributaries, and wetlands that are adjacent to these navigable waterways and their tributaries. Isolated wetlands or wetlands that satisfy the three criteria but have no direct surface connection to navigable waters or their tributaries were no longer afforded federal protection.

The USACE's regulatory ability to claim federal jurisdiction over wetlands was further reduced after the 2006 U.S. Supreme Court cases *Rapanos v. United States*, and *Carabell v. United States*, commonly referred to as Rapanos (2006). While the SWANCC decision gave the USACE federal jurisdiction over perennial streams, intermittent streams, and their adjacent wetlands, Rapanos introduced the concept of a significant nexus when determining federal jurisdiction over intermittent streams and their adjacent wetlands that are indirect tributaries to navigable waters. A significant nexus analysis assesses the flow characteristics of the tributary and the functions of both the tributary and any adjacent wetlands. The assessment seeks to determine if the stream and its adjacent wetlands have significant chemical, physical, and biological effects on downstream, traditional navigable waters (TNWs); thus, a consideration of hydrologic and ecologic factors is considered. The introduction of the significant nexus analysis requires more documentation of wetlands than has traditionally been necessary; additionally, the further the distance from the tributary to the navigable water, the more important it is to gather increasingly more data.

Based on these court decisions, the USACE and the US EPA assert jurisdiction over non-navigable tributaries of TNWs where the tributaries are relatively permanent waters (RPWs); an intermittent or perennial stream; are adjacent to a RPW; or have a significant nexus to a RPW. Additionally, if wetland hydrology is derived from groundwater discharge (spring or seep), or if the wetland was created to mitigate for former impacts, the USACE can decide to take jurisdiction over them; however, these decisions are decided on a case-by-case basis. It is assumed that all wetlands observed in the project area are adjacent to non-traditional navigable waters that flow directly or indirectly into TNW.

3.4.1 Wetlands

The wetland communities identified and delineated in the project area are described in this section. The surveyed wetland boundaries are presented in Volume II. Wetland habitats identified in this delineation have been categorized based on field observation using the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). Three wetland systems were identified within the project area:

Palustrine forested wetland, broad-leaved deciduous (PFO1): These wetlands are characterized by woody vegetation that is 6 meters tall or taller. Palustrine wetlands include nontidal wetlands or wetlands in tidal areas with salinity below 0.5 parts per thousand (ppt). Broad-leaved deciduous wetland vegetation includes woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season.

Observed hydrologic regimes associated with forested wetlands in the project area include temporary flooded (A), seasonally flooded/saturated (E), and temporary tidal (S).

Palustrine scrub-shrub wetland, broad-leaved deciduous (PSS1): These wetlands are characterized by woody vegetation that is less than 6 meters tall. The species include true shrubs, young trees (saplings), and trees and shrubs that are small or stunted because of environmental conditions. Palustrine wetlands include nontidal wetlands or wetlands in tidal areas with salinity below 0.5 ppt. Broad-leaved deciduous wetland vegetation includes woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season.

Observed hydrologic regimes associated with scrub-shrub wetlands in the project area include seasonally flooded/saturated (E), seasonal tidal (R), and temporary tidal (S).

Palustrine emergent persistent (PEM1): These wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. The vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. Persistent emergent wetlands are dominated by species that normally remain standing at least until the beginning of the next growing season. Palustrine wetlands include nontidal wetlands or wetlands in tidal areas with salinity below 0.5 ppt.

Observed hydrologic regimes associated with emergent wetlands in the project area include seasonally flooded/saturated (E).

Hydrologic regimes are listed below.

- Temporary Flooded (A water regime) – Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the growing season.
- Seasonally Flooded/Saturated (E water regime) – Surface water is present for extended periods especially early in the growing season and when surface water is absent, substrate remains saturated near the soil surface for much of the growing season.
- Seasonal-Tidal (R water regime) – Wetlands that are flooded by freshwater tides for extended periods especially early in the growing season, but is absent by the end of the growing season in most years are seasonally flooded-tidal. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.
- Temporary-Tidal (S water regime) – Wetlands with this water regime are flooded by freshwater tides for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the growing season.

3.4.2 Uplands

The upland communities observed within the project area include coastal forest/woodland. These communities are found in more protected areas along the coast, behind dunes and on slopes away from the water, and behind maritime forests. Coastal forests are sheltered from direct daily maritime influences (i.e., they are not in the daily salt spray zone, but do receive wind and salt during storms). The community occurs within climates moderated by proximity to the ocean, where the winters are warmer and the summers are cooler than more inland areas. These areas often occur on sand or bedrock that do not hold water; however, fog and increased precipitation can produce more available water than further inland. Historically, fire was often an important factor in coastal forests. This is a mixed forest that occurs on sandy soils, sandy ravines in pine barrens, or on slopes with rocky soils that are well drained.

The canopy is dominated by a mixture of oaks and pines. Tree oaks (scarlet oak, black oak (*Quercus coccinea and Quercus velutina*), and white oak (*Quercus alba*) and chestnut oak (*Quercus prinus*) are the dominant species of the coastal forest. Red maple (*acer rubrum)*, sassafras (*Sassafras albidum*), black cherry (*Prunus serotina)*, black gum (*Nyssa sylvatica*), beech (*Fagus grandifolia*), pitch pine (*pinus rigida)*, and white pine (*Pinus strobus*) commonly occur, usually in low percentages, but are occasionally abundant. Red cedar (*Juniperus virginiana)* occurs in low percentages in the forests and is sometimes dominant in woodland thickets. A low-shrub heath layer dominated by low bush blueberries (*Vaccinium angustifolium)*, and black huckleberry (*Gaylussacia baccata*) is very characteristic. The herbaceous layer is typically sparse, with Pennsylvania sedge (*Carex pensylvanica)*, bracken fern (*Pteridium aquilinum*), wintergreen (*Gaultheria procumbens*), and wild sarsaparilla (*Aralia nudicaulis*) being typical. Most occurrences of coastal forests have many vines on the edges and in openings of the forest. Poison ivy (*Toxicodendron radicans)*, Virginia creeper (*Parthenocissus quinquefolia)*, grape (*Vitis spp.)*, and greenbriers (Smilax spp.) can be locally abundant.

3.5 Results

Twelve wetland areas were identified and delineated within the limits of the project area. The general characteristics of the delineated wetlands, including the approximate area within the subject property and classification, are summarized in Table 4. It should be noted that many of the delineated wetlands extend off-site and the approximate size represents the area found only within the project area.

Vegetated wetlands within the project area are classified under the WPA as either BVW or ISLF. BVWs are defined in 10.57 CMR (2) as “freshwater wetlands which border on creeks, rivers, streams, ponds and lakes”. ISLF is defined in 10.57 CMR (2)(b)(1) as “an isolated depression or a closed basin which serves as a ponding area for run-off or high ground water which has risen above the ground surface”. Wellfleet and Truro have jurisdiction over both BVWs and ISLFs.

Table 4: Summary of Delineated Wetlands within the Project Area

Wetland	Approximate Size (acres)	Wetland Cover Type	Data Points and/or Photos	Bank	RF	BVW	LUW	BLSF	ILSF
A/B	1.91	PFO1E	B-WET, B-UPL; P1, P2	✓	✓	✓	✓	✓	
C	2.13	PFO1S	C-WET, C-UPL; P3, P4	✓		✓		✓	
D/E	2.09	PSS1Rd	D-WET, D-UPL; P5, P6	✓	✓	✓	✓	✓	
F	0.07	PSS1E	F-WET, F-UPL; P7, P8					✓	✓
G	0.45	PSS1S	G-WET, G-UPL; P9, P10	✓	✓	✓	✓	✓	
H	3.2	PSS1Ed/ PFO1E	H-WET, H-UPL; P11, P12	✓	✓	✓	✓	✓	
I	0.11	PFO1A	I-WET, I-UPL; P13, P14	✓	✓	✓	✓	✓	
J	0.03	PSS1E	J-WET, J-UPL; P15, P16					✓	✓
K/L	0.53	PSS1E	L-WET, L-UPL; P17, P18	✓	✓	✓	✓	✓	
M/N/Q	0.67	PSS1E/ PEM1E	N/Q-WET, N/Q-UPL; P19, P20	✓	✓	✓	✓	✓	
O	0.02	PSS1E	O-WET, O-UPL; P21, P22					✓	✓

Wetland	Approx-imate Size (acres)	Wetland Cover Type	Data Points and/or Photos	Bank	RF	BVW	LUW	BLSF	ILSF
P	NA	PSS1E	P-WET, P-UPL; P23, P24						
Total Field Delineated	11.21								

P=Photograph

Wetland A/B: Wetland A/B is jurisdictional under section 404 of the CWA and was delineated in the field by 44 (A series) and 14 (B series) wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland A/B as a BVW adjacent to tributaries to the Herring River. Wetland A/B extends outside of the project area. This large palustrine forested wetland (PFO1E) associated with the Herring River is dominated by red maple, coastal sweet pepperbush (*Chlethra alnifolia)*, and swamp azalea (*Rhododendron viscosum)*.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on site included surface water and water-stained leaves. The evidence of primary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Freetown and Swansea mucks, which are listed as hydric soils. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil with redoximorphic concentrations was a positive indicator that hydric soils were present.

Wetland C: Wetland C is jurisdictional under section 404 of the CWA and was delineated in the field by 52 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland C as a BVW adjacent to the Herring River. Wetland C extends off-site. This large palustrine forested wetland (PFO1S) associated with the Herring River is dominated by red oak (*Quercus rubra)*, gray birch (*Betula populifolia)*, and southern arrowwood (*Viburnum dentatum)*.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on site included surface water, saturation, inundation visible on aerial imagery, water-stained leaves, and geomorphic position. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Maybid variant silty clay loam, which is a listed hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) soil with redoximorphic features at 6 inches. The presence of a low chroma soil and redoximorphic features was a positive indicator that hydric soils were present.

Wetland D/E: Wetland D/E is jurisdictional under section 404 of the CWA and was delineated in the field by 19 (D series) and 39 (E series) wetland flags and is depicted on the plans (Volume

II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland D/E as a BVW adjacent to the Herring River. Wetland D/E extends off site. This large palustrine scrub-shrub wetland (PSS1Rd) associated with the Herring River is dominated by gray birch, red maple, winterberry, highbush blueberry, and southern arrowwood.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on site included water-stained leaves and the site's geomorphic position in the landscape. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Freetown and Swansea mucks, which is are listed as hydric soils. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland F: Wetland F is jurisdictional under section 404 of the CWA and was delineated in the field by 17 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland F as ILSF. This wetland is separated from Wetland C by Bound Brook Island Road; however, the wetland F is hydrologically connected to wetland C. This palustrine scrub-shrub wetland (PSS1E) is dominated by winterberry (*Ilex verticillata)*, red oak, and huckleberry (*Gaylussacia baccata)*.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on site included surface water and water-stained leaves. The evidence of primary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) with redoximorphic features was a positive indicator that hydric soils were present.

Wetland G: Wetland G is jurisdictional under section 404 of the CWA and was delineated in the field by 14 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland G as a BVW adjacent to the Herring River. Wetland G extends off-site. This large palustrine scrub-shrub wetland (PSS1S) associated with the Herring River is dominated by southern arrowwood and winterberry.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on-site included water-stained leaves and the presence of a water table at 10 inches. The evidence of primary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile was excavated to approximately 18 inches using an auger. The presence of a low chroma soil (<3) with redoximorphic features was a positive indicator that hydric soils were present.

Wetland H: Wetland H is jurisdictional under section 404 of the CWA and was delineated in the field by 64 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland H as a BVW adjacent to a tributary to the Herring River. Wetland H occupies a large portion of the project area and extends off-site. This large palustrine scrub-shrub/forested wetland (PSS1Ed/PFO1E) associated with the Herring River is dominated by swamp rose (*Rosa palustris)*, staghorn sumac (*Rhus typhina)*, southern arrowwood, cinnamon fern (*Osmunda cinnamomea)*, and *Sphagnum* moss.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on site included surface water, saturation, a high water table, water-stained leaves, hydrogen sulfide odor, inundation visible on aerial imagery, and geomorphic position. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Freetown and Swansea mucks, which is are listed as hydric soils. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland I: Wetland I is jurisdictional under section 404 of the CWA and was delineated in the field by 10 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland I as a BVW adjacent to a tributary of Bound Brook. Wetland I extends off-site. This palustrine forested wetland (PFO1A) associated with Bound Brook is dominated by red maple, coastal sweet pepperbush, and common green brier.

This wetland is primarily supported hydrologically by groundwater, precipitation events, and overbank flooding. Other hydrologic indicators observed on site included saturation, a high water table, water-stained leaves, and geomorphic position. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland J: Wetland J is jurisdictional under section 404 of the CWA and was delineated in the field by 9 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland J as ILSF. This palustrine scrub-shrub wetland (PSS1E) is classified as ILSF because it is physically separated from the Herring River. This wetland is dominated by black gum and southern arrowwood.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on-site included surface water and water-stained leaves. The evidence of primary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) and redoximorphic features was a positive indicator that hydric soils were present.

Wetland K/L: Wetland K/L is jurisdictional under section 404 of the CWA and was delineated in the field by 15 (K series) and 14 (L series) wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland K/L as a BVW adjacent to Bound Brook. Wetland K/L extends off-site. This palustrine scrub-shrub wetland (PSS1E) associated with Bound Brook is dominated by red maple, maleberry (*Lyonia ligustrina)*, highbush blueberry (*Vaccinium angustifolium)*, and *Sphagnum* moss.

This wetland is primarily supported hydrologically by groundwater, precipitation events, and overbank flow. Other hydrologic indicators observed on site included surface water, water-stained leaves, inundation visible on aerial imagery, and microtopography. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Freetown and Swansea mucks, which are listed as hydric soils. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland M/N/Q: Wetland M/N/Q is jurisdictional under section 404 of the CWA and was delineated in the field by 12 (M series), 13 (N series), and 15 (Q series) wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland M/N/Q as a BVW adjacent to Bound Brook. Wetland M/N/Q extends off-site. This palustrine scrub-shrub/emergent wetland (PSS1E/PEM1E) associated with Bound Brook is dominated by maleberry, swamp azalea, common green brier, and sensitive fern (*Onoclea sensibilis)*.

This wetland is primarily supported hydrologically by groundwater, precipitation events, and overbank flow. Other hydrologic indicators observed on-site included surface water, saturation, water-stained leaves, saturation visible on aerial imagery, and microtopography. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Freetown and Swansea mucks, which is are listed as hydric soils. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland O: Wetland O is jurisdictional under section 404 of the CWA and was delineated in the field by 7 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would define Wetland O as ISLF. This palustrine scrub-shrub wetland (PSS1E) is dominated by coastal sweet pepperbush.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on-site included surface water, saturation, a high water table, water-stained leaves, and geomorphic position. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

Wetland P: Wetland P is jurisdictional under section 404 of the CWA and was delineated in the field by 7 wetland flags and is depicted on the plans (Volume II). MassDEP and the local Conservation Commission that implements the WPA would likely define Wetland P as a BVW adjacent to Bound Brook. This palustrine scrub-shrub wetland (PSS1E) associated with Bound Brook is dominated by winterberry, highbush blueberry, and coastal sweet pepperbush.

This wetland is primarily supported hydrologically by groundwater and precipitation events. Other hydrologic indicators observed on-site included saturation, a high water table, water-stained leaves, and saturation visible on aerial imagery. The evidence of primary and secondary indicators of wetland hydrology satisfies the criterion that wetland hydrology is present.

This wetland is mapped as Carver coarse sand, which is not listed as a hydric soil. The test pit soil profile, excavated to approximately 18 inches using an auger, included a low chroma (<3) dark grayish brown, non-sticky peat. The presence of a low chroma soil (<3) was a positive indicator that hydric soils were present.

3.6 Bordering Vegetated Wetlands

As defined in 310 CMR 10.55(2)(a), "Bordering Vegetated Wetlands are freshwater wetlands which border on creeks, rivers, streams, ponds and lakes." BVW boundaries are defined in 310 CMR 10.55(2)(c) as "... the line within which 50 percent or more of the vegetational community consists of wetland plants and saturated or inundated conditions exist." As noted in Table 4, most of the delineated wetlands are considered BVW under the WPA.

3.7 Bank

As defined in 310 CMR 10.54 (2)(a)&(c), a Bank is "... the portion of the land surface that normally abuts and confines a waterbody." This land surface "... may be partially or totally vegetated, or it may be comprised of exposed soil, gravel, or stone." "The upper boundary of a Bank is delineated as the first observable break in the slope or the mean annual flood level, whichever is lower." Bank is present between a perennial river, lake or pond and the adjacent BVW or upland and within intermittent streams.

The regulations define a stream as "a body of running water which moves within, into or out of an Area subject to protection of the Act.. Such a body of running water that does not flow throughout the year (i.e. intermittent) is a stream except for that portion upgradient of all bogs, swamps, wet meadows and marshes." Accordingly, only those intermittent channels that convey water in response to a hydraulic gradient and those that are within or downgradient of BVW contain the resource area Bank. Where observed, the banks associated with the perennial rivers within the project area were delineated.

3.8 Land Under Waterbodies and Waterways

Land under Waterbodies and Waterways "is the land beneath any creek, river, stream, pond or lake. Said land may be composed of organic muck or peat, fine sediments, rocks or bedrock. The boundary of Land Under Waterbodies and Waterways is the mean annual low water level" [310 CMR 10.56 (2)(a)&(c)]. LUW extends downgradient from the delineated Bank flags.

3.9 Bordering Land Subject to Flooding

"Bordering Land Subject to Flooding is an area with low flat topography adjacent to and inundated by flood waters rising from creeks, rivers, streams, ponds, or lakes. It extends from the banks of these waterways and waterbodies; where a bordering vegetated wetland occurs, it extends from said wetland" [310 CMR 10.57(2)(a)]. "The boundary of Bordering Land Subject to Flooding is the estimated maximum lateral extent of flood water which will theoretically result from the statistical 100-year frequency storm… determined by reference to the most recently available flood profile data prepared for the community within which the work is proposed… under the Federal Emergency Mapping Agency…" [310 CMR 10.57(2)(c)]. BLSF is defined within the project area by the special flood hazard zone as shown on FIRM map panel 25001C0233J (Zone AE EL = 13.0 FT NAVD88) and 25001C0229J (Zone AE EL = 10.0 FT NAVD88).

3.10 Isolated Land Subject to Flooding

"Isolated Land Subject to Flooding is an isolated depression or closed basin without an inlet or outlet. It is an area which at least once a year confines standing water to a volume of one quarter acre-foot and an average depth of six inches" [310 CMR 10.57(1)(b)].

3.11 Buffer Zone

Per the WPA, Chapter 131, Massachusetts General Law, Section 40 buffer zone refers to that area of land extending 100 feet horizontally outward from the boundary of any area specified in 310 CMR 10.02(1)(a). The interests protected through this law include storm damage control, wildlife protection, and other interests beyond pollutants discharge. Therefore, work within 100 feet of the BVW is an activity requiring compliance with the WPA, administered by the MassDEP and the local Conservation Commission.

Within the project area, land to be disturbed within 100 feet of delineated BVW typically consists of currently developed roadways, driveways, and residential areas. Undeveloped lands consist primarily of mixed upland forest including white, black and red oak, pitch pine, red maple, and gray birch. In addition, the Wellfleet Environmental Protection Regulations (WEPR, 2014) establishes a 50-foot Filter Strip within the 100 foot Buffer Zone. The "50-foot Filter Strip" refers to that area of land extending 50 feet horizontally outward from the boundary of any resource area subject to jurisdiction under the Wellfleet Environmental Protection Bylaw (1986) as defined at WEPR 1.02(a) – (b).

3.12 Riverfront Area

In 1996, the Massachusetts Legislature passed the Massachusetts Rivers Protection Act, which amended the Wetland Protection Act, MGL Chapter 131 Section 40, and provides protection to rivers by regulating activities within a resource area known as the Riverfront Area. This Act identifies eight purposes, which are the same as the WPA's interests: protection of private or public water supply; protection of groundwater; flood control; prevention of storm damage; prevention of pollution; protection of land containing shellfish; protection of wildlife habitat; and protection of fisheries. The Riverfront Area is 200 feet wide and is measured from each side of the river from the mean annual high water line outward horizontally and parallel to the waterway. Five perennial waterways (shown as blue line streams on the USGS quadrangle map) are within the project area. Four are in Wellfleet: Herring River, Bound Brook, and two unnamed waterways, one passing under Pole Dike Road and another passing under Old County Road in the area of Paradise Hollow. In Truro, a perennial waterway is shown passing under Old County Road in the area of Lombard Hollow north and south. Neither a culvert nor a clearly defined channel is observed in the area of Lombard Hollow north. The Riverfront Area primarily consists of the existing roadway, forested/shrub wetlands, residentially developed land and mixed undeveloped forested wetland and uplands.

3.13 Conclusions

The wetland delineation was based on the presence of hydrophytic vegetation, wetland hydrology, and hydric soils, as outlined in the USACE Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987), the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (USACE 2012a), the MassDEP 1995 Delineating Bordering Vegetated Wetlands Manual (Jackson 1995) and the WPA and its enabling regulations. Twelve wetland areas were identified and delineated within the project area limits. The wetland lines were marked in the field with sequentially numbered flags and located by OLS. Representative photographs and field data forms are located in Appendix A. The Wetland Delineation Survey and wetland boundaries are presented in Volume II.

4.0 Existing Conditions Plan

The existing conditions plans for the project site are based on the wetland delineation performed by Louis Berger and described in Section 3.0, along with a site survey performed by OLS in April and May, 2015. The existing conditions plan was augmented using Light Detection and Ranging (LIDAR) terrain files from the Massachusetts Geographic Information System (MassGIS) for elevations below 13 feet NAVD88 and aerial photogrammetry mapping below 13 feet NAVD88.

OLS, registered land surveyors (RLS), completed a comprehensive ground survey of the project site. Based on the survey and additional data, including Louis Berger's wetland delineation, the surveyor prepared an Existing Conditions Survey Plan for each low-lying roadway. Existing Conditions Survey Plans are contained in Volume II, Sheets 7 through 20, and include:

- Roadway and embankment grades;
- Wetlands flagging;
- Calculated wetland buffer zones;
- Federal Emergency Management Agency (FEMA) 100-year flood zone ("A Zones") as depicted on new approved 2014 FIRMs;
- Topographic contours at one foot intervals;
- Utility locations;
- Spot locations and elevation of any utilized benchmarks;
- Culvert inverts; and
- Property lines / limits of roadway layout.

OLS provided Louis Berger with hard copy and digital site plans, scaled to print on full size 22" by 36" and 11" by 17" sheets, that include bounding roadways and adjacent properties. Plans are stamped by a Massachusetts RLS. All topographic and elevation data are presented in feet and are referenced to the vertical datum of NAVD88. The plans also includes property addresses; assessors' map/lot numbers; property owners' names; scale of plan; date of plan; and client name and information.

4.1 Survey

As discussed above, OLS surveyed the roadway segments in April and May, 2015. The rights-of-way and property lines shown on the plans are based on Town of Wellfleet Tax Assessor's Maps, while property ownership is based upon information from the Town of Wellfleet's Assessor's Database. The horizontal datum is NAD83, Massachusetts State Plane, Mainland Zone. The vertical datum is NAVD88. The survey mapping was combined with 2007 photogrametric survey mapping below 13 feet and Massachusetts LIDAR data above 13 feet. The supplemental data was used to generate an existing conditions surface used in Civil3D analysis.

4.2 Existing Conditions

Plans showing existing conditions in the project area are provided in Volume II, Sheets 7 through 20. The OLS survey collected detailed elevation data on the existing roadway embankment within 50 feet of the roadway centerline (50-ft O.C). The width of the existing paved roadway for the project area varies; the narrowest section is 17 feet across (Station 59+00) and the widest section is 24 feet (Station 0+00). The average width of existing paved roadway is 20.5 feet. Along the length of the roadway alignment there are varying widths of unpaved shoulder, ranging from 0 to 3 feet. The average shoulder width for the southbound lanes is 1.5 feet and for the northbound lanes, 2 feet.

The lowest roadway segment is at Station 53+0 at elevation 1.96-ft. This portion of the roadway ranges from elevation 1.96-ft to 3.1-ft, located just south of the main stem of the Herring River. Bound Brook Island Road has multiple segments below elevation 3.5-ft.

In general, most sections of the road have at least some traversable unpaved shoulder on either the northbound or southbound side of the paved lanes. There currently is no paved shoulder along the roadway alignment. On average, there are two 10-foot travelways. Wooden guardrails and concrete bollards are located along the roadway in a few isolated locations, but there are no safety features along the majority of the alignment.

Limited utilities are present along the roadway segments. The only known underground utility is a 6-inch water main located in Pole Dike Road in Wellfleet between Stations 0+00 and 10+50, between Stations 11+50 and 12+00, and between Stations 13+00 and 14+50. There are overhead electric lines located along Bound Brook Island Road and Old County Road (Stations 12+00 to 17+00, Station 45+00 to Station 104+50, and Stations 116+50 to 141+00). A fire pump inlet is located on Bound Brook Island Road near the Herring River at Station 57+50. There is no defined drainage system along the roadway segments. The roads are generally crowned and drain to the unpaved shoulders. There are six existing culverts running underneath the alignment in various locations. These are discussed further in Section 5.0. There are no other utilities present within the alignment. No stromwater treatment facilities were observed along the roadway segments.

5.0 Geotechnical Investigations

Louis Berger conducted a geotechnical investigation and evaluation of the data with respect to the proposed elevation of existing low-lying roadways and replacement of associated culverts as part of the Herring River Restoration Project. Five road segments have been identified for elevation and culvert replacement: Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, and Bound Brook Island Road in northwest Wellfleet, Massachusetts and Old County Road from Prince Valley Road to Ryder Hollow Road in southwest Truro, Massachusetts. The complete Geotechnical Report is contained in Appendix C.

Subsurface conditions were assessed based on ten borings advanced by New Hampshire Boring. These borings were inspected and logged by Louis Berger. Laboratory test results and a geotechnical analysis evaluation was completed to assist in the development of construction plans for the project site, including the cut and fill operations.

Based on a survey performed by OLS, the existing road surface at low-lying areas ranges from 2.3 to 5.2 feet North American Vertical Datum of 1988 (NAVD88), which would be elevated to 4.25 to 7.4 (NAVD88). The goal is to elevate the existing roadway segments 0.5 feet above the storm of record within the project area (3.72 to 6.88 [NAVD88]). The restoration team selected 0.5 feet of freeboard above the storm of record to elevate these roadways, as further discussed in Section 7.0. As a result, about 0 to 4.5 feet of fill is required over existing ground elevations to maintain the final site grading. As part of the re-grading, existing culverts are to be replaced with new circular and box culvert structures.

The subsurface at the site consists of three different strata with different elevations and characteristics underlying the ground surface, below an average 6-inch-thick asphalt surface course within the project site. From top to bottom, these strata are: Stratum 1 – an approximately 2-foot-thick fill layer, Stratum 2 – a discontinuous layer of an average 10-foot-thick sand mixed with organic silt, with peat in some locations, and Stratum 3 – deposits consisting principally of fine to medium to coarse sand, in excess of 10 feet thick. Based on the wetness of the samples and observations during drilling, groundwater is anticipated to be between 1 and 2 feet below the existing grade.

The proposed roadway grade change (increase) would result in settlement. Because of the mostly granular nature of the soils below the existing roadway, settlement due to added loads would consist of primary settlement. The magnitude of the estimated primary settlement is less than 2 inches; more than one-half of this would be occur during construction. However, Stratum 2 generally contains organic matter that will gradually decay over the next several decades, resulting in an additional 3 to 6 inches of settlement. As a result of slow decay and pore pressure, dissipation-related settlement will occur over a time period of a decade or longer. Measures to mitigate long-term settlement due to organic decay may be too costly to implement. The most effective means to control settlement would be to over-excavate the organic material and replace with structural backfill. It should be noted that the existing roadway has shown limited evidence of differential settlement. Therefore, it is recommended to proceed, acknowledging that maintenance paving may be required to repair sections impacted by settlement.

In conjunction with elevating the existing low-lying roads, six existing under-sized culverts would be removed and replaced with new culverts. These culverts include three 24-inch-diameter reinforced concrete pipe (RCP) culverts, a 6-foot by 6-foot concrete box culvert, a 6-foot by 8-foot concrete box culvert, and a 7-foot by 8-foot concrete box culvert. Because of the proposed grade change, the new culverts would be installed within existing Stratum 1 fill and new fill, above the groundwater table. Based on the load-settlement, it is estimated that the loads imposed by the box culverts (all three sizes) are comparable to, and generally less than, the weight of the soils excavated to allow for their installation. Therefore, no added stress or settlement would be induced by their installation. However, the proposed 24-inch-diameter circular culverts would induce an added stress when full, resulting in post-construction settlement on the order of 1 inch. Because the settlements related to the installation of new culverts are tolerable (on the order of an inch), and the long-term settlements related to the decay of organic soils in Stratum 2 would coincide with the future periodic roadway surfacing (i.e., 20 years), no special ground improvement is proposed except for the careful preparation of the subgrade and the new fill as discussed in the following section.

The existing subgrade would need to be dewatered in preparation of culvert placement to 2 feet below bedding material. It is acknowledged that the stratum consists of soft material with low blow counts. The use of a crushed stone working surface and a concrete slab would provide a stable working platform. Further design analysis is required to determine if a deep foundation system is required at the proposed headwall location. This analysis would be completed at the 60% design phase when grading at the culvert inlet/outlet is finalized.

For elevated road segments, the existing asphalt surface/binder/base course would need to be milled/removed to below the bottom of the asphalt. After removal of the existing asphalt, the new embankment could be brought to the proposed design grade in 12-inch lifts. The new embankment side slopes should be no steeper than a 3:1 horizontal to vertical ratio, and the embankment slopes should be compacted and protected against erosion by vegetation. Depending on the hydraulic and hydrodynamic conditions of the site, additional embankment protection may be required to minimize scour damage. Steeper side slopes may be required in isolated areas to minimize impacts to adjacent parcels; stabilization with geotextile fabric and/or rip-rap would be required for slopes greater with a greater than 3:1.

6.0 Preliminary Design for Replacement of Existing Culverts

There are six existing culverts to be replaced within the project area. These include:

- Pole Dike Road, a 36-inch steel pipe located at station 6+90;
- Bound Brook Island Road at Herring River, a 54-inch Reinforced Concrete Pipe (RCP) located at Station 57+13;
- Bound Brook Island at Bound Brook, a 24-inch RCP located at Station 63+65;
- Old County Road at Paradise Hollow, a 12-inch RCP located at Station 83+59;
- Old County Road – Lombard Hollow (S), a pipe of unknown diameter and material located at approximately Station 121+34.66; and
- Old County Rd – Lombard Hollow (N), a pipe of unknown diameter and material located at approximately Station 134+56.82.

There is no detailed existing condition data for the culvert at Old County Rd – Lombard Hollow (North) as it was not able to be located, or the culvert at Old County Rd – Lombard Hollow (South) as it was fully submerged; therefore existing dimensions could not be verified for these two culverts. The existing culverts at Lombard Hollow are likely 10-inch to 12-inch.

6.1 Design Criteria

The criteria used to size the proposed culverts were based upon recommendations established by the Woods Hole Group (WHG) in its “Herring River Hydrodynamic Modeling Model Report” (2012). WHG utilized hydrodynamic modeling to determine the optimal sizing of the culverts at existing locations. The WHG report stated “the utilization of the storm of record for evaluation of the upstream crossings ensured that the installed culverts allowed maximum salinity penetration, would not inhibit upstream sediment propagation during storm events, and provide adequate tidal exchange under future projected climatic change conditions.” The memo stated a secondary criterion was to provide adequate headspace under normal tidal conditions. The height of the culvert was established to have 1-foot of headspace at during normal tidal conditions. The project team will require velocities associated with storm surge at each closing for scour analysis. Scour analysis would be performed at the 60% design stage. The scour analysis would be used to determine if armoring is required at the inlet/outlet of the culvert.

6.2 Recommended Design

The proposed culverts shown in Table 5 below are based upon the specific recommendations from WHG, included in their January 23, 2015 letter report and an undated, untitled summary table; both are provided in Appendix B. It is important to note that the technical memorandum from WHG merges the terms “storm of record” and “100-year storm of record.” For the purpose of this report, the terms are differentiated. Specifically, the term “100-year storm” can be used interchangeably with a flood event having a 1% probability of being equaled or exceeded, while the term “storm of record” refers to a model simulation of an actual storm event that represented a significant coastal flooding event in February 1978. The FEMA 1% flood event or surface is above the elevation projected for the storm of record.

The WHG memo did not include sizing recommendations for the existing culverts at Paradise Hollow and Lombard Hollow, and did not analyze the impacts associated with these structures. The analysis provided a direct hydraulic connection to eliminate attenuation, but lacked an analysis to refine the culvert size. These two areas have a limited role in restoration due to the size of the basins and distance up into the system. However, the WHG recommended the culverts be increased to the 18-inch to 24-inch diameter range.

In the absence of further criteria from WHG, Louis Berger utilized Massachusetts Department of Transportation (MassDOT) and Town standards for culvert design. MassDOT Highway Manual section 8.4.2.3 specifies a minimum recommended cross culvert dimension of 18-inches. In addition, the recommended criteria for local, rural roads are to convey flows from 25-year storm events. The hydraulic criteria utilized for this project are to convey the storm of record through the culvert. The storm of record exceeds the 25-year design storm. Therefore, the proposed culvert openings at Lombard Hollow and Paradise are 24-inches in diameter to allow for increased hydraulic capacity and ease of maintenance.

Compliance with MA State Stream Crossing Standards requires that all new and, where feasible, replacement crossings adhere to stream-crossing guidelines to provide for fish passage, stream continuity, and some wildlife passage. Specifically, the stream-crossing standards are based on six important variables: type of crossing; crossing span; openness; substrate; and water depth and velocity. The stream-crossing standards are applicable for fresh water crossings only. The crossings are currently fresh water but will be restored to tidal systems following restoration. Therefore, the interpretation used by the project team is not to apply the stream-crossing standards to define required crossing span. The span of the culverts is based solely upon the hydraulic capacity required to convey the design storm.

Based on WHG's recommendations and MassDOT guidelines, the following culvert upgrades are proposed:

- Pole Dike Road: Replace existing 36-inch steel pipe with a 7-foot by 8-foot box culvert and a combination flap/slide gate structure to control tidal elevations in the Upper Pole Dike basin;
- Bound Brook Island Road at Herring Rive: replace existing 54-inch circular RCP with a 6-inch by 8-inch box culvert;
- Bound Brook Island at Bound Brook: replace existing 24-inch RCP with a 6-foot by 6-foot box culvert;
- Old County Road at Paradise Hollow: replace existing 12-inch RCP with a 24-inch RCP;
- Old County Road – Lombard Hollow (S): replace existing pipe with a 24-inch RCP; and
- Old County Rd – Lombard Hollow (N), replace existing pipe with a 24-inch RCP.

Table 5 below shows proposed culvert sizes and elevations.

Table 5: Proposed Culvert Size and Elevation

Location	Existing Culvert	Invert Elevation (ft) NAVD88	Existing Road Elevation (ft) NAVD88	Proposed Culvert (height by width (ft)	Invert Elevation (ft) NAVD88	Crown Elevation (ft) NAVD88	Annual High Water (ft) NAVD88	Storm of record (ft) NAVD88
Pole Dike Rd	36”	-1.3	4.7	7 by 8	-1.2	6.9	4.94	6.82
Bound Brook Island Rd at Herring River	54”	-3.5	4.0	6 by 8	-2.7	5.3	4.73	6.44
Bound Brook Island Rd at Bound Brook	24”	-2.3	2.4	6 by 6	-2.2	3.8	4.11	5.53
Old County Rd. Paradise Hollow	12”	0.3	3.5	24-inch	0.66	6.25	4.13	5.75
Old County Rd -Lombard Hollow (S)	Unk.	1.05	4.4	24-inch	1.1	3.1	2.85	3.72
Old County Rd -Lombard Hollow (N)	Not Found	Not Found	4.9	24-inch	1.1	3.1	2.85	3.72

6.3 Construction

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 RCP pipes will be 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. Flow control will be required during construction. Typical details for the culverts as well as for the Pole Dike gate structure are included in Volume II, Sheets 46 – 48.

The subgrade will require dewatering to 2-ft below the proposed bedding subgrade to provide a stable surface for construction. Dewatering to lower the localized water table would be accomplished utilizing either a well point system or sheet pile cofferdam system and sumps. The advantage of the cofferdam system is that the sheeting can be driven deep to effectively cutoff or reduce groundwater flow. However, a disadvantage is that sheet removal may induce settlement due to vibration. Abandoning the sheets in place would increase cost of installation, but may be incorporated into the final foundation design.

A temporary by-pass would be required at each stream crossing during culvert installation. The hydraulic capacity of the by-pass culverts would meet or exceed the capacity of the existing culverts. Increased length and alignments would be factored by calculating the effective hydraulic capacity, which would likely result in an increase the pipe diameter. The temporary, gravity culverts would be either routed through or around the excavation.

7.0 Preliminary Roadway Design Plans

The criteria established by the restoration team were to elevate low-lying roads above the modeled storm of record water elevation throughout the project area. The previous report prepared by CLE (2011) recommended elevating the roads above the storm of record with an approximate 6-inch freeboard to elevation 6. WHG modeled the proposed conditions such that the storm of record would not overtop the roads within the study area. The focus of the hydrodynamic model analysis was to eliminate hydraulic restrictions that would impede salinity penetration to the upper reaches of the basin and thereby maximize tidal restoration. Therefore, the criteria will continue to elevate the roads to make them passable during large coastal storm events (i.e., storm of record); however, these road segments will not be designed to be passable during storm events that exceed the storm of record; specifically, the roadway will be overtopped during the FEMA 1% flood event or 100-year storm.

7.1 Design Criteria

Louis Berger assessed the amount of freeboard to apply in determining minimum road surface elevations. Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed. As noted above, CLE recommended a freeboard of 6 inches if the objective were to make the roads fully accessible during annual high water events and not overtop during the storm of record. The restoration team recommends continuing with 6 inches of freeboard above the storm of record to elevate these roadways.

The criterion established by the Project Team is to elevate the roadway above the storm of record, including 6 inches of freeboard. The elevations associated with the storm of record were based upon model data prepared by WHG. It should be noted that the elevation associated with the storm of record varies along the roadway segment alignment. Provided below in Table 6 is a summary of elevation data along the alignment.

Table 6: Summary Elevation Data

Location	Current Elevation (NAVD88)	Storm Record Elevation (NAVD88)	Proposed Roadway Elevation (NAVD88)
Old County Rd - Lombard Hollow (N)	4.5	3.72	4.25
Old County Rd - Lombard Hollow (S)	4.3	3.72	4.25
Old County Rd Paradise Hollow	2.9	5.75	6.25
Bound Brook Island Rd at Bound Brook	2.3	5.53	6.1
Bound Brook Island Rd at Herring River	3.5-5.2	6.44	7.0
Pole Dike Rd	3.7	6.82-6.83	7.4

The proposed design elevates the roadway segments to have a minimum elevation above the criteria established in Table 6. The proposed roadway alignment maintains the existing horizontal geometry. The centerline of the proposed road matches the centerline of the existing roads.

Horizontal and vertical alignment of the elevated road segments follows published standards by MassDOT, American Association of State Highway and Transportation Officials (AASHTO) Green Book (2011), and the Federal Highway Administration. Several roadway segments are being elevated and these elevated roadway segments need to transition back into existing geometric alignments. The proposed layout essentially consists of the same horizontal alignment of the existing roadway with minor adjustments in vertical alignment to accommodate the increased elevation and culvert crossings (see Volume II, Sheets 21 through 34 for proposed conditions).

The CLE Report recommended the following roadway cross-section: two 12-foot travel lanes and two 5-foot shoulders for total width of 34 feet. Initial direction recommended by the Wellfleet Director of Public Works is to match existing lanes and shoulders. It is also noted that discussions at the public meeting were to increase shoulders for pedestrians, cyclists, and various other recreational activities, while maintaining the rural character of the road segments.

The proposed design maintains a consistent cross-section design for the elevated roads: two 11-foot travelways and two 3-foot unpaved shoulders. The MassDOT design criteria (2006) recommends a travel lane width of 10-foot to 12-foot. The existing roadway has an average width of 10.5-foot. For safety purposes, Louis Berger recommends increasing the travel lane width to 11-foot. The proposed alignment is based upon two (2) 11-foot paved travel ways and two (2) 3-foot unpaved shoulders.

The existing roadways have limited guardrails along the alignment. MassDOT (2006) recommends guardrails on roadways with clear zones, the total roadside border area available for safe use by errant vehicles, of 7-foot to 10-foot on roads with a design speed under 40 miles-per-hour (MPH). 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 would be 5 MPH over posted speed to limit which accounts for traffic volumes and anticipated driver characteristics.

The recommended side slope treatment is 3:1 horizontal to vertical ratio to blend the side slopes into existing grades, avoiding abrupt, steep transitions between the road and adjacent land for the safety of pedestrians, cyclists, and equestrians. A 3:1 horizontal to vertical ratio side slope provides a slope that can be stabilized with natural vegetation, requiring limited scour protection. A steeper 2:1 horizontal to vertical ratio slope would require stone armoring. It should be noted that a 3:1 horizontal to vertical ratio slope is defined as a non-recoverable slope, a slope that is considered traversable, but on which an errant vehicle will continue to the bottom, whereas an errant vehicle may be slowed or stopped on less steep recoverable slopes.

For side slope treatments, the design objectives are to blend the side slopes into existing grades avoiding abrupt, steep transitions and to avoid slopes within the recovery zone to avoid or minimize the need for guardrails per MassDOT standards. Grading will be minimized to limit fill outside the right-of-way and minimize impacts to state and federal jurisdictional resource areas.

The proposed elevated roadways maintain the existing horizontal alignment. The centerline of the roadway is maintained to balance resource impacts and property impacts. The vertical alignment is adjusted to meet the design criteria of elevating the roadways above the design criteria.

Provided in Section 8.0 is the proposed construction sequencing and phasing to facilitate road closure and detour planning. The roadway is too narrow to maintain alternating traffic, which will necessitate road closure during construction.

7.2 Guardrails

In order to comply with MassDOT standards it will be necessary to install 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 will be necessary to put up guard rails along nearly the entire southbound section of proposed elevated roadway and some portions of the northbound proposed elevated lanes. It is estimated that approximately 6,900 linear feet of guardrail will be needed for the southbound side and 4,000 linear feet for the northbound lanes. Final guardrail selection and placement will require further discussion with the project team. Factors to consider are the scenic nature of the roadway and safety.

7.3 Alternatives Analysis

7.3.1 Structural Alternatives

In the analysis of alternatives to the proposed design, various side slopes were evaluated. The design objective was to define a standard geometry that would be effectively minimize impact on adjacent parcels and reduce impact in resource areas. As mentioned in Section 7.1, the proposed roadway cross-section includes two (2) 11-foot travel ways and two (2) 3-foot unpaved shoulders. The discussion contained herein is on the proposed side slope geometry, as it transitions from elevated paved areas to existing topography.

A gradual side slope with increased horizontal to vertical ratio would result in a more natural slope likely reducing the total length of guardrail required per MassDOT Standards. However, it was determined that a more gradual side slope would increase impacts to adjacent resource areas and private properties. Furthermore, gradual side slope (≥4H:1V) would result in additional fill being required along the entire alignment, which translates to a higher construction cost. In summary, a more gradual side slope would reduce the amount of proposed guardrail but would increase impacts outside the right-of-way and project cost due additional fill.

The recommended 3:1 side slope can be stabilized with native plantings without concerns to slope stability. Slopes steeper than 3:1 would require either armor stone and/or geotechnical stabilization mat. It should be noted that the toe of slope will be inundated during an average tidal cycle. Plantings in this tidal regime may be challenging to maintain a consistent, dense growth as the restoration project is phased. Minor sloughing at the toe of slope is anticipated as the area transitions from uplands to tidally inundated salt marsh. Slope stability during this phase would be problematic for steeper, unprotected slopes. Therefore, side slope with the geometry of 3:1 is recommended. Steeper slopes will only be used at culvert locations to maintain existing channel geometry and where head and wing walls will maintain the side slopes.

Shifting the existing roadway centerline was also considered. By shifting the road alignment away from the wetland, the resource area impacts could be minimized while impacts to private properties would increase. However, this shift would result in a significant increase in project cost. Specifically, the current road alignment is cut along steep grades, generally at the toe of natural embankments. In some areas, the existing slope is 1.5:1 with the toe of slope at the pavement cross-section. A shift of the centerline would require significant cuts into adjacent stabilized natural embankments and require the construction of retaining walls. These retaining walls would be significant structures with varying heights depending on roadway alignment. In addition, construction would require clear cutting significant portions of the slope which would likely result in the overall instability of the slope. A detailed engineering analysis would be required to maintain slope stability during construction.

Shifting the roadway centerline away from natural embankments would reduce the need for cutting into slopes on the east side of the alignment and thereby cost less. This option, though more cost beneficial, would result in greater impacts to the adjacent resource areas. For this reason, to compromise between cost and wetlands impact, it was decided to keep the proposed road alignment at the current centerline of the road..

7.3.2 Project Fill Alternatives

It is estimated that elevating the low lying roads will require filling in about 36,000 cubic yards which translates to approximately 57,400 loose cubic yards of select granular fill- sand or gravel meeting AASHTO soil classification of A-1, A-3 or A-2-4. It is estimated that the total project cost of fill and hauling would be the greatest expense for this project - about $1,722,028 or about 41% of the $4.2 million projected cost.

This project will be competitively bid so it will be the bidder/contractor’s responsibility to find sources of fill to support their bid. As part of the design scope, Louis Berger looked into various sources of fill for the project. It was found that there are two potential private companies which offer the appropriate fill for construction projects within 50 miles of the site. Within this distance there are other sand and gravel pits, but they do not offer the required quantities of select fill material that is required per the design specifications of the project at. Cape Cod Aggregates Corporation located in Hyannis, MA and P.A. Landers Incorporated in Forestdale, MA could both potentially provide some of the fill quantity required to elevate the roads. Sand and gravel is a commodity and like all commodities, the price fluctuates based on supply and demand, which is a function of the consumer market. It will be necessary closer to the actual bidding of the project to determine if there would be a cost benefit to sourcing fill from companies further than the assessed 50-mile radius. These companies may have to transport the fill farther distances but could possibly offer more competitive pricing. It is anticipated that sourcing fill further from the project site will raise the cost.

One option to offset the cost of transporting fill long distances is utilizing local public sources of fill. The Town of Wellfleet does own and operate two sand and gravel pits adjacent to the project. One site is located adjacent to the Town transfer station. The second site is located at the intersection of High Toss Bridge Road and Pole Dike Road. The Town uses both areas as sources of fill for roadway projects and general fill needs for the Town. Neither pit likely has enough capacity to provide the fill required for the entire project. In addition, it is a resource that is actively managed to meet the Town's need for infrastructure maintenance/replacement projects. At this stage, the Town would be unable to predict the ability to provide any fill for the purposes of elevating the roads. As the project nears actual bidding, the discussion should be initiated to see if any local fill is available to off-set the project costs.

Another source of fill may be from the removal of portions of the relic railroad embankment within the project area. The WHG recommended widening the opening of the existing rail embankment from 25-feet to 100-feet, removing a minimum of 75 feet of embankment at the Herring River remnant railroad crossing. They suggested that the rail embankment could be removed entirely to maximize marsh restoration. Removing portions of the railroad embankment would provide the benefit of using the cut/fill from the rail embankment for fill to elevate the roadways. While not a significant source of fill, using material from portions of railroad embankment could potentially reduce costs by decreasing fill quantities transported from other sites. If the entire portion of relic railroad embankment between Old Country Road and the transfer station (approximately 933 linear feet) and a 430-foot portion of embankment crossing Bound Brook north of Bound Brook Island Road, this would result in approximately 7,555 cubic yards of compacted fill, or approximately 20% of the total need for compacted fill.

7.4 Stormwater Compliance

The proposed project to elevate the roadways and replace the culverts would meet the definition of a Redevelopment Project (See Standard 7) as defined in the MADEP Massachusetts Stormwater Handbook:

- Maintenance and improvement of existing roadways, including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage systems, and repaving;

- Development rehabilitation, expansion and phased projects on previously developed sites, provided the redevelopment results in no net increase in impervious area; and

- Remedial projects specifically designed to provide improved stormwater management, such as projects to separate storm drains and sanitary sewers, and stormwater retrofit projects.

Redevelopment projects must meet the Stormwater Management Standards to the maximum extent practicable. Where it is not practicable to meet all the standards, the stormwater management system must be designed to improve existing conditions.

Redevelopment (e.g., correcting substandard intersections; road profile improvements; drainage improvements; culvert replacement; footprint bridge replacement; pavement resurfacing, reclamation, and/or shoulder widening with drainage improvements) projects must comply with Standard 7 of the Policy, which requires the project to meet all of the Stormwater Management Standards to the maximum extent practicable. If not practicable to meet all the standards, the storm water management system must be designed at a minimum to improve existing conditions. Specific constraints associated with public infrastructure projects may include limited right-of-way, poor soils, large impervious areas, and existing drainage structures and systems. The goal is to meet as many of the standards as possible to the maximum extent practicable. The design is required to document reasonable efforts to meet the Standards.

In accordance with Standard 7, a redevelopment project is required to meet Stormwater Management Standards 2 and 3 to the maximum extent practicable. In addition, the project must also to adhere to the pretreatment and structural stormwater best management practice requirements of Standards 4 through 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.

“As set forth in Standard 7, the phrase “to the maximum extent practicable” means that:

(1) Proponents of redevelopment projects have made all reasonable efforts to meet the requirements of Standards 2 and 3 and the pretreatment and structural stormwater best management practices requirements of Standards 4, 5, and 6 and to bring existing outfalls into compliance with Standard 1.

(2) They have made a complete evaluation of possible stormwater management measures, including environmentally sensitive site design that minimizes land disturbance and impervious surfaces, low impact development techniques and structural stormwater BMPs; and

(3) If not in full compliance with Standard 1 for existing outfalls, Standards 2 and 3 and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6, they are implementing the highest practicable level of stormwater management.”

Compliance with the stormwater regulations is required to the maximum extent practical for this project. The two primary constraints for this project are the limited right of way and adjacent resource areas. The criterion described above to define “to the maximum extent practicable” provides general guidance to be used in the permit design submission. 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 which will be developed as the design advances would attempt to meet each of the standards, adequately document standards that could be met, and be designed at a minimum to improve existing conditions. 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. However, off-site alternatives may also be practicable. An evaluation of practicable alternatives with sufficient information to support the conclusions of the analysis will follow in subsequent design phases.

7.5 Resource Area Impacts

Construction of this project would result in impacts to BVW, BLSF, ILSF, Bank, LUW, RF, and 100-foot buffer areas in both Wellfleet and Truro. Wetland impacts in the Towns of Wellfleet and Truro would primarily involve the loss of forested and scrub-shrub wetlands bordering associated drainage courses or waterway. No known vernal pools would be impacted by the project. Impacts to wetlands are anticipated with the project and are shown in Table 7. It should be noted that only the permanent impacts to BVW and ILSF have been calculated at this time. Impacts to other resource areas will be determined in future design phases and will include techniques to avoid and minimize impacts to all resource areas. Permanent impacts are the loss of a wetland resource areas following construction and may result from watercourse relocation or alteration and placement of wetland fill. Temporary wetland impacts are anticipated to occur within the zone between permanent wetland impact limit and the Proposed Erosion Control/Limit. These short-term, temporary impacts may include, but are not limited to, installing erosion controls, vegetation removal, establishing work areas, and installing temporary structures. Generally, temporary impacts consist of a 3-foot temporary work zone beyond the limits of the proposed grading, and these areas of temporary impact will be restored to preconstruction conditions following the completion of work through the placement of 12 inches topsoil and the hydroseeding of a wetlands seed mix.

Table 7: Approximate Permanent Wetland Impacts

Wetland ID	Wetland Cover Type	Approximate Impact Area (SF)
A	PFO1E	12,797
B	PFO1S	3,327
C	PSS1Rd	24,569
D	PSS1E	10,673
E	PSS1S	17,227
F	PSS1Ed/PFO1E	2,472
G	PFO1A	7,616
H	PSS1E	14,960
I	PSS1E	264
J	PSS1E/PEM1E	-
K	PSS1E	969
L	PSS1E	598
M	PSS1E/PEM1E	639
N	PSS1E/PEM1E	1,863
	Total (SF)	99,974
	Total (Acres)	2.30

7.6 Property Impacts

Raising the road to the storm of record elevation will result in a wider zone of construction impact. Though the right of way varies over the length of the alignment, the average width of the right of way is 38 feet. In some locations of the project area, it will be necessary to extend the road-grading fill onto some private and municipal properties. It is estimated that this total impact area outside the right of way will be approximately 24,000 square feet or 0.55 acres. The majority of these property impacts lie within Wellfleet. Provided below in Table 8 is a list of properties that are expected to be encroached upon by the elevated road design. It should be noted the final grading also proposes grading adjustments to isolated driveways to eliminate negative sloping and ponding.

The summary of properties expected to be encroached upon is based upon town tax assessor mapping and not based upon actual property line survey. The future design phase will attempt to minimize encroachment onto these properties wherever feasible by adjusting the alignment to stay within the current right of way to avoid impacting areas of privately owned land and raising project cost through purchase of easments. Actual grading easements (if required) should be based upon surveyed property data. The existing data may be sufficient if general property access agreements are acceptable between the project proponent and those owners identified in Table 8.

Table 8: Impacted Parcels

Parcel #	Property Name	Property Address	Municipality	Station	Sheet #
7-46	Greene Diane M & Alexrod Naomi G	15 Pheasant Run	Wellfleet	18+00	22
7-48	Wellfleet Conservation Trust	0 Coles Neck Rd	Wellfleet	20+00	23
7-49	Wellfleet Conservation Trust	0 Bound Brook Island	Wellfleet	23+00	23
7-50	Ryder Marion	1 Bound Brook Island	Wellfleet	18+00	22
7-51	Wellfleet Conservation Trust	0 Bound Brook Island	Wellfleet	17+00	22
7-52	Wellfleet Conservation Trust	0 Bound Brook Island	Wellfleet	6+50	21
7-53	Wellfleet Conservation Trust	0 Bound Brook Island	Wellfleet	3+50	21
7-65	Snow Florence	0 Pole Dike Rd	Wellfleet	2+50	21
7-69	Larsen P Reed	1136 Browns Neck Rd	Wellfleet	7+50	21
2-3	Chapman Lisbeth W.	100 Old County Rd	Wellfleet	84+50	29
59-62	Maclean Howard & Earl G	14 Prince Valley Way	Truro	138+00	34
59-66	Town of Truro	133 Old County Road	Truro	133+75	34
7-51.1	Wellfleet Conservation Trust	0 Coles Neck Rd	Wellfleet	14+00	22
7-602	Brown Lisa Trustee	1200 Bound Brook Island Rd.	Wellfleet	41+50	25
	U.S. Park Service Land Resources Division	Cape Cod National Seashore	Wellfleet	83+50	29

8.0 Traffic Management Analysis

Louis Berger evaluated alternatives for managing traffic flow during construction. Based on Louis Berger’s analysis, a Maintenance Protection of Traffic Plans (MPOT) was developed in accordance with the Federal Highway Manual Uniform Traffic Control Devices (MUTCD).

The existing roadways are too narrow to maintain even a single lane of traffic during construction. Therefore, each roadway segment will require closure. The general approach for traffic management is to break up the roadway segments into construction phases and work zones. During each construction phase, the road undergoing construction will be closed. Longer roadway segments will be open to local traffic and closed to through traffic. The active work zone will be limited to assure access to residences and/or adjacent properties is maintained during construction. No driveway will be isolated during construction. It may be necessary to access some properties via an unpaved roadway for a period of time.

The MPOT consists of three detour loops that will route traffic around sections of roadway that are closed during construction. The detours would take place in phases along with construction, so only one detour would be in place at a time. All three loops lead from the project site in the generally along east-west running roads to US Highway 6, and back to the project site. The three loops ensure that access is maintained to all properties in the project site area throughout the construction process. Below is a description of each detour from south to north; for vehicles traveling from north to south each detour loop would be reversed:

- Phase I (Stations 0+00 TO 15+75): from Pole Dike Road just north of Trotting Park Road southeast along Pole Dike Road and West Main Street, east along Old Chequessett Neck Road, north along Briar Lane, north along US Highway 6, and west along Coles Neck Road to the Pole Dike Road and Bound Brook Island Road intersection.

- Phase II (Stations 15+75 TO 75+00): from the intersection of Pole Dike Road and Bound Brook Island Road near the Wellfleet Transfer Station, east along Coles Neck Road, north along US Highway 6, and west along Pamet Point Road back to Bound Brook Island Road.

- Phase III (Stations 76+00 TO 137+00): from the intersection of Bound Brook Island Road and Old County Road northeast along Pamet Point Road, north along US Highway 6, and west along Prince Valley Road back to Old County Road.

The Detour Plans and MPOT, which show all required road closures and detours, are contained in Volume II, Sheets 4 through 6.

9.0 Preliminary Opinion of Construction Cost

A Preliminary Opinion of Construction Cost has been generated using vendor quotes, R.S. Means Costworks construction data, and unit prices from recent local construction. A mark-up for profit and overhead (15%) was added to vendor quotes. It is anticipated that completion of all roadway elevation and culvert replacement will require approximately $6.2 M. It is noted the cost data included is based upon conceptual level design analysis of rehabilitation needs. As the design progresses, additional items and costs may be uncovered, this could impact actual budget for the project. A total project contingency of 30% was utilized to account for uncertainties based on the level of design.

It should be noted that the updated preliminary opinion of construction cost is significantly larger than the cost estimates presented in the CLE report. There are numerous contributing factors that explain the difference. They are as follows:

- The CLE preliminary design was only raising the road to elevation 6, while the Louis Berger design includes elevating the roadway to elevation 6.1 to 7.4 in many places.

- The CLE cost estimate presents gravel fill quantities with units of cubic yards. It is unknown whether or not this is loose cubic yards or compacted cubic yards. Depending on which, swell factors and/or shrinkage factors must be applied to the quantities to achieve the appropriate quantity. Typically fill quantities are presented in this report as loose cubic yards.

- The CLE design did not include certain items, including culverts, headwalls, traffic management plan, dewatering, and riprap.

- The CLE cost estimate does not including items for Bonding and Insurance and General Conditions during construction, and used a 25% contingency, while the Louis Berger Cost estimate included these items and uses a 30% contingency.

Provided in Appendix D is a summary of cost data used to develop the Preliminary Opinion of Construction Cost.

10.0 Meetings and Communications

Several meetings took place over the course of completing Tasks 1 through 7. These include a project kick-off meeting, the first of two public meetings, and numerous phone meetings among the project team.

10.1 Project Kick-Off Meeting

A project kick-off meeting was held on December 18, 2014. The meeting was attended by representatives of the Friends of Herring River (FHR), the National Oceanographic and Atmospheric Administration (NOAA), the Cape Cod Conservation District, the Town of Wellfleet, and Louis Berger. The meeting involved discussions of the project including an overview, project administration, field work, schedule, and public input. A site visit took place after the meeting. Meeting minutes are contained in Appendix E.

10.2 Public Meetings

A public, pre-design information meeting was held at the Wellfleet Council on Aging on February 4, 2015. The purpose of this meeting was to provide an introduction and overview of the Herring River Restoration Project. An overview of the project, including the project purpose and a description of road segments, culverts, the Pole Dike Gate, traffic management, and upcoming fieldwork was presented. A portion of the meeting was dedicated to discussion and public input on design elements of the project, including safety and drainage, points of interest, road usage, and access to private property. Meeting documentation and materials are contained in Appendix E.

The general consensus communicated at the meeting was to maintain the rural character of the roadway. The rolling hills and turns are viewed by the public as visual aesthetic assets. Several meeting participants requested that the design factor include safe access for pedestrians and cyclists. The project team communicated that the paved travelways and shoulders would be maintained. The project design is not incorporating increased/enhanced shoulders to accommodate pedestrians.

A second public meeting was held June 24, 2015 at the Wellfleet Council on Aging. An overview of the project, including the project purpose and a description of road segments, culverts, the Pole Dike Gate, completed field work and proposed traffic management plan was presented. In addition, the project team reviewed those comments received during the initial meeting in February 2015 and how those comments were integrated into the design.

Many in attendance expressed concerns over the potential need for guardrails on the project. Louis Berger explained that MassDOT guidelines would require a guardrail on the majority of the alignment. It was questioned if the MassDOT standards would apply. Because the study area is not as MassDOT road, guardrails should not be used. In addition, there were several general questions regarding the restoration project the FHR would answer by posting additional information on their website. Meeting documentation and materials are contained in Appendix E.

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12.0 Acronyms

BLSF	Bordering Land Subject to Flooding
BVW	Bordering Vegetated Wetland
CFR	Code of Federal Regulations
CWA	Clean Water Act
FEMA	Federal Emergency Management Agency
FHR	Friends of Herring River
LIDAR	Light Detection and Ranging
LUW	Land Under Water
MassDOT	Massachusetts Department of Transportation
MassDEP	Massachusetts Department of Environmental Protection
MassGIS	Massachusetts Geographic Information System
MPOT	Maintenance Protection of Traffic Plans
MUTCD	Federal Highway Manual Uniform Traffic Control Devices
NOAA	National Oceanographic and Atmospheric Association
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Rate Program
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
PEM1E	Palustrine emergent persistent, seasonally flooded/saturated
PFO1A	Palustrine forested wetland, broad-leaved deciduous, temporarily flooded
PFO1E	Palustrine forested wetland, broad-leaved deciduous, seasonally flooded/saturated
PFO1S	Palustrine forested wetland, broad-leaved deciduous, temporary-tidal
ppt	parts per thousand
PSS1E	Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonally flooded/saturated
PSS1Ed	Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonally flooded/saturated, partially drained/ditched
PSS1Rd	Palustrine scrub-shrub wetland, broad-leaved deciduous, seasonal-tidal, partially drained/ditched
PSS1S	Palustrine scrub-shrub wetland, broad-leaved deciduous, temporary-tidal
RCP	Reinforced Concrete Pipe
SWANCC	Solid Waste Agency of Northern Cook County

TNW	Traditional Navigable Waters
RLS	Registered Land Surveyors
RPW	Relatively Permanent Waters
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
US EPA	U.S. Environmental Protection Agency
US FWS	U.S. Fish and Wildlife Service
WPA	Wetland Protection Act
WHG	Woods Hole Group

Appendix A

Wetland Delineation Information

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MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: B13		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Maianthemum canadense	10	100	Yes	FACU

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Clethra alnifolia*	50	91	Yes	FAC
Frangula alnus*	<5	9	No	FAC
	55			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Acer rubrum	35	78	Yes	FAC
Quercus rubra	10	22	Yes	FACU
	45			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 2

Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? yes [✓ no]
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 2/2	
	3-9”	10YR 4/3	
	9-18”	10YR 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ____________________
- ☐ Depth to free water in observation hole: ____________________
- ☐ Depth to soil saturation in observation hole: ____________________
- ☐ Water marks: ____________________
- ☐ Drift lines: ____________________
- ☐ Sediment Deposits: ____________________
- ☐ Drainage patterns in BVW: ____________________
- ☐ Oxidized rhizospheres: ____________________
- ☐ Water-stained leaves: ____________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____________________
- ☐ Other: ____________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present		X
Other indicators of hydrology present		X
Sample location is in a BVW		X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: B13		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Osmunda cinnamomea*	15	50	Yes	FACW
Maianthemum canadense	15	50	Yes	FACU
	30			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Clethra alnifolia*	30	60	Yes	FAC
Rhododendron viscosum*	20	40	Yes	FACW
	50			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Acer rubrum*	40	80	Yes	FAC
Quercus rubra	10	20	Yes	FACU
	50			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4

Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3"	10YR 2/2	
	3-9"	10YR 2/1	
	9-18"	2.5Y 5/2	10YR 4/3 (10% redox)

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: _Surface water present_________________
- ☐ Depth to free water in observation hole: ________
- ☐ Depth to soil saturation in observation hole: _____
- ☐ Water marks: ________________________________
- ☐ Drift lines: ________________________________
- ☐ Sediment Deposits: ____________________________
- ☐ Drainage patterns in BVW: _______________________
- ☐ Oxidized rhizospheres: __________________________
- ✓ Water-stained leaves: __Present throughout___________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ______________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present	X	
Other indicators of hydrology present	X	
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: C50		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium angustifolium	50	63	Yes	FACU
Gaylussacia baccata	30	37	Yes	FACU
	80			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus alba	<5	50	Yes	FACU
Frangula alnus*	<5	50	Yes	FAC
	10			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	55	100	Yes	FACU

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 4

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Maybid variant silty clay loam, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 2/2	
	3-12”	10YR 6/2	
	12-18”	7.5Y 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ________________________________
- ☐ Depth to free water in observation hole: ______________
- ☐ Depth to soil saturation in observation hole: ___________
- ☐ Water marks: __________________________________
- ☐ Drift lines: ____________________________________
- ☐ Sediment Deposits: ______________________________
- ☐ Drainage patterns in BVW: _______________________
- ☐ Oxidized rhizospheres: ___________________________
- ☐ Water-stained leaves: ____________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	____	_X__
Wetland hydrology present:		
Hydric soil present	_X_	___
Other indicators of hydrology present	____	__X__
Sample location is in a BVW	____	__X__

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: C50		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Maianthemum canadense	5	100	Yes	FACU

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Viburnum dentatum*	10	33	Yes	FAC
Frangula alnus*	10	33	Yes	FAC
Ilex verticillata*	5	17	No	FACW
Prunus serotina	5	17	No	FACU
	30			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	20	67	Yes	FACU
Betula populifolia*	10	33	Yes	FAC
	30			

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Toxicodendron radicans*	5	33	Yes	FAC
Smilax rotundifolia*	5	33	Yes	FAC
Parthenocissus quinquefolia	<5	33	Yes	FACU
	15			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 5

Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Maybid variant silty clay loam, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-6”	10YR 3/2	
	6-18”	2.5YR 4/2	2.5Y 3/3 (20% pore linings)

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _________________
- ☐ Depth to free water in observation hole: ________
- ☐ Depth to soil saturation in observation hole: _____
- ☐ Water marks: ______________________________________
- ☐ Drift lines: ____
- ☐ Sediment Deposits: __________________________________
- ☐ Drainage patterns in BVW: ____________________________
- ☐ Oxidized rhizospheres: ______________________________
- ☐ Water-stained leaves: __ _____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: _______________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present	X	
Other indicators of hydrology present		X
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: D1		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium angustifolium	40	33	Yes	FACU
Carex pensylvanica	5	33	Yes	NI
	45			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Frangula alnus*	10	100	Yes	FAC

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	40	100	Yes	FACU

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2”	10YR 3/2	
	2-8”	10YR 6/3	
	8-18”	10YR 4/5	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ______________________________
- ☐ Depth to free water in observation hole: ______________
- ☐ Depth to soil saturation in observation hole: ___________
- ☐ Water marks: ________________________________
- ☐ Drift lines: _________________________________
- ☐ Sediment Deposits: ____________________________
- ☐ Drainage patterns in BVW: ______________________
- ☐ Oxidized rhizospheres: _________________________
- ☐ Water-stained leaves: ___________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: _______________________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	___	_X_
Wetland hydrology present:		
Hydric soil present	___	_X_
Other indicators of hydrology present	___	_X_
Sample location is in a BVW	___	_X_

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: D1		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Trientalis borealis*	5	50	Yes	FAC
Quercus rubra	<5	50	Yes	FACU
	10			
Shrubs	**Percent Cover**	**Percent Dominance**	**Dominant Plant**	**Wetland Indicator Status**
Ilex verticillata*	15	33	Yes	FACW
Vaccinium corymbosum*	10	22	Yes	FACW
Viburnum dentatum*	10	22	Yes	FAC
Prunus serotina	<5	11	No	FACU
Frangula alnus*	<5	11	No	FAC
	45			
Trees	**Percent Cover**	**Percent Dominance**	**Dominant Plant**	**Wetland Indicator Status**
Betula populifolia*	30	67	Yes	FAC
Acer rubrum*	15	33	Yes	FAC
	45			
Vines	**Percent Cover**	**Percent Dominance**	**Dominant Plant**	**Wetland Indicator Status**
Toxicodendron radicans*	<5	--	No	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 6

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 3/2	
	3-15”	2.5YR 5/3	
	15-18”+	5Y 4/2	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _________
- ☐ Depth to free water in observation hole: _______
- ☐ Depth to soil saturation in observation hole: ____
- ☐ Water marks: ________________________________
- ☐ Drift lines: __________________________________
- ☐ Sediment Deposits: ____________________________
- ☐ Drainage patterns in BVW: ______________________
- ☐ Oxidized rhizospheres: __________________________
- ✓ Water-stained leaves: __Present throughout_____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____
- ✓ Other: _geomorphic position________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	_X__	____
Wetland hydrology present:		
Hydric soil present	___	__X__
Other indicators of hydrology present	__X_	_____
Sample location is in a BVW	__X__	_____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: F16		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium angustifolium	5	100	Yes	FACU

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Gaylussacia baccata	20	57	Yes	FACU
Frangula alnus*	10	29	Yes	FAC
Morella pensylvanica*	5	14	No	FAC
	35			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus alba	35	100	Yes	FACU

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 2/2	
	3-18”	10YR 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ______________________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: ___________
- ☐ Water marks: ______________________________
- ☐ Drift lines: ______________________________
- ☐ Sediment Deposits: ___________________________
- ☐ Drainage patterns in BVW: ______________________
- ☐ Oxidized rhizospheres: _______________________
- ☐ Water-stained leaves: _________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants > # of non-wetland indicator plants	___	_X__
Wetland hydrology present:		
Hydric soil present	__	_X__
Other indicators of hydrology present	___	__X__
Sample location is in a BVW	____	__X__

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: F16		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Gaylussacia baccata	10	100	Yes	FACU

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Ilex verticillata*	20	67	Yes	FACW
Prunus serotina	5	17	No	FACU
Frangula alnus*	<5	17	No	FAC
	30			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	15	100	Yes	FACU

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-6"	10YR 2/2	
	6-18"+	10YR 4/3	10YR 3/3 (15% pore linings)

Remarks: Peat layer present at 6 inches

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

✓ Site Inundated: _Surface water present_________________

☐ Depth to free water in observation hole: __________

☐ Depth to soil saturation in observation hole: ______

☐ Water marks: ____________________________________

☐ Drift lines: ____________________________________

☐ Sediment Deposits: ______________________________

☐ Drainage patterns in BVW: _________________________

☐ Oxidized rhizospheres: ____________________________

✓ Water-stained leaves: __Present throughout_____________

☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
____
____
____

☐ Other: ______________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	___	_X__
Wetland hydrology present:		
Hydric soil present	_X__	_____
Other indicators of hydrology present	__X_	_____
Sample location is in a BVW	__X__	_____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: G1		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Clethra alnifolia*	50	91	Yes	FAC
Frangula alnus*	5	9	No	FAC
	55			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	60	100	Yes	FACU

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Toxicodendron radicans*	<5	--	No	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2"	10YR 2/2	
	2-14"	10YR 6/2	
	8-18"	10YR 4/5	

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ________________________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: ____________
- ☐ Water marks: ________________________________
- ☐ Drift lines: ________________________________
- ☐ Sediment Deposits: ________________________________
- ☐ Drainage patterns in BVW: ________________________
- ☐ Oxidized rhizospheres: ________________________
- ☐ Water-stained leaves: ________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present	X	
Other indicators of hydrology present		X
Sample location is in a BVW		X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: G1		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Maianthemum canadense	5	50	Yes	FACU
Trientalis borealis*	5	50	Yes	FAC
	10			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Viburnum dentatum*	35	50	Yes	FAC
Ilex verticillata*	30	43	Yes	FACW
Amelanchier arborea	<5	7	No	FACU

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Toxicodendron radicans	<5	--	No	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? yes [✓ no]
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-4”	10YR 2/2	
	4-12”	2.5YR 2/2	2.5YR 5/2 (5% Depletions)
	12-18”	2.5YR 5/2	10YR 4/2 (10% Pore linings)

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _________
- ✓ Depth to free water in observation hole: __10 inches______
- ☐ Depth to soil saturation in observation hole: ____
- ☐ Water marks: ____
- ☐ Drift lines: ____
- ☐ Sediment Deposits: ___________________________________
- ☐ Drainage patterns in BVW: _____________________________
- ☐ Oxidized rhizospheres: _________________________________
- ✓ Water-stained leaves: __Present throughout_____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ________________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present	X	
Other indicators of hydrology present	X	
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: H95		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Rubus flagellaris	5	33	Yes	FACU
Lonicera sp.	5	33	Yes	n/a
Carex pensylvanica	<5	33	Yes	NI
	15			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Prunus serotina	35	58	Yes	FACU
Viburnum dentatum*	25	42	Yes	FAC
	60			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus velutina	25	50	Yes	NI
Pinus rigida	25	50	Yes	FACU
	50			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-4”	10YR 3/2	
	4-18”	10YR 3/4	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ____________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: __________
- ☐ Water marks: ____________________
- ☐ Drift lines: ____________________
- ☐ Sediment Deposits: ____________________
- ☐ Drainage patterns in BVW: ______________
- ☐ Oxidized rhizospheres: ______________
- ☐ Water-stained leaves: ______________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	____	X
Wetland hydrology present:		
Hydric soil present	___	X
Other indicators of hydrology present	____	X
Sample location is in a BVW	____	X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: H95		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Osmunda cinnamomea*	15	43	Yes	FACW
Sphagnum sp.*	10	29	Yes	OBL
Onoclea sensibilis*	5	14	No	n/a
Typha angustifolia*	<5	14	No	OBL
	35			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Rosa palustris*	15	33	Yes	OBL
Rhus typhina	10	22	Yes	NI
Viburnum dentatum*	10	22	Yes	FAC
Spiraea tomentosa*	5	11	No	FACW
Frangula alnus*	<5	11	No	FAC
	45			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4

Number of dominant non-wetland indicator plants: 0

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-18”	2.5Y 3/2	

Remarks: Peat layer/sulfur odor present

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: _Surface water present____________
- ✓ Depth to free water in observation hole: __4 inches______
- ✓ Depth to soil saturation in observation hole: _0 inches____
- ☐ Water marks: ____________________
- ☐ Drift lines: ____________________
- ☐ Sediment Deposits: ____________________
- ☐ Drainage patterns in BVW: ____________________
- ☐ Oxidized rhizospheres: ____________________
- ✓ Water-stained leaves: __Present throughout____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____________________
- ✓ Other: _Hydrogen sulfide odor present, geomorphic position, inundation visible on aerial imagery____________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	____
Wetland hydrology present:		
Hydric soil present	X	____
Other indicators of hydrology present	X	____
Sample location is in a BVW	X	____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: I2		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Gaylussacia baccata	15	75	Yes	FACU
Vaccinium angustifolium	5	25	Yes	FACU
	20			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium corymbosum*	5	25	Yes	FACW
Frangula alnus*	<5	25	Yes	FAC
Quercus rubra	<5	25	Yes	FACU
Rhododendron viscosum*	<5	25	Yes	FACW
	20			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	40	80	Yes	FACU
Pinus rigida	5	10	No	FACU
Quercus alba	5	10	No	FACU
	50			

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia*	30	100	Yes	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3 Number of dominant non-wetland indicator plants: 4

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2”	10YR 3/2	
	2-16”	2.5Y 5/3	
	16-18”	5Y 4/4	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ______________________________
- ☐ Depth to free water in observation hole: __________
- ☐ Depth to soil saturation in observation hole: __________
- ☐ Water marks: ______________________________
- ☐ Drift lines: ______________________________
- ☐ Sediment Deposits: ______________________________
- ☐ Drainage patterns in BVW: ______________________________
- ☐ Oxidized rhizospheres: ______________________________
- ☐ Water-stained leaves: ______________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ______________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	____	X
Wetland hydrology present:		
Hydric soil present	____	X
Other indicators of hydrology present	____	X
Sample location is in a BVW	____	X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: I2		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Clethra alnifolia*	50	77	Yes	FAC
Rhododendron viscosum*	10	15	No	FACW
Betula populifolia*	<5	8	No	FAC
	65			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Acer rubrum*	40	100	Yes	FAC

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia*	50	100	Yes	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3

Number of dominant non-wetland indicator plants: 0

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? yes [✓ no]
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-18”	10YR 3/2	

Remarks: Peat layer present

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _________
- ✓ Depth to free water in observation hole: __9 inches______
- ✓ Depth to soil saturation in observation hole: _2 inches___
- ☐ Water marks: ________________________________
- ☐ Drift lines: ________________________________
- ☐ Sediment Deposits: ________________________________
- ☐ Drainage patterns in BVW: ________________________
- ☐ Oxidized rhizospheres: ________________________
- ✓ Water-stained leaves: __Present throughout____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ✓ Other: _Geomorphic position in landscape_______________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	_X__	____
Wetland hydrology present:		
Hydric soil present	_X__	_____
Other indicators of hydrology present	__X_	_____
Sample location is in a BVW	__X__	_____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________
Check all that apply:

☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: J2		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Prunus maritima	5	33	Yes	NI
Frangula alnus*	5	33	Yes	FAC
Prunus serotina	<5	33	Yes	FACU
	15			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Pinus rigida	30	55	Yes	FACU
Quercus rubra	15	27	Yes	FACU
Quercus alba	10	18	No	FACU
	55			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 8 to 15 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 6/2	
	3-18”	10YR 4/4	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ________
- ☐ Depth to free water in observation hole: ________
- ☐ Depth to soil saturation in observation hole: ____
- ☐ Water marks: ________________________________
- ☐ Drift lines: ________________________________
- ☐ Sediment Deposits: ____________________________
- ☐ Drainage patterns in BVW: ______________________
- ☐ Oxidized rhizospheres: _________________________
- ☐ Water-stained leaves: __ __________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____
- ☐ Other: ____________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants		X
Wetland hydrology present:		
Hydric soil present		X
Other indicators of hydrology present		X
Sample location is in a BVW		X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:________________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: J2		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Carex stricta	<5	--	No	OBL
Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Viburnum dentatum*	15	60	Yes	FAC
Acer rubrum*	5	20	Yes	FAC
Vaccinium corymbosum*	<5	20	Yes	FACW
	25			
Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Nyssa sylvatica*	20	67	Yes	FAC
Quercus rubra	10	33	Yes	FACU
	30			
Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia	<5	--	No	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 8 to 15 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? yes [✓ no]
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 2/1	
	3-18”	10YR 3/3	2.5Y 3/3 (20% pore linings)

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: _Surface water present_________________
- ☐ Depth to free water in observation hole: _________
- ☐ Depth to soil saturation in observation hole: _____
- ☐ Water marks: ____________________________________
- ☐ Drift lines: ______________________________________
- ☐ Sediment Deposits: ________________________________
- ☐ Drainage patterns in BVW: __________________________
- ☐ Oxidized rhizospheres: _____________________________
- ✓ Water-stained leaves: __Present throughout____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ______________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present	X	
Other indicators of hydrology present	X	
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: L1		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Gaylussacia baccata	5	33	Yes	FACU
Viburnum dentatum*	<5	33	Yes	FAC
Vaccinium angustifolium	<5	33	Yes	FACU
	<15			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	10	50	Yes	FACU
Frangula alnus*	5	25	Yes	FAC
Viburnum dentatum*	5	25	Yes	FAC
	20			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	25	71	Yes	FACU
Robinia pseudoacacia	<5	14	No	FACU
Pinus rigida	<5	14	No	FACU
	35			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3

Number of dominant non-wetland indicator plants: 4

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-3”	10YR 3/2	
	3-18”	10YR 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ________________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: __________
- ☐ Water marks: ________________________
- ☐ Drift lines: ________________________
- ☐ Sediment Deposits: ________________________
- ☐ Drainage patterns in BVW: ____________________
- ☐ Oxidized rhizospheres: ____________________
- ☐ Water-stained leaves: ____________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ________________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	___	X
Wetland hydrology present:		
Hydric soil present	___	X
Other indicators of hydrology present	___	X
Sample location is in a BVW	___	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: L1		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Sphagnum sp.*	10	67	Yes	n/a
Carex stricta*	5	33	Yes	OBL
	15			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Lyonia ligustrina*	25	71	Yes	FACW
Vaccinium corymbosum*	10	29	Yes	FACW
	35			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Acer rubrum*	35	100	Yes	FAC

Vine	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia*	5	100	Yes	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 6

Number of dominant non-wetland indicator plants: 0

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2”	10YR 2/1	
	2-18”	2.5Y 5/3	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: Standing water present
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: ____________
- ☐ Water marks: ____________________________________
- ☐ Drift lines: ______________________________________
- ☐ Sediment Deposits: _______________________________
- ☐ Drainage patterns in BVW: _________________________
- ☐ Oxidized rhizospheres: ____________________________
- ✓ Water-stained leaves: Present throughout ____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ✓ Other: Inundation visible on aerial imagery, microtopography present

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present		X
Other indicators of hydrology present	X	
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: N11		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	5	50	Yes	FACU
Carex pensylvanica	5	50	Yes	NI
	10			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	15	38	Yes	FACU
Rhododendron viscosum*	10	25	Yes	FACW
Amelanchier arborea	5	12.5	No	FACU
Viburnum dentatum*	5	12.5	No	FAC
Vaccinium corymbosum*	5	12.5	No	FACW
	40			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Quercus rubra	15	75	Yes	FACU
Robinia pseudoacacia	5	25	Yes	FACU
	20			

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia*	<5	--	No	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 4

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-6”	10YR 3/3	
	6-18”	10YR 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ____________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: ____________
- ☐ Water marks: ____________________
- ☐ Drift lines: ____________________
- ☐ Sediment Deposits: ____________________
- ☐ Drainage patterns in BVW: ____________________
- ☐ Oxidized rhizospheres: ____________________
- ☐ Water-stained leaves: ____________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants		X
Wetland hydrology present:		
Hydric soil present		X
Other indicators of hydrology present		X
Sample location is in a BVW		X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: N11		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Onoclea sensibilis*	20	57	Yes	FACW
Parthenocissus quinquefolia	10	29	Yes	FACU
Viburnum dentatum*	<5	14	No	FAC
	<35			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Lyonia ligustrina*	30	55	Yes	FACW
Rhododendron viscosum*	20	36	Yes	FACW
Clethra alnifolia*	5	9	No	FAC
	55			

Vines	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Smilax rotundifolia*	20	100	Yes	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes
hydric soil inclusions: Yes, hydric rating 100

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-18”	10YR 2/1	

Remarks:

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: _Surface water present
- ☐ Depth to free water in observation hole: ________
- ✓ Depth to soil saturation in observation hole: _1 inch_______
- ☐ Water marks: ____
- ☐ Drift lines: ____
- ☐ Sediment Deposits: ____________________________________
- ☐ Drainage patterns in BVW: ____________________________
- ☐ Oxidized rhizospheres: _________________________________
- ✓ Water-stained leaves: __Present throughout_____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____ ____ ____
- ✓ Other: _Saturation visible on aerial imagery, limited microtopography_________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	_X__	____
Wetland hydrology present:		
Hydric soil present	_X__	_____
Other indicators of hydrology present	__X_	_____
Sample location is in a BVW	__X__	_____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant: Friends of Herring River Prepared by: Louis Berger Project location: Herring River Low Lying Roads, Wellfleet, MA DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: O6		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium angustifolium	15	60	Yes	FACU
Quercus rubra	5	20	Yes	FACU
Kalmia angustifolia*	<5	20	Yes	FAC
	25			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Gaylussacia baccata	15	60	Yes	FACU
Clethra alnifolia*	10	40	Yes	FAC
	25			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Pinus rigida	25	100	Yes	FACU
	25			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 2

Number of dominant non-wetland indicator plants: 4

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? yes [✓ no]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2”	10YR 3/1	
	2-12”	10YR 4/3	
	12-18”	10YR 4/6	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ____________________
- ☐ Depth to free water in observation hole: ____________
- ☐ Depth to soil saturation in observation hole: ____________
- ☐ Water marks: ____________________
- ☐ Drift lines: ____________________
- ☐ Sediment Deposits: ____________________
- ☐ Drainage patterns in BVW: ________________
- ☐ Oxidized rhizospheres: ________________
- ☐ Water-stained leaves: ________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): ____ ____ ____
- ☐ Other: ____________________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	___	X
Wetland hydrology present:		
Hydric soil present	___	X
Other indicators of hydrology present	___	X
Sample location is in a BVW	___	X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: O6		Transect Number: Wetland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Clethra alnifolia *	80	100	Yes	FAC
	80			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 1

Number of dominant non-wetland indicator plants: 0

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 3 to 8 percent slopes
hydric soil inclusions: No, hydric rating 0

Are field observations consistent with soil survey? yes [✓ no]
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-4”	10YR 2/2	
	4-18”	2.5Y 5/3	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ✓ Site Inundated: _Surface water present_________________
- ✓ Depth to free water in observation hole: __6 inches______
- ✓ Depth to soil saturation in observation hole: _2 inches____
- ☐ Water marks: ________________________________
- ☐ Drift lines: ________________________________
- ☐ Sediment Deposits: ____________________________
- ☐ Drainage patterns in BVW: _______________________
- ☐ Oxidized rhizospheres: _________________________
- ✓ Water-stained leaves: __Present throughout_____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ✓ Other: _Geomorphic position in landscape________________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	
Wetland hydrology present:		
Hydric soil present		X
Other indicators of hydrology present	X	
Sample location is in a BVW	X	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: P2		Transect Number: Upland	Date of Delineation: 5/13/2015
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Trientalis borealis*	10	67	Yes	FAC
Convallaria majalis	5	33	Yes	NI
	15			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Vaccinium corymbosum*	30	67	Yes	FACW
Viburnum dentatum*	15	33	Yes	FAC
	45			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Prunus serotina	5	100	Yes	FACU
	5			

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-6"	10YR 3/2	
	6-18"	10YR 4/4	

Remarks:

3. Other:

Conclusion: Is soil hydric? yes [✓ no]

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ________________________________
- ☐ Depth to free water in observation hole: ______________
- ☐ Depth to soil saturation in observation hole: ____________
- ☐ Water marks: __________________________________
- ☐ Drift lines: ____________________________________
- ☐ Sediment Deposits: ______________________________
- ☐ Drainage patterns in BVW: ________________________
- ☐ Oxidized rhizospheres: ___________________________
- ☐ Water-stained leaves: ____________________________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ☐ Other: ____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	___
Wetland hydrology present:		
Hydric soil present	___	X
Other indicators of hydrology present	___	X
Sample location is in a BVW	___	X

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_Friends of Herring River___ Prepared by:_Louis Berger_ Project location:_Herring River Low Lying Roads, Wellfleet, MA_ DEP File #:_______________
Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ✓ Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

<table>
<tr><td>Vegetation</td><td colspan="2">Observation Plot Number: P2</td><td>Transect Number: Wetland</td><td>Date of Delineation: 5/13/2015</td></tr>
<tr><td>A. Sample Layer & Plant Species (by common/scientific name)</td><td>B. Percent Cover (or basal Area)</td><td>C. Percent Dominance</td><td>D. Dominant Plant (yes or no)</td><td>E. Wetland Indicator Category*</td></tr>
</table>

Groundcover	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Maianthemum canadense	<5	50	Yes	FACU
Convallaria majalis	<5	50	Yes	NI
	<10			

Shrubs	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Ilex verticillata*	15	33	Yes	FACW
Vaccinium corymbosum*	15	33	Yes	FACW
Clethra alnifolia *	10	22	Yes	FAC
Viburnum dentatum*	5	11	No	FACW
	45			

Trees	Percent Cover	Percent Dominance	Dominant Plant	Wetland Indicator Status
Prunus serotina	<5	--	No	FACU

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4

Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [✓ yes] no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [✓ yes] no
title/date: Barnstable County, MA http://websoilsurvey.nrcs.usda.gov
map number: n/a
soil type mapped: Carver coarse sand, 15 to 35 percent slopes
hydric soil inclusions: Yes, hydric rating 5

Are field observations consistent with soil survey? [✓ yes] no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
	0-2”	10YR 2/2	
	2-16”	2.5Y 5/2	
	16-18”+	10YR 2/1	

Remarks: Decomposed peat layer at 16”

3. Other:

Conclusion: Is soil hydric? [✓ yes] no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: ______________________________
- ✓ Depth to free water in observation hole: __8 inches______
- ✓ Depth to soil saturation in observation hole: _1 inch____
- ☐ Water marks: ______________________________
- ☐ Drift lines: ______________________________
- ☐ Sediment Deposits: ______________________________
- ☐ Drainage patterns in BVW: ______________________________
- ☐ Oxidized rhizospheres: ______________________________
- ✓ Water-stained leaves: __Present throughout____________
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other):
  ____
  ____
  ____
- ✓ Other: _Saturation visible on aerial imagery____________

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	X	____
Wetland hydrology present:		
Hydric soil present	X	_____
Other indicators of hydrology present	X	_____
Sample location is in a BVW	X	_____

Submit this form with the Request for Determination of Applicability or Notice of Intent.

Photo 1: B-Wetland Data Plot location, May 13, 2015

Photo 2: B-Upland Data Plot location, May 13, 2015

Photo 3: C-Wetland Data Plot location, May 13, 2015

Photo 4: C-Upland Data Plot location, May 13, 2015

Photo 5: D-Wetland Data Plot location, May 13, 2015

Photo 6: D-Upland Data Plot location, May 13, 2015

Photo 7: F-Wetland Data Plot location, May 13, 2015

Photo 8: F-Upland Data Plot location, May 13, 2015

Photo 9: G-Wetland Data Plot location, May 13, 2015

Photo 10: G-Upland Data Plot location, May 13, 2015

Photo 11: H-Wetland Data Plot location, May 13, 2015

Photo 12: H-Upland Data Plot location, May 13, 2015

Photo 13: I-Wetland Data Plot location, May 13, 2015

Photo 14: I-Upland Data Plot location, May 13, 2015

Photo 15: J-Wetland Data Plot location, May 13, 2015

Photo 16: J –Upland Data Plot location, May 13, 2015

Photo 17: L-Wetland Data Plot location, May 13, 2015

Photo 18: L-Upland Data Plot location, May 13, 2015

Photo 19: N-Wetland Data Plot location, May 13, 2015

Photo 20: N-Upland Data Plot location, May 13, 2015

Photo 21: O-Wetland Data Plot location, May 13, 2015

Photo 22: O-Upland Data Plot location, May 13, 2015

Photo 23: P-Wetland Data Plot location, May 13, 2015

Photo 24: P-Upland Data Plot location, May 13, 2015

Appendix B

Basis of Design Report

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Louis Berger

Memorandum

DATE: 18 February 2015

TO: Donald Palladino and Martha Rheinhardt, Friends of Herring River
Steve Block, NOAA Restoration Center

FROM: Chris Feeney, Louis Berger

SUBJECT: Herring River Restoration Project Low-lying Road Minimum Elevation and Culvert Sizing

The purpose of this memorandum is to summarize the design criteria used to establish the elevation of the roadways and sizing of the culverts. A basis of design report will accompany the 25% design plans to detail the final criteria used.

Provided in Attachment 1 is the existing mapping showing the following roadway segments included as part of the design study: Old County Road Lombard Hollow (north and south), Old County Road Paradise Hollow, Bound Brook Island Road at Bound Brook, Bound Brook Island Road at Herring River, and Pole Dike Road. The initial drawings have been developed using existing survey data. Water surface elevation data has been obtained from the sensitive receptor and low-lying property KMZ files provided by project partners. These elevational data provided the following tidal elevations: mean high water, mean high water spring, annual high water, and the storm of record.

The FEMA FIRM maps for Towns of Wellfleet and Truro indicate the low lying roads are within a coastal flood area divided into a Zone AE and Zone AE with defined Limits of Moderate Wave Action (LiMWA). The LiMWA with an elevation of 13 feet (NAVD88) encompasses the majority of the Bound Brook basin. Pole Dike and County Road have AE elevations of 10 feet.

Culverts

The criteria used to size the culverts were based upon recommendations established by Woods Hole Group (WHG) (2012[1]). WHG utilized hydrodynamic modelling to determine the optimal sizing of the culverts at existing locations. The WHG memo stated "the utilization of the storm of record for evaluation of the upstream crossings ensured that the installed culverts allowed maximum salinity penetration, would not inhibit upstream sediment propagation during storm events, and provide adequate tidal exchange under future projected climatic change conditions." The memo stated a secondary criterion was to provide adequate headspace under normal tidal conditions. The height of the culvert was established to have 1-foot of headspace at during normal tidal conditions.

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[1] Woods Hole Group. 2012. Herring River Hydrodynamic Modeling Model Report. Prepared for the Town of Wellfleet and the Herring River Restoration Committee.

The proposed culverts shown in Table 1 are based upon the specific recommendations from WHG, included in January 23, 2015 letter report and an undated, untitled summary table. Provided in Attachment 2 are these two data sources. It is important to note that the technical memorandum from WHG merges the term Storm of Record and 100-year storm of record. For the purpose of this memorandum, we are differentiating between the terms "Storm of Record" and 100-year storm. The term 100-year storm can be used interchangeably with a flood event having a 1% probability of being equaled or exceeded. The term Storm of Record refers to a model simulation of an actual storm event that represented a significant coastal flooding event in February 1978. The FEMA 1% flood event or surface is above the elevation projected for the Storm of Record.

Table 1. Proposed Culvert Size and Elevation Based on Recommendations from WHG.

Location	Existing Culvert (inches)	Invert Elevation (ft) NAVD88	Existing Road Elevation (ft) NAVD88	Proposed Culvert (Width (ft) by Height (ft)	Invert Elevation (ft) NAVD88	Crown Elevation (ft) NAVD88	Annual High Water (ft) NAVD88	Storm of Record (ft) NAVD88
Old County Rd Lombard Hollow (N)	Unknown	Unknown	< 4	TBD	TBD	TBD	2.85	3.72
Old County Rd -Lombard Hollow (S)	Unknown	Unknown	3	TBD	TBD	TBD	2.85	3.71
Old County Rd. Paradise Hollow	8	Unknown	<4	TBD	TBD	TBD	4.13	5.55
Bound Brook Island Rd at Bound Brook	24	-2.3	2.69	6 by 6	-2.3	3.7	4.11	5.53
Bound Brook Island Rd at Herring River	60	-3.5	4.45	6 by 8	-3.5	4.5	4.73	6.44
Pole Dike Rd	36	-1.3	4.67	7 by 8	-1.3	6.7	4.94	6.82

The WHG memo did not include sizing recommendations for the culverts at Paradise Hollow and Lombard Hollow and did not analyze the impacts associated with these structures. The analysis provided a direct hydraulic connection to eliminate attenuation, but lacked an analysis to refine the culvert size. These two areas have a limited role in restoration due to the size of the basins and distance up into the system. However, the WHG recommended the culverts be increased to the 18-inch to 24-inch diameter range.

In the absence of criteria, Louis Berger will utilize MassDOT and Town standards. MassDOT has a minimum recommended cross culvert dimension of 18-inches. In addition, the recommended criteria for local, rural roads are to convey flows from 25 year storm event. Therefore, the proposed culvert openings at Lombard Hollow and Paradise will be based upon these criteria.

Compliance with MA State Stream Crossing Standards require that all new and, where feasible, replacement crossings adhere to stream crossing guidelines to provide for fish passage, stream continuity, and some wildlife passage.. Specifically, the stream crossing standards are based on six important variables; type of crossing, crossing span, openness, substrate, and water depth and velocity. Drawing on the expertise of WHG, project partners, and the conservation commission the following will be considered: potential for downstream flooding, effect on upstream, downstream, and riparian habitat, potential for erosion, including headcutting and overall effect on stream stability. The crossing standards for new crossings will be adhered to as much possible.

Roadway Elevation

The criteria established by the project partners were to elevate low lying roads above storm of record water elevation. The previous report prepared by CLE (2011[2]) recommended elevating the roads above the storm of record with an approximate 6-inch free board to elevation 6. WHG modeled the proposed conditions such that the storm of record would not overtop the roads within the study area. The focus of the hydrodynamic model analysis was to eliminate hydraulic restrictions that would impede salinity penetration to the upper reaches of the basin and thereby maximize tidal restoration. Therefore, the criteria will continue to elevate the roads to make them passable during large coastal storm events (ie, storm of record); however, these road segments will not be designed to be passable during storm events that exceed the storm of record, specifically the FEMA 1% flood event or 100-year storm.

Louis Berger assessed the amount of free board to apply in determining minimum road surface elevations. Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed.

It is common to establish a minimum free board definition of 1-foot above the base flood elevation. As noted above, CLE recommended a free board of 6-inches for this specific application. If the objective is to make the low lying roads fully passable during a large coastal storm event (i.e. storm of record), Louis Berger recommends utilizing a free board of 1-foot. If the objective is to make the roads fully accessible during annual high water events and not overtop during the Storm of Record, then a free board of 6-inches would be adequate.

Horizontal and vertical alignment of the elevated road segments will follow published standards by MassDOT, American Association of State Highway and Transportation Officials (AASHTO) Green Book, and Federal Highway. It is noted that only limited roadway segments are being elevated and these elevated roadway segments will need to transition back into existing geometric alignments. The layout will essentially consist of the same horizontal alignment of the existing roadway with minor

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[2] CLE. 2011. Alternative Analysis, Three Low-lying Roads, Herring River Restoration Project, Wellfleet and Truro, Massachusetts.

adjustments in vertical alignment to accommodate the increased elevation and culvert crossings.

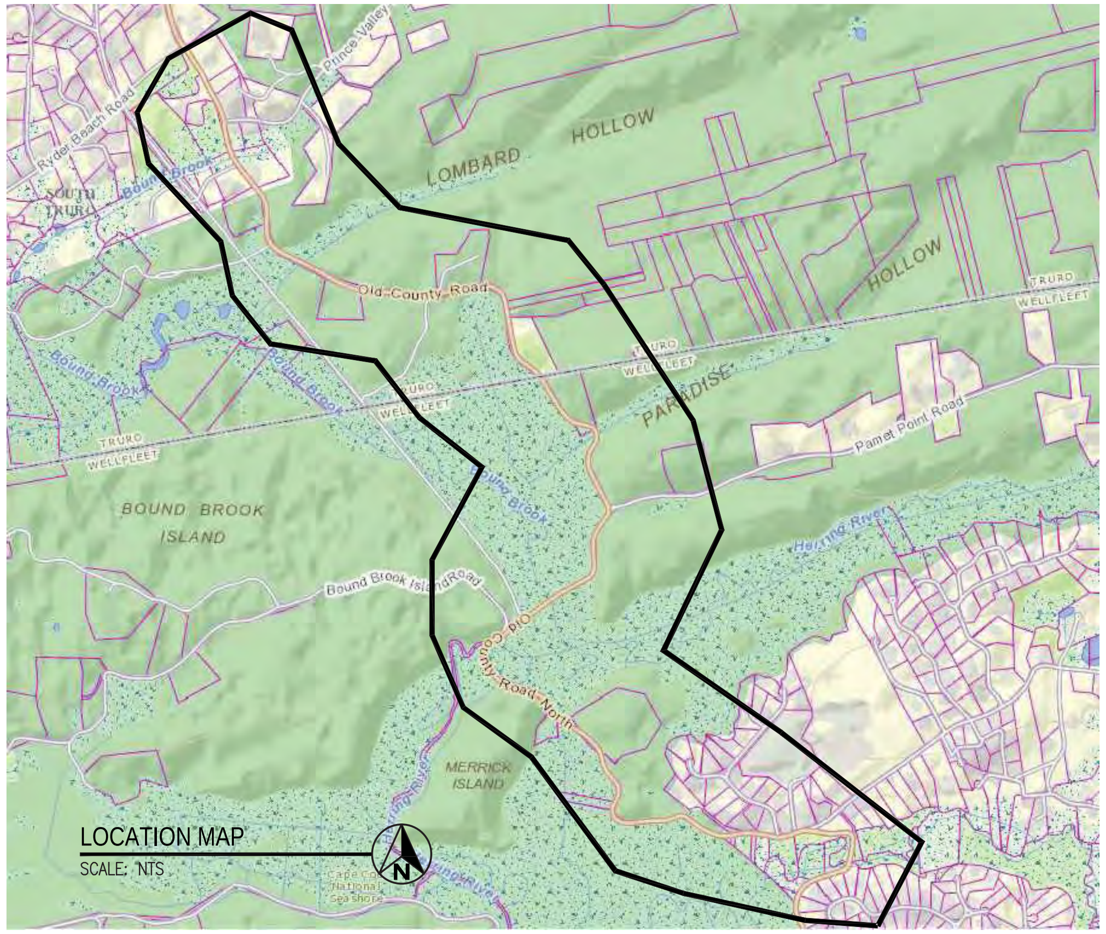
The CLE Report recommended the following pavement cross-section: (2) 12-foot travel lanes and (2) 5-foot shoulders for total width of 34 feet. Initial direction recommended by Wellfleet DPW is to match existing lanes and shoulders. It is also noted that discussions at the public meeting were to increase shoulders for pedestrians and cyclists and various other recreational activities while maintaining the rural character of the road segments. The final design criteria will be determined following survey data confirming existing paved width and follow-up discussions on non-vehicular usage.

For side slope treatments, the design objective is to blend the side slopes into existing grades avoiding abrupt, steep transitions. Furthermore, the objective is to also avoid slopes within the recovery zone to avoid or minimize the need for guard rails per MassDOT standards. Following survey data confirming existing paved width, grading will be minimize to limit fill outside the right-of-way and minimize impacts to state and federal jurisdictional resource areas.

Pole Dike Control Gate

The culvert at Pole Dike is proposed to be controlled by a gate to control tidal elevations in the Upper Pole Dike basin. A table from WHG provided recommended sizing criteria for this culvert structure (see Table 1). However, no data was provided on the required elevation to control the upper basin. The proposed gate structure is a combination flap gate/slide gate. It is envisioned that either additional criteria will be provided or an adaptive management operation would proceed following installation. The gate will have the ability to reduce the height to any established set point. The flap gate component will provide effective upstream drainage of flows during an ebb tidal cycle.

HERRING RIVER RESTORATION PROJECT: ENGINEERING DESIGN TO ELEVATE LOW-LYING ROADWAYS AND REPLACE ASSOCIATED CULVERTS
TRURO AND WELLFLEET, MASSACHUSETTS



LOCATION MAP
SCALE: NTS

Sheet List Table

Sheet Number	Sheet Title
G1	COVER SHEET
G2	GENERAL NOTES
G3	KEY PLAN
G4	TRAFFIC CONTROL PLAN
C1	OLD COUNTY ROAD – NORTH SEGMENT – SHEET 1 OF 3
C2	OLD COUNTY ROAD – NORTH SEGMENT – SHEET 2 OF 3
C3	OLD COUNTY ROAD – NORTH SEGMENT – SHEET 3 OF 3
C4	OLD COUNTY ROAD – PARADISE HOLLOW
C5	OLD COUNTY ROAD AND BOUND BROOK ISLAND ROAD
C6	BOUND BROOK ISLAND ROAD – SHEET 1 OF 6
C7	BOUND BROOK ISLAND ROAD – SHEET 2 OF 6
C8	BOUND BROOK ISLAND ROAD – SHEET 3 OF 6
C9	BOUND BROOK ISLAND ROAD – SHEET 4 OF 6
C10	BOUND BROOK ISLAND ROAD – SHEET 5 OF 6
C11	BOUND BROOK ISLAND ROAD – SHEET 6 OF 6
C12	POLE DIKE ROAD

2/18/2015 5:11:16 PM – FARAH, JOSEPH N – p:\herring river\CAD\G1 COVER SHEET.dwg

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TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

COVER SHEET

DRAWING NO. **G1**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. 1 OF X

GENERAL NOTES

1. BASE MAP INFORMATION WAS OBTAINED FROM MASSGIS AND SURVEY DATA FROM CLE
2. ALL ELEVATIONS ARE NAVD88.
3. UNDERGROUND UTILITIES ARE SHOWN IN APPROXIMATE LOCATIONS AS OBTAINED FROM THE BASEMAPPING. IT IS THE CONTRACTOR'S SOLE RESPONSIBILITY TO VERIFY THE LOCATION OF ALL UTILITIES, GRADES, AND DIMENSIONS PRIOR TO THE START OF CONSTRUCTION. THE CONTRACTOR SHALL NOTIFY DIG SAFE AND VERIFY EXACT LOCATION OF ALL EXISTING UNDERGROUND UTILITIES PRIOR TO THE START OF ANY CONSTRUCTION. TOWN OF DENNIS AND THE ENGINEER ASSUME NO FINANCIAL OR OTHER LIABILITY IF THE CONTRACTOR DAMAGES ANY UTILITY LINE.
4. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS AS THEY RELATE TO NEW CONSTRUCTION. REPORT TO THE ENGINEER ALL OBSERVATIONS AND DISCREPANCIES BEFORE PROCEEDING WITH ANY WORK.
5. ALL TIDAL DATA WAS OBTAINED FROM SENSITIVE RECEPTOR DATA PROVIDED BY THE FRIENDS OF THE HERRING RIVER.
6. PROPOSED GEOTECHNICAL BORING LOCATIONS ARE SHOWN AND CALLED OUT ON THE DRAWINGS WITH "LBG" PREFIX.

2/18/2015 5:11:20 PM – FARAH, JOSEPH N – p:\herring river\CAD\G2 GENERAL NOTES.dwg

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TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

GENERAL NOTES

DRAWING NO. **G2**
PROJECT NO. 2004341
FED AID NO. ______
DATE: JAN 2015
SHEET NO. ---- OF X

PLAN

HEERING RIVER OVERALL KEY PLAN
SCALE: 1"=500'

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KEY PLAN

DRAWING NO. **G3**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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GENERAL TRAFFIC CONTROL NOTES

1.

2.

KEYED NOTES

①

②

PLAN

HEERING RIVER OVERALL KEY PLAN
SCALE: 1"=500'

1"=500'
500 250 0 500 1000
Scale
Feet

2/18/2015 5:11:37 PM – FARAH, JOSEPH N – p:\herring river\CAD\G4 TRAFFIC CONTROL PLAN.dwg

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TRAFFIC CONTROL PLAN

DRAWING NO. G4
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

PLAN

OLD COUNTY ROAD – NORTH SEGMENT – SHEET 1 OF 3
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE E - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	DRY
MEAN HIGH WATER SPRING	DRY
ANNUAL HIGH WATER	DRY
STORM OF RECORD	3.72

TABLE F - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	DRY
MEAN HIGH WATER SPRING	DRY
ANNUAL HIGH WATER	2.85
STORM OF RECORD	3.72

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

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HERRING RIVER RESTORATION PROJECT

OLD COUNTY ROAD - NORTH SEGMENT - SHEET 1 OF 3

DRAWING NO. C1
PROJECT NO. 2004341
FED AID NO. ______
DATE: JAN 2015
SHEET NO. ---- OF X

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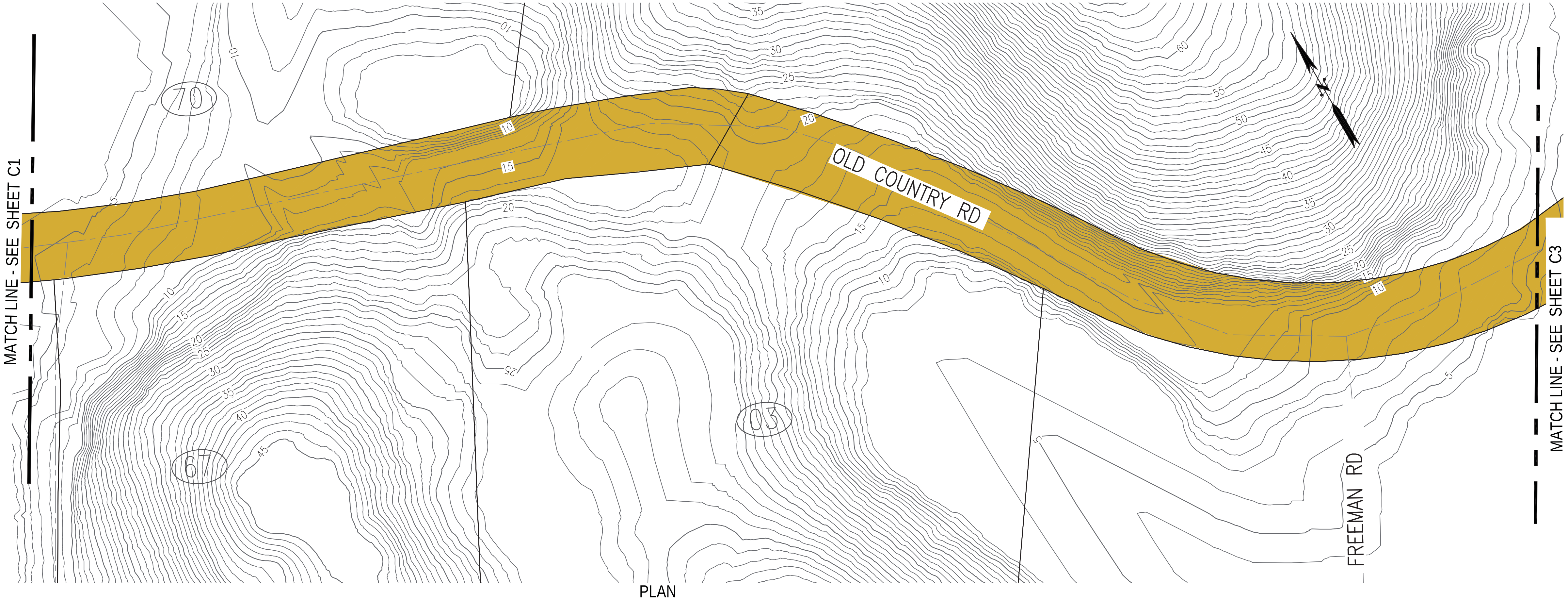

PLAN

OLD COUNTY ROAD – NORTH SEGMENT – SHEET 2 OF 3
SCALE: 1"=40'

GENERAL NOTES

1.

2.

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

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OLD COUNTY ROAD - NORTH SEGMENT - SHEET 2 OF 3

DRAWING NO. **C2**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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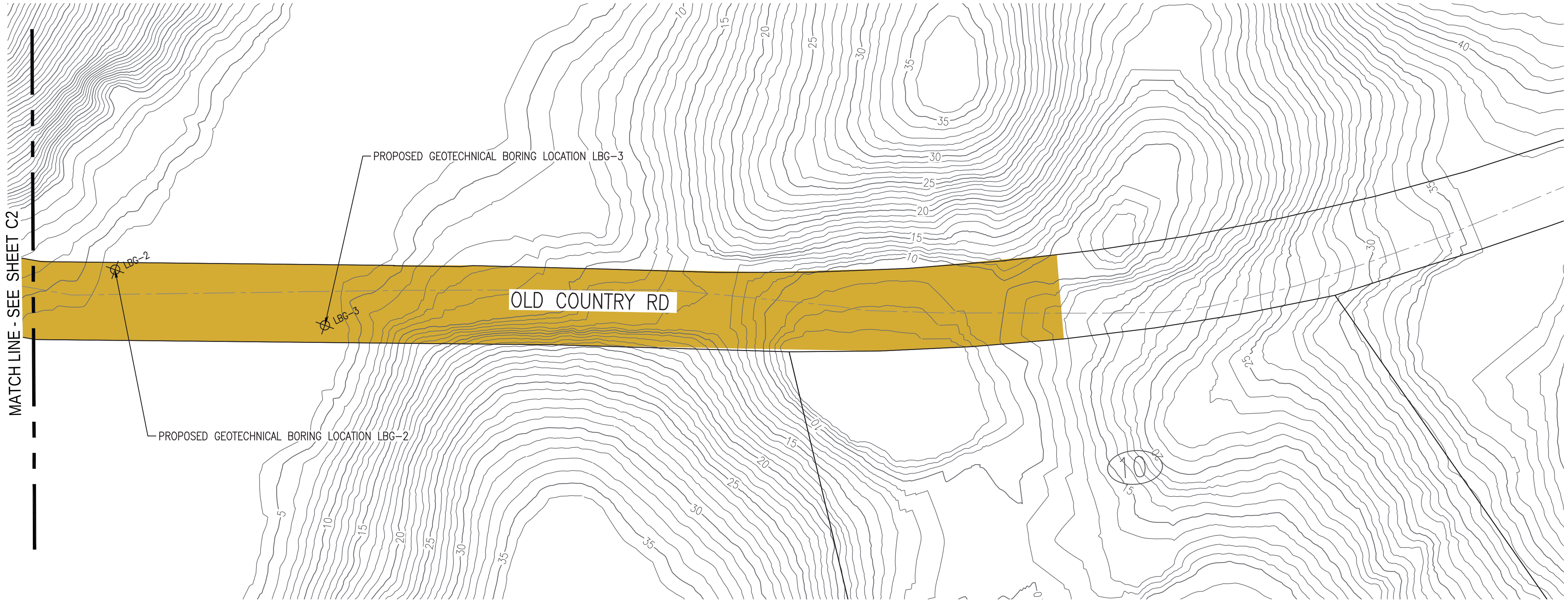

PLAN

OLD COUNTY ROAD – NORTH SEGMENT – SHEET 3 OF 3
SCALE: 1"=40'

GENERAL NOTES

1.

2.

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40'
40 20 0 40 80
Scale Feet

2/18/2015 5:12:05 PM – FARAH, JOSEPH N – p:\herring river\CAD\C3 OLD COUNTY ROAD – NORTH SEGMENT – SHEET 3 OF 3.dwg

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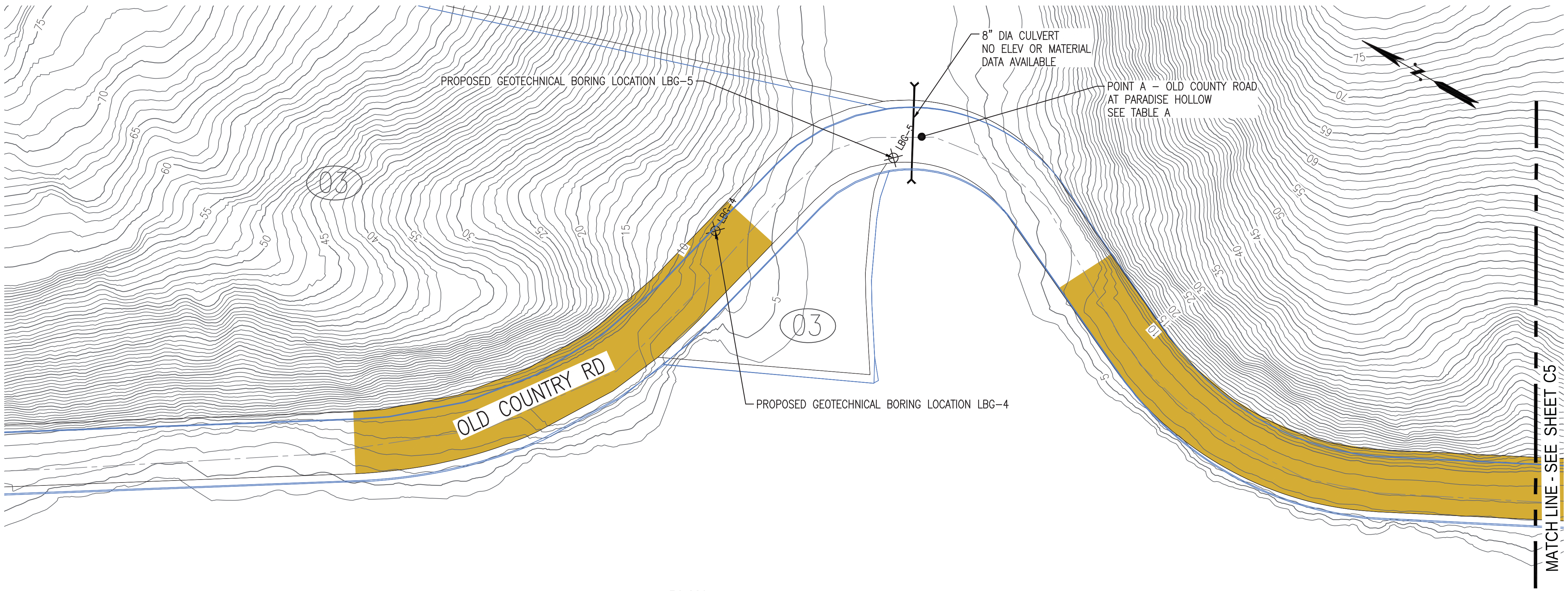
OLD COUNTY ROAD - NORTH SEGMENT - SHEET 3 OF 3

DRAWING NO. **C3**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X



PLAN

OLD COUNTY ROAD – PARADISE HOLLOW
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE A - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	DRY
MEAN HIGH WATER SPRING	DRY
ANNUAL HIGH WATER	4.13
STORM OF RECORD	5.55

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

1

2

1"=40'
40 20 0 40 80
Scale Feet

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OLD COUNTY ROAD - PARADISE HOLLOW

DRAWING NO. C4
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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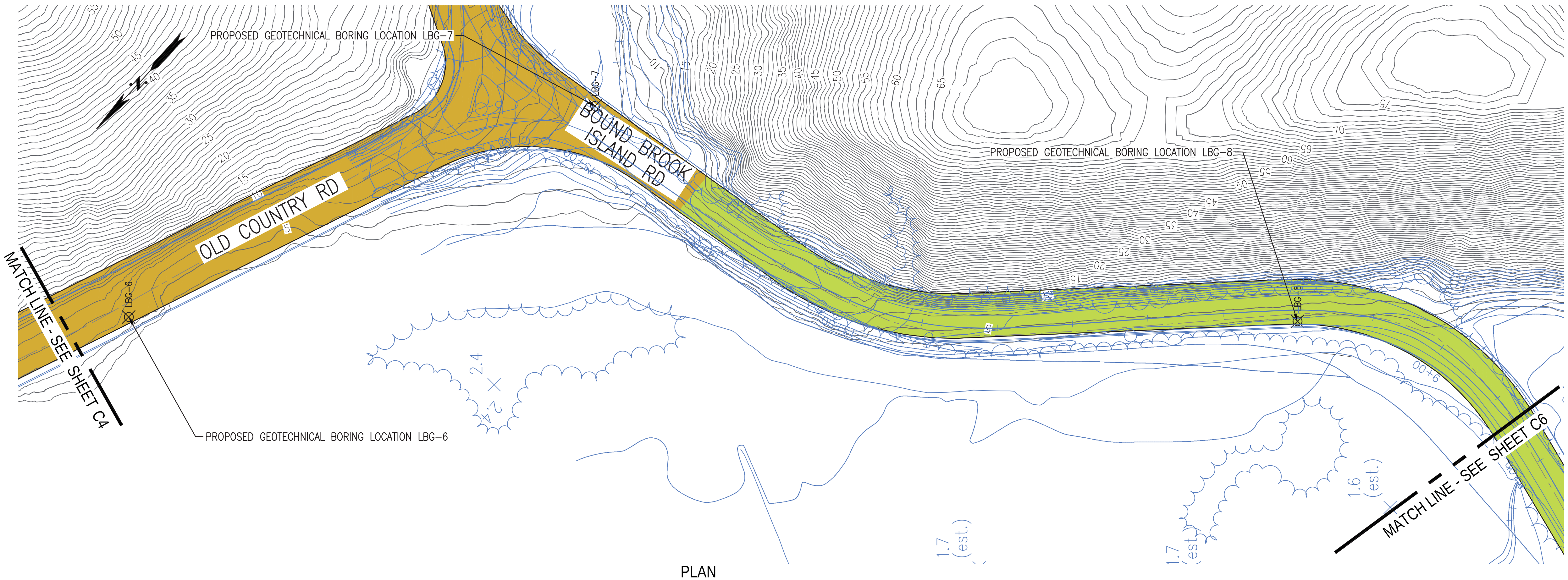

PLAN

OLD COUNTY ROAD AND BOUND BROOK ISLAND ROAD
SCALE: 1"=40'

GENERAL NOTES

1.

2.

🟩 AREA BELOW ELEVATION 8 TO BE SURVEYED

🟧 ADDITIONAL SURVEY AREA

KEYED NOTES

①

②

1"=40' 40 20 0 40 80
Scale Feet

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OLD COUNTY ROAD AND BOUND BROOK ISLAND ROAD

DRAWING NO. **C5**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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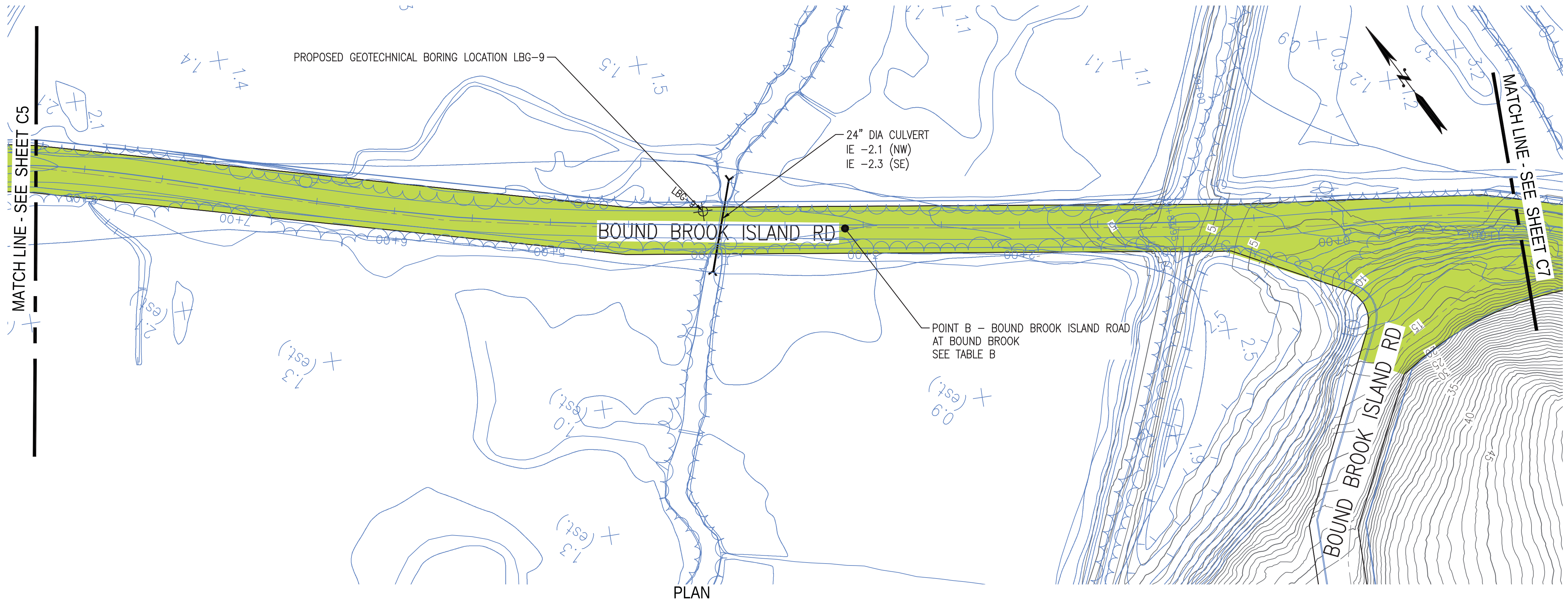

PLAN

BOUND BROOK ISLAND ROAD – SHEET 1 OF 5
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE B - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	DRY
MEAN HIGH WATER SPRING	3.16
ANNUAL HIGH WATER	4.11
STORM OF RECORD	5.53

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

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HERRING RIVER RESTORATION PROJECT

BOUND BROOK ISLAND ROAD - SHEET 1 OF 5

DRAWING NO. C6
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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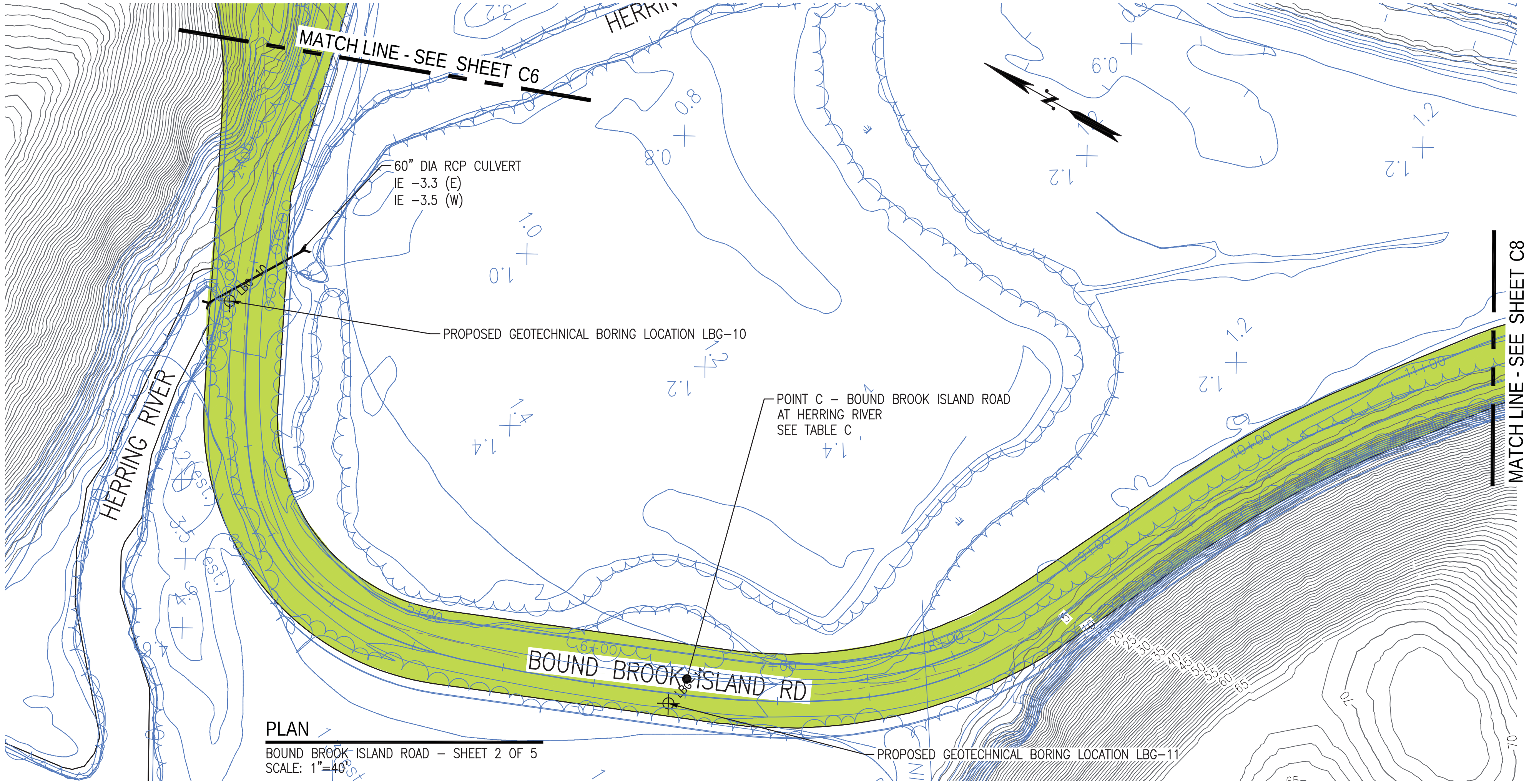

PLAN
BOUND BROOK ISLAND ROAD – SHEET 2 OF 5
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE C - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	2.41
MEAN HIGH WATER SPRING	3.84
ANNUAL HIGH WATER	4.73
STORM OF RECORD	6.44

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40'
40 20 0 40 80
Scale Feet

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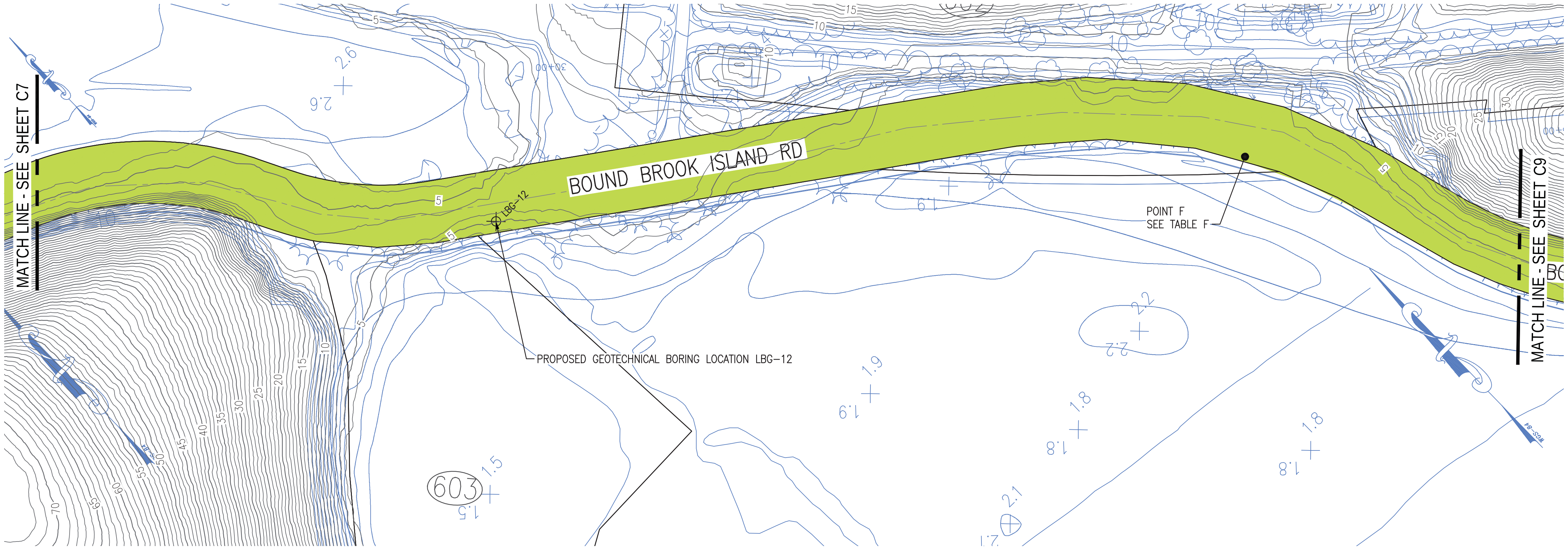
BOUND BROOK ISLAND ROAD - SHEET 2 OF 5

DRAWING NO. **C7**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X



PLAN

BOUND BROOK ISLAND ROAD – SHEET 3 OF 5
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE F - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	3.49
MEAN HIGH WATER SPRING	4.86
ANNUAL HIGH WATER	5.34
STORM OF RECORD	6.86

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟨	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

MARK	REVISION DESCRIPTION	BY	APP.	DATE

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BOUND BROOK ISLAND ROAD - SHEET 3 OF 5

DRAWING NO. C8
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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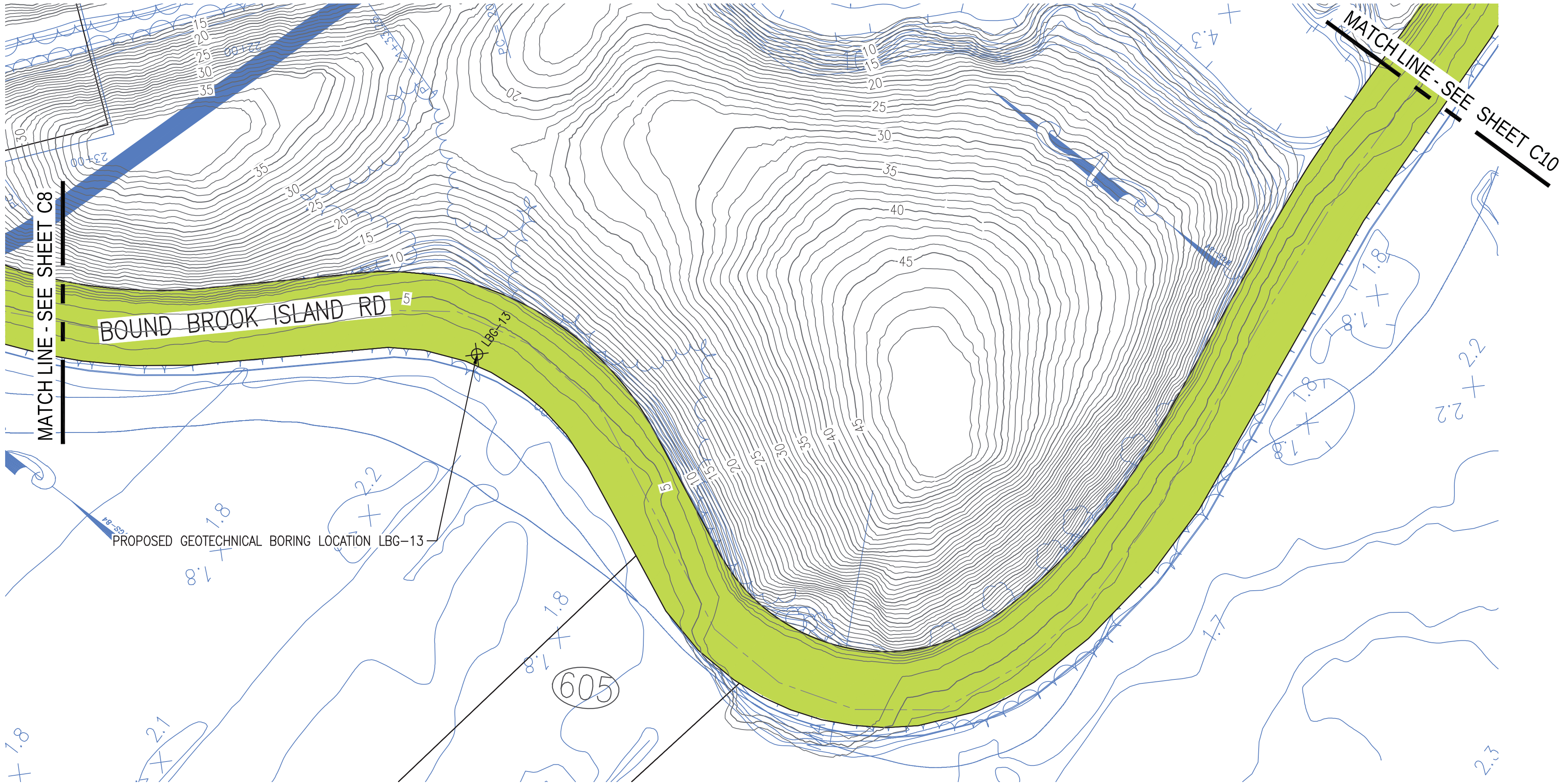

PLAN

BOUND BROOK ISLAND ROAD – SHEET 4 OF 5
SCALE: 1"=40'

GENERAL NOTES

1.

2.

🟩 AREA BELOW ELEVATION 8 TO BE SURVEYED

🟧 ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

MARK	REVISION DESCRIPTION	BY	APP.	DATE

Louis Berger
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Providence | RI | 02909
phone 401.521.5980
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Friends of Herring River

P.O. Box 496
Wellfleet, Massachusetts 02667
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DRAWN BY JF/RV
DESIGN BY CF
CHECK BY
PROJ MGR JR

TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

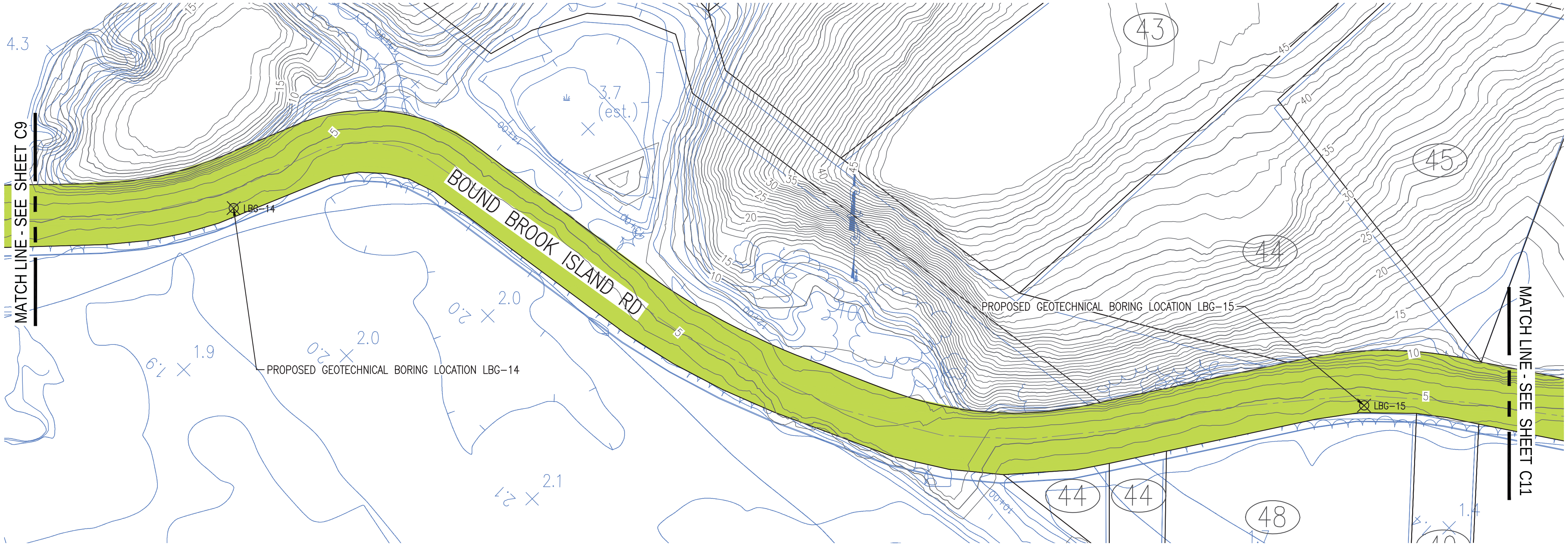
BOUND BROOK ISLAND ROAD - SHEET 4 OF 5

DRAWING NO. **C9**
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

GENERAL NOTES

1.

2.



PROPOSED GEOTECHNICAL BORING LOCATION LBG-14

PROPOSED GEOTECHNICAL BORING LOCATION LBG-15

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

PLAN

BOUND BROOK ISLAND ROAD – SHEET 5 OF 5
SCALE: 1"=40'

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

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TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

BOUND BROOK ISLAND ROAD - SHEET 5 OF 5

DRAWING NO. C10
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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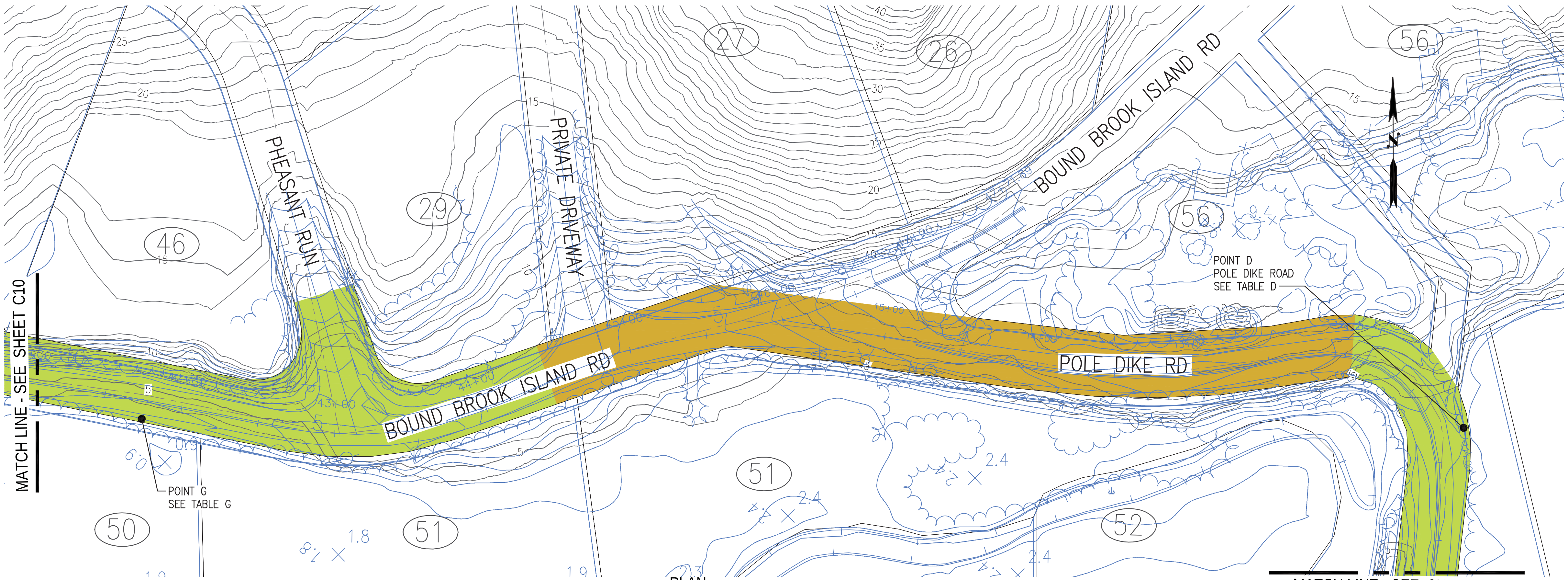

PLAN

BOUND BROOK ISLAND ROAD AND POLE DIKE ROAD
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE D - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	3.23
MEAN HIGH WATER SPRING	4.37
ANNUAL HIGH WATER	4.94
STORM OF RECORD	6.82

TABLE G - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	3.44
MEAN HIGH WATER SPRING	4.75
ANNUAL HIGH WATER	5.25
STORM OF RECORD	6.88

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40' 40 20 0 40 80
Scale Feet

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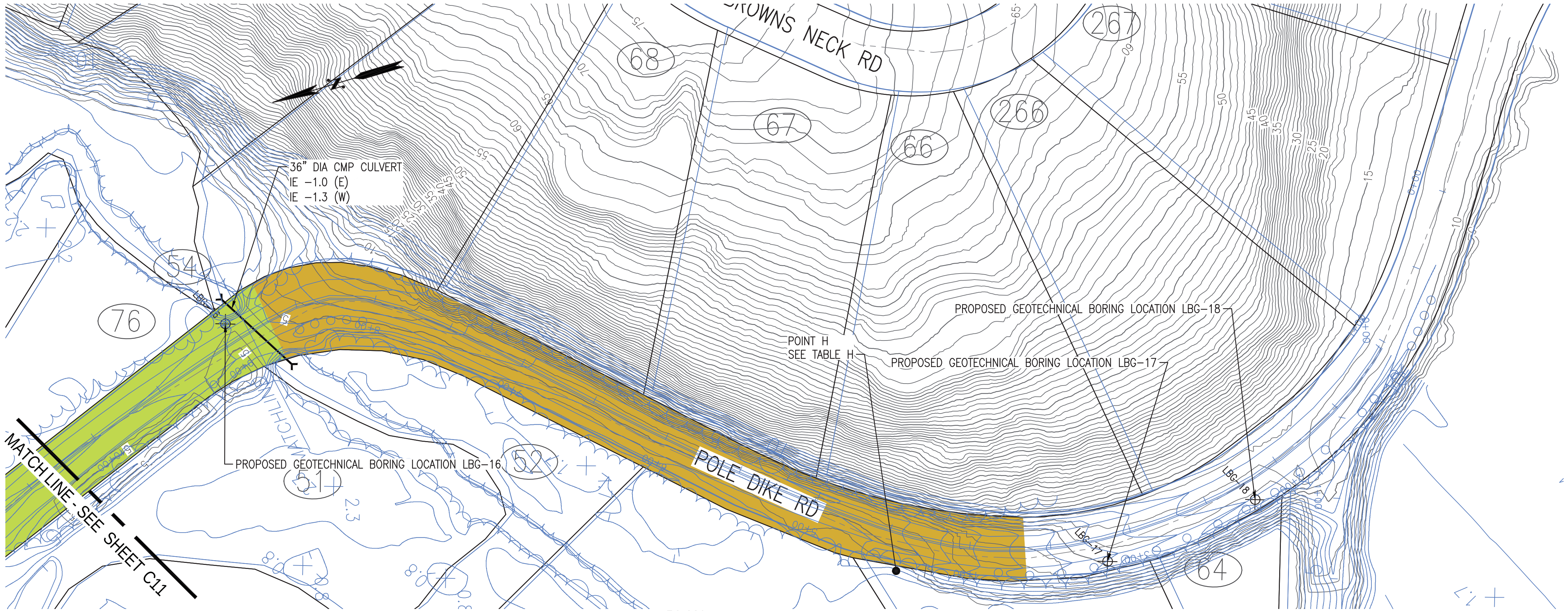
TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

BOUND BROOK ISLAND ROAD AND POLE DIKE ROAD

DRAWING NO. C11
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X



PLAN

POLE DIKE ROAD
SCALE: 1"=40'

GENERAL NOTES

1.

2.

TABLE H - MODELED TIDAL ELEVATIONS	
MEAN HIGH WATER	DRY
MEAN HIGH WATER SPRING	4.68
ANNUAL HIGH WATER	5.16
STORM OF RECORD	6.83

🟩	AREA BELOW ELEVATION 8 TO BE SURVEYED
🟧	ADDITIONAL SURVEY AREA

KEYED NOTES

⟨1⟩

⟨2⟩

1"=40'
40 20 0 40 80
Scale Feet

MARK	REVISION DESCRIPTION	BY	APP.	DATE

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DESIGN BY CF
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TRURO AND WELFLEET, MASSACHUSETTS
HERRING RIVER RESTORATION PROJECT

POLE DIKE ROAD

DRAWING NO. C12
PROJECT NO. 2004341
FED AID NO.
DATE: JAN 2015
SHEET NO. ---- OF X

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WOODS HOLE GROUP

Woods Hole Group 81 Technology Park Drive E. Falmouth, MA 02536 USA TELEPHONE: 508.540.8080 FAX: 508.540.1001 www.woodsholegroup.com

January 29, 2015

SENT BY ELECTRONIC MAIL

Friends of Herring River
ATTN: Mr. Don Palladino
Wellfleet/Truro, Inc.
P.O. Box 496
Wellfleet, MA 02667

RE: Herring River Restoration Project –Sizing of Low-Lying Road Culverts

Dear Mr. Palladino:

Woods Hole Group, Inc. (WHG) is pleased to submit the results for the hydrodynamic assessment of the culverts in the vicinity of the Herring River, Bound Brook, and Pole Dike Creek confluence, a complex area where Old County Road and Bound Brook Island Road intersect (Figure 1). In this area, there are a series of culverts, as well as relic railroad crossings, that influence the flow through the system. As such, Woods Hole Group, Inc. conducted additional hydrodynamic modeling services to determine the optimal sizing of culverts at existing locations, as well as potential remediation strategies at the relic railroad crossing (with no existing culvert) in the same area. While previous modeling efforts (WHG, 2012) indicated these features resulted in minimal tidal attenuation during normal tidal conditions and with a restored Chequessett Neck Road (CNR) opening; the model results also showed overtopping of low lying roadways at some of these crossing locations (even during normal spring tides at some locations). Therefore, the volume of water passing through a restriction consisted of both water transported through the existing culvert(s) and over the roadway(s). As the elevation of these low lying roads are increased as part of the restoration project, the amount of water transported over the roadway during high tides will be eliminated. Therefore, it is likely that the combined effect of these features will result in some tidal attenuation during the fully restored conditions. As such, the tasks presented below are intended to determine the required modifications (if necessary) to the existing culverts and other anthropogenic features (i.e., relic railroad crossings) to eliminate restricted flow through this complex up to the storm of record level (Blizzard of '78). The utilization of the storm of record for evaluation of the upstream crossings ensured that the installed culverts and openings allowed maximum salinity penetration, would not inhibit upstream sediment propagation during storm events, and provided adequate tidal exchange under future projected climate change conditions. In addition, the recommended culvert sizes included a public safely aspect to allow for adequate headspace under normal tidal conditions.

Figure 1. **Culverts and potential flow constrictions in the vicinity of Old County Road and Bound Brook Island Road.**

In the adaptive management simulations (WHG, 2012), which included varying the openings at CNR, the culvert restrictions were removed at all locations at the request of the HRRC (no tidal attenuation). These analyses, present herein re-instate the culverts in the model, with increased road elevations (no overtopping) and assess the appropriate culvert/open channel sizing that eliminates the restrictions (if any). Specifically, Woods Hole Group investigated the performance of the culverts at Bound Brook Island Road, Old County Road, the culvert at the railroad crossing in the northwest corner of the locus map, as well as the relic railroad crossing just upstream of Bound Brook Island Road. Due to the small size of the culvert at Paradise Hollow (0.5 ft), and the relatively small upstream area, this culvert was not included in the investigation.

In addition to examining the level of tidal exchange at these locations, Woods Hole Group also examined the spring tidal range at each culvert in respect to the invert/obvert elevations of the culverts for evaluation of public safety (e.g., adequate headspace). In all recommended culvert sizing a minimum of approximately one foot at both the upstream and downstream openings of the culverts was included.

Existing Conditions

Current culvert details are shown in Table 1 for the three culverts evaluated in this region. Figure 2 shows the location of the culverts within the hydrodynamic modeling mesh. In addition, the historic railroad embankment that resides in the marsh system, and creates a restriction in the system, is also shown (Figure 2). While the culverts are constructed of different materials, and therefore consist of different frictional effects, all existing culverts are currently circular. These existing crossings (including current culverts and road elevations) were evaluated using the results of the storm of record from previous model simulations (WHG, 2012) to evaluate potential attenuation of the tidal signal under a significant volumetric tidal exchange. The CMP crossing of the historic railroad embankment (2 foot culvert) is currently the only culvert that is actively exchanging water at this location. However, there is some evidence that there may be a second culvert approximately 100 feet to the north that could potentially enhance exchange beneath the railroad embankment at this location. This secondary culvert currently is connected via a small channel running parallel to the railroad embankment and is not actively exchanging water, is filled with debris, and may not have a defined connection to the other side of the railroad embankment. This secondary culvert was not included in the model since it is currently inactive and it is unclear if it could be functional in the future.

Table 1. Existing culvert parameters and details.

Location	Material	Shape	Diameter (ft)	Upstream Invert (ft - NAVD88)	Downstream Invert (ft - NAVD88)	Existing Roadway Elevation (ft-NAVD88)
Bound Brook Island	Concrete	Circular	5	-3.3	-3.5	4.45
Old County Rd	Ceramic	Circular	2	-2.1	-2.3	2.69
Railroad grade	CMP	Circular	2	-2.6	-2.6	N/A

Figure 3 shows the time series of water surface elevation at the four locations (as identified in Figure 2) for a portion of time during the storm or record simulation. The subpanels show the water surface elevation on both upstream (green line) and downstream side (triangle markers) of each potential restriction. In addition, the red line shows the difference in the water surface elevation between the upstream and downstream sides of the culvert or embankment, showing the relative magnitude of the restriction. Minimal attenuation of the storm signal was observed at both Bound Brook Island Road (panel a) and Old County Road (panel c) through the existing culverts. However, overtopping also occurs at these crossings due to their relatively low elevations (4.5 ft-NAVD88 and 2.7 ft-NAVD88, respectively). As such, it is feasible that lack of attenuation during the peak of the surge is caused by enough water flowing over the top of the roadway under existing conditions.

There is more pronounced surge attenuation through the existing cut at the railroad embankment (panel b), which clearly restricts flow. The northern railroad crossing at Bound Brook, which is a 2 foot diameter corrugated metal pipe (CMP), also shows considerable attenuation in the signal (panel d), as the culvert is consistently flowing full and always transporting water upstream through the restrictive culvert. This restriction occurs until the railroad embankment is overtopped (just past day 18).

In these existing condition cases, while the model doesn't show significant attenuation at these crossings, there is also water being transported over the low-lying roadways. As such, when the roads are raised, the culverts will attenuate the flow, which will be restricted just to the culverts.

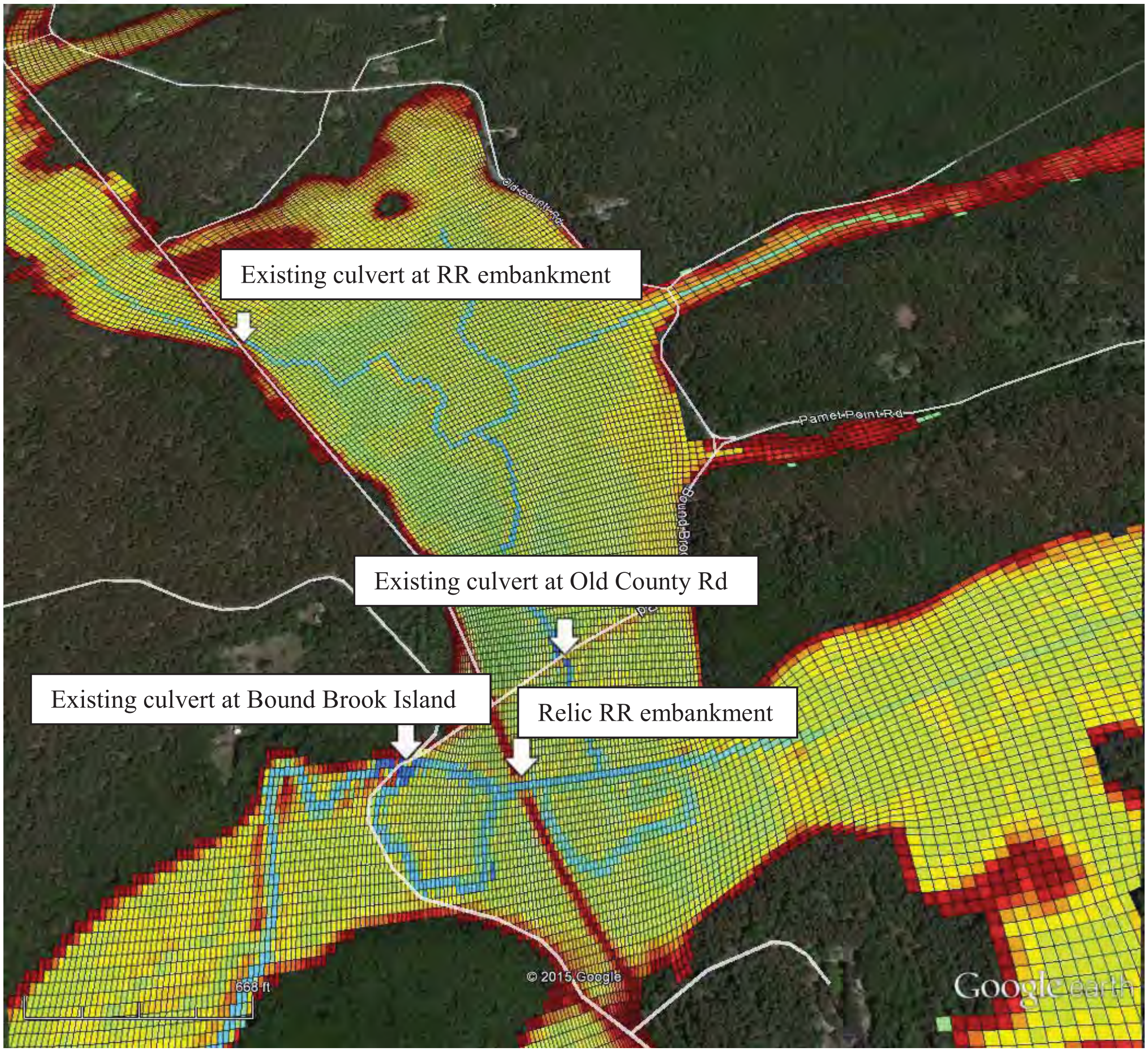

Figure 2. **Locations of restrictions within the Herring River model mesh.**

Proposed Conditions

Proposed conditions were evaluated by raising the roadways to eliminate overtopping in the model and then simulating a wide range of box and circular culverts at the various crossing locations. The culvert optimization process also involved ensuring adequate head space during spring flood tides conditions to increase public safety. A minimum of approximately 1 foot of clearance during spring high tides was specified at each culvert location.

Table 2 lists the recommended minimum culvert sizing at the Bound Brook Island Road, Old County Road, and the northern railroad embankment culverts after evaluating a full range of sizing simulations. In addition, the historic railroad embankment was assessed with a wider opening in the embankment to allow full tidal exchange up to the historic storm of record. Woods Hole Group assumed that the culverts would be replaced using the existing invert elevations listed in Table and assumed the roads could be raised to an elevation that incorporates the recommended head space recommendations.

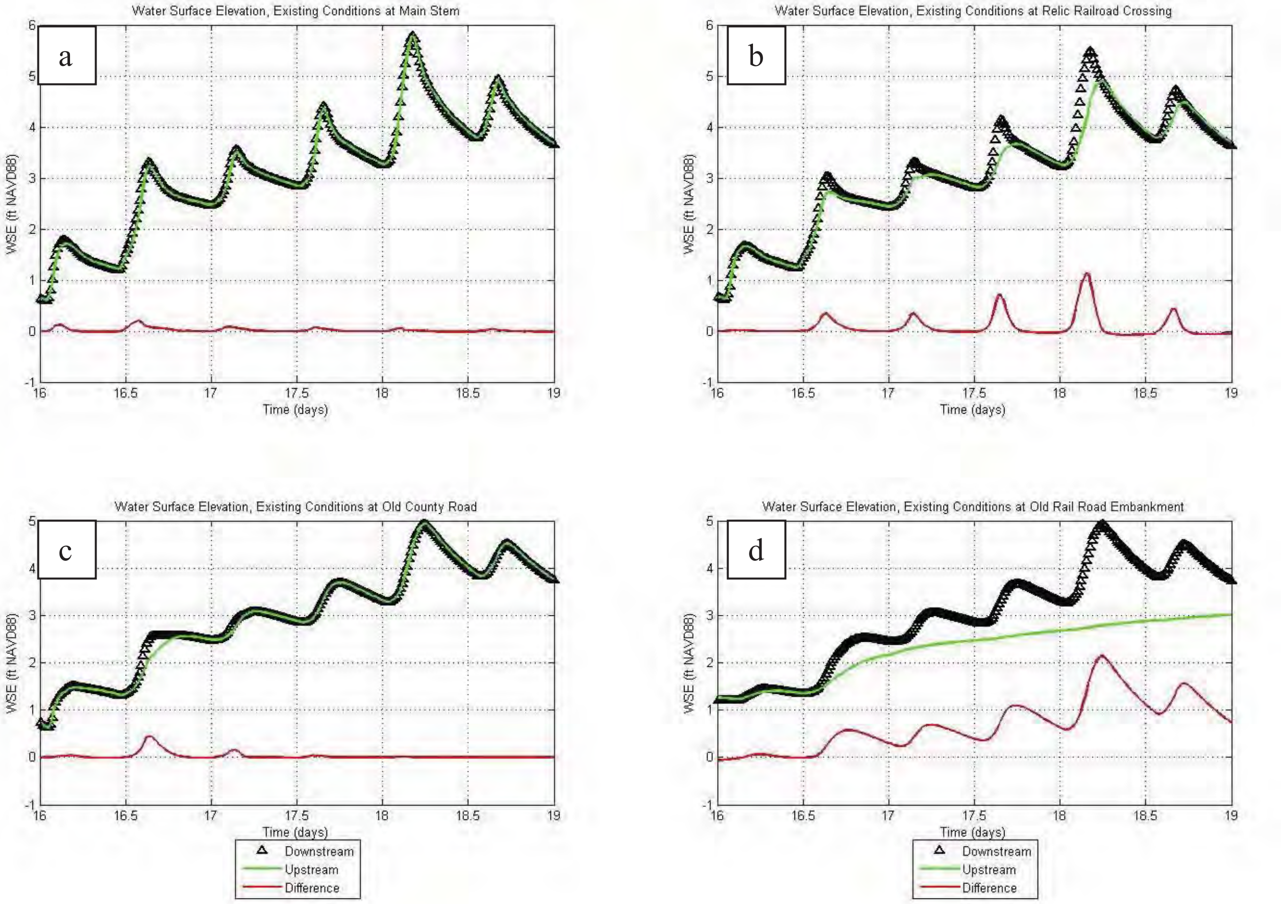

Figure 3. Time series of water surface elevations through during a historic storm of record for existing culvert conditions. a) Bound Brook Island Road culvert, b) existing railroad embankment cut, c) Old County Road culvert, and d) northern railroad embankment culvert.

Table 2. Proposed culvert specifications.

Location	Material	Shape	Size (ft)	Upstream Obvert (ft - NAVD88)	Downstream Obvert (ft - NAVD88)
Bound Brook Island Rd	Concrete	Box	6x8	4.7	4.5
Old County Rd	Concrete	Box	6x6	3.9	3.7
Northern Railroad Crossing	Concrete	Box	6x6	3.4	3.4
Relic Railroad	Restore open channel marsh plain, minimum of 100 feet				

Figure 4 shows time series of water surface elevations both downstream (triangle markers) and upstream (green line) at each of the crossings for the proposed conditions listed in Table 2. . Although there was little apparent tidal attenuation at both Bound Brook Island Road and at Old County Road (Figure 3), raising the road elevation does create an attenuated signal for the storm case and there is also inadequate head space under existing normal tidal conditions. The increase in width at the existing railroad embankment (from approximately 25 feet to 100 feet, an increase of 75 feet) effectively eliminated any reduction in the water surface elevation at the historic railroad embankment (panel b). The proposed 6'x6' box culvert at the northern railroad crossing reduces the attenuation significantly; however, during the peak of the storm surge there is a slight attenuation caused by the relatively sharp approach angle of the channel with the orientation of the culvert. Re-orientation of the box culvert during construction to align more directly with the channel could be considered at this location.

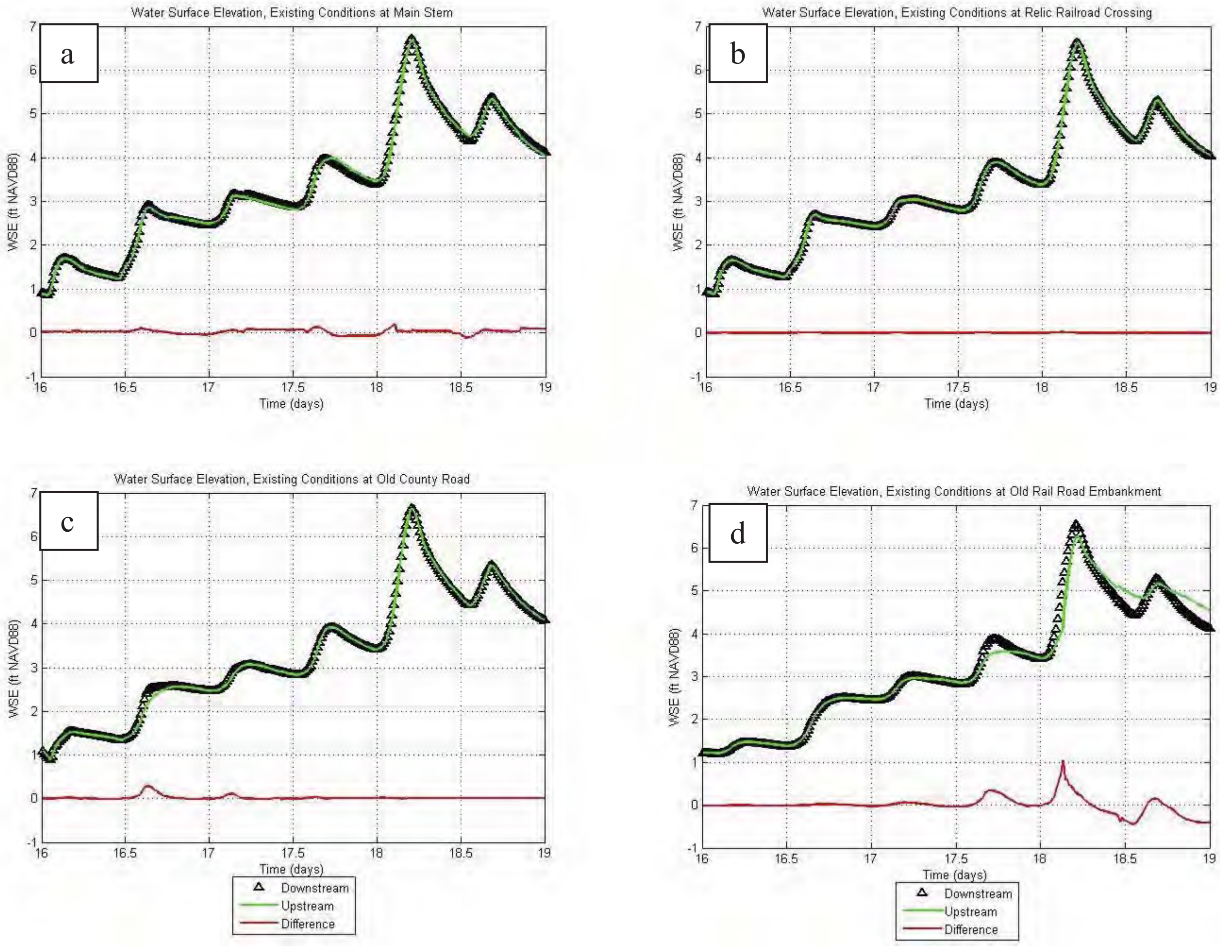

Figure 4. **Time series of water surface elevations through during a historic storm of record for proposed culvert conditions. a) Bound Brook Island Road culvert, b) existing railroad embankment cut, c) Old County Road culvert, and d) northern railroad embankment culvert.**

Summary

Table 3 provides a comprehensive summary of the culvert replacement recommendations in the Bound Brook Island Road complex. This includes both a summary of the existing infrastructure and the proposed modifications. In addition, some notes were included that summarize the hydrodynamic results and thought process on the recommendations. Under current conditions, the culverts at Bound Brook Island Road and Old County Road allow sufficient tidal exchange during normal and storm conditions, but do not provide adequate clearance from a safety perspective. The existing CMP culvert at the railroad embankment restricts tidal exchange and has minimal head space during spring tides. In addition to changing culvert dimensions, Woods Hole Group also recommends increasing the width at the existing railroad embankment from approximately 25 feet to a minimum of 100 feet, although complete removal of the embankment would maximize marsh restoration. Material removed from the railroad embankment can then be beneficially reused in low-lying sections the marsh plain. At the railroad grade culvert, additional reduction in WSE attenuation may be achieved by realignment of the culvert with respect to the stream bed, and additional head space may be obtained by increasing the culvert invert by 0.5 foot which will have negligible impact upon flow dynamics.

The changes recommended in Table 3 are based on simulations using the storm of record event. As such, the results presented herein differ from results presented previously at these upstream area (WHG, 2012) when attenuation at these locations was evaluated only for normal tidal conditions. During normal tidal conditions, the existing structures and features result in minor attenuation of the tide (WHG, 2012). In this analysis, WHG evaluated the upstream crossings in the Bound Brook area focused solely on potential impacts during the storm of record. The purpose of this approach was to ensure that the recommended culverts and openings allowed maximum salinity penetration, would not inhibit upstream sediment propagation during storm events, and provided adequate tidal exchange under future projected climate change conditions. Whether or not the culverts themselves legitimately need to be able to transfer storm surge with no attenuation up to the storm of record is not considered herein by Woods Hole Group, and the Herring River Restoration Committee should consider the merits associated with the proposed culvert sizes.

In addition, discussion of the potential timing of the replacement of the culverts and openings is also warranted. For example, it may take a few decades before the CNR opening is fully opened, thus providing adequate adaptive management time prior to full tidal exchanges being realized. Since the roads are being elevated to reduce overtopping risk once the Chequessett Neck Road entrance is opened, it makes sense to consider concurrently replacing the culverts to allow more than adequate tidal exchange capability and public safety considerations. In the process, getting rid of potential safety issues (fully flowing culverts) while the roads were being elevated is likely warranted. However, removal of the railroad embankments, or culvert replacements at the railroad embankment, may be something that can proceed at a later date since these restrictions may not become active until later in the restoration process.

Woods Hole Group also evaluated salinity penetration as a component of this analysis. Since the culverts and openings were sized to allow full tidal exchange even under a storm of record, this also maximizes salinity penetration under all normal tidal conditions.

Recommendations

Assuming it is warranted to increase the culverts and openings to allow for unimpeded tidal exchange up to a storm of record surge level, the following recommendations are provided, in concert with Table 3. Ultimately, this document was provided for informational purposes and guidance only. The Herring River Restoration Committed can decide if and when the associated recommended changes are warranted at the various sites.

- Herring River at Bound Brook Island Road – Recommend replacing the existing culvert with a 6' x 8' box culvert. Since the road is scheduled to be elevated, there is no reason not to increase the culvert during this construction process. The recommended culvert will provide adequate head space (public safety) and will allow for maximum tidal, sediment, and salinity exchange with room to accommodate future sea level rise projections.

- Bound Brook at Old County Road - Recommend replacing the existing culvert with a 6' x 6' box culvert. Since the road is scheduled to be elevated, there is no reason not to increase the culvert during this construction process. The recommended culvert will provide adequate head space (public safety) and will allow for maximum tidal, sediment, and salinity exchange with room to accommodate future sea level rise projections.

- Herring River remnant railroad crossing – During normal tidal conditions, this feature does not significantly inhibit tidal flows. During storm events, this feature does begin to have more influence on tidal exchange as attenuation reaches a maximum value of approximately 1 foot (Figure 3b). So while there is relatively minimal attenuation of the tide at this location, this feature also will likely impede drainage during a storm surge. To completely eliminate tidal exchange and drainage restrictions a 100 foot opening is reduction in the embankment would be required (this does not mean a 100 foot wide channel is required, rather that the elevation of the embankment is reduced to match the elevation of the marsh plain). Mitigation of this location is a lower priority than the roadways and culverts since the impediment at this location is not as severe. WHG does recommend mitigation of this area at some point in the restoration process, but it also is a location that could be monitored during the adaptive management process and completed at a later date.

- Bound Brook at railroad crossing culvert – Given some of the uncertainty related to this culvert location and that there is no current construction work being proposed, WHG recommends that this location be monitored and re-assessed as part of the adaptive management project. Prior to restoration, this also may involve minor maintenance of the existing culverts and restoration of any connection (channel cleaning, etc.). However, if there is a desire to pro-actively manage this crossing/location, a 6'x6' box culvert could be installed; or if an open channel is desired at this location, a minimum of a 10' wide channel could be created.

Sincerely,
The Woods Hole Group

References

Woods Hole Group. 2012. Herring River Hydrodynamic Modeling Model Report. Prepared for the Town of Wellfleet and the Herring River Restoration Committee, prepared by Woods Hole Group Inc., 2012.

Table 3. Summary of existing culverts and crossings and proposed modifications.

Location	Existing Infrastructure Information					Proposed			
	Culvert DIA. (ft)	Upstream Culvert Invert (ft-NAVD88)	Downstream Culvert Invert (ft–NAVD88)	Approx. Length (ft)	Existing Road Elevation at Crossing (ft-NAVD88)	Proposed Replacement Culvert or Opening	Fully restored approx. MHWS (ft–NAVD88)	Proposed Culvert Obvert (ft-NAVD88)	Notes
Herring River at Bound Brook Is. Rd.	5	-3.3	-3.5	45	4.45	6’x8’ box culvert	3.5	4.5	Existing 5 foot culvert did not significantly restrict flow. However, there is inadequate headspace at the existing culvert and enough of a restriction that it is reasonable to increase the culvert size, especially considering the road is being raised. A 6’x8’ box culvert provides full tidal exchange under storm conditions and provides adequate headspace during normal conditions.
Herring River Remnant RR Crossing	N/A	N/A	N/A	30	N/A	Restore open channel marsh plain, minimum of 100 feet	3.5	N/A	This feature was a significant flow restriction to the areas upstream during events that will flood the marsh plain. It has a similar effect as High Toss Road. Remove embankment to create a more natural open channel and marsh plain. Match existing downstream grades for at least a 100 foot wide area. Ideally remove entire embankment (approximately 500 feet) while matching upstream and downstream grades and beneficially reuse material in a subsided marsh area.
Bound Brook at Old County Rd.	2	-2.1	-2.3	35	2.69	6’x6’ box culvert	2.5-3.0	3.7	This culvert was not restrictive until we improved the RR crossing location (3). Replace with 6’x6’ box culvert as road needs to be raised. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.
Bound Brook at RR Crossing Culvert	2	-2.6	-2.6	80	N/A	6’x6’ box culvert	2.5-3.0	3.4	This culvert was not restrictive until we improved the RR crossing location (3). Replace with a 6’x6’ box culvert, and consider re-alignment of the culvert. As currently situated, flow restrictions occur during larger events due to both the size and orientation of the culvert to the approaching creek. Additionally, may want to consider channel excavation and reconfiguration on the downstream side of this crossing. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.

Location	Existing Infrastructure Information					Proposed			
	Culvert DIA. (ft)	**Upstream Culvert Invert (ft-NAVD88)**	**Downstream Culvert Invert (ft–NAVD88)**	**Approx. Length (ft)**	**Existing Road Elevation at Crossing (ft-NAVD88)**	**Proposed Replacement Culvert or Opening**	**Fully restored approx. MHWS (ft–NAVD88)**	**Proposed Culvert Obvert (ft-NAVD88)**	**Notes**
1) Pole Dike Creek at Pole Dike Rd.	3	-1.0	-1.3	45	4.67	Minimum of 7'x8' box culvert for safety. 4'x8' is adequate for flow	4.8	5.7	Existing circular culvert is restrictive. Replacement culvert as minimal as 4'x8' reduced attenuation; however, this size did not provide adequate headspace during normal tidal conditions. Therefore, a 7'x8' opening is suggested.
2) Bound Brook at Bound Brook Is. Rd.	5	-3.3	-3.5	45	4.45	6'x8' box culvert	3.5	4.5	Existing 5 foot culvert did not significantly restrict flow. However, there is inadequate headspace at the existing culvert and enough of a restriction that it is reasonable to increase the culvert size, especially considering the road is being raised. A 6'x8' box culvert provides full tidal exchange under storm conditions and provides adequate headspace during normal conditions.
3) Bound Brook Remnant RR Crossing	N/A	N/A	N/A	30	N/A	Restore open channel marsh plain, minimum of 100 feet	3.5	N/A	This feature was a significant flow restriction to the areas upstream during events that will flood the marsh plain. It has a similar effect as High Toss Road. Remove embankment to create a more natural open channel and marsh plain. Match existing downstream grades for at least a 100 foot wide area. Ideally remove entire embankment (approximately 500 feet) while matching upstream and downstream grades and beneficially reuse material in a subsided marsh area.
4) Bound Brook at Old County Rd.	2	-2.1	-2.3	35	2.69	6'x6' box culvert	2.5-3.0	3.7	This culvert was not restrictive until we improved the RR crossing location (3). Replace with 6'x6' box culvert as road needs to be raised. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.
5) Bound Brook at RR Crossing Culvert	2	-2.6	-2.6	80	N/A	6'x6' box culvert	2.5-3.0	3.4	This culvert was not restrictive until we improved the RR crossing location (3). Replace with a 6'x6' box culvert, and consider re-alignment of the culvert. As currently situated, flow restrictions occur during larger events due to both the size and orientation of the culvert to the approaching creek. Additionally, may want to consider channel excavation and reconfiguration on the downstream side of this crossing. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.

Appendix C

Geotechnical Report

Louis Berger

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Prepared for
FRIENDS OF HERRING RIVER
In Partnership with the
HERRING RIVER RESTORATION COMMITTEE

GEOTECHNICAL REPORT FOR THE HERRING RIVER RESTORATION PROJECT ENGINEERING DESIGN TO ELEVATE LOW-LYING ROADWAYS and REPLACE ASSOCIATED CULVERTS WELLFLEET and TRURO, MASSACHUSETTS

Prepared by

Louis Berger

166 Valley Street, Bldg. 5
Providence, Rhode Island 02909

June
2015

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

On behalf of the Friends of Herring River (FHR) and the Herring River Restoration Committee (HRRC), Louis Berger investigated and evaluated the geotechnical data associated with the proposed elevation of existing low-lying roadways and replacement of associated culverts as part of the Herring River Restoration Project. Five road segments have been identified for elevation and culvert replacement: Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, and Bound Brook Island Road in northwest Wellfleet, Massachusetts and Old County Road – North Segment in southwest Truro, Massachusetts. Low-lowing roadways are shown in Figures 1, 2A, and 2B.

This report presents a factual account of the subsurface conditions based on 10 borings inspected and logged by Louis Berger; laboratory test results; and associated geotechnical analysis and geotechnical evaluations, with conclusions and recommendations to assist the design team in the development of the project area, including the installation/replacement of new culverts and roadway fill and grading operations. Based on a survey performed by Outermost Land Surveyors, the existing road surface at low-lying areas ranges from 2.3 to 5.2 feet North American Vertical Datum of 1988 (NAVD88), which would be elevated to 4.25 to 7.4 (NAVD88). The goal is to elevate the existing roadway segments 0.5 feet above the storm of record within the project area (3.72 to 6.88 [NAVD88]). The restoration team selected 0.5 feet of freeboard above the storm of record to elevate these roadway. As a result, about 0 to 4.5 feet of fill would be required over existing ground elevations to maintain the final site grading. As part of the re-grading, existing culverts would be replaced with new circular and box culvert structures.

The subsurface at the site consists of three different strata with different elevations and characteristics underlying the ground surface, below an average 6-inch-thick asphalt surface course within the project site. From top to bottom, these strata are: Stratum 1—an approximately 2-foot-thick fill layer, Stratum 2—a discontinuous layer of an average 10-foot-thick sand mixed with organic silt, with peat in some locations, and Stratum 3—deposits consisting principally of fine to medium to coarse sand, in excess of 10 feet thick. Based on the wetness of the samples and observations during drilling, groundwater is anticipated to be between 1 and 2 feet below the existing grade.

The proposed roadway grade change (increase) would result in settlement. Because of the mostly granular nature of the soils below the existing roadway, settlement due to added loads would consist of primary settlement. The magnitude of the estimated primary settlement is less than 2 inches; more than one-half of this would occur during construction. However, Stratum 2 generally contains organic matter that will gradually decay over the next several decades, resulting in an additional 3 to 6 inches of settlement. As a result of slow decay and pore pressure, dissipation-related settlement will occur over a time period of a decade or longer; therefore, measures to mitigate this long-term settlement may not be required.

In conjunction with elevating the existing low-lying roads, six existing under-sized culverts would be removed and replaced with new culverts. These culverts include three 24-inch-diameter reinforced concrete pipe (RCP) culverts, a 6-foot by 6-foot concrete box culvert, a 6-foot by 8-foot concrete box culvert, and a 7-foot by 8-foot concrete box culvert. Because of the proposed

grade change, the new culverts would be installed within existing Stratum 1 fill and new fill, above the groundwater table. Based on the load-settlement, it is estimated that the loads imposed by the box culverts (all three sizes) are comparable to, and generally less than, the weight of the soils excavated to allow for their installation. Therefore, no added stress or settlement would be induced by their installation. However, the proposed 24-inch-diameter circular culverts would induce an added stress when full, resulting in post-construction settlement on the order of 1 inch. Because the settlements related to the installation of new culverts are tolerable (on the order of an inch), and the long-term settlements related to the decay of organic soils in Stratum 2 would coincide with the future periodic roadway surfacing (i.e., 20 years), no special ground improvement is proposed except for the careful preparation of the subgrade and the new fill as discussed in the following section.

For grade change, the existing asphalt surface/binder/base course would need to be milled/removed to below the bottom of the asphalt. After removal of the existing asphalt, the new embankment could be brought to the design grade. The new embankment side slopes should be no steeper than a 1:3 horizontal to vertical ratio, and the embankment slopes should be compacted and protected against erosion by vegetation. Depending on the hydraulic and hydrodynamic conditions of the site, additional embankment protection may be required to minimize scour damage. Steeper side slopes may be required in isolated areas to minimize impacts to adjacent parcels; stabilization with geotextile fabric and/or rip-rap would be required for slopes greater with a greater than 3:1 horizontal to vertical ratio.

1.0 INTRODUCTION

1.1 GENERAL

On behalf of the Friends of Herring River (FHR) and the Herring River Restoration Committee (HRRC), Louis Berger investigated and evaluated the geotechnical data with respect to the proposed road reconstruction of the Herring River Restoration Project. The roads proposed for redesign include portions of Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, and Bound Brook Island Road, located in northwest Wellfleet, along with Old County Road – North Segment in southwest Truro, Massachusetts.

This report presents a factual account of the subsurface conditions based on 10 borings inspected and logged by Louis Berger, laboratory test results, and associated geotechnical analysis and geotechnical evaluations, with conclusions and recommendations to assist the design team in the development of the project area, including the installation/replacement of new culverts and roadway fill and grading operations.

The sites for the proposed roadway elevation includes approximately 1.64 miles of road in Wellfleet and 0.40 mile of road in Truro (Figures 1 and 2).

1.2 PROJECT DESCRIPTION

Based on the data provided by FHR, Louis Berger understands that the proposed site work specific to the geotechnical exploration program consists of elevating portions of Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, and Bound Brook Island Road in Wellfleet, and Old County Road – North Segment in Truro above the elevation of the storm of record with 0.5 feet of freeboard per the direction of FHR. Based on a survey performed by Outermost Land Survey, Inc., the existing road surface at low-lying areas ranges from 2.3 to 5.2 feet (NAVD88), which would be elevated 0.5 feet above the storm of record elevations, from existing elevations of 3.72 to 6.88 (NAVD88) up to new elevations of 4.25 to 7.4 (NAVD88). As a result, about 0 to 4.5 feet of fill would be required over existing ground elevations to maintain the final site grading. It should be noted that fill in excess of 5 feet would be required in isolated areas.

Along with elevating the roadway, six existing culverts would be replaced. Table 1 details proposed culvert replacement.

Table 1: Culverts to be Replaced

Location	Existing Culvert (size)	Proposed Culvert (size)
Old County Rd. Lombard Hollow (N)	unknown	24 inches
Old County Rd. Lombard Hollow (S)	unknown	24 inches
Old County Rd. Paradise Hollow	8 inches	24 inches
Bound Brook Island Rd at Bound Brook	24 inches	6 feet by 6 feet
Bound Brook Island Rd at Herring River	60 inches	6 feet by 8 feet
Pole Dike	36 inches	7 feet by 8 feet

1.3 PURPOSE AND SCOPE OF WORK

The objective of this study is to review the existing subsurface conditions based on the recent boring and laboratory test data conducted as part of the proposed development, conduct a preliminary geotechnical analysis with respect to the proposed development, and develop preliminary recommendations for subgrade preparations for the new culverts, as well as site fill and excavation activities. To achieve these objectives, the following scope of work was performed:

1. Retained a drilling contractor to advance 10 soil borings, collect representative and undisturbed soil samples, observe groundwater, and perform boring Standard Penetration Tests.

2. Provided full-time field inspection services for the borings, soil sampling, and field tests.

3. Performed a laboratory testing program on representative soil samples obtained from the borings. The laboratory testing program consisted of index, classification, strength and preliminary corrosivity tests to confirm field soil classifications and assist with engineering analyses. Selected representative samples for soil characteristics.

4. Prepared this geotechnical report, which includes the following:
   a. A description of the regional geologic features of the project site and subsurface investigation performed for this project
   b. A boring location plan showing the location of completed test borings
   c. The results of the engineering evaluations and recommendations regarding the excavation, fill and earthwork, including:
      - Generalized subsurface conditions, including depths to groundwater
      - Estimated settlements due to grade change
      - Subgrade preparations for the new replacement culverts
      - Recommended soil parameters for earthwork
   d. A discussion of construction-related issues, including:
      - Excavation considerations, including the use of excavated materials
      - Subgrade preparation and backfill requirements
      - Protection of adjacent structures and utilities
   e. Appendices that include test boring logs and laboratory test results

2.0 SUBSURFACE INVESTIGATION AND TESTING

2.1 GENERAL

The subsurface investigation consisted of a field investigation and geotechnical laboratory testing. The field investigation included performing 10 test borings. Selected representative soil samples collected from test borings were sent to ESS Laboratory in Cranston, Rhode Island, to determine various soil characteristics.

2.2 FIELD INVESTIGATION PROGRAM

Ten borings with designated numbers LBG-1, LBG-3, LBG-5, LBG-7, and LBG-9 through LBG-14 were completed within the project area (Figure 2). These test borings were performed between April 30 and May 3, 2015. Borings were drilled from the existing grade to depths ranging from 20 to 40 feet below ground surface (bgs). Louis Berger personnel inspected the boring operations, logged the subsurface samples, and selected and collected samples for laboratory testing.

The test borings were performed by New England Boring Contractors, Inc. (NE Boring) of Brockton, Massachusetts, using a drill rig. Soil samples were obtained using techniques and equipment in general accordance with the American Society for Testing and Materials (ASTM) Standard Specifications, ASTM D6151 – Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling, and D1586 – Test Method for Penetration Test (SPT) and Split-barrel Sampling of Soils. Representative samples were collected using a 1.4-inch inner diameter (I.D.) split-spoon SPT sampler driven with a 140-pound automatic hammer with a 30-inch drop. Blow counts were recorded in accordance with ASTM D1586 to determine the SPT resistance “N” values. Generally, continuous representative soil samples were collected to a depth of 10 feet and then after every 5-foot interval for examination and laboratory testing. The recovered split-spoon soil samples were visually classified and placed in protective glass jars, which were labeled with the project name and number, boring number, sample number and depth, and SPT blow counts. The test boring logs are included in Appendix A.

2.3 LABORATORY TESTING PROGRAM

The geotechnical laboratory testing program for this project consisted of a significant number of sieve analyses because of the granular nature of the subsurface, as well as soil sulfate and chloride tests. The sulfate and chloride analysis was completed to evaluate the potential for sulfate and chloride reaction with the concrete and steel elements of the foundation of the proposed culverts.

The following laboratory tests were conducted:

- Grain size distribution (sieve analysis) in accordance with ASTM D421, D422
- Amount of material in soils finer than the No.200 sieve, in accordance with the ASTM D1140
- Water content in in accordance with ASTM D2216

- Organic content in accordance with ASTM D2974
- Soil sulfide in accordance with U.S. Environmental Protection Agency (USEPA) 9030A
- Soil chloride in accordance with USEPA Method 9250
- Percent solids in accordance with USEPA Method 2540G
- Corrosivity pH in accordance with USEPA Method 9050

Specifically, the following samples were submitted to ESS for laboratory analysis:

- LBG-1
    - SS3 (4–6 feet bgs) – grain size distribution (no hydrometer)
    - SS5 (8–10 feet bgs) – organic content
    - SS2 (2–4 feet bgs) – soil sulfide, soil chloride, pH
- LBG-5 SS1 (0–2 feet bgs) – soil sulfide, soil chloride, pH
    - SS4 (6–8 feet bgs) – organic content, No. 200 sieve
    - SS6 (14–16 feet bgs) – organic content
- LBG-7
    - SS2 (2–4 feet bgs) – organic content, water content
    - SS4 (6–8 feet bgs) – organic content, No. 200 sieve
- LBG-9
    - SS3 (4–6 feet bgs) – organic content, No. 200 sieve
    - SS4 (6–8 feet bgs) – organic content, water content
    - SS5 (8–10 feet bgs) – organic content, soil sulfide, soil chloride, pH
- LBG-10 SS4 (6–8 feet bgs) – organic content, water content
- LBG-11 SS2 (2–4 feet bgs) – organic content, No. 200 sieve
- LBG-12
    - SS3 (4–6 feet bgs) – organic content, No. 200 sieve
    - SS4 (6–8 feet bgs) – grain size distribution (no hydrometer)
- LBG-13 SS5 (8–10 feet bgs) – organic content, No. 200 sieve
- LBG-14
    - SS3 (4–6 feet bgs) – soil sulfide, soil chloride, pH
    - SS5 (8–10 feet bgs) – organic content, No. 200 sieve
    - SS7 (19–21 feet bgs) – grain size distribution (no hydrometer)

Laboratory test results are presented in Appendix B.

2.4 REGIONAL GEOLOGY OF THE PROJECT AREA

The project area lies within the Atlantic Plain physiographic province. According to the U.S. Geological Survey (USGS) *Geologic Map of Cape Cod and the Islands, Massachusetts,*[1] the site lies within an area mapped as Q_{wo}, Wellfleet Plain Deposits, and $Q_{s,}$ Marsh and Swamp Deposits. This map describes the Wellfleet Plain Deposits unit as mostly gravelly sand with scattered boulders, locally including beds and diapirs of clay. Delta beds indicate deposition in Cape Cod Bay Lake. The map unit Q_s, which occupies the channel and floodplain of the Herring River represents marsh and swamp deposits, consists of decaying salt marsh plants mixed with sand, silt, and clay. This unit also includes some freshwater marsh and swamp deposits. The map does not provide sufficient detail, and USGS does not have sufficient ground-truthing, to indicate the localized stratigraphy the site.

The greater portions of the sediments exposed at the surface and within the project site consist locally of Quaternary marsh and swamp deposits, underlain by alluvium.

2.5 SUBSURFACE CONDITIONS

Subsurface conditions are summarized from data obtained from the recently completed borings. Based on the information collected from the 10 borings, there are three different strata with different elevations and characteristics underlying the ground surface, below an average 6-inch-thick asphalt surface course within the project site. From top to bottom, the strata identified are:

- Stratum 1—an approximately2–foot-thick layer fill
- Stratum 2—An average of 10-foot-thick discontinuous layer of sand mixed with organic silt, locally peat
- Stratum 3—deposits consisting principally of fine to medium to coarse sand, in excess of 10-feet thick

A summary of the subsurface conditions, including a brief description of the earth materials and geologic units identified in the record of borings, is presented below.

STRATUM 1:FILL

This stratum was observed immediately below an average 6-inch-thick asphalt surface course, and consisted of asphalt binder and base course over pavement granular base, and/or granular soils. The total thickness of asphalt in fill ranged from 5 to 11 inches, and was generally underlain by dark brown to dark grayish brown, locally reddish brown, generally medium to coarse sand with little to some gravels, generally trace fines. The fill below was observed in all borings with an average thickness of 2 feet, but locally its thickness reached to as much as 4 feet. The SPT resistance “N” values (ASTM Standard D1586) in this stratum ranged from 2 blows/foot to 58 blows/foot. This highly variable compactness represents inefficient subgrade preparation (if any) during prior paving operations.

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[1] Department of the Interior, USGS. *Geologic Map of Cape Cod and the Islands, Massachusett*s, 1763 [map]. Scale not given. 1986.

STRATUM 2: SAND WITH ORGANICS (SP, SM, LOCALLY MIXED WITH MH, AND PT)[2]

This stratum was observed in all borings except in LBG-14. It had an average thickness of 8 feet, but its thickness reached to about 14 feet in LBG-7. Sand with organics is generally described as dark gray to dark brown, fine to medium sand with some organic silt, trace to little gravels, locally peat. The laboratory tests indicated the organic contents ranged from 2.9 percent to 42.5 percent, percentage of fines (silt and clay) ranged from 13.9 percent to 41.7 percent, and the water content ranged from 14.6 percent to 197.7 percent. The SPT resistance "N" values (ASTM Standard D1586) in this stratum ranged from H (weight of hammer) to 5 blows/foot, indicating very loose to loose compactness.

STRATUM 3: SAND (SPAND SM)

This stratum was generally observed 10 feet below the existing grade and consisted of poorly graded sand (SP) and silty sand (SM). Sand consisted of brown to reddish to yellowish brown, fine to medium to coarse sand with about 15 percent silt and generally trace gravels. Laboratory test results indicated that the sand contained less than 1 percent organic soils, an average 20 percent water content, and up to 42 percent fines (silt and clay). The SPT resistance "N" values in sand ranged from 15 blows/foot to 48 blows/foot, indicating generally dense compactness.

2.6 GROUNDWATER CONDITIONS

Based on the wetness of the samples and observations during drilling, groundwater is anticipated to be between 1 and 2 feet below the existing grade. It should be noted that the groundwater table is expected to fluctuate depending on climatic factors, surface drainage conditions, tidal influences, and other factors.

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[2] SP – poorly graded sand; SM – silty sand; MH – elastic silt; PT – peat.

3.0 ENGINEERING RECOMMENDATIONS

3.1 GENERAL

This section of the report presents the geotechnical evaluation with recommendations for the design to elevate the existing roadway by increasing the embankment height by up to 3.8 feet, as well as analysis related to culvert replacement.

3.2 SETTLEMENT

The proposed grade change (increase) and the installation of the three 24-inch RCP culverts would result in an increase in stress, resulting in settlement. . In addition, pursuant to United States Department of Transportation (USDOT) recommendations, 2 feet of soil equivalent stress (surcharge) of 240 pounds per square foot (psf) is assumed for the anticipated live load (i.e., traffic loads). The extra deadweight load from the 3.8 feet of soil, 40 psf traffic loads, and approximately 450 psf deadweight of the 24-inch culverts of the embankment must be borne by the grain skeleton of the subsoil.

Settlement is the consequence of a decrease in the volume of the subsoil. Because of the mostly granular nature of the soils below the existing roadway, settlement due to added loads would consist mostly of primary settlement. The magnitude of the estimated primary settlement is less than 2 inches, and more than one-half of that settlement would occur during construction.

Stratum 2 generally contains organic matter, up to 42.5 percent in one location. Boring logs (Appendix A) show organics are present in 3 to 10-inch-thick bands/layers in the upper 15 feet of the soil profile. Assuming a 10-inch-thick organic rich soil layer (i.e., 42.5 percent% organics and high water content), decay of organic matters over the next several decades would result in an additional 3 to 6 inches of settlement. Because this slow decay and pore pressure dissipation related settlement would occur over a timeframe of a decade or longer, measures to mitigate settlement may not be required. However, if this time-dependent 3 to 6 inches of settlement is not desired, ground improvement would be required.

3.3 PREPARATION OF SUBGRADE FOR CULVERTS AND GRADE CHANGE

NEW EMBANKMENT FOR GRADE CHANGE

The existing asphalt surface/binder/base course would need to be pulverized to below the bottom of the asphalt. The maximum particle size would be reduced to 6 inches. The existing asphalt would be stripped off and sent to an asphalt plant to be used as Recycled Asphalt Pavement. After the existing asphalt pavement is removed, the new embankment could be brought to the design grade as follows:

1. Observing the exposed surface and removing any compressible materials, including wood, plastic, and soft clay. Replacing removed compressible materials with ¾-inch-size crushed stone or recycled concrete aggregate (RCA).

2. Compacting the exposed surface to 95 percent of its dry density as observed in ASTM D1557.

3. Placing embankment fill up to 1 inches below the bottom of the embankment in maximum 12-inch- thick lifts, and compacting each lift to 95 percent of the fill's maximum dry density as observed in ASTM D1557. The embankment fill should have the following grading:

    - Maximum particle size: 12 inches
    - Soil classification A-1, A-3, or A-2-4 of AASHTO.

4. Placing select fill within 12 inches of the pavement box, and compacting it to 95 percent of the select fill's maximum dry density as observed in ASTM D1557. The embankment select fill should have the following grading:

    - Maximum particle size: 3 inches
    - Material passing the No. 200 sieve: maximum 15 percent
    - Soil classification A-1, A2-4, A-2-5, or A3 of AASHTO can be used,

5. Placing asphalt as designed.

It appears that the presence of suitable borrow areas for the new embankment near the project site is possible, because all soils at or near the surface consist exclusively of sand. Naturally, embankment fill should contain only processed or natural materials, should not include compressible materials and organic soils, and should not be in frozen temperatures. The moisture of the fill should be conditioned to remain within 2 percent of the optimum moisture content.

SUBGRADE PREPARATION FOR THE NEW CULVERTS

Bedding would be required to distribute the vertical reaction around the lower exterior surface of the culverts and reduce stress concentrations within the culvert wall. Because granular soils shift to attain positive contact as the culvert settles, an ideal load distribution could be attained through the use of clean coarse sand, well-rounded pea-size gravel, or well-graded crushed stone. Accordingly, the following subgrade preparations are recommended:

1. Observing the surface at the culverts' invert level, and removing any compressible materials, including wood, plastic, and soft clay. Replacing removed compressible materials with ¾-inch size crushed stone or RCA.

2. Compacting the exposed surface to 95 percent of its dry density as observed in ASTM D557.

3. Excavating/leveling 4 inches below the culvert invert, and placing granular bedding fill meeting the following grading requirements:

    - Passing 3/8 in sieve: 100 percent

- Passing No. 4 sieve: 80 percent
- Passing No. 10 sieve: 50 percent
- Passing No. 4 sieve: 20 percent
- Passing No. 200 sieve: 5 percent

4. Placing pipe/box culverts and follow the manufacturers' advice for side backfilling and compaction.

After completion of the backfill and before placement of additional fill or pavement box structures, place stabilization fabric along the trench/pipe/culvert to minimize potential for transverse reflecting cracking of the pavement. The stabilization fabric should spread at least 4 feet along the joint/edge of the culvert, and should comply with AASHTO M288 (e.g., Mirafi X-series, HP series, Tensar GlasPave 50, or equivalent).

3.4 STABILITY OF SLOPES AND SCOUR PROTECTION

The new embankment side slopes should be no steeper than a 3:1 horizontal to vertical ratio, and the embankment slopes should be compacted with a tamping foot roller by walking with a dozer, or by over-building the fill and then removing excess material to the final slope line. It is important to observe the placement of embankment on wing walls and culvert headwalls; materials should be compacted with care so that no excessive pressure against the structure is introduced.

The embankment would need to be protected against erosion by established vegetation. Depending on the site's hydraulic and hydrodynamic conditions, additional embankment protection using riprap may be required to minimize scour damage.

In isolated areas, it may be necessary to have embankments steeper than 3:1 to minimize impacts on adjacent parcels. Slopes steeper than 3:1 would require stabilization with geotextile fabric and/or rip-rap. As noted above, a 3:1 slope stabilized with vegetation is preferred. Guardrails would also be required at steeper cross-sections.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the engineering evaluation, the following conclusions and recommendations are provided:

1. On behalf of FHR and HRRC, Louis Berger investigated and evaluated the geotechnical data associated with the proposed elevation of existing low-lying roadways and replacement of associated culverts as part of the Herring River Restoration Project, which includes portions of Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, Bound Brook Island Road, and Old County Road – North Segment located in northwest Wellfleet and southwest Truro, Massachusetts.

2. This report presents a factual account of the subsurface conditions, laboratory test results, and associated geotechnical analysis and geotechnical evaluations, with conclusions and recommendations to assist the design team in the development of the project area, including the placement of new culverts and cut and fill operations.

3. Based on the data provided by FHR, the proposed site work would consist of elevating of portions of Pole Dike Road, Old County Road at Bound Brook, Old County Road at Paradise Hollow, Bound Brook Island Road, and Old County Road – North Segment in Wellfleet and Truro above the elevation of the storm of record by up to 3.8 feet. The road-re-grading would also require replacing existing culverts with larger capacity circular and box culverts.

4. The geotechnical investigation program included drilling 10 borings, collecting representative and undisturbed soil samples, observing groundwater, providing field inspection services for the borings, collecting soil samples, performing field tests, logging samples, and performing laboratory testing on representative soil samples obtained from the borings.

5. The subsurface at the site consists of three different strata with different elevations and characteristics underlying the ground surface below an average 6-inch-thick asphalt surface course within the project site. From top to bottom, the strata include: Stratum 1—an approximately 2-foot-thick fill layer, Stratum 2—an average of 10-foot-thick discontinuous layer of sand mixed with organic silt and locally peat, and Stratum 3—deposits consisting principally of fine to medium to coarse sand, in excess of 10 feet thick.

6. Based on the wetness of the samples and observations during drilling, groundwater is anticipated to be between 1 and 2 feet below the existing grade.

7. Grade change (increase) would result in settlements. Because of the mostly granular nature of the soils below the existing roadway, settlement due to added loads would be mostly of primary settlement in nature. The magnitude of the estimated primary settlement is less than 2 inches, more than one-half of this settlement would occur during construction. However, Stratum 2 generally contains organic matters, and decay of organic matter over the next several decades would result in additional 3 to 6 inches of settlement. Because this slow decay and pore pressure dissipation related settlement would occur over a timeframe of a decade or more, measures to mitigate settlement may not be required.

8. The proposed roadway grade change development would include installation of three 24-inch- diameter reinforced concrete pipe (RCP) culverts, a 6-foot by 6-foot concrete box culvert, a 6-foot by 8-foot concrete box culvert, and a 7-foot by 8-foot concrete box culvert. Because of the proposed grade change, the new culverts would be installed into Stratum 1 fill and new fill above the groundwater table. Based on the load-settlement, it is estimated that the loads imposed by the box culverts (all three types) are comparable to, and generally less than, the weight of the excavated soils. Therefore, no added stress-related settlements would be induced by their installation. However, the proposed 24-inch-diameter circular culverts would induce an added stress, resulting in a post-construction settlement on the order of 1 inch. Because the settlements related to the installation of new culverts are tolerable (on the order of 1 inch), and the long-term settlements related to the decay of organic soils would coincide with the future periodic roadway surfacing (i.e., 20 years), no special ground improvement is proposed except for the careful preparation of the subgrade and the new fill.

9. For grade change, the existing asphalt surface/binder/base course would need to be pulverized below the bottom of the asphalt. After the existing asphalt pavement is removed, the new embankment could be brought to the design grade as recommended in Section 3.3.

10. The new embankment side slopes should be no steeper than a 3:1 horizontal to vertical ratio. The embankment slopes should be compacted, and would need to be protected against erosion by establishment of vegetation. Depending on the site's hydraulic and hydrodynamic conditions, additional embankment protection by riprap may be required to minimize scour damage.

5.0 LIMITATIONS

Professional judgments were necessary in relation to determining stratigraphy and subsurface conditions from the subsurface investigation. Therefore, the data presented and the opinions expressed in this report are qualified as follows:

1. This report has been prepared by Louis Berger for FHR, to be used solely in the evaluation and performance of the proposed site development work at the site of the Herring River Restoration Project, in Wellfleet and Truro, Massachusetts. The report has not been prepared for use by other parties, and may not necessarily contain sufficient information for the purposes of other parties or other uses. Any undisclosed and/or un-permitted alternate use shall be at that party's own risk and without liability to Louis Berger.

2. The conclusions and recommendations provided in this report are preliminary and based upon Louis Berger's understanding of the described project information and interpretation of the information, the visible conditions for accessible properties, and the data that were available and/or collected during the performance of this study. Unless otherwise stated, the work performed by Louis Berger should be understood to be exploratory and interpretational in character. Any results, findings, or recommendations contained in this report may be the result, at least in part, of professional judgment and not necessarily based solely on pure science and engineering.

3. Professional geotechnical engineering services for this project have been performed using a degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical consultants practicing in this or similar localities. No other warranty, expressed or implied, is made as to the professional advice in this report.

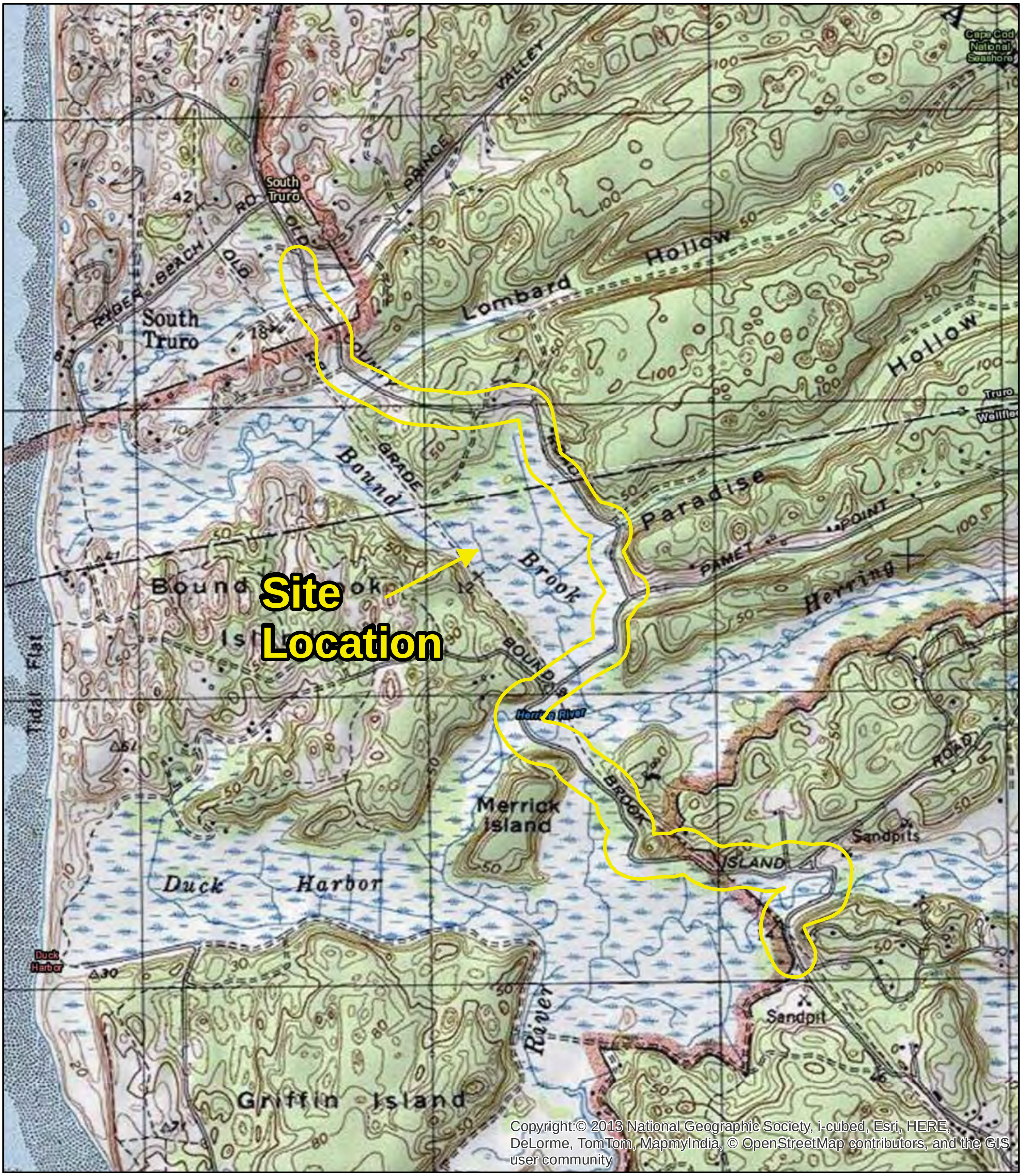
4. In preparing this preliminary report, Louis Berger has relied upon and presumed accurate certain information (or the absence thereof) about the site and adjacent properties provided by governmental officials and agencies, FHR, other consultants, and others identified herein. Except as otherwise stated, Louis Berger has not attempted to verify the accuracy or completeness of any such information. Louis Berger derived the data in this report primarily from visual inspections, examination of records in the public domain, and a limited number of tests where personnel were granted access. The passage of time, manifestation of latent conditions, or occurrence of future events may require further exploration at the site, analysis of the data, and reevaluation of the findings, observations and conclusions expressed in the report.

5. No warranty or guarantee, whether express or implied, is made with respect to the data reported or findings, observations, and conclusions expressed in this report. Further, such data, findings, observations, and conclusions are based solely upon site conditions in existence at the time of investigation.

The data reported and the findings, observations, and conclusions expressed in the report are limited by the Scope of Services, including the extent of subsurface exploration and other tests. The Scope of Services was defined by the requests of FHR, and the availability of access to the site.

This report has been prepared on behalf of and for the exclusive use of FHR, and is subject to and issued in connection with the Agreement and the provisions thereof.

FIGURE 1:
SITE LOCATION PLAN



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Friends of Herring River

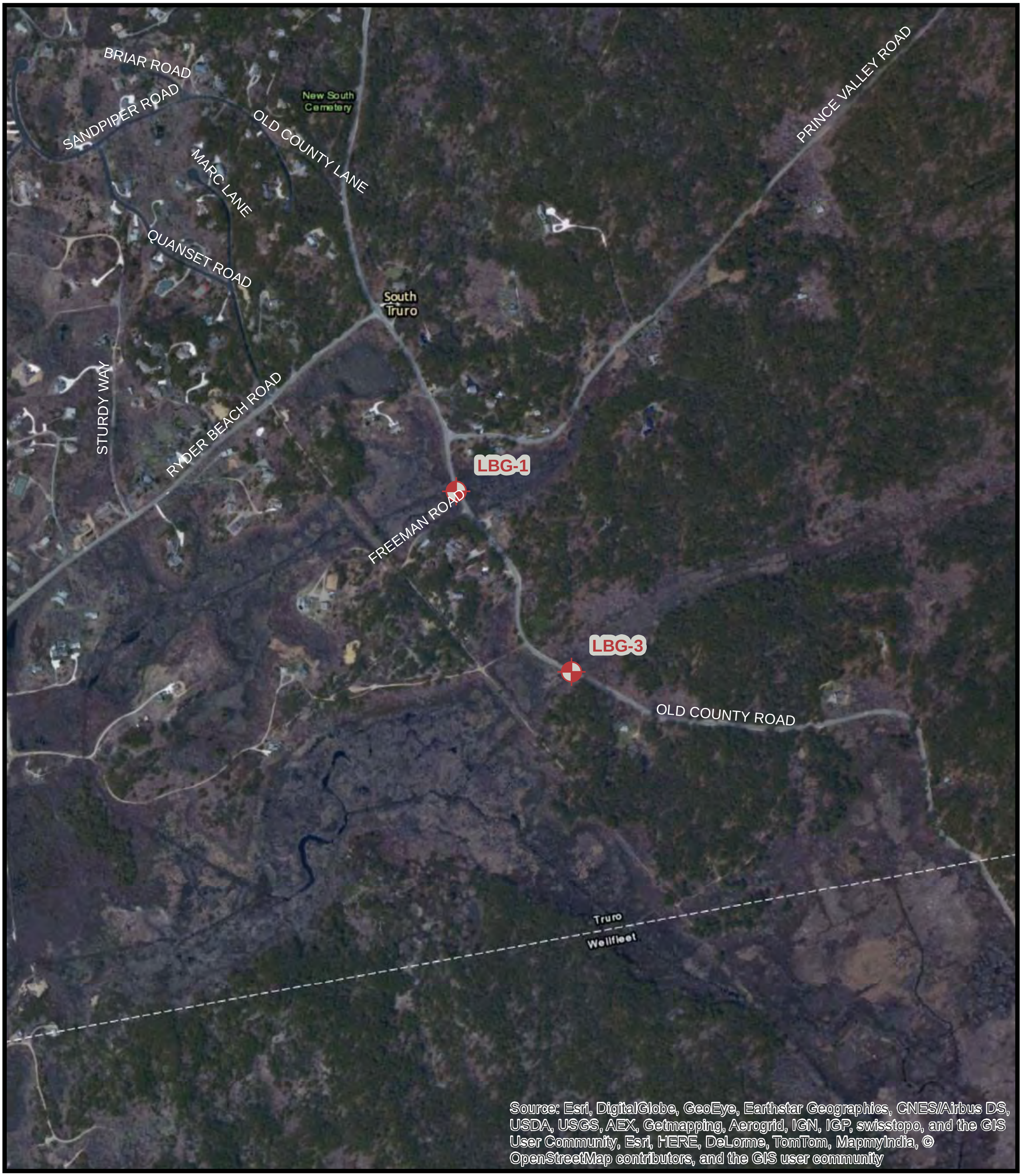
Louis Berger

Herrring River Restoration Project

Figure 1: Site Location

Source: ESRI, Berger	1 inch = 2,000 feet	May 2015

FIGURE 2:
BORING LOCATION PLAN & RECORD OF BORINGS



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Friends of Herring River

Louis Berger

Herrring River Restoration Project

Figure 2A: Boring Locations in Truro, MA

Source: ESRI, Berger	1 inch = 1,000 feet	May 2015

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Friends of Herring River

Louis Berger

Herrring River Restoration Project

Figure 2B: Boring Locations in Wellfleet, MA

N
W E
S

Source: ESRI, Berger	1 inch = 1,000 feet	May 2015

APPENDIX A
BORING LOGS

Project No: *20004341*

Borehole #: LBG-1

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by: A. Sylvia

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.5

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	4.5							
		6" asphalt	0							Fill
1 2	▨	S1 2" ASPHALT 10" very dark brown (10YR 2/2) , fine GRAVEL, some sand; moist.	2.5	S1	SS	18-5-3-4	▨			
3 4	⁘	S2 brown (10YR 4/3), coarse to medium SAND; moist.	2 0.5	S2	SS	4-5-4-5	▨			
5 6	⁘	S3 brown (10YR 4/3), medium SAND, trace fine sand, trace coarse sand, trace silt; moist.	4 -1.5	S3	SS	6-6-4-5	▨			
7 8	⁘	S4 7" brown (10YR 4/3), coarse to medium SAND; moist. 2" very dark brown (10YR 2/2) coarse SAND; moist	6 -3.5	S4	SS	5-3-2-3	▨			
9 10	⁘	S5 brown (10YR 4/3) to dark brown (10YR 3/3) medium to coarse SAND, trace organics; wet.	8 -5.5	S5	SS	4-2-2-3	▨			
11 12 13 14			10 -9.5							
15 16	⁘	S6 very dark gray (10YR 3/1), fine to medium SAND, trace fine gravel, wet.	14 -11.5	S6	SS	9-7-11-13	▨			
17 18 19			16 -14.5							
20 21	⁘	S7 dark yellowish brown (10YR 4/6), coarse SAND, some fine gravel, wet.	19 -16.5	S7	SS	11-11-10-8	▨			
			21							

Drill Method: rollerbit & hollow stem auger

Datum:

Drill Date: 4/2/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-1

Project: *Herring River Restoration*

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: A. Sylvia

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.5

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
21			-16.5							
22 23 24			21 -19.5							
25 26	▒	**S8** no recovery	24 -21.5	S8	SS	7-7-8-10				
27 28 29			26 -24.5							
30 31	▒	**S9** no recovery	29 -26.5	S9	SS	18-16-14-21				
32 33 34			31 -29.5							
35 36	▒	**S10** brownish yellow (10YR 6/6), coarse to medium SAND, wet.	34 -31.5	S10	SS	14-13-16-15	░			
37 38 39 40 41		casing came loose, hole abandoned **End of Borehole**	36 -36.5							
			41							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum:

Drill Date: 4/2/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-3

Project: *Herring River Restoration*

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.3

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	4.3							
		5" asphalt	0	S1	SS	6-9-11-12	▒			Fill
1 2	▨	**S1** 2" ASPHALT dark yellowish brown (10YR 4/4) , fine to medium SAND; moist.	2.3							
3 4	░	**S2** dark yellowish brown (10YR 4/4), coarse to medium SAND; moist.	2 0.3	S2	SS	8-8-6-5	▒			
5 6	░	**S3** yellowish brown (10YR 5/8), coarse to med SAND, trace GRAVEL; wet.	4 -1.7	S3	SS	3-3-2-3	▒			
7 8	░	**S4** 12" dark yellowish brown (10YR 4/4), coarse to medium SAND; wet. 10" very dark brown (10YR 2/2) ORGANICS; wet	6 -3.7	S4	SS	2-2-3-2	▒			
9 10	░	**S5** 1" dark gray (10YR 4/1) fine SAND; wet. 3" dark gray (10YR 4/1) ORGANICS, fine sand, trace silt; wet.	8 -5.7	S5	SS	2-1-1-1	▒			
11 12 13 14			10 -9.7							
15 16	░	**S6** very dark grayish brown (10YR 3/2), fine silty SAND with ORGANICS; wet.	14 -11.7	S6	SS	1-1-1-1	▒			
17 18 19			16 -14.7							
20 21	░	**S7** dark yellowish brown (10YR 5/8), medium SAND, trace gravel; wet.	19 -16.7	S7	SS	13-21-12-13	▒			
			21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/2/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-3

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by : S. Hogan

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.3

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
21			-16.7							
22 23 24			21 -19.7							
25 26	⁙	S8 10" yellowish brown (10YR 5/6) fine to medium SAND; wet. 8" very dark gray (10YR 3/1) coarse to medium SAND; wet.	24 -21.7	S8	SS	16-12-15-24	▨			
27 28 29			26 -24.7							
30 31	⁙	S9 5" yellowish red (10YR 5/6) medium to coarse SAND; wet. 13" dark grayish brown (10YR 4/2) medium to coarse SAND, trace quartz; wet.	29 -26.7	S9	SS	20-17-19-22	▨			
32 33 34			31 -29.7							
35 36	⁙	S10 strong brown (7.5YR 5/8), coarse to medium SAND, trace fine gravel; wet.	34 -31.7	S10	SS	17-17-6-5	▨			
37 38 39 40 41		**End of Borehole**	-36.7							
			41							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/1/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-5

Project: *Herring River Restoration*

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: A. Sylvia

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 2.9

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	2.9							
		5" asphalt	0							
1 2	▩	S1 2" ASPHALT 2" dark grayish brown (10YR 4/2), coarse SAND; moist. 8" dark garyish bown (10YR 4/2) medium to coarse SAND; 5" very dark gray (10YR 3/1) medium to coarse SAND; moist	0.9	S1	SS	14-11-17-20	▮			Fill
3 4	░	S2 very dark gray (10YR 3/1), coarse to medium SAND; wet.	2 -1.1	S2	SS	12-9-6-5	▮			
5 6	░	S3 3" very dark brown (10YR 2/2) ORGANICS; wet. 14" very dark gray (10YR 3/1) medium to coarse SAND; wet.	4 -3.1	S3	SS	2-2-2-2	▮			
7 8	░	S4 9" very dark brown (10YR 2/2) to very very dark gray (10YR 1/1) medium to coarse SAND, some organics, trace silt; saturated.	6 -5.1	S4	SS	2-1-1-H	▮			
9 10	░	S5 dark grayish brown (10YR 4/2), fine to medium SAND, trace gravel; wet.	8 -7.1	S5	SS	8-1-H	▮			
11 12 13 14			10 -11.1							
15 16	░	S6 8" very dark gray (10YR 3/1), medium to coarse SAND; wet. 9" very dark brown (10YR 2/2) fine SAND, trace organics; wet.	14 -13.1	S5	SS	1-5-15-12	▮			
17 18 19			16 -16.1							
20 21	░	S7 yellowish brown (10YR 5/4), fine to medium SAND, some fine gravel; wet.	19 -18.1	S5	SS	12-9-10-11	▮			
			21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/3/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-5

Project: *Herring River Restoration*

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by : A. Sylvia

Site Location: Old County Road, Truro, MA

Checked By: G. Deblois

Coordinates:

Elevation: 2.9

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
21			-18.1							
22 23 24			21 -21.1							
25 26	░	S8 brown (10YR 5/3) fine to medium SAND, some gravel; wet.	24 -23.1	S8	SS	9-11-14-17	▨			
27 28 29			26 -26.1							
30 31	░	S9 yellowish brown (10YR 5/8), medium to coarse SAND, trace gravel; wet.	29 -28.1	S9	SS	10-11-16-14	▨			
32 33 34 35 36 37 38 39 40 41		**End of Borehole**	31 -38.1							
		End of Borehole	41							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/3/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-7

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Bound Brook Island Road, Wellfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: *2.3*

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	2.3							
		6" asphalt	0							
1 2	▩	**S1** 2" ASPHALT; dry. 3" yellowish brown (10YR 8.6), fine to coarse SAND; dry. 4" gray (10YR 5/1), fine to coarse SAND; dry. 6" very dark grayish black (10YR 3/2), ORGANICS, trace fine sand and gravel; dry.	0.3	S1	SS	8-3-2-2	▒			Fill
3 4	⁙	**S2** very dark grayish black (10YR 3/2), ORGANIC SAND, trace fine to coarse gravel; saturated.	2 -1.7	S2	SS	5-H-H-1	▒			
5 6	⁙	**S3** no sample.	4 -3.7	S3	SS	H-H-H-H				
7 8	⁙	**S4** Very dark grayish brown (10YR 3/2), fine to medium sand,some silt, trace coarse sand, trace fine gravel, trace silt; moist.	6 -5.7	S4	SS	H-H-H-2	▒			
9 10	⁙	**S5** Very dark grayish brown (10YR 3/2), ORGANICS, some fine to medium sand, trace coarse sand, trace fine gravel; moist.	8 -7.7	S5	SS	1-1-1-1	▒			
11 12 13 14			10 -11.7							
15 16	⁙	**S6** dark gray (10YR 4/1), fine to medium SAND, some coarse sand, trace fine gravel, moist.	14 -13.7	S5	SS	5-7-9-11	▒			
17 18 19			16 -16.7							
20 21	⁙	**S7** gray (10YR 5/1), fine to medium SAND, some coarse sand, trace fine gravel; saturated.	19 -18.7	S5	SS	5-9-9-8	▒			
			21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/1/15

Sheet: 1 of 2

Project No: 20004341

Project: Herring River Restoration

Borehole #: LBG-7

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Bound Brook Island Road, Wellfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 2.3

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	Symbol	Description	Depth/Elev.	Number	Type	Blows/6"	Recovery	Symbol	Well Data	Remarks
21			-18.7							
22 23 24			21 -21.7							
25 26	░	**S8** gray (10YR 5/1), fine to medium SAND, some coarse sand, trace fine gravel; saturated.	24 -23.7	S8	SS	5-9-9-8	▒			
27 28 29			26 -26.7							
30 31	░	**S9** gray (10YR 5/1), fine to coarse SAND, trace coarse gravel; saturated.	29 -28.7	S9	SS	10-15-20-16	▒			
32 33 34			31 -31.7							
35 36	░	**S10** gray (10YR 5/1), medium to coarse SAND, some fine sand; moist.	34 -33.7	S10	SS	21-15-22-24	▒			
37 38 39			36 -36.7							
40 41	░	**S11** gray (10YR 5/1), fine to coarse SAND, some coarse gravel; moist.	39 -38.7	S11	SS	17-23-25-31	▒			
		End of Borehole	41							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 4/1/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-9

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 5.2

Louis Berger
Providence, Rhode Island

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	Symbol	Description	Depth/Elev.	Number	Type	Blows/6"	Recovery	Symbol	Well Data	Remarks
0		Ground Surface	5.2							
		8" asphalt	0							
1 2		S1 2" ASPHALT; dry. 12" brown (7.5YR 5/2), fine to coarse SAND, trace fine to coarse gravel; dry.	3.2	S1	SS	10-6-14-23				Fill
3 4		S2 1.5" brown (7.5YR 5/2), fine to medium SAND, some coarse sand; dry. 4.5" light yellowish brown (10YR 6/4), fine to coarse sand; dry.	2 1.2	S2	SS	26-30-32-25				
5 6		S3 2.5" light yellowish brown (10YR 6/4), fine to coarse SAND, trace fine gravel; moist. 2.5" dark gray (10YR 4/1), fine to coarse silty SAND, trace fine gravel trace organics; moist.	4 -0.8	S3	SS	1-1-1-2				
7 8		S4 dark gray (2.5Y 4/1); fine SAND, some organics; moist.	6 -2.8	S4	SS	H-1-1-1				
9 10		S5 3" black (5Y 2.5/1); fine to medium SAND, trace coarse sand, trace coarse gravel trace organics; moist. 2" pale olive (2.5Y 6/4), fine to corase SAND, trace coarse gravel; moist. 4" dark gray (2.5Y 4/1), fine to medium SAND, trace coarse gravel; wet.	8 -4.8	S5	SS	2-1-3-6				
11 12 13 14			10 -8.8							
15 16		S6 light olive gray (5Y 6/2), fine SAND, some medium sand, some fine gravel; moist.	14 -10.8	S5	SS	16-12-13-14				
17 18 19			16 -13.8							
20 21		S7 light olive gray (5Y 6/2), fine SAND, some medium sand; moist.	19 -15.8	S5	SS	3-4-5-7				
			21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/1/15

Sheet: 1 of 2

Project No: *20004341*

Project: *Herring River Restoration*

Borehole #: LBG-9

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 5.2

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	Symbol	Description	Depth/Elev.	Number	Type	Blows/6"	Recovery	Symbol	Well Data	Remarks
21			-15.8							
22 23 24			21 -18.8							
25 26	⁙	S8 light yellowish brown (10YR 6/4), medium SAND, some fine sand, some coarse sand, trace gravel; saturated.	24 -20.8	S8	SS	16-14-20-20	▨			
27 28 29			26 -23.8							
30 31	⁙	S9 4" light yellowish brown (10YR 6/4), fine to medium SAND; saturated. 4" light olive gray (2.5Y 6/2) fine SAND; saturated.	29 -25.8	S9	SS	33-19-13-17	▨			
32 33 34			31 -28.8							
35 36	⁙	S10 4" olive yellow (2.5Y 6/6), fine silty SAND, some coarse gravel; saturated. 12" olive yellow (2.5Y 6/6), fine silty SAND; saturated.	34 -30.8	S10	SS		▨			
37 38 39			36 -33.8							
40 41	⁙	S11 brownish yellow (10YR 6/6), fine to medium SAND, trace coarse gravel; saturated.	39 -35.8	S11	SS	10-12-14-24	▨			
		End of Borehole	41							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 4/1/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-10

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by : S. Hogan

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 3.5

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	3.5							
		8" asphalt	0							
1 2	▩	S1 6" ASPHALT; dry. 2" yellowish brown (10YR 8/6), fine to medium SAND; trace coarse SAND; dry. 4" dark brown (7.5YR/ 3/2) fine to medium SAND, trace coarse SAND; moist.	1.5	S1	SS	15-9-5-6	▬			Fill
3 4	▩	S2 brown to black (7.5YR 4/2 to 5Y 2.5/1) fine to medium SAND; moist.	2 -0.5	S2	SS	10-4-1-5	▬			Fill
5 6	░	S3 2" brownish yellow (10YR 6/6), fine to coarse SAND; moist. 4" black (5Y 2.5/1), ORGANICS, trace fine SAND; moist.	4 -2.5	S3	SS	1-1-1-1	▬			Fill
7 8	░	S4 black (5.Y 2.5/1), fine to medium SAND, trace organics; moist.	6 -4.5	S4	SS	H-H-1-1	▬			
9 10	░	S5 dark grayish brown (10YR 4/2), fine to coarse SAND; moist.	8 -6.5	S5	SS	1-1-21-1	▬			
11 12 13 14			10 -10.5							
15 16	░	S6 3" brownish yellow (10YR 6/6), fine to coarse SAND; moist. 1.5" olive gray (2.5Y 5/2), medium to coarse SAND, trace coarse gravel; moist. 1.5" light olive gray (2.5Y 6/2), fine to medium SAND; moist.	14 -12.5	S5	SS	6-5-6-8	▬			
17 18 19			16 -15.5							
20 21	░	S7 light yellowish brown(10YR 6/4), fine SAND, some medium sand; moist.	19 -17.5	S5	SS	20-5-4-6	▬			
			21							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 3/31/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: ***20004341***

Project: *Herring River Restoration*

Borehole #: LBG-10

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 3.5

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	Symbol	Description	Depth/Elev.	Number	Type	Blows/6"	Recovery	Symbol	Well Data	Remarks
21			-17.5							
22 23 24			21 -20.5							
25 26		S8 light yellowish brown (10 YR 6/4), fine SAND, some coarse sand; moist.	24 -22.5	S8	SS	6-6-11-11				
27 28 29			26 -25.5							
30 31		S9 light gray (2.5Y 7/2), fine SAND; saturated.	29 -27.5	S9	SS	8-10-14-24				
32 33 34			31 -30.5							
35 36		S10 light olive gray (2.5Y 6/2), fine SAND, trace medium sand; trace coarse gravel; moist.	34 -32.5	S10	SS	1-2-2-3				
37 38 39			36 -35.5							
40 41		S11 8" pale olive (5Y 6/3) mottled with brownish yellow (10YR 6/8), fine SAND, trace silt; moist. 11" pale olive (5Y 6/3), fine SAND, trace silt; moist.	39 -37.5	S11	SS	6-5-11-14				
		End of Borehole	41							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 3/31/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-11

Project: *Herring River Restoration*

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by: A. Sylvia

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.0

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	4							
		5" asphalt	0							
1 2	▩	**S1** dark gray (10YR 4/1) fine to coarse SAND, some gravel; moist	2	S1	SS	13-18-4-6	▒			Fill
3 4	░	**S2** dark gray (10YR 4/1), medium to coarse SAND, some silt, trace organics; moist.	2 0	S2	SS	1-1-1-1	▒			
5 6	░	**S3** dark gray (10YR 4/1), medium to coarse SAND, trace organics; wet.	4 -2	S3	SS	1-2-3-2	▒			
7 8	░	**S4** dark gray (10YR 4/1), medium to coarse SAND; wet	6 -4	S4	SS	2-2-4-13	▒			
9 10	░	**S5** yellowish brown (10YR 5/8), medium to coarse SAND; wet.	8 -6	S5	SS	17-11-8-6	▒			
11 12 13 14			10 -10							
15 16	░	**S6** yellowish red (5YR 4/6), coarse SAND; wet.	14 -12	S5	SS	7-6-7-6	▒			
17 18 19			16 -15							
20 21	░	**S7** yellowish brown (10YR 5/8), coarse to medium SAND, trace gravel; wet.	19 -17	S5	SS	12-10-12-15	▒			
		End of Borehole	21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/3/15

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-12

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by: A. Sylvia

Site Location: Bound Brook Island Road, Welfleet, MA

Checked By: *G. Deblois*

Coordinates:

Elevation: 3.7

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	3.7							
1 2	▨	4" asphalt **S1** 2" ASPHALT 13" gray (10YR 45/1) , medium to fine SAND, trace gravel; dry.	0 1.7	S1	SS	26-33-25-12				Fill
3 4	⁙	**S2** 4" dark gray (10YR 4/1), medium SAND, moist. 7" fine SAND, trace silt, some organics; moist.	2 -0.3	S2	SS	2-2-1-1				
5 6	⁙	**S3** dark gray (10YR 4/1) fine to coarse SAND, some silt, trace organics; wet.	4 -2.3	S3	SS	1-H-H-H				
7 8	⁙	**S4** dark gray (10YR 4/1) medium to coarse SAND, some silt; wet	6 -4.3	S4	SS	H-H-1-1				
9 10	⁙	**S5** very dark gray (10YR 3/1) medium to coarse SAND, some gravel; wet.	8 -6.3	S5	SS	9-2-2-1				
11 12 13 14			10 -10.3							
15 16	⁙	**S6** yellowish brown (10YR 5/8) medium to coarse SAND; wet.	14 -12.3	S5	SS	4-5-5-6				
17 18 19			16 -15.3							
20 21	⁙	**S7** yellowish brown (10YR 5/8), coarse SAND; wet.	19 -17.3	S5	SS	9-6-6-7				
		End of Borehole	21							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 4/3/15

Sheet: 1 of 2

Project No: 20004341

Borehole #: LBG-13

Project: Herring River Restoration

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Pole Dike Creek Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 3.7

Louis Berger
Providence, Rhode Island

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	3.7							
		5" asphalt	0							
1 2	▩	**S1** 3" dark gray (10YR 4/1), fine to coarse SAND and ORGANICS, asphalt; dry. 4" black (10YR 2/1,) fine to coarse SAND and fine to coarse gravel; dry. 4" light yellowish brown (10YR 6/4), medium to coarse SAND, trace fine to coarse gravel; dry.	1.7	S1	SS	67-13-15-9	▨			Fill
3 4	▩	**S2** 7" dark yellowish brown (10YR 6/4), fine to coarse SAND; dry. 9" dark gray (10YR 4/1), fine SAND and ORGANICS; dry.	2 -0.3	S2	SS	2-1-1-1	▨			Fill
5 6	⁘	**S3** dark gray (10YR 4/1), fine SAND, some medium to coarse SAND; moist.	4 -2.3	S3	SS	1-1-1-2	▨			
7 8	⁘	**S4** no recovery	6 -4.3	S4	SS	H-H-2-2				
9 10	⁘	**S5** 4" very dark gray (5Y 3/1), fine SAND, some silt, trace organics; moist. 6" very dark gray (5Y 3/1), fine to coarse GRAVEL; moist	8 -6.3	S5	SS	1-1-1-1	▨			
11 12 13 14			10 -10.3							
15 16	⁘	**S6** 5.5" gray (5Y 5/1), fine to coarse SAND, trace coarse gravel; moist. 8.5" reddish yellow (7.5YR 6/8), fine to coarse SAND; moist.	14 -12.3	S5	SS	8-15-20-22	▨			
17 18 19			16 -15.3							
20 21	⁘	**S7** 1" reddish yellow (7.5YR 6/8), fine to medium SAND, trace coarse sand; moist. 5" gray (5Y 5/1), fine silty SAND, trace medium and coarse sand; moist.	19 -17.3	S5	SS	2-1-4-5	▨			
			21							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 3/30/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-13

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by : S. Hogan

Site Location: Pole Dike Creek Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 3.7

Louis Berger
Providence, Rhode Island

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
21			-17.3							
22 23 24			21 -20.3							
25 26	░	**S8** 4" pale yellow (5 Y 7/3), fine to medium SAND; moist. 14" pale yellow (5Y 7/3), fine to medium SAND, some coarse sand, trace coarse gravel; moist.	24 -22.3	S8	SS	19-16-20-24	▒			
27 28 29			26 -25.3							
30 31	░	**S9** very pale brown (10YR 7/3), fine to corase SAND, trace coarse gravel; moist.	29 -27.3	S9	SS	22-49-51-54	▒			
32 33 34			31 -30.3							
35 36	░	**S10** strong brown (7.5 YR 5/6), fine to corase SAND, trace fine to coarse gravel; moist.	34 -32.3	S10	SS	30-34-67-34	▒			
37 38 39			36 -35.3							
40 41	░	**S11** reddish yellow (7.5YR 7/6), medium to coarse SAND, trace fine sand, trace fine gravel; moist.	39 -37.3	S11	SS	35-14-9-6	▒			
		End of Borehole	41							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 3/30/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: *20004341*

Borehole #: LBG-14

Louis Berger
Providence, Rhode Island

Project: *Herring River Restoration*

Client: Friends of Herring River

Prepared by: S. Hogan

Site Location: Pole Dike Creek Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

Elevation: 4.4

SUBSURFACE PROFILE				**SAMPLE**						
Depth (ft)	**Symbol**	**Description**	**Depth/Elev.**	**Number**	**Type**	**Blows/6"**	**Recovery**	**Symbol**	**Well Data**	**Remarks**
0		Ground Surface	4.4							
		7" asphalt	0							
1 2	▩	S1 4" ASHPHALT; dry. 8" reddish yellow (7.5 YR 6/8), fine to coarse SAND, trace fine gravel; dry.	2.4	S1	SS	35-17-9-6	▒			Fill
3 4	▩	S2 reddish yellow (7.5YR 6/8), medium to coarse SAND, trace fine sand; moist.	2 0.4	S2	SS	7-6-7-5	▒			Fill
5 6	░	S3 11" gray (7.5YR 6/8), fine to coarse AND, trace fine GRAVEL; moist. 2: light gray (2.5Y 7/1), fine SAND and ORGANICS, trace GRAVEL; moist.	4 -1.6	S3	SS	1-3-3-4	▒			
7 8	░	S4 light gray (2.5Y 7/1), fine to coarse SAND, trace fine gravel; moist.	6 -3.6	S4	SS	2-2-16-19				
9 10	░	S5 5" black (7.5YR 2.5/1), fine SAND, some coarse sand, some fine gravel trace silt, trace organics; moist. 2" black (7.5YR 2.5/1), fine SAND, trace medium sand, trace silt, trace organics; moist. 1" black (7.5YR 2.5/1), fine to coarse SAND; moist.	8 -5.6	S5	SS	2-11-11-15	▒			
11 12 13 14			10 -9.6							
15 16	░	S6 reddish yellow (7.5YR 6/6), fine to coarse SAND; moist.	14 -11.6	S5	SS	2-11-11-15	▒			
17 18 19			16 -14.6							
20 21	░	S7 gray (2.5Y 6/1), fine silty SAND, trace medium to coarse sand, trace fine gravel; moist.	19 -16.6	S5	SS	4-2-18-17	▒			
			21							

Drilled By: NE Boring

Drill Method: rollerbit & hollow stem auger

Drill Date: 3/30/15 & 3/31/15

Hole Size: 2"

Datum: NAVD88

Sheet: 1 of 2

Project No: 20004341

Project: Herring River Restoration

Borehole #: LBG-14

Louis Berger
Providence, Rhode Island

Client: Friends of Herring River

Prepared by : S. Hogan

Site Location: Pole Dike Creek Road, Welfleet, MA

Checked By: G. Deblois

Coordinates:

SUBSURFACE PROFILE				SAMPLE						
Depth (ft)	Symbol	Description	Depth/Elev.	Number	Type	Blows/6"	Recovery	Symbol	Well Data	Remarks
21			-16.6							
22 23 24			21 -19.6							
25 26	░	S8 pale olive (2.5Y 6/3), fine to medium SAND; moist.	24 -21.6	S8	SS	14-23-31-36	▒			
27 28 29			26 -24.6							
30 31	░	S9 (2.5Y 6/6), medium to coarse SAND, trace fine sand, trace coarse gravel; moist.	29 -26.6	S9	SS	20-27-26-31	▒			
32 33 34			31 -29.6							
35 36	░	S10 no recovery	34 -31.6	S10	SS	1-2-4-5				
37 38 39			36 -34.6							
40 41	░	S11 7" (2.5Y 6/2), fine to medium SAND, trace fine gravel; moist. 3" (10YR 5/2), fine to corase SAND, trace fine gravel; moist. 9" (7.5YR 6/2), medium to coarse SAND, trace fine sand, trace fine gravel; moist.	39 -36.6	S11	SS	33-25-27-32	▒			
		End of Borehole	41							

Drilled By: NE Boring

Hole Size: 2"

Drill Method: rollerbit & hollow stem auger

Datum: NAVD88

Drill Date: 3/30/15 & 3/31/15

Sheet: 1 of 2

APPENDIX B
LABORATORY TEST RESULTS

ESS Laboratory
Division of Thielsch Engineering, Inc.

BAL Laboratory
The Microbiology Division
of Thielsch Engineering, Inc.

CERTIFICATE OF ANALYSIS

Samantha Hogan
Louis Berger
295 Promenade Street
Providence, RI 02908

RE: Herring River (N/A)
ESS Laboratory Work Order Number: 1504484

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

REVIEWED
By ESS Laboratory at 12:51 pm, Apr 28, 2015

Laurel Stoddard
Laboratory Director

Analytical Summary

The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with NELAC Standards, A2LA and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

Subcontracted Analvses

CTS - Cranston, RI	Organic Content, Sieve #200, Sieve Analysis, Water Content

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
ESS Laboratory Work Order: 1504484

SAMPLE RECEIPT

The following samples were received on April 21, 2015 for the analyses specified on the enclosed Chain of Custody Record.

The cooler temperature was not within the acceptance limit of <6°C.

Lab Number	Sample Name	Matrix	Analysis
1504484-01	LBG-13 SS5	Soil	§
1504484-02	LBG-14 SS3	Soil	9030A, 9045, 9250
1504484-03	LBG-14 SS5	Soil	§
1504484-04	LBG-14 SS7	Soil	§
1504484-05	LBG-10 SS4	Soil	§
1504484-06	LBG-7 SS2	Soil	§
1504484-07	LBG-7 SS4	Soil	§
1504484-08	LBG-9 SS3	Soil	§
1504484-09	LBG-9 SS4	Soil	§
1504484-10	LBG-9 SS5	Soil	§, 9030A, 9045, 9250
1504484-11	LBG-3 SS2	Soil	9030A, 9045, 9250
1504484-12	LBG-1 SS3	Soil	§
1504484-13	LBG-1 SS5	Soil	§
1504484-14	LBG-5 SS1	Soil	9030A, 9045, 9250
1504484-15	LBG-5 SS4	Soil	§
1504484-16	LBG-5 SS6	Soil	§
1504484-17	LBG-11 SS2	Soil	§
1504484-18	LBG-12 SS3	Soil	§
1504484-19	LBG-12 SS4	Soil	§

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
ESS Laboratory Work Order: 1504484

PROJECT NARRATIVE

Classical Chemistry

1504484-02	**Estimated value. Sample hold times were exceeded (H).** Sulfide
1504484-10	**Estimated value. Sample hold times were exceeded (H).** Sulfide
1504484-11	**Estimated value. Sample hold times were exceeded (H).** Sulfide
1504484-14	**Estimated value. Sample hold times were exceeded (H).** Sulfide

No other observations noted.

End of Project Narrative.

DATA USABILITY LINKS

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

Client Name: Louis Berger
Client Project ID: Herring River
ESS Laboratory Work Order: 1504484

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015D - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP and Graphite Furnace Digestion
3020A - Aqueous ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-13 SS5
Date Sampled: 03/30/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-01
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-14 SS3
Date Sampled: 03/31/15 00:00
Percent Solids: 83

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-02
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Chloride	**WL 352** (36)		9250		1	EEM	04/27/15 12:11	mg/kg dry	CD52713
Corrosivity (pH)	**5.68** (N/A)		9045		1	MJV	04/23/15 10:52	S.U.	CD52321
Corrosivity (pH) Sample Temp	**Soil pH measured in water at 19.8 ºC.**								
Sulfide	**H, WL** ND (0.6)		9030A		1	EEM	04/27/15 12:15	mg/kg dry	CD52714

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-14 SS5
Date Sampled: 03/31/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-03
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-14 SS7
Date Sampled: 03/31/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-04
Sample Matrix: Soil
Units: %

Subcontracted Analysis

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Sequence	Batch
Sieve Analysis	**See Attached** (N/A)										

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-10 SS4
Date Sampled: 03/31/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-05
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Water by Distillation	**See Attached** (1)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-7 SS2
Date Sampled: 04/01/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-06
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Water by Distillation	**See Attached** (1)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-7 SS4
Date Sampled: 04/01/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-07
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-9 SS3
Date Sampled: 04/01/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-08
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-9 SS4
Date Sampled: 04/01/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-09
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Water by Distillation	**See Attached** (1)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-9 SS5
Date Sampled: 04/01/15 00:00
Percent Solids: 80

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-10
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Chloride	**WL** ND (37)		9250		1	EEM	04/27/15 12:13	mg/kg dry	CD52713
Corrosivity (pH)	**3.01** (N/A)		9045		1	MJV	04/23/15 10:52	S.U.	CD52321
Corrosivity (pH) Sample Temp	**Soil pH measured in water at 19.2 ºC.**								
Organic Content	**See Attached** (N/A)								
Sulfide	**H, WL** ND (0.6)		9030A		1	EEM	04/27/15 12:15	mg/kg dry	CD52714

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-3 SS2
Date Sampled: 04/02/15 00:00
Percent Solids: 85

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-11
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Chloride	**WL** ND (35)		9250		1	EEM	04/27/15 12:14	mg/kg dry	CD52713
Corrosivity (pH)	**4.71** (N/A)		9045		1	MJV	04/23/15 10:52	S.U.	CD52321
Corrosivity (pH) Sample Temp	**Soil pH measured in water at 19.0 ºC.**								
Sulfide	**H, WL** ND (0.6)		9030A		1	EEM	04/27/15 12:15	mg/kg dry	CD52714

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-1 SS3
Date Sampled: 04/02/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-12
Sample Matrix: Soil
Units: %

Subcontracted Analysis

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Sequence	I/V	F/V	Batch
Sieve Analysis	**See Attached** (N/A)										

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-1 SS5
Date Sampled: 04/02/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-13
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-5 SS1
Date Sampled: 04/03/15 00:00
Percent Solids: 87

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-14
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Chloride	**WL 132** (34)		9250		1	EEM	04/27/15 12:14	mg/kg dry	CD52713
Corrosivity (pH)	**5.51** (N/A)		9045		1	MJV	04/23/15 10:52	S.U.	CD52321
Corrosivity (pH) Sample Temp	**Soil pH measured in water at 19.7 ºC.**								
Sulfide	**H, WL** ND (0.6)		9030A		1	EEM	04/27/15 12:15	mg/kg dry	CD52714

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-5 SS4
Date Sampled: 04/03/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-15
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-5 SS6
Date Sampled: 04/03/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-16
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-11 SS2
Date Sampled: 04/03/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-17
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-12 SS3
Date Sampled: 04/03/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-18
Sample Matrix: Soil

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Organic Content	**See Attached** (N/A)								
Sieve #200	**See Attached** (N/A)								

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
Client Sample ID: LBG-12 SS4
Date Sampled: 04/03/15 00:00

ESS Laboratory Work Order: 1504484
ESS Laboratory Sample ID: 1504484-19
Sample Matrix: Soil
Units: %

Subcontracted Analysis

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	Sequence	F/V	Batch
Sieve Analysis	**See Attached** (N/A)										

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CD52713 - General Preparation										
Blank										
Chloride	ND	3	mg/kg wet							
LCS										
Chloride	30		mg/L	30.00		99	90-110			
Batch CD52714 - General Preparation										
Blank										
Sulfide	ND	0.05	mg/kg wet							
LCS										
Sulfide	0.5		mg/L	0.5000		100	85-115			

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
ESS Laboratory Work Order: 1504484

Notes and Definitions

Z-10c	Soil pH measured in water at 19.8 ºC.
Z-10b	Soil pH measured in water at 19.7 ºC.
Z-10a	Soil pH measured in water at 19.2 ºC.
Z-10	Soil pH measured in water at 19.0 ºC.
Z-08	See Attached
WL	Results obtained from a deionized water leach of the sample.
U	Analyte included in the analysis, but not detected
H	Estimated value. Sample hold times were exceeded (H).
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
[2C]	Result was taken from the second column. Dual column analysis.

CERTIFICATE OF ANALYSIS

Client Name: Louis Berger
Client Project ID: Herring River
ESS Laboratory Work Order: 1504484

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP)
A2LA Accredited: Testing Cert# 2864.01
http://www.a2la.org/scopepdf/2864-01.pdf

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI0002
http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/documents/AllLabs.xls

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.depweb.state.pa.us/portal/server.pt/community/labs/13780/laboratory_accreditation_program/590095

CHEMISTRY

A2LA Accredited: Testing Cert # 2864.01
Lead in Paint, Phthalates, Lead in Children's Metals Products (Including Jewelry)
http://www.A2LA.org/dirsearchnew/newsearch.cfm

CPSC ID# 1141
Lead Paint, Lead in Children's Metals Jewelry
http://www.cpsc.gov/cgi-bin/labapplist.aspx

LABORATORY TESTING DATA SHEET

Project Name Herring River
Project No. 74-15-0002.01 **ESS-1504484**
Project Manager Liz Ouk/Samantha Hogan

Client ESS/Louis Berger Group
Assigned By Samantha Hogan
Report Date 4/27/15

Reviewed By Matthew [illegible]
Date Reviewed ***4/27/15***

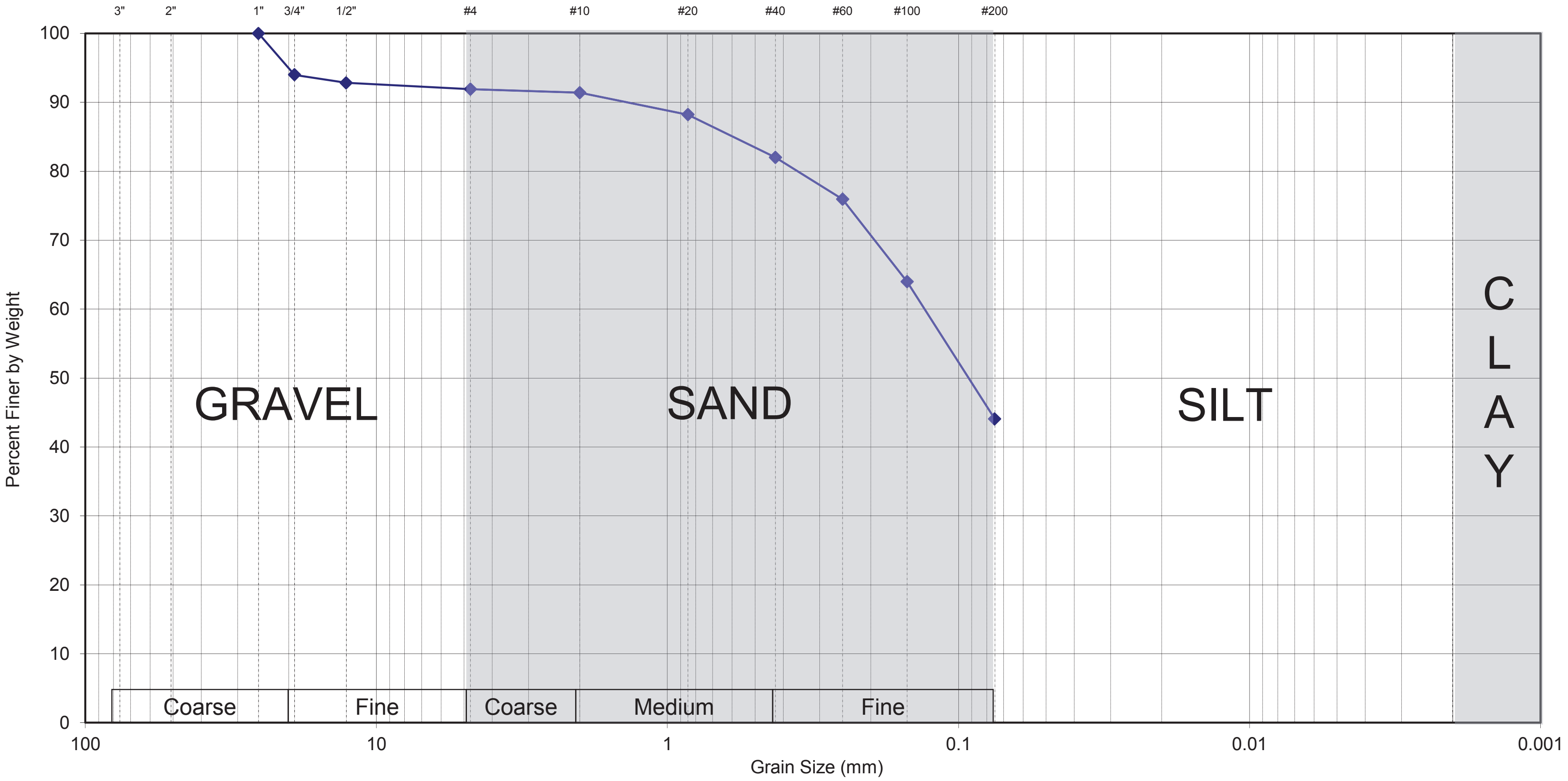
Boring/ Test Pit No.	Sample No.	ESS Sample ID	Lab No.	Identification Tests								Tested	Corrected			
				Water Content %	LL %	PL %	Sieve -200 % (only)	Sieve -200 %	Hyd -2µ %	ORG %	Dry unit wt. pcf	γ_d MAX (pcf) W_{opt} (%)	γ_d MAX (pcf) W_{opt} (%)	Perme-ability cm/sec	Type of Test	Laboratory Log and Soil Description
LBG-13	SS5	1504484-01	15-S-415	41.4			12.3			3.8						
LBG-14	SS5	1504484-03	15-S-416	32.3			7.3			4.9						
LBG-14	SS7	1504484-04	15-S-417	23.4				44.0								Gray-brown Silty Sand (SM)
LBG-10	SS4	1504484-05	15-S-418	43.1						5.1						
LBG-7	SS2	1504484-06	15-S-419	119.2						42.5						
LBG-7	SS4	1504484-07	15-S-420	26.9			13.2			3.8						
LBG-9	SS3	1504484-08	15-S-421	66.8			41.7			6.0						
LBG-9	SS4	1504484-09	15-S-422	58.3						17.8						

THIELSCH
ENGINEERING

195 Frances Avenue
Cranston, RI 02910
401-467-6454

ASTM D422

U.S. STANDARD SIEVE AND HYDROMETER



Gravel	Sand	Fines
8.1%	47.9%	44.0%

Lab #	Boring	ESS Sample ID	Sample	Description	WC	LL	PL	PI
15-S-417	LBG-14	1404484-4	SS7	Gray-brown Silty Sand (SM)	23.4			

Sieve Size	% Passing
¾"	**94.0**
½"	**92.8**
#4	**91.9**
#10	**91.4**
#20	**88.2**
#40	**82.0**
#60	**75.9**
#100	**64.0**
#200	**44.0**

Client: Louis Berger Group
Herring River
ESS Project 1504484
Thielsch CTS Project # 74-15-0002.01
Tested by: MK/MS Date: 4/23/15
Reviewed by: MBP Date: 4/27/15

THIELSCH
ENGINEERING
195 Frances Ave., Cranston, RI 02109
401-467-6454

LABORATORY TESTING DATA SHEET

Project Name Herring River
Project No. 74-15-0002.01 **ESS-1504484**
Project Manager Liz Ouk/Samantha Hogan

Client ESS/Louis Berger Group
Assigned By Samantha Hogan
Report Date 4/27/15

Reviewed By
Date Reviewed 4/27/15

				Identification Tests								Tested	Corrected			
Boring/ Test Pit No.	Sample No.	ESS Sample ID	Lab No.	Water Content %	LL %	PL %	Sieve -200 % (only)	Sieve -200 %	Hyd -2μ %	ORG %	Dry unit wt. pcf	γ_d MAX (pcf) W_{opt} (%)	γ_d MAX (pcf) W_{opt} (%)	Perme-ability cm/sec	Type of Test	Laboratory Log and Soil Description
LBG-9	SS5	1504484-10	15-S-423	14.6						2.9						
LBG-1	SS3	1504484-12	15-S-424	16.9				2.6								Brown Poorly-graded Sand (SP)
LBG-1	SS5	1504484-13	15-S-425	60.6						8.1						
LBG-5	SS4	1504484-15	15-S-426	197.7			8.7			22.4						
LBG-1	SS6	1504484-16	15-S-427	17.2						0.8						
LBG-11	SS2	1504484-17	15-S-428	29.9			14.8			2.2						
LBG-12	SS3	1504484-18	15-S-429	104.2			28.3			9.4						
LBG-12	SS4	1504484-19	15-S-430	23.6				13.9								Gray-brown Silty Sand (SM)

THIELSCH ENGINEERING

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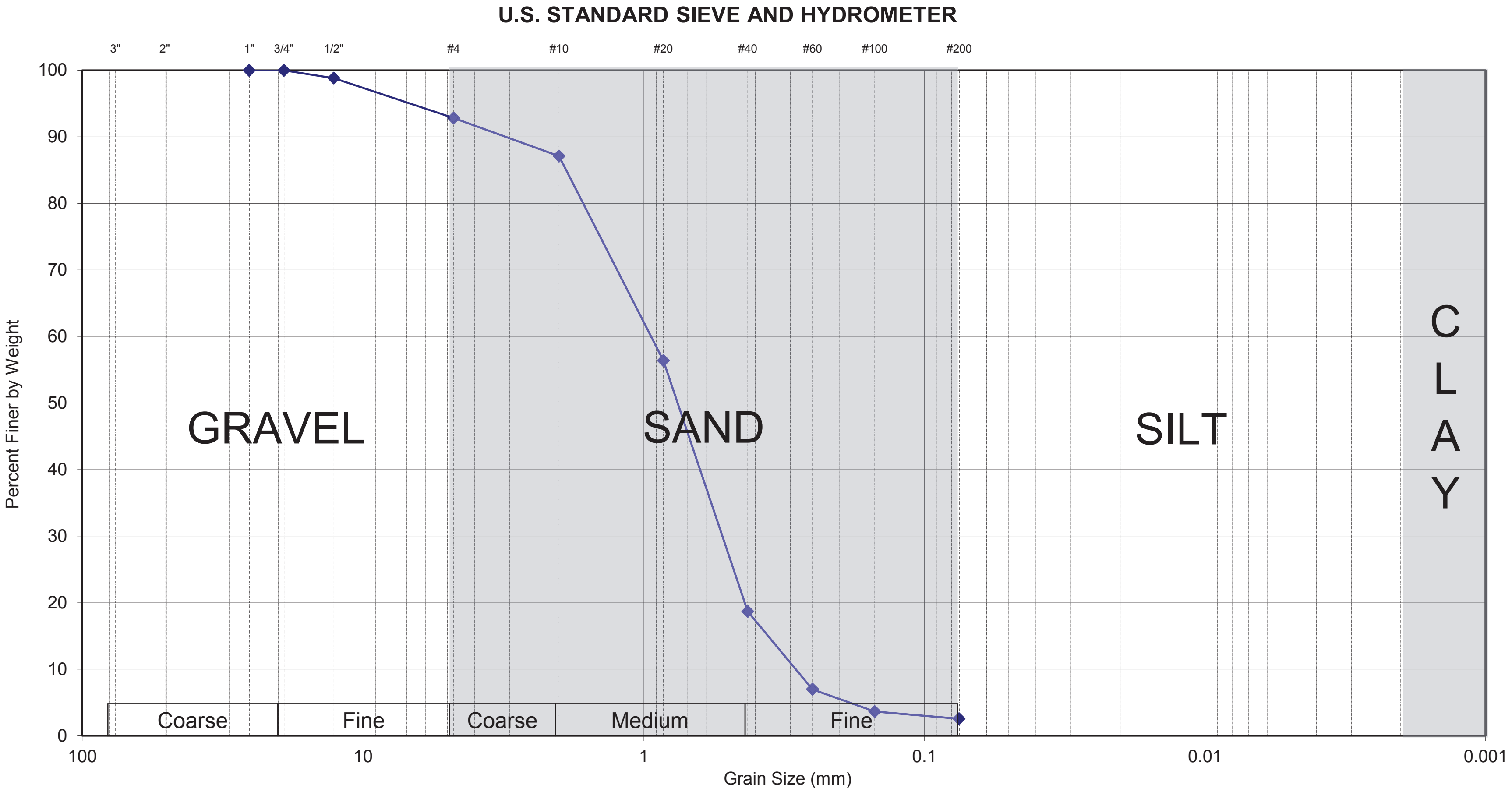
ASTM D422



Gravel	Sand	Fines
7.2%	90.3%	2.5%

Lab #	Boring	ESS Sample ID	Sample	Description	WC	LL	PL	PI
15-S-424	LBG-1	1404484-12	SS3	Brown Poorly-graded Sand (SP)	16.9			

Sieve Size	% Passing
¾"	100.0
½"	98.8
#4	92.8
#10	87.1
#20	56.4
#40	18.7
#60	7.0
#100	3.6
#200	2.5

THIELSCH
ENGINEERING

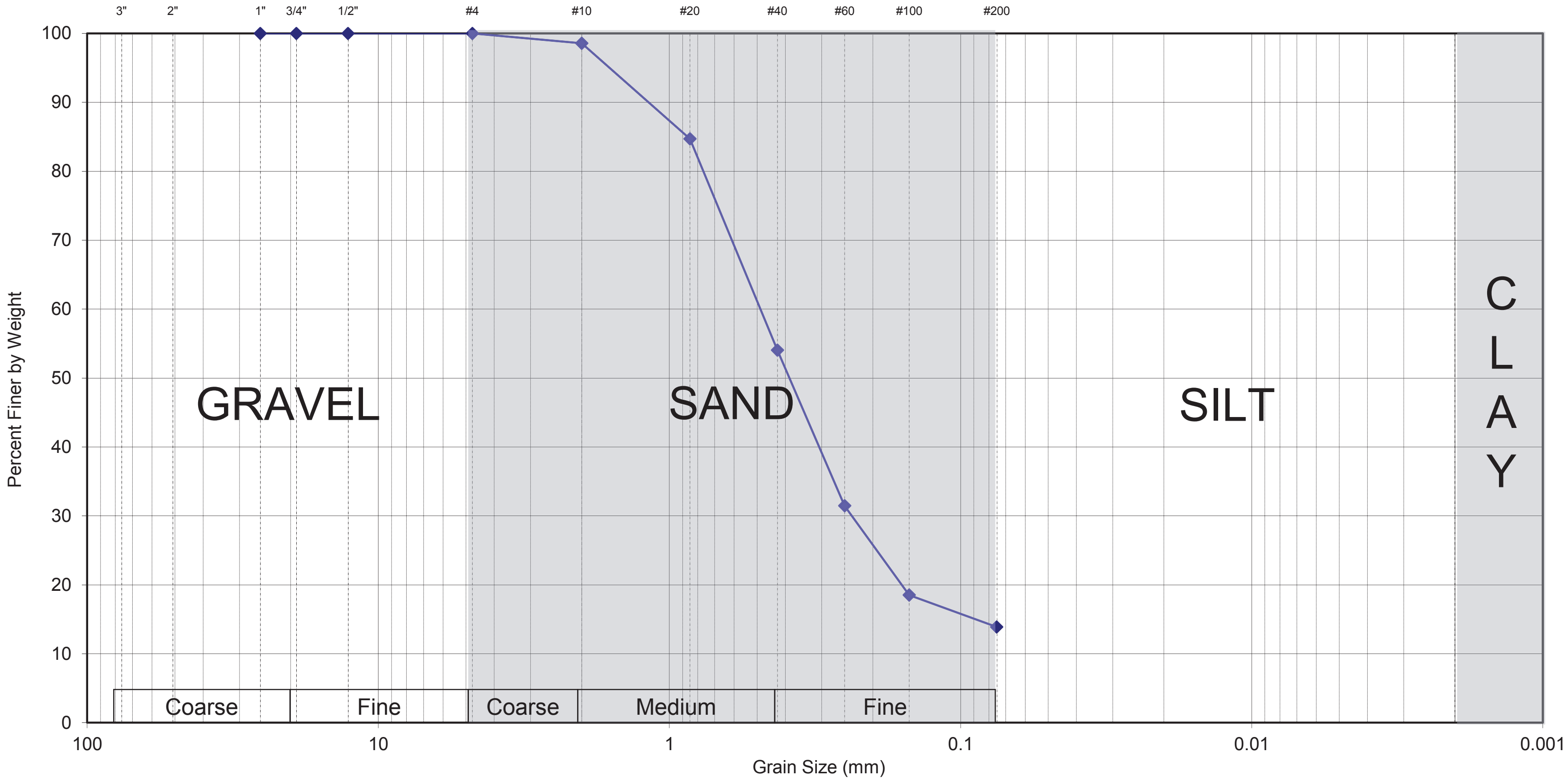
195 Frances Ave., Cranston, RI 02109
401-467-6454

Client: Louis Berger Group
Herring River
ESS Project 1504484
Thielsch CTS Project # 74-15-0002.01

Tested by:	MK/MS	Date:	4/23/15
Reviewed by:	MBP	Date:	4/27/15

ASTM D422

U.S. STANDARD SIEVE AND HYDROMETER



Gravel	Sand	Fines
0.0%	86.1%	13.9%

Lab #	Boring	ESS Sample ID	Sample	Description	WC	LL	PL	PI
15-S-430	LBG-12	1404484-19	SS4	Gray-brown Silty Sand (SM)	23.6			

Sieve Size	**% Passing**
¾"	**100.0**
½"	**100.0**
#4	**100.0**
#10	**98.6**
#20	**84.7**
#40	**54.0**
#60	**31.5**
#100	**18.5**
#200	**13.9**

195 Frances Ave., Cranston, RI 02109
401-467-6454

Client: Louis Berger Group
Herring River
ESS Project 1504484
Thielsch CTS Project # 74-15-0002.01

Tested by: MK/MS Date: 4/23/15
Reviewed by: MBP Date: 4/27/15

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston, RI 02910-2211
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

Page 1 of 2

Turn Time X Standard Other ______
If faster than 5 days, prior approval by laboratory is required # ______

State where samples were collected from: [✓ MA] RI CT NH NJ NY ME Other ______

Is this project for any of the following: MA-MCP* Navy USACE Other ______

Reporting Limits

ESS LAB PROJECT ID 1504484

Electronic Deliverable X Yes ___ No Format ______

Co. Name: Louis Berger
Project #:
Project Name (20 Char. or less): Herring River
Contact Person: Samantha Hogan
Address: 166 Valley St. Bldg #5
City: Providence State: RI Zip: 02909
PO#:
Telephone #: (401) 545-9447
Fax #:
Email Address: shogan@louisberger.com

Circle and/or Write Required Analysis

ESS LAB Sample#	Date	Collection Time	COMP	GRAB	MATRIX	Sample Identification (20 Char. or less)	Number of Containers	Type of Containers	8260 624 524.2	8021 MTBE/BTEX 8015 GRO VPH	8100 TPH 8015 DRO EPH No Targets	8081 Pesticides 8082 PCB 608 Pesticides 608 PCB	8270 625 PAH only	RCRA5 RCRA8 PP13 TAL23	TCLP8 MCP MCPw/Hg NBC7	Organic Content	#200 Sieve	Sieve/no hydrometer	Water content	Soil sulfide	Soil chloride	pH
1	3/30/2015	AM		x	S	LBG-13 SS5										X	X					
2	3/31/2015	AM		x	S	LBG-14 SS3														X	X	X
3	3/31/2015	AM		x	S	LBG-14 SS5										X	X					
4	3/31/2015	PM		x	S	LBG-14 SS7												X				
5	3/31/2015	AM		x	S	LBG-10 SS4										X			X			
6	4/1/2015	AM		x	S	LBG-7 SS2										X			X			
	~~4/1/2015~~	~~AM~~		~~x~~	~~S~~	~~LBG-7 SS3~~														~~X~~	~~X~~	~~X~~
7	4/1/2015	PM		x	S	LBG-7 SS4										X	X					
8	4/1/2015	PM		x	S	LBG-9 SS3										X	X					
9	4/1/2015	AM		x	S	LBG-9 SS4										X			X			

Container Type: P-Poly G-Glass S-Sterile V-VOA
Matrix: S-Soil SD-Solid D-Sludge WW-Waste Water GW-Ground Water SW-Surface Water DW-Drinking Water O-Oil W-Wipes F-Filters

Cooler Present ✓ Yes ___ No
Seals Intact ___ Yes ___ No NA: ✓
Cooler Temp: 22.8 no ice

Internal Use Only
[ ] Pickup DO
[ ] Technicians ______

Comments:

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
	4/21/2015 16:13		4/21/15 1613				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time

*MADEP requires that all additional calibrated analytes found during analysis be disclosed.

Please fax all changes to Chain of Custody in writing.

1 (White) Lab Copy 2 (Yellow) Client Receipt

ESS Laboratory

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www.esslaboratory.com

CHAIN OF COUSTODY

Page 2 of 2

Turn Time X Standard Other ______
If faster than 5 days, prior approval by laboratory is required # ______

State where samples were collected from: [✓ MA] RI CT NH NJ NY ME Other ______

Is this project for any of the following: MA-MCP* Navy USACE Other ______

Reporting Limits

ESS LAB PROJECT ID 1504484

Electronic Deliverable X Yes ___ No Format ______

Co. Name: Louis Berger	Project #:	Project Name (20 Char. or less): Herring River	
Contact Person: Samantha Hogan	Address: 166 Valley St. Bldg #5		
City: Providence	State: RI	Zip: 02909	PO#:
Telephone #: (401) 545-9447	Fax #:	Email Address: shogan@louisberger.com	

Circle and/or Write Required Analysis

ESS LAB Sample#	Date	Collection Time	COMP	GRAB	MATRIX	Sample Identification (20 Char. or less)	Number of Containers	Type of Containers	8260 624 524.2	8021 MTBE/BTEX 8015 GRO VPH	8100 TPH 8015 DRO EPH No Targets	8081 Pesticides 8082 PCB 608 Pesticides 608 PCB	8270 625 PAH only	RCRA5 RCRA8 PP13 TAL23	TCLP8 MCP MCPw/Hg NBC7	Organic Content	#200 Sieve	Sieve/no hydrometer	Water content	Soil sulfide	Soil chloride	pH
10	4/1/2015	AM		x	S	LBG-9 SS5										X				X	X	X
11	4/2/2015	AM		x	S	LBG-3 SS2														X	X	X
12	4/2/2015	PM		x	S	LBG-1 SS3												X				
13	4/2/2015	PM		x	S	LBG-1 SS5										X						
14	4/3/2015	AM		x	S	LBG-5 SS1														X	X	X
15	4/3/2015	AM		x	S	LBG-5 SS4										X	X					
16	4/3/2015	AM		x	S	LBG-5 SS6										X						
17	4/3/2015	PM		x	S	LBG-11 SS2										X	X					
18	4/3/2015	PM		x	S	LBG-12 SS3										X	X					
19	4/3/2015	PM		x	s	LBG-12 SS4												X				

Container Type: P-Poly G-Glass S-Sterile V-VOA

Matrix: S-Soil SD-Solid D-Sludge WW-Waste Water GW-Ground Water SW-Surface Water DW-Drinking Water O-Oil W-Wipes F-Filters

Cooler Present ✓ Yes ___ No
Seals Intact ___ Yes ___ No NA: ✓
Cooler Temp: 2.3.8 NO ice

Internal Use Only
[ ] Pickup DO
[ ] Technicians ______

Comments:

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
	4/21/2015 16:13		4/21/15 1613				
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Date/Time**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**	**Date/Time**

*MADEP requires that all additional calibrated analytes found during analysis be disclosed.

Please fax all changes to Chain of Custody in writing.

1 (White) Lab Copy 2 (Yellow) Client Receipt

Appendix D

Preliminary Opinion of Construction Cost

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Herring River Low Lying Roads Probable Opinion of Cost

Item	Quantity	Unit	Unit Cost	Cost
Straw Waddles	18,500	LF	$ 10.00	$ 185,000.00
Loam and Seed	15,500	SY	$ 5.00	$ 77,500.00
Pavement Demolition/Removal (bituminous roads 4-6" thick)	32,901	SY	$ 9.80	$ 322,426.86
Roadway Compaction (riding, vibrating roller, 6" lifts, 2 passes)	45,921	BCY	$ 0.50	$ 22,960.39
Roadway Excavation (1 C.Y. cap= 100 C.Y./hr) for misc. excavation/water quality channels	7,500	CY	$ 2.54	$ 19,050.00
Borrow Loading and/or Spreading (select granular fill, 3 CY Front End Loader)	57,401	LCY	$ 21.50	$ 1,234,120.90
Hauling Fill material to site (20 min. wait, 25 mph, 6 mile cycle)	57,401	LCY	$ 8.50	$ 487,908.26
Loading Fill at Haul Site (front end loader, 3 C.Y. cap = 130 C.Y./Hr	57,401	LCY	$ 2.12	$ 121,690.06
Hauling and removal of unsuitable material	500	LCY	$ 30.00	$ 15,000.00
Prop Road Base Course (12" Gravel) (crushed stone, 3/4" max size)	20,500	SY	$ 13.50	$ 276,750.00
Prop Road Intermediate Course (2.5" HMA)	20,500	SY	$ 13.55	$ 277,775.00
Prop Road Surface Course (1.5" HMA)	20,500	SY	$ 10.30	$ 211,150.00
Guard rails (Steel, posts 6'3" O.C.)	10,900	LF	$ 28.00	$ 305,200.00
24" RCP Culvert (class 3, no gaskets)	150	LF	$ 69.00	$ 10,350.00
6'x6' Box Culvert (6'x7', precast, 8' long)	80	LF	$ 380.00	$ 30,400.00
6'x8' Box Culvert (6'x7', precast, 8' long)	50	LF	$ 415.00	$ 20,750.00
7'x8' Box Culvert (8'x8', precast, 8' long)	50	LF	$ 455.00	$ 22,750.00
Precast concrete headwall for 24" RCP culverts	6	EA	$ 3,500.00	$ 21,000.00
Concrete headwall for box culverts	6	EA	$ 12,500.00	$ 75,000.00
Riprap for culvert protection, 300 lb average	2,500	TON	$ 29.00	$ 72,500.00
Roadway Excavation (1 C.Y. cap= 100 C.Y./hr) for culverts	1,500	CY	$ 2.54	$ 3,810.00
Crushed stone bedding for culverts	2,500	CY	$ 41.00	$ 102,500.00
Backfill and compaction of bedding	250	LCY	$ 2.86	$ 715.00
Pole Dike Road Gate Structure	1	LS	$ 80,600.00	$ 80,600.00
Pole Dike Road Gate Platform	1	LS	$ 18,000.00	$ 18,000.00
Implementation of Traffic Management Plan	1	LS	$ 20,000.00	$ 20,000.00
Dewatering/By-pass	6	EA	$ 15,000.00	$ 90,000.00
SOE Installation	6	EA	$ 13,500.00	$ 81,000.00
Subtotal				**$ 4,205,906**
Mob/Demob @10%				$ 420,591
Bonding and Insurance @1.5%				$ 63,089
General Conditions @5%				$ 210,295
Contingency @30%				$ 1,261,772
Total=				**$ 6,161,653**

Appendix E

Meetings and Communication

Louis Berger

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Meeting Minutes

DATE: 30 December 2014

FROM: Chris Feeney

SUBJECT: **Herring River Restoration Project: Engineering Design to Elevate Low-Lying Roadways and Replace Associated Culverts**

Meeting Date: 18 December 2014

Time: 1:00 pm to 3:00 pm

Attendees:
Steve Block, NOAA
Martha Rheinhardt, Cape Cod Conservation District
Mark Vincent, Wellfleet DPW Director
Alan Platt, FHR
Chris Feeney, Louis Berger

CC: Don Palladino, FHR

1. Overview/Introduction/Project Administration

S. Block, C. Feeney, M. Rheinhardt reviewed the contract and comments received from MADER and NOAA. Specific language to address the comments on the contract were agreed to in the meeting.

S. Block requested that all deliverables, including invoices, be submitted to M. Rheinhardt and S. Block. All review comments will be coordinated by M. Rheinhardt and S. Block.

C. Feeney will serve as the primary point of contact for Louis Berger.

S. Block stressed the importance of QA/QC on all deliverables prior to submission to the project team for review.

2. Project Discussion

C. Feeney provided a brief overview of proposed field work (i.e. survey, borings). The schedule for the survey work and geotechnical investigation was discussed. The field work will be scheduled three weeks out after the holidays. Louis Berger will coordinate with M. Vincent to coordinate access for field work, discuss Maintenance and Protection of Traffic Plan (MPOT), and potential access to private property. See attached project schedule.

It was noted during the meeting that an RDA will need to be submitted to the Wellfleet Conservation Commission and a negative determination must be issued before borings can occur.

M. Vincent and S. Block requested a detailed submission of the proposed borings and notes on traffic control during borings. The need for police details was discussed at the meeting. This detail would be needed to obtain the required permit for the investigation.

M. Vincent provided drawings of the water line on Pole Dike at the meeting. The drawings are available in hard copy only. No CAD and/or GIS mapping is available. These are the only Town owned utilities within the project area. M. Vincent did note the presence of underground electric in the area.

C. Feeney indicated that Louis Berger will provide follow up written request to document the process of confirming the presence of underground utilities in the project area.

Dig safe would be contacted prior to the geotechnical investigation. Follow up correspondences will be sent to confirm the location of any below grade and above grade gas, power, cable, and telephone lines.

M. Rheinhardt distributed model documentation in advance of the meeting to confirm required dimensions and inverts for proposed culverts. A table summarizing this information was provided (see attached). Additional information will be provided to document the confirmed elevation of the storm of record at each road segment.

C. Feeney indicated that LB would prepare a design criteria memo to summarize the criteria used for the design: culvert geometry, side slope geometry, slope stabilization, protected road elevation, and free board. The memo will also summarize the overall design objectives to meet MADEP storm water guidelines. The goal is to utilizing an above grade naturally vegetated drainage system.

M. Vincent noted concern with existing soils and ability to withstand additional fill associated with elevating the roads. He noted the instability of Bound Brook section during a recent mill and overlay operation.

C. Feeney summarized the design criteria used in the CLE report for a 34-ft paved ROW, based on two 12-ft lanes and two 5-ft shoulders. The project team agreed to match the existing paved dimensions. The paved ROW will not be increased unless required to meet applicable standards.

The project team agreed to keep side slopes within 3:1 to maximize use of natural vegetation. Slopes steeper would only be used when required to minimize impacts to private property or impacts to channel.

The project team discussed how to tie in connecting driveways and roadways to avoid any impacts associated with grades and/or drainage. It is noted that we did visit the driveways during our field trip. Most driveways sloped up so achieving grade shouldn't be too difficult to accommodate. It is noted that grading on private property may be required to transition grades.

Project team discussed road closures and traffic detours required during construction. The existing roadways are narrow making partial road opening during construction difficult. C. Feeney indicated that Berger will develop a detour plan working with the Town that is minimizes impacts to traffic. The detour plan will contain specific construction sequencing language to avoid multiple closures at one time.

S. Block and M. Rheinhardt requested additional scope to address channel modifications at the former rail road ROW. The model results indicated that the current RR bed causes a tidal restriction. The goal of restoration would be to remove approximately 100-ft of the RR embankment. The embankment could be used for fill for the proposed road segments.

3. Public Meeting Forum

M. Vincent and S. Block discussed the schedule and proposed format for the first public meeting. The project team agreed to target the beginning of February for the first public forum. We discussed the potential of having the Wellfleet Community Forum sponsor the public meetings.

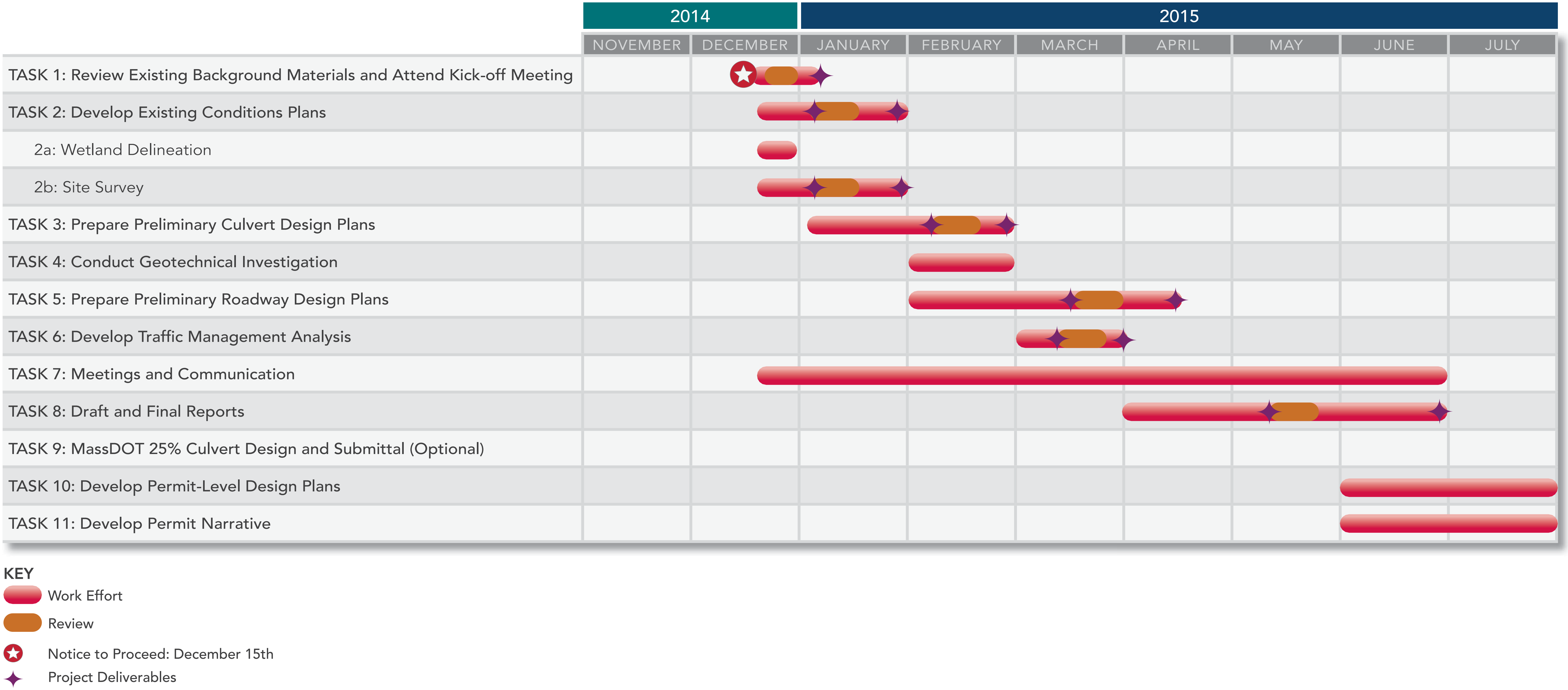
The general content of the two meetings was discussed: 1. Design Charrette (design criteria, purpose/goal, level of protection) and 2. Design Alternative (preferred alternatives).

It was noted that bike accessibility may be an item of discussion at the public forum.

4. Site Visit

Following the meeting, a site visit was convened. S. Block, M. Rheinhardt, and C. Feeney visited each of the four culverts to be replaced.

Follow up question for the Town, would the fire well be replaced following restoration? It was noted that post-restoration would result in high salinity water.


2014
2015
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
TASK 1: Review Existing Background Materials and Attend Kick-off Meeting
TASK 2: Develop Existing Conditions Plans
2a: Wetland Delineation
2b: Site Survey
TASK 3: Prepare Preliminary Culvert Design Plans
TASK 4: Conduct Geotechnical Investigation
TASK 5: Prepare Preliminary Roadway Design Plans
TASK 6: Develop Traffic Management Analysis
TASK 7: Meetings and Communication
TASK 8: Draft and Final Reports
TASK 9: MassDOT 25% Culvert Design and Submittal (Optional)
TASK 10: Develop Permit-Level Design Plans
TASK 11: Develop Permit Narrative
KEY
Work Effort
Review
Notice to Proceed: December 15th
Project Deliverables

Location	Existing Infrastructure Information					Proposed			
	Culvert DIA. (ft)	Upstream Culvert Invert (ft-NAVD88)	Downstream Culvert Invert (ft–NAVD88)	Approx. Length (ft)	Existing Road Elevation at Crossing (ft-NAVD88)	Proposed Replacement Culvert or Opening	Fully restored approx. MHWS (ft–NAVD88)	Proposed Culvert Obvert (ft-NAVD88)	Notes
1) Pole Dike Creek at Pole Dike Rd.	3	-1.0	-1.3	45	4.67	Minimum of 7’x8’ box culvert for safety. 4’x8’ is adequate for flow	4.8	5.7	Existing circular culvert is restrictive. Replacement culvert as minimal as 4’x8’ reduced attenuation; however, this size did not provide adequate headspace during normal tidal conditions. Therefore, a 7’x8’ opening is suggested.
2) Bound Brook at Bound Brook Is. Rd.	5	-3.3	-3.5	45	4.45	6’x8’ box culvert	3.5	4.5	Existing 5 foot culvert did not significantly restrict flow. However, there is inadequate headspace at the existing culvert and enough of a restriction that it is reasonable to increase the culvert size, especially considering the road is being raised. A 6’x8’ box culvert provides full tidal exchange under storm conditions and provides adequate headspace during normal conditions.
3) Bound Brook Remnant RR Crossing	N/A	N/A	N/A	30	N/A	Restore open channel marsh plain, minimum of 100 feet	3.5	N/A	This feature was a significant flow restriction to the areas upstream during events that will flood the marsh plain. It has a similar effect as High Toss Road. Remove embankment to create a more natural open channel and marsh plain. Match existing downstream grades for at least a 100 foot wide area. Ideally remove entire embankment (approximately 500 feet) while matching upstream and downstream grades and beneficially reuse material in a subsided marsh area.
4) Bound Brook at Old County Rd.	2	-2.1	-2.3	35	2.69	6’x6’ box culvert	2.5-3.0	3.7	This culvert was not restrictive until we improved the RR crossing location (3). Replace with 6’x6’ box culvert as road needs to be raised. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.
5) Bound Brook at RR Crossing Culvert	2	-2.6	-2.6	80	N/A	6’x6’ box culvert	2.5-3.0	3.4	This culvert was not restrictive until we improved the RR crossing location (3). Replace with a 6’x6’ box culvert, and consider re-alignment of the culvert. As currently situated, flow restrictions occur during larger events due to both the size and orientation of the culvert to the approaching creek. Additionally, may want to consider channel excavation and reconfiguration on the downstream side of this crossing. Also, may want to consider raising the invert 0.5 feet, which has inconsequential impact on the flow and provides additional headspace.

Louis Berger

Memorandum

DATE: 20 February 2015

TO: Donald Palladino and Martha Rheinhardt, Friends of Herring River
Steve Block, NOAA Restoration Center

FROM: Chris Feeney and Jason Ringler, Louis Berger

SUBJECT: Public Input from Roadway Forum held on February 4, 2015

On February 4, 2015, the Friends of Herring River hosted a Public Forum at the Wellfleet Council on Aging between 6:00 pm and 9:00. The purpose of this "zero design" meeting was to hear and record issues, concerns and questions from the public so these matters can be considered before and during the design phase of this project. The project was present by both the Friends of Herring River and Louis Berger. Below are issues, concerns and questions recorded during this meeting.

- Travel Lane and Shoulder Width
- Bike Shoulders Would Be Preferred
- Traffic Management/Counter
- Power Lines/Utility Being Buried
- Communicate Work Schedule
- Dirt Road Access in Paradise Hollow
- Minimize Visual Impact to Preserve Natural Beauty and “Country Road” Aesthetics
- Horse Traffic Should be Considered
- Proposed Road Improvements Should be Safe For All Users
- One Way/Two Way Traffic Consideration
- Motorcycles Currently Use the Road
- Safety Should Be Factored into Future Design
- Ice and Its Impacts on Proposed Culverts
- Detour – Pole Dike Road Out To Route 6
- Are There Traffic Counts For Pole Dike Road To Transfer Plan
- Smooth Transition Between Existing Road and New Road
- Is Lowering the Speed Limit a Possibility
- Staging Area – To put In Canoes/Kayaks adjacent to the of Herring River
- Audubon Uses Road Currently As Well As Hikers, Joggers
- Traffic Control To Make Road Safer
- Construction During Non-Summer Preferred
- Availability of Survey Data To General Public For Review
- Encourage Future Meetings With The Public
- Show Existing & Proposed Road On Future Plans

Louis Berger

Memorandum

DATE: 29 June 2015
TO: Donald Palladino and Martha Rheinhardt, Friends of Herring River
Steve Block, NOAA Restoration Center
FROM: Chris Feeney and Jason Ringler, Louis Berger

SUBJECT: Public Input from Roadway Forum held on June 24, 2015

On June 24, 2015, the Friends of Herring River hosted a Public Forum at the Wellfleet Council on Aging between 7:00 pm and 9:00 pm. The purpose of this meeting was to present the findings of the recent field work completed (survey, wetland delineation, geotechnical investigation, conceptual design) as well as to share out input from the last public meeting (February 4, 2015) was integrated into the design. The project was present by both the Friends of Herring River and Louis Berger. Below are issues, concerns and questions recorded during this meeting.

- Will the tax payers in Wellfleet and Truro be forced with paying for the project?
- Would the town sand pit be impacted by the project?
- What is the status of the low-lying property mitigation planning?
- Would Federal grant need to be applied for on an annual basis?
- If the current low-lying property mitigation planning effort is to protect structures, is there any consideration given to low-lying land that would be flooded by the project?
- Property Owner at 1200 Bound Brook Island Road currently maintains a hand pump well for personal use as well as by neighbors during the event of a power outage. Would the use of this well be impacted?
- Would the project result in a “take” or condemnation of private property?
- Is there a figure the FHR can provide to the public via their website which depicts what the area tidal inundation will be on a daily basis as well as during larger costal events?
- The Town of Wellfleet is in the process of conducting a large dredge project, could the dredged material be used for elevating the roadways?
- Has the Restoration Team considered utilizing the railroad bed as a detour route during construction rather than having to close road segments?
- When will there be funding available for the entire project, is there a chance that it could start and not have enough funds to finish?
- Has there been a prioritization as to which culverts should be replaced first?
- What will be the vegetative composition throughout the floodplain following full opening of the dike? What will it look like and how long will it take to transition between vegetative communities?
- Has the design factored in any pull offs on the side of the road to allow viewing of the restored marsh?
- Can the FHR provide a figure showing where guardrails are proposed?

- Can there be protective measure implemented to prevent clogging of the tide gate on Pole Dike Road?
- Can the rail embankment be used as a temporary road to minimize construction impacts?
- Can the rail embankment be used as alternative road to the current alignment?
- Will flooding of properties occur without permission as long as structures aren't impacted?
- Will the Pole Dike gate be opened right away?
- How long would each of the three construction phases take?

General Statements

The Restoration Team should considering removing the culvert from Lombard Hollow (north) as historic oil painting depicts cows grazing in the area, so the assumption is the area was historically dry.

Concerns were raised over the aesthetic impacts of the proposed gate structure on Pole Dike. Questions were raised if the gate could be relocated to the rail embankment to minimize the impacts.

Many expressed concerns over the potential need for guardrails on the project. Louis Berger explained that MassDOT guidelines would require a guardrail on the majority of the alignment. It was questioned if the MassDOT standards would apply. Because the study area is not as MassDOT road, guardrails should not be used.

Volume II: Project Plans

Louis Berger

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APPENDIX I: FINAL NATIONAL PARK SERVICE / MASSACHUSETTS HISTORICAL COMMISSION PROGRAMMATIC AGREEMENT

PROGRAMMATIC AGREEMENT AMONG THE MASSACHUSETTS STATE HISTORIC PRESERVATION OFFICE, 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 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 (NHPA, 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 federal 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 SHPO 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 a qualified 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 at 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 among the CACO, SHPO, and, as appropriate, consulting parties and will be implemented in 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 remain state or private property and will be cataloged and curated according to 950 CMR 70 guidelines.

   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 for that area have been reviewed by

the NPS, SHPO and THPO. 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 permitee 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 for review and concurrence.

   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 results of all archeological investigations and any prehistoric and historic materials uncovered during archeological excavations. Ground disturbing activities will be considered to include archeological testing, and THPOs will be given notice of the initiation of testing work with adequate time to observe fieldwork.

6. 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" × 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.

7. Post Review Discoveries

   7a. CACO shall notify SHPO, THPOs and signatories if previously unidentified archaeological resources or if human remains are discovered during 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 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).

   7b. 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).

8. 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.
9. 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.
10. Termination

    10A. 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.

    10B. 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.

    10C. 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, SHPO, Massachusetts Historical Commission — Date

Advisory Council on Historic Preservation:

Reid Nelson, Director, Office of Federal Agency Programs — Date

Cape Cod National Seashore:

George Price, Superintendent — Date

APPENDIX J: DRAFT MOU III HERRING RIVER RESTORATION PROJECT

Draft MOU III
Herring River Restoration Project
December 22, 2015

The following is a list of acronyms used herein:

CCNS: Cape Cod National Seashore
CNR: Chequessett Neck Road
CRP: Conceptual Restoration Plan
DRP: Detailed Restoration Plan
FEIS/EIR: Final Environmental Impact Statement/Report
HREC: Herring River Executive Council
HRRC: Herring River Restoration Committee
MEPA: Massachusetts Environmental Policy Act
MOU: Memorandum of Understanding
NEPA: National Environmental Policy Act
NPS: National Park Service

This Memorandum of Understanding (MOU) is effective upon signature by and among the National Park Service (NPS), a bureau of the United States Department of the Interior, acting through the Superintendent of the Cape Cod National Seashore (CCNS), and the Towns of Wellfleet and Truro, municipal corporations located in Barnstable County, Massachusetts, acting through their Boards of Selectmen. The purpose of this MOU is:

1) To ratify the Detailed Restoration Plan (DRP) set forth in the Final Environmental Impact Statement/Report (FEIS/EIR) for the restoration of the Herring River estuary, completed by the Herring River Restoration Committee (HRRC) pursuant to a previous (November 2007) Memorandum of Understanding (referred to as MOU II) between NPS and the Towns of Wellfleet and Truro;

2) To enable additional planning, engineering, funding, construction and implementation of the agreed-upon restoration plan, using an Adaptive Management Plan, as set forth in the FEIS/EIR.

3) To set forth the structure and responsibilities of an intergovernmental team to direct the Restoration Project.

4) To generally describe the responsibilities of an independent organization which the parties could engage to undertake specified activities in the restoration process.

WITNESSETH

WHEREAS, the National Park Service (hereinafter NPS) administers and manages the Cape Cod National Seashore (hereinafter CCNS), located partially within the Towns of Wellfleet and Truro (hereinafter "the Towns") and including more than 800 acres within the Herring River floodplain; and whereas CCNS is legally authorized by U.S.C. Sections 1-3, 459b-459b-8 as a unit of the National Park System to enter into memoranda of understanding, and;

WHEREAS, the Town of Wellfleet maintains ownership of the Chequessett Neck Road (CNR) Dike, which currently controls tidal flow to the Herring River system, and the Town includes lands and waters within the Herring River estuary that may be affected by the restoration of tidal flow through the Dike, and;

WHEREAS, the Town of Truro includes lands and waters within the Herring River estuary that may be affected by the restoration of tidal flow through the Chequessett Neck Road Dike, and;

WHEREAS, High Toss Road, which crosses the Herring River floodplain, is located within Cape Cod National Seashore and is on land owned by the National Park Service, while the Town of Wellfleet holds rights for public access across it and maintains the road, and;

WHEREAS, the Town of Wellfleet and CCNS, pursuant to a (August 2005) MOU (referred to as MOU I) worked together to determine that restoration of the natural functions to the Herring River estuary is feasible and desirable, and to complete a Conceptual Restoration Plan (CRP), which was accepted by both the Towns of Wellfleet and Truro and CCNS pursuant to a second MOU (MOU II) executed in November 2007, and;

WHEREAS, pursuant to MOU II, the Towns and CCNS agreed that it was imperative that a Detailed Restoration Plan (DRP) be developed with continued public involvement and, when completed, the DRP represent the full consensus of the three primary entities; and whereas, the Towns and the CCNS agreed that alternatives analysis and public involvement approaches of the Massachusetts Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) would provide a mechanism for accomplishing these objectives, and;

WHEREAS, pursuant to MOU II, the Towns and the CCNS organized an interdisciplinary team, the Herring River Restoration Committee (hereinafter HRRC) to develop a detailed and comprehensive plan for restoration of the estuary and directed the Committee to:

a. Review the Herring River Conceptual Restoration Plan (CRP) accepted under MOU II.
b. Review all scientific and engineering reports in support of the CRP;
c. Develop a Detailed Restoration Plan (DRP) that addresses environmental and social concerns through an integrated MEPA/NEPA process of alternatives analysis and public involvement;
d. Develop a Detailed Restoration Plan that is suitable for local, state and federal permitting requirements of procedures;

e. Seek funding sources;
f. Inform the public on a regular basis through public meetings, reports or other forms of outreach, in addition to the public process required by MEPA and NEPA;
g. Produce a third MOU for the Towns' and CCNS's approval, agreeing to collaborate on project implementation per the Detailed Restoration Plan;
h. Deliver products of the MEPA/NEPA process, and;

WHEREAS, the HRRC has developed a DRP that addresses environmental and social concerns through an integrated MEPA/NEPA process of alternatives analysis and public involvement procedures as set forth in the Final Environmental Impact Statement/Report, and;

WHEREAS, the parties have determined that it is in the public interest to enter into this Memorandum of Understanding setting forth a cooperative arrangement between the parties for the next phase of the Herring River Restoration Project including additional planning, engineering, funding, construction and implementation of the agreed-upon Detailed Restoration Plan, using an Adaptive Management Plan, as set forth in the FEIS/EIR, this phase to be known as the implementation phase, and;

WHEREAS, the implementation phase will continue for many years, but at some point in time management responsibilities for tidal control infrastructure will be greatly reduced, this phase to be known as the long-range phase;

NOW THEREFORE, in consideration of the foregoing, the Towns and the CCNS agree as follows:

1. The Town of Wellfleet, the Town of Truro and CCNS hereby accept the Detailed Restoration Plan, including the Preferred Alternative D as set forth in the Final Environmental Impact Statement/Report, attached to this MOU. Implementation of the Detailed Restoration Plan (including but not limited to operation of proposed tide gates at Chequessett Neck Road, Mill Creek and Pole Dike Road) shall be in compliance with federal, state, regional and local permits and the provisions of an approved Herring River Adaptive Management Plan.

2. The Town of Wellfleet, the Town of Truro and CCNS agree to cooperate on implementation of the Detailed Restoration Plan, as set forth below. Representatives of the Town of Wellfleet, the Town of Truro and CCNS will form an intergovernmental team to direct the Restoration Project consisting of the following elements:

a. The Towns and Cape Cod National Seashore shall form a Herring River Executive Council (HREC) to: coordinate project implementation activities; serve as a forum for establishing and providing policy direction; review and approve the Adaptive Management Plan; monitor progress; and ensure compliance with laws, policies and regulations of member towns and the CCNS, project permits and agreements and other applicable legal regulations. The HREC shall meet quarterly or as needed and shall consist of seven members as follows:

1) Two members of the Wellfleet Board of Selectmen and the Town Administrator;
2) Two members of the Truro Board of Selectmen and the Town Administrator;
3) The Superintendent of Cape Cod National Seashore or his/her designee(s).

The HREC shall operate by consensus decision-making (agreement among the two towns and CCNS), recognizing that the towns and Cape Cod National Seashore all have obligations to their own established laws, policies and regulations. In the event that there is dissent among the representatives of one of the towns, they shall determine among themselves the town's position. The HREC shall operate in Open Meetings according to MGL Chapter 30A.

b. The Herring River Restoration Committee (HRRC) established in MOU II as an interdisciplinary management team shall continue to exist and shall serve as an advisory group to the HREC, with representation from the Towns of Wellfleet and Truro, the Cape Cod National Seashore, Commonwealth of MA Division of Ecological Restoration (DER), U.S. Fish and Wildlife Service (USFWS), U.S. Natural Resources Conservation Service (NRCS) and the National Oceanic and Atmospheric Administration (NOAA). The HRRC will:

1) Make project management and funding recommendations to the Herring River Executive Council (HREC);
2) Direct and oversee approved elements of the Restoration Project, as set forth in the FEIS/EIR and Restoration Project permits;
3) Provide planning, engineering, technical, operational and scientific coordination for the Project.

c. The HREC and the HRRC will work with any regulatory oversight group as may be established through federal, state and regional permitting processes.

d. The HREC may consult other individuals or organizations, as needed, such as stakeholder groups and/or science advisors.

e. Any decision to modify or alter tide gate openings at Chequessett Neck Road, Mill Creek and/or Pole Dike Road shall be made by the HREC, only after receiving a recommendation from the HRRC. Such decisions must be in compliance with federal, state, regional and local permits and the provisions of an approved Herring River Adaptive Management Plan.

3. Through separate contracts for services and/or Cooperative Agreements, the Towns and/or the CCNS may engage the services of an independent organization to undertake some or all of the responsibilities and functions outlined below, in coordination with HRRC:

a. Provide and manage professional level technical and administrative staff necessary for the completion of all project elements;

b. Compete for, receive, and administer available project funding from state, federal, and private sector sources;

c. Prepare and submit permit applications, ensure compliance with all permit conditions, noticing requirements, and other environmental compliance obligations;

d. Prepare and advertise bid solicitation packages, manage and oversee competitive bidding processes, select and manage contractors, oversee construction activities, pay invoices, and comply with funder and contractor stipulations;

e. Facilitate agreements with affected landowners;

f. Conduct operations and maintenance of public infrastructure in cooperation with the towns and CCNS as stipulated in any contract agreement(s);

g. Implement the adaptive management plan under the technical direction of HRRC;

h. Perform public outreach and education activities.

4. The Town of Wellfleet, the Town of Truro and CCNS generally agree that the owners of the underlying land should own the components of the new project infrastructure during the implementation phase and for the long-term, as follows[1]:

a. Chequessett Neck Road (CNR) Bridge: *The Town of Wellfleet should continue to own the CNR dike/bridge.*

b. Chequessett Neck Road Tide Gates*: The Town of Wellfleet should own the new CNR tide gates.*

c. Mill Creek Dike: *CCNS should own the new Mill Creek dike.*

d. Mill Creek Tide Gates: *CCNS should own the new Mill Creek tide gates.*

e. High Toss Road: *High Toss Road is within the NPS boundary and located on land under federal ownership, with the Town of Wellfleet holding rights for public access. In order to facilitate tidal flow, the parties agree in principle that the High Toss Road causeway across the Herring River floodplain should be removed, while providing facilities for non-vehicular access to Griffin Island, subject to final town approval.*

f. High Toss culvert: *CCNS should own and maintain any new culvert at High Toss Road. Should the road be removed, no culvert would be needed.*

g. Pole Dike Road: *The Town of Wellfleet should continue to own Pole Dike Road. The Herring River Restoration Project should fund the raising of the road.*

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[1] It is not the intent of this document to make determinations about ownership of assets; the language is descriptive only and thus uses the verb "should" to describe anticipated ownership of the Project infrastructure components.

h. Pole Dike culvert/tide gate: *If a tide gate is installed at Pole Dike Road, the Town of Wellfleet should own the new tide gate.*

i. Old County Road/culverts: *The Town of Wellfleet should continue to own Old County Road and its culverts. The Herring River Restoration Project should fund the raising of the road and installation of new culverts.*

j. Bound Brook Road/culverts: *The Town of Wellfleet should continue to own Bound Brook Road and its culverts. The Herring River Restoration Project should fund the raising of the road and installation of new culverts.*

5. The owners (i.e. the Towns and/or CCNS) of the different elements of Restoration Project tide control infrastructure may wish to engage the services of an independent management organization to construct, operate and maintain this infrastructure (such as bridges, dikes, tide gates and culverts) during the implementation phase, or the owners may wish to perform these functions in-house. Long-term, operation and maintenance responsibilities should be the responsibility of the owner of each element of Project infrastructure.

6. Funding

a. This Memorandum of Understanding and the obligations of the NPS hereunder shall be subject to the availability of funding and staffing, and nothing contained herein shall be construed as binding the NPS to expend in any one fiscal year any sum in excess of appropriations made by Congress and administratively allocated for the purpose of this Agreement for the fiscal year, or to involve the NPS in any contract or other obligation for the further expenditure of money in excess of such appropriations or allocations.

b. This Memorandum of Understanding and the obligations of the Towns hereunder shall be subject to the availability of funding and staff, and nothing herein shall be construed as binding the Towns to expend in any one fiscal year any sums in excess of those appropriated by Town Meeting and made administratively available for the purpose of this Agreement for the fiscal year.

c. Each party shall bear its own costs associated with its participation in this Memorandum of Understanding without reimbursement.

7. This Memorandum of Understanding and the obligations of the NPS hereunder are subject to the laws, regulations and policies governing the NPS and CCNS whether now in force or hereafter enacted or promulgated.

8. This Memorandum of Understanding and the obligations of the Towns hereunder are subject to the laws, regulations, Town Meeting votes and policies governing the Towns, whether now in force or hereafter enacted or promulgated.

9. No Member of, Delegate to, or Resident Commissioner in, Congress shall be admitted to any share or part of this Agreement or to any benefit to arise therefrom, unless the share or part or benefit is for the general benefit of a corporation or company.

10. No part of the money appropriated by any enactment of Congress shall, in the absence of express authorization by Congress, be used directly or indirectly to pay for any personal service, advertisement, telegram, telephone, letter, printed or written matter, or other device, intended or designed to influence in any manner a Member of Congress, a jurisdiction, or an official of any government, to favor, adopt, or oppose, by vote or otherwise, any legislation, law, ratification, policy or appropriation, whether before or after the introduction of any bill, measure, or resolution proposing such legislation, law, ratification, policy or appropriation; but this shall not prevent officers or employees of the United States or of its departments or agencies from communicating to Members of Congress on the request of any such Member or official, at his request, or to Congress or such official, through the proper official channels, requests for any legislation, law, ratification, policy or appropriations which they deem necessary for the efficient conduct of the public business, or from making any communication whose prohibition by this section might, in the opinion of the Attorney General, violate the Constitution or interfere with the conduct foreign policy, counter-intelligence, intelligence or national security activities. Violations of this section shall constitute violations of section 1352(a) of title 31.

11. This Agreement contains the sole and entire agreement of the parties. No oral representations of any nature form the basis of or may amend this Agreement.

12. Failure to enforce any provision of this Agreement by either party shall not constitute waiver of that provision, nor a waiver of a claim for subsequent breach of the same type, nor a waiver of any other term of this Agreement. The waiver of any provision must be express and evidenced in writing.

13. This Memorandum of Understanding may be amended by a unanimous vote of all of the participating parties. It shall remain in effect until superseded by a further MOU or inter-municipal agreement(s) to implement its purposes.

IN WITNESS WHEREOF, the parties have cause this instrument to be executed by their respective duly authorized representatives on the day and year indicated.

To be signed by:

Northeast Regional Director, National Park Service

Chair, Wellfleet Board of Selectmen, after a vote of approval by the Board of Selectmen

Chair, Truro Board of Selectmen, after a vote of approval by the Board of Selectmen